

RENEWABLES IN CITIES

2021 GLOBAL STATUS REPORT

CITY



REN21 MEMBERS

INDUSTRY ASSOCIATIONS

Africa Minigrad Developers Association (AMDA)
 Alliance for Rural Electrification (ARE)
 American Council on Renewable Energy (ACORE)
 Associação Portuguesa de Energias Renováveis (APREN)
 Association for Renewable Energy of Lusophone Countries (ALER)
 Chinese Renewable Energy Industries Association (CREIA)
 Clean Energy Council (CEC)
 European Renewable Energies Federation (EREF)
 Global Off-Grid Lighting Association (GOGLA)
 Global Solar Council (GSC)
 Global Wind Energy Council (GWEC)
 Indian Renewable Energy Federation (IREF)
 International Geothermal Association (IGA)
 International Hydropower Association (IHA)
 Renewable Energy Solutions for Africa (RES4Africa) Foundation
 Solar Power Europe
 World Bioenergy Association (WBA)
 World Wind Energy Association (WWEA)

INTER-GOVERNMENTAL ORGANISATIONS

Asia Pacific Energy Research Centre (APEREC)
 Asian Development Bank (ADB)
 ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE)
 European Commission (EC)
 Global Environment Facility (GEF)
 International Energy Agency (IEA)
 International Renewable Energy Agency (IRENA)
 Islamic Development Bank (IsDB)
 Regional Center for Renewable Energy and Energy Efficiency (RCREEE)
 United Nations Development Programme (UNDP)
 United Nations Environment Programme (UNEP)
 United Nations Industrial Development Organization (UNIDO)
 World Bank (WB)

NGOS

Association Africaine pour l'Electrification Rurale (Club-ER)
 CLASP
 Clean Cooking Alliance (CCA)
 Climate Action Network International (CAN-I)
 Coalition de Ciudades Capitales de las Americas (CC35)
 Energy Cities
 Euroheat & Power (EHP)
 Fundación Energías Renovables (FER)
 Global 100% Renewable Energy
 Global Forum on Sustainable Energy (GFSE)
 Global Women's Network for the Energy Transition (GWNET)
 Greenpeace International
 ICLEI – Local Governments for Sustainability
 Institute for Sustainable Energy Policies (ISEP)
 International Electrotechnical Commission (IEC)
 Jeunes Volontaires pour l'Environnement (JVE)
 Mali Folkecenter (MFC)
 Power for All
 Renewable Energy and Energy Efficiency Partnership (REEEP)
 Renewable Energy Institute (REI)
 SLOCAT Partnership for Sustainable Low Carbon Transport
 Solar Cookers International (SCI)
 World Council for Renewable Energy (WCRE)
 World Future Council (WFC)
 World Resources Institute (WRI)
 World Wildlife Fund (WWF)

SCIENCE AND ACADEMIA

AEE – Institute for Sustainable Technologies (AEE INTEC)
 Council on Energy, Environment and Water (CEEW)
 Fundación Bariloche (FB)
 International Institute for Applied Systems Analysis (IIASA)
 International Solar Energy Society (ISES)
 National Renewable Energy Laboratory (NREL)
 National Research University Higher School of Economics, Russia (HSE)
 South African National Energy Development Institute (SANEDI)
 The Energy and Resources Institute (TERI)

GOVERNMENTS

Afghanistan
 Brazil
 Denmark
 Dominican Republic
 Germany
 India
 Mexico
 Norway
 Republic of Korea
 South Africa
 Spain
 United Arab Emirates
 United States of America

MEMBERS AT LARGE

Michael Eckhart
 Mohamed El-Ashry
 David Hales
 Kirsty Hamilton
 Peter Rae

PRESIDENT

Arthouros Zervos
 National Technical University of Athens (NTUA)

EXECUTIVE DIRECTOR

Rana Adib
 REN21

RENEWABLE ENERGY POLICY NETWORK FOR THE 21st CENTURY



REN21 is the only **global renewable energy community** of actors from science, governments, NGOs and industry. We provide up-to-date and peer-reviewed facts, figures and analysis of global developments in technology, policies and markets. Our goal: enable decision-makers to make the shift to renewable energy happen – now.



The most successful organisms, such as an octopus, have a **decentralised intelligence** and "sensing" function. This increases responsiveness to a changing environment. REN21 incarnates this approach.



Our more than **2,000 community members** guide our co-operative work. They reflect the vast array of backgrounds and perspectives in society. As REN21's eyes and ears, they collect information and share intelligence, by sending input and feedback. REN21 takes all this information to better understand the current thinking around renewables and change norms. We also use this information to connect and grow the energy debate with non-energy players.



Our annual publications, the *Renewables in Cities Global Status Report* and the *Renewables Global Status Report*, are probably the world's most comprehensive crowdsourced reports on renewables. It is a truly collaborative process of co-authoring, data collection and peer reviewing.

TABLE OF CONTENTS

RENEWABLES IN CITIES

Acknowledgements08

Foreword 12

Purpose of This Report..... 13

Executive Summary 14

REPORT CITATION

REN21 (2021), *Renewables in Cities 2021 Global Status Report* (Paris: REN21 Secretariat).

DISCLAIMER:

REN21 releases issue papers and reports to emphasise the importance of renewable energy and to generate discussion on issues central to the promotion of renewable energy. While REN21 papers and reports have benefited from the considerations and input from the REN21 community, they do not necessarily represent a consensus among network participants on any given point. Although the information given in this report is the best available to the authors at the time of publication, REN21 and its participants cannot be held liable for its accuracy and correctness. The designations employed and the presentation of material in the maps in this report do not imply the expression of any opinion whatsoever concerning the legal status of any region, country, territory, city or area or of its authorities, and is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers or boundaries and to the name of any territory, city or area.

1 GLOBAL OVERVIEW OF RENEWABLES IN CITIES22

Drivers and Opportunities for Renewable Energy in 202026

Global Renewable Energy Trends28

Regional Trends36

2 URBAN POLICY LANDSCAPE40

Targets43

Municipal Operations52

City-wide Policies55

City-wide Buildings58

Districts and Neighbourhoods.....69

City-wide Transport.....70



3 MARKETS AND INFRASTRUCTURE..... 74

Buildings and Industry 78

Transport 91

Distribution Infrastructure 97

4 FINANCING AND INVESTMENT IN CITIES..... 104

Financing Mechanisms 107

Investment and Financing in Cities by Region 117

City-specific Challenges to Investing in Renewables 121

5 CITIZEN PARTICIPATION..... 122

Consumer Choice 124

Individual Prosumers 126

Community Energy in Cities..... 126

Participatory Governance 129

Bottom-up Initiatives and Campaigns 132

6 FEATURE: RENEWABLE ENERGY IN SUB-SAHARAN AFRICAN CITIES... 136

Status of Renewables in Sub-Saharan African Cities 138

Cape Town, South Africa 140

Dakar, Senegal 142

Kampala, Uganda 143

Tsévié, Togo 144

Yaoundé IV, Cameroon 145

Barriers and Opportunities for Advancing Renewables ... 146

Reference Tables 148

Data Collection and Validation 150

Methodological Notes 150

Glossary 151

List of Abbreviations 159

Photo Credits 160

Endnotes 162



TABLE OF CONTENTS

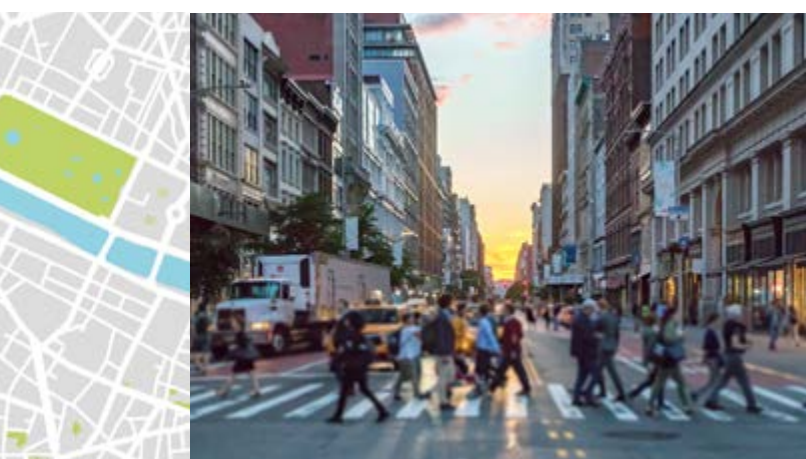
RENEWABLES IN CITIES

SIDEBARS

- Sidebar 1.** COVID-19: General Impact and Responses 27
- Sidebar 2.** Multi-level Governance: The Interdependence of National and Municipal Policies 32
- Sidebar 3.** Linking Renewable Energy and Energy Efficiency in Buildings. 59
- Sidebar 4.** Frontrunners in Solar Thermal Mandates in Cities. 67
- Sidebar 5.** Waste-to-Energy in Cities 76
- Sidebar 6.** Distributed Solar PV to Empower Cities in Developing Countries. 112
- Sidebar 7.** Digitalisation: Enabling Citizen Participation. 125

FIGURES

- Figure 1.** Key Facts and Trends in Cities, 2020 24
- Figure 2.** Renewable Share of Total Final Energy Consumption, by Final Energy Use, 2017. 29
- Figure 3.** Renewable Energy Targets in Cities, 2020 44
- Figure 4.** Renewable Energy Targets in Cities, by Scale of Application and Region, 2020. 44
- Figure 5.** Renewable Energy Targets in Cities, by City Size and Region, 2020. 45
- Figure 6.** Renewable Energy Targets in Cities, by Target Year, 2020 45
- Figure 7.** 100% Renewable Energy Targets in Cities, by Scale of Application and Region, 2020. 46
- Figure 8.** National Renewable Power and Electric Vehicle Targets in Cities, 2020. 50
- Figure 9.** Net-Zero Emission Targets and Renewable Energy Targets in Cities, by Region, 2020 52
- Figure 10.** Renewable Energy Policies in Cities, by Type and Region, 2020. 56
- Figure 11.** Fossil Fuel Bans and Restrictions in Buildings in Cities, 2020 68
- Figure 12.** Number of Cities with Low-Emission Zones and Vehicle Bans on Certain Technologies, 2020. 72
- Figure 13.** Renewable Share of District Heating, by Fuel Source, Top Countries, 2018. 88
- Figure 14.** Global Electric Vehicle Markets in Cities, 2019 ... 95
- Figure 15.** Global Electric Bus Stock, China and Selected Regions, 2015-2019 95
- Figure 16.** Number of Cities with Fossil Fuel Divestments, by Region and Divestment Scope, 2020 109
- Figure 17.** Cities with Climate Emergency Declarations and Renewable Energy Targets, 2020 134
- Figure 18.** Total Final Energy Consumption in the Five Selected Sub-Saharan African Cities, by Sector. ... 138
- Figure 19.** Shares of Energy Use by Carrier in the Five Selected Sub-Saharan African Cities 139



TABLES

Table 1. Overview of Targets, Policies and Actions in Cities, 2020.....	25
Table 2. Number of Public Electric Vehicle Charging Stations and Renewable Energy Uptake in Selected EV Capitals, 2019	102
Table 3. Value of Municipal Bonds to Finance Renewable Energy Installations in Cities Worldwide, 2013-2019.....	111

REFERENCE TABLES

Table R1. Renewable Energy Targets in Cities, 2020	
Table R2. Electric Vehicle Targets and Renewable Power Targets in Cities, 2020	
Table R3. National Renewable Power Targets and E-mobility Targets in Cities, 2020	
Table R4. Emission Reduction and Net-Zero Targets in Cities, 2020	
Table R5. Renewable Energy Policies and Enabling Policies in Cities, 2020	
Table R6. Selected Cities with High Shares of Electricity Generation from Solar PV and Wind, 2019	148

Tables R1-R5: see data online at:
www.ren21.net/cities/datapack



ACKNOWLEDGEMENTS

Note: Some individuals have contributed in more than one way to this report. To avoid listing contributors multiple times, they have been added to the group where they provided the most information. In most cases, the lead topical contributors, lead city contributors, regional contributors, sidebar authors and advisory committee members also participated in the *Renewables in Cities 2021 Global Status Report* data contribution, review and validation processes.



On behalf of:



Federal Ministry
for the Environment, Nature Conservation
and Nuclear Safety

of the Federal Republic of Germany



This report was commissioned by REN21 and produced in collaboration with a global network of research partners. Financing was provided by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) on behalf of the German Federal Ministry of the Environment, Nature Conservation and Nuclear Safety (BMU). It is co-financed by the Covenant of Mayors in Sub-Saharan Africa, an initiative supported by financial contributions of the European Union, the German Federal Ministry for Economic Cooperation and Development (BMZ), and the Spanish Agency for International Development Cooperation (AECID). A major share of the research for this report was conducted on a voluntary basis.

This programme is co-funded by



European Union



REN21 RESEARCH DIRECTION

Lea Ranalder

CHAPTER AUTHORS

Marit Brommer (REinvent)

Henner Busch (Lund University Centre for Sustainability Studies)

Toby Couture (E3 Analytics)

Duncan Gibb (REN21)

Flávia Guerra (REN21)

Teis Hansen (University of Copenhagen)

Joel Nana (Sustainable Energy Africa – SEA)

Lea Ranalder (REN21)

Yachika Reddy (SEA)

Janet Sawin (Sunna Research)

Kristin Seyboth (KMS Research and Consulting)

Freyr Sverrisson (Sunna Research)

SPECIAL ADVISORS

Rana Adib (REN21)

Thomas André (REN21)

Duncan Gibb (REN21)

Hannah E. Murdock (REN21)

Janet Sawin (Sunna Research)

Maryke van Staden (ICLEI – Local Governments for Sustainability)

Peta Wolpe (Independent consultant)

RESEARCH AND PROJECT SUPPORT (REN21 SECRETARIAT)

Dalia Assoum, Flávia Guerra, Mauricio Latapí, Ni Made Dwi Sastriani, Hend Yaqoob

Stefanie Gicquel, Vibhushree Hamirwasia, Chetna Hareesh Kumar, Gwamaka Kifukwe, Fabio Passaro, Shannon Wang, Kritdiyaporn Wongs

COMMUNICATION SUPPORT (REN21 SECRETARIAT)

Tammy Mayer, Laura E. Williamson

Andreas Budiman, Katherine Findlay, Alyssa Harris, Florencia Urbani

EDITING, DESIGN AND LAYOUT

Lisa Mastny, Editor

weeks.de Werbeagentur GmbH, Design

PRODUCTION

REN21 Secretariat, Paris, France

ACKNOWLEDGEMENTS (continued)

SIDEBAR AUTHORS

Sandra Laura Chavez Velazquez (Energy Sector Management Assistance Program – ESMAP, World Bank)
 Zuzana Dobrotkova (ESMAP, World Bank)
 Bärbel Epp (Solrico)
 Flávia Guerra (REN21)
 Catlyne Haddaoui (Coalition for Urban Transition – CUT)
 Tarek Keskes (ESMAP, World Bank)
 Alan David Lee (ESMAP, World Bank)
 Priscilla Negreiros (Cities Climate Finance Leadership Alliance – CCFLA)
 Ni Made Dwi Sastriani (REN21)
 Hend Yaqoob (REN21)

ADVISORY COMMITTEE

Constant Alarcon (C40 Cities)
 Kyra Appleby (CDP)
 Veronica Arias (CC35)
 Alix Bolle (Energy Cities)
 Tabaré Curras (WWF)
 Elizabeth Doris (NREL)
 Amanda Eichel (Global Covenant of Mayors for Climate & Energy)
 Irene Garcia (German Marshall Fund of the United States)
 Nick Godfrey (CUT)
 Catlyne Haddaoui (CUT)
 Victoria Healey (NREL)
 Vincent Kitio (UN-Habitat)
 Stefan Mager (Deutsche Gesellschaft für Internationale Zusammenarbeit – GIZ)
 Shannon McDaniel (Global Covenant of Mayors for Climate & Energy)
 Mohamed Mezghani (International Association of Public Transport – UITP)
 Priscilla Negreiros (CCFLA)
 Martina Otto (UNEP)
 Michael Renner (IRENA)
 Claire Roumet (Energy Cities)
 Irene Skoula (C40 Cities)
 Bella Tonkonogy (CCFLA)
 Philip Turner (UITP)
 Helena Molin Valdez (Climate and Clean Air Coalition)
 Angelika Wasielke (GIZ)

REGIONAL CONTRIBUTORS

Asia

Lead: Tejas P. Shinde (Independent researcher); Muhammad Saladin Islami, Bhaskar Padigala, Happy Tiara (ICLEI Southeast Asia Secretariat); Peter Lundberg (Asia Pacific Urban Energy Association)

China

Lead: Yunqing Bi (Independent researcher); Frank Haugwitz (Asia Europe Clean Energy (Solar) Advisory); Sebastian Ibold (GIZ)

Europe

Lead: Tamsyn Lonsdale (Independent researcher); Frederic Boyer, Eugenia Mansutti (Covenant of Mayors for Climate & Energy); Sebastien Leclef (Council of European Municipalities and Regions)

Latin America

Lead: Nicolas Archury (Independent researcher); Sebastián Navarro (CC35); Alberto Valdés Palacios (Secretaría de Desarrollo Económico de la Ciudad de México); José Luis Samaniego (Economic Commission for Latin America and the Caribbean – CEPAL)

Middle East and North Africa

Akram Al Mohamadi, Elaff Alfadel (RCREEE); Ahmed Samir Elbermbali, Maria Gharesifard (Clean Energy Business Council); Karim Elgendy (Carboun); Franziska Wehinger (Friedrich-Ebert-Stiftung); Hend Yaqoob (REN21)

North America

Lead: Allyson Browne (Independent researcher); Stephen Abbott, Heather House (Rocky Mountain Institute); Megan Day (NREL)

Oceania

Chris Derksema, Carolyn Johnstone, Nik Midlam, Neil Palagedara (City of Sydney); Lee White (Australian National University)

Sub-Saharan Africa

Jean Joel Belinga (CoM SSA project, City of Yaoundé IV); Agbati Camil (University of Lomé, Togo); Zanie Cilliers, Josh Dippenaar, Megan Euston-Brown, Bathandwa Vazi (SEA); Muriel Desgeorges (L'Agence de l'environnement et de la maîtrise de l'énergie – ADEME); Michel Houndjo (CoM SSA project, City of Tsévié); Leila Mahomed Weideman (City of Cape Town); Itumeleng Masenya, Sbu Ntshalintshali (City of Durban); Thierry Nicaise Dognon (City of Bouake); Simon Sambou (City of Dakar)

ACKNOWLEDGEMENTS (continued)

LEAD TOPICAL CONTRIBUTORS

City Overview

Patrick Clerens (European Association for Storage of Energy); Mark Z. Jacobson (Stanford University); Siir Killis (University of Ankara); Silke Krawietz (SETA Network); Jennifer Layke (WRI); Kevin O'Donovan (Freelance advisor)

Buildings

Victoria Burrows (World Green Building Council); Christoph Gollner, Vincent Martinez (Architecture 2030); Margit Noll (JPI Urban Europe); Nora Steurer (Global Alliance for Buildings and Construction)

Citizen Participation

Sara Giovannini (Energy Cities); Margaret Hender (Citizens Own Renewable Energy Network Australia); Lavinia Steinfort (Transnational Institute)

Finance and Investment

Arturo Alarcón (Inter-American Development Bank); Ankit Bhardwaj (New York University); Kes McCormick (International Institute for Industrial Environmental Economics at Lund University); Eszter Mogyorosy (ICLEI); Gerry Muscat, Dirk Roos (European Investment Bank); Yuko Nishida (Renewable Energy Institute); Yimin Zhang (NREL)

Heating and Cooling

Giulia Forgnone (DHC+ Technology Platform); Celia Martinez (UNEP); Gerhard Stryi-Hipp (Fraunhofer ISE); Werner Weiss (AEE INTEC)

Transport

Dale Hall (International Council on Clean Transportation – ICCT); Nikola Medimorec (SLOCAT); Lucy Sadler, Susanne Schlesinger (Sadler Consultants Europe GmbH); Rebecca Sands (AUTONOMY and The Urban Mobility Summit)

LEAD DATA CONTRIBUTORS

Miguel Almeida (Climate Bonds Initiative); Carolyn Amon, Kate Hardin, Soy Lee, Marlene Motyka (Deloitte); Karl Arpon (CDP); Karishma Asarpota, Cesar Carreño, Zoe Durruty, Einav Grinberg, Namrata Joshi, Eszter Mogyorósy, Laura Noriega, Rohit Sen (ICLEI World Secretariat); Albana Kona (European Commission, Joint Research Centre); John Lang (European Consortium of Innovative Universities); Matthew Phillips (United Nations Framework Convention on Climate Change); Evi Pschorr (H2Stations); Florian Remann (GIZ); Lucas Turmena (ICLEI South America Secretariat)

PEER REVIEWERS AND OTHER DATA CONTRIBUTORS

Mohammed Abdalghafoor (Arab Academy for Science Technology & Maritime Transport – AASTMT); Ahmed Abdel Azim (Firnas Shuman); Hassan Aboughalma (Georenco); Ahmet Acar (SHURA Energy Transition Center); Abhijeet Acharya (Walden University); Sujan Adhikari (Renewable energy consultant); Samuel Adunreke (Innovea Hubs); Udochukwu B. Akuru (Tshwane University of Technology); Omar Al Kaaki (KVA); Karamy Saeed Al-areqi (RCREEE and Yemen Equipment and Supply Ltd. – YESCO); Olakunle Alao (PFL Cape Town); David Alemzero (Jiangsu University); Rind Alhage (United Nations Major Group for Children and Youth SDG7 Youth Constituency – UNMGCY SDG7 YC); Mohamed Alhaj (Clean Energy 4 Africa); Ahmed Hamza Ali (Assiut University); Sami Alnabulsi (AASTMT); Mohamed A. Abdel-Raheem (De Montfort University); Sara Anastasiou (Renewable Energy Development Professionals – REDPro); Victor Andrade (The Laboratory of Sustainable Mobility – LABMOB); Hanno Bachler (Anstalt für Verbrennungskraftmaschinen List); Miriam Badino (ICLEI); Eleanor Batilliet (GIZ); Pandora Batra (CDP); Carlo Battisti (International Living Future Europe); Anoucheh Bellefleur (OMEXOM VINCI Energies); Kate Blumberg (ICCT); Anya Boyd (Konsult 360); Derik Broekhoff (Stockholm Environment Institute); Tara Caetano (ICLEI); Myriam Castanié (REScoop); Juan Molina Castro (Colombia Inteligente); Maxine Chan (University of the Philippines Diliman); Anita Chebii (African Centre of Excellence in Energy for Sustainable Development); Yong Chen (IRENA); Zhuolun Chen (Technical University of Denmark – DTU); Sayuri Chetty (GIZ); Pedro Chevez (Consejo Nacional de Investigaciones Científicas y Técnicas – CONICET); Anene Chikwado Emmanuel (African Center of Excellence in Future Energy and Electrochemical Systems); Chuck Chuan Ng (Xiamen University Malaysia); Marlistya Citraningrum (Institute for Essential Services Reform); Suani Coelho (University of São Paulo); André Confiado (UNEP); Lorena Cordero (University College London); Daan Creupelandt (REScoop); Ephraim Daka (Turku University Finland); Fernando De Oliveira (University of São Paulo); Nicolas Demartin (GIZ); Stanislas d'Herbemont (REScoop); Gabriela Prata Dias (DTU); Reghina Dimitrisina (European Geothermal Energy Council – EGEC); Irene Dipadua (Solar Heat Europe); Ahmet Dogan (Nuh

ACKNOWLEDGEMENTS (continued)

Naci Yazgan University); Philippe Dumas (EGEC); Alex Durand (Sciences Po); Madeleine Edl (UNEP); Oghosa Erhahon (The Energy Talk); Mikhail Ermac (Fonds Mondial Pour le Développement des Villes – FMDV); Ashkan Etemad (LEEDinIran); Edmundo Fausto (St. John's Canada); Jinlei Feng (IRENA); Fabrice Fouodji Toche (Vista Organisation for Education and Social Development in Africa); Clarissa Forecchi (Government of Brazil); Mindy Fox (Solar Cookers International); Nicolas Gayet (Quercy Energies); Risa Perlmutter Goldstein (The Goldstein Partnership Architects & Planners); Daniel Hall (PwC UK); Laurence Halphen (ENERGIES 2050); Jonas Hamann (Danfoss); Sikawala Hamwela (Safe and Healthy Energy Zambia Limited); Mark Hankins (African Solar Designs); Rainer Hinrichs-Rahlwes (EREF); Lizzy Igbine (Nigerian Women Agro Allied Farmers Association); Birol Ilkikis (World Alliance for Decentralized Energy); Saladin Ismail (ICLEI); Arne Georg Janssen (Cities Alliance); Mariana C. Jiménez Martínez (Catalonia Institute for Energy Research); Ayoun Jo (United Nations Industrial Development Organization); Injy Johnstone (Victoria University of Wellington); Guillaume Joly (Région Ile-de-France); Jozsef Kadar (Haifa Center for German and European Studies); Mohamed Kamel (Dar); Ezgi Kelleher (C40 Cities); Melissa Kerim-Dikeni (JONES DAY® – One Firm Worldwide™); Mohamedahmed Khalifa (Omdurman Islamic University and UNESCO Chair in Water); Nazar I. Khan (Jamia Millia Islamia); Amjad Khashman (Leipzig University); Herbert Kimani (UN-Habitat); Maria Kottari (The Energy Matrix); Prosper Kuradusenge (Independent researcher); Sigrid Kusch-Brandt (University of Padua); Ferdinand Larona (GIZ); Denis Lenardic (PV Resources); Sofia Lettenbichler (DHC+ Technology Platform); Thomas Lewis (REScoop); Nicola Lezza (ICLEI); Arminel Lovell (CDP); Roberto Lozano (Independent consultant); Kelly Lynch (Sierra Club); Sivuyile Maboda (Parliament of the Republic of South Africa); Takunda Mambo (ICLEI); Yann Mercier (GIZ); Alan Miller (Independent consultant); Ray Minjares (ICCT); Fabia Miorelli (Independent researcher); Sabatha Mthwecu (Solar Rais); Kruti Munot (GIZ); Abubakar Musa Magaga (Horizon Point Limited); Mwewa Chikonkolo Mwape (Zesco Limited); Darius Nassiry (Climate Finance Advisors BLLC); Thi Nguyen (Independent researcher); Tamara Nikolic (World Bank); Marjan Nikolov (Center for Economic Analyses); Jesse Nyokabi (Green Energy Pacesetter); Oluwatosin Ogunsola (Sustainable Green Environment Initiative); Hilda Cristina Mariaca Orozco

(Dirección de Asuntos Ambientales Sectorial y Urbana); Anna Dominique Ortiz (ICLEI); Katie Pastor (WRI); Sanjana Paul (Earth Hacks); Eduardo Peralta (C40 Cities); Stéphane Pouffary (ENERGIES 2050); Pallav Purohit (IIASA); Anik M. Rahman (Ontario Power Generation); Nizomiddin Rakhmanov (Tashkent State Technical University); Bard Rama (Czech Technical University in Prague – CVUT); Debra Roberts (Intergovernmental Panel on Climate Change, Durban City); Elisa Romanato (GIZ); John Romankiewicz (Sierra Club); Rosenberg Romero (Universidad Autónoma del Estado de Morelos); Frieder Rubik (Institut für ökologische Wirtschaftsforschung); Stefen Samarripas (American Council for an Energy-Efficient Economy); Paul Sandsted (Natural Gas Vehicles for America – NGV America); Luisa Schiavon de Araujo (Total Eren); Silke Schlinnertz (EHP); Susanne Schultz (GIZ); Cecile Segueineaud (Independent researcher); Alaa Selim (Schneider Electric); Karim Selouane (Resalliance); Zlata Sergeeva (Higher School of Economics); Vishal Sharma (NREL); Benjamin Sharpe (ICCT); Ted Sheldon (Renewable Cities); Zhang Shuwei (Draworld Center); Remy Sietchiping (UN-Habitat); Camille Sifferlen (International Passive House Association); Sunil Mohan Sinha (GA Energy Solutions); Laiz Souto (University of Girona); Marcus Evandro Teixeira Souza Junior (Universidade Federal de Uberlândia); Cherop Soy (UNMGCY SDG7 YC); Elton Stafa (Network of Associations of Local Authorities in South-East Europe – NALAS); Peter Stalter (Independent researcher); Geoff Stiles (Carbon Impact Consultants); Beniamin Strzelecki (Science Policy Circle and SDG7 YC); Carlo Tacconelli (EnGreen); Claudia M. Treumann (University of São Paulo); Kelly Trumbull (UCLA Luskin Center for Innovation); Galyna Trypolska (Institute for Economics and Forecasting UNAS); Ioannis Tspouridis (REDPro); Natalia Tsuyama Cocolo (Estado MG); Tineke van der Schoor (Hanze University of Applied Sciences Groningen); Rian Van Staden (RE100); Han Vandevyvere (VITO/EnergyVille); Dirk Vansintjan (REScoop); Felix Vidal (Institute for Transportation and Development Policy); Patrici Villarroel (Corte de Apelaciones de Valparaíso, Chile); Judith Voss-Stemping (GIZ); Roland White (World Bank); Anna Wiczorek (Community-based Virtual Power Plant – cVPP); Zifei Yang (ICCT); Ang Ye (Deutsche Energie-Agentur GmbH); Kelmend Zajazi (NALAS); Michael Ziegler (GIZ); Silvia Zinetti (Independent consultant); Emma Zinsmeister (US Environmental Protection Agency)

FOREWORD

As we launch the second edition of the *Renewables in Cities Global Status Report* (REC), we find ourselves in a period of global flux. Economic activity and public life have been disrupted around the world. But we have also witnessed an increasing consciousness and public pressure around the importance of clean and healthy living environments – particularly in cities. Citizens are engaging with renewable energy and pushing local and national governments to act. Many decision makers also are becoming aware of the opportunities that renewables offer for a green recovery.

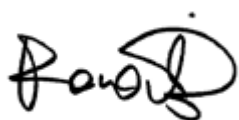
Despite the global challenges triggered by the COVID-19 crisis, we encountered many encouraging stories. Many city governments have installed, purchased or contracted for renewable energy to meet the demand of their own operations. They have also continued to adopt renewable energy targets and to implement policies to incentivise local consumption and generation of renewables, have set net-zero targets and have banned fossil fuels for various uses.

As inspirational as these stories are, we're still a far cry from what is needed. As United Nations Secretary-General António Guterres stated, "Cities are where the climate battle will largely be won or lost." Cities are high-impact areas: they are home to more than 55% of the global population and account for around three-quarters of global final energy consumption. Cities also are essential for accelerating the development of renewables in sectors that continue to lag behind, namely buildings and transport. Still, some national governments underestimate the value of cities to achieve national decarbonisation goals. And some city governments do not have the resources and expertise or just may not recognise their critical role in the shift to a renewables-based economy.

Some things don't change, even with an ongoing global pandemic. We need good, reliable/trusted, and shared data and knowledge to create awareness, inform and convince decision makers, and tell the stories of renewables. At REN21, we collaborate with our international community to provide such data. REC 2021 has benefited from data, expertise and insights from more than 350 renewable energy and city experts, contributors, researchers and authors that have worked together to identify the trends and developments of renewables in cities.

On behalf of the REN21 Secretariat, I would like to thank all those who contributed to the successful production of REC 2021. Special thanks go to all chapter authors; Special Advisors Janet Sawin, Maryke van Staden and Peta Wolpe; Project Manager Lea Ranalder; and the entire team at the REN21 Secretariat. I would also like to thank the Advisory Committee for their guidance, continuous support and pioneering spirit to start building a continuous database to track advancement on renewable energy at the city level.

We hope that REC 2021 will contribute to an active exchange of views on renewables in cities and serve as an inspiration for continuous action to accelerate the uptake of renewables now.



Rana Adib
Executive Director, REN21

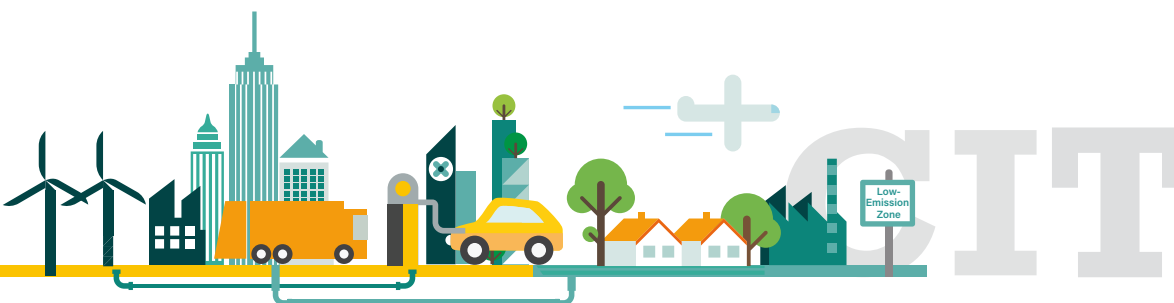
PURPOSE OF THIS REPORT

City governments around the world are taking action to accelerate the global uptake of renewable energy, both in municipal operations as well as city-wide. Municipalities have installed, purchased and contracted for renewable energy to meet the demand of their own buildings and vehicle fleets; adopted renewable energy targets and policies to incentivise the local generation and use of renewables; and supported urban community energy projects.

Traditionally, national governments have been the main entities tasked with governing the energy supply and driving the transition to renewables. Still today, many city governments continue to perceive the national government as the primary entity responsible for defining and implementing the energy agenda. However, city governments are uniquely positioned to lead locally in the shift from fossil fuel-based systems towards renewables, while curbing energy use and related greenhouse gas emissions. Decarbonising heating, cooling and transport, which together represent more than 80% of final energy demand, requires local solutions. Thus, cities – including their governments, inhabitants, and commercial and industrial actors – are essential to building a renewables-based economy, and their active participation is critical in helping to define and implement the energy agenda at the local, national and global levels.

REN21's *Renewables in Cities Global Status Report* (REC) series provides an overview of the status, trends and developments of renewable energy in cities, using the most up-to-date information and data available. The REC's neutral, fact-based approach documents in detail the annual developments in policies, markets, investments and citizen action, with a particular focus on renewables in public, residential and commercial buildings as well as public and private urban transport. The REC complements REN21's *Renewables Global Status Report*, which covers renewable energy market, industry and policy trends. Jointly, these reports contribute to making renewable energy visible in the global debate, drawing decision makers' attention to renewables and continuously providing better data and tracking to inform energy decisions worldwide.

REC 2021 is the result of a collaborative effort, building on REN21's unique data and reporting culture (→ see *Data Collection and Validation* section), with more than 330 data contributors and peer reviewers and over 30 individual interviews from around the world. The report is endorsed by an Advisory Committee of more than 20 organisations, including major renewable energy players and city networks. In this collaborative process, data are collected on hundreds of cities, ranging from mega-cities to small and medium-sized cities and towns. Collectively, this report aims to inform decision makers and to create an active exchange of views and information around urban renewable energy.





EXECUTIVE SUMMARY



EXECUTIVE SUMMARY

01 GLOBAL OVERVIEW OF RENEWABLES IN CITIES

Cities around the world are taking action to accelerate the global uptake of renewable energy. City governments increasingly recognise the potential of renewables to help create clean, liveable and equitable cities: overall, more than 1 billion people lived in a city with a renewable energy target and/or policy in 2020.

National governments typically are seen as the main bodies responsible for governing energy supply and infrastructure and for driving the transition to a renewables-based energy system. However, city governments are uniquely positioned to curb energy use and related greenhouse gas emissions while accelerating the uptake of renewable energy.

Cities are home to more than 55% of the world's population and contribute around three-quarters of the carbon dioxide (CO₂) emissions from global final energy use. In recent years, energy demand in cities has increased rapidly due to rising global population growth, urbanisation and urban economic activity. Although the urban electrification rate is high in most of the world, more than 176 million city dwellers continue to lack electricity access. Municipal governments can play a key role in expanding energy access and achieving other Sustainable Development Goals while contributing to the objectives of the Paris climate agreement by increasing the production and consumption of renewable energy.

Most of the energy in cities is consumed directly either for electricity, for heating and cooling buildings and industrial

activities, or for transporting people and goods. City governments themselves use only a small portion of this energy for municipal buildings and fleets; the rest is used city-wide for residential and commercial buildings, industrial activities and

private transport. Thus, achieving urban renewable energy targets depends not only on political commitment and municipal investment in renewables, but also on governments' ability to mobilise the wider uptake of renewables by other actors, including through comprehensive policies, awareness-raising and stakeholder dialogue.

Renewable energy action in cities often has progressed faster than trends and policy steps at the national level. During 2019 and 2020, municipal governments around the world demonstrated leadership on advancing the energy and climate agendas. Reporting on government operations and city-wide energy and climate targets increased, and several cities raised their ambition by adopting higher targets or setting earlier target years for reaching their goals. Strong sub-national leadership sends a signal to industries and service providers as well as to regional and national governments, and also helps to inform overall procurement processes that require clean services and products.

55% of the
world's
population
lives in cities.

The possibilities and strategies for municipal governments to scale up renewables to achieve their climate and energy targets depend on a variety of factors. One decisive variable in a city's ability to advance the deployment and use of renewable energy is the degree of regulatory and financial power that national governments grant to city governments. Existing regulatory frameworks at the state/provincial, national and regional levels also influence local renewable energy production, target-setting and policy making. In addition, the ability of cities to scale up renewables is greatly affected by market rules, energy regulations and policies set by higher levels of government (including the political dynamics that shape these instruments) and by the degree of economic dependence on fossil fuels.

In 2020, the unfolding of the COVID-19 pandemic and the government-initiated lockdowns to slow the spread of infections had major impacts on both cities and the drivers for renewables. Economic activity fell sharply in the early months of the pandemic, reducing energy demand globally and severely affecting urban energy use, notably in the transport sector. These developments resulted in a shift in government (especially municipal) priorities, as efforts to ensure public health and well-being were pushed up the policy agenda. Images of blue skies and clearer air helped to increase societal pressure towards reduced pollution and a green recovery. Although COVID-19 recovery plans were still being prepared as of early 2021, initial proposals emphasised local economic development and job creation, with some municipal governments announcing green recovery packages – including renewable energy options – in line with similar plans proposed at the national and supra-national levels.

02 URBAN POLICY LANDSCAPE

To achieve their energy and climate targets, municipal governments have procured renewables for their own operations, scaled up renewable energy generation on public buildings and for municipal fleets, and expanded their policy portfolios to encourage the uptake of renewables city-wide.

TARGETS

Globally, at least 834 cities in 72 countries, covering 558 million people, had adopted a renewable energy target in at least one sector by the end of 2020. Altogether, these cities had a combined total of 1,088 targets, including 653 targets for 100% renewable energy use either in municipal operations or city-wide. While municipal renewable energy targets have grown around the world, they are most common in Europe and the United States and remain less widespread in Asia, Latin America and the Caribbean, and Sub-Saharan Africa.

Although renewable energy target-setting has focused heavily on the power sector, targets have grown in the heating and cooling and transport sectors. Several cities have adopted detailed plans to transition to renewables in their heating systems, while the number of cities adopting targets to increase renewables in the transport sector and to expand the use of battery electric or hydrogen vehicles (which can be powered by renewables) has grown. By the end of 2020, at least 67 cities had e-mobility targets, up from 54 in mid-2019, creating opportunities for wider use of renewables in transport.



These sector-specific targets are being adopted alongside municipal targets to reduce CO₂ emissions, which, along with energy efficiency measures, enable the uptake of renewables. By the end of 2020, more than 10,500 cities had passed CO₂ emission reduction targets, and around 800 cities had committed to net-zero emissions, with the number of such net-zero targets increasing roughly eight-fold from 2019. Only a small number of cities had action plans or binding legislation to achieve their net-zero targets, and it remains to be seen how municipal governments specify a role for renewables.

POLICIES

For municipal governments that have direct control over city infrastructure, increasing the share of renewables in their own operations, buildings and fleets often has been a first step towards expanding the use of these technologies city-wide. To achieve their energy and climate targets, municipal governments have supported renewable energy progress either by procuring energy from renewable sources for their own operations or by investing in on-site/distributed renewable generation capacity on public buildings (such as schools, hospitals, sport centres and social housing) and for municipal transport fleets.

However, the success of meeting urban renewable energy targets relies not only on political commitment and municipal investments in renewables, but also on the decisions of individual households, communities, businesses and other urban actors. Municipal governments have expanded their policy portfolios to encourage and support the broader uptake of renewables. By the end of 2020, at least 799 municipal governments had in place regulatory policies, fiscal and financial incentives as well as indirect support policies to enable the uptake of renewables in buildings and transport city-wide (for a combined total of 1,107 policies, with some cities having more than one policy). Most of the cities with policies were in the United States and Europe, followed by Asia and Latin America and the Caribbean.

In the **buildings** sector, municipal governments differentiate their policy approaches between new and existing buildings, as well as by building type (residential, commercial, industrial, public). The number of building codes and mandates that include renewable energy for electricity or heating (usually solar photovoltaics (PV) or solar thermal) has grown. These codes typically apply to new buildings; for existing buildings, renewables often are encouraged via financial and fiscal incentives such as grants, rebates and low-interest loans. Compared to the power sector, city-level policies to increase the share of renewables in heating and cooling in buildings have been less widespread, although these sectors have attracted growing attention, notably in the European Union. Several cities also have adopted policies to support both power and heating (typically for solar PV and solar thermal).

At least
1,107 policies
were supporting
renewables in cities,
mostly concentrated in the
United States and Europe.

In the heating sector, municipal governments increasingly use fossil fuel bans and restrictions that enable the deployment of energy efficiency and renewable energy solutions. By the end of 2020, a total of 53 cities spanning 10 countries had either introduced or planned a ban or restriction on the use of natural gas, oil or coal in buildings for space and water heating purposes, up from only a handful of countries in 2015. In addition, municipal governments are facilitating the integration of renewables into their district energy networks, often in co-operation with public or private partners.

Policy efforts to increase the share of renewables in urban **transport** systems have expanded in recent years, and while biofuels – especially locally produced biofuels – still play a role in some cities' transport decarbonisation plans, momentum is shifting rapidly towards electrification. Several cities have adopted mandates for installing electric vehicle (EV) charging infrastructure in new buildings, which provide a critical entry point for higher uptake of renewables in transport, especially if combined with renewable electricity policies.

In addition to public procurement and direct investment by municipal governments, the transition in the transport sector has been driven mainly by subsidies, grants and rebates for battery electric and fuel cell vehicles. The growing numbers of low-emission zones and of bans/restrictions on certain fuels or vehicles – in place in 249 and 14 cities, respectively, as of late 2020 – also have implications for the use of electricity and renewable fuels in urban transport. A few cities have developed local strategies for the production and use of renewable hydrogen in fleets.

Many cities rely on financial incentives and other support policies set by national and/or state governments to complement the limited resources they themselves have to spend on renewable energy programmes. Policy coherence and integration across different levels of government is key to enable a timely and cost-effective transition to a renewables-based energy system.



03 MARKETS AND INFRASTRUCTURE IN CITIES

Cities are both consumers and producers of energy. Because cities - their governments, inhabitants, and commercial and industrial entities - account for around three-quarters of global final energy use, they have the potential to drive a substantial amount of renewable energy deployment.

No city is an island in the context of energy procurement and use, with each linked in some measure to its surroundings via power grids, fuel pipelines or other regional supply networks. As the renewable component of the regional energy supply rises, generally so does the share of renewables in a city's energy mix. In addition, more and more cities around the world are taking active steps to increase their local use of renewable energy.

City governments tend to focus first on addressing their own municipal energy demand, where they typically can control procurement criteria, and then on enacting policies and programmes that aim to reshape the broader urban supply and demand structure. The private sector (including individuals and businesses) also plays an important role in advancing renewables in urban areas.

BUILDINGS AND INDUSTRY

In cities around the world, municipal governments and other urban actors are producing and procuring renewable electricity to power building systems (including street lighting) and run all forms of commercial and industrial activity. The available options vary according to the local context and can include: installing renewable power generation systems at or near the point of demand (on-site); purchasing renewable electricity through green tariff programmes; and signing power purchase agreements with developers for projects within and outside of urban areas.

Where these options are not available or are insufficient, city governments are pursuing alternative avenues, such as partnering with stakeholders (including utilities and other cities) to engage with national- or state-level legislators and regulators to remove barriers. Many city governments are pursuing community aggregation or the municipalisation of utilities to facilitate direct control of renewable energy supply.

For thermal applications, municipal governments and other city entities are deploying modern renewable energy systems for space and water heating in buildings, and for process heat in industry. Although generally not at the scale of renewable electricity use in cities, a growing amount of direct thermal renewable capacity is being installed for use on-site, in stand-alone applications for individual buildings, and to feed into district energy systems. Direct thermal renewable energy is derived from the combustion of sustainable biofuels as well as from geothermal and solar thermal sources; renewable electricity also is used for thermal applications, powering appliances such as heat pumps.



Kuala Lumpur, Malaysia

TRANSPORT

In many cities, transport consumes more energy than do buildings or industry, and globally urban transport accounts for around 40% of total transport-related CO₂ emissions. The share of renewables in global transport remains low, at 3.7% (the majority provided by biofuels), but many cities are working to increase the penetration of renewable energy in the sector at the local level.

In response to calls for a “green recovery” amid the pandemic, several cities initiated or strengthened efforts in 2020 to ensure that communities have access to safe, reliable, affordable and sustainable transport. Cities continued to lead on vehicle electrification and EV charging infrastructure (facilitating greater penetration of renewables in transport) and were scaling up efforts to increase local production and use of renewable carriers in transport.

Electrification has expanded beyond rail to all modes of urban transport, including buses, cars, vans, two-/three-wheelers as well as some trucks and ferries. In some cases, renewable power capacity is being installed, purchased or contracted to cover the demand of electric vehicles in cities. Biofuel blends and renewable hydrogen are used mostly in heavy-duty transport such as buses and trucks.

The shares of renewables in transport and buildings remain low, especially compared to the electricity sector.



Moscow, Russian Federation

DISTRIBUTION INFRASTRUCTURE

Virtually all cities are physically tied to or otherwise reliant on a larger regional and global network of energy systems, infrastructure and supply lines. All cities depend on their surrounding territories not only for the bulk of energy supply, but also to manage and balance the flow of energy with the pulse of activity within the city. The larger the city, the larger must be the consideration for interactions with wider energy systems and infrastructure.

As cities pivot their energy procurement towards renewable sources, originating from both within and outside of city boundaries, their interactions with and requirements from regional energy systems and infrastructure may change, with implications that go well beyond city boundaries. Likewise, external changes in supply and infrastructure affect cities in ways beyond their control.

In 2019 and 2020, cities took steps including: addressing challenges to local and regional electricity distribution infrastructure (for example, by upgrading existing assets or deploying battery storage capacity); expanding existing district heat networks or commissioning new systems that rely (at least in part) on renewable thermal energy or on heat pumps powered by renewable electricity; and installing EV charging stations, including some that deliver 100% renewable electricity.



04 FINANCING AND INVESTMENT IN CITIES

Global investment in renewable energy capacity has trended upward for the last decade, and the COVID-19 pandemic has not hampered this sustained growth.

Global investment in new renewable energy capacity, including power and fuels (but not including hydropower projects larger than 50 megawatts) totalled USD 282.2 billion in 2019, up 1% over 2018. In the first half of 2020, global investment in new renewable energy capacity rose 5% relative to the first half of 2019. Although the exact share of investment in renewable energy projects within urban boundaries is unknown, a combined 171 renewable energy projects were reported in the pipeline in cities worldwide in 2019, with total project costs of USD 31.2 billion.

Each city operates within a distinctive framework that affects the financial power of city governments and, consequently, the amount and type of renewable energy financing and investment available. Variables include the policies and regulations that govern city actions, the nature of relationships with higher levels of government, partnerships with the private sector, and ownership rights of the electric grid, among others. Municipal governments are responsible for only a small share of the total financing that occurs within a city.

Municipal governments and private actors in cities that aim to increase the shares of renewables in the power, heating and cooling, and transport sectors have many options for financing such projects. These options can be grouped into three general categories:

- the actors may have their own capital available for funding renewable energy projects;
- if they do not have their own capital available, they may be able to raise funds through bonds, or make use of funds provided by other levels of government or external actors (such as local or domestic banks and development banks); and
- they may participate in agreements such as public-private partnerships or power purchase agreements to leverage external funds for a given project.

Regardless of their location (in cities or elsewhere), renewable energy projects face inherent financing challenges, including higher upfront technology costs, information gaps and hard lock-ins – all of which raise the investment risks and related financing costs. Municipal governments may face limited budgetary flexibility, multiple competing claims on their resources and soft lock-ins including limits to institutional capacity and institutional inertia. Barriers also can exist in co-funding arrangements with higher levels of government or limits to borrowing power. Cities in developing countries may face additional barriers to investing in renewable energy projects, such as insufficient tax bases or inadequate perceptions of creditworthiness.

05 CITIZEN PARTICIPATION

Citizens have been increasingly active in engaging in the energy transition, as well as in creating markets for renewable energy at the local level. Among other steps, they have strengthened their roles as prosumers, formed urban community energy projects and participated in urban energy and climate planning.

Individual citizens have supported renewables in cities by choosing green tariffs, purchasing energy from green pay-as-you-go schemes and getting energy from peer-to-peer energy systems, which typically are based on renewable energy generation. Deregulation and technological progress have enabled many city dwellers to become “prosumers” (both consumers and producers of energy) by setting up their own renewable energy systems connected to the grid.

Previously mainly a rural phenomenon, community energy projects have gained more footing in cities. In such projects, citizens come together to collectively manage and often own renewable energy installations. Many municipal governments have supported community energy projects, for example by providing roof space on public buildings such as schools or town halls, and some even have become partners in such projects by providing funding and becoming a shareholder. In 2020, Europe remained a hotspot for community energy projects, but many other countries around the world were joining the trend, including the Republic of Korea, South Africa and the United States.

Increasingly, citizens have made their voices heard in urban energy planning and development, often by invitation from city administrations that include local citizens in planning, budgeting and policy development processes. Against the backdrop of rising global climate movements during 2019-20, citizens also have exerted pressure on their city (and national) governments to push for stricter local climate and energy policies. Partly in response to this, by the end of 2020, a record 1,852 municipal governments in 29 countries had issued climate emergencies and 231 municipal governments had submitted a climate action plan alongside their declaration, in some cases using this to outline and financially support renewable energy deployment.

Citizens have put

**increasing
pressure**

on governments to adopt more ambitious climate and energy targets and policies.

06 FEATURE: RENEWABLE ENERGY IN SUB-SAHARAN AFRICAN CITIES

Despite facing many challenges, city governments across Sub-Saharan Africa have heeded the call to act on renewable energy and have joined global initiatives to advance the deployment and use of renewables.

Due to rapid population growth and urbanisation, as well as rising energy demand, cities across Sub-Saharan Africa increasingly recognise the opportunities around renewable energy use. Common drivers for renewables in the region include improving energy access and reducing energy poverty, as well as boosting the resilience and reliability of power systems.

Cities in Sub-Saharan Africa have supported local renewable energy deployment in a variety of ways, including by facilitating collaborative projects led by national governments, development finance institutions and/or private actors. Some local governments, especially in cities where transport is responsible for a large share of energy consumption, have entered into public-private partnerships to advance e-mobility (sometimes linked to renewable electricity) at the city level. In addition, cities have joined networks such as the Covenant of Mayors in Sub-Saharan Africa (CoM SSA) that help to build knowledge and internal capacity regarding renewable energy data and projects.

While city governments have played a key role in shaping the region's energy landscape – including advancing efforts to meet renewable energy targets set at the country level – legislative, financial and technological constraints persist in many cities. These constraints include weak fiscal decentralisation, limited municipal mandates across key sectors, and limited human capacity to execute municipal functions.

Key barriers and opportunities for advancing renewables in urban settings of Sub-Saharan Africa fit into four categories:

Policy and regulation: Through the CoM SSA, the C40 Climate Action Planning Africa Programme and other initiatives, municipal governments have enacted policies to accelerate the deployment of distributed renewables. These policies cover all energy-consuming sectors, although with less of a focus on the power sector because it remains largely the domain of national governments and/or centralised utilities. While city authorities often have limited powers, they are well placed to co-ordinate efforts to encourage local renewable energy deployment, which require collaboration across various stakeholders, including national policy makers.

Access to financial markets: Most local governments in Africa depend on national government grants as their main source of revenue, which is spent largely on operations instead of capital investments. This leaves little funding to invest in new infrastructure projects such as distributed renewable generation. Nonetheless, cities across the region have demonstrated progressive leadership on renewables through piloting various demonstration projects.

Data needs: Scarcity of primary data in the African context, particularly at the city level, is a major barrier for private investment in grid expansion plans and energy projects more generally. This places local governments, which generally are closer to the population (potential customers), in a unique position to provide investors with such information or to engage with relevant entities, including electric utilities, to facilitate data collection.

Internal capacity: Capacity constraints (in skills, experience and knowledge, and human and financial resources) have limited the ability of local governments to play a more pro-active role in renewable energy deployment. To build internal capacity and knowledge and to support renewable energy implementation, municipalities in Sub-Saharan Africa have formed partnerships with external organisations, established or joined city networks, and developed public-private partnerships to facilitate private sector engagement.



Ruiru, Kenya



An aerial photograph of a city street, showing a row of buildings on the left and a road with a white van and other vehicles on the right. The buildings have various roof colors and styles, and there are trees interspersed among them. The overall scene is a dense urban environment.

Madrid
Milan
Paris
Swansea Bay
City
Lille
Wuhan
Burlington
Auckland
Berlin
Bogota
Boston
London
Mexico City
Pakse
Fortaleza

GLOBAL OVERVIEW

OF RENEWABLES IN CITIES



GLOBAL OVERVIEW OF RENEWABLES IN CITIES

Cityⁱ governments around the world are taking action to accelerate the global uptake of renewable energy. During 2020, the engagement of local governments continued to grow, driven by air pollution concerns, public pressure, and the need to create clean, liveable and equitable communities, among other factors. In some cases, these actions have been reinforced by the global health and economic crisis triggered by the COVID-19 pandemic. City governments use different types of targets, policies and actions to show their renewable energy ambition: overall, more than 1 billion people – around 25% of the urban population – lived in a city with either a renewable energy target and/or policy in 2020 (→ see *Figure 1 and Table 1*).¹ Other actions indirectly support the shift to renewables – such as efforts to reduce carbon dioxide (CO₂) emissions, including through net-zero commitment goals and the electrification of public transport.

More than
1 billion
people
live in a city with a
renewable energy target
and/or policy.

Cities' ambition to support the deployment of renewables is relevant because urban energy use has increased sharply in recent decades. In 1990, cities accounted for less than half (45%) of global final energy use, but by 2018 this share had risen to around three-quarters, and cities release a similar share of global energy-related CO₂ emissions.² Cities are now home to more than 55% of the world's population, and urban inhabitants worldwide are negatively affected by the burning of fossil fuels.³

Energy demand in cities has surged in all end-use sectors – power, transport, industry and buildings – due mainly to rising global population growth, urbanisation and urban economic activity. Municipal government operations account for only a small percentage of urban energy use, including for public buildings, municipal services and vehicle fleetsⁱⁱ. The bulk of urban energy is used at the city-wide level, in the form of electricity, heating and cooling (for residential and commercial buildings and industrial activities) and private transport.⁴

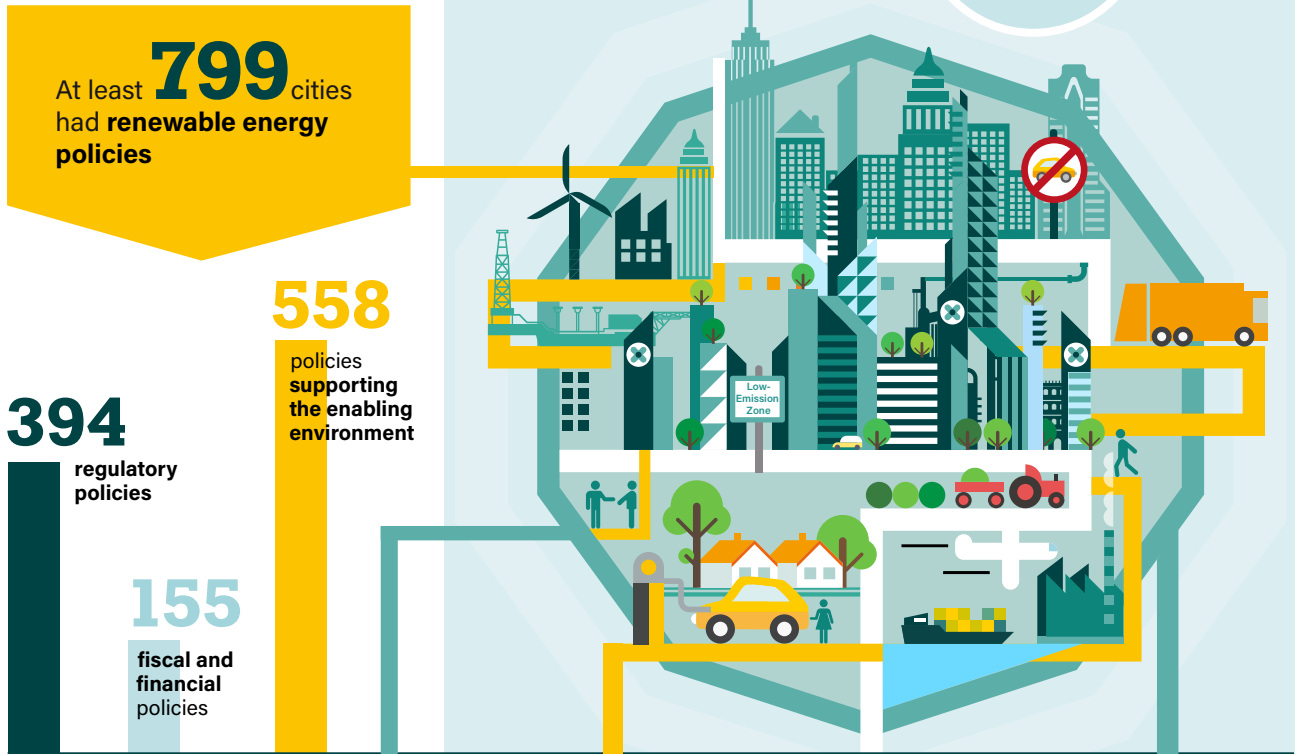
i According to the United Nations, the term "city" can connote a political or civic entity, a geographic unit, a formalised economy or an infrastructure bundle. In some instances, local communities, neighbourhood associations, urban businesses and industries may be subsumed under the term "city". Throughout this report, both "municipal government" and "city government" refer to city-level decision-making bodies and government authorities (the mayor's office, city council, etc.). "Local government" is a more generic term that can refer to different sub-national levels of public administration, including also counties, villages and other intermediate levels of government. In addition to municipal governments, key "urban actors" include individual citizens, groups of citizens and private enterprises, as well as various civil society groups that are active within the city.

ii Depending on ownership structures, municipal transport fleets may entail public transport (e.g., buses and rail systems), street sweeper and refuse collection vehicles, maintenance vehicles, vehicles assigned to police, fire and other public services, taxi and car-sharing fleets, and delivery vehicles (e.g., postal and courier services). See Glossary.

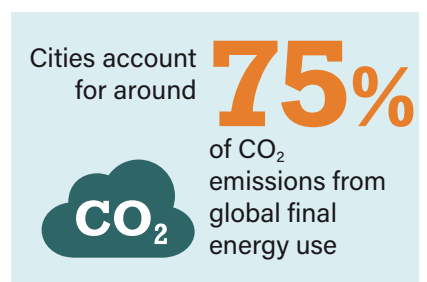
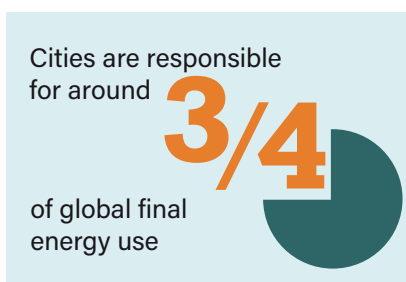
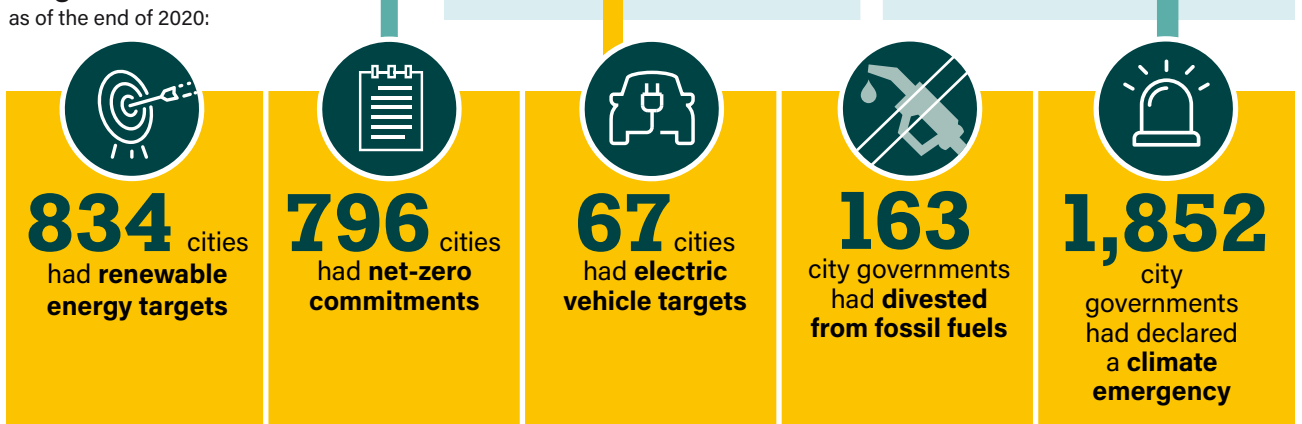
Figure 1. Key Facts and Trends in Cities, 2020

One billion people live in a city with a renewable energy target and/or policy = 25% of urban population

Policies as of the end of 2020:



Targets and Actions as of the end of 2020:



Source: See endnote 1 for this chapter.

Table 1. Overview of Targets, Policies and Actions in Cities, 2020

	Number
Renewable energy targets	
Cities with renewable energy targets and/or policies	1,327
Cities with renewable energy targets	834
Cities with 100% renewable energy targets	617
Cities with renewable power targets	612
Cities with renewable heating and cooling targets	145
Cities with renewable transport targets (excluding e-mobility)	65
Cities with economy-wide renewable energy targets	266
Other targets and declarations	
Cities with emission reduction targets	> 10,500
Cities with net-zero emission targets	796
Cities with e-mobility targets	65
Cities with climate emergency declarations	1,852
Policies	
Cities with renewable energy policies	799
Cities with renewable power policies	363
Cities with renewable heating and cooling policies	144
Cities with renewable transport policies	331
Cities with renewable energy policies in buildings	153

Over
1,300 cities
have renewable energy
targets and/or policies,
covering more than
1 billion people.



Note: The number of cities with renewable energy policies by sector (power, heating and cooling, transport and buildings) does not equal the total number of renewable energy policies in cities, as cities with more than one policy in the same sector are counted only once. Cities with policies in multiple sectors are counted more than once. A total of 192 cities have policies in more than one sector.

Source: See endnote 1 for this chapter.

In addition, cities are responsible for global energy use that does not actually take place within urban boundaries.⁵ They contribute indirectly to energy use (as well as to greenhouse gas emissions) through their supply chains, which include construction materials (concrete, steel, etc.), everyday goods (food, clothing, electronics, etc.) and other products consumed in cities but produced beyond their borders.⁶ Thus, action in cities has the potential to make significant contributions to decarbonising the energy system, enhancing its resilience, and accelerating the development of renewable energy and other projects and investments – all of which contribute to key international goals such as limiting the average global temperature rise to 1.5 degrees Celsius (°C), as stipulated in the Paris Agreement.⁷

In cities with rapidly growing informal settlements and slumsⁱ, often located in the periphery of urban areas, many inhabitants lack access to basic services, including modern energy sources and city infrastructure, such as sanitation and public transport.⁸ Despite rising energy demand, 176 million people in urban areas still did not have access to electricity in 2019, and 2.6 billion people worldwide lacked access to clean cooking.⁹ Municipal governments can play a key role in expanding sustainable energy access and reducing energy poverty for their residents, including the 1 billion urban and peri-urban dwellers living in slums and informal settlements.¹⁰ Considering that the generation and use of renewable energy in cities is critical for achieving sustainable communities, and vice-versa, municipal governments can contribute to achieving United Nations Sustainable Development Goal 7 (on sustainable energy for all) as well as interlinked goals¹¹.

i Various factors have contributed to the emergence of informal settlements and slums, including population growth, urbanisation, lack of affordable housing, economic vulnerability, marginalisation and displacement. See endnote 8 for this chapter.

ii Urban areas are expected to play a key role in achieving the United Nations Sustainable Development Goals (SDGs), in particular SDG 11 on Sustainable Cities and Communities. By one estimate, meeting 65% of the targets of the SDGs depends on the involvement of local governments and how they can engage their citizens and civil society using their roles and core competences in areas such as infrastructure, transport, housing, water use, land use and energy.

DRIVERS AND OPPORTUNITIES FOR RENEWABLE ENERGY IN 2020

The driversⁱ for renewable energy in cities are broad, with efforts motivated by diverse economic, social and environmental objectives depending on the local context and priorities. Generally, municipal governments have pursued the uptake of renewables as an opportunity to create more liveable urban areas and to enable a better quality of life for residents.¹²

In 2020, the unfolding of the COVID-19 pandemic and the government-initiated lockdowns to slow the spread of infections had major impacts on both cities and the drivers for renewables. Economic activity fell sharply in the early months of the pandemic, reducing energy demand globally and severely affecting urban energy use, notably in the transport sector.¹³ Physical distancing measures and fear of contagion led to an unprecedented drop in public transport ridership, greatly altering urban mobility patterns.¹⁴

These developments resulted in a shift in government (especially municipal) priorities, as efforts to ensure public health and well-being were pushed up the policy agenda.¹⁵ Although COVID-19 recovery plans were still being prepared as of early 2021, initial proposals emphasised local economic development and job creation, with some municipal governments announcing “green recovery” packages – including renewable energy options – in line with similar plans proposed at the national and supra-national levels (such as the European Green Deal) (→ see *Sidebar 1*).¹⁶



Kuala Lumpur, Malaysia

Images of blue skies and clearer air during the early lockdowns helped to increase societal pressure towards reduced pollution and a green recovery.¹⁷ Outdoor **air pollution**ⁱⁱ from the burning of fossil fuels – particularly coal, diesel and petrol – is a major source of fine particulate matter and was responsible for an estimated 8.7 million premature deaths in 2018 (earlier estimates were found to be greatly underreporting the effects of air pollution).¹⁸ Increases in industrial activity, heat and power generation, and road transport have been the main sources of outdoor air pollution in many cities worldwide, and in some urban areas the use of charcoal and fuelwood for heating and cooking contributes to poor air quality indoors as well.¹⁹ Several cities have pledged to jointly tackle local air pollution: as of 2020, 37 city governments worldwide had signed the C40 Clean Air Declaration (initiated in 2019), committing to pollution reduction targets and clean air policies by 2025.²⁰

During 2019 and 2020, **citizens** also exerted growing pressure on their city (and national) governments to act on climate change.²¹ Partly in response to this pressure, a record 1,852 cities had declared climate emergencies by the end of 2020 (up from around 1,400 governments in 2019), indicating a shift in priorities for municipal governments, some of which have used the declarations to plan and financially support renewable energy deployment.²²

Other drivers for renewable energy uptake include:

- **Supporting local economic development** by attracting new industries and businesses, and creating local jobs.²³
- **Mitigating climate change**, since renewables can help cities reduce emissions that contribute to global warming and address urban vulnerabilities to the impacts of climate change; these impacts include more-severe storms, fires, droughts, floods and sea-level rise, all of which put pressure on urban water supplies, sewage services, and food and energy security.²⁴
- **Adapting to climate change and enhancing resilience**, since decentralised power generation from renewables can help make energy systems more resilient while reducing risks associated with dependence on external energy sources.²⁵
- **Reducing expenses and managing costs**, by limiting cities' exposure to volatile fossil fuel prices and providing greater savings as the costs of electricity from solar photovoltaics (PV) and wind power continue to decline.²⁶
- **Poverty alleviation**, since greater access to energy and new opportunities for learning and jobs can help reduce energy poverty and support sustainable development.²⁷
- **Ensuring a stable and secure energy supply**, since renewables can support municipal governments in increasing energy security and independence while strengthening energy resilience.
- **Energy justice and democracy**, with sustainable energy access supporting an inclusive and just transition, with energy for all.

i For a detailed discussion of drivers, see REN21's *Renewables in Cities 2019 Global Status Report*, available at www.ren21.net/reports/cities-global-status-report.

ii More than 90% of urban areas were exposed to air pollution, and more than half of the population was exposed to air pollution at least 2.5 times above the guidelines established by the World Health Organization (WHO), from WHO, "9 out of 10 people worldwide breathe polluted air, but more countries are taking action", 2 May 2018, <https://www.who.int/news/item/02-05-2018-9-out-of-10-people-worldwide-breathe-polluted-air-but-more-countries-are-taking-action>.

SIDEBAR 1. COVID-19: General Impact and Responses

The year 2020 was marked by lockdowns in response to the global health crisis precipitated by the COVID-19 pandemic. This triggered a major economic shock with disruptions to various sectors, including energy. Disease prevention and containment measures greatly altered global energy use patterns (including electricity demand) and mobility habits, especially in urban areas with high concentrations of people and economic activity.

Global electricity demand dropped 2.5% in the first quarter of 2020 compared to the same period in 2019. This decline in demand was clearly linked to government containment efforts, as demonstrated in the European Union (EU) where electricity demand returned to normal (2019) levels during August-October 2020, after restrictions were lifted. Despite these declines, renewable electricity supplies worldwide continued to grow. While the demand for coal and gas dropped sharply in 2020, renewables were the only source of electricity in the global energy mix to experience record growth due to low operating costs and priority grid access through regulations. In several EU countries, wind and solar power hit record shares in electricity generation during the lockdown period.

Despite these positive narratives around renewable electricity, however, COVID-19 also had negative impacts on renewable energy deployment. Notably, many cities experienced delays in the development of renewable energy projects due to supply chain disruptions, labour shortages and emerging financing challenges. These impacts varied by technology and region.

Road transport activity decreased 50-75% in cities with lockdowns by late March 2020, resulting in a 17% drop in daily global CO₂ emissions by early April (from average 2019 levels). In Europe, an 88% reduction in car and motorcycle emissions during lockdowns led to a 58% decline in CO₂ emissions. Nitrogen dioxide levels also fell sharply during lockdowns in Wuhan (China) and in European cities such as Madrid (Spain), Milan (Italy) and Paris (France). Overall, the reduced pollution from urban transport led to local air quality improvements during the first half of 2020.

However, the reduction in emissions was only temporary: by the end of 2020, emissions and air pollution increased again, especially in bigger cities, as people opted to drive private cars over using public transport, and because of higher heating demand as people worked from home during the colder months. In the United Kingdom, the use of gas boilers – a major source of local pollutionⁱ – increased an estimated 56% during the winter of 2020 as the majority of people continued to work from home.

In many places, the COVID-19 pandemic stimulated greater societal pressure on city authorities to plan their economic recoveries by adopting integrated, sustainable approaches that place higher emphasis on air quality and the overall living environment. Because municipal COVID-19 recovery plans were still under development as of early 2021, no consolidated overview was available of the role of renewable energy in these actions. However, some examples exist of municipal governments linking the recovery to a scale-up of renewables.

In June 2020, Swansea Bay City (Wales, UK) launched a GBP 60 million (USD 74 million) ocean energy project that aims to accelerate the city's climate actions and to help the county of Pembrokeshire in its COVID-19 economic recovery. Lille (France) allocated EUR 20 million (USD 24.5 million) through its Rebound Fund, a business support programme that requires small businesses to incorporate environmental actions and/or energy transition into their projects to be able to benefit from the fund. Burlington (Vermont, US) announced a Green Stimulus package in April 2020 that allocates USD 800,000 to advance energy efficiency and promote the uptake of heat pumps and electric vehicles (EVs) – both of which can run on renewable electricity – in support of the city's Net Zero Energy goal while helping with the local economic recovery.

The C40 Cities network, through its Global Mayors COVID-19 Recovery Task Force, launched the C40 Mayors Agenda for a Green and Just Recovery in July 2020, outlining steps for the post-COVID period. Through this agenda, more than 40 city mayors committed to an equitable and just recovery based on stimulus packages that focus only on sustainable transition, including providing green jobs, divesting from fossil fuel and creating liveable communities.

Local governments also took more immediate action to alleviate the COVID-19 challenge in their cities, such as establishing bicycle lanes and expanding safe public spaces for pedestrians. These measures were implemented in cities including Auckland (New Zealand), Berlin (Germany), Bogotá (Colombia), Boston (Massachusetts, US), London (UK), Mexico City (Mexico), Milan (Italy) and Paris (France).

In response to the economic and social impacts of COVID-19, several national governments passed economic stimulus packages, and some multilateral development banks and private institutions made available climate funds. However, of the USD 20.5 trillion pledged to recovery efforts as of late 2020, only USD 1.1 trillion was committed to cities, due in part to barriers in directly providing funding to cities.

Source: See endnote 16 for this chapter.

ⁱ In London alone, gas boilers account for 21% of total nitrogen oxide emissions across the city.

GLOBAL RENEWABLE ENERGY TRENDS

At a global level, renewable energy capacity has continued to grow in the power sector, where supportive policy frameworks have helped solar PV and wind power become the most affordable sources of new electricity nearly everywhere in the world.²⁸ Renewable energy broke another record in 2019, with the total installed power capacity of renewables increasing more than 200 gigawatts (GW).²⁹ The renewable power sector also demonstrated greater resilience than fossil fuels during the COVID-19 pandemic, as electricity supplied by renewables was the only source of power generation to grow in 2020.³⁰ The share of electricity production met by variable renewable energy sources (wind and solar PV) reached record levels in several markets during the year, including in China, Europe, India and the United States.³¹

Despite these advances, the global energy system is transforming at a slow pace. Renewables in the heating and cooling and transport sectors have gained significant ground only in a few countries, while globally these sectors continue to lag.³² Unlike for renewable power, renewables in heating and transport have demonstrated greater vulnerability to global shocks, such as the COVID-19 pandemic, than other energy sources.³³ Heating, cooling and transport are critical for shifting the entire energy sector to renewables, as they are responsible for around 80% of final energy demand (→ see *Figure 2*).³⁴ These sectors are nevertheless plagued by weak and inconsistent policy frameworks, which contribute to uncertain and risky long-term investment options.³⁵



CITY RENEWABLE ENERGY COMMITMENTS

Action in cities often has progressed faster than trends and policy steps at the national level. In 2019 and 2020, city governments around the world demonstrated leadership on climate and energy and took action to accelerate the global uptake of renewables.³⁶ Reporting on government operations and city-wide energy and climate targets increased, and several cities raised their ambition by adopting higher targets or setting earlier target years for reaching their goals.³⁷ These city government commitments have taken different shapes, ranging from binding targets and comprehensive policies to participation in initiatives and campaigns. Strong sub-national leadership sends a signal to industries and service providers as well as to regional and national governments, and also helps to inform overall procurement processes that require clean services and products (→ see *Urban Policy Landscape chapter*).³⁸

City governments have directly supported renewables by setting specific **renewable energy targets**, investing in renewables and passing policies to encourage renewables city-wide. By the end of 2020, city governments in at least 834 cities in 72 countries, covering 558 million people, had set renewable energy targets in at least one sector (power, heating and cooling, and/or transport)ⁱⁱⁱ; this includes around 617 cities with targets for 100% renewables.³⁹ Altogether, cities worldwide had a combined 1,088 renewable energy targets.⁴⁰ Despite this momentum, data challenges remain regarding tracking and reporting on progress as well as the scope of application.⁴¹ Geographically, renewable energy targets have increased in all regions of the world, although most targets are in North America^{iv} and Europe, followed by Asia.⁴²

In many cases, city targets and policies are far more ambitious than those in place at higher levels of government.⁴³ While most local renewable energy targets address the power sector – similar to national-level developments – momentum has grown for policies that go beyond power and are expanding to heating and cooling and the transport sector or an integrated policy approach (→ see *Leveraging Renewables City-wide section*).⁴⁴ Given slow advances at the national level worldwide, urban policies and decentralised renewable energy technologies play an important role in decarbonising these sectors.

Targets for renewables

in cities are often more ambitious and have progressed faster than trends and policy steps at the national level.

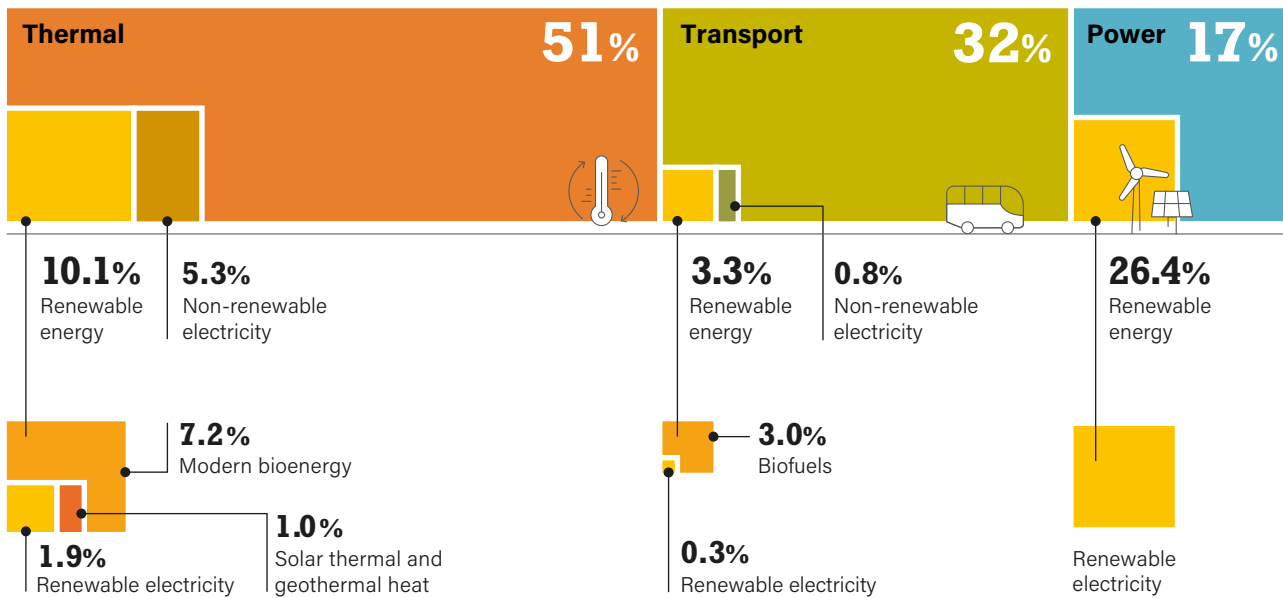
i Wind and solar energy have become increasingly cost-competitive with fossil fuel power plants. In countries on all six major continents, renewables are the cheapest source of new electricity generation, and in some of the world's major energy markets (including China, India, Europe and the United States), building new solar PV or wind plants is more cost-effective than continuing to operate existing coal-fired power plants. Renewables also are outcompeting natural gas-fired power plants on costs. See endnote 28 for this chapter.

ii This refers to the fact that consumption of renewable heat and production of biofuels, which account for the vast majority of renewable energy in transport, were both heavily affected during the crisis. The rapid increase in electric vehicle sales is a counterpoint to this statement; however, electric mobility continues to meet only a marginal share (around 1.3%) of energy demand in transport, and relies mostly on electricity from fossil fuels.

iii Based on REN21 Policy Database; list may not be comprehensive. This total includes multiple targets for the same city. It includes targets for renewable energy consumption of all energy, electricity, heating and cooling, and transport; targets for specific installed capacity; as well as targets for enabling technologies such as e-mobility.

iv In this report, North America includes Canada and the United States; Mexico is considered part of Latin America and the Caribbean.

Figure 2. Renewable Share of Total Final Energy Consumption, by Final Energy Use, 2017

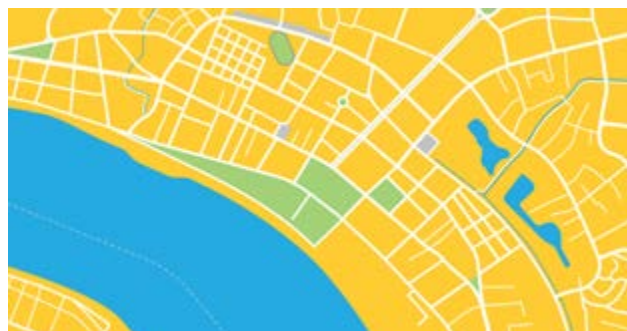


Note: Data should not be compared with previous years because of revisions due to improved or adjusted methodology.

Source: Based on IEA data. See endnote 34 for this chapter.

The growing trend of emission reduction targets – including **net-zero** commitments – had a record-breaking year in 2020. By year's end, more than 10,500 cities globally had adopted CO₂ emission reduction targets, and around 800 cities had committed to net-zero emissions – up sharply from the 100 cities with such commitments by the end of 2019.⁴⁵ Although emission reduction targets typically have not been linked explicitly with renewable energy development, they can stimulate the uptake of renewables indirectly by mandating the reduction or removal of greenhouse gas-emitting technologies. Many cities had yet to publish plans on how renewable energy is being deployed or used to achieve this goal.⁴⁶

Increasingly, city governments are producing climate and/or energy action plans outlining how to achieve their targets. Abundant examples from Australia, Europe and North America are captured through reporting platforms such as the CDP-ICLEI Unified Reporting System (with local governments reporting progress over time), supported by city networks and initiatives including ICLEI – Local Governments for Sustainability and the Global Covenant of Mayors for Climate & Energy.⁴⁷ As such initiatives expand globally, reporting is increasingly supported in Asia, Latin America and Sub-Saharan Africa. Action plans are being developed or updated in cities ranging from Kigali (Rwanda) and Pakse (Lao PDR) to Fortaleza and Recife (Brazil).⁴⁸ Generally, city-level reporting and tracking of the electricity sector is more comprehensive, whereas most cities lack clear reporting on heating and cooling uses and transport (→ see Box 1).⁴⁹



i "Net-zero" emissions can be achieved, for example, by using natural sinks, such as reforestation land or adopting agricultural best practices, or through a technological solution, such as carbon capture and storage. Net-zero targets also are referred to commonly as "climate-neutral", "carbon-neutral" or "zero-emission" targets, although technically these are not the same. Carbon neutrality refers to net-zero emissions of only CO₂, whereas climate neutrality indicates a broader focus on net-zero emissions of all greenhouse gases. There is no agreed-upon definition, and implementation of these targets also varies broadly. See endnote 45 for this chapter.

BOX 1. Data on Renewables in Cities

Tracking the evolution and uptake of renewable energy in urban areas is challenging because of cities' geographical distribution; their different political, economic, social and environmental contexts; and their diverse institutional capacities. As a result, the limited data that are available tend to be outdated and are rarely consolidated. In addition, these data often do not consider the changing roles that cities play in the energy system, including their ability to produce energy. Consolidated data on energy supply/production and energy demand/consumption thus are available only for relatively few cities worldwide.

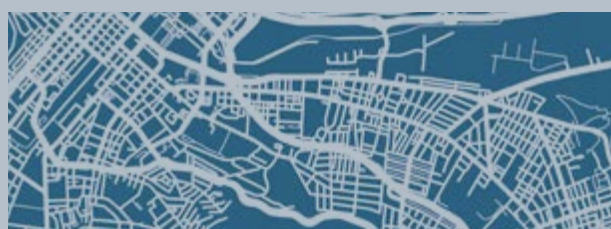
Even where data are reported, imprecise terminology can limit their usefulness: in some instances, it remains unclear whether the data refer to electricity or to energy. Also, since electricity accounts for most cooling needs and for a growing share of heating needs, it can be difficult to identify what amount went to heating and cooling versus lighting and other appliances. In transport, reporting in most cities tracks only the number of electric, plug-in hybrid and hydrogen fuel cell vehicles, but does not track vehicles running on liquid biofuels and biomethane.

Increasingly, reporting is improving on financing indicators and city investment needs as well as on the trend of local governments to create their own funds to implement their renewable energy targets, particularly in the northern hemisphere. However, data gaps and limitations remain in the following key areas:

- shares of renewables in municipal and city-wide energy use;
- targets and policies that promote renewables in the power, heating and cooling, and transport sectors, both for municipal and for city-wide energy use;
- generation capacity for renewable electricity, heating and cooling, and transport fuels, either by municipal authorities and/or public utilities and other urban actors (private sector, residents, communities); and
- community energy projects in cities, including the number of projects, installed capacity and investments.

The lack of comprehensive and consolidated data makes it challenging to effectively assess the role that cities play in advancing renewable energy, to determine objectives and baselines, and to monitor progress. Improving the data situation is important for better engaging cities in the energy debate in a more holistic way, and for integrating policy and regulatory frameworks at the local, sub-national and national levels. More robust data availability also makes it possible to increase knowledge about the opportunities that renewables present for cities and to further accelerate renewable energy development.

Source: See endnote 49 for this chapter.



MULTI-LEVEL GOVERNANCE OF URBAN ENERGY SYSTEMS

The possibilities and strategies for municipal governments to scale up renewable energy to achieve their urban climate and energy targets depend on a variety of factors. Each city has its own characteristics such as urban formⁱ and density, climate, geography and ownership structureⁱⁱ for key infrastructure – all of which influence a city's ability to advance the deployment and use of renewables.⁵⁰

Also, no city is an island in the context of local renewable energy procurement and use, target-setting and policy making. Depending on governance structuresⁱⁱⁱ, cities are subject to **market rules and energy regulations** set at the national and state/provincial levels, and to the political dynamics that shape these instruments.⁵¹ The design of markets and infrastructure – and whether electricity markets are liberalised and decentralised – is determined largely at higher levels of government (→ see *Sidebar 2*).⁵² In addition, municipal governments typically are required to enforce standards that have been established out of their control, at the state or national levels.⁵³

Despite potential limitations resulting from different regulatory systems, city governments around the world have taken different actions to increase renewable deployment. Several local governments have engaged with or challenged higher levels of government to remove legislative or regulatory barriers to the production and procurement of local renewable energy. To raise their voices and increase their advocacy capacity, local governments also have joined forces in national, regional and global networks (→ see *City Leadership: Networks and Initiatives section*).

Persistent subsidies for fossil fuel consumption and production, issued at the national level, present a challenge to increasing the share of renewables in cities. Such policies contribute to ongoing economic dependence on fossil fuels in transport, households, industry and businesses, as well as in electricity production and supply.⁵⁴ Although global subsidies for fossil fuel consumption fell by USD 120 billion in 2019 (to USD 318 billion, down from USD 438 billion in 2018) – mainly because of lower average fuel prices during the year – both subsidies and low fossil fuel prices encourage greater demand for the fuels and challenge renewable energy developments.⁵⁵ If the true costs to society of fossil fuels were accounted for, including negative externalities related to climate change and air pollution, then their total “subsidies” would be considerably higher, at USD 5.2 trillion.⁵⁶

Cities' **energy systems and infrastructure** are physically connected to national or regional systems and rely on them for most of their energy supply and to manage and balance their energy flow. However, the dynamics of this relationship have changed over the last decade as municipal governments have become more aware of the various potential benefits of renewables.⁵⁷

The emergence of distributed renewable energy technologies (such as rooftop solar PV) and digital technologies (such as the Internet of Things) has reshaped the dynamics between end-users and the traditional energy system, which historically has been operated mainly by centralised utilities.⁵⁸ Coupled with new business models, this has enabled municipal governments (as well as households, businesses and communities) to scale up and diversify local production of renewables.⁵⁹ In 2019, households and small- to medium-sized companies installing solar PV on and near their buildings accounted for one-fifth of all renewable capacity deployed globally.⁶⁰ However, in 2020, COVID-related lockdown measures prevented access to many buildings, leading to a slowdown in distributed solar PV installations in cities.⁶¹



- i Urban form refers to a city's physical characteristics, including size, shape and population density. For example, low-density cities (per square kilometre of urban area) tend to have more land and rooftop space available for distributed solar PV, while compact high-density urban areas have the necessary business case for renewable district energy systems (where proximity of floor area is a major determinant). See endnote 50.
- ii For example, where the city government is the owner and operator of municipal energy utilities or of public transport and associated infrastructure, it has greater capacity to develop and invest in renewable energy projects. If this infrastructure is not under municipal control, the shift to renewables entails coordination with a greater number of actors (such as national and state/provincial governments and private companies, for example through public-private partnerships) that may have conflicting priorities. In many developing and emerging economies, the lack of secure, reliable and affordable public transport, exacerbated by low density and sprawling cities, contributes to informal and private on-demand transport. This tends to be more difficult to regulate (and to enforce regulations), including shifting to renewable-based transport solutions.
- iii The governance structure of a city determines the city's level of dependence on higher levels of government in policy making, regulation, renewable energy purchasing, etc.

SIDEBAR 2. Multi-level Governance: The Interdependence of National and Municipal Policies

It is increasingly clear that the fight against climate change will be won or lost in the world's cities. However, even the most empowered city governments can deliver only a fraction of their mitigation potential unilaterally. National leadership and co-ordination, and integration with national-level action – also known as multi-level governance – is vital. Supportive national policies, combined with ambitious and pro-active city targets and action, are key to ensure that rapid urban population growth drives economic productivity within a climate-friendly environment.

National governments generally have recognised the importance of cities in their climate and energy agendas, as evidenced by their endorsement in 2015 of the 2030 Agenda for Sustainable Development, which includes making “cities and human settlements inclusive, safe, resilient and sustainable”. However, national governments worldwide are at varying stages of integrating this recognition in their economic strategies, budget allocations, infrastructure planning and governance structures. As of 2019, around half of all countries had a national strategy for citiesⁱ, and only 23 of the 160 countries that had submitted their Nationally Determined Contributions (NDCs) for reducing emissions under the Paris Agreement acknowledged the urban opportunity for climate change mitigation.

The world is not on track to limit global warming to well below 2°C, let alone 1.5°C as stipulated in the Paris Agreement (to achieve this goal, CO₂ emissions would need to nearly halve by 2030 from 2010 levels, and to reach net-zero around 2050). As the major centres of production and consumption, cities play an important role in meeting the emission reduction targets set at various levels of government, from supra-national to sub-national. A large share of the potential for abating emissions in cities lies in decarbonising the urban electricity supply.

Yet at the same time, the electricity supply needs to expand rapidly to meet the demand of growing urban populations and to achieve the Sustainable Development Goals. This will require massive investments in renewable electricity generation and distribution infrastructure in and around cities to meet electricity demand across end-use sectors such as buildings and transport in a sustainable way. However, investment alone is not enough to address the challenges of the energy transition – energy systems and their evolving governance are also firmly in the spotlight. Energy policy historically has fallen under the mandate of national governments, with national or regional utilities typically supplying electricity to urban areas. In contrast, city governments have had minimal authority over energy supply.

National governments can support local climate action in cities in various ways, including by: clarifying the responsibilities and powers of different levels of government; supporting local actors in designing, financing and implementing low-carbon

measures (including renewable energy projects); and fostering a culture of experimentation, participation and learning that enables successful local initiatives to be scaled and replicated nationwide. For example, the Digital City Strategy of Hamburg (Germany), backed by national legislation and financial support, aims to show how the country's north-east can be supplied with 100% renewable energy by 2035. Greater digitalisation will facilitate decarbonisation and create possibilities for new players to emerge in the market, with potential to challenge the city's distribution company.

National governments are well placed to align climate and energy policies adopted at different governance levels (such as city, state and national) and to disentangle conflicting incentives that support the transition to a renewables-based energy system. Policy clarity and coherence is especially important for stimulating and shaping activity in the private sector. National and state governments also can go farther by empowering local governments to set more ambitious renewable energy targets – for example, by prohibiting the sale of fossil fuel vehicles, banning the use of fossil fuels to heat buildings and introducing renewable energy requirements in building codes and mandates. For example, the United Kingdom has banned sales of new petrol and diesel vehicles starting in 2030, which will have significant implications for the use of renewable fuels and electricity in urban transport. Such an approach ensures that emissions across all cities in a country fall steadily, while enabling ambitious city governments to advance faster.

National governments also play a role in financing low-carbon, resilient and inclusive cities, namely by fostering a fiscal system that generates the desired amount of public revenues and creates appropriate incentives for firms, households and sub-national governments. Responsible fiscal decentralisation can enhance the accountability of city governments for local service delivery and underpins their creditworthiness so that they can access capital markets. Local governments need the authority and capacity to control their own revenues, among others, to be able to provide grants, loans and subsidies to support the decarbonisation of urban systems. For example, the Marburg-Biedenkopf district (Germany) has built on its ability to subsidise the installation of electric vehicle charging stations to set the requirement that the electricity supplied to the stations must be renewable.

National governments can build a multilateral system that fosters inclusive, zero-carbon cities by setting a zero-carbon urban transition firmly on the global agenda, strengthening international frameworks that accelerate rather than undermine the transition, and using multilateral architecture – particularly the multilateral development banks – to support countries' own urban climate actions.

Source: See endnote 52 for this chapter.

i As of 2019, 108 countries out of 195 had a fully formulated national urban policy (termed a “National Urban Policy”, “National Urbanisation Policy”, “National Urban Strategy” or a similarly close variant).

RENEWABLES IN MUNICIPAL OPERATIONS

To increase the share of renewables in their own operations, municipal governments have used their assets to deploy distributed renewable energy generation capacity on and alongside public buildings (for example, schools, hospitals, sport centres and social housing), along city streets (including street lighting) and for municipal fleets. Most of these local projects have been solar PV systems, sometimes combined with battery storage or solar thermal systems. In some cities, municipal governments and other actors also have tapped into local wind, biomass and hydropower resources, either for electricity, direct thermal heat production and co- and tri-generation for power and heat, or to support the integration of renewables in district energy systems.

Some municipal governments have faced constraints to installing renewable energy within city limits – such as high land costs, land scarcity or building regulations. In many cases, they have opted instead to import renewables from outside of urban areas through procurement and strategic partnerships with third-party providers, including neighbouring communities. This has allowed them to use virtually any renewable energy source available, including bioenergy, hydropower, solar, wind, geothermal and ocean energy.⁶² Some municipal governments also have bundled demand with neighbouring cities, building on economies of scale to develop their own renewable energy projects or to procure renewables in bulk; other cities with vast rural hinterlands have established partnerships with these surrounding territories.⁶³

Some city governments have moved from single-sector planning to designing integrated (and circular) urban systems. This includes linking their energy supply with other urban activities to find cost-effective solutions to multiple challenges – for example, using urban waste and wastewater streams as feedstocks to produce biogas, biomethane and other renewable fuels.⁶⁴ The recycling of waste heat (also called waste heat recovery) has evolved, with some cities feeding the heat from industrial activity and data centres into district energy systems. While this is not in itself a renewable energy technology, such innovations have played an important role in creating integrated, efficient urban energy systems.⁶⁵

By scaling up renewables in municipal operations, city governments also have led by example to help drive change city-wide and build up the local capacity. This has been an important first step to demonstrate the business case and raise awareness of the opportunities that renewables present.



LEVERAGING RENEWABLES CITY-WIDE

Achieving urban renewable energy targets depends not only on political commitment and municipal investment in renewables, but also on cities' ability to mobilise and enable the uptake of renewables city-wide, by other actors. To support this broader deployment of renewable energy, municipal governments have expanded their policy portfolios. By the end of 2020, at least 799 municipal governments had implemented regulatory policies, financial and fiscal incentives, and indirect support policies to enable the uptake of renewables in buildings and transport city-wide (→ see *Urban Policy Landscape chapter*).⁶⁶

Policy trends for **buildings** include the rise of municipal building codes that mandate the use of renewable energy for electricity or heating (in addition to focusing on reducing energy demand and promoting nature-based solutions). These codes typically apply to new buildings, while renewables for existing buildings often are encouraged through financial and fiscal incentives such as grants, rebates and low-interest loans.⁶⁷ Most local government policy making has focused on growing the share of renewables in the **power** sector, mainly through solar PV systems, sometimes combined with battery storage or solar thermal systems. Momentum also has grown for electrifying space and water heating in buildings, resulting in more buildings using electricity generated from rising shares of variable renewables in the energy mix. In addition, the emergence of bans and restrictions on fossil fuels for **heating** in buildings, present in more than 53 cities worldwide, has contributed to rising electrification and the use of renewables (→ see *Figure 11 in Urban Policy Landscape chapter*).⁶⁸

In the **transport** sector, city governments have made strides to decarbonise municipal transport fleets and mobility infrastructure to improve urban air pollution, protect public health and well-being, and mitigate congestion and noise.⁶⁹ Although some cities have continued to support the use of biofuels in fleets, urban policies and procurement increasingly have focused on the electrification of transport. However, only a few cities have taken e-mobility as an opportunity to increase the share of renewables in the sector, for example through direct investment in new renewable electricity capacity, via power purchase agreements, by setting obligations/requirements for procurement and by subsidising the use of renewable electricity to charge electric vehicles.

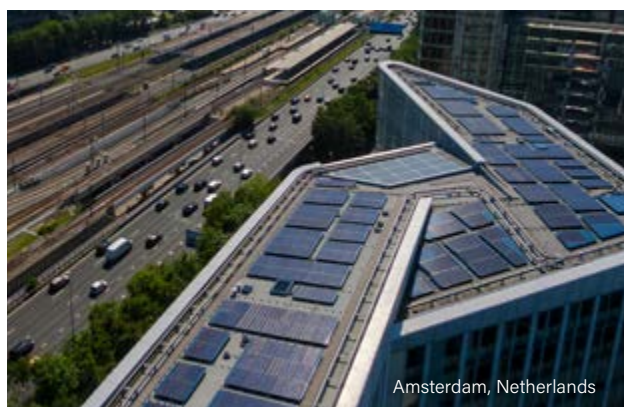
To support the decarbonisation of transport, cities have established low-emission zones and bans on certain fuels or vehicles, which are in place in 249 and 14 cities respectively.⁷⁰ In addition, to reduce the overall need for individual motorised transport, city governments have encouraged the transition to more efficient modes of transport – such as (renewables-based) public transit, including buses, metros and trams – and have improved walking and cycling infrastructure.⁷¹

i For an overview of the status of renewable energy technologies, see the Market and Industry Trends chapter in REN21's *Renewables 2020 Global Status Report*, available at www.ren21.net/gsr.

City governments also have shaped urban energy systems to better accommodate rising shares of renewables in the energy mix. They have expanded district energy networks and grid infrastructure, implemented efficient end-use technologies, expanded the electrification of transport and thermal demand (supported by technologies such as heat pumps and energy storage systems) and facilitated other demand-side flexibility. All of these measures provide the potential side-benefits of greater system efficiency, improved reliability of service and lower overall system costs.⁷²

Trends in urban financing and investment for renewables generally depend on the availability of capital for funding projects, including the ability of municipal governments to mobilise their own fiscal revenue collection and borrow money. Many cities have limited funds at their disposal and/or depend on national governments to provide a significant amount of finance.⁷³ Despite context-specific challenges, the finance and investment trends related to renewables in cities closely mimic those at the global level, including divestment from fossil fuels and re-investment in renewables (→ see *Financing and Investment chapter*). As of 2020, more than 160 city governments and pension funds had divested from fossil fuels, including 12 members of the C40 Cities network that pledged, as part of their COVID-19 economic recovery plans, to divest city assets from fossil fuel companies and then re-invest the funds in climate solutions.⁷⁴

Municipal governments are responsible for only part of the financing that occurs within a city. Businesses, households, communities and other urban actors also play a role, often encouraged by policies. In Europe and the United States, as well as elsewhere, more and more citizens have chosen to purchase energy from providers offering renewable electricity or heat, to increase self-consumption of renewables, and to join together to create community energy projects in cities. City governments also have used participatory governance to include citizens in urban planning, budgeting and policy development processes.⁷⁵



CITY LEADERSHIP: NETWORKS AND INITIATIVES

Local governments have worked together in global and regional networks to raise their voice, increase their advocacy capacity and sharpen their role in the climate, sustainable development and energy debates. Collectively, these networks have played an important role in encouraging cities to adopt renewable energy targets and implement local climate action, and they have offered a platform for effective information and resource exchange and inspiration.⁷⁶

- In 2020, more than 1,750 cities were part of the network of **ICLEI - Local Governments for Sustainability**, committing to sustainable urban development.⁷⁷ ICLEI worked with CDPⁱⁱ in 2019 to launch the CDP-ICLEI Unified Reporting System in an effort to streamline city climate and energy reporting. During 2020, 812 local governments from 93 countries reported their data to this system.⁷⁸
- By mid-2020, 97 cities were part of the **C40 Cities** network (no change from 2019), representing more than 700 million citizens and one-quarter of the global economy.⁷⁹ C40 cities aim to collectively halve their local greenhouse gas emissions by 2030, and 88 of the cities have signed on to *Deadline 2020*, a commitment to develop a climate action plan compatible with the Paris Agreement.⁸⁰ During 2019 and 2020, C40 cities continued to be frontrunners in climate and energy ambition, including:
 - By 2019, 28 cities (including 5 non-C40 cities) had joined the *Net Zero Carbon Buildings Declaration*, committing to net-zero carbon for new buildings by 2030 and for all buildings by 2050.⁸¹
 - In 2019, 35 cities (including 7 non-C40 cities) pledged to procure only zero-emission buses starting in 2025 and to ensure that a major area of the city is zero-emission by 2030.⁸²
- **Energy Cities**, the European association of cities in the energy transition, brought together 1,000 local governments in 30 countries as of 2020, with the goal of transforming European governance and legal frameworks to enable cities to play their part in the energy transition.⁸³
- As of 2020, the **ASEAN Smart City Network**, launched in 2018, brought together 26 pilot cities in member states of the Association of Southeast Asian Nations to work on smart, sustainable urban development.⁸⁴



i These 12 cities are signatories of the Divesting from Fossil Fuels, Investing in a Sustainable Future Declaration.

ii CDP, previously the Carbon Disclosure Project, is a disclosure platform for companies, states, cities and regions; see www.cdp.net.

iii These initiatives are, respectively, the Green and Healthy Streets Declaration and the Fossil Fuel Free Streets Declaration.

Many city networks also exist at the regional level, often in collaboration with global partners. Some local governments have organised themselves in national networks (as in Austria).⁸⁵ In the United Kingdom, the UK 100 network brings together around 100 local governments that have pledged to shift to 100% clean energy by 2050; in 2020, some member cities committed to achieve net zero by 2045.⁸⁶

Momentum also grew during 2019 and 2020 for specific initiatives and campaigns that engage local governments in energy and climate action, often in collaboration with city networks.

- The **Global Covenant of Mayors for Climate & Energy**ⁱ is the largest global coalition of cities and local governments. Signatories commit to reducing community-scale greenhouse gas emissions, adapting to climate change and improving access to sustainable energy (i.e., renewables and energy efficiency). As of mid-2020, more than 10,500 cities in 142 countries had committed to the Global Covenant of Mayors (232 new cities in 2019 and 177 as of mid-2020), with most of these cities (more than 9,600) in Europe, followed by Latin America and the Caribbean and North America.⁸⁷ Of the total signatories, 9,482 had climate change mitigation targets, and 5,460 of these also had mitigation plans; 1,870 cities had set adaptation goals, and 335 of these also had adaptation plans.⁸⁸
- The **Covenant of Mayors for Sub-Saharan Africa** (CoM SSA) was established in 2015 as part of the Global Covenant of Mayors, and by 2020 it had been signed by 175 local governments from more than 35 countries across Sub-Saharan Africa.
- CC35, under the **Mayors for Climate** ("Alcaldes por el clima") initiative, brings together local governments in Latin America to pass binding decarbonisation legislation, and had 274 members as of mid-2020.⁸⁹

- **Race to Zero**, a global campaign under the United Nations Framework Convention on Climate Change and supported by leading net-zero initiatives and city networks, brings together businesses, cities, regions and investors to facilitate the shift to a decarbonised economy. By the end of 2020, the campaign had 454 participating city governments, with the goal of mobilising 1,000 by the time of the United Nations Climate Change Conference in Glasgow (Scotland) in late 2021.⁹⁰

- To demonstrate city action towards the Paris Agreement, in 2020 a record 255 cities from 53 countries participated in **WWF's One City Planet Challenge**, a competition that was won by Mexico City.⁹¹

- By 2020, under the **Sierra Club's Ready for 100** campaign, 172 US cities had made commitments to 100% renewable energy by 2050 at the latest (up from 131 cities in mid-2019), and 48 cities had already achieved that goal.⁹² Other initiatives in the United States include the We Are Still In campaign, the Climate Mayors network and the US Conference of Mayors Climate Protection Agreement.⁹³

Although most countries' Nationally Determined Contributionsⁱⁱ towards reducing emissions under the Paris Agreement do not reference city-level renewable energy commitments (or specify the role of cities in achieving emission reductions), national governments will need to rely on urban actors to fulfil their obligations.⁹⁴ Many of the NDCs highlight urban adaptation and resilience and include targets that also apply to urban areas, such as the decarbonisation of buildings, energy, transport and waste.⁹⁵ By the end of 2020, 190 parties had submitted their first NDCs, and 8 had submitted their second.⁹⁶ Cities can contribute to attaining NDCs not only by reducing their own emissions, but also by participating in international initiatives.



Havana, Cuba

City networks

have encouraged municipal governments to adopt renewable energy targets and implement local climate action.

i The initiative started as the European Union's Covenant of Mayors in 2008 but has since grown to cities in 140 countries by the end of 2020. The Global Covenant of Mayors for Climate & Energy combined the EU's Covenant of Mayors with the Compact of Mayors (launched in September 2014 by UN Secretary-General Ban Ki-moon). See European Commission, "EU Covenant of Mayors and Compact of Mayors launch largest global coalition of cities committed to fighting climate change", press release (Brussels: 22 June 2016), https://ec.europa.eu/commission/presscorner/detail/it/IP_16_2247.

ii NDCs include policies, targets and measures that serve as the basis for national climate plans. See World Resources Institute, "National Climate Action under the Paris Agreement", <https://www.wri.org/ndcs>, viewed 15 November 2020.

REGIONAL TRENDS

EUROPE

European cities have been global leaders on urban energy and climate issues, often driven by the push for greater climate action as well as a desire to improve the health of city residents.⁹⁷ For example, cities in Europe spearheaded the “climate emergency” movement and accounted for 45% (826) of the total 1,852 climate emergency declarations issued worldwide as of the end of 2020.⁹⁸ Additionally, at least 357 European cities had a renewable energy target in place by year’s end.⁹⁹

European cities were the most numerous participants in city networks and dominated local climate action in 2020: by the end of the year, more than 10,000 cities in 43 European countries had signed the Covenant of Mayors for Energy & Climate, and over 6,700 of these had submitted action plans as well, many of which specify a role for renewables.¹⁰⁰ In line with the European Green Deal, cities also have been committing to net-zero goals and developing more holistic strategies and integrated solutions to decarbonise activities in urban areas, including scaling up renewables on municipal buildings, using waste and wastewater as inputs to produce renewables, integrating solar and geothermal district heating, and shifting to renewable-based municipal vehicle fleets.¹⁰¹

In late 2020, the European Green City Accord was launched with the aim of speeding Europe’s transition to sustainable development by getting different levels of government to work together and mobilise other stakeholders. The Accord will support city efforts towards achieving the following five goals by 2030: significant improvement in air quality; important progress in improving the quality of water bodies and the efficiency of water use; considerable progress in conserving and enhancing urban biodiversity; advancement towards the circular economy; and significant reduction in noise pollution.¹⁰²

In contrast to many other regions, cities in Europe are shaped by infrastructure that extends back centuries, and they typically have a more settled urban form and low rates of new building construction. The focus is thus on renovating and retrofitting existing structures, often with dedicated funding from other levels of government, such as the EU’s “renovation wave” strategy.¹⁰³ Cities and communities have taken on growing importance at the EU level, exemplified by targeted projects providing financing for innovative cities.¹⁰⁴ For example, so-called lighthouse cities have been selected as climate innovation leaders to set positive examples and lay the path for other cities to follow.¹⁰⁵ In contrast, only a few national governments have fully understood the key role of local authorities in the energy and climate transition.¹⁰⁶



Hagafoss, Norway

Europe and North America

remain leading regions for city-level renewable energy and climate action.



Milan, Italy

i The EU’s renovation wave strategy focuses on the need to improve, retrofit and decarbonise existing buildings. See European Commission, “Renovation wave”, https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/renovation-wave_en, updated 18 January 2021.

NORTH AMERICA

North America remained a leading region for city-level renewable energy action, driven by local ambition to decarbonise and diversify energy supplies while increasing economic competitiveness and boosting resiliency.¹⁰⁷ As of the end of 2020, at least 350 municipal governments in the United States and Canada had renewable energy targets, and several cities had made significant progress towards their 100% renewable electricity goals, with several cities achieving these during 2019 and 2020.¹⁰⁸ Key trends in the region included procurement of renewables for municipal operations, galvanised support for distributed renewable energy generation projects, diverse community solar models, and robust incentives or mandates for energy efficiency upgrades and building electrification. North American cities continued to leverage municipal green bonds, federal and state funding, clean-tech incubator support and other innovative financing mechanisms to support the development of renewables.¹⁰⁹

In the United States, local government renewable energy transactions increased considerably after the federal government stated its intention in 2017 to withdraw from the Paris Agreement (the country rejoined in January 2021).¹¹⁰ Cities accounted for most of the new renewable power capacity added by local governments during 2019 and 2020 – primarily through off-site power purchase agreements (PPAs) signed with developers of large-scale solar PV projects, mainly in California and Texas.¹¹¹ In Canada, a major policy focus in large cities – notably Montreal, Toronto and Vancouver – was increasing the share of renewable energy across not just the power sector but also heating, cooling and transport.¹¹²

Although North American cities have struggled to deploy renewables more widely in heating, cooling and transport, an increasing share of municipal governments partnered with legislative or regulatory bodies at higher levels of governance, as well as with community stakeholders and/or the private sector, to remove legal, technical and financial barriers restricting renewable energy deployment and use across all end-use sectors.¹¹³



Oak View, California, United States

ASIA

In Asia, growing concerns about air pollution and smog have driven public demand for renewable energy technologies and electric vehicles to improve public health.¹¹⁴ Although national governments have tended to dominate city-level actions to promote renewables, municipal-level commitment has been growing. By the end of 2020, at least 51 municipal governments in Asia had set renewable energy targets, and 37 had implemented renewable energy policies, most of which were in buildings and transport.¹¹⁵ In addition, local governments have been instrumental in pushing the national governments in Japan and the Republic of Korea to commit to carbon neutrality and/or adopt net-zero targets.¹¹⁶ Cities in Asia increasingly have sought to develop and strengthen public-private partnerships and to take advantage of digitalisation and use smart technology to attract more foreign direct investments in renewables.

Chinese cities have actively promoted renewables, guided mainly by national and regional policies and action plans, many aimed at reducing air pollution.¹¹⁷ In addition, several municipal governments have subsidised renewables in buildings and supported the phase-out of fossil fuels for heating purposes. China dominates the global e-mobility market, accounting for 98% of the world's electric buses and for the majority of electrified cars, two-/three-wheelers and trucks.¹¹⁸ Green hydrogen for transport (and other uses) also is garnering interest in both China and the Republic of Korea, with several cities having ongoing or planned pilot projects.¹¹⁹ Municipal governments in the Republic of Korea have dominated the number of climate emergency declarations issued in the region, representing 228 out of the 288 as of 2020.¹²⁰

India launched a smart cities programme in 2015 to increase solar power generation capacity in urban areas, and some of these efforts have been coupled with the electrification of urban transport (part of the country's Faster Adoption and Manufacturing of Electric Vehicles (FAME)-II in 2019-2020).¹²¹ Momentum is growing for the expansion of district cooling in the Indian cities of Amaravati, Gujarat International Finance Tec-City (GIFT City) and Rajkot, as well as elsewhere in Asia including in Bangkok (Thailand), Cyberjaya (Malaysia), Manila (Philippines) and Singapore.¹²² Still, data on renewable energy progress in Asia remain limited, often due to language barriers and to low participation in international reporting.



Bacoor, Philippines

SUB-SAHARAN AFRICA

Due to rising urbanisation, population growth and energy demandⁱ, the opportunities around renewable energy use in cities are increasingly recognised in Sub-Saharan Africa. At least 19 cities, including Cape Town and Durban (both South Africa) and Kampala (Uganda) have in place renewable energy targets, and 34 cities have policies.¹²³ Common drivers for renewables in the region include reducing poverty and inequality (including by addressing energy access and energy poverty) and boosting the resilience and reliability of power systems.¹²⁴

City governments play a key role in shaping the energy landscape of Sub-Saharan Africa. However, competing development priorities, weak fiscal decentralisation, limited municipal mandates across key sectors, and constraints in skilled capacity to execute municipal functions continue to hinder the wider adoption of renewables.¹²⁵ Nonetheless, cities have supported local renewable energy deployment in a variety of ways, including by facilitating collaborative projects led by national governments, development finance institutions and/or private actors.¹²⁶ Some Sub-Saharan local governments, especially in cities where transport is responsible for a large share of energy consumption, also have entered into public-private partnerships to advance e-mobility (sometimes linked to renewable electricity) at the city level.¹²⁷

Still, the number of cities and towns in the region that have reported data on renewables remains low, due in part to poor or non-existent Internet access, lack of technical (information technology) equipment for local government staff, and the absence of systematic and robust data collection (a worldwide challenge) – all of which impact the availability of data necessary for analysis and trend identification over time.¹²⁸ This affects local decision making and resource allocation, and also is a barrier for private investors.¹²⁹ To address this challenge and to access technical guidance, many Sub-Saharan African cities have joined international city networks such as ICLEI and initiatives like the Covenant of Mayors in Sub-Saharan Africa, which support knowledge and internal capacity on renewable energy data collection and developing robust implementation projects (→ see *Feature chapter*).¹³⁰

LATIN AMERICA AND THE CARIBBEAN

In Latin America and the Caribbean, concerns about traffic and congestion, inadequate infrastructure, air pollution and the effects of climate change have accelerated investment in renewables

and the electrification of public transit.¹³¹ By the end of 2020, several municipal governments had renewable energy targets (39 targets), and cities in the region were among the frontrunners in setting net-zero targets (212 targets).¹³² Many cities already have high shares of renewable electricity in their energy mixes, including Bogotá (Colombia), Curitiba (Brazil) and Quito (Ecuador).¹³³ This has been facilitated by the large contribution of hydropower to national and regional grids, emerging national-level regulations for integrating distributed power generation, the growing penetration of wind and solar PV power (incentivised by national policies) and the emergence of renewable energy auctions.¹³⁴

The liberalisation of electricity markets in Argentina, Brazil, Colombia, Mexico and Peru has made it possible for municipal governments and other large energy consumers in these countries to procure renewable electricity directly from local or nearby projects (although residential users remain excluded from choosing their supply companies).¹³⁵ Additional trends include the integration of solar PV and solar thermal systems in public buildings; the creation of public-private partnerships to implement larger decarbonisation projects (such as investments in public transit infrastructure); and growing momentum for the electrification of public bus fleets, with e-buses operating in cities in more than 10 countries.¹³⁶

Despite facing many challenges,

city-level action

to support renewables is expanding, including in developing and emerging economies.



Cape Town, South Africa



Baños, Ecuador

ⁱ Despite rising energy use in the region, energy consumption in Sub-Saharan Africa remains among the lowest in the world and relies heavily on traditional biomass, mainly wood and charcoal. See International Energy Agency (IEA), *Africa Energy Outlook 2019 – Analysis Scenarios* (Paris: 2019), and IEA, *World Energy Outlook 2020* (Paris: 2020).

OCEANIA

Renewable energy deployment varies widely across Oceania. Many Pacific island nations have turned to renewables to decrease their dependence on fossil fuel imports, reduce energy costs, and increase energy security and resilience, with most of these efforts being dominated by national and/or sub-national governments.¹³⁷ In Australia and New Zealand, momentum is growing for renewable energy in cities, also facilitated by rising concerns about climate change and energy insecurity. By the end of 2020, 114 municipal governments in Australia and New Zealand had declared a climate emergencyⁱ, and 16 cities had a renewable energy target in place, including several cities that have committed to (or already achieved) 100% renewable energy targets, including Adelaide, Melbourne and Sydney (all Australia).¹³⁸

Renewable power purchase agreements gained momentum in Australia, with several major cities, including Melbourne and Sydney, negotiating PPAs in 2019 and 2020 to help achieve their ambitious renewable electricity goals.¹³⁹ Australian cities also continued efforts to decarbonise transport, with electric refuse trucks starting operation in Adelaide, Casey and Yarra.¹⁴⁰ Investment in renewable energy projects in Australia has increased in recent years, mainly in the private sector and supplied by domestic banks. In the wake of the widespread 2019 wildfires, municipal governments created several recovery and reconstruction funds to support the installation of solar PV systems in cities and towns.¹⁴¹

MIDDLE EAST AND NORTH AFRICA

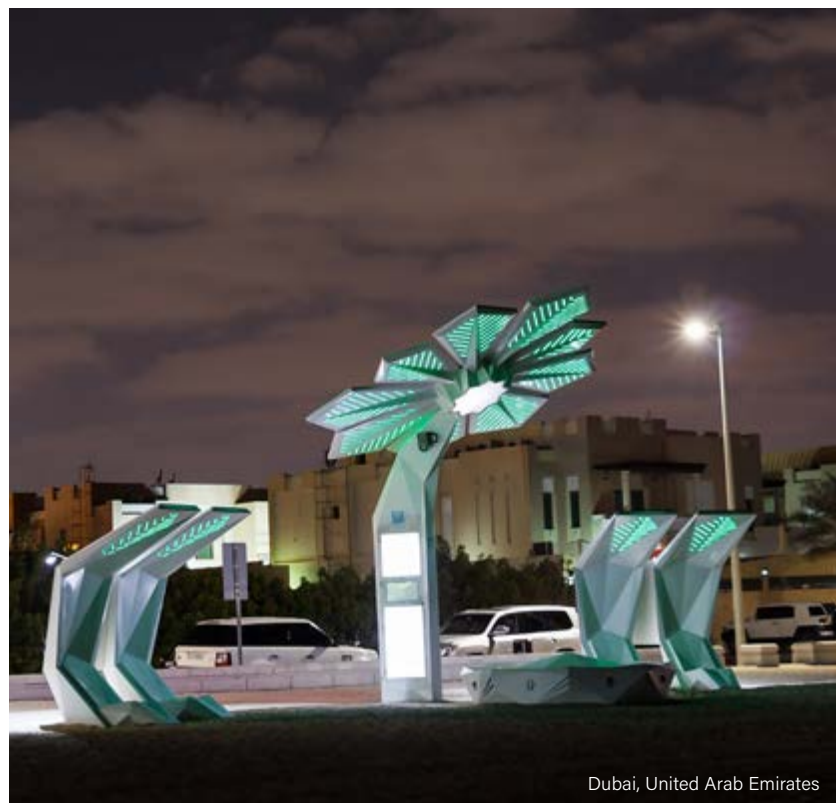
Across the Middle East and North Africa, concerns about air pollution and health have risen, and energy security challenges remain. Generally, municipal-led renewable energy developments have progressed slowly, due to lack of financial and human resources and strong centralisation of the energy system.¹⁴²

City governments tend to have comparatively little political autonomy, and thus national rather than municipal governments have largely driven efforts to deploy renewables (exceptions include Abu Dhabi, Dubai and Ras Al Khaimah in the United Arab Emirates).¹⁴³ Some renewable energy projects in cities have been funded by national governments, whereas in less affluent regions investment has been supported by foreign development aid as well as rising involvement from the private sector and civil society.

The key drivers for renewables vary across world regions, but concerns about **air pollution** are global.



Taupo Volcanic Zone, New Zealand



Dubai, United Arab Emirates

ⁱ At the end of 2020, New Zealand's national government also declared a climate emergency and set a goal to be carbon neutral by 2025.



Windhoek
Copenhagen
Frankfurt
Houston
Araçatuba
Las Vegas
Zhangjiakou
Singapore
Santiago
Pico Truncado
Beijing
Dubai
Aalborg
Evora

URBAN POLICY 2

LANDSCAPE



Orlando
Adelaide
Rajkot
Seoul

URBAN POLICY LANDSCAPE

Municipal governments around the world have been moving renewable energy up the policy and planning agenda, driven by the desire to improve public health and well-being, alleviate poverty, tackle climate change and improve local resilience, among other goals, and supported

Around
260 cities
set new targets or passed
new policies in 2020.

by the falling prices of renewables; overall, more than 1 billion people – around a quarter of the global urban population – lived in a city with a renewable energy target and/or policy (for a total of over 1,300 cities), and around 260 cities set new targets or passed new policies in 2020.¹ In many cases, municipal targets and policies are far more ambitious than those in place at higher levels of government.²

Municipalities have numerous policy options to stimulate renewable energy deployment. They can set targets and scale up the use of renewables for their own **municipal operations**

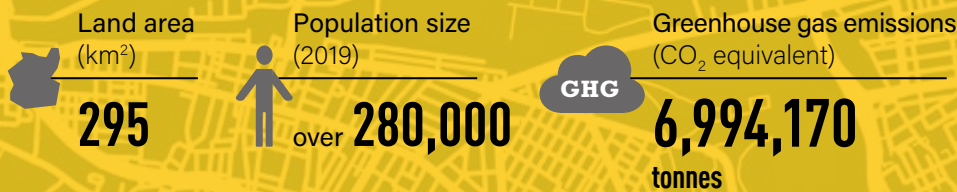
(whether in buildings or transport fleets) through on-site generation and procurement policies. They also can use their role as regulators and policy makers to implement direct regulatory policies, financial and fiscal incentives as well as indirect support policies to encourage the **city-wide** adoption of renewable technologies.³ In addition, municipal governments can raise awareness about the benefits of renewables, facilitate dialogue, and engage local residents, businesses and other stakeholders in the energy transition.⁴

Municipal governments have been advancing the production and use of renewable energy through various measures, including integrating renewables directly into near- and long-term energy and resource planning (→ see *City Snapshot: Orlando*).⁵ For example, mandating the inclusion of renewable technologies and/or electric vehicle charging infrastructure in new construction can enable higher renewable energy shares while helping to achieve other city-wide goals. Governments also can advance renewables by planning infrastructure and the built environment in more efficient ways, considering urban density, building orientation and related effects on mobility to enable greater renewable energy use in key sectors such as buildings, industry and transport.⁶

i For more on the multiple roles of municipal governments in the energy transition, see Chapter 1, “Cities in the Renewable Energy Transition”, in the REN21, *Renewables in Cities 2019 Global Status Report* (Paris: 2019), https://www.ren21.net/wpcontent/uploads/2019/05/REC-2019-GSR_Full_Report_web.pdf.

ORLANDO

FLORIDA (UNITED STATES)



The City of Orlando has a strong reputation for its city-wide achievements in sustainability and resilience. Over the last decade, the Green Works Orlando initiative has revolutionised the city by adding a sustainability chapter to the local municipal code. The implementation of sustainability policies and plans has made the city a leader in developing environmentally friendly communities.

In 2020, the Orlando Utilities Commission (OUC) began developing its Electric Integrated Resource Plan, with the aim of becoming carbon neutral by 2050 (with interim CO₂ emission reduction targets of 50% by 2030 and 75% by 2040). The plan also acts as a pillar to achieve the mayor’s ambitious goal of 100% renewable electricity generationⁱ in the city by 2050. It supports the phase-out of coal by 2027 and provides a roadmap to diversify the city’s existing electricity mix. Although solar PV will remain the main source of new energy, Orlando will invest in energy storage and other related technologies to ensure reliability and resilience.

The OUC has a major role in making solar energy affordable and accessible in the city and has found innovative ways to harness power from the sun. In 2017, it established long-term power purchase agreements to buy power from the 12.6 megawatt (MW) Kenneth P. Ksionek Community Solar Farm, the first in the country to include a solar PV array that sits atop a by-product landfill. In 2020, the OUC backed the construction of two new solar PV farms – the Harmony Solar Energy Center in St. Cloud and the Taylor Creek Solar Energy Center in east Orange Countyⁱⁱ,

together capable of powering 30,000 homes – and started purchasing power from them.

Orlando also is home to more than 1 MW peak of floating solar PV and has been a pioneer in this new application since 2017. The OUC will continue to study the performance and scalability of floating solar PV in collaboration with the National Renewable Energy Laboratory thanks to a USD 1 million grant from the US Department of Energy. In 2020, the City of Orlando unveiled the new “floatovoltaics” at its international airport, showcasing this unique solar application. The local government has installed several “solar sculptures” and “solar trees” in the city to generate electricity and educate customers on the benefits of solar power.

Source: See endnote 5 for this chapter.



ⁱ According to the CDP-ICLEI Unified Reporting System, the share of renewables in electricity generation in Orlando was 2% (no date specified).

ⁱⁱ These are two of five projects being developed in the context of the Florida Municipal Solar Project, a partnership between the Florida Municipal Power Agency and 16 Florida public power utilities, including the OUC.

TARGETS

RENEWABLE ENERGY

Globally, at least 834 cities in 72 countries had a renewable energy target in at least one sectorⁱ by the end of 2020.⁷ This means that an estimated 558 million people worldwide are living in a city with at least one renewable energy target.⁸ Altogether, these cities have a combined total of 1,088 targets, as several cities have adopted more than one renewable energy target (whether for municipal operations and/or city-wide energy use) (→ see *Figures 3 and 4 and Reference Table R1*).⁹ Although most municipal targets are aimed exclusively at the power sector (62%), several municipalities have enacted targets specifically for heating and cooling or for transport, and some have committed to cross-sector or economy-wide targets.¹⁰

Geographically, the number of municipal renewable energy targets has increased in all regions of the world, although most targets are in North America and Europe (a combined 81%) followed by Asia (8%).¹¹ In Europe, targets are especially prevalent in Germany and Italy, facilitated by rising awareness of the influence of cities within the EU as well as by governance structures that allow local participation in energy issues.¹² In North America, targets are most common in the United States, which is home to 419 targets (39% of the global total), demonstrating the long-term commitment of municipal authorities despite the temporary US withdrawal from the Paris Agreement.¹³ Overall, more than 80% of renewable

energy targets globally are in regions that have higher income per capita, and are predominantly in countries with colder climates.¹⁴ Generally, small and medium-sized cities in the population range of up to 500,000 inhabitants have emerged as frontrunners in target-setting, home to 74% of all targets (→ see *Figure 5*).¹⁵ However, some larger cities and megacities – such as Beijing (China), Cape Town (South Africa), Copenhagen (Denmark) and Frankfurt (Germany) – also have targets.¹⁶

Municipal renewable energy targets differ in several waysⁱⁱ. Although many targets are aspirational goals, taking the form of pledges, some cities have enacted legally binding targets.¹⁷ The scope of targets ranges from municipal operations to city-wide energy production or use, and timelines vary widely (→ see *Figure 6*).¹⁸ Some cities also break down their targets into interim, shorter-term targets to facilitate the tracking of progress, and align their action plans accordingly.¹⁹ The majority of cities aim their targets at increasing the overall share of energy from renewables, although many also apply specific capacity or generation goals.²⁰

Despite the momentum at the municipal level to establish renewable energy targets, city reporting on actual progress towards achieving these targets has lagged.²¹ Many cities are either not gathering or not providing sufficient data to enable adequate monitoring and benchmarking. As a result, it remains difficult to determine the extent to which cities are on track to reach their targets (→ see *Box 1 in Global Overview chapter*).²²



Small and medium-sized cities have emerged as **frontrunners** in renewable energy target-setting.



i This total includes multiple targets for the same city. It covers renewable targets for consumption of all energy as well as for energy specifically in the power, heating and cooling, and transport sectors, as well as targets for specific installed capacity. It excludes targets for enabling technologies such as e-mobility and energy efficiency targets. In some cases, city governments have passed renewable energy targets but it remains unclear whether they are for renewable electricity or economic-wide targets (→ see *Box 1 in Global Overview chapter*).

ii For more on the nature of renewable energy targets in cities, see REN21, *Renewables in Cities 2019 Global Status Report* (Paris: 2019), https://www.ren21.net/wpcontent/uploads/2019/05/REC-2019-GSR_Full_Report_web.pdf.

Figure 3. Renewable Energy Targets in Cities, 2020

834 cities worldwide have renewable energy targets

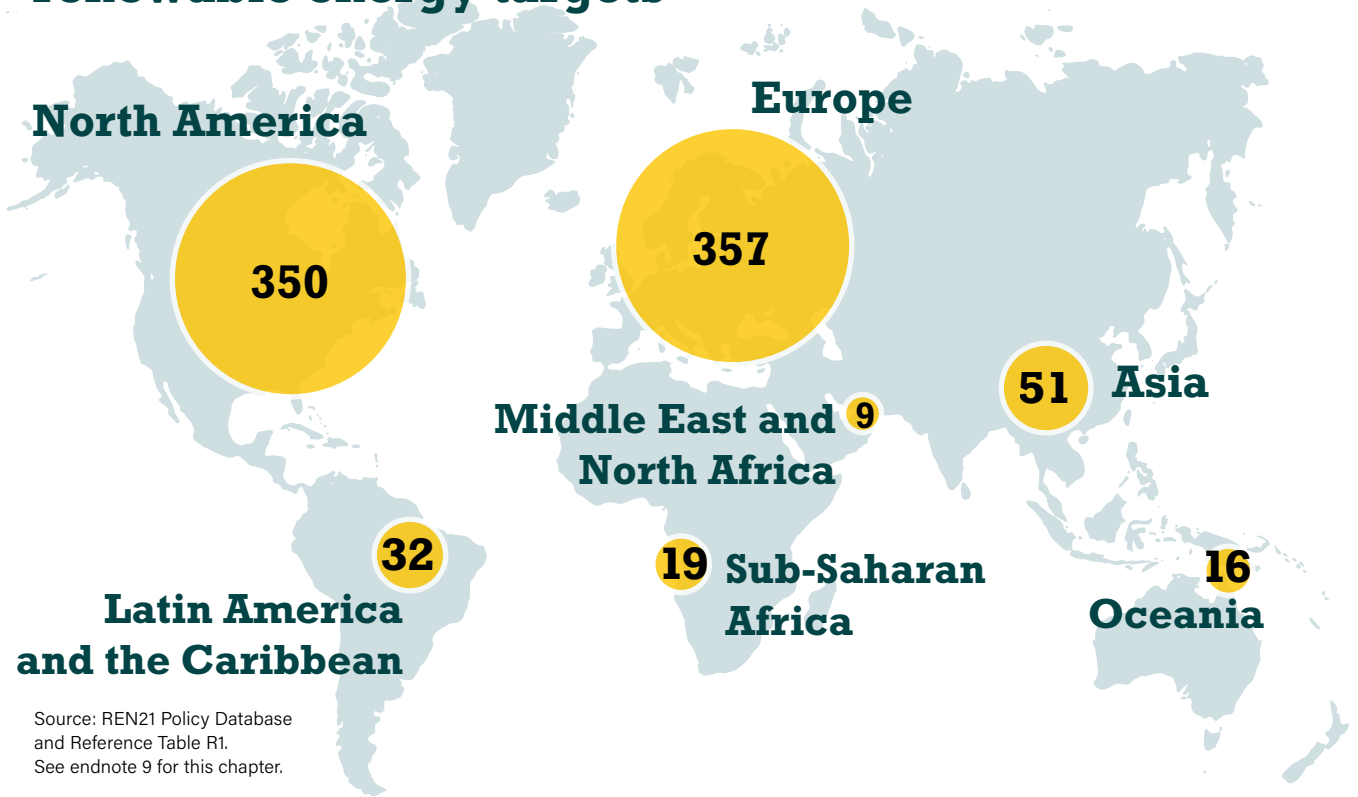
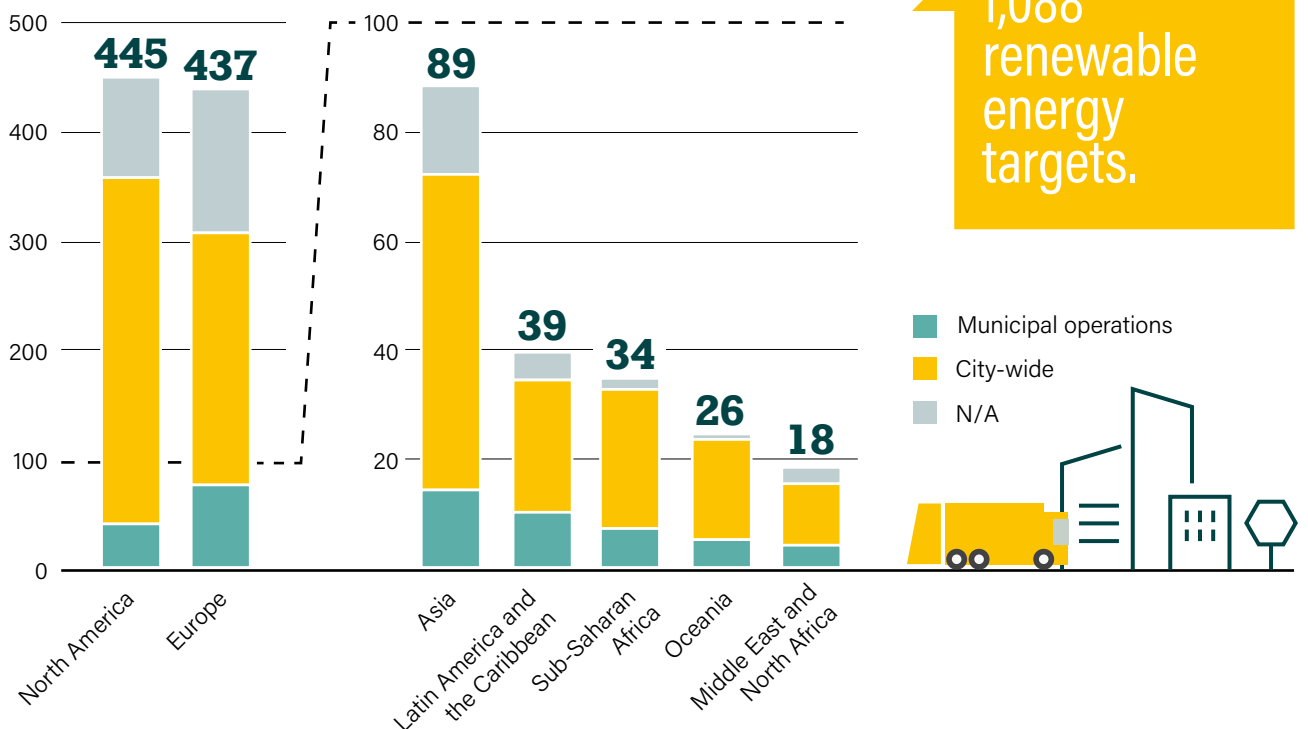


Figure 4. Renewable Energy Targets in Cities, by Scale of Application and Region, 2020

Number of renewable energy targets by scale of application

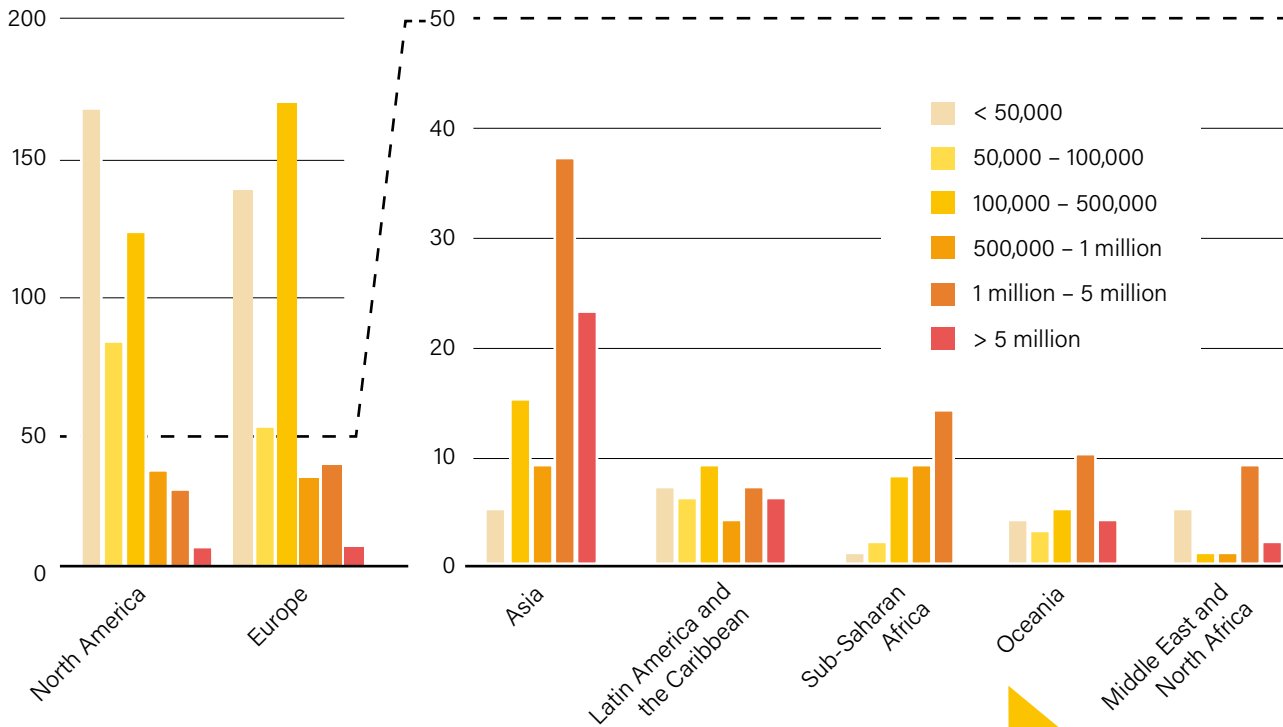


Note: The figure includes cities with renewable energy targets either for municipal operations or for city-wide energy use, or for both. Some cities have more than one renewable energy target. N/A = scale of application not available.

Source: REN21 Policy Database and Reference Table R1. See endnote 9 for this chapter.

Figure 5. Renewable Energy Targets in Cities, by City Size and Region, 2020

Number of renewable energy targets by city population size



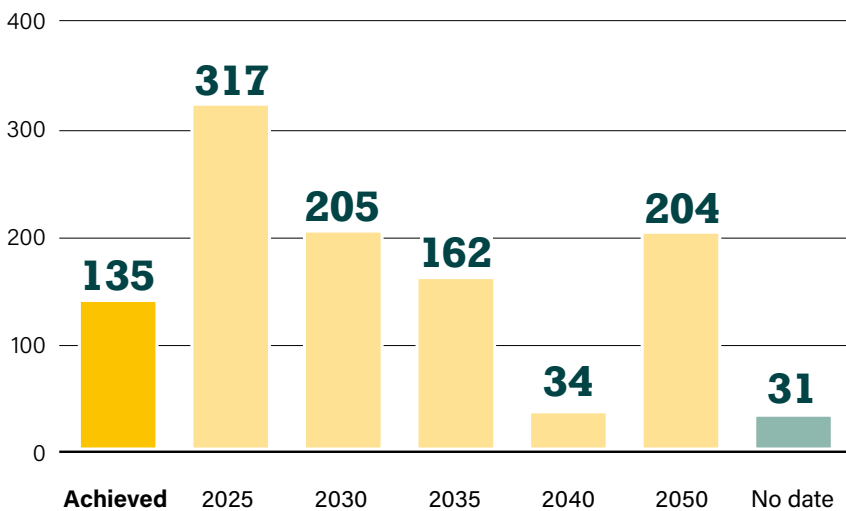
Note: Some cities have multiple renewable energy targets.

Source: REN21 Policy Database and Reference Table R1. See endnote 15 for this chapter.

Cities with less than 500,000 people are home to **74% of all renewable energy targets.**

Figure 6. Renewable Energy Targets in Cities, by Target Year, 2020

Number of renewable energy targets by target year



Note: Data for target years also include targets within the span of years prior to those specified (e.g., 2026-2029 for the 2030 target year).

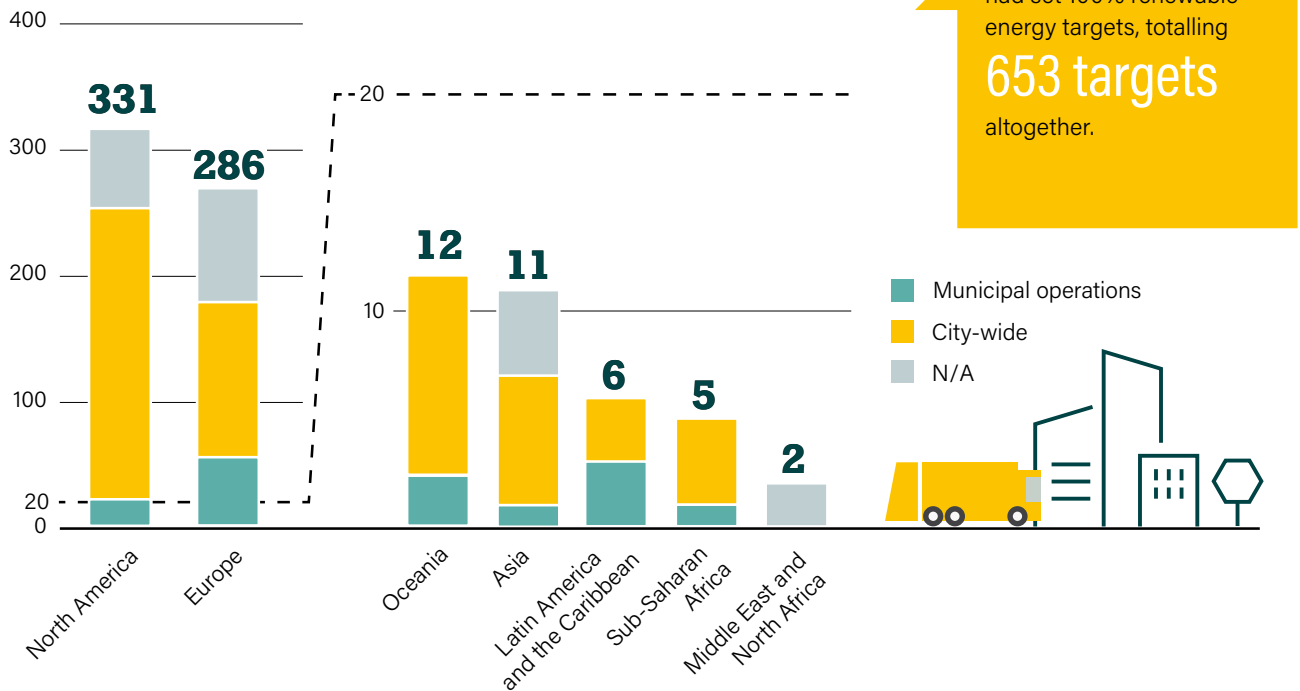
Source: REN21 Policy Database and Reference Table R1. See endnote 18 for this chapter.



The movement towards 100% renewable energy – particularly 100% renewable electricity – has continued to gain traction. Globally, 617 cities had set 100% targets for either municipal operations or city-wide energy use as of 2020, together totalling 653 targets (→ see Figure 7).²³ Most of these commitments are for the power sector only. Although most such targets aim for years in the 2030 to 2050 period, at least 125 cities (including 47 in the United States alone) already had achieved their 100% renewable electricity targets by the end of 2020 (→ see *City Snapshot: Adelaide*).²⁴ For example, Houston (Texas) has met its target of powering its municipal operations – including its wastewater treatment plants, zoo and three airports – with 100% renewable electricity, making it the largest US city to power its operations entirely by renewables.²⁵

Figure 7. 100% Renewable Energy Targets in Cities, by Scale of Application and Region, 2020

Number of 100% renewable energy targets by scale of application



Note: The figure includes cities with 100% renewable energy targets either for municipal operations or for city-wide energy use, or for both. Some cities have more than one 100% renewable energy target. N/A = scale of application not available.

Source: REN21 Policy Database and Reference Table R1. See endnote 23 for this chapter.

ADELAIDE

AUSTRALIA



As part of a power purchase agreement, the City of Adelaide's municipal operations have been powered by 100% renewables since July 2020, using electricity generated from wind farms in mid-north South Australia and new solar PV farms on Eyre Peninsula and in the South East. This long-term commitment supports the Adelaide Carbon Neutral Strategy 2015-2025, which sets a target for carbon neutrality by 2025.

As a step towards achieving this goal, the City adopted the Carbon Neutral Adelaide Action Plan 2016-2021 to reduce greenhouse gas emissions. The plan sets out 104 actions for council and local government under several low-emission pathways: energy-efficient built form, promoting walking and cycling, hybrid and electric vehicles for individuals and businesses, "zero-emission" transport, towards 100% renewables with solar PV and solar hot water, reducing emissions from waste and water use, and offsetting carbon emissions. The projects under the 100% renewable pathway generate cost savings for residents and businesses along with reducing emissions. In total, the city had installed 8.3 MW-peak of solar PV capacity as of 2019, including 2,362 kilowatts (kW) at city-owned and -operated sites.

Local government investments in energy storage support the deployment of new affordable storage technologies. For example, the Hornsdale Power Reserve, referred to as South Australia's Big Battery, was established in 2017 with 100 MW-peak, and another 50 MW-peak had been added in early 2020. Located next to the 316 MW Hornsdale Wind Farm, the Power Reserve is one of the world's largest lithium-ion batteries, providing grid services that enable the penetration of variable renewable energy sources like wind and solar power.

In addition, the Carbon Neutral Adelaide Action Plan provides incentives to create new economic opportunities and to support the business sector. Building upgrade finance provided by private financiers in partnership with the local council helps to improve the energy, water and environmental efficiency of non-residential buildings and infrastructure. This mechanism offers loans from the financier to building owners, which are repaid by the local council. Upgrading the infrastructure provides financial returns and has the potential to reduce electricity use 43% by 2030.

The Sustainability Incentive Scheme and the CitySwitch Green Office support city residents with financial incentives for the uptake of sustainability practices, technology and trends for low-carbon living. Rebates of up to AUD 5,000 (USD 3,831) are available for households, businesses and car parks for the installation of energy-saving technologies, solar PV systems, EV charging, solar hot water systems and energy storage systems.

The City of Adelaide also is assessing adaptation actions to increase the energy self-sufficiency of its wastewater treatment plants by harnessing biogas to generate renewable electricity. A total of 39,000 megawatt-hours (MWh) was generated from wastewater biogas in 2018-19. In parallel, the local government has been exploring the potential of carbon offset projects. In 2017, a demonstration carbon sequestration site was established near Adelaide High School to provide the community with a practical example of a carbon sink.

Source: See endnote 24 for this chapter.

City governments continued reporting on renewable energy targets, with 812 cities providing data to the CDP-ICLEI Unified Reporting System by the end of 2020.²⁶ Of these, 95 were in the progress of developing a renewable energy target in 2020 and 152 intended to pass one in the next two years.²⁷

Targets in the **power** sector have continued to receive most of the attention. As of 2020, at least 612 cities had renewable energy targets focused on the power sector (678 targets altogether), including targets to switch to renewable electricity consumption or targets for a specific amount of renewable generation.²⁸ Cities with new renewable power targets in 2020 included Araçatuba (Brazil); Blacksburg, Houston, Las Vegas and Louisville (all US); Evora (Portugal); Murcia (Spain); and Singapore.²⁹

A growing number of cities have set targets for renewable **heating and cooling**, particularly in Europe and the United States. This trend is especially pronounced in cities that have adopted net-zero or other climate targets, as recognition grows of the critical role that the heating and cooling sector plays in achieving decarbonisation.³⁰ In Scandinavia, Baerum (Norway) and Helsingør (Denmark) have targets for the use of 100% renewables in district heating, and Helsingør has specified that its district system will rely entirely on bioenergy.³¹ Momentum also has grown for the adoption of solar water heater targets, particularly in developing countries. Mexico City committed in 2019 to retrofitting eight public buildings with solar water heating, and similar targets also exist in Alheim (Germany) and Antofagasta (Chile).³²

In the **transport** sector, most city-level targets focus on electric vehicles, with some linked directly to renewable power (→ see *E-mobility and Hydrogen section*).³³ Although most **biofuel targets** for transport are set at higher levels of government, a few examples exist in cities, including in Auckland (New Zealand) since 2014, and in Helsingborg (Sweden) and Mexico City (Mexico) since 2019.³⁴ Some municipal governments also have worked with ports and port authorities to develop decarbonisation targets and strategies, including for increasing the production and use of renewables (→ see *Box 1*).³⁵



At least
67 cities
have e-mobility targets.

E-MOBILITY AND HYDROGEN

E-mobility targets dominate urban transport-related targets and increasingly are being adopted in cities worldwide. Overall, at least 67 cities had e-mobility targets as of the end of 2020, up from 54 in mid-2019.³⁶

Electrification offers the potential to increase the use of renewable energy in transport.³⁷ Although most cities with e-mobility targets do not link them directly to renewable electricity, several cities have adopted separate targets for e-mobility and renewable electricity – including Amsterdam (Netherlands), Cape Town (South Africa), Dubai (United Arab Emirates), Hamburg (Germany), Portland (Oregon, US) and Toronto (Canada) (→ see *Figure 8 and Reference Tables R2 and R3*).³⁸

E-mobility targets often aim for a certain number or percentage of EVs either sold, in circulation or registered in a city by a certain year. In 2019 and 2020, at least four cities – Delhi (India), Los Angeles (California, US), Santiago (Chile) and Seoul (Republic of Korea) added to their existing e-mobility targets, and at least three additional cities – Hamburg (Germany), Singapore and Tallinn (Estonia) – announced their first e-mobility targets.³⁹ To reduce local air pollution, the government of Delhi (India) set targets in 2019 for at least 500,000 EV registrations by 2024, and for delivery companies in the city to electrify 50% of their fleet by 2023 and 100% by 2025.⁴⁰ Also in 2019, Los Angeles (California, US) announced plans to increase the city's share of zero-emission vehiclesⁱ in operation to 25% by 2025, 80% by 2035 and 100% by 2050.⁴¹ In 2020, Santiago (Chile) announced a target to electrify 4,250 of its 6,600 buses by the end of 2021.⁴²



Hamburg, Germany

i Researchers and policy makers increasingly recognise that to truly decarbonise the transport sector, e-mobility targets need to be linked directly with or at least complemented by renewable electricity targets. See REN21 and FIA Foundation, *Renewable Energy Pathways in Road Transport* (London: November 2020), https://www.ren21.net/wpcontent/uploads/2019/05/REN21_FIA-Fdn_Renewable-Energy-Pathways_FINAL.pdf.

ii Zero-emission vehicles do not produce tailpipe emissions. These air pollutants, emitted during the operation of a vehicle, often include greenhouse gases, particulate matter, volatile organic compounds, nitrogen oxides, carbon monoxide and sulphur dioxide.

BOX 1. Renewable Energy in Urban Ports and Port Authorities

Since most ports are located in cities, many interlinkages exist between ports and the urban environment. These linkages often have negative consequences at the local level: for example, in Hong Kong (China) more than half of the city's sulphur dioxide emissions are related to shipping. To address these concerns, both municipal policies and port development strategies increasingly have included measures to reduce emissions, mitigate the environmental impacts of port activities (including loading and unloading) and scale up renewable energy.

Nearly 90% of Europe's port authorities are publicly owned, meaning that local and other governments have a key role to play in the uptake of renewables at these ports. For example, the Climate Neutral Roadmap 2050 of Amsterdam (Netherlands), published in 2020, includes plans to transform the city's port into a "battery" to store and distribute renewable electricity and produce renewable hydrogen. In general, on-site hydrogen production via electrolysis using renewable energy sources (mainly solar PV and wind power) has begun attracting the attention of city ports around the world (→ see *Markets and Infrastructure* chapter).

Several city ports have adopted decarbonisation targets and strategies that affect not only port activities but also the diverse industries often hosted by ports, including shipping,

cruise tourism, heavy transport and power generation. In 2019, in partnership with the municipal government, the Port of Oslo (Norway) set a target for an 85% reduction in its greenhouse gas emissions by 2030, with the goal of eventually becoming the world's first zero-emission port. Strategies to achieve this include working with operators to electrify ferries and building shore powerⁱ connections that allow boats to cut their engines and plug in to the grid when docked.

In 2020, the Port of Esbjerg (Denmark) and the Port of Rotterdam (Netherlands) announced plans to build on-site facilities to supply renewable power to ships. The first shore power supply plant at the Port of Kiel (Germany) has been in operation since 2019, supplying ferries with renewable electricity. In North America, the use of shore power is mandatory under state regulation at ports in California (US), including Los Angeles, Oakland, San Diego and San Francisco. Shore power connections also are available in Halifax (Nova Scotia, Canada), Seattle (Washington, US) and Vancouver (British Columbia, Canada). Starting in 2020, the Port of Houston became the first US port to agree to purchase renewable electricity for port-wide activities.

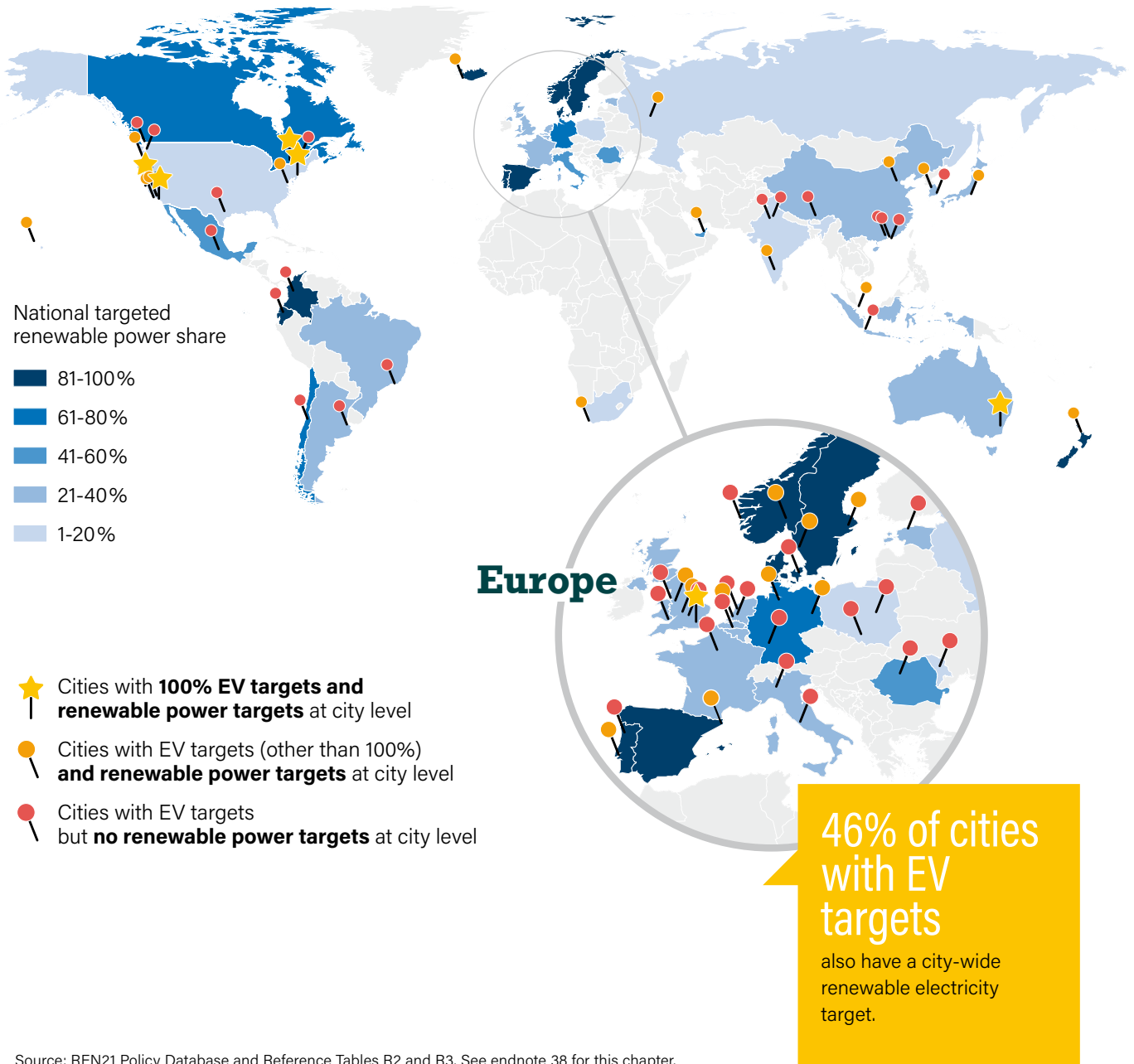
Source: See endnote 35 for this chapter.



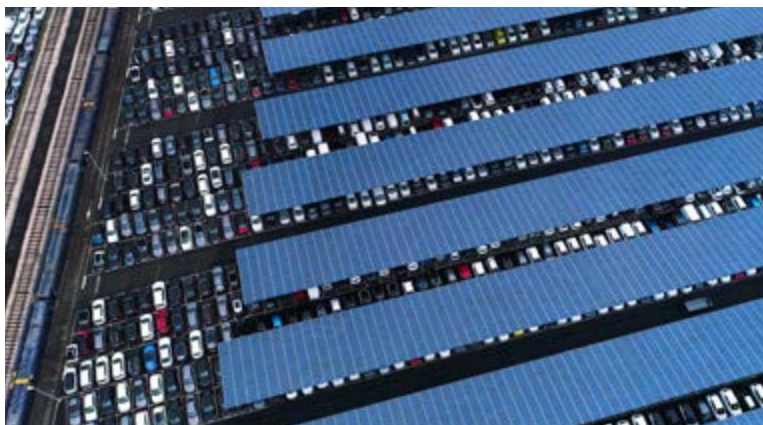
Rotterdam, Netherlands

ⁱ Shore power is the process of providing electrical power from the shore to a ship while it is docked. The provision of shore power offers the potential to increase the use of renewable electricity when ships are at berth, depending on the share of renewables in the port's electricity mix. By the end of 2019, nearly 80 ports, three-quarters of them in Europe, had shore power capability.

Figure 8. National Renewable Power and Electric Vehicle Targets in Cities, 2020



Source: REN21 Policy Database and Reference Tables R2 and R3. See endnote 38 for this chapter.



Feletto Umberto, Italy

Some cities have committed to phasing out fossil fuel vehicles in certain fleets (typically public transport fleets such as buses and ferries) and to procuring only “carbon-neutral”, “zero-emission” or “clean”ⁱⁱⁱ vehicles. In 2019, Turku (Finland) committed to 100% carbon-neutral public transport by 2029.⁴³ Hamburg (Germany) has pledged to procure only zero-emission buses from 2020.⁴⁴ Also in 2020, Singapore set a target to transition its entire bus fleet to clean energy by 2040, and Seoul (Republic of Korea) announced plans to phase out diesel vehicles in public fleets by 2025 and replace them with battery electric and hydrogen-powered vehicles.⁴⁵

Targets for the use of **renewable hydrogen**ⁱⁱ in transport are not commonⁱⁱⁱ, but policy attention and interest in fuel cell vehicles are emerging in some cities, especially in East Asia, Australia, California (US) and Europe (although typically without requirements for renewable hydrogen).⁴⁶ In 2020, the municipal government of Zhangjiakou (Hebei Province, China) announced a target to have more than 2,000 fuel cell vehicles and 16 hydrogen refuelling stations in operation by 2022.⁴⁷ (→ see *Policies section in this chapter, and Markets and Infrastructure chapter.*)



Seoul, Republic of Korea

EMISSION REDUCTION AND NET-ZERO TARGETS

Several cities have adopted climate-related targets, focusing on reductions in carbon and/or broader greenhouse gas emissions. Although such targets do not necessarily specify a role for renewable energy, renewables are expected to be instrumental in efforts to achieve them, alongside promoting energy efficiency and other actions.⁴⁸ Globally, by the end of 2020, around 10,500 municipal governments, representing some 946 million inhabitants^{iv}, had committed to reducing their carbon emissions by a specific date; most of these cities are in Europe, but targets are emerging elsewhere as well.⁴⁹

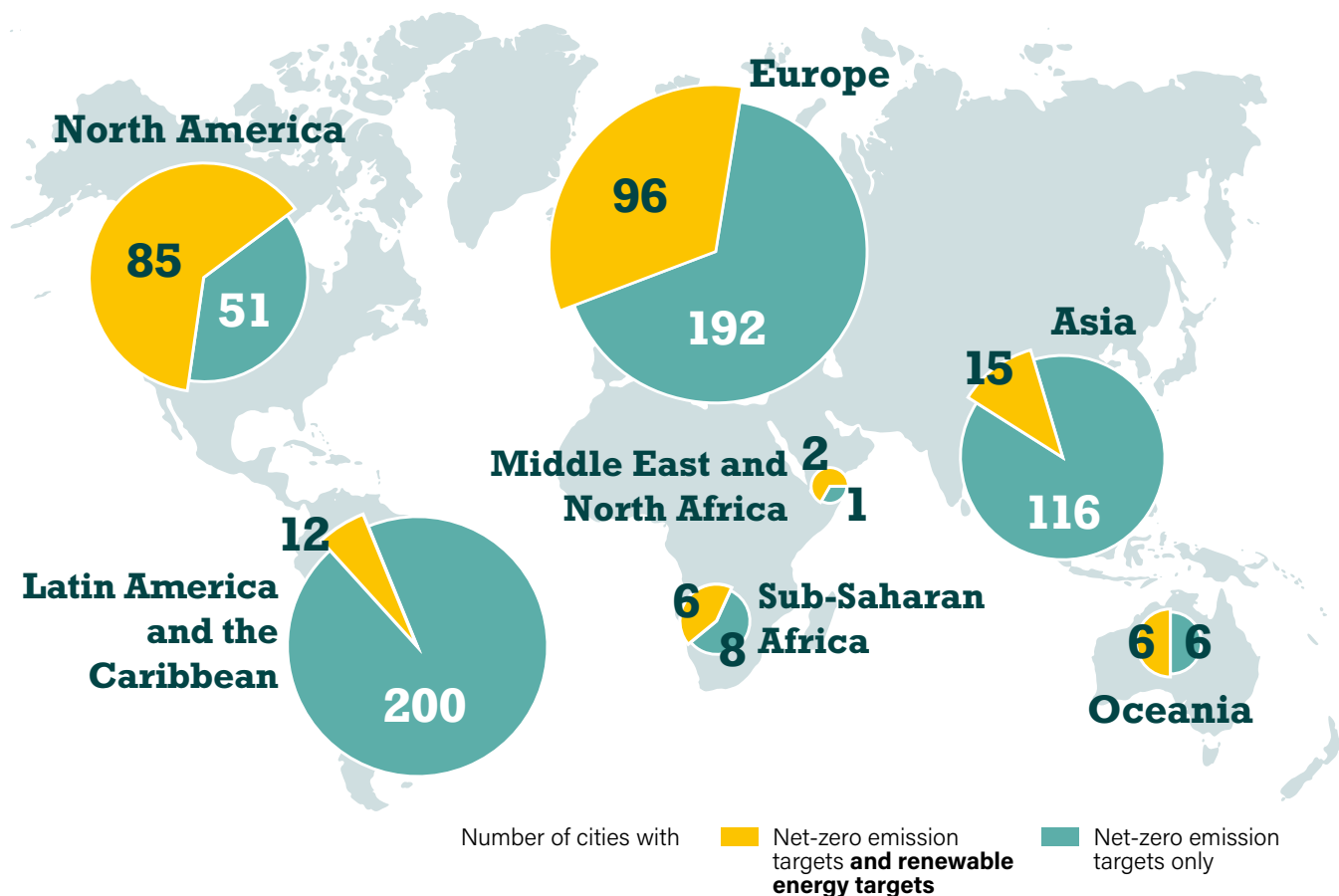
Momentum also has grown for the adoption of net-zero^v commitments – achieving a balance between CO₂ emissions and removals. Overall, the number of net-zero targets in cities has increased roughly eight-fold from 2019 (even growing amid the COVID-19 crisis), and by the end of 2020 a total of 796 municipal governments in 63 countries had adopted such targets.⁵⁰ This means that around 700 million people (9% of the global population) live in a city with a net-zero target (excluding targets set at the state, national or other levels of government).⁵¹ Net-zero targets are most prevalent in Europe and in Latin America and the Caribbean, followed by East Asia and the Pacific and North America.⁵²

Some municipal governments are making net-zero pledges on their own, and many are joining networks of like-minded actors. For example, the Carbon Neutral Cities Alliance as well as 88 members of C40 Cities have signed on to Deadline 2020, committing them to being greenhouse gas emissions neutral and climate-resilient by 2050.⁵³ Municipal interest in becoming net-zero also was catalysed by the launch of the Climate Ambition Alliance at the United Nations Climate Conference in December 2019 and by the launch of Race to Zero^{vi} in early 2020.⁵⁴

It remains to be seen how municipal governments will implement their net-zero targets in their policy documents and specify a role for renewables. Of the 796 municipal governments with net-zero targets, 222 had passed a renewable energy target as of the end of 2020, either specified as part of their net-zero commitment or as an independent target (→ see *Figure 9 and Reference Table R4*).⁵⁵ For example, Adelaide (Australia) plans to achieve net zero through a variety of energy efficiency measures as well as 100% renewable energy.⁵⁶

- i The terminology used in this chapter mimics the terminology that cities generally use in setting targets and policies to decarbonise transport. Different cities adopt different concepts, such as “carbon-neutral”, “zero-emission” or “clean” vehicles, which typically refer to electric vehicles and are not necessarily linked with renewable energy.
- ii Also referred to as green hydrogen. See Glossary for definition.
- iii A few countries have targets for renewable hydrogen at the national level that could be complementary to city-level hydrogen targets. See REN21, *Renewables 2021 Global Status Report* (forthcoming).
- iv As stipulated under the Global Covenant of Mayors for Climate & Energy.
- v This can be achieved, for example, by using natural sinks, such as reforesting land or adopting agricultural best practices, or through a technological solution, such as carbon capture and storage. Net-zero targets also are referred to commonly as “climate-neutral”, “carbon-neutral” or “zero-emission” targets, although technically these are not the same. Carbon neutrality refers to net-zero emissions of only CO₂, whereas climate neutrality indicates a broader focus on net-zero emissions of all greenhouse gases. There is no agreed-upon definition, and implementation of these targets also varies broadly. See endnote 48 for this chapter.
- vi Race to Zero is mobilising a coalition of leading net-zero initiatives, bringing together businesses, cities, regions and investors to facilitate the shift to a decarbonised economy ahead of the 2021 United Nations Climate Change Conference. See <https://racetozero.unfccc.int>.

Figure 9. Net-Zero Emission Targets and Renewable Energy Targets in Cities, by Region, 2020



Source: REN21 Policy Database and Reference Table R4. See endnote 55 for this chapter.

As with renewable energy targets, net-zero targets vary in the scope of emissions covered (CO₂ only or also other greenhouse gas emissions), the scale of application (municipal only or city-wide) and the timeline.⁵⁷ While some cities, such as Adelaide (Australia) and Copenhagen (Denmark), aim to become net zero by 2025, most cities have targeted 2050, and others (including 21 of the 454 cities in Race to Zero) aim for various years before 2050.⁵⁸ As of 2020, only a few municipal governments (including 25 of the 454 cities in Race to Zero) had created action plans or binding legislation to achieve their net-zero targets.⁵⁹ Thus, how cities will implement and report on action in this area remains to be seen.

MUNICIPAL OPERATIONS

To achieve their renewable energy targets, municipal governments have adopted various policy measures to advance renewables in the power, heating and cooling, and transport sectors. Some cities have implemented policies to increase renewables across municipally owned operations (→ see *Markets and Infrastructure chapter* for more on renewable energy installations in cities and on the procurement of renewables in the buildings and transport sectors). Other municipal governments have used their role as policy makers and regulators to pass comprehensive (city-wide) policies to encourage the uptake of renewables among residents, businesses and other urban actors. (→ see *Policies section in this chapter*).

MUNICIPAL BUILDINGS

In jurisdictions where it is possible, municipal governments have increased their investments in renewables for their own-use in municipal buildings, whether through direct investment in on-site generation, procurement processes or strategic purchasing of renewable energy directly from third-party providers.⁶⁰

Municipal governments have implemented policies to install renewable **power** capacity on or near municipally owned buildings such as city halls, sport facilities and schools. In Dublin (Ireland), the city council issued a contract in 2019 to equip seven sports centres with solar PV, saving EUR 129,000 (around USD 158,400) in energy costs and reducing 321 tonnes of carbon emissions annually.⁶¹

In some cases, cities have installed renewable power specifically to boost their resilience and energy security, particularly during extreme weather events.⁶² In 2020, Portland (Oregon, US) installed a solar PV system with battery storage at its main fire station to provide sustained, reliable power in the event of prolonged grid outages.⁶³ Adelaide (Australia) completed a 12 MW ground-mounted solar PV project at its main drinking water pumping station in 2020 as part of its plan to meet its electricity needs with 100% renewables.⁶⁴ Boston and Los Angeles (both US) as well as Quezon City (Philippines) have begun incorporating renewable energy infrastructure directly into their resilience planning.⁶⁵

For municipal governments that face constraints to installing renewables within city limits (such as high land costs or land scarcity), among the only ways to achieve renewable energy targets are to increase their procurement of renewable electricity or to partner with third-party operators to develop projects outside of city boundaries. Municipal procurement of renewables has spread

rapidly in cities around the world, including Chennai (India), Karak (Jordan), Pico Truncado (Argentina) and Windhoek (Namibia).⁶⁶

Between 2015 and mid-2020, cities in the United States supported a total of 433 renewable power procurement deals for a combined 9,188 GW of capacity.⁶⁷ Partly as a result of these arrangements, the total renewable energy capacity installed annually in US cities nearly tripled from 1,042 MW in 2017 to 2,716 MW in 2019.⁶⁸ Most of these deals consisted of community solar initiatives and power purchase agreements signed with developers beyond city borders, although they also included efforts to procure renewable power directly for municipal operations (such as projects sited at municipal buildings).⁶⁹

Officials in Breckenridge (Colorado, US) explored several options to develop or procure as much renewable energy as possible within the city to achieve its goal of 100% renewable electricity in municipal use by 2025.⁷⁰ However, developing projects within city limits was deemed uneconomical due to the high cost of land, and it was more financially attractive to purchase power from off-site "solar gardens" (community solar projects) in surrounding areas.⁷¹ Upon completion of these projects, Breckenridge will have met its 100% goal five years early.⁷²

Municipal governments

have increased their investments in renewables for municipal buildings.

2



Quezon City, Philippines



Breckenridge, United States

Compared to the power sector, policies to increase the share of renewables directly in the **heating and cooling** of municipal operations are less widespread, due to the decentralised character of this demand and the limited awareness of available options. However, the importance of heating and cooling has moved up the policy agenda in some areas, notably among local energy suppliers and at the EU level.⁷³ To reduce CO₂ emissions and improve air quality, the municipal government of Gdynia (Poland) has called for replacing solid fuel stoves with renewable energy sources (or gas boilers) in all municipally owned buildings by 2023.⁷⁴ Some municipal governments also have implemented bans and restrictions on fossil fuels for city-owned buildings. For example, the new public hospital in Canberra (Australia) will ban the use of natural gas and be powered 100% by renewables.⁷⁵

Increasingly, municipal governments are facilitating the integration of renewables into their district energy networks, often in co-operation with public or private partners. In Temuco (Chile), the municipal government is developing district heating infrastructure (using biomass) through public-private financing and with the support of the National District Energy Office.⁷⁶

Most public procurement of

zero-
emission
vehicles

focuses on electric
vehicles.

MUNICIPAL TRANSPORT

City governments have made strides to decarbonise transport fleets and mobility infrastructure to improve local air pollution and mitigate other impacts of urbanisation such as congestion and noise.⁷⁷ In most cases, cities rely on public procurement or direct investment to source renewable fuels for public and municipal fleets, to replace internal combustion engine vehicles with electric vehicles that can be renewably powered, and/or to build associated infrastructure.

Although most **biofuel** policies are enacted at the national or regional levels, some cities have sought to increase the use of biofuels in public fleets.⁷⁸ Santa Barbara (California, US), stimulated by state and national mandates and building on its local feedstocks, announced in 2019 that it would replace petroleum diesel with biodiesel to fuel its municipal bus fleet.⁷⁹ Also in 2019, Longmont (Colorado, US) started sourcing locally produced biogas to fuel new refuse trucks.⁸⁰ In 2020, the Liverpool City Council (UK) commissioned a fleet of 20 refuse trucks that run on biogas.⁸¹

Still, most public procurement of zero-emission vehicles focuses on **electric vehicles**, with electric buses garnering the most attention from city governments worldwide. Although Chinese cities continued to dominate the global electric bus market during 2019 and 2020, interest in electrified bus transport also expanded to cities in North America, Latin America, Europe and elsewhere.⁸²

Policies that promote electric vehicles are not in themselves renewable energy policies; however, they provide a critical entry point for higher uptake of renewables in transport, especially if combined with renewable electricity policies set by municipal, state and/or national governments.⁸³ A few cities require the use of renewables to charge electric buses: in 2019, São Paulo (Brazil) integrated 15 electric buses into its fleet that must be



China



charged using solar power, and new electric buses in Portland (Oregon, US) will be 100% wind-powered as part of the city's aim for a non-diesel fleet by 2040.⁸⁴

Electric vehicles also are being procured for municipal delivery and refuse fleets, including in cities bound by renewable energy targets and policies.⁸⁵ In 2020, Leeds City Council (UK) took delivery of 122 electric vans to be used for services ranging from property maintenance to civil enforcement.⁸⁶ That same year, several cities started testing and integrating electric refuse trucks in their municipal fleets – including Blue Mountains (New South Wales, Australia) and Jersey City and New York City (both US).⁸⁷

In some cases, EV procurement programmes are the result of public authorities increasingly adopting related purchasing obligations.⁸⁸ For example, the Supreme Council of Energy of Dubai (United Arab Emirates) has directed government organisations to increase the share of electric and hybrid vehicles they procure annually to at least 10% by the end of 2024, 20% by the end of 2029 and 30% from 2030 onwards.⁸⁹ Under Dubai's Clean Energy Strategy, in force since 2015, the share of renewable electricity used to charge EVs is targeted to grow from 7% in 2020 to 25% in 2030 and 75% by 2050.⁹⁰

Several cities in East Asia, particularly in China, have procured **hydrogen** fuel cell buses. However, since nearly all of the hydrogen produced globally today is based on fossil fuels, only a few of the buses operate on hydrogen produced with renewable electricity.⁹¹ In 2019, Zhangjiakou (Hebei Province, China) added 174 fuel cell electric buses to its expanding hydrogen fleet, which is fuelled with renewable hydrogen.⁹² The municipality of Aalborg (Denmark) purchased three fuel cell buses that begun circulating in 2020 and rely on renewable hydrogen.⁹³



Oregon, United States



Tigard, Oregon, United States

CITY-WIDE POLICIES

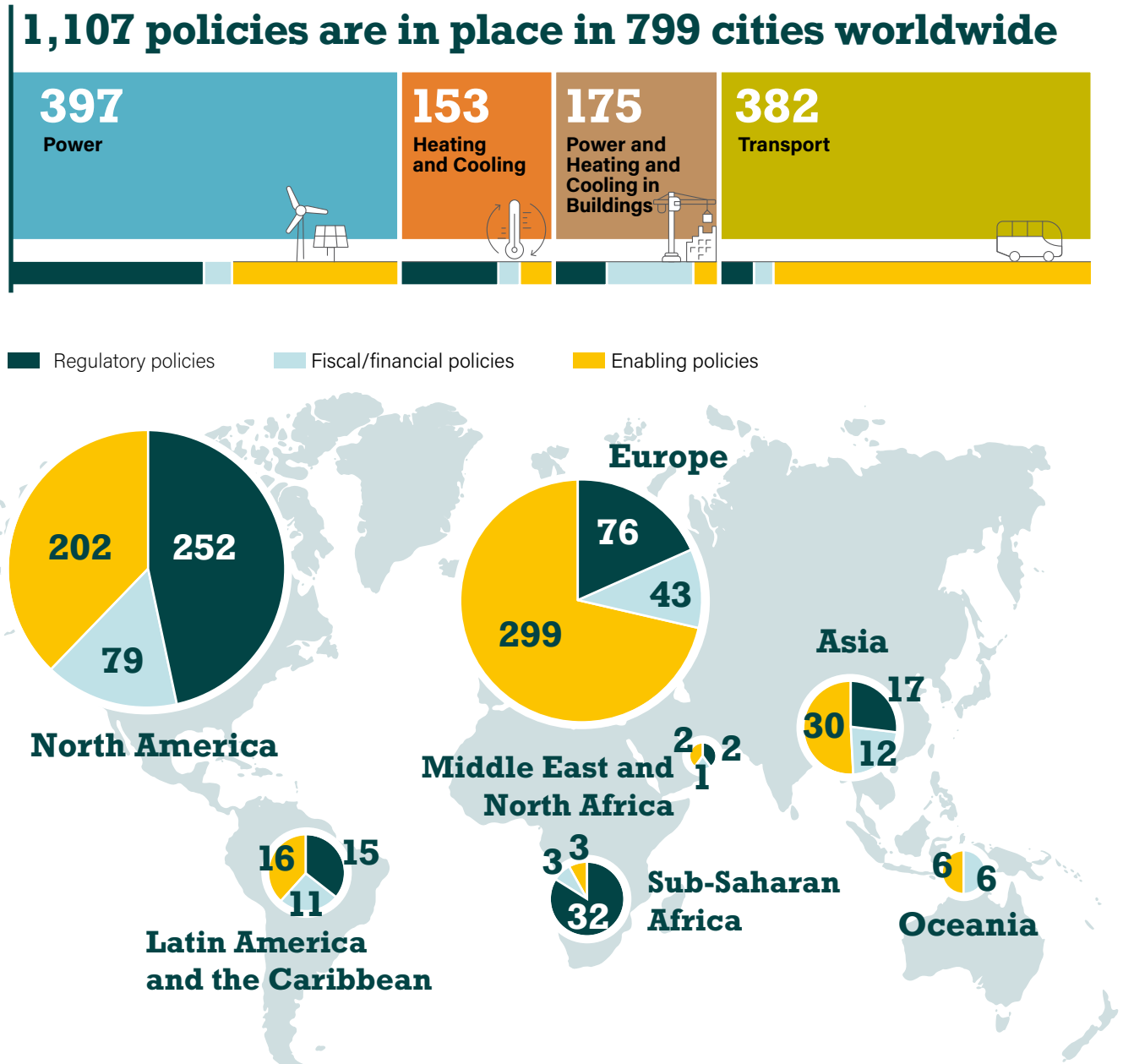
Municipal operations often account for only a small portion of urban energy use. Thus, the success of cities in meeting their energy and climate goals relies not only on municipal investments in city facilities and fleets, but also on the decisions made by citizens, businesses and other urban actors regarding how to heat and cool their buildings, move around goods and people, and power their lights, appliances and activities.

To encourage the uptake of renewables city-wide, municipal governments have adopted a range of comprehensive policies.⁹⁴ By the end of 2020, at least 799 municipal governments had in place either renewable energy policies or policies supporting the scale-up of renewables across buildings and transport (for a combined total of 1,107 policies, with some cities having more than one policy).⁹⁵ These included regulatory policies (394 policies), fiscal and financial incentives (155 policies) and indirect policies that support the overall enabling environment for renewables (558 policies).⁹⁶ Most of the cities with policies were in the United States (532 policies) and Europe (418 policies), followed by Asia and Latin America and the Caribbean (→ see *Figure 10 and Reference Table R5*).⁹⁷

At least
799
municipal
governments
had in place renewable
energy policies.



Figure 10. Renewable Energy Policies in Cities, by Type and Region, 2020



Source: REN21 Policy Database and Reference Table R5. See endnote 97 for this chapter.

Note: Some city governments have more than one renewable energy policy. Policies in buildings apply in the buildings sector and can include power, heating and cooling and/or transport elements.



City-level policy portfolios

have expanded beyond power to sectors that are lagging at the national level.

The most successful city-level efforts have made use of different policy approaches in creative and synergistic ways. For example, a wide variety of city-led solar gardens (community solar projects) are starting to emerge around the world, creating new ways for the city government to partner with local citizens and businesses on accelerating the urban energy transition. Local governments are engaging either by investing the city's own resources or by making available municipal land for the development of local solar power projects. By doing so, the city government, individual citizens, as well as local businesses can purchase a portion of the project's output to meet all or part of their electricity needs.

Other city policies encourage investments in EV charging infrastructure, including by making it easier to lease municipal land to build charging stations. In turn, this infrastructure can help meet the growing charging needs of both municipal fleets and the wider community. In addition, some municipal governments are using renewable technologies specifically to alleviate energy poverty at the household level (→ see Box 2).⁹⁸

Such policies have a direct impact on the adoption of renewable energy technologies and help expand the market. In turn, in jurisdictions with higher annual installations and more market activity, installers tend to find more ways to improve installation times and reduce overall costs to stay competitive.⁹⁹ Such reductions in "soft costs"ⁱ can bring down overall costs for end-users, helping to increase demand.¹⁰⁰

i Soft costs consist of all non-hardware costs associated with renewable energy development, including permitting, installation, customer acquisition and supply chain costs. In the United States, soft costs make up an estimated 64% of the cost of a solar PV system. See US Department of Energy, Office of Energy Efficiency and Renewable Energy, "Soft costs 101: The key to achieving cheaper solar energy"; <https://www.energy.gov/eere/articles/soft-costs-101-key-achieving-cheaper-solar-energy>, updated 25 February 2016.

BOX 2. Municipal Policies Using Renewables to Reduce Energy Poverty

A growing number of cities have recognised the potential of renewable energy technologies to alleviate energy povertyⁱ. In developing countries, renewable energy can help improve access to modern energy services, while in developed countries it can reduce the share of urban household energy spending, including for electricity, heating and cooling, and transport fuels.

A few cities have developed policy strategies to deploy solar systems to fight energy poverty. In major urban and peri-urban areas in Sub-Saharan Africa, such as Arusha (Tanzania) and Lagos (Nigeria), solar home systems – small solar arrays connected to a battery bank – have driven access to direct, local renewable energy supply. In Seoul (Republic of Korea), solar PV systems have been deployed on low-income housing as part of the city's target to install more than 1 million individual solar PV systems on city rooftops (including all government buildings) by 2022. Solar PV systems also have been installed on low-income housing in a growing number of US cities, including on senior housing as a means to reduce monthly energy costs for residents.

Such projects can be supported by municipal financial incentives. For example, in Honolulu (Hawaii, US), the municipal government provides loans for low-income homeowners to install solar water heating systems. In 2017, the municipality of Porto Torres (Italy) created a revolving fund of EUR 250,000 (USD 307,061) to support rooftop solar installations for families in need.

In some cases, municipal governments have partnered with energy suppliers to alleviate energy poverty. Vienna (Austria) has worked with the country's largest energy provider, Wien Energie,

to safeguard the supply of energy to people in precarious living situations – for example, by cancelling so-called dunning costsⁱⁱ and interest. In Spain, Martorelles and other municipalities have collaborated with Som Energi, a green energy co-operative, to cover the electricity bills of households in need. Hackney (UK) is implementing a Green Homes programme through the publicly owned energy company Hackney Light and Power that provides free insulation and trials renewable heating upgrades to help residents save on energy bills while reducing greenhouse gas emissions. Also in the UK, the Mayor of London and Octopus Energy formed London Energy in 2019, a renewable energy company that aims to fight the fuel poverty affecting 1 million Londoners.

Source: See endnote 98 for this chapter.



Maloti hills, Lesotho

i See Glossary for definition.

ii Dunning involves any communication between the utility and the customer such as phone calls or letters to ensure the collection of payment on outstanding invoices. Dunning costs refer to any additional expenses associated with this process.

CITY-WIDE BUILDINGS

In the buildings sector, some municipal governments differentiate their policy approaches between new and existing buildings, as well as by building type (residential, commercial, industrial, public).¹⁰¹ Especially in regions with high rates of urbanisation and population growth, such as Sub-Saharan Africa and parts of Asia, the distinction between new and existing buildings can be critical, as much of the building stock that is projected to be in place in 2050 has not yet been built.¹⁰² Even in Vancouver (Canada), 40% of the floor space expected to exist in 2050 has yet to be built, underscoring the importance of policies and regulations specifically for new construction, such as the introduction of more stringent energy performance standards and renewable energy mandates for such construction.¹⁰³

Large swaths of Europe and North America are home to structures built before the introduction of energy performance standards or energy-related building codes. In Europe, the rate at which new construction is added relative to existing construction is only 1-2%.¹⁰⁴ For regions with slow building replacement rates, the focus on retrofitting initiatives has grown, often with dedicated funding support from other levels of government, such as the EU's recent renovation wave.¹⁰⁵

However, developing and implementing policies for existing buildings has faced resistance, fuelled by factors such as high upfront costs, inertia and split incentives due to the ownership structure of buildings. Rather than using mandates, municipal governments often offer financial incentives such as grants, rebates and low-interest loans to encourage changes to existing structures. In Paris (France), regulations banning the installation of oil-based heating systems as of 2022 are limited to new buildings, whereas grants are being used to encourage the substitution of existing heating systems with cleaner and renewable options.¹⁰⁶

In the buildings sector, by the end of 2020, around 150 cities had a total of around 180 policies aimed at decarbonising buildings through renewable power and/or renewable heating (typically for solar PV and solar thermal). In addition, some of the around 400 policies aimed exclusively at the electricity sector and some of the around 150 policies focused on heating and cooling more broadly also apply to buildings.¹⁰⁷ That said, electricity accounts for most cooling needs, as well as for a growing share of heating needs and for a small but growing share of transport needs.¹⁰⁸ This highlights the importance of cross-sectoral and integrated policy making, which some municipal governments have started to pursue as part of efforts to scale up renewables. In addition, municipal governments are taking advantage of synergies between energy efficiency and renewable energy by improving the efficiency of energy use in urban infrastructure (→ see *Sidebar 3*).¹⁰⁹

ⁱ The EU's "renovation wave" strategy focuses in large part on the need to improve, retrofit and decarbonise existing buildings. See European Commission, "Renovation wave", https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/renovation-wave_en, updated 18 January 2021.



Helsinki, Finland

Around
150 cities

have policies in place to support both renewables-based power and heating in buildings.



SIDEBAR 3. Linking Renewable Energy and Energy Efficiency in Buildings

Energy efficiency is fundamental to achieving higher shares of renewable energy in a timely and cost-effective manner. All things equal, energy efficiency reduces the amount of energy required to deliver a product or service. It offers benefits including energy security and improved economic performance and competitiveness. As such, cities increasingly are linking energy efficiency and renewable energy efforts in buildings.

Higher efficiency in urban buildings can make renewable energy technologies – such as renewable heating and cooling systems – more cost-effective compared to fossil fuel options. The US cities of Boulder (Colorado), New York City and Washington, D.C. have partnered with manufacturers, distributors, utilities and government agencies to decarbonise heating and cooling systems in buildings by supporting the installation of high-efficiency heat pumps that are increasingly powered by renewable electricity sources.

Cities – in their roles as energy consumers, managers of energy networks and potential energy producers – are uniquely positioned to harness the synergies between renewable energy and energy efficiency to curb energy use and related emissions from buildings. In 2020, three Albanian cities – Georgios Karaiskakis, Nikolaos Skoufa and Vlora – participated in a demonstration project to reduce energy consumption and CO₂ emissions from schools and other public buildings, using a combination of smart building, energy efficiency and renewable energy technologies to improve heating and cooling.

To stimulate such projects, municipal governments have implemented policy tools including building energy codes and standards, local ordinances, and combined targets for energy efficiency and renewable energy. Building codesⁱ for energy efficiency typically are enacted at the national level, and as of 2019 some 73 countries had in place mandatory or voluntary building energy codes, with 4 more countries developing them for 2021 onward. However, national building codes for energy efficiency often are insufficient (either because they are outdated, voluntary or lack enforcement).

In some cases, municipal governments can adopt stricter “reach” codes or requirements that strive to achieve a standard of energy performance above and beyond the minimum set at the state or national level for new municipal, residential and/or commercial buildings. Since 2012, Stockholm (Sweden) has allowed a maximum of 55 kilowatt-hours (kWh) per square metre (m²) of energy consumption

(including electricity and heating and cooling) for new buildings on municipally allocated land, with a view to reduce this to 45 kWh per m². As a result, energy use by the city’s new buildings is on average 30% below the values set at the national level.

Some jurisdictions have leveraged their building energy codes to require on-site or off-site renewable energy generation in combination with energy efficiency. In California (US), the city councils of San Jose and Palo Alto approved new reach codes in 2019 mandating that new construction be electric-only (meaning that it does not include natural gas to meet on-site cooking or heating and cooling needs) and that it integrates solar readinessⁱⁱ and energy efficiency. San Francisco has mandated that all commercial buildings over 50,000 square feet (4,645 m²) be powered with renewable electricity by 2030. This policy, combined with a new reach code for all-electric new construction, will ensure that these buildings are 100% renewables-based for power, heating and cooling.

As of 2020, 475ⁱⁱⁱ local governments within the CDP-ICLEI Unified Reporting System had set or planned energy efficiency targets to reduce energy and/or electricity demand, as a means to cut greenhouse gas emissions and energy imports or to trim budgets. Of the 200 local governments that had in place energy efficiency targets, at least 150 also had a renewable energy target, another 16 had a target in progress, and 13 were planning to enact a target in the next two years. For example, Leuven (Belgium) has linked its efficiency and renewables targets, aiming for 60% of the existing building stock to reduce energy use to the “lowest possible level” through retrofits, and the remaining 40% to reduce energy use and also to shift to renewable energy.

Source: See endnote 109 for this chapter.



i Building energy codes are integral in setting construction standards to reduce the long-term energy demand of buildings.

ii Solar readiness refers to a requirement that new buildings include the wiring required to facilitate the addition of a solar PV system in the future.

iii Of the 812 local governments reporting to the CDP-ICLEI Unified Reporting System in 2020, 185 indicated that they already had an energy efficiency target in place, another 110 had a target in progress, and 93 were planning to enact a target in the next two years.

CITY-WIDE POWER

Regulatory policies

While many cities benefit from renewable energy regulatory policies introduced at other levels of government – such as state or national feed-in tariffs or feed-in premiums – around 190 cities had in place their own regulatory policies for renewable power capacity by the end of 2020, particularly in North America.¹¹⁰ In addition, some cities also have regulatory policies to support either renewable power and/or heating and cooling in buildings more broadly.

Municipal-level **feed-in tariffs** (FITs) are present in numerous cities, including Canberra (Australia), Fukushima (Japan), Gainesville (Florida, US), Harare (Zimbabwe), Hong Kong (China), Rajkot (India) and Recoleta (Chile).¹¹¹ In South Africa, 28 municipalities have in place either net FIT or net billing policies that define the price that (typically) municipal utilities must pay for buying or compensating surplus electricity from solar PV systems in the city (→ see *Feature chapter*); this has been driven by efforts to reduce reliance on predominantly coal-fired generation from the national utility.¹¹² Similar mandates requiring municipal utilities to purchase power from citizens and local businesses exist in Dubai (United Arab Emirates), Los Angeles (US) and cities throughout Australia.¹¹³

Several municipal governments have adopted **net metering** policies, which enable electricity customers to supply their own power on-site and then export any surplus generation to the grid in exchange for a one-to-one credit on their bill for every surplus kWh produced.¹¹⁴ Although most net metering policies worldwide have been adopted at the national or state levels, municipal-level policies are gaining ground, mainly in the United States (including in San Antonio, Texas).¹¹⁵ Although net metering has come under pressure at all levels in recent years, some municipal governments reaffirmed their policies. The city council of Springfield (Illinois, US) voted in early 2020 to continue net metering, rejecting the municipal utility's proposal to lower the compensation rate for surplus electricity.¹¹⁶

A growing number of utilities (including municipal utilities) have started to tighten the rules, offering customers with solar PV systems a separate compensation rate for their net surplus generation that is below the retail rate and that is often linked either directly or indirectly to market prices or to the utility's avoided costsⁱⁱ (as in San Antonio).¹¹⁷ In other instances, the compensation rate differs depending on whether the solar system is owned by a residential or a commercial customer. Georgetown (Texas, US) offers residential customers one-to-one net metering at the retail rate, whereas commercial customers are compensated at the lower avoided fuel cost rate.¹¹⁸

Some municipal regulations are specific only to new construction – or are more stringent for new construction than for existing buildings – allowing municipalities to raise the bar for all future construction city-wide. A growing number of cities have introduced **building codes and/or ordinances** specifically requiring solar PV on new construction (some also require either solar PV and/or solar thermal). Such mandates typically apply to buildings above a certain size (in square metres of total building footprint) or, in the case of the residential sector, to buildings above a certain number of storeys.^{iii,119}

In 2014, Davis (California, US) adopted an ordinance requiring solar PV on all new single-family construction; in 2019, it expanded the ruling to require all non-residential construction to feature solar PV systems large enough to supply 80% of the electricity used on-site, or to integrate a certain amount of solar capacity per square metre of suitable roof space.^{iv,120} In Sacramento (California, US), all new residential buildings are required as of 2020 to meet their on-site needs with solar PV, either through the installation of on-site systems or by buying into the local utility's "solar shares" programme, which enables households to own shares in larger community solar projects located outside of the city.¹²¹

In India, the municipal government of Karimnagar passed a regulation in 2019 making it mandatory for new buildings to install rooftop solar PV if the building area exceeds 2,700 square feet (251 m²).¹²² The city offers end-users a 30% subsidy for such installations, and the buildings connect to the grid via a net metering mechanism.¹²³ Rajkot (India) also has a mandate requiring solar PV rooftop systems on new buildings (→ see *City Snapshot: Rajkot*).¹²⁴ In Lahore (Pakistan), the local development authority adopted a regulation in 2019 mandating new commercial buildings to install rooftop solar PV systems to cover at least 20% of a building's total power requirement.¹²⁵ In Germany, the municipal government of Amberg passed a mandate in 2019 requiring solar PV in future developments, and similar mandates exist in Freiburg, Hamburg, Heidelberg, Konstanz and Waiblingen (→ see *City Snapshot: Heidelberg*).^{v,126}



i See Glossary for definition.

ii There are many different ways of determining a utility's avoided costs, with varying outcomes depending on the methodology employed.

iii Such mandates also exist at the national level such as in France as well as at the state level in countries such as Australia and the United States. However, efforts to introduce state-level mandates have encountered push back, leading to a search for local solutions. For instance, after lawmakers in California (US) introduced a solar mandate on all new construction that was scheduled to begin in 2020, challenges to the mandate led some city governments and local utilities to develop their own policies.

iv In Davis, California, the regulations stipulate 161 watts (direct current) per square metre of rooftop area that is deemed suitable for the installation of solar PV.

v See *City Snapshot: Heidelberg* online at www.ren21.net/cities



RAJKOT

INDIA



Rajkot, the fourth largest city in the western Indian state of Gujarat, has committed to reducing its greenhouse gas emissions 14% by 2022-23 (from 2015-16 levels). Energy consumption in residential buildings totalled 606 million kWh in 2015-16, accounting for around half of all electricity consumption and contributing 35% of greenhouse gas emissions from economy-wide activities in the city. Recent efforts have focused on reducing energy consumption and enhancing energy efficiency in residential buildings. The Capacity Building for Low Carbon and Climate Resilient City Development project (CapaCITIES) has helped maximise the use of renewables in the city, reducing the need to tap into the predominantly coal-based national grid.

The Krantiveer Khudiram Bose social housing complex (known as 11A) consists of five buildings with a total of 140 dwelling units. At full occupancy, common amenities (lifts, lights, pumps, etc.) consume 3,000 kWh of electricity per month. To encourage the adoption of solar PV, a 31.5 kW-peak grid-connected solar PV system is being installed on-site and will be operated and maintained by the contractor/developer for a period of 10 years. The system consists of 100 polycrystalline solar PV panels of 315 watt-peak capacity each, mounted on a frame at a 21-degree panel tilt. It will generate around 3,780 units of electricity per month (45,360 kWh per year) and has the potential to reduce 37 tonnes of CO₂-equivalent greenhouse gas emissions annually. Overall responsibility for the safety, security and periodic cleaning of the panels will lie with the township's Residential Welfare Association, which has been trained on panel maintenance.

Because of its efforts in low-carbon action and community engagement, Rajkot Smart City was selected as the national winner of WWF's Global One Planet City Challenge in 2020. Other noteworthy initiatives in Rajkot that support this award include: the installation of 9,629 kWh of grid-connected solar PV systems on residential buildings (with a further proposed 500 kWh on municipal buildings); retrofitting of 63,178 public street lights with light-emitting diodes (LEDs), resulting in annual energy savings of 11.5 million kWh; the implementation of Smart Ghar III, an affordable green home concept aimed at maintaining indoor thermal comfort with minimal climate impact; and plans to replace diesel buses with electric ones, along with the provision of solar PV charging.

Source: See endnote 124 for this chapter.



Some municipal governments have developed building energy codes with performance standards that aim to achieve higher energy efficiency levels and support the adoption of renewable technologies. As of mid-2020, at least 35 cities in California (US) had adopted building codes specifically to reduce their reliance on natural gas in new construction (→ see *Overall enabling environment section*).¹²⁷ In some cases, the code is coupled with a renewable energy requirement: for example, Richmond (California) requires new residential buildings under three storeys to be all-electric, and new residential buildings of any size must install a minimum amount of on-site solar (thermal or PV)ⁱ (→ see *Sidebar 4*).¹²⁸ By October 2020, roughly 10% of California's population was living in a city that had building codes requiring solar readiness and/or EV charging readiness (the wiring required to enable the rapid addition of solar PV or EV charging) or the addition of solar PV or solar thermal (→ see also *City-level Transport section*).¹²⁹

Fiscal and financial incentives

Globally, municipal governments were providing fiscal and/or financial incentives such as rebates and grants, low-interest loans, and tax credits and deductions to increase renewable power.¹³⁰ Generally, these support mechanisms do not differentiate between new and existing buildings.

Municipal governments offer **investment subsidies** such as **rebates and grants** to encourage the installation of renewable power capacity. For example, the municipal utility serving San Antonio (Texas, US) offers residential rebates of USD 2,500 per solar installation, as well as commercial rebates of 60 US cents

per watt (for systems up to 25 kW) and 40 US cents per watt (for systems above 25 kW).¹³¹ Philadelphia (Pennsylvania, US) provides rebates totalling up to USD 500,000 per fiscal year to commercial and residential solar PV installations completed after 1 July 2019.¹³²

In 2020, Beijing, Guangzhou, Shanghai and Xian (all China) announced financial support policies for distributed solar PV through 2025, providing a subsidy per kWh produced.¹³³ In Gdynia (Poland), the municipal government provides one-off subsidies for renewable electricity production that uses solar PV and micro power plants, offering PLN 2,500 (around USD 674) for single-family buildings and PLN 5,000 (over USD 1,348) for multi-family buildings.¹³⁴ In Freiburg (Germany), where a subsidy to fund new energy storage systems went into force in 2019, the city provides EUR 150 (USD 184) per kWh of storage capacity (provided the solar PV system has at least 1.25 kW of output per kWh of storage capacity).¹³⁵ Similar municipal support for customer-sited solar PV exists in Berlin, Braunschweig, Jena, Stuttgart and Wallenhorst (all Germany), Los Angeles and San Francisco (both US), Tokyo (Japan) and Vienna (Austria).¹³⁶

Some municipal governments provide direct investments in the community for the installation of renewables (→ see *City Snapshot: Seoul*).¹³⁷ As part of Australia's efforts to help communities recover from the devastating wildfires of 2019, several local municipalities in Victoria state dedicated recovery and reconstruction funds specifically for renewable energy and storage projects.¹³⁸ The initiative will fund the installation of roughly 50 solar PV systems (of 6.5 kW each) at not-for-profit community organisations in several cities and towns, including at schools, emergency service buildings, sporting clubs and community centres that need to be rebuilt.¹³⁹



Municipal governments

are providing fiscal and/or financial incentives to increase renewable power.



i The minimum required share of energy provided by solar PV or solar thermal systems is calculated based on the total square footing of the building.

SEOUL

REPUBLIC OF KOREA



In July 2020, Seoul, the capital of the Republic of Korea, responded to the country's commitment to achieve climate neutrality by 2050 by developing an integrated policy approach focused on five key areas: buildings, mobility, forestry, clean energy and waste management. Seoul's vision is to be a sustainable city where "human, nature and future co-exist".

The Republic of Korea's policy approach towards climate neutrality mirrors the EU's Green Deal to achieve net-zero emissions and respond to climate change. By 2025, the Korean government will invest around USD 37 billion in Green New Deal policies and a further USD 7 billion in carbon-cutting measures. Seoul has put forward two intermediate goals ahead of the 2050 climate-neutrality goal: to achieve 40% emission reduction by 2030 and 70% emission reduction by 2040 (compared to 2005 levels).

Since 2012, Seoul has adopted policies to reduce its dependency on nuclear energy through two phases of the One Less Nuclear Power Plant Project. In 2017, Solar City Seoul was launched with the goal of adding 1 GW-peak of solar power capacity by supplying PV panels to 1 million households by 2022. The programme, which has a budget of around USD 1.46 billion (funded mostly by public investment), aims to reduce CO₂ emissions by 544,000 tonnes annually and to add 4,500 new jobs by 2022. The programme exceeded its intermediate goal by installing a total of 357.1 MW of solar panels for 285,000 households by 2019.

One of the challenges facing the Solar City Seoul programme is securing enough space at buildings and public facilities to install solar panels. As part of the green energy initiative of the Seoul 2050 climate neutrality plan, Seoul is identifying new installation sites (including urban infrastructure); increasing

the standards for solar generation in zero-energy buildings; providing subsidies for building-integrated PV; extending the feed-in tariff system to on-site solar power generators and supporting new solar PV technology.

Source: See endnote 137 for this chapter.



In an innovative policy that focuses on adjusting the electricity rates that customers *pay*, rather than the payment levels they *receive* when exporting their net surplus generation, Newstead (Australia) has set out, in partnership with the local utility, to introduce “solar sponge” tariffs that offer much lower rates to customers during the daytime hours when solar power is abundant.¹⁴⁰ The reduced tariffs are available to all customers that have suitable metering infrastructure, in particular meters that support time-of-use tariff structures.¹⁴¹ The regional distributor, South Australia Power Networks, started offering the solar sponge tariffs in July 2020, in part to help stabilise the grid during the daytime surge in solar power and to mitigate challenges associated with the “duck curve”.¹⁴²

Some municipal governments offer **tax credits and deductions** for producing on-site renewable electricity.

Low-interest loans have remained an important tool for municipal governments. In Milwaukee (Wisconsin, US), the city partnered with a local credit union to offer low-interest loans of up to USD 20,000 for homeowners to finance rooftop solar PV; similar incentives exist for households in Boulder (Colorado, US) and Honolulu (Hawaii, US) and for commercial and non-profit entities in Baltimore (Maryland, US).¹⁴³ Since 2018, the municipal bank of Godoy Cruz (Argentina) has provided citizens low-interest loans to finance solar PV systems, and the municipality facilitates approvals and installation.¹⁴⁴

An increasingly popular financial tool is Property Assessed Clean Energy (PACE) financing, which enables citizens and businesses to repay their solar loans to the municipality through an annual surcharge on the yearly property tax assessment. As of 2020, PACE programmes were available in at least 62 US cities and were starting to be deployed across Europe, including in Olot (Spain) and with plans under way in cities in Austria, Belgium, Italy, Poland and Romania.¹⁴⁵ Frisco (Texas, US), a local PACE administrator, partnered with national banks and the municipality in 2019 to provide long-term, low-interest loans to finance renewable energy projects in the community.¹⁴⁶

Some municipal governments offer **tax credits and deductions** for producing on-site renewable electricity. Rio de Janeiro (Brazil) passed a tax exemption in 2020 for renewable power produced by distributed generation projects.¹⁴⁷ In Salvador (Brazil), the municipal government offers property tax discounts for installing solar PV; the system must correspond to a minimum percentage consumed by the property.¹⁴⁸ A solar rebate programme in Boulder (Colorado, US), launched in 2019, offers a sales and use tax rebate of around 15% on qualifying solar PV and solar thermal installations.¹⁴⁹ Municipal tax exemptions also are available in US cities such as Chicago, New York and Washington, D.C.¹⁵⁰

Overall enabling environment

In addition to enacting direct policy measures for renewables, municipal governments are putting in place indirect support policies and improving their permitting and administrative procedures for renewable power projects developed within city limits.¹⁵¹

Even residents with sufficient disposable income to invest in on-site renewable power projects may be held back by a lack of suitable roof space, as many live in multi-unit buildings, are tenants rather than owners or face heritage-related restrictions that make installing their own solar system difficult.¹⁵² To overcome this, cities and local governments have embraced a variety of approaches, including developing solar gardens (community solar projects). Many such projects rely on **virtual net metering**, an important enabling policy that allows users to offset their on-site electricity consumption by using electricity generated elsewhere on the grid. Under such models, consumers that participate in community solar projects receive credits on their electricity bills on a pro-rata basis according to their individual share of investment in the project as a whole. When Delhi (India) revised its solar policy in 2019, it introduced virtual net metering to allow residents and businesses without suitable roof space to invest in solar energy systems, overcoming a key barrier to solar uptake in the densely populated city.¹⁵³

Another barrier for some is the inability to conduct maintenance on their solar PV system, whether because of age or mobility, lack of training in the community, the time and cost for maintenance, or other factors. Several approaches have gained momentum to overcome such barriers. In Haystacks (New South Wales, Australia), construction began in 2020 on a community-owned solar garden project that offers members the opportunity to buy one or more of the 300 “plots” of roughly 3 kW each.¹⁵⁴ The approach removes the need for individuals or businesses to engage in operations and maintenance, while the power generated by each member’s share of the garden is then credited on their electricity bill.¹⁵⁵

Another policy option that has rapidly gained ground in the United States and is starting to emerge in Australia and the United Kingdom is **community choice aggregation (CCA)**.¹⁵⁶ Under a CCA, municipalities (independently or in partnership with an agency running the CCA) aggregate the electricity demand of residents and businesses and set out to procure electricity for all participating customers city-wide, either through direct contracts with energy producers or via third-party agreements.¹⁵⁷ By enabling local communities to procure their own electricity, CCAs can be an attractive option for cities that want more local control over their electricity mix. The aggregation of demand also helps cities and local governments negotiate better rates with suppliers and lock in contracts for higher shares of renewables, including 100%.¹⁵⁸

i The “duck curve” refers to the duck-shaped curve of electricity demand in a given jurisdiction that arises as the share of daytime solar PV increases in the system. See J. St. John, “The California duck curve is real, and bigger than expected”, Greentech Media, 3 November 2016, <https://www.greentechmedia.com/articles/read/the-california-duck-curve-is-real-and-bigger-than-expected>.

In the United States, the number of CCAs has grown from just three in 2000 – in Lowell (Massachusetts) and in Cincinnati and Cleveland (both Ohio) – to several hundred nationwide.¹⁵⁹ In California alone, CCAs were present in 182 cities and counties as of 2020, meeting the needs of more than 12 million electricity customers.¹⁶⁰ In 2020, 14 cities and counties across the state were supplying their customers with 100% renewable electricity.¹⁶¹ Elsewhere in the country, voters in Columbus (Ohio) approved a ballot measure in November 2020 to enable the city to establish its own CCA to help meet its goal of supplying 100% renewable electricity by 2023.¹⁶²

In California, CCAs are present in
182 cities and counties.

An approach similar to a CCA has been adopted in Newstead (Australia), where the local government is developing a 5 MW community solar project on a public plot and offering residents the option to sign up for 100% renewable electricity via a local retailer that will own and operate the project.¹⁶³ By tapping into both economies of scale and increasingly low-cost solar, the project promises customers lower electricity bills than those from the region's current retailers.¹⁶⁴ Similar to a CCA, customers will be able to opt in, and the project is designed to be large enough to cover the needs of the entire community.

In addition, some municipal governments have started to benchmark local renewable energy potential, which helps raise awareness and encourages higher uptake among urban actors (→ see Box 3).¹⁶⁵

BOX 3. Benchmarking to Harness Renewable Energy Potential in Cities

For many cities, untapped renewable energy potential exists within city limits at locations such as airports, along major rail and road ways, near or on water reservoirs, and on rooftops and vacant land. Cities also often have local sources of bioenergy – including wood chips, local agricultural wastes, and waste fats from restaurants, hotels and food producers that can be used for biodiesel – that can be considered part of the local renewable energy potential (→ see *Sidebar 5 in Markets and Infrastructure chapter*).

The potential for solar PV in cities is significant. For example, one analysis found that two-thirds of commercial buildings in New York City (US) had roof space suitable for solar PV, with the potential to supply around 14% of the city's total electricity consumption, including residential, commercial and municipal demand. An analysis of the solar potential in Berlin (Germany) found that using the city's available rooftop space could power up to 25% of city-wide electricity needs. Cities can better harness this potential by creating solar maps and introducing supportive policies that create the right enabling environments for investment.

Solar maps are tools (often interactive) that allow users to assess the potential and costs of installing solar PV or solar thermal systems on buildings and open land. Although these maps can be customised to produce tailored outputs for projects of all sizes, their main purpose generally is to facilitate greater solar use among property owners. Solar maps have been made available by municipal governments around the world, including in Calgary (Canada), Durban (South Africa), London (UK), Rome (Italy) and several US cities including New York.

One way to tabulate a city's success in harnessing its solar energy potential in new construction is to evaluate what share of the total new rooftop space built in a given year was equipped with solar PV or solar thermal systems. For example, among Germany's 14 most-populated cities, Hannover and Nuremberg managed to harness nearly half of their available rooftop potentialⁱ, whereas Hamburg and Munich tapped into less than 10%. Such benchmarking can highlight which cities are most successful in encouraging the adoption of solar (whether building-integrated, rooftop PV or solar thermal) in new construction city-wide.

Source: See endnote 165 for this chapter.



Nuremberg, Germany

ⁱ To calculate this solar potential, the study compared the total newly built rooftop solar PV potential in a given year to the total annual installed solar PV capacity that year.

CITY-WIDE HEATING AND COOLING

Regulatory policies

Municipal regulatory policies to shift to renewables-based heating and cooling in buildings are less widespread than policies in the power sector.¹⁶⁶ Where these policies exist, they often focus on the installation of solar thermal systems for water and space heating (→ see *Sidebar 4*), particularly in new construction.¹⁶⁷

In Carlsbad (California, US), a water heating ordinance that built on the city's 2015 Climate Action Plan came into effect in January 2020, requiring all new single-family and low-rise multi-family residential buildings to install either a solar water heating system or an electric heat pump coupled with a 0.3 kW solar PV system.¹⁶⁸ In China, Luanzhou's Special Plan for Green Buildings covering the period 2020-2025 requires new residential buildings with fewer than 12 floors to install a solar water heating system for each household (if suitable); for higher buildings the systems must be installed up until the 12th floor.¹⁶⁹ Similar regulatory policies exist in Abu Dhabi (United Arab Emirates), Los Altos Hills (California, US), Loures (Portugal), Montevideo (Uruguay) and São Paulo (Brazil).¹⁷⁰

Regulatory policies mandating renewables-based heating and cooling in **existing buildings** remain rare. One exception is Basel (Switzerland), where a mandate to replace oil and gas heaters with renewable energy technologies at the time of equipment replacement went into force in 2017; a revision introducing a fine for non-compliance came into force in 2020.¹⁷¹

Fiscal and financial incentives

Municipal fiscal and financial support policies for heating and cooling have emerged in cities, particularly in the form of **grants and rebates**.¹⁷² In 2019, as part of its Solar City initiative, the municipal government of Mexico City (Mexico) allocated funding to provide grants to businesses and residential buildings to install solar thermal heating.¹⁷³ During the programme period (until 2024), the grants will provide businesses with up to MXP 80 million (USD 4 million; with the target of supporting 400 businesses annually) and will provide residential buildings with MXP 170 million (USD 8.5 million; with the target of supporting around 135,000 systems).¹⁷⁴

As part of a regional action plan to combat air pollution, between 2018 and 2020 the municipal government of Jiaozuo (China) provided a one-time equipment rebate of CNY 40 (USD 6.1) per square metre of heating area to residents who shifted from using coal to using biomass combined heat and power (CHP), ground-source heat pumps and/or sewage-source heat pumps.¹⁷⁵ In a similar effort to improve air quality, the municipal government of Olsztyn (Poland) allocated a special budget to help co-finance investments in more environmentally friendly heating sources in residential buildings, such as covering a portion of the costs of connecting to the local district heating network.¹⁷⁶

In Berlin (Germany), the city government initiated a heating exchange programme to replace oil heating systems with wood pellet boilers, solar thermal systems and heat pumps. Owners of residential buildings can apply for grants distributed from a total budget of up to EUR 6 million (USD 7.4 million) for 2020 and 2021.¹⁷⁷ In a similar initiative in Leicester (UK), the municipal government provides grants of GBP 1,000 to GBP 7,000 (USD 1,357 to USD 9,504) for small businesses to implement renewable heating systems and energy efficiency measures.¹⁷⁸ In Barcelona (Spain), the municipal government renewed its housing renovation subsidy in 2020 to offer subsidies of up to 55% of the total costs of renovations to residential households that install solar thermal or solar PV.¹⁷⁹

Fiscal and financial policies for heating and cooling have emerged in cities particularly in the form of

grants and rebates.



SIDEBAR 4. Frontrunners in Solar Thermal Mandates in Cities

Building codes are widely used as a way to improve the energy performance of new and refurbished buildings. In around 20 countries worldwide, codes also include requirements that a certain amount or share of hot water and/or space heating demand is met using renewable sources or specifically solar heat. These additional regulations are respectively called renewable and solar thermal mandates.

Over the last two decades, cities have taken the lead in implementing solar thermal mandates, using their regulatory authority to stipulate the use of solar thermal systems on buildings for heating and cooling to reduce local air pollution and achieve climate targets. Mandates force the construction sector to consider renewable energy technologies early in the planning process. Given the labour-intensive nature of the building sector, which is dominated largely by local businesses, this approach also creates local jobs.

As early as 2000, Barcelona (Spain) – Europe's pioneer in solar mandates – adapted its building code to require that solar thermal energy cover at least 60% of the hot water demand in new buildings and in buildings undergoing major renovation. This solar mandate has been the main driver behind Barcelona's emergence as a mature solar thermal market, with more than 96,000 m² of collector area installed by small local companies in the last two decades. The policy also spurred broader action as some 50 Spanish towns and cities followed Barcelona's example, culminating in the implementation of national technical building regulations in 2007.

In some countriesⁱ (such as Germany and South Africa), building codes or mandates are set at the national level, making new solar or other mandates binding at lower levels of governance as well. In such cases, the key role for municipal administrations is to effectively implement the national regulation. In South Africa, a new building standard came into force in September 2011 (followed by a six-month transition period) stipulating that a minimum 50% of annual hot water demand must be provided by means other than electric resistance heating and fossil fuels. The city of Cape Town was able to fully apply the standard from April 2012 onwards, whereas other municipalities delayed the implementation by several years (→ see *Feature chapter*).

The experience of Bengaluru, the capital of Karnataka state (India), illustrates how strict implementation rules increase the effectiveness of solar mandates. To combat chronic power shortage, Karnataka enacted a solar mandate in 2007 requiring developers to install solar water heaters in all dwellings with at least 600 square feet (56 m²) of floor space. Two years later, the municipal utility Bangalore Electricity

Supply Company (BESCOM) started denying grid access to households that were not equipped with a solar water heater. This strict compliance rule led to 1,234 million m² of collector area installed across the city by 2017. BESCOM's policy was copied by other utilities across Karnataka, making it the leading Indian state for solar water heater capacity.

In countries where building codes can be set at the local level, several cities have emerged as frontrunners in solar thermal ambition, despite facing challenges. In 2007, São Paulo was among Brazil's first cities to enforce a solar mandate (applicable to all new residential and non-residential buildings), and by 2015 more than 110,000 m² of collector area had been installed across the city. Rosario (Argentina) is one of the few towns/cities in that country to have established a solar mandate (adopted in 2012), requiring 50% of hot water consumption in public buildings to be covered by solar thermal systems.



Some cities have pioneered stricter standards or requirements than those set at higher levels of government. In 2019, Honolulu (Hawaii, US) issued a stricter solar mandate, applying also to town halls and condominiums, than the overall state mandate for residential buildings that has been in force since 2010. The Hawaii mandate was the first on the continent and resulted in a high solar thermal penetration in buildings, with one in every two single-family houses using solar-heated water.

Source: See endnote 167 for this chapter.

ⁱ Solar mandates at the national level have proven to be able to boost solar thermal markets. Famously, in response to the oil crisis of the 1970s, Israel mandated the installation of solar water heaters in new residential buildings. Today, residential solar thermal systems are standard in the country, with 85% of households showering with solar energy. In Australia, a solar mandate issued in Victoria in 2005 requires residential home owners to install either a solar water heater or a rainwater tank for toilet flushing; 15 years later, 70% of new houses in the province have solar hot water systems.

Overall enabling environment

Municipalities increasingly have introduced enabling policies for renewable heating and cooling in buildings, such as **bans and/or restrictions** on the use of fossil fuel technologies (for example, new natural gas or oil-based boilers) as a way to improve local air quality and encourage the uptake of renewables. By the end of 2020, a total of 53 cities spanning 10 countries had either passed or proposed a ban or restriction on the use of natural gas, oil or coal in buildings for space and water heating purposes (→ see Figure 11).¹⁶⁰ While most of these policies target new buildings, some apply to existing buildings.

In the United States, several cities (mainly in California) have issued bans on natural gas infrastructure in new construction; although some of these have been contested in court. Berkeley was the first to ban the construction and use of natural gas lines for new residential buildings (in 2019), and more cities in the state have followed suit, including Milpitas and Palo Alto. Other California cities – including Carlsbad, Morgan Hill, Mountain View, Oakland and San Jose – have adopted regulations phasing out natural gas connections for new construction over time.¹⁸¹ San Francisco banned the use of natural gas in newly built public buildings starting in 2020 and in new residential and

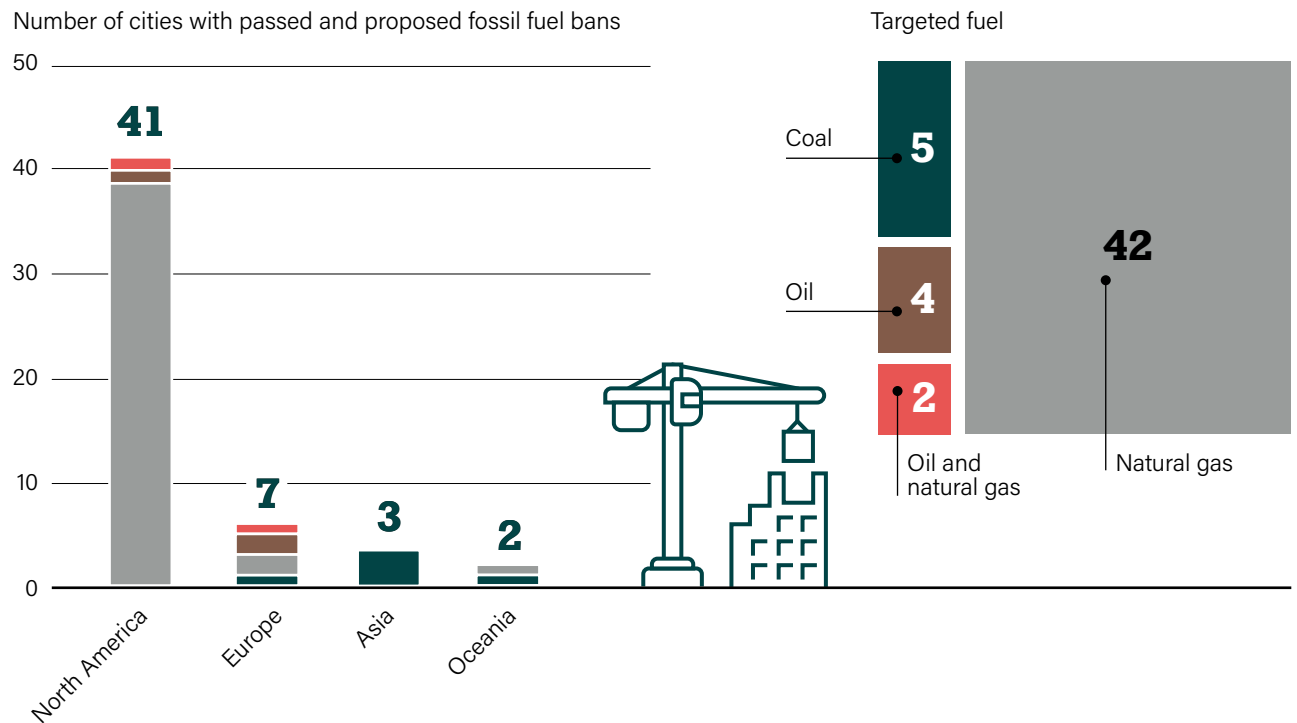
commercial buildings and major building renovations starting in mid-2021.¹⁸² Brookline (Massachusetts) bans both heating oil and natural gas for new residential and non-residential buildings.¹⁸³ In Canada, the Vancouver city council approved a bylaw requiring zero-emission space and water heating for all residential buildings of three storeys or less starting in January 2022 (→ see *City Snapshot: Vancouver*).¹⁸⁴

In Europe, Hamburg (Germany) introduced a ban in 2019 on oil-based heating and air conditioning, which will come into force in late 2021.¹⁸⁵ Amsterdam (Netherlands), in its wide-ranging climate-neutral roadmap published in 2020, pledged to phase out natural gas use in the city entirely by 2040.¹⁸⁶ Bans also are planned or in place in Krakow (Poland) and London (UK), among other European cities.¹⁸⁷

In an example of the interplay that often occurs among various levels of government to drive meaningful change at the local level, the district of Ginninderry (Canberra, Australia) succeeded in overturning state-level laws that would have made natural gas supply mandatory for new construction.¹⁸⁸ The change to the state legislation now makes gas connections for new construction voluntary, and has enabled Ginninderry to establish one of Australia’s first “gas-free” suburbs.¹⁸⁹

ⁱ See City Snapshot: Vancouver online at www.ren21.net/cities

Figure 11. Fossil Fuel Bans and Restrictions in Buildings in Cities, 2020



Source: REN21 Policy Database and Reference Table R5. See endnote 180 for this chapter.

DISTRICTS AND NEIGHBOURHOODS

Municipal governments have a direct influence over district- and neighbourhood-level planning. They can engage in integrated urban and energy planning processes that take into account the specific spatial, environmental and economic perspectives of these areas. Scaling up renewables in key districts or neighbourhoods can contribute greatly to wider city-level renewable energy strategies and climate targets. Policy activities that local governments have undertaken in their role as planners and regulators include setting targets and plans at the district and neighbourhood levels for the share of district heating, cooling or electricity; the share of district energy in public or other buildings; and the number of buildings connected.¹⁹⁰

Several cities have sought to scale up renewables at the neighbourhood level. Through the innovative "Barrio 31" Infrastructure Plan, which ended in 2019, Buenos Aires (Argentina) built 120 new homes with access to public services as a way to integrate this marginal neighbourhood into the city.¹⁹¹ The plan included energy efficiency measures as well as solar panels and solar water heating systems.

In the "smart" city of Eliat (Israel), a municipal bylaw requires every new neighbourhood to include infrastructure for solar panels on the rooftops of homes.¹⁹² The city's Mitzpe Yamthat neighbourhood aims to reduce energy consumption through energy efficiency in public buildings and private homes, and to upgrade existing infrastructure by installing LED lights on utility poles and public buildings, outfitting homes with energy-saving equipment and offering professional guidance on its use.¹⁹³ The neighbourhood is seen as a holistic unit, creating a model for other neighbourhoods in the city and elsewhere to replicate.

In Vienna (Austria), a ban on natural gas in new buildings led city authorities to estimate that by autumn 2020, "climate protection areas" would become possible in 8 of the city's 23 districts, with the rest following in 2021.¹⁹⁴ Within these areas, Vienna will be able to produce renewable heat for 80% of new buildings.¹⁹⁵ The city also has an ambitious heat zoning plan, with four districts already banning fossil fuel heating in new buildings and a targeted ban on fossil fuel heating in all buildings city-wide by 2040.¹⁹⁶

The Haarrjin neighbourhood in Utrecht (Netherlands) aims to power as many as 1,400 households with clean energy from a new floating solar PV plant, which will contribute to the energy-neutral neighbourhood that already has many solar panels on its roofs.¹⁹⁷ In the new residential neighbourhood of Tamarinden in Örebro (Sweden), 600 housing units are being developed with plans to reduce, produce and share renewable energy.¹⁹⁸

Momentum also has grown (particularly in Europe) for **positive energy districts**: energy-efficient and energy-flexible urban areas that produce net-zero greenhouse gas emissions and have surplus renewable energy generation.¹⁹⁹ These districts focus on energy production, efficiency and flexibility as a means to achieve local environmental, social and economic sustainability.

As of 2020, 61 European cities were developing plans for positive energy districts.²⁰⁰ Most were in the implementation stage, and only a few had been realised or were in operation, including (since 2018) the Carquefou district in Nantes (France). Carquefou's La Fleuriaye "eco-neighbourhood", which consists of 620 housing units with 6,000 m² of solar PV panels, provides 80% of the district's energy needs through solar electricity and is expected to be one of Europe's largest positive energy districts when completed in 2022.²⁰¹ Another programme in Europe supports the planning, deployment and operation of "100 Positive Energy Districts and Neighbourhoods" region-wide by 2025.²⁰²

53 cities

have either introduced or planned a ban on the use of natural gas, oil or coal in buildings.



Some US cities have **ecodistricts**ⁱ that involve urban planning to integrate the twin objectives of social equity and sustainable development, including reducing the ecological footprints of neighbourhoods. For example, the High Falls Ecodistrict, established in 2017 in Rochester (New York), aims to advocate and educate for reduced energy use through energy efficiency upgrades, to catalyse greater use of renewables, and to provide clean, energy-efficient transport options.²⁰³ In Boston (Massachusetts), the Talbot-Norfolk Triangle eco-innovation district (also established in 2017) is implementing projects focused on equitable transit-oriented development, local renewable energy generation, open space, walkability, bikeability, urban agriculture, green infrastructure, public health and safety, and local job creation, addressing both sustainability and economic prosperity within a holistic urban regeneration process.²⁰⁴

Ecodistricts being built elsewhere include Yennenga, a sustainable city located 15 kilometres from Ouagadougou (Burkina Faso). The city, which runs on renewable electricity generated in part by a 270 MW solar PV plant, welcomed its first inhabitants in 2020 and is expected to house some 100,000 people by 2030.²⁰⁵



High Falls, United States

CITY-WIDE TRANSPORT

Until recently, efforts to increase the use of renewables in transport focused primarily on biofuels, whether ethanol, biodiesel or related fuels.²⁰⁶ However, in recent years the opportunity to accelerate the uptake of renewables in the transport sector via electrification – using renewable electricity to charge vehicles – has attracted growing attention among urban policy makers worldwide.²⁰⁷

Regulatory policies

By the end of 2020, at least 33 cities had issued mandates or obligations to advance or enable the use of renewables in transport.²⁰⁸ While **biofuel blending**ⁱⁱ **mandates** generally are set at higher levels of government, some cities have adopted plans and procurement requirements to promote the local use of biofuels (as well as the use of local biofuels). In 2020, Bogotá (Colombia) adopted a new development plan that encompasses a package of measures to increase the city-wide use of renewable energy, including advanced biofuelsⁱⁱⁱ.²⁰⁹

As momentum behind e-mobility continues to grow, **EV charger mandates** for new buildings have become more commonplace at the city level.²¹⁰ In 2019, several cities, including San Mateo (California, US) and Vancouver (Canada), adopted new or revised building energy codes requiring that certain new buildings be both “EV ready” and “solar ready”, equipped with the electrical infrastructure required to enable EV charging stations to rely on renewable electricity.²¹¹ Also in 2019, the government of Delhi (India) approved its Electric Vehicle Policy, which among other measures requires all new residential and workplace parking to have EV charging spaces.²¹² In 2020, Chicago (Illinois, US) adopted an ordinance requiring new buildings to be equipped with EV charging infrastructure; this new policy – in combination with the city’s target to power all buildings with renewable electricity by 2035 – will make it possible to meet the transport needs of building residents or users fully with renewable electricity.²¹³

EV charger mandates

for new buildings
have become more
commonplace.

i Ecodistricts are home to positive energy buildings, or buildings that produce more energy than they consume.

ii Biofuel blending mandates require that transport fuels are blended with a minimum percentage of biofuel such as ethanol or biodiesel.

iii Advanced biofuels are fuels that can be manufactured from various types of non-food biomass, including waste and agricultural residues. See Glossary for definitions.

Several countries have adopted **hydrogen** strategies that have potentially far-reaching implications for cities. In 2019, the Republic of Korea announced plans to set up three hydrogen-powered cities by 2022, which entails a significant scale-up of hydrogen vehicles as well as hydrogen refuelling infrastructure (although it remains unclear whether the hydrogen will be renewables-based).²¹⁴ In China, both Guangzhou (Guangdong province) and Kunshan (Jiangsu province) adopted local development plans in 2020 for the production and use of renewable hydrogen in urban fleets.²¹⁵ China also was developing an ambitious roadmap to support the deployment of hydrogen vehicles in more than 20 cities, backed with several policy measures including financial subsidies.²¹⁶

Fiscal and financial incentives

By the end of 2020, at least 17 cities were providing fiscal and financial incentives – including grants, subsidies, tax rebates and tax exemptions – for the purchase and operation of zero-emission vehicles, mainly **electric vehicles**, as well as for associated infrastructure.²¹⁷ In a small number of cases, the incentives link EVs directly with new renewable power capacity. For example, in 2020 the municipality of Baden (Austria) and the car dealership Czaker promoted the combination of solar electricity and e-mobility, giving EV buyers a bonus if they already had a solar PV system at their house, and offering a subsidy of up to 30% more for installing a solar PV system if an EV is registered at the same address.²¹⁸

Some financial incentive programmes are directed at expanding electric taxi fleets in cities, although without an explicit link to renewable electricity. Cities that have supported the shift to electric taxis include Edinburgh (Scotland, UK), Medellín (Colombia), Montevideo (Uruguay) and Vitoria-Gasteiz (Spain).²¹⁹ Since the end of 2019, Amsterdam (Netherlands) has provided financial incentives for zero-emission vehicles, offering rebates of up to EUR 3,000 (USD 3,684) for a taxi and EUR 40,000 (USD 49,129) for a delivery van, truck or bus.²²⁰

In China, the national New Energy Vehicles (NEV) policy has been the biggest driver for the uptake of electric passenger vehicles.²²¹ However, some cities also have provided municipal subsidies to NEV consumers in recent years.²²² In 2020, the local government of Shanghai started offering subsidies of CNY 5,000 (USD 766) to NEV buyers, while the city of Shenzhen offered CNY 20,000 (USD 3,064) for the purchase of a new battery electric vehicle and CNY 10,000 (USD 1,532) for a plug-in hybrid.²²³

In the United States, the District of Columbia's Clean Energy Omnibus Amendment Act, passed in 2019, aims to electrify all public buses and other fleet vehicles in Washington, D.C. and to incentivise owners of private, non-commercial vehicles to purchase fuel-efficient vehicles, in an effort to curb greenhouse

gas emissions in the city.²²⁴ The Act establishes a vehicle tax based on fuel efficiency, offers tax rebates for vehicles that are more efficient than the established benchmark and exempts EVs from the tax.²²⁵ In 2019, São Paulo (Brazil) granted an exemption from the Vehicle Property Tax (IPVA) to electric, hybrid and hydrogen vehicles registered in the city.²²⁶

While financial incentives for **hydrogen** vehicles are still limited, some examples exist (although not linked to renewable electricity). Between late 2018 and mid-2020, Arnhem (Netherlands), in partnership with Gelderland province, supported the H2-Drive initiative, under which citizens could request financial support for leasing or buying a hydrogen fuel cell car.²²⁷ The programme initially aimed to finance 90 hydrogen cars but stopped at 70 due to the COVID-19 pandemic.²²⁸

Financial tools remain popular among different levels of government supporting the transition to renewable fuels and alternative propulsion vehicles. Many cities rely on financial incentives and support policies set by national and/or state governments to complement the limited resources they themselves have to spend on such programmes. For example, in 2020 the North Central Texas Council of Governments (US) set up a grant funding programme for local governments and private companies working with local governments to replace heavy-duty diesel vehicles with alternative fuelⁱ vehicles.²²⁹



Arnhem, Netherlands

ⁱ In the context of the programme, "alternative fuel" vehicles encompass vehicles that can rely on renewable fuels (such as biodiesel and ethanol) as well as electric vehicles and vehicles fuelled by hydrogen, natural gas and propane.

Overall enabling environment

As of the end of 2020, at least 14 cities had proposed or passed **bans and/or restrictions** on the circulation of certain types of vehicles in their jurisdictions.²³⁰ Most of these measures focus on banning either just diesel vehicles (as many cities in Germany and Spain have announced plans to do) or banning/phasing out all internal combustion engine vehicles, regardless of whether they burn diesel, petrol or liquefied natural gas. Bans on sales of internal combustion engine vehicles have been more common at the national level, and can affect the uptake of biofuels, drop-in fuels and some renewable synthetic fuels that can be used in conventional engines; meanwhile, cities mostly have adopted bans or restrictions on the use of fossil fuel vehicles, which incentivise all renewable fuels and electricity use in urban transport.²³¹

Beginning in 2020, diesel cars up to the Euro 5 emission standardⁱ are banned on certain roads in Stuttgart (Germany), with similar restrictions in place in Barcelona (Spain), Berlin (Germany) and Bucharest (Romania).²³² Amsterdam (Netherlands) announced in 2019 that any cars and motorbikes running on petrol or diesel would be banned from driving in the city starting in 2030, and non-electric buses will no longer be able to enter the city centre from 2022.²³³ Oslo (Norway) has outlined a plan to make its city

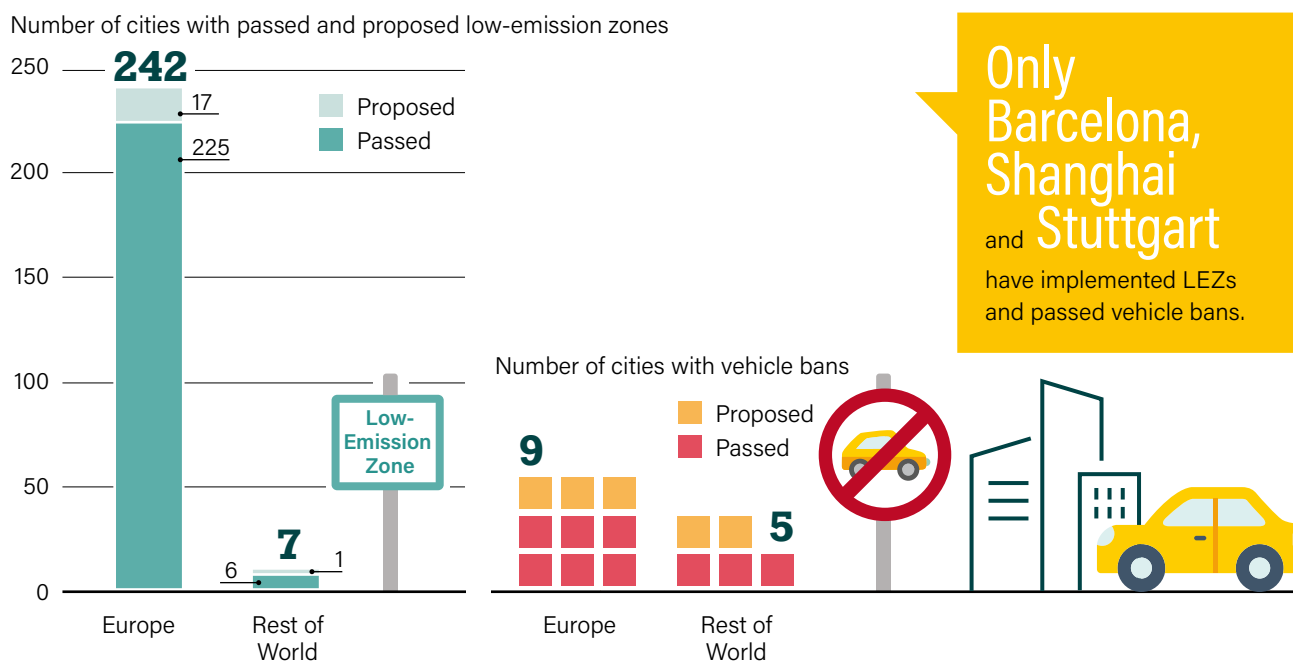
centre fossil-free by 2024 and to be the first city to have a fully emissions-free transport sector by 2030.²³⁴ Reykjavik (Iceland) took a different approach, pledging in 2019 to halve the number of petrol stations in the city by 2025 in an effort to phase out internal combustion engine vehicles.²³⁵

Low-emission vehicle zones (LEZs) continued to spread during 2019 and 2020, predominantly in Europe. By mid-2020, of the 249 passed or proposed LEZs worldwide, more than 97% of them were in European cities (→ see Figure 12).²³⁶ Poland's first LEZ was established in Krakow in 2019, and additional LEZs were approved in Stockholm (Sweden) and in UK cities including Aberdeen, Bath, Birmingham, Dundee, Edinburgh, Leeds, Leicester and Southampton.²³⁷ Due to measures enacted in response to COVID-19, some planned UK-based LEZs (including in Oxford) were postponed, and some existing LEZs and associated financial penalties and congestion charges were suspended and then later reinstated – including in Barcelona (Spain), London (UK) and Milan (Italy).²³⁸

Although the main goal of LEZs is to improve local air quality, they also can result indirectly in greater use of renewable fuels and electricity in transport by allowing concessions to alternative powertrains. In Madrid (Spain), for example, only certain vehicle types – including battery electric, fuel cell electric and plug-in

i Since 1992, new car models in the EU have had to meet increasingly stringent emissions limits, known as the Euro emissions standards, before they can be sold. The Euro 5 emissions standard, which relates to the EU standard for pollutants put in place in 2009, covers carbon monoxide, hydrocarbons, nitrogen oxides and particulate matter, and introduces particulate filters for diesel vehicles.

Figure 12. Number of Cities with Low-Emission Zones and Vehicle Bans on Certain Technologies, 2020



Source: SLOCAT, REN21 Policy Database and Reference Table R5. See endnote 236 for this chapter.

Note: The figure includes cities with LEZs and vehicle bans which have been passed or proposed. Of the total of 231 cities with passed LEZs, 195 were passed before 2020 (between 2006 and 2019), 23 were passed in 2020 and 13 are scheduled to be enforced between 2021 and 2028. Of the 9 cities that have passed vehicle bans, three were enforced in 2019 and 2020 and the remaining six were scheduled to come into force during 2021-2025.

hybrid vehicles with a minimum electric range of 40 kilometres, and range-extended EVs – are allowed to circulate and park in the LEZ without restrictions.²³⁹ In 2020, Paris (France) stipulated that only battery electric and fuel cell vehicles will be permitted in its LEZ by 2030.²⁴⁰

Outside of Europe, LEZs have emerged in Chinese cities such as Foshan, Guilin, Huia'an, Shanghai, Suzhou and Zhengzhou.²⁴¹ Israel's first LEZ was established in 2018 in Haifa, and in 2020 a new LEZ was implemented in Jerusalem.²⁴²

The use of **fees and levies** to encourage or discourage certain behaviours and investment choices also can stimulate the transition to zero-emission transport alternatives – and, indirectly, greater use of renewables.²⁴³ Several Dutch cities – including Amsterdam, Eindhoven, The Hague, Rotterdam and Utrecht – offer **free public EV charging**, as does Lisbon (Portugal).²⁴⁴ Lisbon also offers free EV parking, while at least 12 Chinese cities, including Hefei and Shenzhen, offer reduced parking fees for EVs.²⁴⁵

During 2019 and 2020, many city governments – including Delhi (India) and Hong Kong and Shenzhen (both China) – continued to promote the use of EVs by subsidising the installation of charging infrastructure within city boundaries.²⁴⁶ Community choice aggregation programmes also have started to explore scaling up investments in EV charging infrastructure and

increasing the share of renewables used in charging, especially in cities across California (US).²⁴⁷ By contrast, Amman (Jordan) was forced to cancel its EV financial incentive scheme due to the lack of charging stations to accommodate the growing number of EVs in circulation.²⁴⁸

More joint transport-related commitments involving cities and other jurisdictions were announced in 2019 and 2020. Under the Climate Mayors Electric Vehicle Purchasing Collaborative, some 182 US cities and counties have committed to purchasing a total of more than 3,500 EVs before the end of 2021.²⁴⁹ Additionally, through the C40 Fossil Fuel Free Streets Declaration, 35 cities (including 7 non-C40 cities) pledged to establish major zero emission areas within their cities by 2030.²⁵⁰ However, there is a high risk that these efforts will not be implemented or successfully linked to renewable energy without complementary policies, such as those highlighted throughout this chapter.

At least
14 cities
have proposed or implemented bans on the circulation of fossil fuel vehicles.



Chongqing, China



Bradley, United States



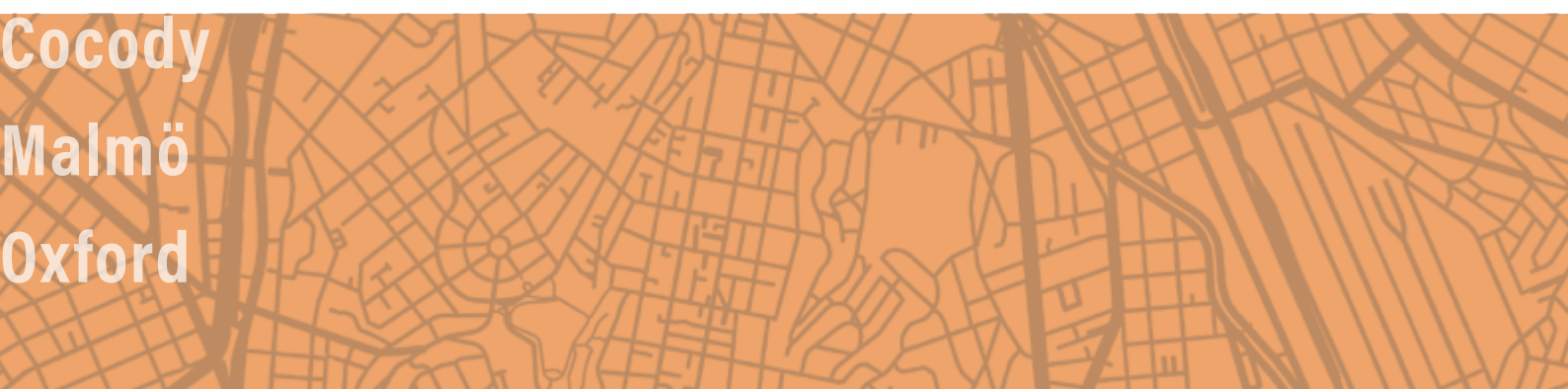
Toronto
Bristol
Klemetsrud
Duiven
Tampa
Cotonou
Lagos
Lalitpur
Hong Kong
Salt Lake City

3

MARKETS

AND

INFRASTRUCTURE



Cocody
Malmö
Oxford

MARKETS AND INFRASTRUCTURE

Cities are both consumers and producers of energy. They account for around 75% of global energy useⁱ and are the leading growth markets for utilities.¹ Because cities (including their governments, inhabitants, and commercial and industrial entities) use so much energy, they have the potential to drive large amounts of renewable energy deployment. However, cities worldwide vary greatly in their energy use – depending on factors such as the level of economic development and the presence of industry, among others – and in their overall ability to deploy renewables, which may reflect local resource and other constraints. In 2020, the COVID-19 pandemic sharply reduced energy use in many cities, particularly in the transport sector (→ see *Sidebar 1 in Global Overview chapter*).²

City governments often are constrained by policies and regulations at higher levels of government, as well as by the availability and condition of energy distribution infrastructure. When provided sufficient autonomy, however, a city can exercise greater flexibility over its energy mix and define, to a large extent, the trajectory of its energy future. Overall, cities have significant opportunity and potential to steer the energy system towards renewable energy – not just locally, but well beyond.

Globally, a relatively small but growing share of the energy consumed in cities comes from modern renewable sourcesⁱⁱ. To some extent, this renewable share is expanding in direct proportion to developments outside of the urban purview, thanks to the greater deployment of renewables elsewhere. For example, state/provincial or national mandates, as well as the changing economics of energy technologies, have led to rising shares of renewable electricity or fuels in regional grids – which has led to higher city shares as well. At the same time, more and more cities worldwide are directly increasing their production and consumption of energy from renewable sources.³

Urban demand for renewables is rising in response to growing recognition of the diverse economic, environmental, social and other benefits associated with renewable energyⁱⁱⁱ. So far, the greatest focus has been on meeting municipal government demand (via city procurement authority) followed by efforts to reshape the wider urban energy supply and demand structure. Private procurement also plays a growing role, as individuals and businesses determine their own renewable energy needs. Although most of the renewables used in cities are still sourced from outside the urban area (through regional grids, pipelines and other infrastructure), local production of renewable energy – in the forms of electricity, direct thermal energy and transport fuels – is significant and growing.⁴

i Not including energy embedded in imported agricultural, electronic and other products or materials. See endnote 1 for this chapter.

ii In many cities (especially in sub-Saharan Africa), the traditional use of biomass for heating and cooking is still widespread. See Glossary for definitions of modern renewable energy and traditional biomass.

iii See Drivers chapter in REN21, *Renewables in Cities 2019 Global Status Report* (Paris: 2019), https://www.ren21.net/wpcontent/uploads/2019/05/REC-2019-GSR_Full_Report_web.pdf.

Around the world, city governments as well as urban households and commercial and industrial actors are shaping their energy infrastructure and use to better accommodate rising shares of renewables. They are expanding district heating and cooling networks, implementing efficient end-use technologies, increasing electrification of the transport and heating sectors, installing energy storage capacity and facilitating greater flexibility on the demand side – all of which can provide benefits such as greater system efficiency, improved reliability of service and lower overall system costs.⁵ To address multiple urban challenges in a cost-effective manner, city governments also are linking energy supply with other municipal activities – for example, using rapidly growing urban waste and wastewater streams as feedstocks to produce solid, liquid and gaseous biofuels (→ see *Sidebar 5*).⁶

The availability and reliability of energy data vary greatly across countries and cities. In general, data on renewable energy capacity and generation are tracked at the national (and often state/provincial) level, but not always at the local level. As a result, comprehensive global statistics on urban renewable markets (for both energy and technologies) and generation are incomplete or lacking.⁷ Further, although energy consumption is reasonably well documented at the national level, the urban/rural breakdown of this use is generally unavailable.

Within these limitations, this chapter provides an overview of city-level renewable energy market and infrastructure developments during 2019 and 2020. It examines the installation of renewable energy technologies and associated infrastructure in cities, the energy capacity procured for use in cities, as well as relevant consumption trends across the buildings, industry and transport sectors (→ see *Global Overview chapter*).



SIDEBAR 5. Waste-to-Energy in Cities

The rise of urban refuse, including municipal solid waste (MSW) and wastewater, has been a major component of the rapidly growing global waste streamⁱ. As the volume of refuse in urban areas skyrockets – driven by population growth, urbanisation and changing patterns of consumption – cities have faced major challenges, leading many to undertake measures to improve their waste management systems.

Key challenges include: the effective and comprehensive collection and transport of refuse to waste processing facilities; separating and capturing recyclable materials and energy content from the waste stream (including methane emissionsⁱⁱ); and identifying adequate land for treatment and disposal of remnants (often at high economic cost) – all while minimising the impacts on public health from local air, soil and water contamination. In developing countries and emerging economies, more than two-thirds of MSW is deposited improperly in open landfills that lack advanced environmental protection, let alone adequate energy and material recovery protocols.

At the same time, waste is a resource that, if properly recycled, can be recovered to be used as an input for new products. Cities have numerous opportunities to manage their waste in a more sustainable (and economically beneficial) manner. To minimise the volume of waste going to landfill and to recapture both material and energy resources, many cities divert, capture and recycle usable materials. Any refuse with direct energy potential (meaning usable fuel and direct heat, as opposed to recaptured embedded energy in materials such as processed metals) can be captured for direct and indirect energy applications.

For example, organic waste can be extracted and reformed into solid, liquid or gaseous biofuels to generate electricity, to directly provide heat via combustion (for cooking and heat in buildings, and in industry) and to fuel vehicles. Organic waste also can be processed into organic fertiliser, which displaces demand for fossil fuel-based fertilisers and avoids emissions associated with using fossil fuel as a feedstock.

To extract energy from waste, cities have adopted a variety of technologies, including anaerobic digestion of solid and liquid organic waste to produce biogas, the capture and use of landfill gas, and direct combustion of solid wasteⁱⁱⁱ. Biogas, whether from digesters or landfill, is considered to be a renewable fuel. It has high methane content and can be combusted directly to produce electricity and/or heat.

In Santiago (Chile) in 2017, the water utility Aguas Andinas transformed three wastewater treatment plants into the Greater Santiago Biofactory, which converts the city's effluent to biogas to produce heat and electricity; the utility also reuses the additional sewage sludge as fertiliser for agriculture. In 2019, the plant generated 57.2 gigawatt-hours (GWh)

of electricity and reused 69% of bio-solid as fertiliser. In Victoria (Australia), the Environmental Protection Authority approved construction in 2020 of a second biogas plant at the Melbourne Regional Landfill, which is expected to generate 68,000 MWh of electricity annually.

Cities also are converting food waste to biogas. In the United States, both legislation and public demand to limit landfill sizes and reduce carbon footprints has motivated city actors to take action. In 2020, Los Angeles (California) expanded the capacity of its food-to-biogas plant from 165 tonnes to 550 tonnes of separated food waste per day, which is used to produce fuel for electricity generation and for transport vehicles. In New York City, the Newtown Creek Wastewater Treatment Plant has processed around 3% of the city's daily liquefied food waste into biogas for electricity generation since 2016, and plans were announced in 2019 to double the plant's capacity.

New Zealand was building its first large-scale food waste-to-biogas plant with anaerobic digester technology in Reporoa on the North Island in 2020. The facility, expected to be operational in 2022, aims to process up to 75,000 tonnes of household and commercial food waste from Auckland annually to provide electricity for the equivalent of around 2,500 households in the region and to provide bio-fertiliser for 2,000 hectares of local farmland, as well as to produce CO₂ and heat for local greenhouses.

Biogas can be upgraded to biomethane and used as a transport fuel or injected into fossil natural gas pipelines. Biomethane plants have become increasingly common, particularly in Europe where the number of facilities rose 51% between 2018 and 2020, from 483 to 729. Lille (France) converts more than 108,000 tonnes of household waste annually into biomethane to fuel half the city's bus fleet. In 2020, Bristol (UK) partly funded the deployment of 77 buses fuelled with biomethane derived from anaerobic digestion of food waste. Toronto (Canada) partnered with the gas company Enbridge Gas to install biogas upgrading equipment for biomethane production at the Dufferin Solid Waste Management Plant. The facility is expected to produce some 3.3 million cubic metres of biomethane per year for injection into the natural gas distribution grid, which supplies fuel to waste collection trucks and other municipal vehicles as well as heat for Toronto's buildings and other facilities.

- i Global waste generation increased more than 50% between 2012 and 2016, from around 1.3 billion tonnes to 2.01 billion tonnes, according to the latest data available. See endnote 6 for this chapter.
- ii Methane, emitted during the decomposition of organic wastes, is a potent greenhouse gas that contributes to climate change and can potentially cause explosions at waste facilities if ignited.
- iii Not all energy produced from the remaining waste is renewable. Energy derived from MSW combustion cannot be considered entirely renewable, as MSW also contains inorganic material. Generally, about 50% of this energy is classified as renewable.

The direct disposal of MSW through incineration is a common practice, and more than 4,800 incinerators are in operation worldwide, a growing number of which use the thermal energy released through combustion to generate usable heat and electricity. However, only the energy produced from the organic portion of MSW can be considered renewable, and emissions from incineration greatly affect air quality in the absence of pollution control systems. Cities have begun to install control systems to reduce air emissions from incinerators. In 2018, the Norwegian government initiated a carbon capture project at the Klemetsrud waste-to-energy facility – which processes more than 400,000 tonnes of waste annually – to generate electricity and heating for the city of Oslo. In 2019, the Dutch waste-to-energy company AVR equipped its waste combustion plant in Duiven (Netherlands) with a flue gas purification system to reduce CO₂ emissions.

Source: See endnote 6 for this chapter.



Auckland, New Zealand



Toronto, Canada

BUILDINGS AND INDUSTRY

PRODUCTION AND PROCUREMENT OF ELECTRICITY

In towns and cities around the world, municipal governments and other urban actors – including residents, businesses, universities and places of worship – are producing and procuring renewable electricity to power building systems and run all forms of commercial and industrial activity. Depending on their local resource options, laws and regulations, and other location-specific variables (including institutional and financial capacities), these entities are pursuing activities in at least three general areas to increase their use of renewable electricity:

- installing distributed renewable power systems at or near the point of demand (on-site);
- purchasing renewable electricity through green tariff programmes; and
- signing power purchase agreements (PPAs) with developers for projects in and outside of urban areas.⁸

In cities where these options are not available or are insufficient – often because national and state/provincial laws and regulations govern activities related to energy production, procurement,

i See Glossary for definition.

and electricity transmission and distribution – municipal governments and other urban actors use alternative avenues to achieve their local renewable energy goals.⁹ In many instances, city governments have partnered with diverse stakeholders, including utilities and other cities, to engage with legislators and regulators to remove barriers.¹⁰ Many city governments are pursuing community aggregation efforts or the municipalisationⁱ of electricity procurement and distribution (→ see *Citizen Participation chapter*).

ON-SITE GENERATION

Thousands of examples exist of recent on-site projects in cities, ranging in capacity from a few kilowatts to hundreds of megawatts. Based on available information, most of these local projects are solar PV systems (combined with battery storage in a small but increasing number of systems), although many cities also tap into local wind, biomass and hydropower resources. These systems are being installed on or near government buildings, schools and universities, single-family homes and high-rise apartment buildings, hospitals, airports, commercial and industrial facilities, places of worship, carports, rail and bus stations, urban waste sites and city streets (→ see *Box 1*).¹¹

BOX 1. Solar Streetlights

Public street lighting consumes as much as 40% of the electricity budget in some cities. To reduce costs, municipal governments around the world are embracing renewably powered streetlights (as well as energy-efficient lighting programmes) as cost-effective and reliable solutions.

In 2020, Epperson, a master-planned community in Tampa (Florida, US) was deploying more than 10,000 solar streetlights that will run entirely off the grid. In Canada, Prince George (British Columbia) launched a pilot project to test an off-grid solar-powered streetlight, and in Australia the Mareba Shire Council (Queensland) installed 10 solar-powered off-grid public lights, which helped the council save more than 30% on lighting costs in addition to improving road safety.

Solar street lighting also is providing more reliable illumination across Africa. In 2020, Djoum and Yaoundé in Cameroon, which suffer frequent power outages, installed solar streetlights, and 12 towns in Liberia's upper Bong County switched on 60 solar streetlights, serving more than 5,500 residents. In Senegal, a project to install 50,000 solar streetlamps in several cities was delayed by COVID-19 but was 50% complete by mid-2020, providing lighting to more than 20,000 urban dwellers. Cotonou (Benin) and Lagos (Nigeria) were testing solar traffic lights, mainly to reduce road congestion and accidents caused by unstable power supply.

At the same time, some cities with existing solar lights that no longer function due to theft or lack of maintenance are exploring other options. Ekurhuleni (South Africa), Harare (Zimbabwe), Kampala (Uganda) and Kathmandu and Lalitpur (both Nepal) have all opted for “smart” electric streetlamps, which send signals to a central power control module when they experience technical problems so that they can be fixed promptly.

Source: See endnote 11 for this chapter.



Colombo, Sri Lanka

In the **United States**, local government transactions related to renewable energy (for both on-site and off-site systems) increased considerably after the federal government announced in 2017 that it would withdraw from the Paris Agreement.¹² Many US cities – including Cincinnati (Ohio), Honolulu (Hawaii), Los Angeles, San Diego and San Jose (all California), New Orleans (Louisiana) and Phoenix (Arizona) – have built small-scale on-site or community solar projects as a first step towards achieving their renewable electricity goals.¹³ By 2019, public authorities, residents and businesses in Los Angeles had installed some 440 MW of grid-connected solar PV capacity, supplying around 11% of the city's electricity mix and making Los Angeles the top US city for grid-connected solar PV.¹⁴ Honolulu leads for solar PV capacity per capita, with more than 646 watts for each city inhabitant as of the end of 2018.¹⁵

In the US northeast, most renewable energy deals made by local governments are for on-site projects due in part to favourable policies for distributed energy (particularly solar PV).¹⁶ New York City's transit authority launched an initiative in 2019 to lease many of its rooftops and parking lots for solar projects, and city agencies announced plans in 2020 to install solar PV on 46 public schools, a wastewater facility and other buildings as part of a goal to install 100 MW on New York public buildings by 2025.¹⁷

Elsewhere in the country, Seattle (Washington) generated nearly all of its electricity with renewables in 2019, thanks to an estimated 8,000 solar buildings and a public utility that has been carbon-neutral since 2005 (due mainly to hydropower).¹⁸ Fayetteville (Arkansas) completed a solar project in 2019 to power two wastewater facilities that account for most of the municipal government's electricity use.¹⁹

Across **Europe**, numerous city governments added renewable power capacity in 2019 and 2020, with local projects including biomass facilities as well as other renewable power systems. In Ukraine, the eastern city of Dnipro began operating a 16 MW biopower plant in 2019.²⁰ In the United Kingdom, Glasgow (Scotland) opened an anaerobic digestion facility to convert organic landfill waste into methane for electricity generation, with the goal of powering nearly 26,500 households annually.²¹ Exeter (England) was developing its first solar-plus-storage project in 2020, consisting of a 1.2 MW ground-mounted solar array co-located with a 1 MW / 2 MWh battery to provide electricity for city council operations.²²

As of 2020, Athens (Greece) planned to install solar PV systems on 50 schools to cover all school electricity needs in the municipality, and Kaunas (Lithuania) planned to install systems on 77 city buildings, including schools and healthcare facilities – both with support from their respective national governments.²³ Tychy (Poland) announced plans to add hundreds of renewable energy systems, including 647 solar PV systems, by the end of 2021 to improve local air quality and reduce energy costs.²⁴ In Bordeaux (France), a 59 MW plant under construction on the site of a former landfill was expected to produce the equivalent of 28% of the city's electricity consumption when completed.²⁵

i See Glossary for definition.

In **Asia**, much of the city-focused activity has occurred in India, where several "smart cities"^{vi} have embraced renewables. In 2018, Diu Smart City became the country's first city to operate on 100% renewable electricity, thanks in part to a 9 MW solar PV park and solar panels installed on 79 government buildings; several other smart cities issued tenders in 2019 and 2020 for local solar PV capacity atop buildings, canals and sewage treatment facilities.²⁶ In Delhi, solar PV installations on government and educational buildings totalled around 105 MW in 2019, with another 5 MW on residential buildings.²⁷ By the end of 2019, the industrial city of Pune had more rooftop solar capacity (130 MW) than any other Indian city.²⁸ Across India, the higher electricity rates, readier access to financing and larger rooftops for industrial versus residential users have encouraged the industrial adoption of solar PV.²⁹

Urban consumers in many other Asian countries have opted for solar PV rooftop systems. Hong Kong Disneyland (China) installed a 1.8 MW system that became viable after local utilities introduced a feed-in tariff scheme to help achieve Hong Kong's green goals.³⁰ In Malaysia, supermarkets, retail chains and one of the world's largest solar glass manufacturers (Xinyi Glass Holdings) launched projects or plans for substantial urban rooftop capacity during 2019 and 2020.³¹

In **Latin America**, falling solar PV system costs have propelled significant investments in several cities. The government of Mexico City (Mexico) installed rooftop solar PV on some municipal buildings in 2020 as part of the city-wide initiative Solar City.³² Private consumers in the region also have embraced solar PV, with Walmart deploying systems on its Mexican stores in Aguascalientes, León, Puebla and Salamanca.³³ In Colombia in 2020, Bancolombia installed nearly 2,000 solar panels at its headquarters in Medellín, and in Bogotá the Diverplaza mall inaugurated a solar PV system with nearly 700 panels.³⁴ In Brazil, Uberlândia nearly tripled its solar PV capacity between mid-2019 and mid-2020, to nearly 50 MW, making it the nation's top city for solar PV.³⁵

Across **Africa**, municipal governments as well as large commercial and industrial actors have deployed a significant number of distributed renewable energy systems to ensure reliable and affordable electricity supply (→ see *City Snapshot: Cocody*).³⁶ During 2020, several solar power projects were being developed in Libya to reinforce local grids and ensure security of supply, including in Benghazi, Kufra, Rajban, Sebha, Tripoli, Ubari and Zintan.³⁷ In the Democratic Republic of the Congo, the city of Goma inaugurated a 1.3 MW hybrid solar power plant (with a storage system) and distributes electricity to the local community via a mini-grid.³⁸ Egypt's New Administrative Capital east of Cairo planned to install rooftop solar PV systems on 65 municipal buildings starting in 2020.³⁹

Private sector solar PV projects in Africa included the 2019 installation of the first system in Tatu City (Kenya) atop the headquarters of Dormans Coffee, and the installation of an off-grid system on the Windhoek (Namibia) production facility of beverage multinational Coca-Cola.⁴⁰ The furniture manufacturer Maroc Bureau installed solar panels on its factory rooftops in Casablanca and Rabat (both Morocco) in 2020.⁴¹

COCODY

CÔTE D'IVOIRE

Land area
(km²)



135

Population size
(2018)



800,000



The City of Cocody, located north of Abidjan on the coast of Côte d'Ivoire, released its Green City Plan in 2017, pledging to reduce carbon emissions 70% by 2030 to combat climate change. The city established the pledge to complement efforts to achieve the national goal of 42% renewable electricity generation by 2030, as put forward in Côte d'Ivoire's 2016 Nationally Determined Contribution towards reducing emissions under the Paris Agreement. Achieving the city's emissions reduction target will be challenging due to Cocody's rising energy demand, which is caused largely by rapid urban development and economic growth.

Cocody Green City is an ambitious plan that aims to minimise local greenhouse gas emissions while also creating 100,000 direct jobs and 400,000 indirect jobs, promoting women's empowerment and increasing citizen participation in adopting sustainable living. This community-based climate action plan aims to reduce CO₂ emissions by up to 90% by 2030, using renewable energy and carbon sequestration efforts. The city has set up a Reforestation and Carbon Sequestration Program that includes the development of green spaces and the restoration and replanting of 2 million mangrove trees to protect local climate health.

The Green City plan takes a holistic approach towards upgrading energy use and generation, transport, habitat restoration and land use, conservation and protection of water resources, community sensitisation and adoption. As of 2017, 23 measures were under development, including using solar energy to power large public buildings, installing 5,000 solar lamp posts, installing 1,600 solar traffic lights at 400 crossroads and supplying 200,000 solar PV power kits to households. Other measures to reduce carbon

emissions include distributing to households 300,000 efficient cook stoves that run on ethanol procured locally from sugarcane manufacturers, producing 1,000 solar dryers for community women, distributing solar water heaters and setting up four wind farms on the banks of Ebrie lagoon.

The Cocody Green City plan also emphasises the development of sustainable transport and mobility plans through a Transport Demand Management scheme that aims to remove 1,000 old vehicles annually from city roads to improve local air quality and eliminate some 50 million tonnes of CO₂ emissions per year. In addition, a used vehicle repair centre has been created to provide 100,000 catalytic exhaust systems for polluting vehicles.

Source: See endnote 36 for this chapter.



In the **Middle East**, as part of the Shams Dubai Initiative, the Dubai Electricity and Water Authority (United Arab Emirates) connected more than 1,300 solar PV installations (totalling 125 MW) on residential, commercial and industrial buildings across the city by the end of 2019.⁴² As of 2020, Israel's Tel Aviv Solar Roof Project aimed to install solar PV systems on the roofs of residential and commercial buildings in the city to reduce living costs for residents and to protect the environment.⁴³

Renewable power systems also have been installed at places of worship in the Middle East and North Africa (as well as elsewhere).⁴⁴ As of 2019, around 500 mosques in Jordan were relying on on-site solar power, thanks to a national initiative that aims to extend solar PV to most of the country's 6,500 mosques (as well as its smaller number of churches) to reduce energy costs and increase awareness of renewables.⁴⁵ In Casablanca (Morocco), the Hassan-II Mosque, Africa's largest, was undergoing extensive renovations in 2020 to install solar PV panels and reduce the building's energy use by more than half.⁴⁶

In **Oceania**, the University of Monash (Melbourne), Australia's largest university, installed its first on-campus solar panels in 2010, and in 2019 it launched a Net Zero Initiative to achieve 100% renewable energy by 2030.⁴⁷ The university aims to transform its four domestic campuses to operate fully on renewable electricity (including converting all buildings, appliances and vehicles to electricity), relying as much as possible on on-site solar systems.⁴⁸ One of Australia's largest behind-the-meter solar installations, a 12 MW solar farm at Melbourne airport, was nearing completion in 2020.⁴⁹ Several other towns and cities nationwide, including Mosman, Greater Shepparton and Shoalhaven, have installed rooftop solar PV on local sports facilities.⁵⁰ As of early 2020, New Zealand's then-largest solar array (1.17 MW) was being built atop Foodstuffs North Island's distribution centre in Auckland.⁵¹

GREEN TARIFFS

In cities where this option is available, numerous urban electricity consumers are participating in green tariff programmes, purchasing electricity from traditional utilities along with associated renewable energy certificates or RECs (in the United States) and guarantees of origin or GOs (in Europe)ⁱ (→ see Box 2).⁵² Commercial and industrial customers have driven most of these green tariff deals, but local governments are playing a role as well, often with a preference for deploying projects nearby that can provide local economic and environmental benefits.⁵³

As of 2019, consumers in more than 80 cities and communities across 16 US states and Washington, D.C. were purchasing renewable electricity via green tariff programmes, for a combined total of nearly 8.6 billion kWh annually.⁵⁴ In early 2020, Charlotte (North Carolina) became the most populous US city to procure renewable electricity through a green tariff programme; the city is partnering with developers on a 35 MW solar PV project, and the utility Duke Energy will purchase the generated electricity and deliver it to Charlotte.⁵⁵

In Europe, the market for GOs reached record levels in 2018 (latest data available).⁵⁶ Although corporations account for nearly all green electricity purchases, commercial businesses and residential consumers as well as local councils and government departments have turned to green tariffs to claim larger shares of renewable electricity (→ see *Citizen Participation chapter*).⁵⁷ Bedford Borough Council (UK) plans to rely on GOs from the local energy supplier to operate all council-owned and operated buildings as well as street lighting on 100% renewable electricity starting in April 2021.⁵⁸



Melbourne, Australia

There are **thousands** of on-site renewable energy projects in cities, ranging in capacity from a few kilowatts to hundreds of megawatts.



ⁱ RECs and GOs are electronic certificates that verify that a specific amount of electricity corresponds to electricity from a specified renewable source. See Glossary for definitions.

BOX 2. RECs/GOs and Questions of Additionality

The concept of “additionality” originated in greenhouse gas project accounting and has been adopted by the renewable energy community to describe purchases of renewables that drive incremental (additional) investment and capacity and, perhaps, investment that otherwise might not have occurred. For accounting purposes, the concern is to avoid double-counting of credits for renewable energy and, at a minimum, to avoid the circumstance where purchases of RECs and GOs actually displace or undermine new and local capacity expansion.

The purchase of unbundled RECs/GOs (RECs or GOs purchased separately from the associated energy production) can undermine claims of additionality. The ample supply and resulting low prices for RECs/GOs further limits their support for the construction of new capacity. Therefore, while RECs and GOs provide a convenient way to lay claim to a share of the renewable energy supply, there is a risk of consumers claiming credit for renewable energy that is already being supplied or planned for service to other consumers.

In 2020, the Belgian renewable energy supplier Bolt returned 1,000 GOs to the Icelandic government in protest over the GOs’ potential adverse impacts on Belgium’s renewable energy market. Because all electricity in Iceland is renewable, no local GO market exists, and the country also is electrically isolated from the European power market. Yet, in accordance with EU market rules, GOs for electricity consumed in Iceland have been sold to suppliers of non-renewable electricity in Europe, enabling these suppliers to claim their product as “green energy” without any additional renewable energy being generated. Bolt claimed that this “greenwashing” both misleads consumers and undermines the actual renewable energy market in Belgium.

In other instances, the marketing of unbundled credits can lead to credits issued without the associated energy ever being produced. For example, in 2015 Luxembourg and the Netherlands had the highest share of consumers opting

for green tariffs, yet both countries lagged in meeting their renewable energy targets. Although energy suppliers in these countries were selling a high number of GOs to customers, this did not translate into added domestic renewable electricity generation.

Many large corporations have achieved their renewable energy targets through purchases of RECs/GOs. However, as other cost-competitive options for purchasing renewables have become available, corporate actors are shifting towards sourcing options that allow them to play a more active role in adding new renewable capacity to the grid. Corporate power purchase agreements gained considerable momentum in the late 2010s, particularly in the United States and Europe. Still, the additionality of some PPAs, especially off-site, has been brought into question.

For example, Dutch Railways (Nederlandse Spoorwegen, NS) states that its customers’ travel is “climate neutral” thanks to a recent offshore wind PPA. However, just over half of the company’s renewable energy demand is supplied by projects in the Netherlands, while the remainder comes from wind parks in Belgium, Finland and Sweden. These wind parks were tendered and subsidised by their respective national governments, which are bound by their own renewable energy and emission reduction targets. It is thus debatable to what extent the PPA that NS signed has led to additional renewable energy capacity, especially on the Dutch grid.

The additionality discussion has extended beyond electricity, particularly since late 2018 when the demand for “green gas” certificates and GOs started growing. In the United Kingdom, a consumer buying a green gas certificate cannot claim to have directly produced “additional green gas”. Because additionality is a difficult thing to prove under any circumstance, both credibility and transparency are key when making an additionality claim about renewable energy.

Source: See endnote 52 for this chapter.

Corporate actors

are shifting towards sourcing options that allow them to play a more active role in adding new renewable capacity to the grid.



Flevoland, Urk, Netherlands

POWER PURCHASE AGREEMENTS (PPAS)

Cities were responsible for thousands of megawatts of new renewable energy capacity procured through PPAs during 2019 and 2020, either already in operation or under development.⁵⁹ In the United States and Europe,

City actors have
signed PPAs

for increasingly large amounts of renewable energy for both municipal operations and city-wide use.

city actors have signed PPAs for increasingly large amounts of renewables for both municipal and community-wide use.⁶⁰ Most existing PPAs are for off-site capacity, although the use of PPAs for on-site urban projects also has increased, and municipal governments often stipulate that projects be constructed close enough to provide local jobs and other benefits.⁶¹ Towns and cities also have pooled their resources to negotiate more favourable terms.⁶²

For local governments in the United States, off-site PPAs between cities and developers of large-scale projects accounted for the vast majority (90%) of new renewable power capacity from 2015 to early 2020.⁶³ During 2019 and 2020, local governments in at least 11 states signed 57 PPAs for off-site projects, totalling more than 3,730 MW of capacity; of this, nearly 80% was solar PV and the rest was wind and geothermal power capacity.⁶⁴

Los Angeles (California) entered into a PPA in 2019 for what was then the largest solar and battery storage system in the country (400 MW / 1,200 MWh), at the then-lowest price for solar-plus-storage of less than 2 US cents per kWh.⁶⁵ Other US cities that have contracted for large solar capacity include Chambersburg (Pennsylvania), Cincinnati (Ohio) and Montgomery (Alabama).⁶⁶ In Florida, the first two (totalling 149 MW) of five planned solar PV plants began operating in 2020 under a PPA between the project developer and Florida Municipal Power Agency in partnership with 16 municipal utilities.⁶⁷ By aggregating the demand from multiple Florida cities, the project was able to deploy larger, more efficient facilities to minimise costs to consumers.⁶⁸

In Europe, the number of annual PPAs for solar PV at the municipal level increased six-fold between 2016 and 2018 – rising from 66 to 399 – but then declined to around 300 in 2019 and to just over 200 in 2020.⁶⁹ Examples include a PPA between London (UK) and Voltalia in 2020 for an off-site 49 MW solar farm in Dorset; a contract for a wind farm in Motilla del Palancar (Spain) designed to create local jobs and provide electricity to the city; and a PPA for one-third of the output of Åndberg wind farm in Sweden to provide 250 GWh annually to the municipal utility in Skellefteå.⁷⁰ City airports in Europe – such as Bristol Airport (UK) and Frankfurt International Airport (Germany) – also have signed PPAs for offshore wind power to meet their electricity needs.⁷¹

In Australia, PPAs negotiated in several major cities in 2019 and 2020 are aimed at helping to achieve ambitious renewable energy goals. Adelaide plans to power all of its municipal operations with solar and wind energy, and in Melbourne seven large energy consumers signed a joint 10-year wind energy contract.⁷² Sydney entered into a 10-year PPA requiring, among other things: that all solar PV and wind power projects be new capacity and located in New South Wales to reduce the marginal loss factor (particularly losses in electricity transmission) and create regional jobs; that the facilities achieve a combined 80% load matchingⁱ; to include a demand-response option for consumers; and that at least one project be community-operated.⁷³

OVERCOMING CHALLENGES: PARTNERING WITH STAKEHOLDERS AND TAKING CONTROL OF SUPPLY

Although city governments often are more active in supporting renewable energy than national ones, they also are limited by laws and regulations issued at the national and state/provincial levels. These higher-level policies and regulations, as well as decisions by utilities, can create roadblocks to cities' renewables goals and commitments.⁷⁴ Cities have sought to address these challenges in a variety of ways, including by: influencing policy or regulation at higher levels of government (often in partnership with other stakeholders); partnering with utilities; municipalising local utilities; and launching community choice aggregation programmes (→ see *Citizen Participation chapter*).

Influencing higher-level policy and regulations

Several city governments have engaged with or challenged higher levels of government to remove legislative or regulatory barriers to local renewable energy production and procurement. For example, in 2017, Cape Town challenged the government of South Africa in court to release the city from having to procure coal-fired electricity from the centrally controlled national energy utility (Eskom) and to enable it instead to procure electricity from independent power producers.⁷⁵ In late 2020, the country's Department of Mineral Resources and Energy took a landmark step by amending national electricity regulations to allow municipalities in good financial standing to deploy their own electricity generation projects (→ see *Feature chapter*).⁷⁶

City governments across the United States have partnered with community stakeholders, other cities and towns, and/or legislative or regulatory bodies at higher levels of governance to remove laws and regulations that restrict the deployment and use of renewables, or to enact new measures that encourage or require greater procurement of renewable electricity.⁷⁷ By one estimate, between early 2019 and early 2020, 24 US cities took at least 27 actions – including submitting comments on public utility commission proceedings, launching community choice aggregation programmes and formally partnering with electric utilities – to advance energy efficiency and renewables in the power sector.⁷⁸

i This means that the combined electricity output of the wind and solar power facilities should, on average, achieve an 80% match to the electricity load (demand) profile of the city.

The US state of Virginia until recently limited the ability of many communities to purchase renewable energy. In response, localities worked to influence state-level regulations and policies, engaging with utilities to develop green tariff options and to reduce premiums on renewable energy programmes, and pooling their buying power with other cities, corporations and universities to demonstrate strong local demand for renewables.⁷⁹ Partly as a result of such efforts, in early 2020 Virginia committed to 100% zero-carbon electricity by 2050 and removed key restrictions on solar PV installations for local governments, businesses and others.⁸⁰

Several cities have
challenged
higher levels of
government to remove
legislative or regulatory
barriers to local renewable
energy production and
procurement.

Partnering with utilities

Increasingly, city governments have leveraged their status as large electricity consumers (sometimes in partnership with other cities) and worked directly with investor-owned utilities to encourage them to increase renewable energy generation.⁸¹ A number of cities with renewable energy targets have formed productive partnerships with their local utilities, often collaborating to achieve shared goals for the deployment of renewables and energy efficiency technologies.⁸²

Minneapolis (Minnesota) was among the first large US cities to partner with local utilities on increasing renewable power capacity to achieve a 100% renewable energy goal.⁸³ Several cities have since followed suit. In 2019, Denver (Colorado) entered a formal partnership with the utility Xcel Energy to achieve shared energy and climate goals through energy retrofits and renewable electricity procurement.⁸⁴ In Utah, after a three-year collaboration, Salt Lake City, Park City and Summit County, along with investor-owned utility Rocky Mountain Power, announced the passage in 2019 of the state's Community Renewable Energy Act, which allows the utility to work with communities to tailor electricity portfolios to meet their renewable energy targets.⁸⁵

In several European cities – including Heidelberg and Munich (both Germany) – inhabitants are working with their municipally owned utilities to achieve renewable energy goals.⁸⁶ For example, Munich's municipal energy provider SWM is a co-owner of the DanTysk offshore wind farm, which is helping the city achieve its goal of being fully powered by renewable electricity by 2025.⁸⁷

Municipalising local utilities

City governments that own their own utilities – such as Austin (Texas, US), Basel (Switzerland), Copenhagen (Denmark), Munich (Germany) and many others – have greater control over their energy sources and can provide renewables to their customers directly.⁸⁸ Although municipal utilities may have less financial clout than their larger national or private counterparts, due in part to their smaller scale, they also have the potential to quickly implement goals that are aligned with customer demands.⁸⁹

Several cities have (re)municipalised their electricity systems (or debated doing so) in order to pursue renewable energy options.⁹⁰ In 2017, Barcelona (Spain) approved the creation of Barcelona Energia, the country's largest public electricity distributor.⁹¹ Barcelona Energia, whose mission includes promoting locally produced renewables, began supplying renewable electricity to city council buildings and facilities as well as other entities in 2018, and to the general public in 2019.⁹² Barcelona has inspired city councils in other Spanish cities, including Cádiz and Pamplona, to opt for similar models.⁹³ Additional cities that have pursued or considered (re)municipalisation include Berlin and Hamburg (both Germany), Hebron (State of Palestine), Madrid (Spain), and the US cities of Chicago (Illinois) and San Francisco (California) (→ see *Citizen Participation chapter*).⁹⁴

CONSUMPTION OF ELECTRICITY

Based on their estimated share of global energy demand (around 75%), cities may account for the same share of global electricity consumption (around 20,000 terawatt-hours, TWh).⁹⁵ Assuming that renewable electricity use in cities mirrors the global average share of supplyⁱ (an estimated 27.3%), then overall city consumption of renewable electricity could total around 5,500 TWh annually.⁹⁶ However, this figure may well be higher, to the extent that cities have successfully increased their renewable electricity supply relative to rural areas (through either committed external supply or local generation).

Differentiating city demand for renewable electricity from regional or national consumption patterns remains challenging, in part because most cities draw the majority of their electricity from regional or national grids. Even as more cities strive to increase their production and procurement of renewable electricity, city-wide accounting of renewable electricity consumption is lacking. In instances where cities do report this consumption, many (if not most)ⁱⁱ simply use local grid averages as a proxy for the city-wide electricity mix. Moreover, data on city-specific renewable energy achievements often refer only to the municipal load (city government and services) rather than to city-wide demand.⁹⁷

i This first-order estimate makes no adjustment for any structural differences in average electricity consumption patterns between urban and ex-urban/rural areas, between relatively city-oriented demand (e.g., wastewater treatment and water supply, street lighting and traffic signals, data centres and general cooling load) and perhaps more predominantly ex-urban activity, such as energy-intensive industry (e.g., metals manufacturing).

ii For example, data from CDP reflect that most cities that qualify/comment on their reported values note them as being regional or national values, based on local/regional grid data.

Further complicating the picture, city governments define their renewable energy commitments in different ways, with some specifying renewable shares of the electricity mix within a given time frame, some specifying commitments in terms of carbon reductions or carbon neutrality, and others specifying certain technologies. In some cases, cities have deployed solar and/or wind power capacity in connection with their wider city plans and have set targets to deploy even more (→ see **Reference Table R6**).

Cities that already have high or rapidly rising shares of renewable electricity use can be divided into two distinct groupings. In one group are cities that benefit from large existing or rapidly rising renewable electricity supplies on regional and national grids, regardless of their own efforts to affect change to the electricity mix. Where renewable supply is already high, this is often due to plentiful and economical hydropower. In such cases, further rapid expansion of renewable electricity use may be somewhat limited, although many cities – including Montreal (Canada), Oslo (Norway), Reykjavik (Iceland), São Paulo (Brazil), Seattle (Washington, US) and Zurich (Switzerland) – are filling in the balance of existing and incremental demand with new and diverse renewable electricity supplies.⁹⁸

In the other group are cities (and their surrounding areas) that are not endowed with grid-supplied hydropower but have greatly advanced their use of local renewable energy (particularly

solar PV and wind power) to achieve technical proficiency and economic competitiveness, sometimes despite substantial resource and cost constraints. Examples include many interior US cities, such as Austin and Dallas (both Texas), Denver (Colorado), Iowa City (Iowa) and Kansas City (Missouri), as well as Adelaide and Canberra (both Australia) and Copenhagen (Denmark).⁹⁹

In all cities, the renewable energy supply grows at least in proportion to the expansion of renewables on the regional grid, but additional local commitment further increases the renewable share for the city, and for the regional supply mix as well. Examples of this interaction between internal and external effects are found in the US state of Texas, where the regional renewable electricity supply expanded from 19% of net generation in 2019 to 22% in 2020.¹⁰⁰ This advancement is driven in part by local efforts and initiatives that directly affect both local and regional supply. Houston, located in Texas' oil and gas heartland, has increased its renewable energy use beyond grid-supply averages: in 2020, the city government began purchasing enough renewable electricity to meet its entire municipal requirements (around 3% of total city demand), in line with its Climate Action Plan.¹⁰¹ Meanwhile, Austin (Texas), which retains its own municipal utility and thus has significant autonomy in procurement decisions, exceeded the regional average to reach 43% renewable electricity consumption in 2019.¹⁰²



Lillehammer, Norway



Lofoten village, Norway

HEATING AND COOLING: PRODUCTION AND PROCUREMENT OF THERMAL ENERGY

Municipal governments and other city entities are deploying modernⁱ renewable energy systems to generate thermal energy for space and water heating as well as cooling in buildings, and for process heat in industry. Modern sources of renewable heating and cooling include direct thermal energy from renewable sources (through the combustion of solid, liquid and gaseous biofuels, as well as energy from geothermal and solar thermal sources) and renewable electricity, which is used to operate heating appliances, such as heat pumps.

Although urban production and procurement of renewable thermal energy is not at the scale of renewable electricityⁱⁱ in most cities, an increasing amount of direct thermal renewable capacity is being installed for use on-site, in stand-alone applications for individual buildings, and to feed into district energy systems that connect multiple buildings. Tracking these market trends and opportunities is difficult due to a lack of city-level data (and the fact that some heating and virtually all cooling consumption is electrically driven); however, new capacity has been added in cities around the world, driven by building mandates, fiscal incentives, and other support policies, as well as plans to phase out or ban the use of fossil fuels for heating (→ see *Urban Policy Landscape chapter*).¹⁰³

Stand-alone renewable energy systems use a variety of technologies and typically include solar thermal systems and modern biomass stoves and boilers (fuelled by, for example, wood pellets and forestry or agricultural residues, such as bagasse and straw). In addition, renewable electricity can be used to heat or cool with electrically driven appliances such as heat pumps. In urban areas, stand-alone systems have been installed on rooftops, façades and outside of buildings.¹⁰⁴

While thousands of stand-alone thermal systems have been deployed around the world, consolidated data on how many of these are in cities are not available. In China, the chemical company Solvay installed a biomass boiler at its facility in Zhangjiagang in 2019 to switch from natural gas to renewables, and six large solar thermal systems were completed in five other cities to provide hot water for schools (in Hangzhou and Zhejiang), an office building (in Shanghai) and several large blocks of flats (in Hangzhou, Linyi, Nanchang and Zaozhuang).¹⁰⁵ In Turkey, solar hot water systems have been installed at several prisons, including in Diyarbakir in 2019.¹⁰⁶ Stand-alone solar thermal systems also are popular in German cities, especially for multi-family buildings, with new projects completed in Heilbronn and Regensburg in 2020.¹⁰⁷

Markets for heat pumps have expanded rapidly, meeting an estimated 5% of the global heating demand for commercial and residential buildings in 2019.¹⁰⁸ Heat pumps require energy input (typically grid electricity) to power the transfer of thermal energy, which makes up a portion of the total energy output. For a heat source (or a heat sink in cooling mode), heat pumps can use ambient air, surface water bodies (lakes and rivers) or the ground

(whether dry or water-coupled to aquifers). Electrically driven heat pumps serve as a bridge between variable renewable electricity supply (mostly solar PV and wind power) and the demand for heat, which traditionally has been met mainly through the combustion of fuels. The benefit is two-fold: allowing variable renewable energy to supply the heat market, while allowing the heat market to act as a regulating demand-buffer, which helps integrate ever larger shares of variable renewables into the electricity mix.¹⁰⁹

Most heat pumps are relatively small stand-alone units serving individual or a small group of dwellings, although a growing number of district heat systems use heat pumps to tap low-temperature sources on a large scale, such as rivers or wastewater streams. Although both air- and ground-source heat pumps (the two most common applications) are very effective, ground-source units can have an efficiency advantage for heating because of the relative constancy of ground temperatures. In 2019, ground-source heat pumps represented 167 TWh (600 petajoules, PJ) of global heat supply.¹¹⁰

In October 2020, a ground-source heat pump was installed in the first of 60 existing homes in Blackbird Leys, Oxford (UK); the project's heat pumps are connected to a series of boreholes incorporating communal ground arrays.¹¹¹ Later phases in Oxford will see up to 240 new-build homes, and potentially various commercial properties, fitted with ground-source heat pumps.¹¹² Similar initiatives were implemented in Drammen (Norway) and in Glasgow (UK) in 2019.¹¹³ In Toronto (Canada) a ground-source heat pump system to provide heating and cooling for a new 600-unit apartment complex was completed in 2019.¹¹⁴ That same year, Belgrade (Serbia) presented its long-term district heating and cooling plan, which builds on large heat pumps.¹¹⁵



Tavira, Portugal

i Excluding the traditional use of biomass for heating and cooking. See Glossary for definition.

ii Note, however, that electricity accounts for the vast majority of global cooling demand, and for a growing amount of heating demand.

District energy systems, which provide thermal energy to residential, commercial, public and industrial buildings, generally are located in densely populated urban areas. Existing district heating and cooling systems can be upgraded, or new networks can be created, to enable the integration of renewable energy technologies. Renewable district heating and cooling can be provided by sustainable biomass, geothermal, solar thermal, renewable gases and heat pumps operated using renewable energy.¹¹⁶

District energy systems supplied around 6% of global heat consumption in 2018.¹¹⁷ Fossil fuels were the dominant energy source for district heating and cooling networks that year, with renewables accounting for only an estimated 8%.¹¹⁸ However, the renewable contribution is growing: between 2009 and 2018, renewable energy use for district energy increased more than two-thirds, due largely to the shift from fossil fuels to bioenergy in the EU.¹¹⁹ In addition, cities increasingly have used urban waste in waste-to-heat plants to deliver thermal energy through district networks, and have taken advantage of waste heat from industrial processes (which is primarily an energy efficiency measure).¹²⁰

Each district heating system differs in its use of renewable energy. Because virtually all district heat systems serve urban areas (where population density makes the systems economical), it can be assumed that virtually all energy use in such systems reported in national data represents the energy demand of cities.¹²¹ The Russian Federation and China dominate in total production of district heating (relying heavily on natural gas and coal), followed by Germany, the United States and Ukraine.¹²² In Iceland, renewable energy supplies nearly 100% of the country's district heating

needs and is derived mostly from high-temperature geothermal energy (plus some renewable electricity).¹²³ Other countries with high renewable shares in district heating include Sweden (69%), Denmark (58%) and Estonia (56%) (→ see Figure 13).¹²⁴

Although many cities are starting to use a diversity of renewable thermal sources (as well as renewably powered heat pumps) for district heating, **bioenergy** is the most widely used renewable energy source in these networks, with an estimated 95% share.¹²⁵ Europe is home to most of this capacity (representing 87% of all biomass used for renewable district heating), where it continues to expand.¹²⁶ In 2019, the local district heating network of Lyon-Confluence (France) was connected to the central network of Lyon, and a new 51 MW biomass plant was commissioned to supply the networks.¹²⁷ Salaspils (Latvia) inaugurated a wood chip boiler as well as a 15 megawatts-thermal (MW_{th}) solar field in 2019, which together meet 90% of the district heating demand.¹²⁸ The district heating system in Oslo (Norway), which covers a quarter of the city's total heating demand, has shifted almost entirely (around 99%) to renewables, including biomass from residual waste.¹²⁹

The number of **solar** district heating systems increased significantly in 2019, particularly in Denmark, Germany and China.

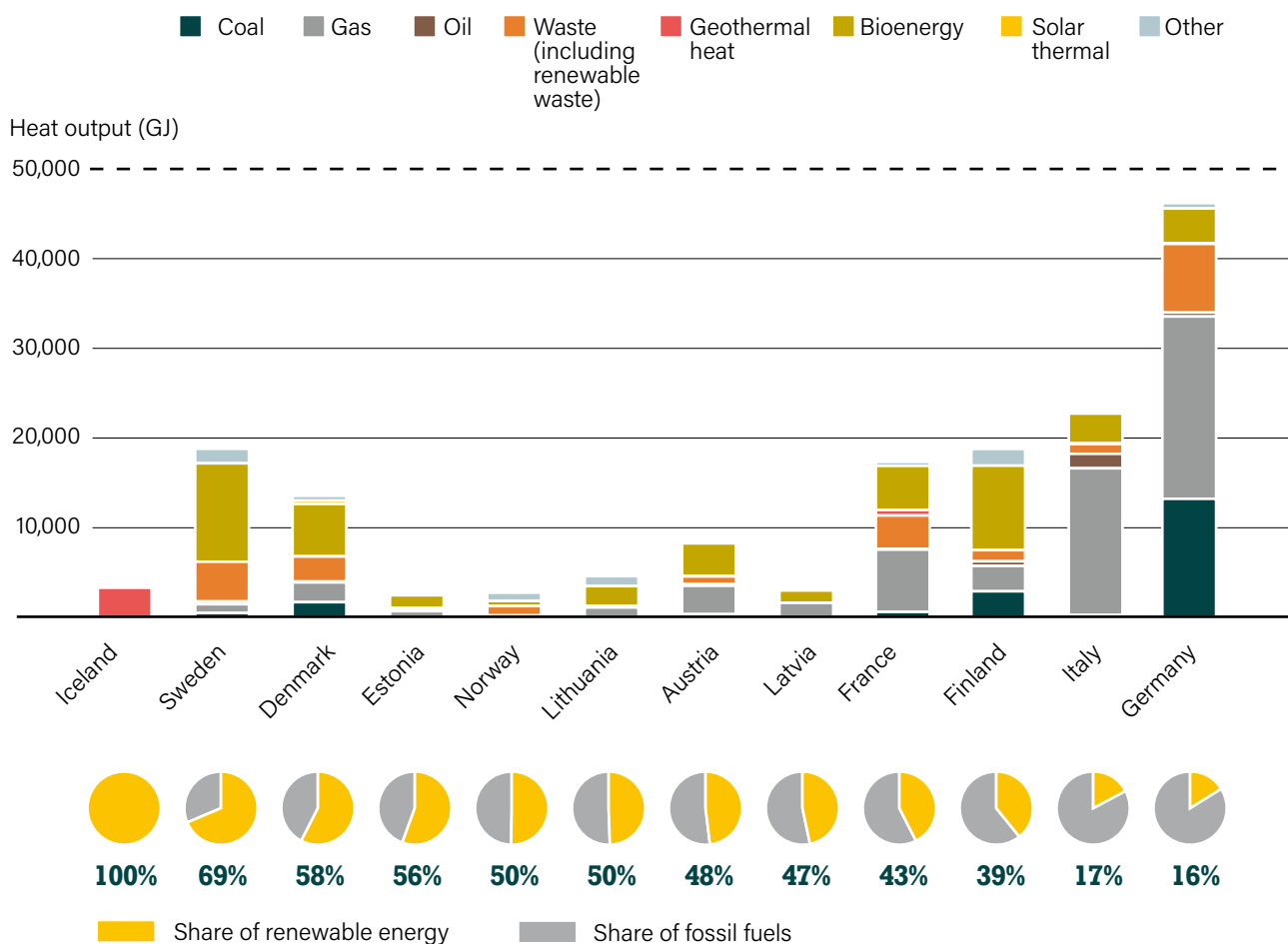
Cities are starting to use a diversity of renewable thermal sources in their

district heating networks.

3



Figure 13. Renewable Share of District Heating, by Fuel Source, Top Countries, 2018



Note: "Other" includes waste heat recovery, non-renewable electricity, nuclear and any source not otherwise accounted for.
 Source: IEA. See endnote 124 for this chapter.

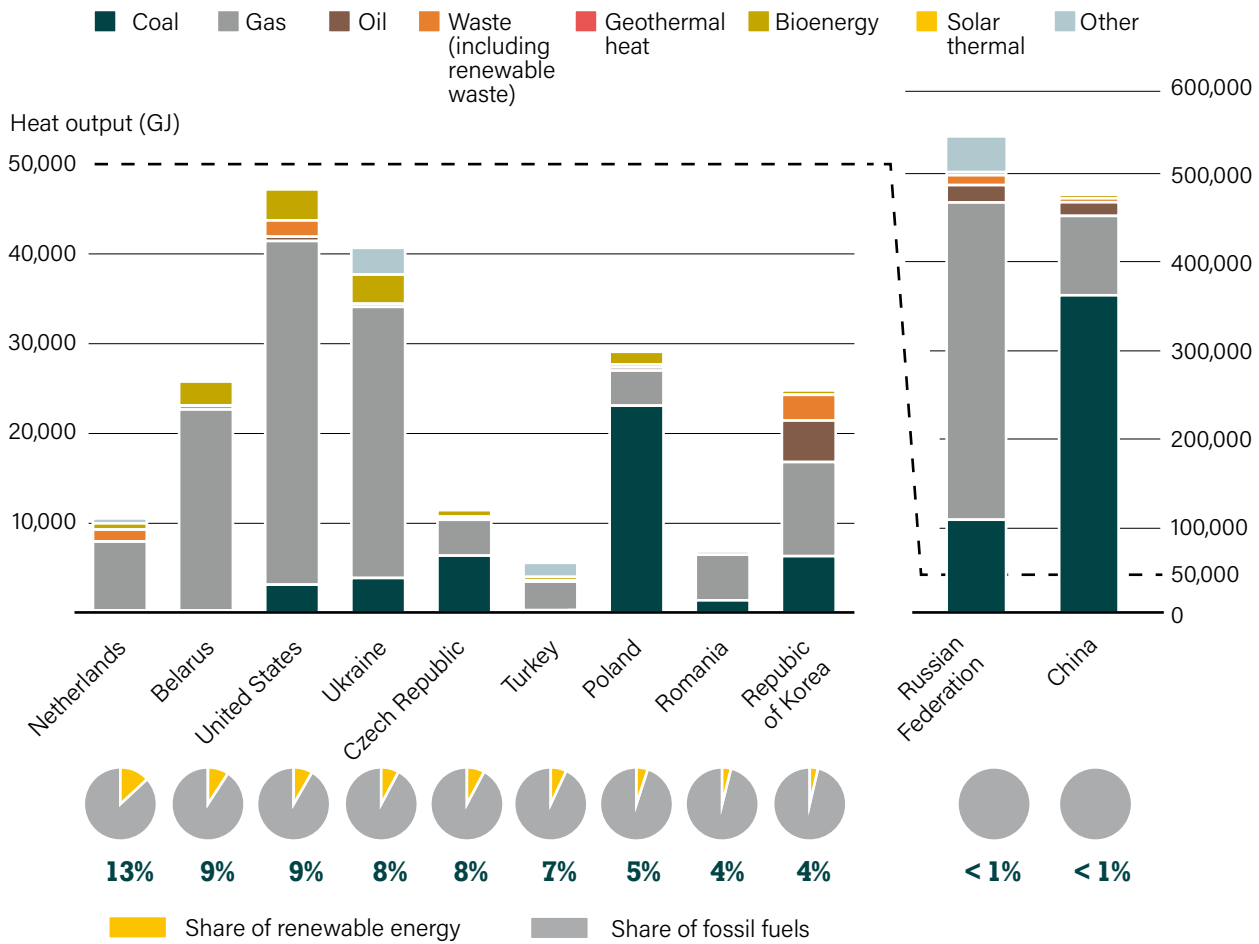
By year's end, at least 417 solar district heating and central hot water systems were in operation worldwide (up from 345 systems in 2018), with a cumulative capacity of more than 1.7 gigawatts-thermal (GW_{th}) (including glazed and concentrating solar thermal collectors).¹³⁰

In Denmark, the world leader in solar district heating capacity, 10 new plants were brought online in 2019 and 5 were expanded, for a total of 134 MW_{th} added; altogether, more than 113 Danish villages, towns and cities use solar heat in their district systems.¹³¹ In Germany, six new solar district heating systems (totalling 9.9 MW_{th}) were added in 2019, and the country's largest solar district heating plant (10.4 MW_{th}) was under construction in Ludwigsburg.¹³² In China, three solar district heating systems were commissioned in the Tibetan towns of Shenzha, Zhongba

and Saga in late 2019.¹³³ Additional projects under construction worldwide included solar fields in the district heating networks of at least three Croatian cities near Zagreb in 2020.¹³⁴

Direct useⁱ of **geothermal** energy can meet various thermal energy demands in cities, including space heating and hot water supply. In 2019, geothermal direct use capacity totalled an estimated 30 GW_{th}, supplying 117 TWh (421 petajoules) of thermal energy.¹³⁵ Direct use of geothermal energy harnesses medium- to high-temperature geothermal fluid either directly or by direct transfer via heat exchangers. The majority of high-temperature geothermal energy is devoted to space heating and personal hot water applications such as bathing and swimming, and can therefore be assumed to be concentrated in urban applications, predominantly using district heat systems.¹³⁶

i This does not include the use of shallow geothermal resources, specifically ground-source heat pumps, and the renewable portion of their final energy output. Direct use refers here to deep geothermal resources, irrespective of scale, that use geothermal fluid directly (i.e., direct use) or by direct transfer via heat exchangers.



The use of direct geothermal heat for district heating systems has increased, particularly in China and in several European countries, including Germany, Hungary and Sweden (→ see *City Snapshot: Malmö*).¹³⁷ China's largest geothermal heating system came online in Fengxi New City (Shaanxi province) at the end of 2019, providing water heating and space heating and cooling for a combined buildings area of around 1.6 million m².¹³⁸ Additional district heating projects, using deep rock geothermal and waste water, are being planned in Chanba (Xi'an).¹³⁹

In Munich (Germany), drilling was completed in early 2020 for a geothermal plant that exceeds 50 MW_{th}, which was expected to go online in 2021 and to supply heat for more than 80,000 residents.¹⁴⁰ In the Paris (France) region, district heating systems have gradually increased their geothermal heating capacity.¹⁴¹

Also in France, the community of Champs-sur-Marne launched a EUR 40 million (USD 45 million) district heating project in 2019, while Drancy and Bobigny started drilling four geothermal boreholes, with expected project completion in 2021.¹⁴² Szeged (Hungary) continued to expand its geothermal district heating plant, and as of 2019 geothermal energy provided heat for 23 Hungarian towns, in some instances supplementing heat from natural gas on existing networks.¹⁴³

Cities in Europe and in China have been increasing their geothermal heating capacity and use in district heating.

MALMÖ

SWEDEN

Land area
(km²)



76.8

Population size
(2018)



344,000

Greenhouse gas
emissions
(CO₂ equivalent)



52.7 million tonnes



The City of Malmö has a track record of urban development initiatives that have led to its recognition as a pioneering sustainable city. The most well-known examples in the city are the Western Harbour district (Västra Hamnen), which has operated on 100% renewables since at least 2012, and Augustenborgin, an industrial area that has 450 square metres of solar thermal panels connected to the central heating system.

Malmö's goal is to make all city government activities climate neutral by 2020 and to ensure that the entire city runs on 100% renewables by 2030. Malmö plans to achieve its 100% renewable energy goal from a mix of renewable sources, waste-to-energy and recycled energy. As of 2020, around 43% of Malmö's energy was from renewable sourcesⁱ, primarily wind energy.

The city has identified two challenging sectors that need to be addressed to stay on track to achieving the 2030 goal: transport and district heating. Sweden's substantial district heating network was built in the 1950s, and many cities in the country have extensive systems. Malmö's district heating system runs on a combination of biomass and fossil fuels. To help reduce fossil-based energy use, all of the municipalities in southern Sweden send their waste to Malmö, where it is processed and converted to heat that is fed into the district heating network. For example, at the Sysav waste-to-energy facility, the waste is reduced through thermal treatment processes to produce energy in the forms of electricity and heat.

Additionally, Malmö is constructing a 50 MW_{th} geothermal deep-heat plantⁱⁱ, which is expected to start operation in 2022. The city plans to build a total of five geothermal heat plants by 2028, each with an installed capacity of 50 MW_{th}, to replace the use of biofuels and biogas for heat generation. The estimated budget for this pilot project is EUR 5.4 million (USD 6 million), with the Swedish Energy Agency providing EUR 1.2 million (USD 1.34 million). The city's partners include E.ON, a privately owned energy supplier that is investigating the geological conditions, as well as the Swedish Geological Survey and the University of Uppsala.

Source: See endnote 137 for this chapter.

Malmö is replacing the use of biofuels and fossil fuels in heat generation with **geothermal heat** in order to achieve its energy and climate goals.

ⁱ This includes organic waste incineration and industrial waste heat.

ⁱⁱ Boreholes will be in the range of five to seven kilometres deep, and the temperature of around 160°C is expected to be sufficient to directly enter the district heating network. This project will be one of Europe's first geothermal power plants to extract heat from such a depth at the industrial level.



District cooling networksⁱ are less widespread than district heating but are present in cities around the world, including Berlin and Hamburg (both Germany), Dubai (United Arab Emirates), Geneva (Switzerland) and Toronto (Canada), all of which have had operational networks for years.¹⁴⁴ Momentum is growing to expand existing cooling networks and to commission new ones, especially in Southeast Asia, the Middle East and Africa (→ see *Distribution Infrastructure* section).

Although relatively few district cooling networks rely on renewables, there are some exceptions, and systems that use heat pumps offer the potential to operate with renewable electricity. For example, in addition to the new geothermal heating plant, the utility in Munich plans to expand the city's district cooling network, using absorption chillers coupled to the geothermal supply.¹⁴⁵

In 2019, Toronto (Canada) announced a new investment into its district cooling system (launched in 2004) utilising direct heat exchangers and the municipal water supply from Lake Ontario to cool hospitals, data centres, educational campuses, government buildings, and commercial and residential buildings.¹⁴⁶ In 2018, China's largest district heating and cooling network using river water and a water-source heat pump started running in public buildings in the Chongqing Jiangbeizui CBD, which covers more than 4 million m² of new residential areas.¹⁴⁷ However, such systems are mainly energy efficiency measures that displace energy demand rather than being examples of renewable energy use, with the exception of any renewables used to run heat pumps for cooling.

ⁱ District cooling networks are centralised systems that provide chilled water to air conditioning systems.

ⁱⁱ Hydrogen produced with renewable energy, also referred to as "green hydrogen". See Glossary for definition.

ⁱⁱⁱ These efforts have focused on promoting active modes of transport via the establishment of car-free zones and new infrastructure such as cycling lanes, bicycle parking and expanded walkways.

^{iv} Renewable diesel is a diesel substitute fuel made by treating animal and vegetable oils and fats with hydrogen, also known as hydrotreated vegetable oil (HVO) or hydrotreated esters and fatty acids (HEFA).

TRANSPORT

Globally, the share of renewable energy in transport was 3.7% in 2018, most of which was biofuels (3.7 exajoules, EJ) followed by renewable electricity (0.3 EJ).¹⁴⁸ The transport sector accounts for 29% of total final energy consumption and is responsible for 25% of global energy-related CO₂ emissions.¹⁴⁹

More and more cities around the world are working to increase local production and consumption of renewable energy carriers such as biofuels, renewable electricity and renewable hydrogenⁱⁱ in urban transport in order to reduce local air pollution and CO₂ emissions, and improve security of supply.¹⁵⁰

In 2020, the COVID-19 health crisis deeply affected urban mobility patterns, as large numbers of people avoided public transport and altered other transport-related behaviours.¹⁵¹ Lockdown measures resulted in sharp reductions in transport demand and in related air pollution in cities worldwide, prompting calls for a "green recovery".¹⁵² In response, several cities initiated or strengthened efforts to ensure that communities have access to safe, reliable, affordable and sustainable transportⁱⁱⁱ.¹⁵³

Although COVID-19 restrictions and recovery packages so far have not led to structural changes in the production and use of renewable fuels in cities, the purchase and use of electric vehicles (especially electric bikes) increased throughout 2020, as did the share of renewables in electricity generation.¹⁵⁴

PRODUCTION AND PROCUREMENT OF TRANSPORT FUELS AND ELECTRICITY

The majority of biofuels used in transport are **liquid biofuels**, namely ethanol (produced mostly from corn, sugar cane and other crops) and biodiesel (fatty acid methyl ester, or FAME, fuels produced from vegetable oils and fats).¹⁵⁵ However, the production of other diesel substitutes such as **renewable diesel**^{iv}, as well as **gaseous biofuels**, namely biomethane, is growing in many countries.¹⁵⁶ While most transport biofuel is produced outside of cities, organic waste generated in cities, including waste cooking oil, also is an important urban source of liquid biofuels and biomethane (→ see *Sidebar 5*).¹⁵⁷

Although the production of transport biofuel was deeply affected by the COVID-19 crisis, some positive developments occurred at the city level during 2020.¹⁵⁸ Public authorities in Mexico City (Mexico), in partnership with the National Polytechnic Institute, built a biodiesel production plant that uses waste cooking oil from local households, food manufacturing facilities and restaurants to produce 500 litres of biodiesel daily, with the aim of fuelling 200 public transport vehicles.¹⁵⁹ In Venice (Italy), waste cooking oil began being collected and transformed into biodiesel for use by the local

BOX 3. Water Transport in Cities

Waterways are an important part of transport infrastructure for many cities around the world. They expand the capacity of urban transport systems while re-directing some road traffic. City efforts to improve urban mobility are expanding to public ferries, water taxis and other boat fleets, with some of these vehicles shifting to renewable energy, including liquid biofuels, renewable electricity and renewable hydrogen.

Although biofuels represent a promising renewable solution to decarbonise water transport, most projects to date have focused on international shipping rather than on city boat fleets. Still, a few city-level examples exist. In 2017, the New York City Council (US) passed legislation encouraging the use of biodiesel to power the city's ferries, and in 2018 the Red and White Fleet – a sightseeing and cruise ferry business in the San Francisco Bay Area (California, US) – began operating a plug-in hybrid ferry running on 100% biofuel, as part of its commitment to have a zero-emission vessel fleet by 2025. In 2020, Copenhagen (Denmark) received delivery of five electric ferries that use renewable diesel for heating.

Several other electric ferry operations have embraced renewable electricity. In 2020, a solar-powered water taxi began operation in Nusa Penida (Indonesia), and renewably powered ferries were being developed to serve commuters in Cardiff-Bristol (UK) and resort guests in Bora Bora (French Polynesia). In 2017, India's first solar-powered commuter ferry started operations in the Alappuzha district of Kerala state, and in Europe a car ferry with 15 solar panels began navigating the Moselle River between Oberbillig (Germany) and Wasserbillig (Luxembourg).

Globally, around 185 battery electric vessels were operating or scheduled for delivery as of 2018, 58 of which were

passenger ferries. In 2020, two such ferries were being tested on the Chao Phraya River in Bangkok (Thailand), and once the trials are successful a new fleet of electric ferries is scheduled for roll-out in 2021 as part of a plan to cut air pollution and improve the city's image for visitors.

In Norway, several electric ferries rely on the country's high share of renewable electricity, and a new hydrogen-powered ferry is planned to start operating on the Hjelmeland-Skipavik-Nesvik route in Ryfylket in 2021. Another hydrogen ferry, being developed for the Oslo-Frederikshavn-Copenhagen route in Scandinavia, is expected to be fuelled with hydrogen produced by an electrolyser in Copenhagen (Denmark) using electricity from offshore wind turbines. In Brisbane (Australia), local companies began building fuel cell passenger ferries in 2020 that are expected to be fuelled with renewable hydrogen.

Source: See endnote 160 for this chapter.



transport company ACTV to fuel its lagoon boat fleet (→ see Box 3 for additional examples of the use of renewables in water transport).¹⁶⁰

Also in Italy, a former petrochemical plant in Gela was converted in 2019 into a renewable diesel production facility that can process up to 750,000 metric tonnes annually of used cooking oil, animal fat, other by-products and algae.¹⁶¹ In the United States, Neste (Finland) has partnered with the City of Oakland (California, US) since 2019 to fuel the city's fleet with renewable diesel made from used cooking oil and other waste material sourced from businesses in the surrounding metropolitan area.¹⁶²

Interest in **biomethane** has risen in several countries as well as in individual cities that aim to move towards a circular economy.^{i,163} In 2020, the number of operating biomethane plants worldwide (both biogas upgrading and biomass gasification facilities)

exceeded an estimated 1,000, with some 20% providing vehicle fuel, 60% injecting biomethane into the gas distribution network and the rest serving a variety of other local uses.¹⁶⁴ In 2020, a new biogas upgrading facility near Bakersfield (California, US) began using cow manure to produce biomethane to fuel heavy-duty trucks and buses.¹⁶⁵

Although the use of **renewable electricity** in transport remains low, a few cities began coupling their transport electrification efforts with renewables in 2020. In The Hague (Netherlands), a new solar PV park opened to offset the electricity needs of the inter-city rail line connecting The Hague, Rotterdam and Zoetermeer.¹⁶⁶ Poznan (Poland) announced plans to transform local organic waste into electricity to fuel the city's electric bus fleets.¹⁶⁷ In the United Kingdom, Abbey Ecosse Limited secured permission to build an anaerobic digester and biomass boiler plant

i A circular economy is a closed-loop system in which the waste from one process is a resource that can be used as input for another. By having a flow of resources that is circular rather than linear, the production of waste is eliminated. See Glossary.

near Thurso (Scotland) that will use the waste from whisky distillation to produce biogas to generate electricity for EV charging in Caithness County.¹⁶⁸

Although more than 98% of today's **hydrogen** is produced from fossil fuels, interest in using renewable electricity for this process (currently less than 1%) is rising.¹⁶⁹ Several cities have turned to renewable hydrogen for transport fuel. In Fukushima (Japan), Toshiba and partners completed a 10 MW electrolyser in 2020 that uses electricity from solar PV to produce hydrogen for transport use.¹⁷⁰ Also that year, a consortium of businesses announced plans to build a 10 MW electrolyser to produce renewable hydrogen for fuelling buses and trucks in Copenhagen (Denmark).¹⁷¹

Hydrogen projects were under way at several urban ports during 2020. In the United States, a 2.3 MW hydrogen plant was being built to supply renewable hydrogen to Toyota's facilities at the port of Long Beach (California) and to fuel the company's fuel cell trucks and consumer vehicles.¹⁷² The Port Authority of Santa Cruz de Tenerife (Spain) partnered with Hyundai Canarias and Enagás to build a facility to generate renewable hydrogen for transport use.¹⁷³ In the Arabian Sea port of Duqm, in Oman's Al Wusta governorate, a Belgian company was conducting a feasibility study in 2020 to build a hydrogen production facility powered by solar PV and wind energy.¹⁷⁴

Although many cities continue to support the production and use of biofuels,

electrification of transport

has been expanding rapidly.

CONSUMPTION OF TRANSPORT FUELS AND ELECTRICITY

Urban transport consists of two main groupings: *passenger transport* – which includes rail (light rail and metro), road transport (buses, cars, two- and three-wheelers) and water transport (public ferries and water taxis) – and *freight transport*, including light-duty commercial vehicles and heavy-duty trucks. In 2015 (latest data available), urban transport accounted for around 40% of the energy used in the transport sector and contributed an estimated 37% of transport-related CO₂ emissions (32% from urban passenger transport and 5% from urban freight).¹⁷⁵

In some cities, the transport sector consumes more energy than do the buildings or industry sectors, highlighting the importance of integrated measures to reduce transport demand, shift to more efficient modes, and transition to renewable fuels and electricity.¹⁷⁶ Despite recent efforts to develop local urban capacity to produce renewable energy carriers for transport, most cities continue to source their fuels and electricity from beyond city limits.¹⁷⁷ Of the energy carriers used in urban transport, biofuels and hydrogen are used mostly in heavy-duty transport (such as buses and trucks), whereas electricity use has now expanded beyond rail to all modes of public and private transport (→ see Figure 14).¹⁷⁸

URBAN RAIL TRANSPORT

Rail boasts the highest renewable energy share of any transport sector, at 11%, and virtually all urban rail networks are powered by **electricity**.¹⁷⁹ As of 2019, nearly 200 cities worldwide had metro systems (with a combined track length exceeding 32,000 kilometres), and more than 220 cities had light rail systems (another 21,000 kilometres).¹⁸⁰ The length of urban rail lines expanded 3.5% annually on average between 2010 and 2019, with new metro systems opening in 46 cities (34 of them in Asia) and new light rail systems launched in 65 cities (28 in Europe and the rest split roughly evenly among Asia, North America, and the Middle East and North Africa).¹⁸¹ Sub-Saharan Africa's first light rail systems entered into operation in Ethiopia in 2015 and Nigeria in 2018.¹⁸²

As the most electrified transport sector, rail has benefited from rising renewable energy shares in the electricity mixes of many countries.¹⁸³ To specifically cover the electricity demand of their metros and trains, some city authorities also have started to install their own distributed renewable power capacity or to purchase or contract for new or existing renewable capacity, as has occurred in Delhi and Nagpur (both India), London (UK), Medellín (Colombia), Santiago (Chile), São Paulo (Brazil), Seattle (Washington, US) and Utrecht (Netherlands).¹⁸⁴

To date, the testing of **hydrogen**-powered trains has focused mostly on regional/inter-urban systems, including in northern Germany and in the Dutch province of Groningen.¹⁸⁵ In Groningen and Friesland (Netherlands), some inter-urban trains also run on **biodiesel**.¹⁸⁶ In the United Kingdom, the first **biomethane**-fuelled trams started testing in Birmingham and in Warwickshire county in 2020.¹⁸⁷



Hamburg, Germany

URBAN ROAD TRANSPORT: PASSENGER VEHICLES

Road transport contributes to urban congestion and local air pollution, leading to varying health impacts.¹⁸⁸ The severity of these impacts has driven municipal governments and other urban actors to pursue measures such as banning the circulation of fossil fuel vehicles, shifting to electric vehicles and encouraging the use of more-efficient transport modes such as renewables-based buses, among others (→ see *Urban Policy Landscape chapter*).

Buses

By 2020, over 3 million city buses were in circulation worldwide.¹⁸⁹ Diesel remained the most popular bus fuel, used in more than half of the world's buses, followed by electricity (17%), compressed natural gas (10.5%) and biodiesel (4.1%).¹⁹⁰

During 2019 and 2020, some cities launched bus fleets that run on **biofuel** blends (although many more cities have opted for electric buses). In 2019, Shanghai (China) started a programme to run 2,000 city buses on B5ⁱ, and Trondheim (Norway) began operating nearly 200 city buses able to be fuelled with biogas or biodiesel.¹⁹¹ As of early 2020, all of the buses in Tartu (Estonia) were running on biomethane, making the city one of only a fewⁱⁱ in Europe with a 100% renewably fuelled public transport system.¹⁹² Several US cities started fuelling their buses using biodiesel (produced outside of the urban area) – including Columbia (South Carolina) in 2019 and Grand Forks (North Dakota) in 2020.¹⁹³

As of 2019, around half a million **electric** buses were in circulation globally (→ see *Figure 15*), 98% of which were in China and most of which were operating in cities.¹⁹⁴ Although new electric bus registrations declined some 20% overall in 2019 (relative to 2018), due mainly to China's gradual phase-out of subsidies, the number of new electric buses procured in cities outside of Chinaⁱⁱⁱ continued to increase.¹⁹⁵ Since many cities have high and/or rising shares of renewable electricity, the electrification of buses brings opportunities for increasing the share of renewable energy in transport.



Sanya, China

During 2019 and 2020, new electric buses started circulating in many European cities, including Hamburg (Germany), London (UK), Milan (Italy) and Warsaw (Poland).¹⁹⁶ The transport provider Qbuzz in Utrecht (Netherlands) acquired 55 electric buses in 2019 that are charged using locally produced solar electricity.¹⁹⁷ The electrification of bus fleets also was under way in several US cities, with Portland (Maine) introducing new electric buses that run on 100% wind energy, and Gulfport (Mississippi), Jackson (Wyoming) and Wichita (Kansas) rolling out their first electric buses (as did the Canadian city of Brampton (Ontario)).¹⁹⁸

Some of Latin America's most populous cities – including Bogotá (Colombia) and São Paulo (Brazil) – have started to electrify their bus fleets to address local air quality concerns.¹⁹⁹ By late 2020, an estimated 1,229 electric buses were in operation in 10^{iv} countries across the region.²⁰⁰ Santiago (Chile)^v, with 452 electric buses, reportedly had the largest electric urban bus fleet outside of China.²⁰¹

Several cities in India – including Ahmedabad, Bengaluru, Delhi, Gurugam and Pune – increased the number of electric buses in circulation due to procurement programmes launched in 2019 and 2020.²⁰² In some cases, developing-country cities rely on their national governments to buy electric buses for use in urban fleets. As of 2019, the Philippine government had introduced 90 electric jeepneys with integrated solar PV in the city of Tacloban to replace the ageing combustion engine fleet.²⁰³ In Cairo (Egypt), the first electric bus line was launched in 2020 as part of a nationally led initiative.²⁰⁴

A few city governments have ordered both biodiesel and electric buses. In 2019, Gothenburg (Sweden) placed the largest single order for electric buses in Europe (157 buses) as well as an order for 27 biodiesel buses, and the RATP Group in Paris (France) started converting all city bus depots to support fleets running on electricity and biogas.²⁰⁵

Several Asian (particularly Chinese) and European cities have begun adopting **hydrogen** fuel cell buses, but so far only a few operate on hydrogen produced with renewable electricity.²⁰⁶ Zhangjiakou (Hebei Province, China) is a renewable

The electrification of bus fleets around the world brings opportunities for increasing the share of renewable energy in transport.

hydrogen demonstration zone, with more than 70 fuel cell transit buses running on renewable hydrogen since late 2018.²⁰⁷ In Aberdeen (UK), the first green hydrogen-powered double-decker buses started operating in 2020.²⁰⁸

i 5% biodiesel blend in petrol.

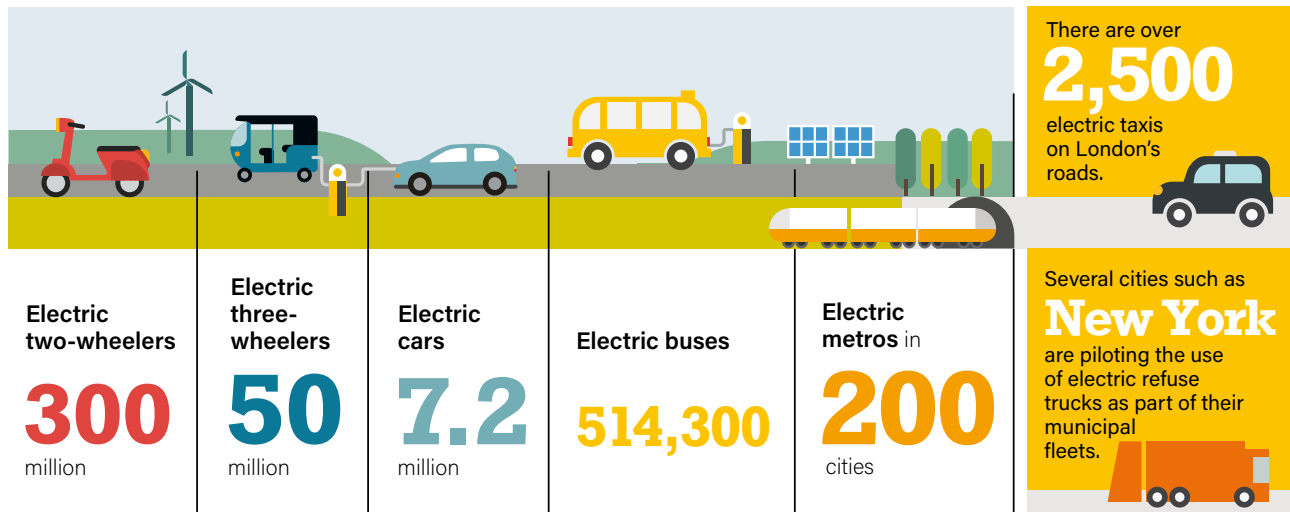
ii For example, in Stockholm (Sweden), all urban rail systems and buses have been using 100% renewable energy since 2017. Oslo (Norway) had a target to fuel all public transport with renewable energy by 2020. See Smart City Sweden, "Sustainable Public Transport in Stockholm", <https://smartcitysweden.com/best-practice/368/sustainable-public-transport-in-stockholm>, viewed 26 January 2021, and Oslo, "Public transport in Oslo", <https://www.oslo.kommune.no/politics-and-administration/green-oslo/best-practices/public-transport-in-oslo>, viewed 26 January 2021.

iii In 2019, 95% of new electric bus registrations were in China, compared to 98% in 2018. See International Energy Agency (IEA), *Global EV Outlook 2020* (Paris: 2020), <https://www.iea.org/reports/global-ev-outlook-2020>.

iv Argentina, Brazil, Chile, Colombia, Ecuador, Mexico, Panama, Paraguay, Peru and Uruguay.

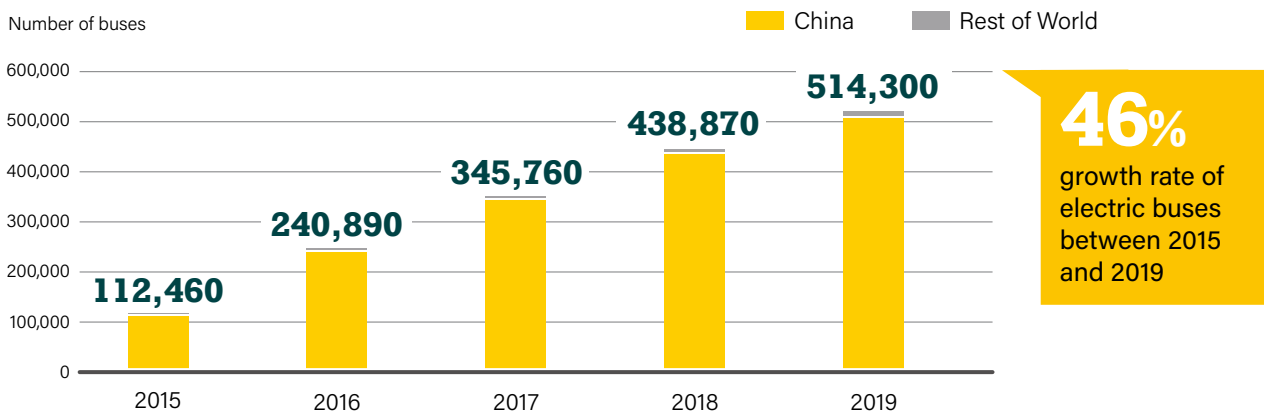
v The renewable share of electricity generation in Chile was 45% in 2019; calculated based on IEA, "Chile", <https://www.iea.org/countries/chile>, viewed 10 December 2020.

Figure 14. Global Electric Vehicle Markets in Cities, 2019

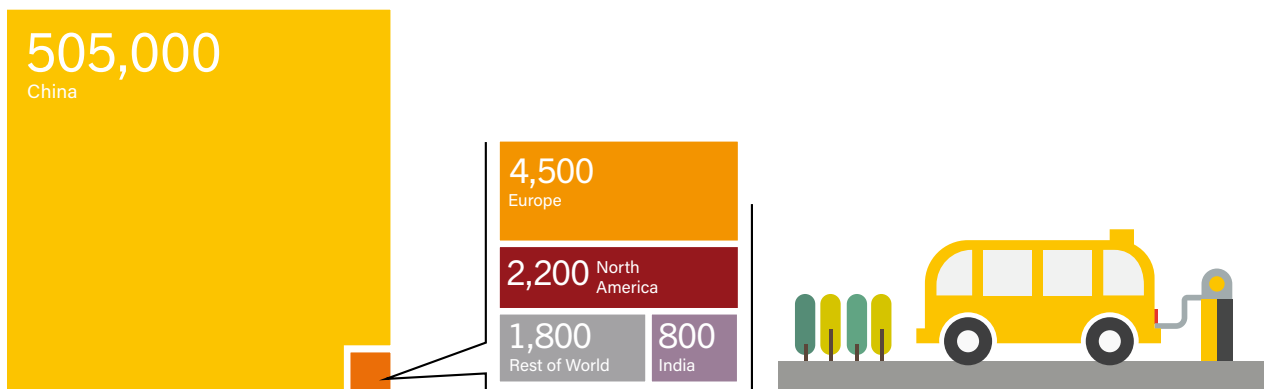


Source: Based on IEA data. See endnote 178 for this chapter.

Figure 15. Global Electric Bus Stock, China and Selected Regions, 2015-2019



Number of electric buses, 2019



Note: Discrepancies related to values reported in IEA's *Global EV Outlook 2020* are due to rounding.

Source: IEA. See endnote 194 for this chapter.

Passenger cars

Cities also have been exploring ways to encourage the use of renewable fuels and/or alternative propulsion technologies for passenger cars, to address the negative impacts associated with motorised individual transport, including associated air pollution and related illnesses (and fatalities).²⁰⁹

Although the number and share of **electric vehicles** on the world's roads is still small relative to vehicles with internal combustion engines, annual sales are increasing rapidly, and the EV share of the fleet is also rising. Electric cars accounted for 2.6% of worldwide car sales and for around 1% of the global car stock in 2019.²¹⁰ By year's end, an estimated 7.2 million electric carsⁱ were on the road, up 40% from 2018.²¹¹ A large portion of these vehicles were being operated in cities. The leading cities for passenger EV sales in 2019 were all in China (Shenzhen with 81,427 units sold, Beijing with 80,567 and Guangzhou with 72,270), while the leaders in the share of new passenger EVs sold were Oslo (Norway) at 64%, San Jose (California, US) at 20% and Shenzhen (China) at 19%.²¹²

In some cities, municipal governments or private companies have made EVs available to residents and visitors via carsharing programmes; while some of these vehicles are offered for free public use (as in Trikala, Greece), others are for hire (as in Los Angeles (California, US) and Bristol (UK)).²¹³ The market for carsharing (as well as ridehailing services) has continued to grow, as has the industry's interest in electrification. A few companies – including WeShare in Berlin (Germany) and We Drive Solar in Utrecht (Netherlands) – procure renewable electricity for charging their electric fleets.²¹⁴

Electric taxis have been in use for several years in cities worldwide, including Columbus (Ohio, US), Hong Kong, Macao and Shenzhen (all China), London (UK), Nairobi (Kenya) and New York City (US).²¹⁵ In 2019, India's Energy Efficiency Services – responsible for managing procurement programmes for government vehicles – was seeking to lease EVs to cab companies due to delays in integrating them into public fleets.²¹⁶ Also that year, four electric taxis started trials in Kigali (Rwanda) as part of the Moving Rwanda Initiative.²¹⁷ In Canada, the electric taxi service Téo Taxi put 55 EVs on the roads of Gatineau and Montreal in 2020.²¹⁸

Passenger cars account for the majority of **hydrogen** fuel cell vehicles. In 2019, some 10,500 fuel cell vehicles were sold, for a total global stock of 22,350 vehiclesⁱⁱ (up from 5,800 vehicles sold and 12,950 total stock in 2018).²¹⁹ The hydrogen car market remains concentrated in California (US) – particularly in Greater Los Angeles and the San Francisco Bay Area – and a few pilot projects are under way in some European cities.²²⁰ The taxi company Hype rolled out 100 hydrogen taxis in Paris (France) in 2019, with the goal of achieving a total of 600 in 2020, and a fleet of hydrogen taxis started operating in Copenhagen (Denmark) in 2019 using locally produced renewable electricity.²²¹

i Including battery electric, plug-in hybrid electric and fuel cell cars.

ii Including passenger cars, buses and trucks.

iii See Glossary for definition.

iv See Glossary for definition.

v See Glossary for definition.

Two- and three-wheelers / Micromobility

The number of **electric** micromobilityⁱⁱⁱ vehicles in use has expanded rapidly, with more than 350 million electric two- and three-wheelers in circulation in 2019, up from 300 million in 2018.²²² Although heavily concentrated in China, electric scooters, electric-assist bicycles and electric mopeds were present in over 600 cities in more than 50 countries, including in Europe, India and the United States.²²³

In a small but growing number of cities, electric two- and three-wheelers are being charged using renewable energy. Solar-powered hybrid rickshaws started operating at the Indian Institute of Technology's Delhi campus in 2019.²²⁴ In Kampala (Uganda), motorcycle taxis ("boda bodas") began relying on a network of solar-powered charging stations in 2020, and in Windhoek (Namibia) the local company Ebikes4Africa produces SunCycles, or electric bicycles powered by solar energy.²²⁵

URBAN ROAD TRANSPORT: FREIGHT

Freight traffic accounts for a large share of urban traffic volume, contributing to air and noise pollution.²²⁶ Urban freight transport^{iv} involves mainly road-based vehicles, specifically light commercial vehicles* (such as vans) and heavy-duty trucks.

Light commercial vehicles

Around 380,000 light commercial **electric vehicles** were operating in 2019, often as part of company or municipal fleets circulating in cities.²²⁷ China had the largest fleet of electrified light commercial vehicles worldwide in 2019, with 65% of the global stock, followed by Europe (31%).²²⁸

Numerous fleet owners switched to EVs for delivery services in 2020, and some coupled these vehicles with renewable energy. In 2020, the e-commerce delivery company Sendle (Australia) rolled out electric delivery vans powered by a rooftop solar PV system in western Sydney.²²⁹ In the United Kingdom, the Royal Mail announced plans to trial a new electric van for deliveries across several cities, and the retailer John Lewis (which also operates the supermarket chain Waitrose) announced plans to transition its delivery fleets to electric in 2021, starting with 1,700 electric vans.²³⁰ The Dutch supermarkets Albert Heijn and Picnic and the parcel delivery services DHL and PostNL were using various types of light-duty EVs in cities across the Netherlands during 2020.²³¹



Cardiff, Wales, United Kingdom

Heavy-duty trucks

Trucks remain the dominant mode for transporting goods in cities, and the rise in urban energy use in recent years is attributed in part to the growing demand for delivery services in city centres. To address this challenge, municipal services, private companies and others have worked to mitigate the social and environmental impacts of truck traffic through the use of renewable fuels and electrification.²³²

Truck fleets in numerous cities have begun using **biofuels**. As of 2019, the municipally owned Orlando Utilities Commission (Florida, US) was using biodiesel (B20) to reduce greenhouse gas emissions from its 775 trucks, and in Hong Kong (China) the restaurant group Maxim's partnered with Shell (Netherlands) to launch a pilot programme to fuel more than 100 delivery trucks with biodiesel produced from used cooking oil.²³³ In 2020, 22 new biogas refuse trucks entered into circulation in Esbjerg (Denmark), and in the Netherlands the fast food retailer McDonald's partnered with Neste (Finland) to recycle used cooking oil into renewable diesel to fuel delivery trucks in Dutch cities.²³⁴

Increasingly, city actors are exploring the **electrification** of heavy-duty freight vehicles. Although global sales of refuse collection trucks (which reached 62,155 units in 2018) continue to be dominated by internal combustion vehicles, support for electric refuse trucks is growing in cities worldwide due to favourable government policies, product innovation and the push for environmental sustainability.²³⁵ In China, the shift from conventional heavy-duty trucks is mostly towards battery electric alternatives, used primarily for refuse collection and other municipal operations.²³⁶ In 2018, the Chinese manufacturer BYD was contracted to deliver 500 electric refuse trucks to operate in its home town of Shenzhen.²³⁷

In the United States, Los Angeles and Sacramento (both California) began operating small fleets of electric refuse trucks in 2019, and the waste management company Recology acquired its first electric refuse truck in Seattle (Washington) that year.²³⁸ In Australia, electric refuse and recycling collection trucks went into service in Adelaide, Casey and Yarra during 2020, with the electricity used for recharging Adelaide's truck being offset by a 36 kW solar PV system.²³⁹

Progress with electric trucks in Europe has been limited, with most deployments still in demonstration and customer trials.²⁴⁰ A fully electric 16-tonne truck designed for inner-city freight deliveries began trialling in London (UK) in 2020.²⁴¹ Also in the UK, the contractor responsible for waste management in Manchester concluded an agreement to purchase 27 new electric refuse collection trucks to replace their diesel predecessors.²⁴² Several pilot projects involving hydrogen fuel cell waste collection trucks also were active in European cities, including in Eindhoven and Veldhoven (both Netherlands).²⁴³

The use of
**renewable
fuels and
electricity in
trucks**

has been slowly gaining momentum.

DISTRIBUTION INFRASTRUCTURE

No city is an island in the context of energy procurement and use. All cities are physically tied to and reliant upon a larger regional network of energy systems, infrastructure and supply lines. Cities rely on the territories that surround them not only for the bulk of their energy supply, but also to manage and balance the flow of energy with the pulse of activity within city limits. Typically, the larger a city is, the larger are its interactions with wider energy systems and infrastructure.²⁴⁴

As cities pivot their energy procurement towards renewable sources (sourced from within and outside of city boundaries), their interactions with and requirements from regional energy systems and infrastructure may change – with significant implications that go well beyond city boundaries. Likewise, external changes in supply and infrastructure affect cities in ways beyond their control.

In some instances, such shifts may create relative system redundancies that represent economic sunk costs – both within and outside the city – in infrastructure networks that were built over many years to accommodate a different energy mix and supply structure.²⁴⁵ In other cases, a relatively rapid, large-scale transition to renewable energy may hit system shortages and economic constraints, such as physical or technical bottlenecks that disrupt the orderly flow of energy. For example, growth in distributed electricity generation may either relieve or overload local distribution capacity during different time periods.²⁴⁶



Strømmen, Norway



Amsterdam, Netherlands

The distribution infrastructure relevant to cities pursuing renewable energy is varied. The physical elements include mainly wires and pipes (both within and outside of cities) as well as rail systems, road transport, ships and barges. Transmitting renewable electricity from centralised generation facilities requires high-voltage lines and then sub-stations where the electricity is stepped down to lower voltages to serve urban customers with varying voltage requirements. Alternatively, distributed (often low-voltage) renewable electricity can feed the distribution system directly, sometimes entirely off the network (behind the meter).²⁴⁷

Renewable fuels – whether gaseous, liquid or solid – are distributed by pipelines or vehicles, sometimes blended with non-renewable fuels (such as methane mixed with natural gas and ethanol blended with petrol). Secondary distribution systems carry transformed renewable energy for specific applications within cities. For example, district heating networks carry usable thermal energy that has been acquired from primary (such as renewable fuels or geothermal heat) or secondary renewable sources (such as the output of heat pumps driven by renewable electricity).

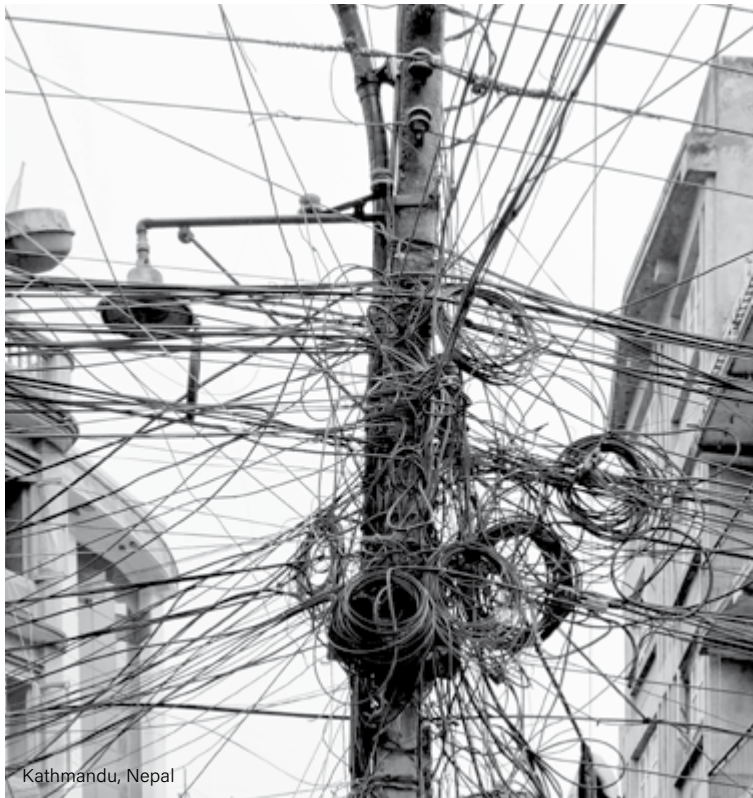
Some of the distribution infrastructure does not carry any energy but instead assists in the proper function and efficiency of the wider distribution network. Examples include storage facilities (such as tanks and batteries), metering devices that keep track of the energy flow and allow for the efficient allocation and distribution of energy (for example, “smart” meters), energy transformation devices (such as transformers, boilers, fuel cells and heat pumps) and system control infrastructure (for example, telecommunication systems and dispatch centres).

In 2019 and 2020, cities worldwide took steps to: address challenges to local and regional electricity distribution infrastructure (for example, by upgrading existing assets or deploying battery storage capacity); expand existing district heat networks or commission new systems that rely (at least in part) on renewable thermal energy or on heat pumps powered by renewable electricity; and install electric vehicle charging stations, including some that deliver 100% renewable electricity.

ELECTRICITY DISTRIBUTION

A city's electricity distribution grid is tied to, and dependent on, a larger regional or national power grid. Therefore, all city actions related to the procurement and use of electricity have implications for the broader electricity system.

In the case of distributed generation within city limits, the build-up of resources such as rooftop solar PV systems and electricity storage may relieve existing constraints on the regional transmission system and reduce excessive load on the local distribution system. However, rapidly expanding distributed (and variable) generation without also expanding system flexibility can create new challenges for the distribution network (→ see *City Snapshot: Oxford, and Citizen Participation chapter*).²⁴⁸



Kathmandu, Nepal

City actions

related to the procurement and use of renewable energy have implications for the broader electricity system.



Delhi, India

OXFORD

UNITED KINGDOM

Land area
(km²)

45.6

Population size
(2019)



152,450

Greenhouse gas
emissions
(CO₂ equivalent)



718,082 tonnes



In January 2019, Oxford City Council unanimously declared a climate emergency in Oxford and agreed to create a Citizens' Assembly to help consider new carbon targets and additional measures to reduce emissions in the city. As a result, Oxford aims to become a net-zero carbon emitter by 2030, a full 20 years ahead of the UK national target. In addition, Oxford City Council pledged to achieve net-zero carbon emissions in its own operations by the end of 2020, after the Citizens' Assembly requested such a move. Oxford City Council is a member of Low Carbon Oxford, a network of 40 public and private organisations that aimed to reduce city-wide emissions 40% below 2005 levels by 2020. Oxford also is part of the UK100, a network of local government leaders who have pledged to shift to 100% clean energy by 2050.

To decarbonise energy in transport and heat systems (the major sources of carbon emissions in Oxford) and to achieve the 40% emission reduction, the City Council has facilitated an energy storage project, the Energy Superhub Oxford (ESO). It is expected to be the world's largest hybrid energy storage system, with a 50 MW grid-scale batteryⁱ that will support a 10-kilometre network of EV charging points and ground-source heat pumps for around 300 households.

The ESO project, which started construction in 2020, will help reduce 20,000 tonnes of CO₂ annually by 2021 and 44,000 tonnes of CO₂ annually by 2032. The project will be capable of integrating multiple sources of energy to manage energy demand, including renewables. Because Oxford is part of the UK100 network, by 2050 the ESO is to run entirely on renewable energy.

The GBP 41 million (USD 53.8 million) project will help accelerate the use of electric vehicles in Oxford, by providing charging points powered by the spare capacity of the battery to City Council depots and key businesses including local bus companies, taxi providers and commercial fleet depots. The project also aims to develop the first rapid charging hub in Oxford, making available around 20 ultra-rapid EV chargers for public use. Charging speeds will range between 10 and 30 minutes.

The project scope also includes a "Trial before you buy" programme by the City Council for taxi drivers in Oxford. This will help the taxis transition from 100% diesel to 100% electric by 2025. In total, the ESO pilot project will last for 36 months; once successful, the technology is to be expanded to up to 44 other sites across the United Kingdom.

Source: See endnote 248 for this chapter.



ⁱ The battery, connected to the Cowley sub-station in Blackberry Lane, South Oxford, will store and deliver electricity (including renewable electricity) to electricity suppliers and help balance the local requirements for the grid. Electricity will be stored at times of low demand and then resupplied back to the grid when demand peaks. The technology is capable of shifting demand to periods of low prices, minimising consumers' energy bills and overcoming local network constraints.

Procuring electricity via power purchase agreements for renewable projects outside of city limits may create or exacerbate constraints in the regional transmission system, depending on the scale and location of the renewable capacity under contract. Likewise, because most such PPAs are for electricity generated by solar PV or wind power facilities, system operators need to balance the variability of the contracted resources against other system resources across the regional or national control area.²⁴⁹

When city governments set targets to achieve a 100% renewable electricity supply by a future date, this allows time for planning the required resource commitment and any needed strengthening of energy infrastructure, in co-operation with regional regulators and system planners and operators. Moreover, once the newly committed off-site renewable generating capacity is built and interconnected to meet a city's energy needs, it typically serves not only the city but also the wider regional power grid as an interconnected resourceⁱ. Importantly, the city (with the assistance of the local utility and system operator) needs to ensure that the electricity purchased has somewhere to flow when it is generated.

In 2019, Salt Lake City (Utah, US) and more than 20 nearby communities entered into an agreement with the local utility to enable the achievement of net-100% renewable electricity no later than 2030.²⁵⁰ The goal of this plan is to catalyse the construction of enough renewable power capacity to meet all net community electricity needs on an annual basis. However, the agreement acknowledges that this cannot be achieved without reliance on regional system-wide resources to help balance the community demand against the available committed resources; this requires relying at times on non-renewable resources to make up moments of shortfall, and sometimes sharing a surplus.²⁵¹

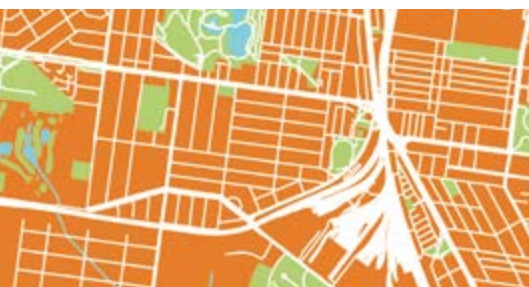
Some cities have sought to address specific challenges related to the local and regional distribution infrastructure. For example, they have built new (or upgraded existing) transmission and distribution assets both within and outside city boundaries to reinforce the capacity to transfer electricity. They also have expanded the ability to buffer supply by installing greater storage capacity (such as via pumped hydropower, batteries or hydrogen conversion). Adding storage increases the system's capability to match load against available supply and to capture and use available renewable generation at each moment in time (regardless of demand) while also relieving potential transmission and distribution constraints.

In 2020, Los Angeles (California, US) announced plans to pursue a combined approach (upgrading transmission and enhancing storage) to support its goal of 100% renewable electricity.²⁵² As part of this effort, the city plans to replace an existing coal-fired power plant in Utah with a 840 MW gas-fired unit coupled with hydrogen storage in on-site underground salt caverns.²⁵³ The hydrogen, generated using renewable electricity (via electrolysis), will be used to store any surplus electricity generated from variable renewable energy resources (such as wind or solar power) and will subsequently be used for electricity generation at the power plant as supply and demand conditions change.²⁵⁴ The city also will build additional transmission interconnection to accommodate the bi-directional flow of electricity between Los Angeles and the new generating facility for the effective integration of renewables.²⁵⁵ Upon its completion in 2025, the Utah facility would run on up to 30% renewable hydrogen (the balance being natural gas), with the aim of 100% renewable hydrogen use by 2045.²⁵⁶

Upgrading transmission and distribution assets and enhancing

storage capacity

can help cities achieve 100% renewable goals.



Salt Lake City, United States

i On the power grid, electrons flow to wherever they are demanded at each instant in time – it is only on a net basis that annual city demand is actually matched with the output of the specific resources committed to the city.

In addition to pursuing infrastructure improvements, some cities are striving to match the generating profile and other characteristics of the contracted supply against their demand profiles. For example, in 2020 Sydney (Australia) achieved its goal of meeting 100% of municipal electricity demand (buildings, facilities and streetlights)ⁱ with renewables via PPAs from solar and wind projects in New South Wales.²⁵⁷ The PPA criteria included local supply to minimise transmission losses, and high load matchingⁱⁱ (80%) for economic and system efficiencies.²⁵⁸ The city also is pursuing solar PV on municipal buildings and battery storage to improve the reliability and resilience of the distribution network.²⁵⁹

London (UK) offers an example of how storage can be used to time-shift system demand to match the available renewable supply. In a pilot project, battery storage is being deployed at some London homes to allow residential consumers to purchase excess electricity during off-peak periods (and thus at lower cost), which they can then store for later use during times of peak demand. This approach provides both load matching and grid management benefits, while potentially reducing the cost of supply.²⁶⁰

Many cities, especially in developing countries, struggle with insufficient distribution infrastructure. In these cases, renewable energy projects will require investment in local infrastructure. Building mini- and micro-grids can facilitate the deployment of reliable and relatively affordable renewable energy in locations with limited electricity access or where the main grid is frail and overburdened.²⁶¹



Sweden

DIRECT THERMAL ENERGY DISTRIBUTION

District energy networks are present in the urban areas of more than 30 countries worldwide, with an estimated 80,000 systems in total (including more than 6,000 each in the United States and Europe).²⁶² In China, district energy networks provide heating to over 5.7 million m² of floor space.²⁶³ The vast majority of these district networks worldwide are used for heating.²⁶⁴

During 2019 and 2020, several cities expanded their district energy infrastructure or commissioned new systems. Often, this activity was driven by the desire for an efficient, stable and reliable heat supply with low heat loss; for cost-effective cooling of large residential and office buildings; and for more options to integrate multiple renewable energy sources.²⁶⁵

In 2020, the first **district heating** network in Scotland (UK) using large-scale water-source heat pumps entered into operation in Clydbank to serve municipal, commercial and residential buildings, taking advantage of Scotland's nearly 100% renewable electricity mix.²⁶⁶ The municipal government in Leeds (UK) plans to invest GBP 24 million (USD 31.5 million) in six new district heating networks (relying on biomass or heat pumps), following the success of the city's first such network, which was expected to provide waste-derived heat to some 2,000 homes by the end of 2020.²⁶⁷ Montauban (France) is installing a district heating network using residual waste to heat 4,200 homes, with completion scheduled for 2023.²⁶⁸

Although less widespread, **district cooling** networks have operated for years in many European cities, particularly in Denmark (Aalborg, Aarhus, Copenhagen, Høje Taastrup) and Sweden (Gothenburg, Helsingborg, Linköping) but also in France (Bordeaux, Paris) and Germany (Berlin, Hamburg).²⁶⁹ Elsewhere, district cooling networks are present in Canada (Toronto), Japan (Osaka, Tokyo, Yokohama), Kuwait, the United Arab Emirates and the United States (Boston, Chicago, New York).²⁷⁰



Berlin, Germany

i Sydney's municipal electricity demand represents 115 buildings, 75 parks, 5 swimming pools and 23,000 streetlights.

ii In this instance, the load matching was achieved by skewing the PPAs towards wind power over solar because the generating profile of wind power better matches the predominantly night-time demand of the city government (i.e., street lighting).

Several city governments, especially in Asia, plan to add new district cooling infrastructure, although it is uncertain whether these systems will incorporate renewables. Bangkok (Thailand) is developing a district system, expected to be operational in late 2022, to serve the cooling needs of several office, retail and residential properties.²⁷¹ Amaravati (India) signed a concession to develop a district cooling system slated for operation in 2021.²⁷² Singapore announced plans for a district cooling network for the Punggol Digital District, and new district cooling systems also were commissioned in Cyberjaya (Malaysia), Gujarat City (India) and Manila (Philippines), among others.²⁷³

A few cities in Scandinavia have developed **integrated district heating and cooling systems**. Copenhagen (Denmark) has a district heating capacity of 3,000 MW and a cooling capacity of 50 MW; the network is connected to a waste-to-energy combined heat and power plant and supplies the city itself as well as 24 surrounding municipalities.²⁷⁴ In Stockholm (Sweden), the district energy network, co-owned by the city and a private company, has a 3,600 MW heating and 220 MW cooling capacity, supplying six municipalities.²⁷⁵ Since Stockholm's last coal-fired plant closed in early 2020, heat supply has been based on biofuel and municipal waste, with plans to use 100% renewable fuels by 2022.²⁷⁶

i Of these, around 90% were private, light-duty vehicle slow chargers.

EV CHARGING NETWORKS

Widespread roll-out of EV charging infrastructure is key to the continued growth of electric vehicles and plays an important role in increasing the use of renewable energy in the urban transport sector.²⁷⁷ Of the estimated 7.3 million EV chargersⁱ worldwide in 2019, most were concentrated in urban areas of China.²⁷⁸ Although the vast majority of chargers are not linked to renewable electricity, several municipal governments as well as private actors in cities in Australia, Europe, the United States and Latin America have made an explicit connection between EV charging and renewables.²⁷⁹

As of 2019, Adelaide (Australia) had installed 49 EV fast-charging points, which the city planned to run on 100% renewable electricity.²⁸⁰ Chargefox, Australia's largest EV charging network, opened the country's first ultra-rapid charging station, delivering 100% renewable electricity in the city of Keith.²⁸¹ In Europe, Oslo (Norway) and Stockholm (Sweden) are among the leaders in the number of EV chargers per person, and their charging stations benefit from the high shares of renewables in the national electricity mixes (→ see Table 2).²⁸² Since 2019, Oslo's municipal government has worked with private companies to deploy wireless-charging infrastructure for the city's growing electric taxi fleet.²⁸³

Table 2. Number of Public Electric Vehicle Charging Stations and Renewable Energy Uptake in Selected EV Capitals, 2019

City (State, Country)	No. of public chargers per million population	Share of renewables in city's electricity mix*
Asia		
Shenzhen (China)	4,800	28%
Beijing (China)	1,920	
Shanghai (China)	1,690	
Europe		
Oslo (Norway)	3,000	98%
Amsterdam (Netherlands)	2,750	18%
Stockholm (Sweden)	717	69%*
London (UK)	405	37%
Paris (France)	307	22%
North America		
San Jose (California, US)	1,200	48%*
Los Angeles (California, US)	590	32%*

Charging stations

in several EV capital cities benefit from high shares of renewables in the national electricity mixes.



Note: EV charger data were reported by ICCT in late 2019 and 2020. *Renewable electricity data for Los Angeles, San Jose and Stockholm are from 2018. All other city renewable electricity shares refer to national-level data from 2019.

Source: See endnote 282 for this chapter.

New York City (US) added 50 solar-powered EV charging stations in 2018.²⁸⁴ In Latin America, renewable-powered charging infrastructure was being developed in 2019 and 2020 in Santiago (Chile) and across São Paulo state (Brazil), among others.²⁸⁵ In addition, “smart charging”ⁱ solutions have been deployed and tested in some cities, mostly in Europe, including Amsterdam, Arnhem and Utrecht (all Netherlands) and Cranfield (UK).²⁸⁶ In Tokyo (Japan), a partnership among utilities, automakers and other stakeholders is testing bi-directional EV charging stations.²⁸⁷

FUEL DISTRIBUTION

Much of the renewable fuel used in transport, including biofuels and hydrogen, is still produced outside of city limits. As a result, providing sufficient distribution and refuelling infrastructure in cities is key to enabling citizens to access alternatives to fossil fuels (which rely on established distribution networks and widely available petrol filling stations).²⁸⁸

Biofuel blends typically are transported from refineries to distribution terminals and sold at existing petrol filling stations.²⁸⁹ In 2019, nearly 250 stations in Shanghai (China) were selling

B5 biodiesel.²⁹⁰ That same year, a new terminal for biodiesel storage and blending opened in Antwerp (Belgium).²⁹¹ In 2020, the US company Eco-Energy entered the final stage of construction of its ethanol distribution facility in Phoenix (Arizona, US).²⁹²

Hydrogen generally is distributed by pipeline, high-pressure tube trailers and liquefied hydrogen tankers. The costs associated with hydrogen distribution and delivery infrastructure depend on whether the fuel is produced centrally at large industrial sites (high distribution costs) or at the point of end-use such as in fuelling stations in cities (low distribution costs).²⁹³

The number of hydrogen refuelling stations remains low but has continued to increase. By the end of 2019, some 470 such stationsⁱⁱ were in operation worldwide, up more than 20% from the previous year.²⁹⁴ Most hydrogen refuelling stations are publicly available and located in cities, although only an estimated 24% of the stations globally provide renewable hydrogen.²⁹⁵ Shell’s hydrogen refuelling stations in Beaconsfield and Cobham (both UK) supply hydrogen produced on-site using electricity from renewable sources.²⁹⁶ The first hydrogen filling station for passenger trains in Bremervörde (Germany) was scheduled to begin construction in late 2020, with the hydrogen to be produced on-site using renewable electricity.²⁹⁷

ⁱ See Glossary for definition.

ⁱⁱ Since virtually all hydrogen is still produced from fossil fuels, most of the hydrogen available in these stations is fossil fuel-based hydrogen.



Frankfurt, Germany



Milan
Warsaw
Paris
Toronto
Mokoloki
New Delhi
Chicago
Portland
Piaui
Mangalore
Aswan

4

FINANCING AND INVESTMENT IN CITIES



Palmas
North Lombok Regency

FINANCING AND INVESTMENT IN CITIES

Global investment in new renewable energy capacity, including power and fuels (but not including hydropower projects larger than 50 MW) totalled USD 282.2 billion in 2019, up 1% over 2018.¹ In the first half of 2020, global investment in new renewable energy capacity rose 5% relative to the first half of 2019, suggesting sustained growth despite the COVID-19 pandemic.² Some of this investment occurred in city-related projects – by municipal governments as well as other residential, commercial and industrial actors within cities – but the exact amount is unknown. Although data are becoming more available, no comprehensive dataset on renewable energy investment in cities by sector exists.

This chapter explores financing and investment in cities, including the provision of funding for renewable energy projects and the process of investing in projects to turn a profit. The discussion examines common financing mechanisms applied by cities worldwide and how these mechanisms are being used to support renewables across the world's regions. The chapter concludes with an overview of the challenges that cities face in investment and finance of renewable energy projects.

Each city operates within a distinctive framework that affects the amount and type of renewable energy financing and investment available. Variables include the policies and regulations that govern city actions, the nature of relationships with higher levels of governments, partnerships with the private sector, ownership rights of the electric grid, etc.

Municipal governments are responsible for only a small share of the total financing that occurs within a city; in contrast, private individuals and companies account for far more of the investment in city-related projects – whether in the energy, buildings, commercial or industrial sectors – and have their own priorities, planning horizons and funding constraints. The total finance package allocated to renewables therefore results from many different players, regulations, institutions and financing mechanisms and is specific to every city.



BOX 1. Global and Urban Climate Finance Flows

Global climate finance flows reached an estimated USD 608-622 billion in 2019, up 6-8% from the 2017/18 averages of USD 574 billion annually. Climate flows, which crossed the USD half-trillion mark for the first time in 2017, were highly concentrated on mitigation efforts (representing 93% of total flows in 2019). By sector, renewable energy generation accounted for the largest share of the flows tracked, largely due to more investments originating in China (particularly solar, wind and hydropower investments) and the United States (with an increased volume of investments in solar PV and onshore wind). The second largest investment during 2017/2018 was in sustainable transport (around USD 140 billion annually, making it the fastest-growing sector for climate finance), followed by investment in energy efficiency (around USD 33 billion annually).

Cities face major capacity constraints in financing climate change mitigation and adaptation projects. First, the public sector, notably city governments, often has budget capacity limitations and low rates of creditworthiness, which hinders private investment or any major borrowing scheme. Also, many

long-term climate-smart infrastructure investments need highly technical capacity to pull together investor-ready bankable projects with sufficient size and quality to increase climate finance flows. Many countries forbid their local governments from issuing any kind of debt, including municipal bonds. Also, many private investors lack experience working with sustainable urban infrastructure, which often impedes investments.

Because cities are key players in achieving the Paris Agreement, investments must be scaled to promote the shift to the low-carbon, climate-resilient infrastructure that is needed to face the climate emergency. However, while there is a clear picture of global climate finance flows, information on **urban climate finance**ⁱ flows is lacking. By producing clear data, measuring progress, and understanding gaps and opportunities, city governments can have a better picture of the sources of finance, the financial instruments employed, and the policies that can more effectively drive investment, leading to improved policy planning in cities.

Source: See endnote 5 for this chapter.



Sanxia Dam, Yangtze River, China



New Bedford, United States

ⁱ For further information on financing of city-level climate action, see the Cities Climate Finance Leadership Alliance, www.citiesclimatefinance.org, and its forthcoming report, *State of Cities Climate Finance 2021*.

Financing for renewables also must be tailored to meet the unique characteristics of each end-use sector: power, heating and cooling, and transport. In the power sector, municipal governments and other urban actors generally target renewable energy projects in two main categories: small-scale, on-site generating capacity (for example, rooftop solar PV on single buildings or on somewhat larger areas such as parking or waste sites), and larger-scale projects (for example, solar PV or wind farms) that often are located outside of geographical city limits.

In the heating and cooling sector, cities often target district heating networks. Different ownership models for these networks affect the allocation of financing and include, for example, municipal ownership, long-term concession agreements with private operators and “unbundled” networks with private ownership. The networks can be fed by large-scale heat pumpsⁱ, municipal waste incineration, biomass boilers, industrial waste recovery, solar thermal and geothermal energy, although the share of renewables across these options can vary.³

In the transport sector, cities working towards climate mitigation goals typically target projects related to mass public transit and

Each city operates within a

distinctive framework

that affects the amount and type of renewable energy financing and investment available.

zero-emission vehicles (including electric vehicles), which enables renewable electricity to replace fossil fuels in some transport applications (particularly through smart chargingⁱⁱ).⁴

FINANCING MECHANISMS

Municipal governments and other urban actors that aim to increase the share of renewables in their power, heating and cooling, and transport sectors have many options for financing such projects.

These options can be grouped into three general categories:

- the actors may have their own capital or assets available for funding renewable energy projects;
- if they do not have their own capital available, they may be able to raise funds through bonds, or make use of funds provided by other levels of government or external actors (such as local or domestic banks and development banks); and
- they may be able to leverage external funds for renewable energy projects by participating in arrangements such as public-private partnerships or power purchase agreements.

In addition, cities have relied on climate finance from private and public sources, some of which has included funding for renewables (→ see Box 1).⁵

USING OWN AVAILABLE CAPITAL OR ASSETS

In the first category, actors may have their own financing available or may be able to generate the necessary capital to develop renewable energy projects (→ see *City Snapshot: Palmas*).⁶ Some municipal governments fund renewable energy projects based on fees and returns from the project itself. To generate capital, one option is to sell or lease land or assets.⁷ For example, land value capture can be used to help finance new infrastructure projects by harvesting a portion of the increase in value of nearby property caused by the investment. Land value capture has been used in some cities to finance electric transport and new metro and rail investments.⁸ Municipal governments, alongside other actors, also may indirectly support renewable energy by divesting from fossil fuels and reinvesting in renewable energy companies (→ see Box 2).⁹



Warsaw, Poland



i Although heat pumps are not renewable energy technologies in themselves, they may be viewed as enabling technologies because they can be powered by renewable electricity.

ii See Glossary for definition.

PALMAS

BRAZIL

Land area
(km²)



100.6

Population size
(2020)



306,000



Palmas City, the capital of the state of Tocantins in north-central Brazil, aims to generate 100% of its electricity from solar power by 2022 and to have 100% of its local electricity energy supply based on solar energy by 2035 (foregoing the use of hydropower from the regional grid). Hydroelectric dams located on the Tocantins River account for nearly 97% of the electricity consumed in the city, in addition to providing power elsewhere in the country. However, electricity bills in Palmas are among the highest in Brazil, and growing uncertainties about hydropower's stability and climate and environmental risks have heightened interest in exploring the local solar resource.

The Palmas Solar project, established in 2015, provides tax incentives for companies and households to install solar PV panels and to feed surplus generation to the electricity grid. The benefits include reducing the city's dependence on hydropower and non-renewable energy sources, improving air quality and reducing greenhouse gas emissions. The main drivers for reducing hydropower are rising energy bills and the environmental risks of this generation source.

At first, the project focused on solar PV installations only in new buildings, but it has since extended city-wide. Users are encouraged to install solar panels in exchange for a discount of up to 80% on two municipal taxes – the Property and Urban Land Tax and the Real Estate Transfer Tax – for a period of five years. The costs for private users are drastically reduced, as the solar power they generate is fed into the grid and discounted from their energy bills. The local utilities maintain the distribution infrastructure, for which users pay a minimal equipment cost.

For Palmas, the tax incentives did not affect public revenue because the project was launched right after a tax increase, foreseeing that a share of municipal revenue would be allocated to this project.

Three private banks, Banco da Amazônia, Banco do Nordeste and Banco do Brasil, have helped finance any remaining costs. The programme has led to the creation of a solar PV market with more than 20 local enterprises selling and installing imported or locally manufactured solar panels. As of October 2020, the city had granted discounts totalling BRL 415,785 (around USD 103,000) and supported 3.8 MW of installed decentralised generation capacity under the Palmas Solar programme.

In parallel, Palmas implemented the Parque Solar project. During phase 1 of the project in 2018, the government-owned bank Caixa Econômica Federal provided financing to install solar panels on public schools, saving the municipality an estimated BRL 5,000 (USD 1,240) per month. Phase 2 involves building a 5 MW solar farm to power all municipal buildings with solar energy, although funding is yet to be secured.

Source: See endnote 6 for this chapter.

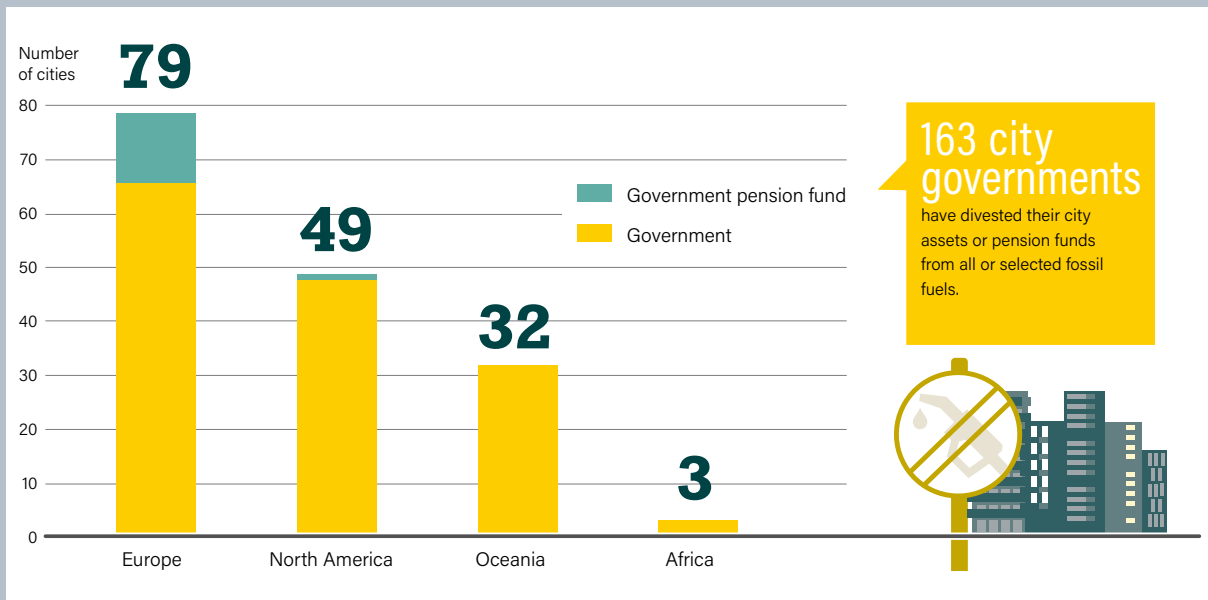


BOX 2. Divestment of Municipal Public Funds from Fossil Fuels

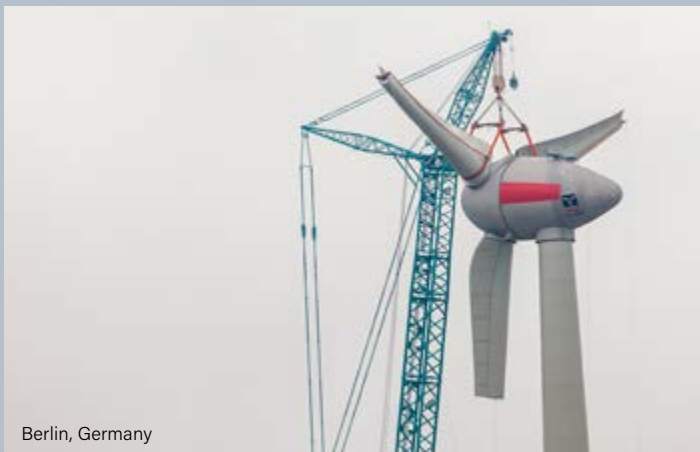
By 2020, more than 1,300 institutions with around USD 14 trillion in investment value had sold off their financial interests in fossil fuel companies. Although the institutions undertaking this divestment are diverse, two entities critical to this movement at the city level are government bodies and their pension funds. The C40 Cities network, launched in 2018 in close co-operation with London (UK) and New York City (US), the C40 Divest/Invest Forum, an initiative that helps guide cities interested in divesting their pension funds and investing in climate-friendly solutions (14 cities signed up to the Divest declaration). Funds divested from fossil fuel companies are not necessarily reinvested in companies associated with renewable energy, however.

Numerous cities worldwide have taken strong action to divest their city assets or pension funds and, in some cases, to increase the investment in sustainable infrastructure (→ see Figure 16). For example, in 2020, as part of their COVID-19 recovery plans, 12 cities (Berlin, Bristol, Cape Town, Durban, London, Los Angeles, Milan, New Orleans, New York, Oslo, Pittsburgh and Vancouver) pledged to divest from fossil fuel companies and advocate for greater sustainable investment within the C40 framework.

Figure 16. Number of Cities with Fossil Fuel Divestments, by Region and Divestment Scope, 2020



Source: See endnote 9 for this chapter.



RAISING FUNDS FROM EXTERNAL SOURCES

If an actor is unable to draw from its own funds or assets, a number of options are available from other levels of government or external sources to address a given shortage of capital. Cities that are eligible to generate debt may choose to issue municipal green or climate bonds to support renewable energy projects.¹⁰ Municipal actors also can apply for grants, subsidies and loans from national governments and international entities, such as the EU, multilateral and bilateral financial institutions, and multilateral development banks. On average, direct budgetary contributions from national governments supply 40% of urban infrastructure finance for transport, water, energy and other projects in developed countries and 60-65% in emerging and developing countries.¹¹

Two common approaches for raising funds from external sources – issuing municipal or green bonds, and acquiring funds through development finance – are discussed in the following sub-sections. Another more novel approach is crowdfunding, or raising money from a relatively large number of people in small, individual amounts, generally via the Internet and social media. Crowdfunding is a growing option for both public and private projects and has been used in Africa (especially for small, off-grid projects), Asia, Australia, Europe and North America.¹²

MUNICIPAL AND GREEN BONDS

Since they were first used in the early 19th century, municipal bonds have become one of the most widely applied instruments for municipal finance, helping to fund trillions of dollars of urban infrastructure projects.¹³ Bonds tend to provide more attractive conditions for financing long-term infrastructure projects than do traditional bank loans, and many municipalities (particularly larger cities) consider municipal bonds to be the best tool to meet their financing needs.¹⁴ However, in some countries, particularly in developing or emerging economies, national legislation that limits borrowing power may restrict cities from using bonds (→ see *Challenges* section).

Although municipal bonds traditionally have been used to fund major infrastructure or other projects, they also have provided funding for renewable energy projects (especially solar PV) in cities around the world (→ see *Table 3 and Sidebar 6*).¹⁵ The two main types of municipal bonds are general obligation bonds and revenue bonds. General obligation bonds are loans that can be repaid through a variety of tax and income sources available to the municipality; they rely first and foremost on the creditworthiness of the issuing municipality, not on the financial return or attractiveness of the project.¹⁶ In the case of revenue bonds, repayment of the loan is backed by a specific revenue stream, such as electricity sales generated by a renewable energy project, or power tariffs collected by the municipal utility.

Cities worldwide

have been using municipal bonds to fund renewable energy projects since 2013.

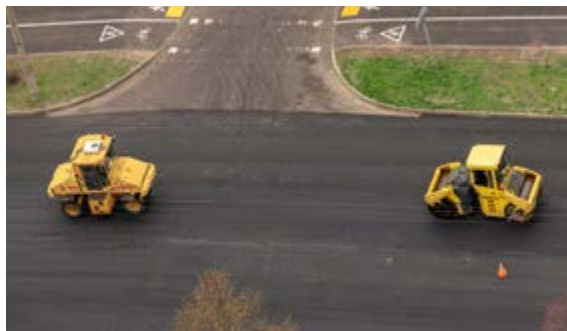


Table 3. Value of Municipal Bonds to Finance Renewable Energy Installations in Cities Worldwide, 2013-2019

City (State, Country)	2013	2014	2015	2016	2017	2018	2019	Total
In USD million								
Africa								
Johannesburg , South Africa	-	136.4	-	-	-	-	-	136.4
Asia								
Tokyo Metropolitan Government, Japan	-	-	-	-	88.2	88.4	91.8	268.5
Europe								
Paris , France	-	-	319.8	-	-	-	-	319.8
Gothenburg , Sweden	78.8	270	126.6	120.3	138.3	165.6	393.1	1,293.8
Lund , Sweden	-	-	-	-	85.2	66.1	-	151.2
Malmö , Sweden	-	-	-	-	153.2	110.5	128.2	392.0
Nacka Kommun, Sweden	-	-	-	-	-	57.4	-	57.4
Norrköping , Sweden	-	-	-	68.3	-	-	-	68.3
Örebro Kommun, Sweden	-	103.8	-	58.0	59.2	55.0	155.2	431.1
Östersund Municipality, Sweden	-	-	-	-	95.6	-	85.2	180.8
Västerås , Sweden	-	-	-	81.2	-	-	-	81.2
Vellinge Municipality, Sweden	-	-	-	-	-	41.2	20.4	61.6
North America								
Toronto , Canada	-	-	-	-	-	-	150.7	150.7
Auburn , New York, United States	-	-	8.7	-	-	-	-	8.7
Honolulu (City and County), Hawaii, United States	-	-	-	143.8	-	-	-	143.8
Otis , Massachusetts, United States	-	-	6.2	-	-	-	-	6.2
Richland , Washington, United States	-	-	-	-	-	-	3.1	3.1
San Francisco (City and County), California. United States	-	-	-	-	-	-	247.8	247.8
Spokane , Washington, United States	-	181.2	-	-	-	-	-	181.2

Note: Table includes only city (and in some cases, county) governments that have used bonds to finance renewable energy projects. Within city boundaries, other entities such as banks, utilities and school districts also have used bonds for such projects.

Source: See endnote 15 for this chapter.

SIDEBAR 6. Distributed Solar PV to Empower Cities in Developing Countries

Grid-tied distributed solar PV is changing electric power systems worldwide, alongside other consumer-level, distributed technologies such as batteries. Installed on rooftops, as canopies above car parks, or floating on industrial ponds, solar cells can even be integrated into building materials such as glass and tiles, as well as into the surfaces of sidewalks and highways. The installed capacity of commercial and residential solar PV surged from just a few megawatts in 2000 to 259 GW in 2019. Since distributed solar PV energy is consumed close to where it is generated, it can provide affordable and resilient electricity service for consumers, help grid operators reduce energy losses and grid congestion, and defer or avoid expensive grid upgrades, among other benefits.

Distributed solar PV offers distinct solutions or use cases. Often such systems are used to reduce customer energy bills and to provide a least-cost back-up solution for consumers who otherwise rely on costly diesel generators to make up for unreliable or insufficient grid electricity. Governments that subsidise diesel fuel can incentivise the use of distributed solar PV as part of a subsidy reform strategy. In islands and similar settings, distributed solar PV can be a least-cost generation option due to the absence of land for ground-mounted power stations. In cities where the power grid lacks sufficient capacity to transmit and distribute bulk power to consumers, the utility or third-party provider may be able to deploy distributed solar PV, perhaps with batteries, as a fast, modular, cost-effective alternative to investing in traditional grid upgrades.

For low-income consumers, distributed solar PV can provide community social support to make electricity more affordable while also addressing fiscally responsible social inclusion. Many low-income consumers have a volumetric tariff rate below operating costs ("social tariff") and live in housing unsuitable for individual distributed solar PV deployment, and/or they lack access to finance to cover the upfront costs of distributed systems. City as well as national governments can install community-level distributed solar PV to serve subscribed consumers and mitigate the financial burden of social tariffs and/or to reduce chronic financial losses for retailers of grid electricity. The government also can deploy distributed solar PV to reduce the arrears of public institutions that are unable to pay their electricity bills.

Viable business models are crucial to support the deployment of distributed solar PV. Broadly, three generations of distributed solar PV business models have evolved over time: 1) direct deployment of distributed systems by individual consumers (first generation); 2) reliance on third-party providers who aggregate projects and facilitate some part of the design, installation and financing (second generation); and 3) engaging utilities to help drive deployment (third generation). Different models may be available simultaneously in cities: some users can buy the distributed solar PV systems from installers for self-consumption, while utilities

can integrate distributed solar PV in their business by partnering with third-party companies to actively engage in deployment and share the value of increasing consumers' access to low-cost financing.

New financing models open up win-win opportunities for the stakeholders involved. For instance, the issuance of "solar bonds" by governments can potentially increase the availability of debt for distributed solar PV projects and lowers its costs. In India, a municipal entity aggregates projects for third-party distributed PV developers and enables them to overcome barriers to accessing debt capital markets. Solar bonds in India are expected to lower costs by up to 12%, and the funds are disbursed via a public-private partnership. Such public financing, especially at early stages of distributed solar PV market development, can help attract large-scale private sector participation, and can then be phased out over time in favour of a deepening commercial financing pool as the market becomes self-sustaining. In addition to direct and indirect financing, the public sector support may take the form of: a legal, policy and regulatory framework; planning, technical and operational capacity; government-sponsored guarantees; and investment in enabling infrastructure such as smart grids.

Financing also can be offered from third parties to creditworthy customers, such as renewable energy service companies, in the form of: a solar lease; a fixed monthly fee for a predetermined period with the option of buying the system at the end of the lease; and PPAs, with a fixed kilowatt-hour fee normally lower than that from the incumbent utility. Aggregating small projects can help attract more attention from investors and reduce transaction costs.



Douala, Cameroon

Urban settings, where there is higher potential for distributed PV projects, can be particularly effective in aggregating small projects. Users themselves also can collectively finance small-scale distributed PV projects via crowdfunding. Both Argentina and Mexico have online platforms where users can invest in distributed solar PV projects or access cheaper financing for installing a distributed system.

In India, New Delhi's largest distribution company, BSES Radjhani, with 2.3 million customers, is leading community distributed solar PV by aggregating projects and leasing or selling systems to customers. Multiple distributed systems are connected to the grid at a single metering point, with consumption costs and production benefits (such as lower electricity bills) shared among all households in the community. The involvement of distribution companies and community-level intermediaries assures both households and investors that the programme is viable. Intermediaries help ease the complicated application processes and contracting of distributed solar PV vendors. Once installation costs are paid off in full, ownership is transferred to the customers.

Nigeria is exploring the viability of microgrids or mini-grids for communities underserved by distribution companies. Microgrids up to 1 MW in size, for example, can improve service reliability compared to existing grid service while leveraging existing distribution infrastructure to achieve lower system cost than isolated mini-grids. Four business models have been identified, each led by a different actor: 1) a private operator, who would engage the distribution company and community; 2) a special purpose vehicle (SPV) formed by a distribution company's investors, for example, with certain functions subcontracted to an operator; 3) a co-operative

formed by the community; and 4) a collaborative SPV where ownership and operation functions are shared among the operator, community co-operative and distribution company investors. Nigeria's first commercial "undergrid mini-grid" is under development in Mokoloki in Ogun State, with the first tripartite contract in which the mini-grid operator will pay a distribution usage fee to the distribution company.

Source: See endnote 15 for this chapter.



Ogun State, Nigeria



New Delhi, India



New Delhi, India

In recent years, green bonds or climate bonds have emerged as an alternative financial instrument to enable national and municipal governments, as well as companies, to tap into financing. Green bonds differ from normal bonds in that the proceeds are earmarked for qualifying investments in renewable technologies or in various forms of climate adaptation and mitigation.¹⁷ Binding definitions regarding which projects qualify for green bonds are typically applied on a voluntary basis, although more uniform taxonomies have been developed, for example by the EU or Climate Bonds Initiative.¹⁸

Green bonds

give investors greater visibility over the actual use of funds than traditional bonds.

With green bonds, investors (typically institutional investors, often with an environmental, social and governance (ESG) mandate or environmental interest) obtain a certain interest rate over a stipulated period of time, and the funds must be used for the specific purposes for which the bond was issued. This provides investors with greater visibility over the actual use of the funds than is the case for traditional bonds. Gothenburg (Sweden) was the first city to issue a green bond in 2013.¹⁹ In 2019, the United States and China led in the total value of green bonds issued and in the number of issuers.²⁰

DEVELOPMENT FINANCE

In many cases, dedicated funds from development finance institutions (also known as development banks) have supported renewable energy projects in cities. Municipal governments can receive these funds, which often require close co-operation across a range of stakeholders (including national governments) and a long-term commitment to renewables.²¹ Development banks frequently partner with local banks to provide the catalytic finance required to unlock investments in renewable energy assets, including capital-intensive projects such as district heating networks. Such institutions step in where local commercial banks are either unwilling or unable to provide the financing required, offering long-term financing. Around 75% of finance for climate mitigation or adaptation activities in cities from development finance institutions comes at commercial rates, but concessional finance (for example, below-market rates) is also an option.²² For decades, loans from development banks have been accompanied by safeguard policies on environmental and social impacts.²³

Development banks also provided financing for renewable energy generation projects within in cities.²⁴ In one recent example, in 2019, the Green Climate Fund made available EUR 87 million (USD 107 million) to cities in nine countries (Albania, Armenia, Georgia, Jordan, Moldova, Mongolia, North Macedonia, Serbia and Tunisia) through the European Bank for Reconstruction and Development's (EBRD) Green Cities Program.²⁵ The programme provides grants and concessional funds for renewable energy projects along with projects in the areas of water, air and waste management.

LEVERAGING EXTERNAL FUNDS

In the final category of financing, actors may be able to leverage funds from external parties for a given renewable project. Three notable approaches for doing this are: mobilising private finance through public-private partnerships; borrowing through green banks; and signing power purchase agreements to encourage private finance.

PUBLIC-PRIVATE PARTNERSHIPS

Public-private partnerships (PPPs) provide an alternative means of financing for municipal governments that lack the funds to develop renewable energy or infrastructure projects when there is no guarantee that the private sector will invest.²⁶ Such projects typically are funded by means of government finance, private/corporate finance or project finance in which loans are secured for a specific partnership.²⁷ A blend of finance in PPPs is also possible: for example, if the private sector raises financing, it may be easier or more sensible for the government to take on some aspects or risks of the project.²⁸

In the PPP model, local governments may leverage private investment to expand projects (→ see *City Snapshot: North Lombok*).²⁹ Such arrangements enable municipalities to access financing and technical expertise and to benefit from operational efficiency, while shifting performance and technology risks to the private sector.³⁰ On the down side, PPPs may have comparatively high transaction costs and may be complicated by differing timelines in the private and public sectors (with the latter heavily influenced by elections).³¹ PPP arrangements vary across countries, sectors and projects and may take the form of build-operate-transfer, design-build-operate and lease-develop-operate.³² Most PPPs supporting renewables are in the power sector, although examples exist of PPPs for renewable heat, such as in the village of Rittershofen (France), where a PPP helped support a geothermal project to supply process heat to a local biorefinery.³³

Although PPPs are used worldwide, historically they have been more frequent in developing countries.³⁴ Data on private participation in infrastructure (PPI, which also may encompass agreements that are not necessarily PPPs) gives a rough indication of PPP use worldwide. In low- and middle-income countries, PPI investments are dominated by the transport sector (mainly road and railway projects), which attracted USD 47.8 billion across 123 projects in 2019.³⁵ By comparison, the energy sector received USD 40.1 billion across 169 projects, of which 136 were renewable energy projects, mainly solar PV and wind power.³⁶



NORTH LOMBOK REGENCY INDONESIA



Land area (km²)

776.3



Population size

200,000



North Lombok is the youngest regency (municipality) in the Indonesian province of West Nusa Tenggara, located on Lombok Island. Energy demand in West Nusa Tenggara totalled more than 1,950 GWh in 2019 and was growing by 5.9% annually. With increased economic development in the region, energy demand is expected to continue to grow rapidly to 2030.

To reduce greenhouse gas emissions in the city and to support the provincial target to generate 35% of electricity from renewable sources by 2025, the local government has set ambitious goals to deploy renewables in a cost-efficient and sustainable manner. North Lombok has rich potential for cheap biomass residues and opportunities to harness wind and solar energy. Out of 8.97 MW of operating power plant capacity in North Lombok, 8.82 MW is derived from renewables, primarily micro-hydropower (the 7 MW Segara and 1 MW Santong plants) and solar energy in Gili Islands.

To support local communities, the North Lombok government developed a Cost-sharing Financing Scheme for Household-scale Biogas to simultaneously reduce dependence on traditional biomass and cut greenhouse gas emissions in the residential sector. Although this scheme was originally an initiative of the provincial government, the North Lombok government has taken measures to adopt it in the city region. The cost is shared between the local government and Hivos / Yayasan Rumah Energi, along with the household users of the biogas, who pay a small amount to ensure citizen participation and ownership.

As of 2020, some 1,152 household-scale biogas units using organic waste had been installed in the North Lombok region through this scheme. The cost of one unit of biogas is IDR 13 million (USD 933), and the local government shares this amount by

contributing IDR 4-5 million (roughly USD 290-360) per unit (30-40%). To support the technical portion of the project, Hivos / Yayasan Rumah Energi provide high-quality biogas digesters to the users as well as three years of after-sales service for civil buildings and one year for pipe and stove installations.

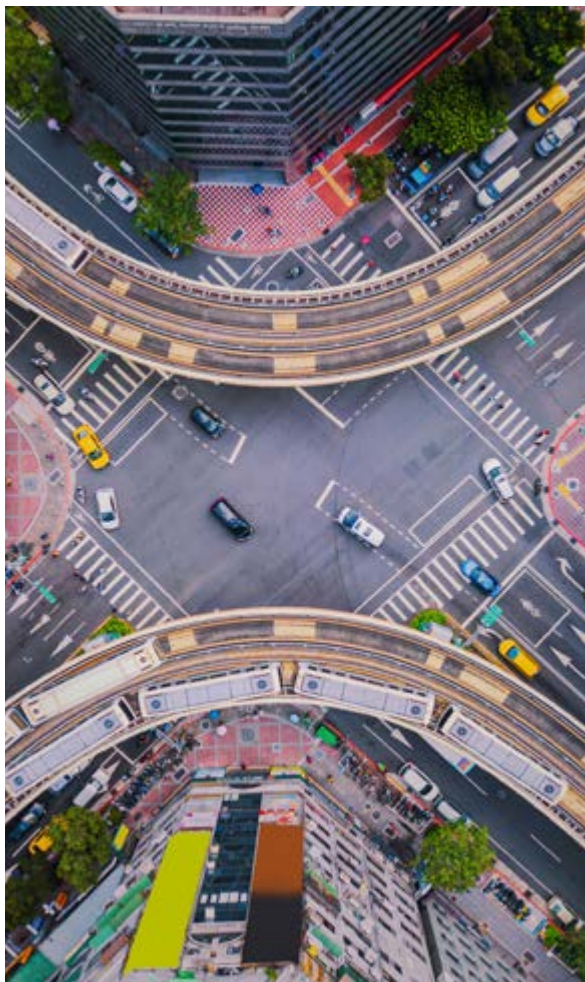
Source: See endnote 29 for this chapter.



GREEN BANKS

Green banks offer another option for leveraging funds for renewable energy projects, in a PPP of sorts. Green banks function as banks only in terms of being financial intermediaries – they do not fall under traditional banking regulations, and are typically set up as a public financing authority that leverages limited public funds to attract additional private capital for renewable and other related technologies.³⁷ However, just like a traditional bank, green banks conduct their own financial assessments and lend funds to qualifying projects. The initial cash infusion to create the green bank can be raised in a range of ways, including through the issuance of bonds, surcharges on local utility bills (particularly in cities with their own municipal utility), direct government allocation of funds, and revenues from dedicated taxes, such as on carbon.

As of May 2020, there were 21 established green banks worldwide, with the majority (14) in the United States and others in Australia, Japan, Malaysia, South Africa, Switzerland, the United Arab Emirates and the United Kingdom.³⁸ They include green banks in the US cities of Washington, D.C. (D.C. Green Bank) and New York City (New York City Energy Efficiency Corporation).³⁹



POWER PURCHASE AGREEMENTS

A final option commonly used to mobilise private sector financing is power purchase agreements (PPAs), which are a useful tool for both municipal governments and corporations.⁴⁰ PPAs are long-term contracts in which a buyer agrees to purchase the energy generated by a renewable energy project for a fixed price during the contract's tenure.⁴¹ A PPA typically specifies at least three factors: the volume, price and contract length for the electricity or heat that will be sold.⁴² Although PPAs are usually associated with renewable electricity, they also can be used for heat supply to industry, agrifood and space heating.

Under most PPAs, the developer is responsible for financing, building and operating the renewable energy project.⁴³ City governments may initiate projects, for example by committing to buy electricity from a dedicated wind farm or solar PV plant. This essentially guarantees a steady income to the project developer, helping to incentivise the project and to enable the developer to secure financing. In this framework, PPAs are a way for cities to leverage private finance for a renewable energy project (→ see also *Markets and Infrastructure* chapter).

In some jurisdictions, cities wishing to pursue a PPA are limited by existing regulations that cover retail choice and electricity franchises. In markets that allow retail choice with favourable franchising, municipal actors typically can pursue PPAs, whereas in markets that do not allow retail choice they may be prohibited from purchasing electricity from any entity besides the existing utility.⁴⁴ In the latter case, a city still may have the opportunity to create a virtual PPA, in which the renewable electricity generated by the project is bought and sold into a power market that may or may not be the same as the customers.⁴⁵

City governments have two main options for participating in a renewable energy PPA: they can sign a municipal PPA themselves, or they can work with other local institutions to arrange a joint-collective PPA.⁴⁶ The latter is particularly attractive for cities whose electricity demand is too small to make a bilateral PPA possible. Bilateral PPAs have been used most widely in the United States but also in Australia and South Africa.⁴⁷ Collective PPAs for renewable energy have been initiated in Melbourne (Australia) and in 20 US cities, including Boston (Massachusetts), Chicago (Illinois), Houston (Texas) and Portland (Oregon).⁴⁸



Australia

INVESTMENT AND FINANCING IN CITIES BY REGION

In the 533 cities that self-reported to the CDP-ICLEI Unified Reporting System in 2019, a combined 171 renewable energy projects were in the pipeline with total project costs of USD 31.2 billion.⁴⁹ In addition, between 2015 and 2019, municipal governments identified USD 7 billion in finance and investment needs for energy infrastructure through ICLEI's Transformative Actions Program.⁵⁰ Generally, cities use distinctive approaches to finance renewable energy projects, depending on their government structure, development status and cultural norms. The following sub-sections explore the varying financing mechanisms used for renewable energy in cities across different world regions.



Tokyo, Japan



Valenzuela City, Philippines

ASIA

China and India account for most of the renewable energy investment in Asia (see later discussion). Outside of these countries, the non-OECD Asia-Pacific region accounted for USD 15.2 billion of renewable energy investment in 2019, up 17% from 2018 due largely to investment in offshore wind power in Chinese Taipei.⁵¹ Diverse financial mechanisms have been used across the region, although data are limited. In Cambodia, dedicated funds from the Asian Development Bank have supported a number of PPPs for solar PV plants, including a 10 MW project in Bavet City and two 60 MW plants in the Krakor and Tek Phos districts.⁵² In the Philippines, the private sector has been active in financing solar PV plants in San Carlos City and in cities in Cebu.⁵³

In Japan, renewable energy investment totalled USD 16.5 billion in 2019, down 10% from 2018.⁵⁴ This drop reflected grid and land constraints that continued to hold back solar PV developer activity and auction bidding in the country.⁵⁵ Japan's cities, towns and villages lie under the jurisdiction of 47 prefectural local government areas, and it is common for renewable energy projects to be funded privately by individual companies or by a consortium of companies.⁵⁶ Prefectural governments occasionally use their own revenue to subsidise projects, at times with co-funding from the national government. For example, the Ministry of the Environment's Local Decarbonization Investment Promotion Fund provides capital contributions and loans for local renewable energy projects.⁵⁷

Projects in Japan also rely on public or green bonds.⁵⁸ In the town of Shikaoi-cho (Hokkaido) in 2004, a biogas power plant that provides electricity and heat for greenhouses and fish farming and fuel gas for vehicles was financed mainly by a national subsidy (80%), with the remainder supplied via a public bond issued by the town.⁵⁹ The Tokyo Metropolitan Government used green bonds to finance building retrofits that included renewable energy technologies, and the city of Tsuru issued JPY 17 million (USD 164,640) in public bonds to build a 20 kW hydropower station in 2005 that supplies electricity to the city hall.⁶⁰

Prefectural governments in Japan use PPPs (in different forms) to push developers to invest in renewables. A recent and innovative trend is for Japanese local governments to either invest in local energy companies or establish their own local energy companies, in part to ensure the incorporation of renewables in the energy mix and to aid in the circulation of related finance.⁶¹

Diverse financial mechanisms have been used across Asia, although data are limited.

For example, the city of Kitakyushu provided funds to establish its own local energy company together with the private sector and is planning a 5,000 kW waste-to-energy plant and a 10 MW offshore wind power plant.⁶²

CHINA

China has dominated global investment in renewable energy capacity since 2012.⁶³ In 2019, however, renewable energy investment in the country fell 8%, to USD 83.4 billion, following a slowdown in the solar PV market after the central government suspended the feed-in tariff for solar PV in 2018.⁶⁴

In contrast to the bottom-up approach used in many Western countries to drive renewable energy development, projects in Chinese cities frequently are driven by policies and targets set by the central government, which officials at lower levels of jurisdiction then are required to implement.⁶⁵ The central and provincial governments often provide loans, grants and subsidies to finance project development, although finance for renewables also may originate from bank loans, venture capital, public and private funds, and bonds.⁶⁶

Governments at the county and township levels often act as co-ordinators, linking financing with technological expertise in a PPP of sorts.⁶⁷ In Shanghai, the municipal government facilitated a partnership with Shanghai Electric in 2007 to expand offshore wind power capacity near the city.⁶⁸ Since then, other Chinese cities (for example, in Shandong and Guangdong provinces) have partnered with Shanghai Electric to build more offshore wind power projects.⁶⁹ The Nanjing municipal government joined with two private investors (Nanjing Fengsheng Industry Holding Group and Fengsheng New Energy Technology Consortium) to build a large-scale heat pump project sourced by river water.⁷⁰

To reduce project costs by shifting away from renewable power plants located far from load centres, a number of Chinese cities (such as Beijing, Guangzhou, Shanghai and Shenzhen) have implemented small-scale wind power pilot projects closer to city boundaries.⁷¹ Developers or private investors have funded most of these projects, supported by PPAs signed by utilities or grid companies to ensure that the electricity is sold at a specified price.⁷²

Green bonds have been used to facilitate renewable energy investment in China. Between 2016 and late 2019, USD 17.5 billion in green bonds had been issued at the local level, most of them by provincial governments, although examples exist at the county and township levels as well.⁷³ Most of the green bonds issued locally were for low-carbon transport (such as local mass transit systems) or water infrastructure.⁷⁴ However, in 2020 Datang Henan Power Generation Co., Ltd issued a USD 144 million green bond to finance 14 offshore wind power projects.⁷⁵

Some Chinese cities (such as Zhangjiakou) have been pro-active in developing and investing in hydrogen for transport, especially for buses.⁷⁶ In a few cases, the emphasis has been on hydrogen produced with renewable electricity. In 2019, the state-owned Hebei Renewables Construction and Investment Company completed the Zhangjiakou Guyuan wind power hydrogen generation project, with an investment of CNY 2 billion (USD 306.4 million).⁷⁷ Meanwhile, Shanghai and Shenzhen have been involved in China's push for electric vehicle infrastructure: in 2020, Shanghai completed a pilot programme that will allow utilities to co-ordinate EV charging with the availability of renewables.⁷⁸

INDIA

Investment in renewable energy capacity in India fell 14% in 2019, to USD 9.3 billion.⁷⁹ Financing for renewables in Indian cities originates from three main sources: national and state-level schemes (such as the 100 Smart Cities Mission), which have increased in scale and number over time; international financing agencies and development banks, with many of these projects being small and experimental; and local private capital, for which very little information is available.⁸⁰ Although municipal bonds have been used to a limited extent for infrastructure projects in India, they have not been adopted for renewable energy projects to date.⁸¹

Historically, Indian cities have not been at the forefront of financing renewables, in large part because energy governance in the country remains constitutionally with the central and state governments.⁸² In 2015, however, the government launched the 100 Smart Cities Mission, creating a new vision for the role of cities in renewable energy projects.⁸³ Subsequently, around 100 cities in India created plans for investing in energy distribution and supply, including solar PV, waste-to-energy and wind energy (to a limited extent), as well as electric mobility.

Of the first 60 approved proposals, around 10% of the budget – a total of INR 13,161 crore (USD 1.8 billion) – was for such energy projects, with the remainder directed towards other infrastructure projects such as water, buildings, transport and waste management.⁸⁴ The cities allocating the most of their proposed budgets to solar PV were New Delhi (INR 535 crore or USD 73 million), Mangalore (INR 311.85 crore or USD 42.5 million) and Vishakapatnam (INR 305.83 crore or USD 41.7 million), whereas the cities allocating the most to waste-to-energy were Jaipur (INR 200 crore or USD 27.3 million), followed by Kalyan and Surat.⁸⁵ The cities allocating the most to e-mobility were Chandigarh (INR 163.15 crore or USD 22.3 million), followed by Pune and Dharamshala.⁸⁶



New Delhi, India

AFRICA AND THE MIDDLE EAST

Investment in renewable energy capacity in Africa and the Middle East fell 8% in 2019 to USD 15.2 billion, down from a record USD 16.5 billion invested in 2018.⁸⁷ Most of this investment was in the United Arab Emirates, followed by South Africa and Kenya.⁸⁸

Development finance is important for renewable energy projects across the region, and many funds are available, some of which are applied in city settings.⁸⁹ One notable effort is the USD 4 billion solar PV park (comprising multiple smaller projects) outside of Aswan (Egypt), which is being financed by several international development banks on land donated by the Egyptian government, and is supported by a 25-year PPA with the local electricity transmission company.⁹⁰

In 2020, the German development bank KfW announced a EUR 9.6 million (USD 11.8 million) grant for Kigali (Rwanda) to develop a “green city” project powered by solar PV, which also will be financed by the Rwandan government and the Green Climate Fund.⁹¹ In addition, KfW provided USD 25 million to finance two solar PV plants in the Ghanaian cities of Kaleo and Lawra.⁹² In the United Arab Emirates, loans from international banks were key for the USD 4.33 billion concentrating solar thermal power (CSP) and solar PV project south of Dubai, which dominated investment in the region in 2019.⁹³

Cities in Africa and the Middle East also have relied on PPPs. Since 2011, South Africa’s Renewable Energy Independent Power Producer Programme (REIPPP) has helped independent power producers design, develop and operate biomass, landfill gas, hydropower, solar PV, CSP and onshore wind power plants across the country, many of them in or near cities.⁹⁴ Private investors have readily supported the projects, since the government mitigated project risks through a transparent procurement process.⁹⁵

In Kenya, a tender was issued in 2020 for a build-own-operate-transfer PPP to support a new 140 MW geothermal power plant, from which Kenya Power and Lighting Company (KPLC) will buy electricity under a 25-year PPA to supply local businesses, the city of Naivasha and several surrounding towns.⁹⁶ In Qatar, an 800 MW solar PV farm near the village of Al Kharsaah reached financial close in 2020, supported by a build-own-operate-transfer PPP and USD 330 million in loans from international banks.⁹⁷

Comparatively few African cities have used green bonds to support renewable energy projects. Notably, Johannesburg (South Africa) issued a USD 143 million green bond to fund projects across a range of sectors including new dual-fuel buses and the conversion of 30 buses to biogas.⁹⁸ Although some larger players in the Middle East have issued green bonds (such as the Egyptian government and Qatar National Bank), cities in that region have not yet used this mechanism for renewable energy projects.⁹⁹

Development finance

is important for renewable energy projects in cities across Africa.

LATIN AMERICA

Investment in renewable energy capacity across Latin America has grown markedly, up 43% in 2019 to a record USD 18.5 billion.¹⁰⁰ Four countries dominated this investment: Brazil (up 74% to USD 6.5 billion), Chile (up 302% to USD 4.9 billion), Mexico (up 17% to USD 4.3 billion) and Argentina (down 18% to USD 2.0 billion).¹⁰¹ PPPs, PPAs and development finance provide key support for projects in cities across the region.¹⁰²

PPPs have been used widely in Latin America to finance transport-related projects as well as distributed generation. In 2019, Mexico used the PPP model to attract USD 2.1 billion for 15 solar PV projects, and in Santiago (Chile) a PPP was established to install 104 EV charging points of 22 kW each (which eventually will use renewable electricity) at a total cost of USD 2.5 million.¹⁰³ The state government of Piauí (Brazil) opened bidding in 2020 for a USD 32 million PPP to build eight solar PV plants of 5 MW each in six municipalities (Caraúbas do Piauí, Miguel Alves, Piracuruca, Jose de Freitas, Cabeceiras do Piauí and Canto do Buriti) as a way to meet the power demand of all state-owned buildings.¹⁰⁴ Also in Brazil, São Paulo initiated a PPP for a USD 32.6 million investment in solar PV to supply the city’s health department, and Curitiba partnered with the local utility to jointly finance (51%/49%) a 5 MW solar-biomass project that will supply 43% of the municipal building’s electricity needs.¹⁰⁵

The public and private sectors have used PPAs to establish large-scale wind power and solar PV projects as well, both within and outside cities.¹⁰⁶ Private companies often are driven by a desire to meet sustainability goals. For example, in Mexico the beer producer Grupo Modelo signed a PPA for the construction of a 220 MW wind farm that will supply electricity for the company’s brewery.¹⁰⁷

National banks increasingly have helped finance renewables in the region.¹⁰⁸ The Development Bank of Colombia (Bancoldex) offers a green credit line totalling USD 14.4 million to finance renewable energy and energy efficiency projects in cities across the country.¹⁰⁹ In São Paulo (Brazil), the state’s Bureau of Energy and Mining and the São Paulo Development Agency (Desenvolve SP) provide long-term, low-interest loans for small-scale renewable energy projects including solar PV, wind, and small hydropower plants, as well as equipment for biogas plants.¹¹⁰ International agencies that finance distributed generation usually co-ordinate through partnerships with national and regional banks.¹¹¹

Some innovative instruments have been used to provide finance for smaller-scale projects, especially for solar PV. This includes crowdfunding in Argentina and Mexico and the use of energy service companies (ESCOs) in Brazil, Chile and Colombia.¹¹² Municipal bonds and green bonds have not been used to the extent seen in some other world regions, although examples exist.¹¹³ Mexico City (Mexico) issued Latin America’s first municipal green bond in 2016 with a focus on mobility, energy efficiency, water infrastructure and management projects.¹¹⁴

EUROPE

Investment in renewable energy capacity in Europe fell 7% in 2019, to USD 54.6 billion, with large variations across countries and technologies.¹¹⁵ Most of the investment occurred in Spain (an increase to USD 8.4 billion), the Netherlands (an increase to USD 5.5 billion) and the United Kingdom (a decrease to USD 5.4 billion).¹¹⁶ In Germany, local governments have relied mainly on their own funds to finance infrastructure projects, with contributions from the national and state governments and other purpose-tied investment allocations.¹¹⁷ Only around 20% of finance for municipal infrastructure in the country has come from borrowed funds, mostly bank loans.¹¹⁸

Nonetheless, the use of green bonds is rising across Europe, with notable increases in 2019 in France (up 113% to USD 30.1 billion), Germany (up 144% to USD 18.7 billion) and the Netherlands (up 105% to 15.1 billion).¹¹⁹ Although national governments account for the majority of government green bond issuance in Europe, several local governments and cities have issued a steady stream of bonds – including the Canton of Geneva (Switzerland), Gothenburg and Stockholm's Lans Landsting (Sweden), Ile-de-France (France) and Oslo (Norway).¹²⁰

In Europe, both the aggregate value of PPP transactions that reached financial close in 2019 and the average transaction size decreased in 2019.¹²¹ Although the transport sector dominated these transactions, PPPs also have been used for renewable electricity and heat. Ljubljana (Slovenia) announced a renovation project in 2020 that uses a tested PPP model with a consortium of companies to renovate sports centres, schools and a concert hall with energy efficiency and renewable energy solutions; the city will use the energy savings to repay project costs.¹²² The Serbian cities of Niš and Pirot used PPPs to replace heating oil boilers with biomass boilers in schools.¹²³

The EU provides funding (in the form of grants, equity, loans, guarantees or other) for urban renewable energy projects through various programmes, including the Connecting Europe Facility, EU Integrated Territorial Investments, European Local Energy Assistance, Horizon 2020 SC3 Energy, the Innovation Fund, the LIFE Programme, URBACT and Urban Innovative Actions.¹²⁴ Among recent examples of such support in the heating sector, Rīga (Latvia) attracted EU co-financing to implement a 50 MW boiler house and biomass-fired water boilers of 4 MW each.¹²⁵ The EBRD provided Banja Luka (Bosnia and Herzegovina) with a loan of EUR 8.3 million (USD 10.2 million) to build a 49 MW district heating boiler plant fired by wood biomass.¹²⁶ Pancevo (Serbia) received a loan from the EBRD and KfW to construct a solar thermal field in 2017 as part of a solar district heating project.¹²⁷

Financing for renewables

in cities across Europe is diverse. Cities provide their own funds, rely on national or EU funds and use PPPs or green bonds.

OCEANIA

Investment in renewable energy projects in Australia has increased in recent years, although it fell slightly in 2019 to around AUD 7 billion (USD 5.4 billion), down from AUD 8.5 billion (USD 6.5 billion) in 2018.¹²⁸ Most of the investment was in the private sector, supplied by domestic banks, but overseas financing has played an increasing role. Households have driven small-scale investment in renewables as well, with more than 25% of Australian homes now fitted with rooftop solar PV, many of them in cities.¹²⁹ Around 10% of the country's rooftop solar installations have been financed via short-term credit.¹³⁰

PPAs also are being used in Australia. Historically, developers entered into PPAs with electricity retailers, but corporate PPAs are on the rise, and in some cases municipal governments have joined the ranks. To reach its goal of powering its streetlights, pools, sports fields, depots and other buildings with 100% renewables – which it did in 2020 – Sydney (Australia) signed an AUD 60 million (USD 46 million) PPA for electricity supplied mainly from a 270 MW wind farm and a 120 MW solar PV farm (plus a 3 MW community solar project) in New South Wales.¹³¹ In Melbourne, 14 public and private institutions including the city, banks, universities and local councils signed a collective PPA in 2017 to enable the construction of an 80 MW wind farm in western Victoria state.¹³²

In the Solomon Islands, the country's first ever PPP was signed in 2019 for more than USD 200 million for a 15 MW hydropower project 20 kilometres south-west of the capital city of Honiara.¹³³ Although the original plan considered only private sector financing, the final package also included dedicated funds from the World Bank, the Green Climate Fund, the Asian Development Bank and others.¹³⁴

NORTH AMERICA

In the United States, a leading country in investment in renewable energy capacity, investment grew 28% in 2019 to USD 55.5 billion.¹³⁵ Since 2015, a majority of renewable electricity capacity transactions announced by cities have been supported by PPAs (mostly for capacity located outside of city limits).¹³⁶ This capacity is financed mainly by private rather than public entities, as private entities have the requisite tax liability to take advantage of national and state-level tax incentives. US cities are addressing this by partnering with private companies and by signing PPAs with private developers.¹³⁷

US cities signed PPAs for a total of 2,625 MW of renewable power capacity in 2019, up from 2,056 MW in 2018.¹³⁸ Cincinnati (Ohio) signed a PPA in which the city agreed to purchase the electricity from a 100 MW solar PV farm some 64 kilometres east of the city to fulfil its renewable energy goals.¹³⁹ The PPA model also has been used in Canada: for example, in 2020 the Royal Bank of Canada signed a PPA for two utility-scale solar PV farms in Alberta totalling 39 MW.¹⁴⁰

Some renewable electricity projects in the United States have been financed using municipal green bonds. Richmond (Washington) aims to use a USD 3 million green bond issued by the state in 2019 to build a 1 MW / 4 MWh solar energy battery storage system and training facility.¹⁴¹ In Sacramento (California), the community-owned, not-for-profit electricity provider issued a USD 400 million green bond in 2020 to fund solar PV, hydropower and infrastructure projects.¹⁴²

By contrast, the main source of finance in the transport sector is federal, state and municipal grants or budget allocations, although projects often are supported by or are in partnership with a nonprofit or private sector partner.¹⁴³ In Los Angeles (California), a USD 400,000 grant is providing four zero-emission mobility pilots to the city and the surrounding county, including two EV carsharing projects, an EV charging project and an e-bike project charged by solar PV.¹⁴⁴

CITY-SPECIFIC CHALLENGES TO INVESTING IN RENEWABLES

Regardless of their location, renewable energy projects face inherent financing challenges that raise the investment risks and related financing costs.¹⁴⁵ These challenges include higher upfront technology costs, information gaps and hard lock-ins (the idea that once infrastructure is built, “green” retrofits can be costly or technically impossible to implement before the end of the productive life cycle).¹⁴⁶ Barriers to innovation – in the form of design, products, and new institutions or practices – also are a source of perceived risk for both public and private investors who may be unwilling or unable to evaluate unfamiliar investments.¹⁴⁷

Any city wishing to invest in infrastructure faces challenges in mobilising revenue and allocating budgets.¹⁴⁸ Before seeking investment, municipal governments also must finance the pre-feasibility stage and project preparation, which can represent more than 10% of the total project cost.¹⁴⁹ Governments often have limited budgetary flexibility and face multiple competing claims on their resources, including public safety, water supply, pension liabilities, unemployment, poverty, roads, bridges and waste management.¹⁵⁰ Rapid urbanisation has intensified these pressures.

Municipal governments also may struggle with soft lock-ins, which include limits to institutional capacity and institutional inertia.¹⁵¹ Additional barriers relate to a lack of organisational capacity, knowledge of funding opportunities, and/or equity and debt instruments.¹⁵² For example, even when a municipal or other actor has identified centrally managed EU funds for a given renewable energy project, it must submit an application in English (often not the mother tongue of the applicant country) and partner with organisations from EU Member States to receive these funds. Finding international partners and preparing applications requires time, human resources and often knowledge on technical information and risk assessment.¹⁵³ Local governments in South Africa have reported that the complexity of available international/intergovernmental grants and the high level of human resource investment with no guarantee of return can result in inaction or paralysis.¹⁵⁴

Although higher levels of government can help cities accrue sufficient capital for renewable energy projects, barriers can exist in co-funding arrangements or in limitations to borrowing power. Local governments often depend on national governments to provide a significant amount of finance, which can be inadequate, unpredictable or declining. For example, in the EU more than half of small sub-national governments have reported a decrease in grants from their federal governments since 2010.¹⁵⁵ In terms of limitations to borrowing power, less than half of countries (42%) are recorded as having devolved fiscal or legislative powers to sub-national governments, and of these the depth of revenue-raising powers is highly variable.¹⁵⁶ Only 22 countries (14%) allow borrowing without restriction, and 56% forbid outright borrowing by local governments.¹⁵⁷

Cities in developing countries face additional barriers.¹⁵⁸ Poorer developing countries often suffer from a tax base that is inadequate to finance the cost of basic infrastructure.¹⁵⁹ Many developing-country cities are not perceived as creditworthy, making it more difficult for them to take out bonds and loans as well as to attract private investment.¹⁶⁰ Typically, cities that have lower credit ratings are charged higher interest rates to finance projects.¹⁶¹ Of the 500 largest cities in developing countries, less than 20% are deemed creditworthy in their local context, and less than 4% are creditworthy in international capital markets.¹⁶²



Los Angeles, United States

Any city wishing to invest in renewables faces

challenges

in mobilising revenue and allocating budgets.



Brussels
Mexico City
Barcelona
Mandurah
Cadiz
Bristol
Silkeborg
Slavutych
Vienna
Seoul
Brooklyn
Durban
Strasbourg

5

**CITIZEN
PARTICIPATION**

Recife
Jakarta



CITIZEN PARTICIPATION

Citizen participation in renewable energy can be defined broadly as the different ways in which inhabitants are involved in planning, funding, managing, governing and/or executing the development of renewables in cities.¹ Citizensⁱ can support the development of urban renewable energy by, for example:

- choosing to purchase energy from a provider that offers renewable electricity or heat, in cities where consumer choice, such as green tariffs, is an option;
- becoming individual prosumersⁱⁱ by producing all or part of their own energy;
- getting together to form community energy projects;
- participating in setting the direction for the development of urban energy systems; and
- making their voices heard through bottom-up initiatives and campaigns in favour of renewables.

The active engagement of citizens in renewable energy development – as energy producers and as members of energy communities engaging in decision-making processes and wider campaigns – has been pivotal to the rising penetration of renewablesⁱⁱⁱ.² Citizen participation stimulates investments by individuals and local communities in renewable energy generation.³ Citizen participation also is central to enabling a

just transition to a decarbonised energy system that simultaneously considers the needs of impacted communities, addresses energy poverty and delivers on climate mitigation.⁴

Although citizen participation is usually based on bottom-up approaches and on the actions of inhabitants, municipal governments, because of their proximity to citizens, can play a strategic role in facilitating the involvement of citizens. Through their planning processes, municipal governments can include citizens in the design, ownership and management of energy systems to account for citizens in their positions as prosumers, owners of energy storage facilities, and holders of rights and entitlements to shape the development of urban energy systems.⁵

In return, engaging citizens at the local level increases public awareness about renewables and can accelerate cities' transitions to renewable energy. For example, the siting of renewable energy projects generally is easier if all stakeholders are involved in the planning from the beginning and understand the potential benefits.⁶ Citizens also can play a central role in providing sites and investment for small-scale distributed projects. Further, citizen participation may address interlinked social issues relating to fuel poverty, health and well-being.⁷ Decision-making processes that involve active citizen participation can increase trust in the local community and government.⁸

i Here, "citizens" refers to people living in a particular place, rather than to people holding specific legal rights due to their nationality. Usually, residents within a city (regardless of citizenship) are able to shape city-level energy transitions. See Oxford Learner's Dictionaries, "Citizen", <https://www.oxfordlearnersdictionaries.com/definition/english/citizen>, viewed 15 November 2020.

ii Both consumers and producers of energy. See Glossary for full definition.

iii For more information, see chapter on "Public support" in REN21's *Renewables 2020 Global Status Report*, available at www.ren21.net/gsr.

The ability of municipal governments to engage citizens at the city level is greatly conditioned by decisions at higher levels of government. In addition, intermediary organisations, such as energy offices, innovation hubs and private consultants, play central roles in promoting citizen participation in the development of urban energy systems. These organisations can, for example, act as liaisons between local governments and communities; support existing or potential prosumers or community energy co-operatives by providing information, advice and investment support; assist in the implementation of technologies; and defend the interests of adopters.

Engaging citizens at the local level increases

public awareness

about renewables and can accelerate cities' transitions to renewables.

CONSUMER CHOICE

For urban populations that have access to affordable electricity, the most basic way that citizens can participate in energy systems is through consumer choice, or allowing people to choose among different energy suppliers. While consumer choice is available outside the city context as well, it provides a key opportunity for urban residents to influence energy supply through their energy preferences. Consumer choice most commonly exists in the electricity sector, but it also can stimulate the uptake of renewables in the heating and cooling and transport sectors.⁹

One precondition for consumer choice is that energy markets have been liberalised, making it possible for consumers to select among a number of different suppliers that deliver energy to the city.¹⁰ Although the ongoing liberalisation of energy markets supports the development of green tariff programmes – where utilities buy renewable energy to match a portion or all of the electricity bought by consumers – it does not ensure them, and these decisions generally are undertaken at the national or state level.¹¹ Municipal governments can support green tariffs through marketing campaigns that highlight the personal and societal benefits of renewable energy. Such awareness campaigns are particularly important for making green tariff schemes attractive to “light green” consumers who may have positive attitudes towards renewables but are not yet purchasing them.¹²

In some jurisdictions, interest in buying renewables has surged, often driven by the declining price of renewable power relative to other electricity sources, by awareness-raising on energy and climate issues, and in some cases by rising electricity prices.¹³ In 2020, more than half (53%) of US residential consumers found it “extremely” or “very” important that renewable energy contribute a portion of their electricity supply, marking the first time in a US survey that renewables ranked higher than energy affordability.¹⁴ A survey in the United Kingdom found that green tariff purchases motivated 19% of consumer switches between energy suppliers in mid-2020, up from only 9% in 2018.¹⁵

Consumer choice can manifest in different ways:

- **Green tariff programmes** typically allow consumers to choose among a variety of utility-offered plans that supply electricity or district heat generated fully or partly from renewables. Under “guarantee of origin” rules, the utilities are required to demonstrate the renewable energy content of this supplied energy.¹⁶
- **Pay-as-you-go (PAYGo) services** offer customers an alternative to contracting with utilities. These services are prevalent in cities where the electricity grid is not fully developed or lacks stability, or where electricity is expensive. Typically, the PAYGo electricity comes from decentralised solar PV systems.¹⁷
- **Peer-to-peer energy trading programmes** enable consumers in some cities to purchase renewable energy from other citizens or businesses rather than from utilities (→ see *Individual Prosumers section in this chapter*). Enabled by digitalisation, such programmes are becoming available for larger groups of consumers (→ see *Sidebar 7*).¹⁸ Peer-to-peer trading is emerging as an important option for expanding renewable energy consumption in the future.¹⁹

One way that municipal governments seek to increase consumer choice opportunities for city inhabitants is by lobbying for the rights of citizens to be able to purchase renewable energy. In California (US), local officials in Los Angeles and San Jose have protested against exit feesⁱ paid to incumbent utilities, which effectively disincentivise citizens from participating in community choice aggregation programmes (→ see *Urban Policy Landscape chapter*).²⁰ Cities can attract more citizens to such programmes by offering competitive tariff rates, greater shares of renewable energy, and a portfolio of incentives that provide environmental and economic benefits to participants, including small grants subsidising the purchase of solar PV equipment.²¹

Generally, green electricity markets have expanded in recent years, although no consolidated data on them exist at the city level, and data also are hampered by definitional differences (for example, in the types of green tariffs).²² Among recent examples, in Ankara and Istanbul (both Turkey), a green tariff programme for 100% renewable energy became possible in 2020 following changes in national legislation.²³ In the United States, the share of households with access to green electricity purchasing increased from 14% in 2016 to 20% in 2020, and the share of households actually buying green electricity increased from 6% to 11%.²⁴ In the United Kingdom, more than 50% of the electricity tariffs available on the market in 2019 had renewable energy content, up from only 9% in 2016.²⁵

However, not all countries with liberalised energy markets offer green tariff programmes for citizens. In Latin America, for example, the situation varies. In Argentina, Chile and Mexico, urban residents are able to purchase renewable power only if they buy a specified minimum amount of electricity, which effectively excludes much of the population from selecting renewable options.²⁶ In some cities, PAYGo models are filling the gap by offering a greater choice of providers and electricity sources.²⁷ In Medellín, Colombia, the public utility has a PAYGo offering that allows residential users to regulate their electricity consumption through pre-payment based on their real purchasing power.²⁸

i Exit fees are intended to compensate utility companies for previous investments they have made in, for example, energy infrastructure such as transmission and distribution lines.

SIDEBAR 7. Digitalisation: Enabling Citizen Participation

Digitalisation refers to the increasing reliance of business models on digital technologies. In the case of renewable energy, digitalisation enables both consumer choice and prosumerism, allowing for increased flexibility and transparency for customers and greater profitability for prosumers.

On the consumer choice side, for example, the Australian company Power Ledger provides an energy trading platform to utilities, energy retailers and others that uses blockchainⁱ technology to enable greater transparency in energy sourcing. Rather than simply choosing renewables, customers can fully design their own energy mix by selecting the specific projects that generate their electricity, from a certain wind turbine to a neighbour's solar PV installationⁱⁱ.

To support prosumers, peer-to-peer energy trading built on blockchain technology makes it possible for residential producers to supply other citizens with electricity, including in cities such as London (UK), Medellín (Colombia), New York (US) and Singapore. The municipal-level Brooklyn Microgrid

in New York City, launched in December 2019, provides a digital platform for households to sell renewable energy to others. In New Delhi (India), communities in the Dwarka neighbourhood trialled group net metering solutions in 2020 whereby surplus solar electricity is sold to neighbours rather than fed into the grid. Such approaches can result in improved profitability for prosumers and in access to cheaper, renewable energy for neighbours.

Municipal governments can support pilot programmes that demonstrate the technical and commercial feasibility of new digital technologies. They also can provide financial incentives for deploying advanced metering infrastructure that allows two-way communication between prosumers and system operators. Such approaches help ensure that the data are used for the benefit of citizens by, for example, enabling people to better understand their energy use and the possibilities for reducing it or for shifting their time of use.

Source: See endnote 18 for this chapter.

- i Blockchain technology is a distributed ledger technology that permits the storing of data on servers around the world while also allowing every network member to view all data stored on other members' servers.
- ii Although consumers choose to support specific renewable energy projects, this does not mean that their electricity actually originates from these projects, as it is impossible to control where specific electrons go once they enter the grid.



New Delhi, India

INDIVIDUAL PROSUMERS

In their decision to consume renewable energy, individuals, households and businesses may opt to produce part or all of this energy themselves, in their role as prosumers (both consumers and producers of energy).²⁹ Rooftop solar PV is the preferred technology choice, particularly in cities where space is limited, but prosumers also are adopting solutions ranging from micro wind turbines to wood pellet heating (connected to district heating systems).³⁰ Prosumerism is an attractive option in many places. In a 2020 survey in Brazil, 90% of respondents said they would like to produce electricity at home, typically from solar PV systems.³¹ However, consolidated data on prosumers in cities remain scarce.

Many of the policies supporting prosumers – including feed-in tariffs, net metering schemes and policies ensuring full compensation for electricity or heat fed back to the grid – are adopted at the state or national level.ⁱ However, some examples exist at the city level (→ see *Urban Policy Landscape chapter*), and municipal governments support prosumers in a variety of ways. In Brussels (Belgium), the regional government provides low-interest loans for households to invest in renewable energy equipment.³² Mexico City (Mexico) allocates USD 17.1 million annually for distributed solar capacity, with the aim of adding 350 MW by 2024.³³ Municipal governments also play an important role in co-ordinating consumer awareness campaigns.

Another emerging trend is solar leasing agreements, whereby developers or financing institutions cover the long-term leases for rooftop solar PV installations, and citizens then pay a periodic fee to use the generated power rather than having to invest in the system themselves. The resulting energy cost savings or the profit from feeding electricity into the grid are shared with the citizen. Although public authorities typically are not involved directly in solar leasing, city governments can promote it by ensuring the availability and comparability of information on related costs.³⁴ Solar leasing was first developed in the United States but is diffusing rapidly, including across India and Malaysia in Asia.³⁵

Among other innovations emerging at the city level is the provision of collective energy storage. In the Meadow Springs suburb of Mandurah (Australia), the PowerBank Community Storage System enables 52 individual prosumers to store excess energy from their solar panels in a shared battery facility, and then withdraw up to 8 kWh of electricity per day for a daily fee of AUD 1 (USD 0.77).³⁶

Municipal governments support prosumers and community energy projects in a variety of ways.

COMMUNITY ENERGY IN CITIES

Traditionally a rural phenomenon, community energy projects have increasingly made their way into cities. In its most basic form, community energy refers to energy systems that are managed by local people for the benefit of local people.³⁷ This generally entails collective local ownership along with decision-making power that lies with a group of local inhabitants. Most community energy projects are focused on renewable energy production, but projects also exist for energy storage, energy efficiency, mobility, sharing and trading, among others. Assessing the full scope of community energy initiatives in cities is challenging because of a lack of data and varying definitions of the termⁱⁱ.

The collective character of community energy sets it apart from “simple” prosumerism. Community energy usually brings local benefits such as job creation and improved societal welfare, greater energy security through cost savings and price certainty, and expanded awareness and public acceptance of renewable energy technologies – in addition to contributing to wider sustainable development objectives and emission reductions.³⁸ Because community energy arrangements depend on collective decision making by local inhabitants, this broadens participation in the energy system and strengthens local cohesion and democratic processes, often empowering citizens beyond the respective community energy projects.³⁹ Community energy makes participants conscious about their rights and responsibilities and adds to a sense of energy citizenship and energy democracy.⁴⁰



i Worldwide, as of the end of 2019, feed-in policies were in place in 113 jurisdictions at the national, state or provincial levels. In 2019, the shift continued away from feed-in policies and towards mechanisms such as auctions and tenders. See REN21's *Renewables 2020 Global Status Report*, available at www.ren21.net/gsr. In the European Union, the recent Clean Energy Package has greatly empowered prosumers, including ensuring their right to receive compensation that reflects the market value of the electricity that they supply to the grid.

ii For example, two formal terms for community energy are “citizen energy community” and “renewable energy community”. In Germany, community energy refers narrowly to citizen associations, whereas in the United States it includes projects for which electric utilities (not necessarily municipal utilities) or third-party providers sell “shares” to local consumers. Nevertheless, the trends show that renewable energy initiatives involving citizens are increasingly present in cities worldwide.

Community energy projects are most common in countries that have liberalised energy markets and where incumbent energy providers are less powerful. The number and character of community energy projects within cities varies widely: projects are more frequent in European countries such as Belgium, Denmark, Germany and the United Kingdom, as well as in the United States, but they also are emerging in Australia, Canada, Japan, the Republic of Korea and Thailand, among others.⁴¹

While many community energy projects originate at the grassroots level, local authorities often actively support these efforts through funding schemes, favourable procurement rules, and the provision of expertise as well as access to public spaces (such as public land or roof space on schools, courthouses and other public buildings).⁴² In the EU, municipalities can legally become members of community energy projects.⁴³ Through such support, cities can tap into the creativity, expertise and financial resources of residents as a way to meet their own local renewable energy and climate goals and strengthen citizen support for renewables through direct participation.⁴⁴ Municipal governments and citizens thus become allies in the transition towards a renewable-based energy system.

Municipal governments around the world play various roles in supporting community energy projects:

- **Regulatory and policy enablers.** Governments create an enabling environment for community energy development by, for example: including targets for community ownership in municipal climate and energy strategies; making it mandatory for developers to offer community ownership options; securing partnerships with rural hinterlands to set up urban-rural projects; and using urban planning to steer new neighbourhoods towards community energy.⁴⁵
- **Project partners and facilitators.** Governments directly support community energy projects by, for example: creating a dedicated body at the city level to provide projects with information and know-how; mapping the city's renewable energy potential; acting as a liaison to bring interested stakeholders to the table; helping to secure funding from municipal sources or third parties; and even becoming a member of a community energy project.⁴⁶
- **Infrastructure operators.** Governments invite community involvement in energy infrastructure by, for example: allowing community participation in municipality-owned utilities; providing opportunities for participatory financing; and teaming up with community energy initiatives to advance remunicipalisation efforts, which open the door for further community energy projects (→ see *Remunicipalisation section*).⁴⁷

In **Europe**, EU Member States are required under the 2019 Clean Energy for All Europeans package to provide legal definitions of community energy projects and to develop supportive legal frameworks.⁴⁸ The number of active community energy projects across Europe increased from some 2,400 in 2015 to more than 3,600 in 2019.⁴⁹ Around 1,500 projects are members of REScoop, the European association of community energy projects, which represents more than 1 million citizens and acts as both an intermediary and lobby organisation.⁵⁰ Most community energy



projects are in Germany, Denmark and the Netherlands, although no coherent trend exists and the situation varies greatly among EU Member States.⁵¹ Studies point to the region's large potential for citizen-financed community energy projects.⁵²

The COVID-19 pandemic appears to have slowed the growth in community energy in Europe, with existing projects reporting lower turnover and delays in installing new equipment.⁵³ However, the emerging pandemic recovery packages and the European Green New Deal could have a positive influence on projects in cities and elsewhere. In Croatia, COVID-19 recovery funds enabled the construction of 1,000 community-owned solar PV systems in 10 cities, supported by the European Institute of Innovation and Technology and the Climate KIC Cities Accelerator Programme.⁵⁴

In Spain, urban citizens are involved in community energy projects through several large regional co-operatives, including Som Energia (67,800 members) and GOIENER (more than 10,000 members).⁵⁵ The concept of collective self-consumption, introduced in 2019, allows citizens in densely populated areas to join together and become "off-site prosumers" by investing in solar PV installations near their homes and on neighbouring buildings, to the benefit of the wider community.⁵⁶ Municipal governments have spearheaded community energy projects in Spanish cities including Barcelona, Cadiz, Girona, Madrid, Pamplona, San Sebastian, Valencia and Valladolid.⁵⁷

Germany has been a leading country in community energy development, with an estimated 1,750 projects in 2020.⁵⁸ Spurred by a strong domestic renewables sector and feed-in tariffs, many communities have benefited economically from renewable energy projects.⁵⁹ The number of new community energy projects in Germany peaked in 2011, with 167 initiatives added that year.⁶⁰ Since then, changes in national legislation – specifically, a shift from feed-in tariffs to an auction system – have created difficulties for community energy groups, and only 14 new projects were added in 2019.⁶¹ Most of Germany's projects are

located in rural areas, but some are in cities, for example in Jena where communities act as shareholders with decision-making power over their local energy suppliers.⁶²

Denmark has a long history of community energy development. Although community-owned wind power projects often are located in rural areas, solar-based district heating systems frequently occur in or near cities. In 2019, Denmark was home to 120 such plants, including in the town of Silkeborg.⁶³ In Marstal, on the island of Ærø, a solar district heating system supplies 55% of the total heat demand (the rest is from wood chips and a heat pump), and citizens collectively own both the plant and the heating grid.⁶⁴

At least 300 community energy groups were active in the United Kingdom in 2019.⁶⁵ These groups were involved mainly in electricity generation (with fewer projects related to heat generation), installing more than 15.4 MW of new electricity in 2019 for a cumulative total of 264.9 MW.⁶⁶ Groups pushed to finalise community-owned electricity projects in anticipation of the ending of the feed-in tariff programme in March 2020.⁶⁷ Among community energy activities in UK cities, the Community Energy London Network, which connects 700 people involved in 30 projects, has resulted in 450 tonnes of CO₂ savings since the start of the network in 2018.⁶⁸ In Edinburgh (Scotland), the Community Solar Cooperative produces 1.1 GWh of electricity per year from 24 solar PV systems.⁶⁹ Community energy projects also exist in Brighton, Bristol and Bournemouth (all England) and in Cardiff (Wales).⁷⁰

Community energy projects have grown in Belgian cities as well.⁷¹ In 2019, citizens in Brussels installed a rooftop solar PV system on a public building – producing 36,000 kWh annually – and then connected it with a public electric vehicle charging station.⁷² A community project in Leuven installed a 57-panel solar PV plant in 2020 with a capacity of 16 kW-peak, and the city also worked with co-operatives to install two rooftop PV installations that citizens can invest in that supply a local daycare and a community centre with 98,000 kWh and 11,500 kWh annually, respectively.⁷³

Also in Belgium, Cooperative Energy Mouscron installed 100 solar PV systems on residential homes in the city of Mouscron, with

a total of 1,145 PV panels producing an estimated 292 MWh per year.⁷⁴ In Eeklo, the municipality and local citizens formed a co-operative to build two wind turbines in 2011, and by 2020 the project was supplying some 48,500 members with renewable energy; citizens who cannot afford a co-operative share get access through municipality-held shares.⁷⁵ Another co-operative, Pajopower, active in the Flanders region, creatively supported the city of Halle in replacing 445 public street lights with LEDs by having citizens “adopt” the street light in front of their door, thereby raising the EUR 225,000 (USD 276,355) needed for the project.⁷⁶

Elsewhere in Europe, citizens and companies in Almere (Netherlands) financed a project to repower the 320 MW Zeevolde wind park by replacing 220 old wind turbines with 91 new ones.⁷⁷ In 2019, the Solar Town project in Slavutych (Ukraine) installed 200 kW-peak of solar PV on local roofs, in an initiative co-owned by local residents and private investors and financed via crowdfunding.⁷⁸ In Vienna (Austria), between 2012 and October 2020, 6,000 citizens had taken part in a programme whereby the city-owned utility Wien Energie installs solar panels on buildings and then offers people the opportunity to buy the panels and lease them back to the utility for an annual return.⁷⁹ In Strasbourg (France), a community solar PV project started in 2020 aims to be more inclusive by making shares available for only EUR 100 (USD 122.8); it relies on a network of people to identify feasible new sites for solar PV, and the project managers negotiate with homeowners and facilitate the installation.⁸⁰

In the **United States**, energy communities differ from those in Europe and elsewhere in that they generally invite members to only purchase the renewable energyⁱ produced from community projects, rather than buying shares outright. However, the set-up and ownership structure of US community solar projects usually resembles that in other parts of the world. The number of community solar projects in the United States has increased, with an estimated 297 new projects operating in 2019 and another 43 projects operating in 2020, for a total capacity of 566 MW-peak among these 340 projects.⁸¹



Municipal governments use participatory governance to

include citizens

in decision making related to energy and climate protection.

i The Coronavirus Amendment Order extended feed-in tariff accreditation to September 2020.

ii According to the National Rural Electric Cooperative Association, US co-operatives cover a territory equivalent to 56% of the country's landmass, powering more than 20 million businesses, homes, schools and farms across 48 states and serving 42 million people in more than 2,500 counties. Collectively, the 843 distribution co-operatives and 63 generation and transmission co-operatives generate 5% of all US electricity and deliver 12% of it. While 95% of the co-operatives include renewables in their energy mix, only 17% of the total energy they produce comes from renewable sources (10 GW). See National Rural Electric Cooperative Association, "America's Electric Cooperatives", June 2020, <https://www.electric.coop/wp-content/uploads/2021/01/Co-op-Facts-and-Figures.pdf>.

Among US projects in cities, the boroughs of Brooklyn and the Bronx in New York City deployed 20 and 16 new projects, respectively, between 2018 and 2020.⁸² Based on a local ballot measure in 2018, Portland (Oregon) set up the Portland Clean Energy Community Benefits Fund, which supports renewable energy installations to benefit disadvantaged communities; it is anticipated to bring USD 44-61 million in new annual revenue for green jobs, healthy homes and a climate-friendly Portland.⁸³

In **Asia**, many of the existing community energy projects were developed in response to Japan's 2011 Fukushima nuclear disaster, including initiatives in Japan and Thailand.⁸⁴ In the Republic of Korea, communities had established more than 100 renewable energy projects by late 2018, many of them in cities.⁸⁵ The country's first project, comprising five solar PV power stations built in leased public space, was installed in Seoul's Eunpyeong district in 2013, with a total capacity of 332 kW.⁸⁶ The community is planning another six or seven plants, totalling 600-700 kW, by 2021.⁸⁷ The surge in renewable energy communities in the Republic of Korea is attributed in part to the 2012 Cooperative Act, issued in response to the Fukushima disaster.⁸⁸

Government funding for community energy in **Latin America** has tended to prioritise electrification projects in remote rural communities.⁸⁹ As a result, several urban areas have turned to crowdfunding to support community-based projects. The collective funding platform Red Giralsol connects small-scale investors with citizens and companies that want to invest in renewable energy projects in Mexico City and elsewhere.⁹⁰ In Brazil, community-owned solar systems sprung up after the National Energy Agency changed its regulations in 2015 to allow for shared distributed generation; by 2019, at least eight community energy initiatives were operating in the country, including solar options for urban residents who do not own the buildings they live in.⁹¹ In 2020, a community solar PV project was started in Rio de Janeiro's *favela* (slum) that will supply 30 families with electricity from a 26 kW-peak solar PV system; the system will be refinanced by 50% of the savings on the energy bills of its members.⁹²

In **Oceania**, community energy projects have emerged across Australia, supported by federal policies.⁹³ A solar garden in the Riverina region, which comprises 333 "virtual plots" of 3 kW each that will produce an estimated 4.2 MWh each per year, supports citizens who wish to become involved in renewable energy production but are unable to for various reasons (including living in an apartment, renting their property, heritage challenges or a lack of knowledge about solar panels).⁹⁴ The town of Yackandandah in Victoria state, in a community-led approach to bringing renewables to citizens, hosts three microgrids and a power storage project, all of which stem from a 100% volunteer-run initiative that aims to achieve energy sovereignty by 2022.⁹⁵ To the north, the renewable energy hub in Narrabri (New South Wales), established in September 2020, is one of 50 planned



hubs in Australia to support new community energy projects.⁹⁶ The initiative demonstrates how cities can take an active role in supporting intermediaries and providing their services free of charge to community groups.

Community energy projects in **Sub-Saharan Africa**, where more than 600 million people still lack access to electricity, can help greatly to address this challenge.⁹⁷ Small-grant programmes enable citizens to invest in mini-grid solutions that bring electricity to low-income households in rural areas as well as in low-income urban areas with unreliable or no grid access.⁹⁸ Urban community energy projects help spread renewable installations in places that already have reliable grid access. In Cape Town (South Africa), where the local government facilitated the installation of an 84 kW solar PV system at Wynberg Girls High School, citizens who buy shares in the project receive a dividend over a 20-year period (→ *see Feature chapter*).⁹⁹

■ PARTICIPATORY GOVERNANCE

Municipal governments have the opportunity to use participatory governance to include citizens in a range of decision making related to energy and climate protection – whether in planning, budgeting or policy development processes. Whereas at higher levels of governance, energy and climate planning have tended to occur without the involvement of civil societyⁱ, municipal governments are generally closer to residents and thus have been able to use participatory governance more often to advance their sustainable development and energy transition goals (→ *see City Snapshot: Jakarta*).¹⁰⁰

ⁱ Several European countries have introduced citizen assemblies to inform climate and energy policies. In France, the government set up a citizen assembly of 150 people in response to the 2018 yellow vest protests. This assembly, whose task is to suggest policies that can cut French emissions 40% by 2030 in a socially just way, will debate and propose laws in an approach that is "unfiltered" either by the French parliament or by referendum. Comparable bodies exist in Ireland, the United Kingdom and Spain, where the government set up the assembly after the country declared a climate emergency.

JAKARTA

INDONESIA

Land area
(km²)



7,639

Population size
(2019)



10.1 million

Greenhouse gas
emissions
(CO₂ equivalent)

GHG

34.5 million tonnes

As the capital of Indonesia, Jakarta is taking effective action to reach its goal of reducing the city's greenhouse gas emissions 30% by 2030, a target set in 2012. The local action plan serves as a means to help achieve Indonesia's national emission reduction target of 29% by 2030, with a focus on renewable energy. Jakarta also committed in 2016 to reducing its water and energy consumption 30% and to achieving 30% renewables in its energy mix by 2030. To meet this latter target, the municipal government plans to increase its solar panel capacity by 600 kW-peak per year and to develop waste-to-energy plants.

The local government also is actively engaging citizens and stakeholders in the formulation of the Ikhtiar Jakarta ("city promise") initiative, which outlines Jakarta's commitments in the areas of energy, green buildings, transport, clean water, waste and disaster management. Six public consultations with a total of 300 attendees were conducted in 2018-19 to promote sustainable lifestyles and support the initiative. Jakarta also is developing a Regional Energy Plan (RUED-P), which contributes to achieving the targets set in the National Energy General Plan (RUEN) and the National Energy Policy (KEN).

In 2019, Jakarta implemented Governor Instruction No. 66, which mandates the city's Transmigration, Manpower and Energy Agency to install rooftop solar on large public buildings, including all schools, sport facilities, hospitals and government buildings during 2019-22. In 2019, a total solar capacity of 2,060 kW-peak was installed on 98 schools, bringing the combined rooftop solar capacity on schools and government buildings to 2,675 kW-peak and showcasing the great potential to minimise local carbon footprints.

Source: See endnote 100 for this chapter.



In Jakarta
citizens have
actively helped
shape the city's climate action plan.

Municipal governments have a variety of tools at their disposal to increase citizen participation in decision making. Cities around the world invite citizen feedback by permitting ordinary people to review policies before they enter into force. Through **participatory planning**, cities enable citizens to develop and choose among different options for urban energy plans. Some cities also support participatory budgeting, through which citizens are granted the ability to allocate a share of the city budget following open and democratic deliberation. Although no consolidated data exist on participatory governance at the municipal level, the approach is being used increasingly in cities in Europe and the United States, among other places.¹⁰¹

The COVID-19 pandemic has negatively affected traditional approaches to participatory governance by limiting the ability to hold in-person meetings, which has raised concerns about community voices not being heard.¹⁰² In response, some municipal governments have used digital tools such as apps and online forums to gather ideas from citizens. For example, Edinburgh (Scotland) initiated the Edinburgh Climate Talks to encourage citizens to get involved in developing local recovery plans and to support efforts to reach the city's net-zero emissions goal by 2030.¹⁰³

In 2019 and 2020, several municipal governments involved their citizens in **developing climate and energy plans**. In Ii (Finland), the municipality and nearly 500 citizens jointly created a plan to reduce greenhouse gas emissions 80% by 2030 (from 1990), based on energy efficiency measures, the use of renewables in all public buildings and switching the municipal fleet to electric vehicles.¹⁰⁴ By 2020, they had already achieved a 62% reduction in greenhouse gas emissions.¹⁰⁵ In Münster (Germany), 1,200 local citizens helped draft the city's 2050 climate roadmap, which targets a 95% reduction in greenhouse gas emissions by 2050.¹⁰⁶ Citizens in Sønderborg (Denmark) participated in developing the city's 2025 energy roadmap.¹⁰⁷ In Amsterdam (Netherlands), citizens were invited to contribute to the city's heat transition vision for a fossil-free heating system by 2040, which was open to public comment until May 2020.¹⁰⁸ Citizens in Ghent (Belgium) contributed to designing the new mobility concept of the Dampoort neighbourhood in consultations through December 2020.¹⁰⁹

Many cities and municipalities in the United States rely on a participatory governance model, holding town halls, city council hearings and other fora to hear from community members. This has pushed forward the development of community choice in energy provision as well as cleaner transport measures (such as electrification of urban transport infrastructure and electric vehicle charging). In Savannah (Georgia), high turnout and interest in the February 2020 town hall meeting led to the goal of switching the city to 100% renewable electricity by 2035.¹¹⁰ Under California's community choice aggregation programmes, which are municipally owned and operated, citizens have a say in how the utilities conduct business and what they prioritise by virtue of influencing municipal climate action.¹¹¹

South Africa's planning processes are by law open to comment from citizens. eThekweni municipality, which includes the city of Durban, aims to achieve at least 40% renewable energy supply by 2030 and 100% by 2050.¹¹² The Draft Energy Policy, which outlines how the municipality plans to reach these goals, was open to public comment until 15 January 2021 on the municipality's website.¹¹³ Also in South Africa, the social enterprise iShack has helped disadvantaged communities in Stellenbosch and Cape Town, among other cities, electrify in a participatory manner. iShack's projects in various locations provide households that lack grid access with funding to install off-grid solar PV systems to meet basic energy needs.¹¹⁴ In 2018, GreenCape's Witsand Informal Settlements project in Cape Town used a participatory co-design approach to identify people's energy needs, leading to the provision of 50 solar-powered streetlights and Wi-Fi hotspots in 2020.¹¹⁵

Cities in Europe increasingly have introduced **participatory budgeting**. Paris (France) reserves 5% of its investment budget for this purpose, with one-fifth of this funding, or EUR 100 million (USD 122.8 million), earmarked for climate-friendly investments.¹¹⁶ Mouscron (Belgium) initiated a project in 2017 – financed through a participatory budgeting process that began in 2016 – to install solar panels on school buildings in low-income neighbourhoods; it then sold 55% of the shares in the panels to local residents at favourable rates to form a community energy project.¹¹⁷ In Latin America, participatory budgeting is used in Bogotá (Colombia) and Porto Alegre (Brazil), but whether and how these governance mechanisms influence the deployment of renewables in these cities is unclear.¹¹⁸



Cape Town, South Africa

Several municipal governments have
involved their citizens
in developing climate and energy plans.

■ BOTTOM-UP INITIATIVES AND CAMPAIGNS

Rising public awareness and concerns related to climate change have increased citizen engagement in energy issues. During global climate strikes in 2019 and 2020, millions of citizens in cities around the world filled the streets demanding action to address climate change and shift energy systems away from fossil fuels.¹¹⁹ In response to rising public pressure, cities have adopted climate and energy plans, and many have strengthened existing plans. Against the backdrop of increasing public awareness of sustainability and energy concerns and mounting public pressure, municipal as well as regional, national and supra-national governments have adopted more ambitious climate and energy strategies, remunicipalised local utilities and declared climate emergencies.

Many citizen groups target their local municipalities through bottom-up climate and energy initiatives. In the Netherlands, the group Lochem Energie is pushing for the city of Lochem to achieve “energy autarky” by 2030, meaning that all energy in the municipality is to be produced by citizens, companies or public suppliers within local borders.¹²⁰ In the United Kingdom, citizens successfully campaigned in Leicester and Eastbourne to have these cities adopt ambitious climate plans.¹²¹

Public demands also have helped address environmental problems related to fossil energy projects while simultaneously supporting renewables. Citizen pressure in Chile led to closure of the Ventanas 1 coal power plant and to the creation of an urban development plan for Puchuncaví and Quintero in 2020 that includes renewable energy and energy efficiency measures.¹²² Also in Chile, following public demand, the coal power plant in Concepción will be taken out of service by 2022, and the city aims to expand its renewable energy capacity through hydropower and other renewables.¹²³

A growing number of residents have joined efforts with their municipalities to regain control over key municipal infrastructure. In the last decade, **(re-)municipalisation** campaigns have pushed more cities to take control of local power suppliers and grids. These campaigns frequently are a reaction to disappointment with the outcomes of previous privatisations in the energy sector.¹²⁴ (Re-)municipalisation has been seen as an important tool to advance renewable energy in cities, in addition to achieving broader objectives such as local economic growth and re-industrialisation.¹²⁵

Globally, (re-)municipalisation of energy infrastructure peaked in 2016, but the upward trend has continued.¹²⁶ At least 1,408 cases of remunicipalisation of critical infrastructureⁱ were recorded as of late 2020, including 369 energy-related cases (13 of them occurring between 2018 and late 2020).¹²⁷ The bulk of these cases (305, or around 80%) were in Germany, followed by Spain (18), the United Kingdom (13) and the United States (11).¹²⁸

The case of Eau de Paris, the water utility in Paris (France), is an example of how city governments can use local utilities to support the development of renewables in a cross-sectoral manner. After taking water provisioning back into public hands in 2009, citizens of Paris did not simply benefit from lower tariffs for drinking water. In addition, the democratically elected board of Eau de Paris installed solar PV panels (generating 17,500 MWh of electricity in 2018) and decided to set an internal goal of 95% renewables in the company's power mix by the end of 2020.¹²⁹

In Wolfhagen (Germany), citizens initiated a process of remunicipalisation of the local power supplier in 2012, and by 2020 the city together with a citizen co-operative owned the power provider. The co-operative has a 25% ownership share, effectively granting it two of the nine seats on the company board.¹³⁰ In the last decade, a number of UK municipalities attempted to set up publicly owned energy providers to address energy poverty in the country by offering low tariffs for struggling citizens. However, two of the main municipal-owned companies – Robin Hood Energy in Nottingham and Bristol Energy – were sold after severe financial losses.¹³¹

In Spain, the cities of Barcelona, Cadiz, Madrid and Zaragoza all initiated remunicipalisation projects that returned critical energy infrastructure into public hands, giving local politicians the chance to retain profits from energy sales and to set up local projects, such as an energy poverty fund in Cadiz.¹³² Barcelona's publicly owned power provider, Barcelona Energía, buys renewable energy directly from small-scale producers in the region and sells it to citizens in the city, offering value-added tax reductions and favourable tariffs for disadvantaged citizens to ensure that all people can benefit from renewables.¹³³



i Including water, transport, energy and waste.

In the Middle East, remunicipalisation took place in the city of Hebron (State of Palestine), where the publicly owned Hebron Electric Power Company is developing solar PV on all municipal buildings and an additional 500 rooftop PV systems on schools, for a total capacity of up to 35 MW.¹³⁴

In another example of bottom-up action, by the end of 2020 more than 1,850 municipal governments in 29 countries (up from around 1,400 governments in 2019) had declared a **climate emergency**, representing 980 million citizens around the world.¹³⁵ Several national governments and supra-national institutionsⁱ have since followed suit. In 2020 alone, 411 municipal governments issued climate emergency declarations, many of them in Canada and the United Kingdom but also cities such as Barcelona (Spain), Boston (Massachusetts, US), Mülheim (Germany) and Osaka (Japan), along with the national assembly of mayors representing 226 local authorities in the Republic of Korea.¹³⁶ Municipal governments in Europe dominated these efforts, with a total of 826 declarations, followed by Canada (504), the Republic of Korea (228), the United States (127) and Australia (98).¹³⁷

Climate emergency declarations have been leveraged to initiate or halt projects based on their climate performance.¹³⁸ Many municipal governments have issued **climate action plans** that complement their emergency declarations (→ see *City Snapshot: Recife*).¹³⁹ Although by the end of 2020, only 231 municipal governments had submitted a climate action plan alongside their declaration, the total number of governments doing so increased rapidly.¹⁴⁰ Between the middle and end of 2020, the number of action plans almost doubled, driven largely by UK municipal governments which added 87 plans in September alone.¹⁴¹ Further action plans are expected in the near future, as

emergency declarations usually include initiating a process to develop an action plan and then reporting back to council within three to six months.¹⁴²

It remains to be seen how municipal governments will implement their climate emergency plans in their policy documents and specify a role for renewables. Of the more than 1,850 municipal governments with climate emergency declarations, over 180 had already passed a renewable energy target as of late 2020, either specified as part of their climate action plan or as an independent target.¹⁴³ Cities that have issued both climate declarations and renewable energy targets are mainly in Europe (115) and North America (55) but also include Newcastle (Australia), Seoul (Republic of Korea) and Wellington (New Zealand) (→ see *Figure 17*).¹⁴⁴ Among these, some 61 cities had a climate action plan as well, in particular UK cities including Bristol, Edinburgh, Glasgow and Leeds, but also Auckland (New Zealand), Barcelona (Spain), Melbourne (Australia), San Diego (California, US), and Vancouver (Canada).¹⁴⁵

More than 1,850 municipal governments in

29 countries

have declared a climate emergency, representing 980 million citizens around the world.



Barcelona, Spain



i In November 2019, the EU parliament declared a climate emergency.

Figure 17. Cities with Climate Emergency Declarations and Renewable Energy Targets, 2020

1,852 cities worldwide have signed climate emergency declarations

Only **61** of them have a climate action plan and a renewable energy target in place

1,493

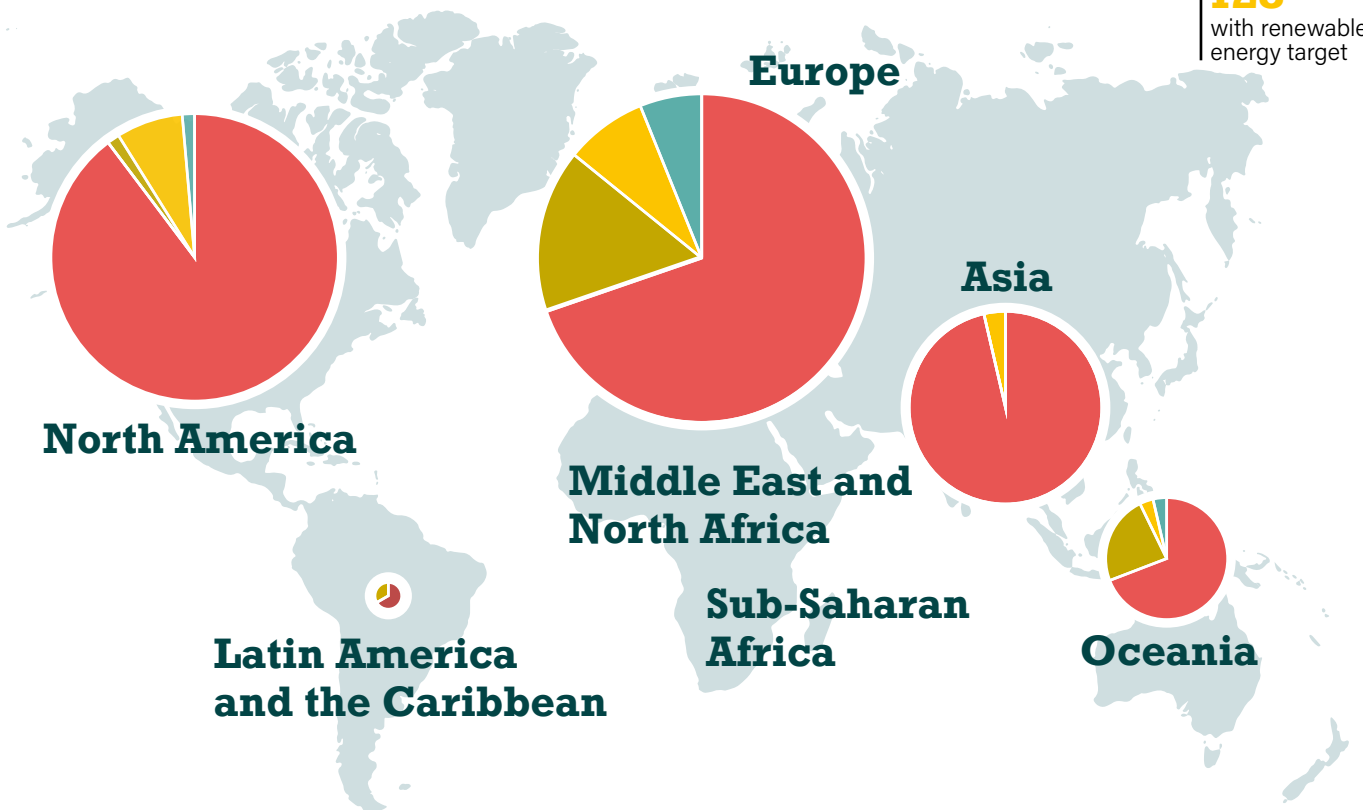
Climate emergency declaration **only**

170

with climate action plan

128

with renewable energy target



Climate emergency declaration **only**

Climate emergency declaration **and** climate action plan

Climate emergency declaration **and** renewable energy target

Climate emergency declaration, climate action plan and renewable energy target

Of all 1,852 cities that have signed climate emergency declarations,

10%

have renewable energy targets.



Source: See endnote 144 for this chapter.



RECIFE

BRAZIL



Recife, an Atlantic seaport in north-eastern Brazil, is the first city in the country to formally declare a climate emergency. According to the Intergovernmental Panel on Climate Change, Recife is the 16th most vulnerable city in the world to climate change. Drastic changes in the local weather have motivated the local government to make commitments towards a low-carbon future. In 2019, in response to its climate emergency declaration, Recife committed under the City Climate Action Plan to becoming carbon neutral by 2050. The local government also aims to achieve 100% renewable energy in city-wide operations by 2037.

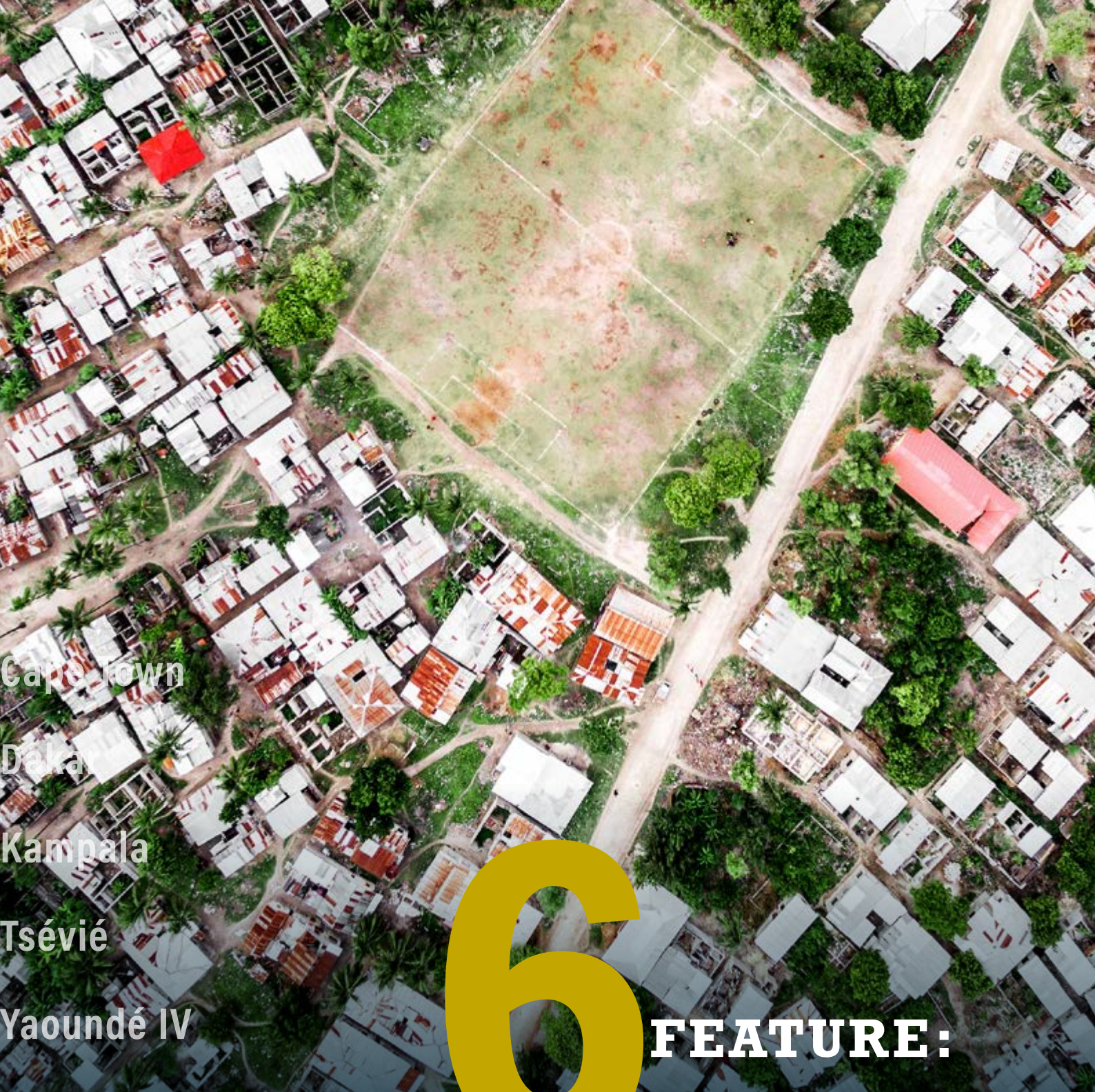
In 2013, Recife created two municipal fora, Comclima and Geclima, to formulate climate change and sustainability policies. As a part of the Urban LEDS project, the city also has developed measures to reduce its greenhouse gas emissions. Under the Urban LEDS network, Recife was selected to receive support from the climate finance laboratory to install a pilot 17 kW-peak solar PV system at the Women’s Hospital of Recife (HMR), which is expected to be operational by 2021. In addition, Recife City has approached a local energy company, Companhia Energética de Pernambuco (CELPE), to finance an initial investment of EUR 200,000 (around USD 225,000) to help define model financing for energy efficiency measures, distributed generation and replicability of actions in other buildings in the municipality.

To assist the city’s sustainable development efforts, the Energy Efficiency Program (PEE) – promoted by CELPE in the regulations of the National Electrical Energy Agency (ANEEL) – provides

0.4% of the net operating revenue of local energy companies to fund research and development projects and the implementation of energy efficiency and renewable energy measures in the city. To promote greater citizen participation, CELPE holds public hearings where it presents the plans and results of renewables and efficiency projects in the region. Through public calls, it seeks partners to promote the development of new technologies, transform energy efficiency markets and create rational habits and practices for the use of electricity.

Source: See endnote 139 for this chapter.





Cape Town
Dakar
Kampala
Tsévié
Yaoundé IV

6

FEATURE:

**RENEWABLE ENERGY
IN SUB-SAHARAN
AFRICAN CITIES**



FEATURE: RENEWABLE ENERGY IN SUB-SAHARAN AFRICAN CITIES

Sub-Saharan Africa was home to an estimated 1.1 billion people in 2019, with around 40% of this population living in urban areas.¹ The region contains 27 of the world's 28 poorest countries and had an average poverty rate of 41% in 2018.² Major barriers to reducing poverty in Sub-Saharan Africa include conflict, a lack of robust institutions, and inadequate access to basic infrastructure services (such as drinking water, sanitation and electricity).³ The region also is home to the world's most rapidly urbanising cities: Africa's urban population increased more than 16-fold between 1950 and 2018, from 33 million to 548 million.⁴ This rapid urban growth is a key driver of energy consumption, with average annual energy use on the continent increasing 3% between 2000 and 2010 and 2.5% between 2010 and 2018.⁵

Even so, energy consumption in Sub-Saharan Africa remains among the lowest in the world, at around 17 GJ per capita per year in 2018 (excluding Nigeria and South Africa), nearly five times below the world average (84 GJ per capita per year).⁶ Traditional biomass, mainly wood and charcoal, accounts for 66% of total final energy consumption region-wide and is used across all non-transport sectors, making Sub-Saharan Africa the only region in the world with such heavy reliance on biomass.⁷ Despite the abundance of local renewable energy resources, renewables accounted for only 7% of the total primary energy supply, 8% of total final energy consumption and 26% of power generation in the region as of 2018.⁸

Meanwhile, many Sub-Saharan African governments have made great strides in integrating renewable energy into regional, national and even sub-national planning. By 2018, of the 53 African countries that had submitted Nationally Determined

Contributions for reducing greenhouse gas emissions under the Paris Agreement, 45 had adopted quantified renewable energy targets.⁹ Regionally, the Economic Community of West African States (ECOWAS) has set a target for 48% renewable electricity by 2030, and the East African Community (EAC) aims for 21% renewables in the power generation mix by 2038.¹⁰

City governments play a key role in shaping the energy landscape of Sub-Saharan Africa, including meeting country-level renewable energy targets. However, legislative, financial and technological constraints – such as weak fiscal decentralisation, limited municipal mandates across key sectors and capacity constraints to executing municipal functions – continue to impede wider adoption of renewables.¹¹ Nonetheless, many cities in the region have joined global clean energy initiatives. For example, signatories to the Covenant of Mayors in Sub-Saharan Africa have voluntarily committed to implementing climate and energy actions in their communities, and the Climate Action Planning Africa Programme, led by C40 Cities, brings together 11 megacities in Sub-Saharan Africa – including Accra (Ghana) and Nairobi (Kenya) – that have pledged to become net-zero carbon by 2050.¹²

City governments

play a key role in shaping the energy landscape of Sub-Saharan Africa.

These locally driven ambitions have led to positive outcomes. In 2019, Nairobi enforced a national regulation that requires large buildings to use solar PV for water heating to reduce pressure on the electricity grid.¹³ Rwanda is developing Africa's first "green" city – within the capital Kigali – to be powered completely by renewable energy, and in 2017 Accra initiated an incentive programme that reduces building permit fees by 10% if applicants include a 20 kW solar PV system in the design.¹⁴ In Nigeria, Eko Atlantic City in Lagos State secured its first-ever EDGE (Excellence in Design for Greater Efficiencies) green building certification from the International Finance Corporation in January 2020, giving homeowners the assurance that their homes are designed and built to be resource efficient.¹⁵

The following sections provide an overview of the status of renewable energy in five Sub-Saharan African cities, highlighting existing practices as well as opportunities for scaling up deployment.

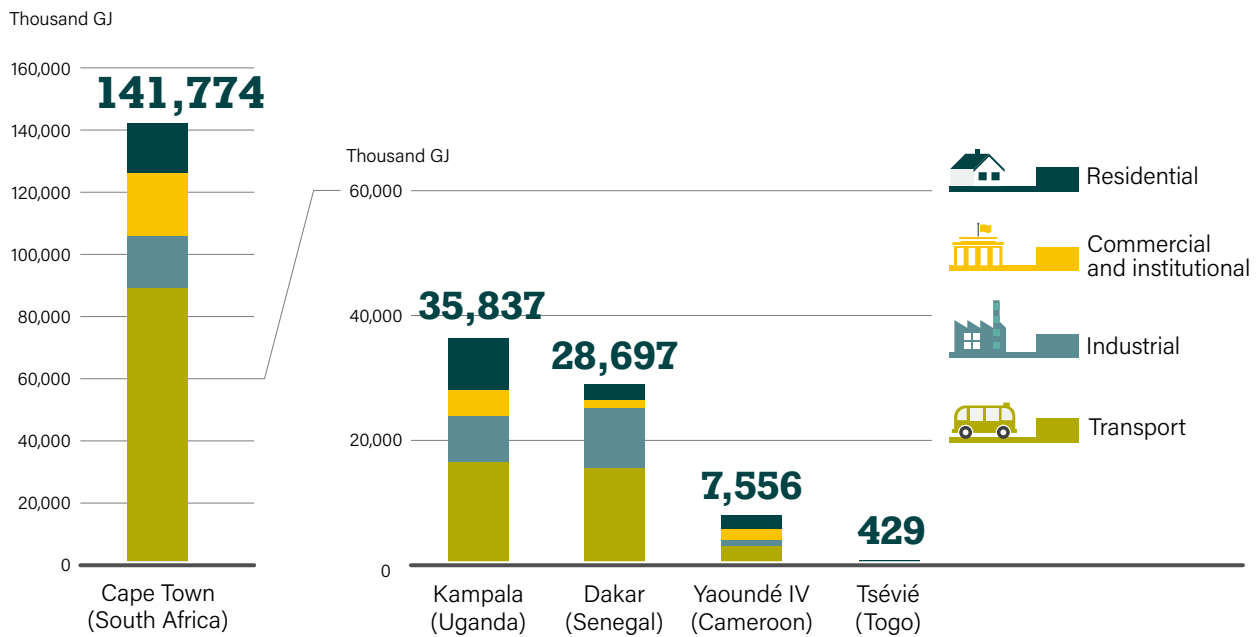
STATUS OF RENEWABLES IN SUB-SAHARAN AFRICAN CITIES

Cities in Sub-Saharan Africa differ widely based on their national context, area and population size, level of urbanisation, level of socio-economic development, access to energy and more. These factors directly influence their total energy demand and energy use by sector. The following sections explore renewable energy trends in five cities – Cape Town (South Africa), Dakar (Senegal), Kampala (Uganda), Tsévié (Togo) and Yaoundé IV (Cameroon) – selectedⁱ mainly because of their geographic and socio-economic diversity as well as the availability of primary (field-based) data.¹⁶

Cape Town has a much higher energy demand than the other four cities, reflecting its larger population as well as the relative economic advancement of South Africa. In the smaller cities (such as Tsévié), where the commercial and industrial sectors are less extensive, the residential sector accounts for a higher share of energy use. Meanwhile, in the bigger cities (Cape Town, Kampala and Dakar), where there is greater movement of people and goods, the transport sector plays a more prominent role in energy consumption (→ see Figure 18).¹⁷

i The selected cities, while not wholly representative of the vast environmental and historical contexts of Sub-Saharan Africa, depict the varying socio-economic and energy development realities of the region as well as the diversity of challenges and opportunities experienced in its cities.

Figure 18. Total Final Energy Consumption in the Five Selected Sub-Saharan African Cities, by Sector



Note: Data are from various years.

Source: See endnote 17 for this chapter.

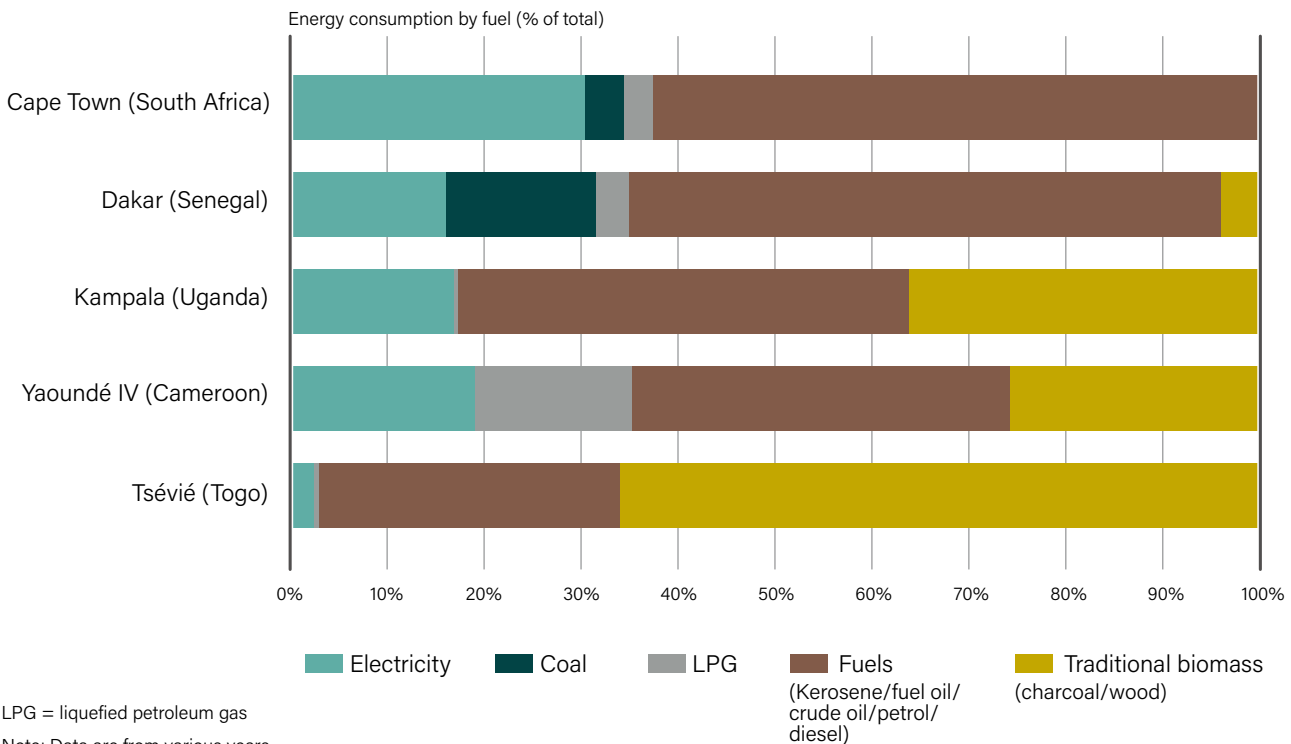
The large urban economies also tend to have substantial transport infrastructure, a wealthier populace (resulting in higher car ownership) and greater economic activity (leading to increased freight).¹⁸

Because of the inefficient use of carbon-intensive diesel and petroleum fuels, the transport sector accounts for the highest share of greenhouse gas emissions in the five cities.¹⁹ Vehicle emissions also are a major source of air pollution, as Sub-Saharan Africa's vehicle fleet consists largely of ageing vehicles (mainly from Europe and North America) that no longer meet emission standards in their countries of origin.²⁰

In the less-urbanised cities of the region, high shares of residential energy use (in the case of Tsévié, representing up to 73% of final energy consumption) reflect the low levels of industrialisation of these economies.²¹ Overall, the residential sector accounts for 65% of total final energy consumption in Sub-Saharan Africa, compared to only 22% globally.²² In Tsévié, traditional biomass (wood and charcoal) represents more than 50% of final energy consumption, mainly for cooking (→ see Figure 19).²³



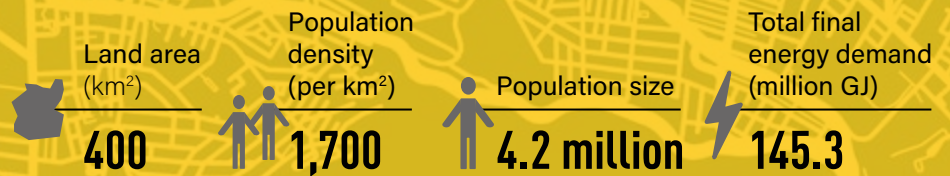
Figure 19. Shares of Energy Use by Carrier in the Five Selected Sub-Saharan African Cities





CAPE TOWN

SOUTH AFRICA



Cape Town is South Africa's second largest economic hub, with a population of around 4.2 million in 2018 and a land area of more than 400 square kilometres.²⁴ Cape Town contributed 9.8% of the national economic output in 2018 and is dominated by the service sector, with significant finance, insurance, real estate and business activities.²⁵

Coal contributed 83% of South Africa's electricity generation capacity in 2016 (latest available data), with nuclear power and natural gas representing 4% and 5% respectively and renewable energy making up the remaining 8%.²⁶ The government aims to increase the renewable share in the generation mix to around 40% by 2030 through various policy instruments, as promulgated in the Integrated Resource Plan (IRP)ⁱ of 2019.²⁷

The City of Cape Town has taken an active leadership role in renewable energy deployment, emphasising not just technology change but also the need to improve governance and institutions and to engage key players in the energy transition, from national government to business and civil society.²⁸ The decoupling of electricity demand from economic growth in the Metropolitan Municipality over the last decade is attributed to energy efficiency and renewable energy interventions in the face of soaring electricity prices and insecure electricity supply in South Africa.²⁹

The transport sector, which relies almost exclusively on petrol and diesel, accounts for 62% of Cape Town's total final energy demand and contributes a third (32%) of the Metro area's greenhouse gas emissions.³⁰ The sector's high energy use is largely a result of the city's sprawling and segregated form, which reflects the legacy of apartheid's spatial planning.³¹ The commercial sector is the second most energy-intensive sector

(14% of total final energy demand) followed by households (12%) and industry (12%) (→ see Figure 18).³²

Electricity is the main energy carrier in Cape Town's non-transport sectors, and because most of the electricity in South Africa comes from high-carbon coal-fired power plants, the built environment accounted for 55% of the city's greenhouse gas emissions in 2018.³³ Residential electricity use in Cape Town is split largely across cooking, lighting and space heating applications, while in the commercial sector electricity use is dominated by lighting, heating and ventilation in office buildings.³⁴

The City of Cape Town has been a pioneer in providing more affordable and secure energy access and in reducing the city's carbon footprint while also tackling rapid urbanisation and associated energy poverty, urban sprawl and vulnerability to climate change. Cape Town's long history of renewable energy efforts includes the establishment of a dedicated energy and climate change unit.³⁵ As early as 2000, an energy advisor was seconded to the City as part of the Sustainable Energy for Environment and Development (SEED) programme of Sustainable Energy Africa (SEA), bringing an energy lens to City operations and service delivery.³⁶ In 2003, with technical support from SEA, Cape Town completed its first *State of Energy* report, and in 2006 it became the first African city to approve a municipal Energy and Climate Change Strategy, setting an initial target for 10% renewable and clean energy by 2020.³⁷

The city benefited from learning by doing. Catalysed by the Energy Efficiency and Demand Side Management Programme, launched by South Africa's Department of Mineral Resources and Energy, Cape Town began an extensive and ambitious drive in 2008 to improve

ⁱ The IRP provides a medium-term plan for expanding electricity generation in South Africa. It aims to guide sector investment to allow the country to meet its forecasted electricity demand at the least cost and accounting for considerations such as environmental sustainability and water use. The plan incorporates objectives such as affordable electricity, reduced greenhouse gas emissions, diversified generation sources, localisation and regional development.

the energy efficiency of municipal operations, saving a cumulative ZAR 225 million (USD 16 million) through 2019.³⁸ The City began supporting small-scale “embedded generation” in 2011, making it South Africa’s first city to develop tariffs and rules for distributed renewables and serving as a blueprint for the rest of the country.³⁹

In 2013, when South Africa had no national standards in place for solar PV on buildings, Cape Town published guidelinesⁱ promoting the safe and legal installation of distributed renewables in commercial and residential settings.⁴⁰ By 2019, the City had the highest concentration of registered rooftop solar PV systems nationwide.⁴¹ In total, between 2011 and 2020, Cape Town approved the installation of nearly 42 MW of rooftop solar PV and installed 0.6 MW on City buildings through its rooftop PV programme.⁴² These systems feed into the local electricity distribution network, helping to reduce reliance on coal-fired power from the national grid. Similar processes, guidelines and tariffs have since been adopted in more than 40 other South African municipalities.⁴³

Building on earlier roll-outs of solar water heaters in low-income communities, in 2013 Cape Town implemented a programme to promote this technology more widely, helping to reduce energy from one of the highest electricity-consuming end-uses for city households, water heating.⁴⁴ By 2015, some 46,000 solar water heaters had been installed city-wide, saving 128,000 MWh per year, creating employment equivalent to 1,300 job-yearsⁱⁱ, contributing more than ZAR 380 million (USD 27 million) to the local economy and reducing more than 132,000 tonnes of carbon emissions per year.⁴⁵

In 2015, the Cape Town Energy 2040 Vision, developed through an extensive process of energy modelling and stakeholder engagement, set ambitious city-wide targets for increasing energy access, improving energy efficiency and reducing carbon emissions.⁴⁶ It also set a target to achieve at least 500 MW of renewable and clean energy capacity by 2040.⁴⁷ To help achieve this ambition, the City of Cape Town elevated the role of energy institutionally, combining its two energy-related divisions (one focused on energy and climate change and the other on electricity generation and distribution) into a single new Energy and Climate Change Directorate.⁴⁸

This change also signaled Cape Town’s intention to expand its role in local electricity supply. In 2017, the City entered into a court challenge with the national government to enable it to purchase electricity from independent power producers (IPPs) and not be confined to procuring coal-fired power from Eskom, the centrally controlled national energy utility.⁴⁹ In a landmark step in October 2020, South Africa’s Department of Mineral Resources and Energy amended

The City of Cape Town has taken an **active leadership role** in renewable energy deployment.

the country’s electricity regulations to enable municipalities in good financial standing to develop their own power generation projects, as a way to ensure security of energy supply in a co-ordinated manner aligned to the national IRP and the municipal Integrated Development Plans (which guide overall planning and development for municipalities in South Africa).⁵⁰

The City of Cape Town has begun laying the foundations for supplying renewable energy at scale. Based on a legislative change in late 2020, the municipal government is exploring the commercial, legal and technical aspects of a municipal-level Renewable Energy Independent Power Procurement Programme (REIPPP) and is developing a guide on how to engage with industries in procuring energy from IPPs.⁵¹ As of 2020, the City was working on a Zero Carbon 2050 action plan (and related policies) as well as developing low-income energy services, a framework for electric vehicles and innovative financing opportunities for engaging households in small-scale rooftop solar PV.⁵²

Cape Town is also honouring its international commitments to climate action. It is a signatory to various initiatives including the Mexico City Pact, CDP, the carbonn Climate Registry, the Covenant of Mayors in Sub-Saharan Africa and the C40 Cities Leadership Programme.⁵³ The City also has committed to achieving carbon neutrality by 2050, recognising that this will require ambitious actions across all sectors.⁵⁴ To translate these commitments into action, Cape Town has woven them into its Integrated Development Plan for the period 2017-2022.⁵⁵

The City’s transport plan includes exploring the potential production and use of biofuels in transport, using renewables for infrastructural facilities such as depots and transport interchanges, and replacing the municipal diesel bus fleet with electric buses (which eventually would be powered with renewables).⁵⁶ In a pilot project in early 2018, the City’s “MyCITI” bus rapid transport service added 11 locally manufactured electric buses to its fleet.⁵⁷

Cape Town is working to prepare its power grid for high EV penetration in the near future. The Electric Vehicle Framework includes leveraging EV roll-out and charging to increase the share of renewables in final energy consumption, and is considering requiring public EV charging stations that exceed a specific demand threshold to operate on renewable energy.⁵⁸ This energy is expected to be either generated from local solar PV capacity or purchased through a contractual arrangement.⁵⁹

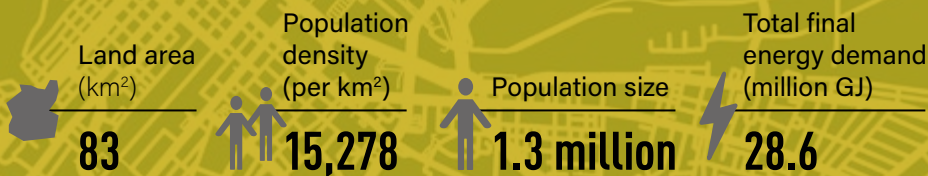


i The guidelines, which are non-binding, outline a comprehensive list of City-approved suppliers of inverters, the steps for installing solar systems and the application process for registering and selling electricity to the City.
 ii A job-year refers to one of year of work for one person.



DAKAR

SENEGAL



Dakar is the capital of Senegal in West Africa and is located at the western tip of the country. It is an Atlantic port city covering an area of 83 square kilometres with an estimated population of more than 1.3 million inhabitants.⁶⁰ As of 2016, the greater Dakar region was home to 50% of Senegal's urban population, 95% of its industrial and commercial companies, 80% of its infrastructure and services and 87% of its formal employment; as a consequence, Dakar contributed an estimated 68% of the country's gross domestic product (GDP).⁶¹

As of 2019, Senegal had around 864 MW of total installed electricity capacity, 13% of which was renewable (7% from hydropower and 6% from solar PV).⁶² The National Energy Development Plan (Lettre de Politique de Développement du Secteur de l'Énergie, or LPDSE), signed in 2012, targets increasing the renewable share in power generation from 10% in 2016 to 15% in 2020.⁶³ The country's national economic and social development plan (Plan Senegal Emergent, PSE 2025) aims for a 23% share of on-grid renewables in power generation by 2030.⁶⁴

The City of Dakar reinforces these objectives through municipal policies and strategies such as the Environmental Action Plan (P.ACT.E.) and the Master Plan for Urban Development of Dakar and Its Surroundings (PDU 2035). The PDU aims to achieve 15% local electricity production from renewables by 2035 and to reduce reliance on diesel power generation from 90% in 2013 to 5% in 2035.⁶⁵ The City intends to finalise (by March 2021) its Plan Climate Énergie Territoriale (PCET), which will be the integrated energy and climate change development plan informing Dakar's short- and long-term renewable energy roadmap.⁶⁶ The PCET is being developed as a result of Dakar's commitment under the C40 Cities Leadership Programme to be net-zero carbon by 2050.⁶⁷

The transport sector dominates the city's energy demand – accounting for 55% of total energy consumption – followed by the industrial (34%) and residential (8%) sectors (→ see *Figure 18*).⁶⁸ Despite Dakar's high electrification rate of more than 95%, household electricity use remains low at around 153 kWh per capita annually (compared to 10,649 kWh per capita in the United States), with lighting as the main end-use application.⁶⁹ Liquefied petroleum gas (LPG) is the primary energy source for cooking (averaging 12 kilograms per month per household), followed by charcoal (0.2 kilograms per person per day) and some use of firewood.⁷⁰

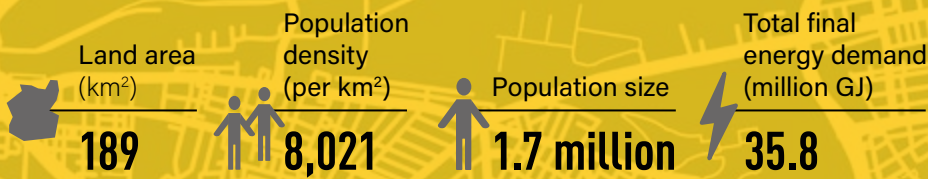
The high energy demand for transport reflects Dakar's deteriorating road infrastructure, inefficient public transport networks and ageing vehicle fleet, with 80% of on-road vehicles estimated to be more than five years old.⁷¹ This has led to urban mobility challenges, including permanent traffic jams at peak hours that contribute to high air pollution and negatively affect residents' economic competitiveness, health and well-being, and quality of life.⁷² In response, the national transport entity, Conseil Exécutif des Transports Urbains de Dakar (CETUD), piloted the city's mobility and urban planning strategy, the PDUD 2008-2025. The plan articulates three ambitious infrastructure projects – the Express Transit Train (TER), bus rapid transit and renewal of the on-road transport fleet – with a common goal of increasing the share of electrification and reducing fossil fuel dependence across these three transport modes while also reducing air pollution from on-road transport emissions by 2030.⁷³

Although the local authority has control over municipal buildings only, the City recently completed a pilot energy audit of all municipal and public buildings, as the first phase of an ambitious target to equip more than half of municipal buildings with grid-connected distributed rooftop solar PV by 2030, as envisaged in the PCET.⁷⁴

i As of late 2020, no reporting had been identified to verify that this renewable energy target had been met.

KAMPALA

UGANDA



Kampala is the capital city and largest urban centre of Uganda, with more than 1.7 million inhabitants in 2020.⁷⁵ As the country's economic hub, it accounted for 80% of Uganda's industrial and commercial activities in 2016 and generated around 65% of national GDP that year.⁷⁶ City operations fall under the responsibility of the Kampala Capital City Authority (KCCA).

KCCA is a pioneer signatory to the Covenant of Mayors in Sub-Saharan Africa (joining in 2015), through which the city developed its first energy and climate action plan – the Kampala Climate Change Action Strategy – in 2016.⁷⁷ This strategy frames KCCA's approach to furthering the deployment of renewables through assessing the local renewable energy potential, supporting the city's green economy, promoting the implementation of a feed-in tariff system and reducing the use of individual motorised transport in favour of non-motorised mobility and green and public transport.⁷⁸ KCCA's strategy is consistent with the Draft National Energy Policy of 2019, which promotes the deployment of non-hydropower renewable generation sources to diversify the energy mix and thereby mitigate Uganda's over-reliance on hydropower, which accounted for 90.5% of the national electricity supply in 2018.⁷⁹

The transport sector dominates Kampala's energy demand, accounting for 45% of the total in 2016, followed by the residential (23%), industrial (21%) and services (11%) sectors (→ see *Figure 18*).⁸⁰ The majority of this energy demand is fuelled by fossil fuels used in transport (55%) and by (mainly traditional) biomass used for cooking and water heating (36%).⁸¹ After biomass, electricity (90% of which comes from hydropower) is the second largest non-transport energy carrier, accounting for 17% of total final energy consumption; it is used across the industrial, services and residential sectors, mainly for lighting, cooling and the powering of heavy machines.⁸²

The transport sector's large share of energy consumption is seemingly in contrast with Kampala's service-based economy. However, the service sector has low energy intensity, in part because 57% of businesses in the city were informal as of 2017, focused mainly on non-tradeable services such as retail, transport and restaurants.⁸³ Informal roadside vending has added to city congestion, and significant passenger travel also occurs through inefficient transport modes such as motorcycles (boda boda) and private cars, which together accounted for 70% of total passenger transport energy demand in 2016.⁸⁴

These transport and mobility challenges helped shape KCCA's Climate Change Action Strategy 2016 and the Kampala City Strategic Plan 2025, which hinges on the principle of 'SMART mobility' to improve the efficient movement of people and goods within and through Kampala City.⁸⁵ The City established an air quality monitoring and assessment system and is promoting electric mobility to gradually replace conventional commercial motorcycles as a way to reduce noise and air pollution, petrol demand and traffic jams.⁸⁶

KCCA's leadership has enabled successful public-private partnerships, and by 2020 start-ups such as Bodawerk and Zembo had resulted in the use of more than 200 new and retrofitted electric motorcycles for public transport in the city (charged mostly from the hydropower-dominant grid).⁸⁷ Electric mobility through e-motorcycles provides a framework for KCCA to contribute to national and international climate change mitigation efforts by deploying renewables in the transport sector. Because electric motorcycles require little infrastructure, are silent and produce virtually no emissions (thereby improving air quality levels), they hold promise for successful uptake among boda boda riders.

i The SMART mobility strategy, detailed in the Transport Master Plan for the Kampala Metropolitan Area, supports the construction and operation of a Mass Rapid Transit System based on buses, rail and cable cars by 2040.

TSÉVIÉ

TOGO



Tsévié, a small town 35 kilometres north of Togo's capital Lomé, had a population of around 103,000 in 2017, growing at a rate of 2.8% annually.⁸⁸ The town has minimal industrial activity, and its economy is built largely on agricultural activities centred on crop production and livestock farming, generating a low annual economic output of USD 519 per capita.⁸⁹

Togo's electricity infrastructure development plan, as outlined in the national Electricity Sub-Sector Strategic Plan of 2010, is based on a least-cost electricity supply and demand balance, taking into account security of supply and the environment.⁹⁰ This led to the development of the Togo National Action Plan for Energy Efficiency (PANEE) and the Togo National Renewable Energy Action Plan (PANER), which respectively define the country's objectives for energy efficiency and renewable energy deployment by 2030.⁹¹ The national objective for renewables is to increase the share of solar PV in total final energy consumption to 10% in 2030, including both on- and off-grid PV.⁹²

Due to Tsévié's low levels of industrialisation and electricity access (estimated at 24% in 2017), traditional biomass in the form of wood and charcoal is the single most important fuel in the peri-urban settlement.⁹³ Traditional biomass accounts for 64% of total final energy consumption and is used to meet household cooking and water heating needs.⁹⁴ The residential sector is responsible for 73% of total final energy consumption, followed by the transport sector (25%) and the town's few commercial facilities (2%).⁹⁵ Because of the low levels of electrification, the town's street network is largely unilluminated, limiting potential economic activity in the evenings.⁹⁶

To boost local energy access and development, Tsévié implemented a three-year municipal energy programme (2017-2020) under the Covenant of Mayors in Sub-Saharan Africa, with the goal of developing a community-wide energy and climate action plan

(the Plan d'Action en faveur d'un Accès à l'Énergie Durable et du Climat (PAAEDC) de la commune de Tsévié). Under this flagship programme, the municipality aims to achieve its sustainability ambitions in four strategic areas: 1) sustainable biomass use, 2) deployment of distributed rooftop solar PV, 3) increased adoption of electric motorcycles and 4) a modal shift to public transport.⁹⁷

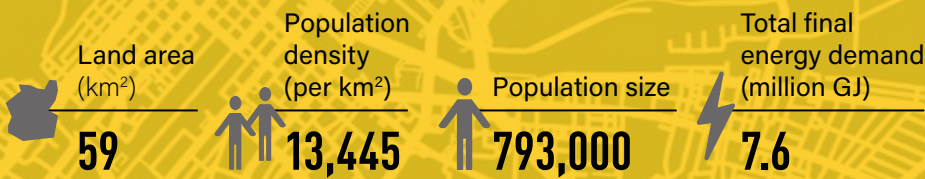
Under the PAAEDC framework and with funding from the European Union, Tsévié led a series of pilot projects in 2018-2020 to boost energy access and development and increase the share of renewables in energy consumption.⁹⁸ To improve access to clean cooking facilities, the municipality distributed 8,200 improved and efficient cook stoves in the town and its environs as a means to limit the prolific household use of traditional biomass for cooking and water heating (and thus improve indoor air quality and human well-being).⁹⁹ The city also sought to bridge the electricity access gap and to improve lighting solutions by installing 75 solar street lamps for public lighting, distributing 95 solar home systems to the most vulnerable households and installing five community solar kits in schools.¹⁰⁰

To boost local energy access and development, Tsévié implemented a **three-year municipal energy programme.**



YAOUNDÉ IV

CAMEROON



Yaoundé IV is one of the seven communes of Yaoundé (Cameroon), with an estimated 793,000 inhabitants in 2018 spread over an area of around 59 square kilometres.¹⁰¹ Yaoundé IV is primarily a service-oriented city, with a major informal economy that includes unlicensed street vendors (locally referred to as "sauveteurs") and small neighbourhood boutiques.¹⁰² This translates to a low annual economic output (GDP) of around USD 1,632 per capita, comparable to the Sub-Saharan African average of USD 1,585 per capita.¹⁰³

Renewable energy (exclusively from hydropower) makes up 73% of the power generation mix in both Cameroon and Yaoundé IV, with oil and gas constituting the remaining 27%.¹⁰⁴ Based on the national Economic Emergence Plan 2035, the country has ambitions to deploy increasing amounts of renewable energy, particularly hydropower and solar PV, to reduce its greenhouse gas emissions by 32% by 2035.¹⁰⁵

Although the national government does not allow municipalities to undertake electricity generation and distribution projects, a number of decrees provide local authorities with the ability to receive technical and financial support towards climate action.¹⁰⁶

Yaoundé IV's residential sector is the second most energy-intensive sector (accounting for 30% of total final energy consumption) after transport (35%).¹⁰⁷ An estimated 86% of households cook and heat their water with LPG, which represents 51% of the total residential final energy use.¹⁰⁸ Household electricity consumption averages 507 kWh per capita per year, above the national average of 280 kWh, and is used mostly for lighting and water heating services.¹⁰⁹

As a signatory city of the Covenant of Mayors in Sub-Saharan Africa, Yaoundé IV in 2020 adopted its short-term energy

and climate action plan (Plan d'Action Communal en faveur d'un Accès à une Energie Durable et du Climat, or PACAEDC), which sets out the municipality's ambitions to reduce greenhouse gas emissions and increase energy access by 2030.¹¹⁰ As

part of the plan, the city aims to increase the renewable energy share through multiple cross-sectoral actions, such as installing 3,000 solar streetlights in the 65 neighbourhoods, installing distributed rooftop solar PV on 30 municipal buildings, distributing 3,600 solar kits to poor households and incentivising increased adoption of electric motorcycles (to 5% by 2030, running mostly on electricity from the hydropower-dominant grid).¹¹¹

Motivated by studies suggesting that switching to biogas to offset just 20% of household LPG use could reduce residential greenhouse gas emissions by more than 12%, the municipality (through the PACAEDC) rolled out a demonstration project in 2019 to build nine micro biogas plants, each with a capacity of 20 cubic metres.¹¹² As of 2020, six of the systems were operational, meeting the cooking energy demand of 135 low-income households with biogas.¹¹³ The success of the project has paved the way for similar programmes, notably ENERGIE PLUS, a municipal energy programme which in collaboration with relevant national entities and international donors seeks to build an industrial-scale biogas plant to supply electricity to Yaoundé IV and its environs.¹¹⁴

The city aims to increase renewable energy, installing 3,000 solar streetlights and distributing **3,600 solar kits** to poor households.

■ BARRIERS AND OPPORTUNITIES FOR ADVANCING RENEWABLES

The competitive advantage of renewable energy can be a key lever to power the economic growth of Sub-Saharan African cities, providing greater access to modern energy services.¹¹⁵ Renewables also offer important co-benefits such as reducing air pollution (and thus improving public health), mitigating climate change, creating more liveable urban areas and enabling a better quality of life through increased access to basic services.¹¹⁶ However, municipal governments in the region face numerous barriers to the deployment of renewables. Key areas of both challenge and opportunity include policy and regulation, underdeveloped grids and infrastructure, unstable off-taker arrangements, access to financial markets, data needs and internal capacity.

POLICY AND REGULATION

The control of energy supply in Sub-Saharan African cities remains largely the domain of national governments or utilities, with an emphasis on centralised, large-scale generation. As highlighted in the five city case studies, national energy strategies that chart country-wide renewable energy roadmaps rarely make provisions for local governments, whose roles are still considered secondary. Even when regulations and policies are in place to support renewable energy deployment and use, the requirements are often expensive, complex and difficult to navigate.¹¹⁷

However, municipal governments in most Sub-Saharan African countries have mandates to issue building permits, which could serve as incentives or mandates to advance the deployment of renewable energy systems. Local governments could fast-track permits for buildings that embed distributed renewables, or they could include renewable energy deployment as a requirement for obtaining a permit (or receiving one at a reduced fee, as in Accra).

In addition, the case studies illustrate how cities might leverage their facilitative roles to develop enabling policies or regulatory frameworks – such as local net metering and feed-in tariffs – to support the deployment and use of renewable electricity.¹¹⁸ Focused local plans and policies can enable energy efficiency improvements and the uptake of renewables, even if national policy is inhibitive.

Although city authorities in Sub-Saharan Africa may have limited influence over infrastructure and services, they can all take action to encourage local renewable energy deployment. Developing low-carbon pathways requires multiple collaborations across a broad range of stakeholders, including national policy makers. City authorities are well placed to facilitate and co-ordinate such efforts.¹¹⁹

ACCESS TO FINANCIAL MARKETS

Although numerous fiscal programmes and instruments exist at the national level across Africa, fiscal decentralisation – whether through transfers from the central government or by granting local governments revenue-raising powers – remains a serious challenge for empowering local governments.¹²⁰ Most local governments in Africa depend on national government grants as their main revenue source; they borrow little money (even if they are formally able to) and spend most of their revenue on operations instead of capital investments.¹²¹ This means that they have few funds to invest in new infrastructure projects such as distributed renewable generation.¹²²

As a result, nearly all renewable energy projects in Sub-Saharan Africa rely on some form of non-commercial grant or equity investment, with funding coming largely from development finance institutions, donor agencies, foundations and governments.¹²³ Although this helps to reduce debt risk, it is not always adequate to enable renewables to achieve true scale into the future.¹²⁴ Moreover, factors such as the lack of available income to allocate to energy consumption – as well as the prevalence of a strong informal sector that experiences poor housing quality, irregular income flows and low demand for electricity – constrain the business case for electrification for utilities.¹²⁵

Nonetheless, cities across the region have demonstrated progressive leadership through piloting various demonstration projects. For example, Yaoundé IV was able to leverage on the visibility and proof-of-concept of its pilot biogas micro-project and to draw sufficient interest from investors to take the pilot project to scale.

In most cases, national policies also allow local governments to enter into public-private partnerships. Although such partnerships are few and generally have occurred outside the scope of electricity generation and distribution projects, the rise of electric mobility in Kampala is a strong example of how such relationships could be leveraged to advance the renewable energy agenda at the city level.

Notably, local governments are constrained in how they can spend public funds (for example, to ensure public finance management best practice, as articulated in South Africa's Municipal Finance Management Act).¹²⁶ However, this can pose a barrier when trying to demonstrate and pilot pioneering and innovative work.



DATA NEEDS

Primary data are notoriously difficult to access in the African context, particularly at the city level given the often limited capacity, funding and political ambitions to undertake such exercises. This is a major barrier for private investors who often do not have access to statistical data on key parameters needed for investment and for project-level decisions, such as grid expansion plans, consumer baseload, customer willingness to pay, etc.¹²⁷

This places local governments, which generally are closer to the population (potential customers), in a unique position to provide investors with such information or to engage with relevant entities (including electric utilities) to facilitate data collection. Such leverage helped the City of Dakar to complete the energy audit of its own buildings in a bid to generate sufficient data for future renewable energy deployment strategies.¹²⁸ Building data resources is crucial to support decision making and resource allocation, as evidenced by the City of Cape Town.

INTERNAL CAPACITY

Due to capacity constraints (in skills, experience and knowledge as well as human and financial resources), local governments in Sub-Saharan Africa generally are limited in their ability to play a more pro-active role in renewable energy deployment. The ability to influence local uptake of renewables often requires new areas of work and new skillsets to deal with the complexities of this development.

To help build internal capacity and knowledge, municipalities can form partnerships with external organisations (for example, universities and environmental organisations / intermediary organisationsⁱ) that could bring much-needed skills and capacity, and can establish or join other local city networks (such as the Urban Energy Network in South Africaⁱⁱ) or international urban-related networks (such as the C40 Cities Leadership Programme and the Covenant of Mayors SSA Programme, which helps to share implementation experience (technology, regulatory frameworks, funding, etc.).¹²⁹

Municipalities also could develop public-private partnership platforms to facilitate private sector engagement with local government to aid the implementation of renewable energy.¹³⁰

Renewable energy deployment

benefits from collaboration between municipalities and like-minded stakeholders.

To leverage these opportunities, it is important for municipalities to build a support base of like-minded stakeholders, such as renewable energy industry players and specialists in energy and urban development from academia, non-governmental organisations, development institutions and other cities. This would enable cities to further their renewable energy deployment aims, participate in networks and develop their own networks – signalling a more dynamic system involving many more players.

As demonstrated in the five case studies, the effective implementation of city energy action plans necessitates developing a unit within the lead department that can drive the process over the short, medium and long terms. This unit must steer the critical stakeholder collaboration and establish fora for information exchange and action plan collaboration, including guidance and feedback.¹³¹ A particular challenge in many cities is interdepartmental collaboration.¹³² Because energy projects are often cross-cutting in nature, the lead department or unit must overcome the lack of communication and co-ordination that often prevents departments from working together.



- i A local intermediary organisation such as a non-governmental organisation, academic institution or civil society organisation with experience in energy research, implementation and capacity building is important, as it gives rise to capacity building beyond municipal staff and ensures that the approaches and solutions are locally appropriate, rather than being generated solely from foreign expertise that may lack the deeper local context.
- ii The Urban Energy Network is a 20-year-old learning partnership for cities in South Africa run by Sustainable Energy Africa, the South African Local Government Association and the South African Cities Network. The network aims to build municipal staff capacity on current sustainable energy issues, to enable lesson sharing and co-ordination among municipalities and to develop relationships and facilitate information flow between different levels of government.

REFERENCE TABLES

Tables R1-R5: see data online at: www.ren21.net/cities/datapack

TABLE R6. Selected Cities with High Shares of Electricity Generation from Solar PV and Wind, 2019

City	Population	Wind and solar share of electricity mix (2019)	Renewable* share of electricity mix (2019)	Renewable energy and emission reduction targets
Örebro, Sweden	156,000	100%	100%	Carbon neutral by 2050
Georgetown, Texas, United States	50,000	100%	100%	100% local renewable energy generation (achieved in 2018)
Diu, India	52,000	100% (during day)	100% (during day)	N/A
Denton, Texas, United States	139,000	83%	83.8%	100% renewable electricity by 2020
Gladsaxe, Denmark	70,000	52%	77%	100% renewable energy by 2035
Adelaide, Australia	1,300,000	51%	51%	100% renewable electricity in municipal operations (achieved in mid-2020)
San Diego, California, United States	1,400,000	33%	35%	100% renewable electricity by 2035
Madrid, Spain	3,260,000	24%	41%	N/A
London, United Kingdom	8,980,000	21%	23%	1 GW solar by 2030 and 2 GW solar by 2050; carbon neutral by 2050
Birmingham, United Kingdom	1,100,000	21%	33%	60% emission reduction by 2027 (from 1990 baseline); national carbon neutral target by 2050
Los Angeles, California, United States	3,990,000	21%	34%	100% renewable energy by 2045; carbon neutral by 2050
Jaipur, India	3,070,000	20%	45%	N/A
Hamburg, Germany	1,850,000	15%	30%	100% renewable electricity by 2035; 55% emission reduction by 2030 (from 1990 baseline); carbon neutral by 2050
Toronto, Canada	2,930,000	13%	37%	75% renewable energy by 2050
Bangalore, India	11,440,000	10%	25%	N/A
Nelson Mandela Bay, South Africa	1,150,000	10%	10%	N/A
Santiago, Chile	7,300,000	9%	51%	100% renewable electricity by 2040
Zaragoza, Spain	7,000,000	8%	14%	N/A
Paris, France	2,300,000	7%	21%	Carbon neutral and 100% renewable energy by 2050
Seoul, Republic of Korea	10,300,000	7%	8%	Carbon neutral by 2050
Barcelona, Spain	1,600,000	7%	18%	45% emission reduction by 2030 (from 2005 baseline); carbon neutral by 2050
Manchester, United Kingdom	2,800,000	6%	13%	Carbon neutral by 2038

■ TABLE R6. Selected Cities with High Shares of Electricity Generation from Solar PV and Wind, 2019 (continued)

City	Population	Wind and solar share of electricity mix (2019)	Renewable* share of electricity mix (2019)	Renewable energy and emission reduction targets
Calgary, Canada	1,300,000	5%	10%	80% emission reduction by 2050 (from 2005 baseline)
eThekweni, South Africa	3,900,000	5%	5%	40% renewable electricity by 2030 and 100% by 2050; 40% emission reduction by 2030 and 80% by 2050 (from 2015 baseline)
Tainan, Chinese Taipei	1,900,000	5%	7%	20% renewable electricity and 20 GW cumulative installed solar PV capacity by 2025
Buenos Aires, Argentina	15,100,000	4%	32%	20% renewable electricity for the city's largest public sector users by 2025
Singapore	5,600,000	4%	4%	50% reduction in the city's 2030 peak greenhouse gas emissions by 2050
Istanbul, Turkey	15,500,000	4%	32%	33% emission reduction by 2030 (from 2015 baseline)
Taoyuan, Chinese Taipei	2,200,000	3%	5%	850 MW cumulative installed renewable power capacity by 2021
Chicago, Illinois, United States	2,700,000	3%	5%	100% renewable energy for municipal buildings by 2025
Berlin, Germany	3,600,000	1%	3%	Carbon neutral and 25% solar electricity by 2050
Tokyo, Japan	14,000,000	1%	9%	30% renewable energy by 2030
Hyllie, Sweden	700,000	N/A	N/A	100% renewable or recycled** energy by 2030

Notes:

* Includes solar, wind, biomass, geothermal and hydropower. City-level targets for renewables are listed unless otherwise noted.

** Energy recycling from waste and wastewater to generate district heating, electricity and biogas.

N/A = data not available.

Source: Deloitte analysis and REN21 Policy Database (2020), available at www.ren21.net/cities/datapack and Reference Table R1. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, ICLEI, C40, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and therefore may not be exhaustive. For a list of cities with over 1 million people, see United Nations, *The World's Cities in 2018* (New York: 2018), https://www.un.org/en/events/citiesday/assets/pdf/the_worlds_cities_in_2018_data_booklet.pdf; for shares of wind and solar power, see CDP, "CDP Open Data Portal", <https://data.cdp.net>, updated November 2020. City-level targets for renewables are listed unless otherwise noted. Deloitte, "Smart Renewable Cities", from https://www2.deloitte.com/content/dam/insights/us/articles/4971_Smart-renewable-cities/DI_Smart-renewable-cities.pdf. It identifies and classifies cities globally that are deploying solar and/or wind power in connection with their smart city plans. This requires that cities have a publicly available city plan that presents a vision integrating renewables and smart city initiatives. In addition, the city must have already deployed solar and/or wind power (at least 1% of its energy mix) and plan to deploy more.

■ DATA COLLECTION AND VALIDATION

REN21 has developed a unique renewable energy reporting culture, allowing it to become recognised as a neutral data and knowledge broker that provides credible and widely accepted information. **Transparency is at the heart** of the REN21 data and reporting culture, and the following text explains some of REN21's key processes for data collection and validation in the context of the *Renewables in Cities Global Status Report* (REC).

DATA COLLECTION

Production of REN21's REC begins with an Expression of Interest form to mobilise contributors. The data collection process then involves the following elements:

- 1. Global tracking database.** The REC team compiles data on city-specific indicators, especially targets and policies, building mostly on existing consolidated datasets at the global or regional level.
- 2. Open city questionnaire.** In the city questionnaire, contributors from around the world submit data on renewable energy in their respective cities or cities of interest. This covers information about technology and market trends, targets and policy developments, investment, citizen participation and other local developments. Each data point is provided with a source and verified independently by the REC team.
- 3. Regional contributors.** For each world region, REN21 appoints one principal data contributor to provide city-specific data regarding renewable energy across different sectors and to share an overview of general trends and developments in cities in the respective region. The contributions of other organisations and individuals in each region also are collected, mostly through the questionnaire and peer review feedback.
- 4. Open peer review.** To further collect data and project examples and to ensure that significant developments have not been overlooked, REC-GSR contributors and reviewers participate in an open peer review process that typically occurs halfway through the report's production cycle. Peer review is open to all interested experts.
- 5. Expert interviews.** REN21's global community consists of a wide range of professionals who provide their expert input on renewable energy trends ad hoc in specific topics, including through interviews and personal communication with the REN21 REC team and chapter authors. The vast majority of the information is backed up by primary sources.
- 6. Desk research.** To fill in remaining gaps in the report and to pursue new topics, the REN21 REC team and chapter authors conduct extensive desk research. Topics of research can vary among REC editions and depend on emerging topics, important trends and annual availability of relatively recent formal or informal data in cities.

7. Data sharing agreements. REN21 holds several data sharing agreements with some of the largest and most reliable data providers/aggregators in the energy sector. These formal data are used exclusively in some cases or, in others, form the foundation of calculations and estimations presented in the REC.

DATA VALIDATION

REN21 ensures the accuracy and reliability of its reports by conducting data validation and fact-checking as a continuous process. Beginning during the first submission of the country questionnaires, data are continually verified up through the design period and until the final report is published. **All data provided by contributors, whether written or verbal, are validated by primary sources, which are published alongside the full report.**

■ METHODOLOGICAL NOTES

This 2021 report is the second edition of the *Renewables in Cities Global Status Report*. Readers can see the previous REC edition for additional details.

Most 2019 and 2020 dataⁱ for national and global capacity, output, growth and investment provided in this report are preliminary. Where necessary, information and data that are conflicting, partial or older are reconciled by using reasoned expert judgment. Endnotes provide additional details, including references, supporting information and assumptions where relevant.

Each REC edition draws from thousands of published and unpublished references, including: official government sources; reports from international organisations and industry associations; input from the REN21 community, including questionnaires submitted by regional and technology contributors as well as feedback from several rounds of formal and informal reviews; additional personal communications with scores of international experts and special advisors, including an international advisory committee created specifically to support the production of each report; and a variety of electronic newsletters, news media and other sources.

Much of the data found in the REC is built from the ground up by the authors with the aid of these resources. Other data, often very specific and narrow in scope, come more-or-less prepared from third parties. The REC attempts to synthesise these data points into a collective whole for the focus years.

The REC endeavours to provide the best data available in each edition; as such, data should not be compared with the previous version of this report to ascertain year-by-year changes.

ⁱ For information on city-level renewable energy data and related challenges, see Box 1 on Page 30.

NOTE ON ESTABLISHING RENEWABLE ENERGY SHARES OF TOTAL FINAL ENERGY CONSUMPTION (TFEC)

For methodology related to calculating renewable energy shares of TFEC see methodological notes in REN21's *Renewables 2020 Global Status Report*.

DEFINITION OF HEATING AND COOLING AND THERMAL APPLICATIONS

In the REC, the term "heating and cooling" refers to applications of thermal energy including space and water heating, space cooling, refrigeration, drying and industrial process heat, as well as any use of energy other than electricity that is used for motive power in any application other than transport. In other words, thermal demand refers to all end-uses of energy that cannot be classified as electricity demand or transport.

OTHER NOTES

This report includes data on projects, policies and other information prior to 31 December 2020. Editorial content of this report closed by 31 January 2021. Data provided for 2020 in the figures, tables and reference tables are as of the end of 2020, unless indicated otherwise. Growth rates in the REC are calculated as compound annual growth rates (CAGR) rather than as an average of annual growth rates. All exchange rates in this report are as of 31 December 2020 and are calculated using the OANDA currency converter (<http://www.oanda.com/currency/converter>). Corporate domicile, where noted, is determined by the location of headquarters.

GLOSSARY

Absorption chillers. Chillers that use heat energy from any source (solar, biomass, waste heat, etc.) to drive air conditioning or refrigeration systems. The heat source replaces the electric power consumption of a mechanical compressor. Absorption chillers differ from conventional (vapour compression) cooling systems in two ways: 1) the absorption process is thermochemical in nature rather than mechanical, and 2) the substance that is circulated as a refrigerant is water rather than chlorofluorocarbons (CFCs) or hydrochlorofluorocarbons (HCFCs), also called Freon. The chillers generally are supplied with district heat, waste heat or heat from co-generation, and they can operate with heat from geothermal, solar or biomass resources.

Auction. See Tendering.

Bagasse. The fibrous matter that remains after extraction of sugar from sugar cane.

Behind-the-meter system. Any power generation capacity, storage or demand management on the customer side of the interface with the distribution grid (i.e., the meter).

Biodiesel. A fuel produced from oilseed crops such as soy, rapeseed (canola) and palm oil, and from other oil sources such as waste cooking oil and animal fats. Biodiesel is used in diesel engines installed in cars, trucks, buses and other vehicles, as well as in stationary heat and power applications. Most biodiesel

is made by chemically treating vegetable oils and fats (such as palm, soy and canola oils, and some animal fats) to produce fatty acid methyl esters (FAME). (Also see Hydrotreated vegetable oil (HVO) and hydrotreated esters and fatty acids (HEFA).)

Bioenergy. Energy derived from any form of biomass (solid, liquid or gaseous) for heat, power and transport. (Also see Biofuel.)

Biofuel. A liquid or gaseous fuel derived from biomass, primarily ethanol, biodiesel and biogas. Biofuels can be combusted in vehicle engines as transport fuels and in stationary engines for heat and electricity generation. They also can be used for domestic heating and cooking (for example, as ethanol gels). Conventional biofuels are principally ethanol produced by fermentation of sugar or starch crops (such as wheat and corn), and FAME biodiesel produced from oil crops such as palm oil and canola and from waste oils and fats. Advanced biofuels are made from feedstocks derived from the lignocellulosic fractions of biomass sources or from algae. They are made using biochemical and thermochemical conversion processes, some of which are still under development.

Biogas/Biomethane. Biogas is a gaseous mixture consisting mainly of methane and carbon dioxide produced by the anaerobic digestion of organic matter (broken down by microorganisms in the absence of oxygen). Organic material and/or waste is converted into biogas in a digester. Suitable feedstocks include agricultural residues, animal wastes, food industry wastes, sewage sludge, purpose-grown green crops and the organic components of municipal solid wastes. Raw biogas can be combusted to produce heat and/or power; it also can be transformed into biomethane through a process known as scrubbing that removes impurities including carbon dioxide, siloxanes and hydrogen sulphides, followed by compression. Biomethane can be injected directly into natural gas networks and used as a substitute for natural gas in internal combustion engines without risk of corrosion.

Biomass. Any material of biological origin, excluding fossil fuels or peat, that contains a chemical store of energy (originally received from the sun) and that is available for conversion to a wide range of convenient energy carriers.

Biomass, traditional (use of). Solid biomass (including fuel wood, charcoal, agricultural and forest residues, and animal dung), that is used in rural areas of developing countries with traditional technologies such as open fires and ovens for cooking and residential heating. Often the traditional use of biomass leads to high pollution levels, forest degradation and deforestation.

Biomass energy, modern. Energy derived from combustion of solid, liquid and gaseous biomass fuels in high-efficiency conversion systems, which range from small domestic appliances to large-scale industrial conversion plants. Modern applications include heat and electricity generation, combined heat and power (CHP) and transport.

Biomass gasification. In a biomass gasification process, biomass is heated with a constrained amount of air or oxygen, leading to partial combustion of the fuels and to production of a mix of combustion gases that, depending on the conditions, can include carbon monoxide and carbon dioxide, methane, hydrogen and more complex materials such as tars. The resulting gas can

be either used for power generation (for example, in an engine or turbine) or further purified and treated to form a “synthesis gas”. This then can be used to produce fuels including methane, alcohols, and higher hydrocarbon fuels, including bio-gasoline and jet fuel. While gasification for power or heat production is relatively common, there are few examples of operating plants producing gas of high-enough quality for subsequent synthesis to more complex fuels.

Biomass pellets. Solid biomass fuel produced by compressing pulverised dry biomass, such as waste wood and agricultural residues. Pellets typically are cylindrical in shape with a diameter of around 10 millimetres and a length of 30-50 millimetres. Pellets are easy to handle, store and transport and are used as fuel for heating and cooking applications, as well as for electricity generation and CHP.

Biomethane. Biogas can be turned into biomethane by removing impurities including carbon dioxide, siloxanes and hydrogen sulphides, followed by compression. Biomethane can be injected directly into natural gas networks and used as a substitute for natural gas in internal combustion engines without risk of corrosion. Biomethane is often known as renewable natural gas (RNG), especially in North America.

Blockchain. A decentralised ledger in which digital transactions (such as the generation and sale of a unit of solar electricity) are anonymously recorded and verified. Each transaction is securely collected and linked, via cryptography, into a time-stamped “block”. This block is then stored on distributed computers as a “chain”. Blockchain may be used in energy markets, including for micro-trading among solar photovoltaic (PV) prosumers.

Building energy codes and standards. Rules specifying the minimum energy standards for buildings. These can include standards for renewable energy and energy efficiency that are applicable to new and/or renovated and refurbished buildings. See Renewable building codes.

Capacity. The rated power of a heat or electricity generating plant, which refers to the potential instantaneous heat or electricity output, or the aggregate potential output of a collection of such units (such as a wind farm or set of solar panels). Installed capacity describes equipment that has been constructed, although it may or may not be operational (for example, delivering electricity to the grid, providing useful heat or producing biofuels).

Capital subsidy. A subsidy that covers a share of the upfront capital cost of an asset (such as a solar water heater). These include, for example, consumer grants, rebates or one-time payments by a utility, government agency or government-owned bank.

Carbon neutrality. The achievement of a state in which every tonne of carbon dioxide emitted to the atmosphere is compensated for by an equivalent tonne removed (e.g., sequestered). Emissions can be compensated for by carbon offsets. Carbon neutrality refers to net zero emissions of only carbon dioxide, whereas **climate neutrality** indicates a broader focus on net-zero emissions of all greenhouse gases.

Circular economy. A closed-loop system in which the waste from one process is a resource that can be used as input for

another. By having a flow of resources that is circular rather than linear, the production of waste is minimised.

City. No international criteria or standards exist to determine what a city is. Most definitions of “cities” rely on settlement density and/or population numbers, although the criteria vary widely across countries. Generally, the term “urban area” refers to settlement areas that are more densely populated than suburban or peri-urban communities within the same metropolitan area. The term “city”, meanwhile, has broader meanings: according to the United Nations, it can connote a political or civic entity, a geographic unit, a formalised economy or an infrastructure bundle. In some instances, local communities, neighbourhood associations, urban businesses and industries may be subsumed under the term “city”. Throughout the report, municipal and city government refers to the local decision-making bodies and government authorities (the mayor’s office, city council, etc.), unless noted otherwise. “Local government” is a more generic term that can refer to different sub-national levels of public administration, including also counties, villages and other intermediate levels of government. In addition to municipal governments, key city-level stakeholders include individual citizens, groups of citizens and private enterprises, as well as various civil society groups that are active within the city.

City-wide. Extending or happening in all parts of a city.

Combined heat and power (CHP) (also called co-generation). CHP facilities produce both heat and power from the combustion of fossil and/or biomass fuels, as well as from geothermal and solar thermal resources. The term also is applied to plants that recover “waste heat” from thermal power generation processes.

Community choice aggregation (CCA). Under a CCA, municipalities themselves (independently or in partnership with an agency running the CCA) aggregate their residents’ and businesses’ electricity demand and set out to procure electricity for all participating customers city-wide through direct contracts with energy producers or through third-party energy providers. By enabling local communities to procure their own electricity, CCAs can be an attractive option for cities that want more local control over their electricity mix, for instance to increase the share of renewable electricity.

Community energy. An approach to renewable energy development that involves a community initiating, developing, operating, owning, investing and/or benefiting from a project. Communities vary in size and shape (for example, schools, neighbourhoods, partnering city governments, etc.); similarly, projects vary in technology, size, structure, governance, funding and motivation.

Competitive bidding. See Tendering.

Concentrating solar collector technologies. Technologies that use mirrors to focus sunlight on a receiver (see Concentrating solar thermal power). These are usually smaller-sized modules that are used for the production of heat and steam below 400°C for industrial applications, laundries and commercial cooking.

Concentrating solar thermal power (CSP) (also called solar thermal electricity, STE). Technology that uses mirrors to focus sunlight into an intense solar beam that heats a working fluid

in a solar receiver, which then drives a turbine or heat engine/generator to produce electricity. The mirrors can be arranged in a variety of ways, but they all deliver the solar beam to the receiver. There are four types of commercial CSP systems: parabolic troughs, linear Fresnel, power towers and dish/engines. The first two technologies are line-focus systems, capable of concentrating the sun's energy to produce temperatures of 400°C, while the latter two are point-focus systems that can produce temperatures of 800°C or higher.

Crowdfunding. The practice of funding a project or venture by raising money – often relatively small individual amounts – from a relatively large number of people (“crowd”), generally using the Internet and social media. The money raised through crowdfunding does not necessarily buy the lender a share in the venture, and there is no guarantee that money will be repaid if the venture is successful. However, some types of crowdfunding reward backers with an equity stake, structured payments and/or other products.

Demand-side management. The application of economic incentives and technology in the pursuit of cost-effective energy efficiency measures and load-shifting on the customer side, to achieve least-cost overall energy system optimisation.

Demand response. The use of market signals such as time-of-use pricing, incentive payments or penalties to influence end-user electricity consumption behaviours. Demand response is usually used to balance electrical supply and demand within a power system.

Digitisation. The conversion of something (for example, data or an image) from analogue to digital.

Distributed generation. The generation of electricity from dispersed, generally small-scale systems that are close to the point of consumption.

Distributed renewable energy. Energy systems are considered to be distributed if 1) the systems are connected to the distribution network rather than the transmission network, which implies that they are relatively small and dispersed (such as small-scale solar PV on rooftops) rather than relatively large and centralised; or 2) generation and distribution occur independently from a centralised network. Specifically for the purpose of this report, “distributed renewable energy” meets both conditions. It includes energy services for electrification, cooking, heating and cooling that are generated and distributed independent of any centralised system, in urban areas.

Distribution grid. The portion of the electrical network that takes power off the high-voltage transmission network via substations (at varying stepped-down voltages) and distributes electricity to customers.

Ecodistrict. A district relying on integrated urban planning that encompasses the objectives of sustainable development and social equity and is aimed at reducing the ecological footprint of a neighbourhood, urban area or region.

Electric vehicle (EV) (also called electric drive vehicle). A vehicle that uses one or more electric motors for propulsion. A battery electric vehicle is a type of EV that uses chemical

energy stored in rechargeable battery packs. A plug-in hybrid EV can be recharged by an external source of electric power. Fuel cell vehicles are EVs that use pure hydrogen (or gaseous hydrocarbons before reformation) as the energy storage medium. Also see Plug-in hybrid electric vehicle.

Energy. The ability to do work, which comes in a number of forms including thermal, radiant, kinetic, chemical, potential and electrical. Primary energy is the energy embodied in (energy potential of) natural resources, such as coal, natural gas and renewable sources. Final energy is the energy delivered for end-use (such as electricity at an electrical outlet). Conversion losses occur whenever primary energy needs to be transformed for final energy use, such as combustion of fossil fuels for electricity generation.

Energy audit. Analysis of energy flows in a building, process or system, conducted with the goal of reducing energy inputs into the system without negatively affecting outputs.

Energy efficiency. The measure that accounts for delivering more services for the same energy input, or the same amount of services for less energy input. Conceptually, this is the reduction of losses from the conversion of primary source fuels through final energy use, as well as other active or passive measures to reduce energy demand without diminishing the quality of energy services delivered. Energy efficiency is technology-specific and distinct from energy conservation, which pertains to behavioural change. Both energy efficiency and energy conservation can contribute to energy demand reduction.

Energy intensity. Primary energy consumption per unit of economic output. Energy intensity is a broader concept than energy efficiency in that it is also determined by non-efficiency variables, such as the composition of economic activity. Energy intensity typically is used as a proxy for energy efficiency in macro-level analyses due to the lack of an internationally agreed-upon high-level indicator for measuring energy efficiency.

Energy poverty. In poor countries, the term refers to the lack of access to modern energy services (for example, electricity and clean cooking). In wealthier countries, fuel poverty is associated with having energy costs above typical levels and mostly affects low-income households.

Energy service company (ESCO). A company that provides a range of energy solutions including selling the energy services from a (renewable) energy system on a long-term basis while retaining ownership of the system, collecting regular payments from customers and providing necessary maintenance service. An ESCO can be an electric utility, co-operative, non-governmental organisation or private company, and typically installs energy systems on or near customer sites. An ESCO also can advise on improving the energy efficiency of systems (such as a building or an industry) as well as on methods for energy conservation and energy management.

Energy subsidy. A government measure that artificially reduces the price that consumers pay for energy or that reduces the energy production cost.

Ethanol (fuel). A liquid fuel made from biomass (typically corn, sugar cane or small cereals/grains) that can replace petrol in

modest percentages for use in ordinary spark-ignition engines (stationary or in vehicles), or that can be used at higher blend levels (usually up to 85% ethanol, or 100% in Brazil) in slightly modified engines, such as those provided in “flex-fuel” vehicles. Ethanol also is used in the chemical and beverage industries.

Fatty acid methyl esters (FAME). See Biodiesel.

Feed-in policy (feed-in tariff or feed-in premium). A policy that typically guarantees renewable generators specified payments per unit (e.g., USD per kWh) over a fixed period. Feed-in tariff (FIT) policies also may establish regulations by which generators can interconnect and sell power to the grid. Numerous options exist for defining the level of incentive, such as whether the payment is structured as a guaranteed minimum price (e.g., a FIT), or whether the payment floats on top of the wholesale electricity price (e.g., a feed-in premium).

Final energy. The part of primary energy, after deduction of losses from conversion, transmission and distribution, that reaches the consumer and is available to provide heating, hot water, lighting and other services. Final energy forms include, among others, electricity, district heating, mechanical energy, liquid hydrocarbons such as kerosene or fuel oil, and various gaseous fuels such as natural gas, biogas and hydrogen.

(Total) Final energy consumption (TFEC). Energy that is supplied to the consumer for all final energy services such as transport, cooling and lighting, building or industrial heating or mechanical work. Differs from total final consumption (TFC), which includes all energy use in end-use sectors (TFEC) as well as for non-energy applications, mainly various industrial uses, such as feedstocks for petrochemical manufacturing.

Fiscal incentive. An incentive that provides individuals, households or companies with a reduction in their contribution to the public treasury via income or other taxes.

Generation. The process of converting energy into electricity and/or useful heat from a primary energy source such as wind, solar radiation, natural gas, biomass, etc.

Geothermal energy. Heat energy emitted from within the earth’s crust, usually in the form of hot water and steam. It can be used to generate electricity in a thermal power plant or to provide heat directly at various temperatures.

Green bond. A bond issued by a bank or company, the proceeds of which will go entirely into renewable energy and other environmentally friendly projects. The issuer will normally label it as a green bond. There is no internationally recognised standard for what constitutes a green bond.

Green building. A building that (in its construction or operation) reduces or eliminates negative impacts and can create positive impacts on the climate and natural environment. Countries and regions have a variety of characteristics that may change their strategies for green buildings, such as building stock, climate, cultural traditions, or wide-ranging environmental, economic and social priorities – all of which shape their approach to green building.

Green energy purchasing (also called green tariffs). Voluntary purchase of renewable energy – usually electricity, but also heat

and transport fuels – by residential, commercial, government or industrial consumers, either directly from an energy trader or utility company, from a third-party renewable energy generator or indirectly via trading of renewable energy certificates (such as renewable energy credits, green tags and guarantees of origin). It can create additional demand for renewable capacity and/or generation, often going beyond that resulting from government support policies or obligations.

Heat pump. A device that transfers heat from a heat source to a heat sink using a refrigeration cycle that is driven by external electric or thermal energy. It can use the ground (geothermal/ ground-source), the surrounding air (aerothermal/air-source) or a body of water (hydrothermal/water-source) as a heat source in heating mode, and as a heat sink in cooling mode. A heat pump’s final energy output can be several multiples of the energy input, depending on its inherent efficiency and operating condition. The output of a heat pump is at least partially renewable on a final energy basis. However, the renewable component can be much lower on a primary energy basis, depending on the composition and derivation of the input energy; in the case of electricity, this includes the efficiency of the power generation process. The output of a heat pump can be fully renewable energy if the input energy is also fully renewable.

Hydropower. Electricity derived from the potential energy of water captured when moving from higher to lower elevations. Categories of hydropower projects include run-of-river, reservoir-based capacity and low-head in-stream technology (the least developed). Hydropower covers a continuum in project scale from large (usually defined as more than 10 MW of installed capacity, but the definition varies by country) to small, mini, micro and pico.

Hydrotreated vegetable oil (HVO) and hydrotreated esters and fatty acids (HEFA). Biofuels produced by using hydrogen to remove oxygen from waste cooking oils, fats and vegetable oils. The result is a hydrocarbon that can be refined to produce fuels with specifications that are closer to those of diesel and jet fuel than is biodiesel produced from triglycerides such as fatty acid methyl esters (FAME).

Inverter (and micro-inverter), solar. Inverters convert the direct current (DC) generated by solar PV modules into alternating current (AC), which can be fed into the electric grid or used by a local, off-grid network. Conventional string and central solar inverters are connected to multiple modules to create an array that effectively is a single large panel. By contrast, micro-inverters convert generation from individual solar PV modules; the output of several micro-inverters is combined and often fed into the electric grid. A primary advantage of micro-inverters is that they isolate and tune the output of individual panels, reducing the effects that shading or failure of any one (or more) module(s) has on the output of an entire array. They eliminate some design issues inherent to larger systems, and allow for new modules to be added as needed.

Investment. Purchase of an item of value with an expectation of favourable future returns. In this report, new investment in renewable energy refers to investment in: technology research and development, commercialisation, construction of manufacturing facilities and project development (including the construction of wind farms and the purchase and installation of

solar PV systems). Total investment refers to new investment plus merger and acquisition (M&A) activity (the refinancing and sale of companies and projects).

Investment tax credit. A fiscal incentive that allows investments in renewable energy to be fully or partially credited against the tax obligations or income of a project developer, industry, building owner, etc.

Joule. A joule (J) is a unit of work or energy equal to the work done by a force equal to one newton acting over a distance of one metre. One joule is equal to one watt-second (the power of one watt exerted over the period of one second). The potential chemical energy stored in one barrel of oil and released when combusted is approximately 6 gigajoules (GJ); a tonne of oven-dry wood contains around 20 GJ of energy.

Light commercial vehicle. Vehicle used for commercial purposes that has a gross vehicle weight of less than 3,500 kilograms.

Low-emission vehicle zone. A type of vehicle restriction that limits or prohibits the access of certain types of fossil fuel vehicles in defined city areas.

Mandate/Obligation. A measure that requires designated parties (consumers, suppliers, generators) to meet a minimum – and often gradually increasing – standard for renewable energy (or energy efficiency), such as a percentage of total supply, a stated amount of capacity, or the required use of a specified renewable technology. Costs generally are borne by consumers. Mandates can include renewable portfolio standards (RPS); building codes or obligations that require the installation of renewable heat or power technologies (often in combination with energy efficiency investments); renewable heat purchase requirements; and requirements for blending specified shares of biofuels (biodiesel or ethanol) into transport fuel.

Market concession model. A model in which a private company or non-governmental organisation is selected through a competitive process and given the exclusive obligation to provide energy services to customers in its service territory, upon customer request. The concession approach allows concessionaires to select the most appropriate and cost-effective technology for a given situation.

Micromobility. A range of small, lightweight vehicles such as bicycles and scooters often used by individuals to travel short distances in cities.

Mini-grid/Micro-grid. For distributed renewable energy systems for energy access, a mini-grid/micro-grid typically refers to an independent grid network operating on a scale of less than 10 MW (with most at very small scale) that distributes electricity to a limited number of customers. Mini-/micro-grids also can refer to much larger networks (e.g., for corporate or university campuses) that can operate independently of, or in conjunction with, the main power grid. However, there is no universal definition differentiating mini- and micro-grids.

Monitoring. Energy use is monitored to establish a basis for energy management and to provide information on deviations from established patterns.

Municipal operations. Services or infrastructure that are owned and/or operated by municipal governments. This may include municipal buildings and transport fleets (such as buses, police vehicles and refuse collection trucks).

Municipal solid waste. Waste materials generated by households and similar waste produced by commercial, industrial or institutional entities. The wastes are a mixture of renewable plant and fossil-based materials, with the proportions varying depending on local circumstances. A default value that assumes that at least 50% of the material is “renewable” is often applied.

(Re-)Municipalisation. Legal process by which municipalities assume control of their electricity procurement and distribution assets, generally through purchase from private entities.

Net metering / Net billing. A regulated arrangement in which utility customers with on-site electricity generators can receive credits for excess generation, which can be applied to offset consumption in other billing periods. Under net metering, customers typically receive credit at the level of the retail electricity price. Under net billing, customers typically receive credit for excess power at a rate that is lower than the retail electricity price. Different jurisdictions may apply these terms in different ways, however.

Net-zero carbon building / Net-zero energy building / Nearly zero energy building. Various definitions have emerged of buildings that achieve high levels of energy efficiency and meet remaining energy demand with either on-site or off-site renewable energy. For example, the World Green Building Council’s Net Zero Carbon Buildings Commitment considers use of renewable energy as one of five key components that characterise a net-zero building. Definitions of net-zero carbon, net-zero energy and nearly zero energy buildings can vary in scope and geographic relevance.

Net-zero strategy. Policy or plan to achieve carbon neutrality by a certain date. In most cases, this involves reducing community-wide emissions as much as possible, for instance through improvements in energy efficiency and a transition to renewable energy, while investing in carbon mitigation options or offsets elsewhere in the world.

Ocean power. Refers to technologies used to generate electricity by harnessing from the ocean the energy potential of ocean waves, tidal range (rise and fall), tidal streams, ocean (permanent) currents, temperature gradients (ocean thermal energy conversion) and salinity gradients. The definition of ocean power used in this report does not include offshore wind power or marine biomass energy.

Off-take agreement. An agreement between a producer of energy and a buyer of energy to purchase/sell portions of the producer’s future production. An off-take agreement normally is negotiated prior to the construction of a renewable energy project or installation of renewable energy equipment in order to secure a market for the future output (e.g., electricity, heat). Examples of this type of agreement include power purchase agreements and feed-in tariffs.

Off-taker. The purchaser of the energy from a renewable energy project or installation (e.g., a utility company) following an off-take agreement.

Pay-as-you-go (PAYGo). A business model that gives customers (mainly in areas without access to the electricity grid) the possibility to purchase small-scale energy-producing products, such as solar home systems, by paying in small instalments over time.

Plug-in hybrid electric vehicle. This differs from a simple hybrid vehicle, as the latter uses electric energy produced only by braking or through the vehicle's internal combustion engine. Therefore, only a plug-in hybrid electric vehicle allows for the use of electricity from renewable sources. Although not an avenue for increased penetration of renewable electricity, hybrid vehicles contribute to reduced fuel demand and remain far more numerous than EVs.

Positive energy district (PED). An area within a city that is capable of generating more renewable energy than it consumes.

Power. The rate at which energy is converted into work, expressed in watts (joules/second).

Power purchase agreement (PPA). A contract between two parties, one that generates electricity (the seller) and one that is looking to purchase electricity (the buyer).

Primary energy. The theoretically available energy content of a naturally occurring energy source (such as coal, oil, natural gas, uranium ore, geothermal and biomass energy, etc.) before it undergoes conversion to useful final energy delivered to the end-user. Conversion of primary energy into other forms of useful final energy (such as electricity and fuels) entails losses. Some primary energy is consumed at the end-user level as final energy without any prior conversion.

Primary energy consumption. The direct use of energy at the source, or supplying users with unprocessed fuel.

Product and sectoral standards. Rules specifying the minimum standards for certain products (e.g., appliances) or sectors (industry, transport, etc.) for increasing energy efficiency.

Production tax credit. A tax incentive that provides the investor or owner of a qualifying property or facility with a tax credit based on the amount of renewable energy (electricity, heat or biofuel) generated by that facility.

Property Assessed Clean Energy (PACE) financing. Provides access to low-interest loans for renewable energy that can be repaid through increases on property taxes.

Prosumer. An individual, household or small business that not only consumes energy but also produces it. Prosumers may play an active role in energy storage and demand-side management.

Public financing. A type of financial support mechanism whereby governments provide assistance, often in the form of grants or loans, to support the development or deployment of renewable energy technologies.

Pumped storage. Plants that pump water from a lower reservoir to a higher storage basin using surplus electricity, and that reverse the flow to generate electricity when needed. They are not energy sources but means of energy storage and can have overall system efficiencies of around 80-90%.

Regulatory policy. A rule to guide or control the conduct of those to whom it applies. In the renewable energy context, examples include mandates or quotas such as renewable portfolio standards, feed-in tariffs and technology-/fuel-specific obligations.

Renewable building codes. Building energy codes that mandate that a certain amount of energy demand be met by renewable energy (e.g., solar obligations). They differ from green building codes, which tend to focus on improving the performance of buildings by using materials, equipment and components that enhance energy efficiency. See Green building.

Renewable energy. This includes all forms of energy produced from renewable sources, including solar, wind, ocean, hydropower, biomass, geothermal resources and biofuels.

Renewable energy certificate (REC). A certificate awarded to certify the generation of one unit of renewable energy (typically 1 MWh of electricity but also less commonly of heat). In systems based on RECs, certificates can be accumulated to meet renewable energy obligations and also provide a tool for trading among consumers and/or producers. They also are a means of enabling purchases of voluntary green energy.

Renewable hydrogen (also referred to as green hydrogen). Hydrogen produced from renewable energy, most commonly through the use of renewable electricity to split water into hydrogen and oxygen in an electrolyser. The vast majority of hydrogen is still produced from fossil fuels, and the majority of policies and programmes focused on hydrogen do not include a focus on renewables-based production.

Renewable portfolio standard (RPS). An obligation placed by a government on a utility company, group of companies or consumers to provide or use a predetermined minimum targeted renewable share of installed capacity, or of electricity or heat generated or sold. A penalty may or may not exist for non-compliance. These policies also are known as "renewable electricity standards", "renewable obligations" and "mandated market shares", depending on the jurisdiction.

Sector integration (also called sector coupling). The integration of energy supply and demand across electricity, thermal and transport applications, which may occur via co-production, combined use, conversion and substitution.

Shore power (also called cold ironing). This entails connecting a maritime vessel to the power grid while at berth in a port so that the electricity demand from the vessel while hotelling is supplied directly by the grid rather than by the generator on the vessel, which typically is diesel powered.

Smart charging. Optimisation of the charging process of an electric vehicle according to external inputs (e.g., user requirements, power system characteristics, grid constraints and renewable energy availability). Smart charging includes unidirectional controlled charging (V1G), bi-directional vehicle-to-grid (V2G) and vehicle-to-home/building (V2H/B). Developing smart charging brings several advantages for balancing the grid, also helping to integrate renewables into the system and possibly improving operating expenses for consumers. Also see Vehicle-to-grid.

Smart city. A city that utilises digital technologies to collect data that is then used to manage assets, resources and services more efficiently, improve operations across the city and generally increase the quality of life of citizens.

Smart energy system. An energy system that aims to optimise the overall efficiency and balance of a range of interconnected energy technologies and processes, both electrical and non-electrical (including heat, gas and fuels). This is achieved through dynamic demand- and supply-side management; enhanced monitoring of electrical, thermal and fuel-based system assets; control and optimisation of consumer equipment, appliances and services; better integration of distributed energy (on both the macro and micro scales); as well as cost minimisation for both suppliers and consumers.

Smart grid. Electrical grid that uses information and communications technology to co-ordinate the needs and capabilities of the generators, grid operators, end-users and electricity market stakeholders in a system, with the aim of operating all parts as efficiently as possible, minimising costs and environmental impacts and maximising system reliability, resilience and stability.

Solar collector. A device used for converting solar energy to thermal energy (heat), typically used for domestic water heating but also used for space heating, for industrial process heat and to drive thermal cooling machines. Evacuated tube and flat plate collectors that operate with water or a water/glycol mixture as the heat-transfer medium are the most common solar thermal collectors used worldwide. These are referred to as glazed water collectors because irradiation from the sun first hits a glazing (for thermal insulation) before the energy is converted to heat and transported away by the heat transfer medium. Unglazed water collectors, often referred to as swimming pool absorbers, are simple collectors made of plastics and used for lower-temperature applications. Unglazed and glazed air collectors use air rather than water as the heat-transfer medium to heat indoor spaces or to pre-heat drying air or combustion air for agriculture and industry purposes.

Solar home system. A stand-alone system composed of a relatively low-power photovoltaic module, a battery and sometimes a charge controller that can provide modest amounts of electricity for home lighting, communications and appliances, usually in rural or remote regions that are not connected to the electricity grid. The term solar home system kit also is used to define systems that usually are branded and have components that are easy for users to install and use.

Solar photovoltaics (PV). A technology used for converting light directly into electricity. Solar PV cells are constructed from semiconducting materials that use sunlight to separate electrons from atoms to create an electric current. Modules are formed by interconnecting individual cells. Building-integrated PV (BIPV) generates electricity and replaces conventional materials in parts of a building envelope, such as the roof or façade.

Solar photovoltaic-thermal (PV-T). A solar PV-thermal hybrid system that includes solar thermal collectors mounted beneath PV modules to convert solar radiation into electrical and thermal

energy. The solar thermal collector removes waste heat from the PV module, enabling it to operate more efficiently.

Solar-plus-storage. A hybrid technology of solar PV with battery storage. Other types of renewable energy-plus-storage plants also exist.

Solar water heater. An entire system consisting of a solar collector, storage tank, water pipes and other components. There are two types of solar water heaters: pumped solar water heaters use mechanical pumps to circulate a heat transfer fluid through the collector loop (active systems), whereas thermosiphon solar water heaters make use of buoyancy forces caused by natural convection (passive systems).

Storage battery. A type of battery that can be given a new charge by passing an electric current through it. A lithium-ion battery uses a liquid lithium-based material for one of its electrodes. A lead-acid battery uses plates made of pure lead or lead oxide for the electrodes and sulphuric acid for the electrolyte, and remains common for off-grid installations. A flow battery uses two chemical components dissolved in liquids contained within the system and most commonly separated by a membrane. Flow batteries can be recharged almost instantly by replacing the electrolyte liquid, while simultaneously recovering the spent material for re-energisation.

Target. An official commitment, plan or goal set by a government (at the local, state, national or regional level) to achieve a certain amount of renewable energy or energy efficiency by a future date. Targets may be backed by specific compliance mechanisms or policy support measures. Some targets are legislated, while others are set by regulatory agencies, ministries or public officials.

Tender (also called auction/reverse auction or tender). A procurement mechanism by which renewable energy supply or capacity is competitively solicited from sellers, who offer bids at the lowest price that they would be willing to accept. Bids may be evaluated on both price and non-price factors.

Thermal energy storage. Technology that allows the transfer and storage of thermal energy.

Transmission grid. The portion of the electrical supply distribution network that carries bulk electricity from power plants to sub-stations, where voltage is stepped down for further distribution. High-voltage transmission lines can carry electricity between regional grids in order to balance supply and demand.

Urban form. Refers to a city's physical characteristics, including size, shape and population density.

Urban freight transport. The movement of goods in to, out from, through or within the urban area made by light or heavy vehicles, including but not limited to service transport, construction material transport and reverse logistics for waste removal.

Variable renewable energy (VRE). A renewable energy source that fluctuates within a relatively short time frame, such as wind and solar energy, which vary within daily, hourly and even sub-hourly time frames. By contrast, resources and technologies that are variable on an annual or seasonal basis due to environmental

changes, such as hydropower (due to changes in rainfall) and thermal power plants (due to changes in temperature of ambient air and cooling water), do not fall into this category.

Vehicle-to-grid (V2G). A system in which electric vehicles – whether battery electric or plug-in hybrid – communicate with the grid in order to sell response services by returning electricity from the vehicles to the electric grid or by altering the rate of charging.

Virtual net metering. Virtual (or group) net metering allows electricity utility consumers to share the output of a renewable power project. By receiving “energy credits” based on project output and their ownership share of the project, consumers are able to offset costs on their electricity utility bill.

Virtual power plant (VPP). A network of decentralised, independently owned and operated power generating units combined with flexible demand units and possibly also with storage facilities. A central control station monitors operation, forecasts demand and supply, and dispatches the networked units as if they were a single power plant. The aim is to smoothly integrate a high number of renewable energy units into existing energy systems; VPPs also enable the trading or selling of power into wholesale markets.

Virtual power purchase agreement (PPA). A contract under which the developer sells its electricity in the spot market. The

developer and the corporate off-taker then settle the difference between the variable market price and the strike price, and the off-taker receives the electricity certificates that are generated. This is in contrast to more traditional PPAs, under which the developer sells electricity to the off-taker directly.

Watt. A unit of power that measures the rate of energy conversion or transfer. A kilowatt is equal to 1 thousand watts; a megawatt to 1 million watts; and so on. A megawatt-electrical (MW_e) is used to refer to electric power, whereas a megawatt-thermal (MW_t) refers to thermal/heat energy produced. Power is the rate at which energy is consumed or generated. A kilowatt-hour is the amount of energy equivalent to steady power of 1 kW operating for one hour.

Wheeling. Refers to the transport of electric energy from within an electrical grid from one party (the seller) to another party (the buyer). Wheeling deals with the use of the network and the cost of delivering the energy.

Zero-emission vehicle. A vehicle that does not produce tailpipe emissions (the air pollutants emitted during the operation of a vehicle). These emissions often include greenhouse gases, particulate matter, volatile organic compounds, nitrogen oxides, carbon monoxide and sulphur dioxide. The term zero-emission vehicle typically refers to an electric vehicle, although the charging of the vehicle is not necessarily linked with renewable energy.



■ LIST OF ABBREVIATIONS

ADB	Asian Development Bank	kW/kWh	Kilowatt/kilowatt-hour
ASEAN	Association of Southeast Asian Nations	LED	Light-emitting diode
AUD	Australian dollar	LEZ	Low-emission zone
BRL	Brazilian real	LPG	Liquefied petroleum gas
CCA	Community choice aggregation	MENA	Middle East and North Africa
CDP	Carbon Disclosure Project	MSW	Municipal solid waste
CHP	Combined heat and power	MW/MWh	Megawatt/Megawatt-hour
CNG	Compressed natural gas	MW _{th}	Megawatt-thermal
CNY	Chinese yuan	MXN	Mexican peso
CO ₂	Carbon dioxide	NDC	Nationally Determined Contribution
COP26	26 th Conference of the Parties	NEV	New Energy Vehicle
COVID	Coronavirus disease	NUP	National urban policy
CSP	Concentrating solar thermal power	OECD	Organisation for Economic Co-operation and Development
DHC	District heating and cooling	PACE	Property Assessed Clean Energy
EBRD	European Bank for Reconstruction and Development	PAYGo	Pay as you go
EDGE	Excellence in Design for Greater Efficiencies	PCET	Plan Climat-Energie Territorial
EJ	Exajoule	PHEV	Plug-in hybrid electric vehicle
ESCO	Energy service company	PLN	Polish zloty
ESG	Environmental, social and corporate governance	PM _{2.5}	Fine particulate matter
EU	European Union	PPA	Power purchase agreement
EUR	Euro	PPI	Private participation in infrastructure
EV	Electric vehicle	PPP	Public-private partnership
FIT	Feed-in tariff	PV	Photovoltaic
GBP	Pound sterling	REC	Renewable energy certificate
GDP	Gross domestic product	REIPPP	Renewable Energy Independent Power Procurement Programme
GJ	Gigajoule	SDG	Sustainable Development Goal
GO	Guarantee of origin	SEA	Sustainable Energy Africa
GSR	Global Status Report	SEED	Sustainable Energy for Environment and Development
GW/GWh	Gigawatt/gigawatt-hour	SEK	Swedish krona
GW _{th}	Gigawatt-thermal	SPV	Special purpose vehicle
HEFA	Hydrotreated esters and fatty acids	SSA	Sub-Saharan Africa
HVO	Hydrotreated vegetable oil	TW/TWh	Terawatt/Terawatt-hour
ICCT	International Council on Clean Transportation	UK	United Kingdom
ICE	Internal combustion engine	UN	United Nations
ICLEI	International Council for Local Environmental Initiatives	URBACT	Urban development network programme
IDR	Indonesian rupiah	US	United States
IEA	International Energy Agency	USD	United States dollar
INR	Indian rupee	WHO	World Health Organization
IPP	Independent power producer	ZAR	South African rand
IPVA	Vehicle Property Tax		
IRP	Integrated Resource Plan		
JPY	Japanese yen		
KCCA	Kampala Capital City Authority		
km ²	Square kilometre		
KPLC	Kenya Power and Lighting Company		



■ PHOTO CREDITS

- Page 01: Maputo, Mozambique, Africa; © Sopotnicki; shutterstock
 Page 04: Budapest, Hungary; © Dmitry Pistrov; shutterstock
 Page 05: Barcelona, Spain; © Edylaras; shutterstock
 Page 06: Manhattan, New York City, United States; © Ryan DeBerardinis; shutterstock
 Page 07: Madrid, Spain; © Rafal Michal Gadomski; shutterstock
 Page 14: Hong Kong; © leungchopan; shutterstock
 Page 16: London, United Kingdom; © Yau Ming Low; shutterstock
 Page 16: Bamako, Mali; © Thomas Brissiaud; shutterstock
 Page 17: London, United Kingdom; © Alena Veasey; shutterstock
 Page 18: Kuala Lumpur; © Md Aziman; shutterstock
 Page 19: Moscow, Russian Federation; © vaalaa; shutterstock
 Page 19: © aSuruwataRi; shutterstock
 Page 21: Ruiru, Kenya; © Lidia Daskalova; shutterstock
 Page 22: Amsterdam, the Netherlands; © Ingus Krukltis; shutterstock
 Page 25: Stellenbosch, Cape Town, South Africa; © Moobatto; shutterstock
 Page 26: Kuala Lumpur, Malaysia; © Abdul Razak Latif; shutterstock
 Page 28: © maroke; shutterstock
 Page 29: Pakse, Laos; © Tiew.Zog.Zag; shutterstock
 Page 30: Cape Town, South Africa; © Ahturner; shutterstock
 Page 30: Madagascar; © KRIS75; shutterstock
 Page 31: Vienna, Austria; © IndustryAndTravel; shutterstock
 Page 34: Amsterdam, Netherlands; © Donaldb; shutterstock
 Page 35: Havana, Cuba; © Susana Ortega; shutterstock
 Page 36: Hagafoss, Norway; © Mr Ton Dogleg; shutterstock
 Page 36: Milan, Italy; © DZeta; shutterstock
 Page 37: Oak View, California, United States; © Joseph Sohm; shutterstock
 Page 37: Bacoor, Philippines; © MarceloMayoPH; shutterstock
 Page 38: Cape Town, South Africa; © Roxane 134; shutterstock
 Page 38: Baños, Ecuador; © Michael Zysman; shutterstock
 Page 39: Geothermal power Station, Taupo Volcanic Zone, New Zealand; © Chrispo; shutterstock
 Page 39: Dubai, United Arab Emirates; © Juliya_Ka; shutterstock
 Page 40: Gangnam square, Seoul, Korea; © sayan uranan; shutterstock
 Page 42: Lake Eola Park, Orlando, United States; © Zhukova Valentyna; shutterstock
 Page 42: © Jillian Cain Photography; shutterstock
 Page 43: Hong Kong, China; © Bruce Au; shutterstock
 Page 45: © beeboys; shutterstock
 Page 46: Houston, United States; © Sean Pavone; shutterstock
 Page 47: Adelaide, Australia; © myphotobank.com.au; shutterstock
 Page 48: Hamburg, Germany; © FrankHH; shutterstock
 Page 49: Port of Rotterdam, the Netherlands; © Catstyecam; shutterstock
 Page 50: © Fly_and_Dive; shutterstock
 Page 50: Feletto Umberto, Italy; © PHLD Luca; shutterstock
 Page 51: Seoul, Republic of Korea; © Surachet Jo; shutterstock
 Page 53: Quezon City, Philippines; © Michael D Edwards; shutterstock
 Page 53: Breckenridge, United States; © Virrage Images; shutterstock
 Page 54: China; © mayday6510; shutterstock
 Page 54: © FedotovAnatoly; shutterstock
 Page 55: Oregon, United States; © Bogdan Denysyuk; shutterstock
 Page 55: Tigard, Oregon, United States; © Tada Images; shutterstock
 Page 55: © Nick Starichenko; shutterstock
 Page 56: © Dzmitro; shutterstock
 Page 57: © Beate Wolter; shutterstock
 Page 58: Helsinki, Finland; © T. Miettinen; shutterstock
 Page 59: Stockholm, Sweden; © Elena B Olesik; shutterstock
 Page 60: India; © XandriethXs; shutterstock
 Page 61: Rajkot city; © Suresh K Srivastava; shutterstock
 Page 61: © Kliksm4; shutterstock
 Page 62: © petrimalinak; shutterstock
 Page 63: Seoul, South Korea; © Kampon; shutterstock
 Page 63: © KIM JIHYUN; shutterstock
 Page 63: © KIM JIHYUN; shutterstock
 Page 65: Nuremberg, Germany; © franconiaphoto; shutterstock
 Page 66: © Africa Studio; shutterstock
 Page 67: © Felix Mizioznikov; shutterstock
 Page 69: Amsterdam, Netherlands; © Tsetso Photo; shutterstock
 Page 70: High Falls, United States; © gary718; shutterstock
 Page 71: Arnhem, Netherlands; © Fortgens Photography; shutterstock
 Page 73: Chongqing, China; © xujun; shutterstock
 Page 73: Bradley, United States; © Sheila Fitzgerald; shutterstock
 Page 74: Antigua, Guatemala; © Nino Weg; shutterstock
 Page 76: Santiago, Chile; © Jose Luis Stephens; shutterstock
 Page 77: Auckland, New Zealand; © Emagnetic; shutterstock
 Page 77: Toronto, Canada; © Philip Lange; shutterstock
 Page 78: Colombo, Sri Lanka; © DESIGNFACTS; shutterstock
 Page 80: © Roman Yanushevsky; shutterstock
 Page 80: © Roman Yanushevsky; shutterstock
 Page 81: Hybrid energy storage system; © redT energy; shutterstock
 Page 82: Flevoland, Urk, Netherlands; © esbobeldijk; shutterstock

- Page 85: Lillehammer, Norway; © jstuij; shutterstock
- Page 85: Lofoten village, Norway; © Nickmcfloyd; shutterstock
- Page 86: Tavira, Portugal; © Pierre-Olivier; shutterstock
- Page 87: © Zigmunds Dizgalvis; shutterstock
- Page 90: Malmö, Sweden; © Cinematographer; shutterstock
- Page 91: MONTREAL,CANADA: © Colin Woods; shutterstock
- Page 92: Norwegian electric car-ferry; © Iver Daaland Ase iverdaa; shutterstock
- Page 93: Hamburg, Germany; © FrankHH; shutterstock
- Page 94: Sanya, China; © Amateur007; shutterstock
- Page 96: Cardiff, Wales, United Kingdom; © GarethWilley; shutterstock
- Page 97: Strømmen, Norway; © Olav Eng; shutterstock
- Page 97: Kathmandu, Nepal; © www.hollandfoto.net; shutterstock
- Page 98: Delhi, India; © Vadim Petrakov; shutterstock
- Page 98: Amsterdam, Netherlands; © Don Mammoser; shutterstock
- Page 99: Oxford, United Kingdom; © Pajor Pawel; shutterstock
- Page 99: Oxford, United Kingdom; © syahmi azman; shutterstock
- Page 100: Salt Lake City, United States; © Michael Gordon; shutterstock
- Page 101: Sweden; © stilrentfoto; shutterstock
- Page 101: Berlin, Germany; © laranik; shutterstock
- Page 103: Frankfurt, Germany; © twentyoneaerials; shutterstock
- Page 104: Sao Paulo, Brazil; © Gustavo Frazao; shutterstock
- Page 105: Barbados; © Milan Portfolio; shutterstock
- Page 106: Sanxia Dam, Yangtze River, China; © burakyalcin; shutterstock
- Page 106: New Bedford, United States; © Dan Logan; shutterstock
- Page 107: Warsaw, Poland; © meowKa; shutterstock
- Page 107: © fotogruhl; shutterstock
- Page 108: Palmas, Tocantins, Brazil; © Giovanni Zacchini; shutterstock
- Page 108: © Rawpixel.com; shutterstock
- Page 109: Berlin, Germany; © Cineberg; shutterstock
- Page 110: © katjen; shutterstock
- Page 110: © AlexLab; shutterstock
- Page 110: © sakoat contributor; shutterstock
- Page 112: Douala, Cameroon; © Sidoine Mbogni; shutterstock
- Page 113: New Delhi, India; © Maximillian cabinet; shutterstock
- Page 113: Ogun State, Nigeria; © Agbebiyi Adekunle Sunday; shutterstock
- Page 113: New Delhi, India; © Shashank Agarwal; shutterstock
- Page 114: Wadi Rum Village, Jordan; © Kristof Bellens; shutterstock
- Page 115: © Syamim Sopian; shutterstock
- Page 115: Biogas digester Pvc plastic model; © Thatsanaphong Chanwarin; shutterstock
- Page 115: © Alastair Munro; shutterstock
- Page 116: © Tavarius; shutterstock
- Page 116: Australia; © Elias Bitar; shutterstock
- Page 117: Tokyo, Japan; © yoshi0511; shutterstock
- Page 117: Valenzuela City, Philippines; © Shernielyn Dela Cruz; shutterstock
- Page 118: New Delhi, India; © PradeepGaur; shutterstock
- Page 121: Los Angeles, United States; © vesperstock; shutterstock
- Page 122: Tokyo, Japan; © Shawn.ccf; shutterstock
- Page 125: New Delhi, India; © ALensAndSomeLuck; shutterstock
- Page 126: Milan, Italy; © DELBO ANDREA; shutterstock
- Page 127: Madrid, Spain; © Rafal Michal Gadomski; shutterstock
- Page 128: Bristol, United Kingdom; © Kollawat Somsri; shutterstock
- Page 129: Tahara city, Japan; © Masa Kato; shutterstock
- Page 130: Jakarta, Indonesia; © AsiaTravel; shutterstock
- Page 130: Jakarta, Indonesia; © Artush; shutterstock
- Page 131: Cape Town, South Africa; © Authentic travel; shutterstock
- Page 132: Paris, France; © Ekami; shutterstock
- Page 133: Barcelona, Spain; © Edylaras; shutterstock
- Page 134: Seocho-gu, Seoul, South Korea; © Stock for you; shutterstock
- Page 135: Boa Viagem Beach, Recife, Pernambuco, Brazil; © Gustavo Frazao; shutterstock
- Page 135: Recife, Brazil; © Marcio Jose Bastos Silva; shutterstock
- Page 136: Fishing village on Zanzibar island; © In Green; shutterstock
- Page 139: © Chadofski; shutterstock
- Page 139: © africa924; shutterstock
- Page 140: © michaeljung; shutterstock
- Page 141: © ImageArc; shutterstock
- Page 142: © Curioso.Photography; shutterstock
- Page 143: © Lizelle Lotter; shutterstock
- Page 144: © EiZivile; shutterstock
- Page 145: © Firefighter Montreal; shutterstock
- Page 146: © Agarianna76; shutterstock
- Page 147: City hall of cape town, south africa; © michaeljung; shutterstock
- Page 147: Microcredit Foundation Bweyale branch office, Uganda; © GODONG-PHOTO; shutterstock
- Page 158: Montreal, QC, Canada; © Derek Robbins; shutterstock

GLOBAL OVERVIEW OF RENEWABLES IN CITIES

- 1 REN21 Policy Database (2020) and Tables R1-R5, available at www.ren21.net/cities/datapack. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and may not be exhaustive. **Figure 1** and **Table 1** from Ibid; Fossil Free Divestment, "Divestment commitments overview", <https://gofossilfree.org/divestment/commitments>, viewed 14 December 2020.
- 2 Estimates for urban energy consumption vary between 56% and 78% (central estimate, 76%) of global final energy use. See the following: K. C. Seto et al., "Human settlements, infrastructure and spatial planning", in O. Edenhofer et al., eds., *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge, UK and New York, NY: Cambridge University Press, 2014), https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_chapter12.pdf; International Energy Agency (IEA), "Cities are at the frontline of the energy transition", press release (Paris: 7 September 2016), <https://www.iea.org/newsroom/news/2016/september/cities-are-at-the-frontline-of-the-energy-transition.html>; United Nations Department of Economic and Social Affairs (UN DESA), *World Urbanization Prospects: The 2018 Revision* (New York: 2018), <https://population.un.org/wup/Publications/Files/WUP2018-Report.pdf>.
- 3 Seto et al., op. cit. note 2; World Bank, "Urban development", <https://www.worldbank.org/en/topic/urbandevelopment/overview>, viewed 15 November 2020.
- 4 Seto et al., op. cit. note 2; World Bank, op. cit. note 3.
- 5 United Nations Environment Programme (UNEP), *The Weight of Cities: Resource Requirements of Future Urbanisation* (Nairobi: 2018), <https://www.resourcepanel.org/reports/weight-cities>.
- 6 Greenhouse gas accounting in cities can be done using either a sector-based approach or a consumption-based approach. Both include emissions resulting from household use of fuels and electricity as well as goods and services produced and consumed *within* a city's boundaries. However, there are key differences between the two approaches. A sector-based greenhouse gas inventory also includes emissions arising from *exported* goods and services. The consumption-based approach excludes emissions from the goods and services that are exported from the city but includes emissions from *imported* goods and services. From A. A. Morini, M. J. Ribeiro and D. Hotza, "Early stage materials selection based on embodied energy and carbon footprint", *Materials & Design*, vol. 178 (September 2019), p. 107861, <https://www.sciencedirect.com/science/article/pii/S0264127519302990>; C40, *Consumption-based GHG Emissions of C40 Cities* (New York: March 2018), <https://www.c40.org/researches/consumption-based-emissions>.
- 7 IEA, *World Energy Outlook 2018* (Paris: 2018), p. 27, <https://www.iea.org/weo2018>; Renewable Energy Network for the 21st Century (REN21), *Renewables 2020 Global Status Report* (Paris: 2020), <https://www.ren21.net/gsr-2020>; ICLEI – Local Governments for Sustainability, "100% Renewables Cities and Regions Roadmap", <https://iclei.org/en/100RECitiesroadmap.html>, viewed 10 January 2021.
- 8 UN Habitat, *Habitat III Issue Papers, 22 – Informal Settlements* (New York: May 2015), https://unhabitat.org/sites/default/files/download-manager-files/Habitat-III-Issue-Paper-22_Informal-Settlements-2.0%20%282%29.pdf.
- 9 Estimate based on the fact that 4.2% of the global population in urban areas does not have access to electricity, from IEA, *SDG7: Data and Projections: Access to Electricity* (Paris: October 2020), <https://www.iea.org/reports/sdg7-data-and-projections/access-to-electricity>, and 55% of the global population (4.2 billion inhabitants) lives in cities, from World Bank, op. cit. note 3. IEA, *SDG7: Data and Projections: Access to Clean Cooking* (Paris: October 2020), <https://www.iea.org/reports/sdg7-data-and-projections/access-to-clean-cooking>.
- 10 Between 2000 and 2014, the proportion of the urban population living in slums worldwide decreased by 20%; but by 2018 it had again risen to 23.5% or 1 billion people in total, mainly in Eastern and South-Eastern Asia (370 million), Sub-Saharan Africa (238 million) and Central and Southern Asia (227 million). From UN Stats, "Make cities and human settlements inclusive, safe, resilient and sustainable", <https://unstats.un.org/sdgs/report/2019/goal-11>, viewed 11 January 2021.
- 11 Seto et al., op. cit. note 2; World Bank, op. cit. note 3; Organisation for Economic Co-operation and Development (OECD), "Achieving the SDGs in cities and regions", <http://www.oecd.org/about/impact/achievingthesdgsincitiesandregions.htm>, viewed 13 November 2020; World Future Council, "100% RE and SDGs", 6 June 2017, <https://www.worldfuturecouncil.org/100re-sdg/>; I. Alloisio, "SDG 7 as an Enabling Factor for Sustainable Development", presentation at Expert Group Meeting, United Nations Headquarters, New York, 25 January 2018, https://sustainabledevelopment.un.org/content/documents/26618Alloisio_Session_5_SDG_7_EGM_01_2018.pdf.
- 12 REN21, *Renewables in Cities 2019 Global Status Report* (Paris: 2019), https://www.ren21.net/wp-content/uploads/2019/05/REC-2019-GSR_Full_Report_web.pdf; International Renewable Energy Agency (IRENA), *Renewable Energy in Cities* (Abu Dhabi: 2016), https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2016/IRENA_Renewable_Energy_in_Cities_2016.pdf.
- 13 IEA, "The Covid-19 Crisis and Clean Energy Progress", in *Tracking Clean Energy Progress* (Paris: June 2020), <https://www.iea.org/reports/the-covid-19-crisis-and-clean-energy-progress/transport#abstract>.
- 14 A. Sharifi and A. R. Khavarian-Garmsir, "The COVID-19 pandemic: Impacts on cities and major lessons for urban planning, design, and management", *Science of the Total Environment*, vol. 749 (2020), p. 142391, <https://doi.org/10.1016/j.scitotenv.2020.142391>; International Growth Centre, "Impact of COVID-19 on public transport", 6 August 2020, <https://www.theigc.org/blog/impact-of-covid-19-on-public-transport>; Deloitte, *COVID-19: How Municipalities Can Respond, Recover, and Thrive in the Pandemic Era* (2020), <https://www2.deloitte.com/content/dam/Deloitte/ca/Documents/public-sector/ca-covid19-how-municipales-respond-aoda-en.pdf>; KPMG, *Cities and Local Governments. COVID-19 and Municipal Infrastructure* (Amstelveen, The Netherlands: June 2020), <https://assets.kpmg/content/dam/kpmg/ca/pdf/2020/06/covid-19-cities-infrastructure-en.pdf>.
- 15 S. Pathak, "With coronavirus lockdown, India's cities see clear blue skies as air pollution drops", NPR, 10 April 2020, <https://www.npr.org/sections/coronavirus-live-updates/2020/04/10/831592401-with-coronavirus-lockdown-indias-cities-see-clear-blue-skies-as-air-pollution-dr>; C40 Cities, "Mayors call for green recovery that will create jobs and save lives; urge national governments to end fossil fuel subsidies", press release (London: 28 October 2020), https://www.c40.org/press_releases/mayors-call-for-green-recovery-that-will-create-jobs-and-save-lives-urge-national-governments-to-end-fossil-fuel-subsidies.
- 16 UN, "Sustainable Cities: Why They Matter" (New York: 2020), https://www.un.org/sustainabledevelopment/wp-content/uploads/2019/07/11_Why-It-Matters-2020.pdf; UN, "Goal 11: Make cities inclusive, safe, resilient and sustainable", <https://unstats.un.org/sdgs/report/2019/goal-11>, viewed 5 November 2020; World Health Organization, "9 out of 10 people worldwide breathe polluted air, but more countries are taking action", press release (Geneva: 2 May 2018), [https://www.who.int/news-room/detail/02-05-2018-9-out-of-10-people-worldwide-breathe-polluted-air-but-more-countries-aretaking-action](https://www.who.int/news-room/detail/02-05-2018-9-out-of-10-people-worldwide-breathe-polluted-air-but-more-countries-are-taking-action). **Sidebar 1** based on the following sources: UN, "Sustainable Cities", op. cit. this note; OECD, "OECD policy responses to coronavirus (COVID-19)", <https://www.oecd.org/coronavirus/policy-responses/cities-policy-responses-fd1053ff>, viewed 13 November 2020; IEA, *Covid-19 Impact on Electricity* (Paris: January 2021), <https://www.iea.org/reports/covid-19-impact-on-electricity>; IEA, *Global Energy Review 2020* (Paris: April 2020), <https://www.iea.org/reports/global-energy-review-2020/electricity>; D. Broom, "These 3 charts show what COVID-19 has done to global energy demand", World Economic Forum (WEF), 3 August 2020, <https://www.weforum.org/agenda/2020/08/covid19-change-energy-electricity-use-lockdowns-falling-demand>; R. Gregory, "Green light for £60 million Pembrokeshire marine energy project", *Wales247*, 12 June 2020, <https://www.wales247.co.uk/green-light-for-60-million-pembrokeshire-marine-energy-project>; EuroCities, "Lille – 32 millions to support local economy", 5 June 2020, <https://covidnews.eurocities.eu/2020/06/05/lille-32-millions-to-support-local-economy>; C40 Cities, "C40 Mayors Agenda for a Green and Just Recovery", <https://www.c40.org/other/agenda-for-a-green-and-just-recovery>, viewed 13 November 2020; D. Springer, "It's time for a green stimulus: Here's how a small Vermont utility can show the way", *Utility Dive*, 15 June 2020, <https://www.utilitydive.com/news/its-time-for-a-green-stimulus-heres-how-a-small-vermont-utility-can-show/579757>; Burlington Electric Department, "Green stimulus", <https://burlingtonelectric.com/greenstimulus>, viewed 28 January 2021; M. Taylor and S. Laville,

- "City leaders aim to shape green recovery from coronavirus crisis", *The Guardian* (UK), 1 May 2020, <https://www.theguardian.com/environment/2020/may/01/city-leaders-aim-to-shape-green-recovery-from-coronavirus-crisis>; I. Skoula, C40, personal communication with REN21, 13 October 2020; International Labour Organization, *ILO Monitor: COVID-19 and the World of Work. Fifth Edition* (Geneva: 2020), https://www.ilo.org/global/topics/coronavirus/impacts-and-responses/WCMS_755910/lang--en/index.htm; UNEP, "Cities – where the fight for a green recovery will be won or lost", 6 August 2020, <https://www.unenvironment.org/news-and-stories/story/cities-where-fight-green-recovery-will-be-won-or-lost>; T. Dixon, "What impacts are emerging from Covid-19 for urban futures?", Center of Evidence Based Medicine, 8 June 2020, <https://www.cebm.net/covid-19/what-impacts-are-emerging-from-covid-19-for-urban-futures/>; WEF, "Despite lockdown, greenhouse gases have risen to record highs, UN says", 14 September 2020, <https://www.weforum.org/agenda/2020/09/greenhouse-gases-record-covid19-lockdown-united-nations/>; C. Le Quéré et al., "Temporary reduction in daily global CO₂ emissions during the COVID-19 forced confinement", *Nature Climate Change*, vol. 10 (2020), pp. 647-53, <https://doi.org/10.1038/s41558-020-0797-x>; R. Harrabin, "More pollution expected from stay-home workers", BBC, 21 October 2020, <https://www.bbc.com/news/business-54634166>; IEA, "Covid-19 and the resilience of renewables", in *Renewables 2020* (Paris: 2020), <https://www.iea.org/reports/renewables-2020/covid-19-and-the-resilience-of-renewables>; World Bank, "Air pollution: Locked down by COVID-19 but not arrested", 2 July 2020, <https://www.worldbank.org/en/news/immersive-story/2020/07/01/air-pollution-locked-down-by-covid-19-but-not-arrested>; M. Earley, "Coronavirus: Auckland footpaths, cycle lanes widened for safe Covid-19 physical distancing", 24 April 2020, <https://www.stuff.co.nz/national/health/coronavirus/121265191/coronavirus-roads-across-auckland-widened-for-safe-covid19-physical-distancing>; D. Jones, "Analysis: Coronavirus has cut CO₂ from Europe's electricity system by 39%", Carbon Brief, 29 April 2020, <https://www.carbonbrief.org/analysis-coronavirus-has-cut-co2-from-europes-electricity-system-by-39-per-cent>; European Space Agency, "Air pollution remains low as Europeans stay at home", 16 April 2020, http://www.esa.int/Applications/Observing_the_Earth/Copernicus/Sentinel-5P/Air_pollution_remains_low_as_Europeans_stay_at_home. Cities Climate Finance Leadership Alliance, *Urban Climate Finance in the Wake of COVID-19* (London: 2020), <https://www.citiesclimatefinance.org/wp-content/uploads/2020/12/Urban-Climate-Finance-in-the-Wake-of-COVID-19.pdf>.
- 17 Pathak, op. cit. note 15; C40 Cities, op. cit. note 15.
- 18 Earlier estimates of premature deaths greatly under-reported the effects of air pollution. A. Vohra et al., "Global mortality from outdoor fine particle pollution generated by fossil fuel combustion: Results from GEOS-Chem", *Environmental Research*, vol. 195 (April 2021), p. 110754, <https://www.sciencedirect.com/science/article/pii/S0013935121000487>.
- 19 IRENA, *The True Cost of Fossil Fuels* (Abu Dhabi: 2016), https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2016/IRENA_REmap_externality_brief_2016.pdf.
- 20 C40, "Clean Air Cities: Our commitment to healthy air for every citizen", <https://www.c40.org/other/clean-air-cities>, viewed 15 January 2021.
- 21 M. van Staden, ICLEI, personal communication with REN21, 30 October 2020; V. Burrows, World Green Buildings Council, personal communication with REN21, 23 October 2020; G. Stryi-Hipp, Fraunhofer ISE, personal communication with REN21, 6 November 2020; J. Layke, World Resources Institute (WRI), personal communication with REN21, 23 October 2020.
- 22 Cedamia, "Climate Emergency Declaration", <https://www.cedamia.org/global>, viewed 9 November 2020.
- 23 S. Bachra et al., *The Co-benefits of Climate Action* (London: CDP, 2020), https://6fefcbb86e61af1b2fc4-c70d8ead6ced550b4d987d7c03fcd1d.ssl.cf3.rackcdn.com/cms/reports/documents/000/005/329/original/CDP_Co-benefits_analysis.pdf.
- 24 REN21, op. cit. note 12.
- 25 CDP, *Protecting Our Capital* (London: no date), <https://www.c40.org/researches/protecting-our-capital>.
- 26 REN21, op. cit. note 7.
- 27 World Future Council, op. cit. note 11.
- 28 Carbon Tracker Initiative, *How to Waste Over Half a Trillion Dollars: The Economic Implications of Deflationary Renewable Energy for Coal Power Investments* (London: 2020), <https://carbontracker.org/reports/how-to-waste-over-half-a-trillion-dollars>; BloombergNEF, "Scale-up of solar and wind puts existing coal, gas at risk", 28 April 2020, <https://about.bnef.com/blog/scale-up-of-solar-andwind-puts-existing-coal-gas-at-risk/>; SolarPower Europe, *Global Market Outlook for Solar Power, 2019-2023* (Brussels: 2019), p. 9, 13, <https://www.solarpowereurope.org/global-marketoutlook-2019-2023>; J. Yan et al., "City-level analysis of subsidy-free solar photovoltaic electricity price, profits and grid parity in China", *Nature Energy*, 12 August 2019, <https://www.nature.com/articles/s41560-019-0441-z>; K. Samanta, "India's renewable energy cost lowest in Asia Pacific: WoodMac", *Reuters*, 29 July 2019, www.reuters.com/article/us-india-renewables-woodmac/indias-renewable-energy-cost-lowest-in-asia-pacific-woodmacidUSKCN1UO0L8.
- 29 REN21, op. cit. note 7.
- 30 IEA, *Renewables 2020* (Paris: 2020), <https://www.iea.org/reports/renewables-2020>.
- 31 REN21, op. cit. note 7.
- 32 Ibid.
- 33 IEA, op. cit. note 30.
- 34 The heating and cooling sector accounts for around 50% of total final energy consumption, and the transport sector around 30%. See Figure 1.1 in IRENA, IEA and REN21, *Renewable Energy Policies in a Time of Transition: Heating and Cooling* (Abu Dhabi and Paris: 2020), <https://www.ren21.net/heating-and-cooling-2020>. **Figure 2** from Ibid.
- 35 REN21, op. cit. note 7; IRENA, IEA and REN21, op. cit. note 34; REN21 and FIA Foundation, *Renewable Energy Pathways in Road Transport* (Paris and London: 2020), https://www.ren21.net/wp-content/uploads/2019/05/REN21_FIA-Fdn_Renewable-Energy-Pathways_FINAL.pdf.
- 36 van Staden, op. cit. note 21; REN21 Policy Database, op. cit. note 1. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and may not be exhaustive.
- 37 van Staden, op. cit. note 21.
- 38 Burrows, op. cit. note 21.
- 39 REN21 Policy Database, op. cit. note 1. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and may not be exhaustive.
- 40 Ibid.
- 41 Ibid.
- 42 Ibid.
- 43 IRENA, *The Rise of Renewables in Cities* (Abu Dhabi: October 2020), https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Oct/IRENA_Renewables_in_cities_2020.pdf.
- 44 REN21 Policy Database, op. cit. note 1. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and may not be exhaustive.
- 45 United Nations Framework Convention on Climate Change (UNFCCC), "The Race to Zero", <https://racetozero.unfccc.int/what-is-the-race-to-zero>, viewed 13 November 2020; Global Covenant of Mayors for Climate & Energy, <https://www.globalcovenantofmayors.org>, viewed 3 November 2020; New Climate Institute and Data-Driven EnvironLab, *Navigating the Nuances of Net-Zero Targets* (Berlin and Singapore: October 2020), https://newclimate.org/wp-content/uploads/2020/10/NewClimate_NetZeroReport_October2020.pdf; UNFCCC, "Net-zero double in less than a year", press release (Bonn: 21 September 2020), <https://unfccc.int/news/commitments-to-net-zero-double-in-less-than-a-year>.
- 46 New Climate Institute and Data-Driven EnvironLab, op. cit. note 45.

- 47 Carbonn Center, <https://carbonn.org>, viewed 10 January 2021; CDP, "Why your city should disclose", <https://www.cdp.net/en/cities-discloser>, viewed 10 January 2021.
- 48 Urban-LEDS II is implemented by UN-Habitat and ICLEI. Urban-LEDS II, "Urban LEDS Phase II", <https://urban-leds.org>, viewed 10 January 2021; CDP-ICLEI Unified Reporting System, "Cities – CDP", <https://data.cdp.net/browse?category=Renewable%20Energy> viewed 12 January 2021.
- 49 CDP-ICLEI Unified Reporting System, op. cit. note 48; REN21, op. cit. note 7. **Box 1** based on the following sources: Seto et al., op. cit. note 2; UN DESA, op. cit. note 2; IEA, op. cit. note 30; A. Aznar et al., *City-Level Energy Decision Making: Data Use in Energy Planning, Implementation, and Evaluation in U.S. Cities* (Golden, CO: National Renewable Energy Laboratory, July 2015), <https://www.nrel.gov/docs/fy15osti/64128.pdf>; CDP-ICLEI Unified Reporting System, op. cit. note 48; van Staden, op. cit. note 21.
- 50 IRENA, op. cit. note 12; McKinsey & Company, "Five COVID-19 aftershocks reshaping mobility's future", 17 September 2020, <https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/five-covid-19-aftershocks-reshaping-mobilitys-future>; REN21, op. cit. note 12; M. Grosso, "Urban form and renewable energy potential", *Renewable Energy*, vol. 15, no. 1-4 (1998), pp. 331-36, [https://doi.org/10.1016/S0960-1481\(98\)00182-7](https://doi.org/10.1016/S0960-1481(98)00182-7); World Future Council, *100% Renewable Energy – and Beyond – for Cities* (Hamburg: March 2010), https://epub.sub.uni-hamburg.de/epub/volltexte/2015/40518/pdf/welli_2010_5_p.pdf. See also J. Živković, "Urban form and function", in W. Leal Filho et al., *Climate Action. Encyclopedia of the UN Sustainable Development Goals* (Berlin: Springer, 2018), https://doi.org/10.1007/978-3-319-71063-1_78-1.
- 51 IRENA, op. cit. note 43.
- 52 **Sidebar 2** from Coalition for Urban Transitions, *Climate Emergency, Urban Opportunity: How National Governments Can Secure Economic Prosperity and Avert Climate Catastrophe by Transforming Cities* (Washington, DC: 2019), <https://urbantransitions.global/wp-content/uploads/2019/09/Climate-Emergency-Urban-Opportunity-report.pdf>; R. Harrabin, "Ban on new petrol and diesel cars in the UK from 2030 under PM's green plan", BBC News, 18 November 2020, <https://www.bbc.com/news/science-environment-54981425>; Klimashutz Germeinsam Marburg-Biedenkopf, "Förderung von Ladestationen für Elektroautos", <https://klimaschutz.marburg-biedenkopf.de/mobilitaet-554/foerderung-von-ladestationen-fuer-elektroautos.html>, viewed 18 February 2021.
- 53 IRENA, op. cit. note 43.
- 54 Coalition for Urban Transitions, op. cit. note 52
- 55 Fossil fuel subsidies based on 2019 estimates from IEA, "Energy subsidies: Tracking the impact of fossil-fuel subsidies", <https://www.iea.org/topics/energy-subsidies>, viewed 25 January 2021; 2018 estimates from W. Matsumura and Z. Adam, "Fossil fuel consumption subsidies bounced back strongly in 2018", IEA, 13 June 2019, <https://www.iea.org/commentaries/fossil-fuel-consumption-subsidies-bounced-back-strongly-in-2018>.
- 56 Renewable subsidies amounted to USD 140 billion in 2016, according to estimates from the International Monetary Fund (IMF), from D. Coady et al., *Global Fossil Fuel Subsidies Remain Large: An Update Based on Country-Level Estimates* (Washington, DC: IMF, 2019), p. 8, <https://www.imf.org/en/Publications/WP/Issues/2019/05/02/Global-Fossil-Fuel-Subsidies-Remain-Large-An-Update-Based-on-Country-Level-Estimates-46509>.
- 57 IRENA, op. cit. note 43.
- 58 Ibid.
- 59 Layke, op. cit. note 21.
- 60 IEA, *Global Energy Review 2020* (Paris: April 2020), <https://www.iea.org/reports/global-energy-review-2020/renewables>.
- 61 Ibid.
- 62 B. Miriam, *100% Renewables Cities and Regions Roadmap – Dossier on the applicability of existing transition pathways towards 100% RE for cities and regions* (forthcoming), <https://renewablesroadmap.iclei.org>.
- 63 IRENA, op. cit. note 43.
- 64 S. Kaza et al., *What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050* (Washington, DC: World Bank, 2018), https://datatopics.worldbank.org/what-a-waste/trends_in_solid_waste_management.html; M. Yan, J. Waluyou and P. Agamuthu, "Challenges for sustainable development of waste to energy in developing countries", *Waste Management & Research*, vol. 38, no. 3 (2020), pp. 229-31, <https://journals.sagepub.com/doi/pdf/10.1177/0734242X20903564>; European Biogas Association (EBA), *European Biogas Association Statistical Report: 2019 European Overview* (Brussels: January 2020), <https://www.europeanbiogas.eu/eba-statistical-report-2019-european-overview>; S. Jain, *Global Potential of Biogas* (London: World Biogas Association (WBA), June 2019), https://www.worldbiogasassociation.org/wp-content/uploads/2019/07/WBA-globalreport-56ppa4_digital.pdf; Bioenergy International, "ReNu Energy's Goulburn Bioenergy Project commences commercial operation", 13 February 2018, <https://bioenergyinternational.com/biogas/renu-energys-goulburn-bioenergy-project-commences-commercial-operation>; Bioenergy Insight, "EPA approves second biogas facility at Melbourne Regional Landfill", 17 September 2020, <https://www.bioenergy-news.com/news/epa-approves-second-biogas-facility-at-melbourne-regional-landfill>; A. Karidis, "Los Angeles to combine food waste, biosolids for massive energy project", *Waste360*, 11 March 2019, <https://www.waste360.com/anaerobic-digestion/los-angeles-combine-food-waste-biosolids-massive-energy-project>; L. Dawson, "How cities are turning food into fuel", *Politico*, 21 November 2019, <https://www.politico.com/news/magazine/2019/11/21/food-waste-fuel-energy-sustainability-070265>; A. Sherrard, "Construction start for New Zealand's first large-scale food waste-to-bioenergy plant", 6 August 2020, <https://bioenergyinternational.com/biogas/construction-start-for-new-zealands-first-large-scale-food-waste-to-bioenergy-plant>; EBA, "The 'European Biomethane Map 2020' shows a 51% increase of biomethane plants in Europe in two years", press release (Brussels: June 2020), https://www.europeanbiogas.eu/wp-content/uploads/2020/06/Biomethane-map_Press-Release_EBA_GiE.pdf; EBA, "Finland: City of Lahti hosts the largest biogas plant in Finland", <https://www.europeanbiogas.eu/finland-city-of-lahti-hosts-the-largest-biogas-plant-in-finland>, viewed 20 October 2020; Sustainable Bus, "Lille, the biomethane fleet by Keolis and Iveco Bus", 22 May 2018, <https://www.sustainable-bus.com/cng-Ing/lille-buses-cng-biomethane-iveco-bus-keolis>; Bioenergy Insight, "77 biomethane-powered buses launched in Bristol, UK", 18 February 2020, <https://www.bioenergy-news.com/news/77-biomethane-powered-buses-launched-in-bristol-uk>; WBA, "Brazil, biogas and becoming a zero emissions economy", <https://www.worldbiogasassociation.org/brazil-biogas-and-becoming-a-zero-emissions-economy>, viewed 8 October 2020; Ecoprog, *Waste to Energy 2019/2020*, Extract of 12th Edition (Cologne, Germany: Ecoprog GmbH, 2019), https://www.ecoprog.com/fileadmin/user_upload/extract_market_report_WtE_2019-2020_ecoprog.pdf; Confederation of European Waste-to-Energy Plants, "First tonnes of CO₂ captured from residual waste supplied to greenhouse horticulture", 8 October 2019, <https://www.cewep.eu/avr-duiven-ccu>; D. T. Kearns, *Waste-to-Energy with CCS: A Pathway to Carbon-Negative Power Generation* (Melbourne: Global CCS Institute, 2019), https://www.globalccsinstitute.com/wp-content/uploads/2019/10/Waste-to-Energy-Perspective_October-2019-5.pdf.
- 65 EUREC, "Waste heat is a sustainable source for district heating networks", <https://eurec.be/waste-heat-is-a-sustainable-source-for-district-heating-networks>, viewed 10 January 2021.
- 66 Burrows, op. cit. note 21.
- 67 REN21 Policy Database, op. cit. note 1. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and may not be exhaustive.
- 68 Ibid.
- 69 IRENA, op. cit. note 43; Agora Verkehrswende, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and WEF, *Transport for Under Two Degrees – The Way Forward. 10 Key Insights for the Decarbonisation of the Transport Sector* (Berlin: 2020), https://www.t4under2.org/pdf/T4under2_Global-foresight-study_FINAL.pdf.
- 70 REN21 Policy Database, op. cit. note 1. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary

- reporting and may not be exhaustive. Complemented by Urban Access Regulations in Europe, <https://urbanaccessregulations.eu>, viewed 10 December 2020.
- 71 The Avoid-Shift-Improve framework focuses on the mobility needs of citizens, aiming to decrease traffic congestion, improve air quality and reduce greenhouse gas emissions in cities by avoiding the need for motorised travel and travel length, shifting from most energy-intensive and polluting modes of transport towards active transport (including walking and cycling) or public transport, and improving fuel efficiency and integrating renewables into transport. From D. Bongardt et al., Transformative Urban Mobility Initiative, *Sustainable Urban Transport: Avoid – Shift – Improve (A-S-I)* (Bonn and Eschborn: GIZ, 2019), https://www.transformative-mobility.org/assets/publications/ASI_TUMI_SUTP_iNUA_No-9_April-2019.pdf.
- 72 REN21, op. cit. note 7.
- 73 OECD, "Fiscal Decentralization Database", <http://www.oecd.org/tax/federalism/fiscal-decentralisation-database>, viewed 10 January 2021; Tax Policy Centre, "What are the sources of revenue for local governments?", <https://www.taxpolicycenter.org/briefing-book/what-are-sources-revenue-local-governments>, viewed 10 January 2021.
- 74 Fossil Free Divestment, "Divestment commitments overview", <https://gofossilfree.org/divestment/commitments>, viewed 14 December 2020; C40 Cities Climate Leadership Group, *Divesting from Fossil Fuels, Investing in Our Future: A Toolkit for Cities* (London: 2020), <https://c40.my.salesforce.com/sfc/p/#36000001Enhz/a/1Q000000MmBe/0sK2VDoRdYwGyPuXNGTakGB47EnJKXFUE5qWGpJEawg>; DivestInvest, "Commitments to DivestInvest", <https://www.divestinvest.org/commitments>, viewed 27 December 2020; J. C. Figueira, "12 major cities commit to divest from fossil fuel companies", Climate Action, 25 September 2020, <http://www.climateaction.org/news/12-major-cities-commit-to-divest-from-fossil-fuel-companies>; M. Rowling, "Cities promise to divest from fossil fuels to boost green recovery", Thomson Reuters Foundation News, 22 September 2020, <https://news.trust.org/item/20200922131602-u2ee2>; C40 Cities, "The Divesting from Fossil Fuels, Investing in a Sustainable Future Declaration", <https://www.c40.org/divest-invest>, viewed 10 November 2020.
- 75 S. Haf and R. Robison, *How Local Authorities Can Encourage Citizen Participation in Energy Transitions* (London: UK Energy Research Centre, 2020), https://energy-cities.eu/wp-content/uploads/2020/05/HafRobison_LAs-and-citizen-participation_published.pdf.
- 76 IRENA, op. cit. note 43.
- 77 ICLEI, "Our pathways, our approach", https://iclei.org/en/our_approach.html, viewed 15 January 2021.
- 78 CDP-ICLEI Unified Reporting System, "2020 Renewable Energy Targets", <https://data.cdp.net/Renewable-Energy/2020-Cities-Renewable-Energy-Targets/i464-dbd>, viewed 5 January 2021.
- 79 C40 Cities, *C40 Cities Annual Report 2019* (New York: 2019), https://c40-production-images.s3.amazonaws.com/other_uploads/images/2574_C40_2019_Annual_Report.original.pdf.
- 80 Ibid.
- 81 Ibid.
- 82 C40 Cities, "Fossil Fuel Free Streets Declaration", <https://www.c40.org/other/green-and-healthy-streets>, viewed 10 November 2020.
- 83 Energy Cities, "Vision and mission", <https://energy-cities.eu/vision-mission>, viewed 12 January 2021.
- 84 The 26 ASCN Pilot Cities are: Bandar Seri Begawan, Battambang, Phnom Penh, Siem Reap, Makassar, Banyuwangi, DKI Jakarta, Luang Prabang, Vientiane, Johor Bahru, Kuala Lumpur, Kota Kinabalu, Kuching, Nay Pyi Taw, Mandalay, Yangon, Cebu City, Davao City, Manila, Singapore, Bangkok, Chonburi, Phuket, Da Nang, Hanoi and Ho Chi Minh City. From ASEAN, "ASEAN Smart Cities Network", <https://asean.org/asean/asean-smart-cities-network>, viewed 12 January 2021.
- 85 Österreichischer Städtebund, "Österreichischer Städtebund", <https://www.staedtebund.gv.at/organisation/oesterr-staedtebund>, viewed 11 November 2020.
- 86 UK100, "Our members", <https://www.uk100.org/our-members>, viewed 15 November 2020.
- 87 Global Covenant of Mayors for Climate & Energy, "Our regions", <https://www.globalcovenantofmayors.org/our-regions>, viewed 15 February 2021; Covenant of Mayors for Climate & Energy Europe, "Covenant in figures", <https://www.eumayors.eu/about/covenant-initiative/covenant-in-figures.html>, viewed 15 February 2021.
- 88 Global Covenant of Mayors for Climate & Energy, "Our regions", op. cit. note 87.
- 89 Alcaldes por el clima, "Local government heads", <https://www.alcaldesporelclima.org/local-government-heads.html>, viewed 11 November 2020.
- 90 C40, "1,000 cities racing to zero emissions", Race to Zero, 9 November 2020, <https://racetozero.unfccc.int/1000-cities-racing-to-zero-emissions>; UNFCCC, "Race to Zero Campaign", <https://unfccc.int/climate-action/race-to-zero-campaign>, viewed 10 January 2021.
- 91 WWF, "Mexico City – global winner in WWF's One Planet City Challenge 2020", https://wwf.panda.org/projects/one_planet_cities/one_planet_city_challenge/city_challenge_2019_2020, viewed 10 November 2020.
- 92 Sierra Club, "Check out where we are Ready for 100%", <https://www.sierraclub.org/ready-for-100/map>, viewed 11 November 2020.
- 93 Sierra Club, "Ready for 100 Campaign", <https://www.sierraclub.org/ready-for-100>, viewed 10 January 2021; We Are Still In, "America is all in", <https://www.wearestillin.com>, viewed 10 January 2021; Climate Mayors, <https://climatemayors.org>, viewed 10 January 2021; Sara Durr, "Mayors strongly oppose withdrawal from Paris Climate Accord", US Conference of Mayors, 1 June 2017, <https://www.usmayors.org/2017/06/01/mayors-strongly-oppose-withdrawal-from-paris-climate-accord>.
- 94 WRI, "National Climate Action under the Paris Agreement", <https://www.wri.org/ndcs>, viewed 15 November 2020.
- 95 UN-Habitat, *Sustainable Urbanization in the Paris Agreement* (Nairobi: 2017), https://urban-leds.org/wp-content/uploads/2019/resources/guidance_and_tools/Integrated_climate_action/Sustainable%20Urbanization%20in%20the%20Paris%20Agreement%20-%20Comparative%20Review%20of%20NDC%20-%20July%202018.pdf.
- 96 By the end of 2020, eight countries had submitted their second NDCs: Argentina, Grenada, Marshall Islands, Nepal, Papua New Guinea, Suriname, Tonga and the United Arab Emirates. UNFCCC, "NDC registry", <https://www4.unfccc.int/sites/NDStaging/Pages/All.aspx>, viewed 10 February 2021.
- 97 See, for example: Fridays for Future, "About #FridaysForFuture", <https://www.fridaysforfuture.org/about>, viewed 21 October 2020; Extinction Rebellion, <https://rebellion.earth>, viewed 21 October 2020.
- 98 Cedamia, op. cit. note 22.
- 99 REN21 Policy Database, op. cit. note 1.
- 100 Covenant of Mayors for Climate & Energy Europe, op. cit. note 87.
- 101 SDH, "Solar District Heating. The European Union's Horizon 2020 research and innovation programme under grant agreement No 691624", www.solar-district-heating.eu/en/about-sdh, viewed 10 January 2021.
- 102 Eurocities, "The Green City Accord is here", 23 October 2020, <https://eurocities.eu/latest/the-green-city-accord-is-here>.
- 103 European Commission, "Renovation wave", https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/renovation-wave_en, viewed 14 January 2021.
- 104 Energy Cities, *National Energy and Climate Plans. Is the Role of Local Authorities Acknowledged?* (Brussels: 2020), https://energy-cities.eu/wp-content/uploads/2020/10/Role-of-local-authorities-in-final-NECPs_October-2020_final.pdf.
- 105 Smartcity.eu, "Lighthouse Cities", <https://smartcity.eu/about/lighthouse-cities>, viewed 10 January 2021.
- 106 Energy Cities, op. cit. note 104.
- 107 North American cities see the business case for sustainability in addition to the environmental, social and economic benefits of transitioning to 100% renewable energy. Based on A. Browne, independent researcher, personal communication with REN21, August 2020, on S. Abbott and H. House, Rocky Mountain Institute (RMI), personal communication with REN21, 9 November 2020, and on other sources used throughout this report.
- 108 100% Renewable Energy Atlas, <https://www.100-percent.org>, viewed 10 December 2020; Sierra Club, op. cit. note 92.
- 109 Browne, op. cit. note 107; Abbott and House, op. cit. note 107.

- 110 T. Gonçalves and Y. Liu, "How US cities and counties are getting renewable energy", WRI Blog, 24 June 2020, <https://www.wri.org/blog/2020/06/renewable-energy-procurement-cities-counties>; The White House, "Executive Order: Paris Climate Agreement", 20 January 2021, <https://www.whitehouse.gov/briefing-room/statements-releases/2021/01/20/paris-climate-agreement>.
- 111 Based on data from the beginning of 2015 through the first quarter of 2020, from Gonçalves and Liu, op. cit. note 110; American Cities Climate Challenge, "Local Government Renewables Action Tracker", <https://cityrenewables.org/local-government-renewables-action-tracker>, viewed 10 December 2020.
- 112 REN21 Policy Database, op. cit. note 1. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and may not be exhaustive.
- 113 Layke, op. cit. note 21; US Environmental Protection Agency, "Sources of greenhouse gas emissions", <https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions>, viewed 10 December 2020; Natural Resources Canada, "Energy and greenhouse gas emissions (GHGs)", <https://www.nrcan.gc.ca/science-data/data-analysis/energy-data-analysis/energy-facts/energy-and-greenhouse-gas-emissions-ghgs/20063>, viewed 10 December 2020; K. Uhlenhuth, "Kansas City clean energy goals could get a boost from utility partnership", Energy News Network, 3 May 2018, <https://energynews.us/2018/05/03/midwest/kansas-city-clean-energy-goals-could-get-a-boost-from-utility-partnership>; S. Abbott, "What good are city clean-energy targets?" RMI, 12 August 2019, <https://rmi.org/what-good-are-city-clean-energy-targets>; J. Duncan, "A new era for local governments and public utility commissions: The city perspective", Institute for Market Transformation, 9 July 2019, <https://www.imt.org/a-new-era-for-local-governments-and-public-utility-commissions-the-city-perspective>; L. Shaver and H. House, "INSIDER: Beyond buying renewables: How cities can influence the energy system", WRI Blog, 27 July 2020, <https://www.wri.org/blog/2020/07/insider-beyond-buying-renewables-how-cities-can-influence-energy-system>; D. Ribeiro et al., *The 2020 City Clean Energy Scorecard* (Washington, DC: American Council for an Energy Efficient Economy, October 2020), <https://www.aceee.org/sites/default/files/pdfs/u2008.pdf>; ChargePoint, Inc., "Cities and towns", <https://www.chargepoint.com/solutions/cities-and-towns>, viewed 10 December 2020; EVgo, "Utility and government agencies", <https://www.evgo.com/ev-charging-business/utility-companies>, viewed 10 December 2020; Climate Mayors Electric Vehicle Purchasing Collaborative, "What is the Collaborative", <https://driveevfleets.org/what-is-the-collaborative>, viewed 10 December 2020; Natural Resources Canada, "Zero Emission Vehicle Infrastructure Program", <https://www.nrcan.gc.ca/energy-efficiency/energy-efficiency-transportation/zero-emission-vehicle-infrastructure-program/21876>, viewed 10 December 2020.
- 114 IQ Air, AirVisual, "World most polluted cities 2018 (PM2.5)", <https://www.airvisual.com/world-most-polluted-cities>, viewed 10 October 2020; H. Ellis-Petersen, "India: Five million pollution masks to be handed to Delhi residents", *The Guardian* (UK), 2 November 2019, <https://www.theguardian.com/world/2019/nov/02/fivemillion-pollution-masks-to-be-handed-to-delhi-residents>; "Delhi restricts cars in attempt to lessen pollution", *The Guardian* (UK), 4 November 2019, <https://www.theguardian.com/world/2019/nov/04/delhi-restricts-cars-in-attempt-to-lessen-pollution>.
- 115 REN21 Policy Database, op. cit. note 1. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and may not be exhaustive.
- 116 H. Kim, "Is South Korea on the right path to carbon neutrality?", *China Dialogue*, 2 December 2020, <https://chinadialogue.net/en/climate/south-korea-path-to-carbon-neutrality>; Y. Park, "The crucial role of local governments in South Korea's bold actions towards carbon neutrality by 2050", *CityTalk*, 19 November 2020, <https://talkofthecities.iclei.org/the-crucial-role-of-local-governments-in-south-koreas-bold-actions-towards-carbon-neutrality-by-2050>; ICLEI, "Japan to go climate neutral with support of net zero cities", 26 October 2020, <https://iclei.org/en/media/japan-to-go-climate-neutral-with-support-of-net-zero-cities>.
- 117 Central Government, "State Council's issue of winning the blue sky defense war: Notice of three-year action plan", 3 July 2018, http://www.gov.cn/zhengce/content/2018-07/03/content_5303158.htm (using Google Translate); China National Radio, "Multiple departments jointly issued the 'Beijing-Tianjin-Hebei and surrounding areas 2019-2020 autumn and winter comprehensive treatment of air pollution action plan'", 16 October 2019, http://china.cnr.cn/xwwgf/20191016/t20191016_524818440.shtml (using Google Translate); Ministry of Housing and Urban Rural Development, "Announcement of the Ministry of Housing and Urban-Rural Development on Issuing the National Standard 'Green Building Evaluation Standards'", 13 March 2019, http://www.mohurd.gov.cn/wjfb/201905/t20190530_240717.html (using Google Translate); Central Government, "Notice of the Ministry of Finance and the Ministry of Housing and Urban-Rural Development on Issuing the 'Renewable Energy Building Application Urban Demonstration Implementation Plan'", 6 July 2009, http://www.gov.cn/gongbao/content/2010/content_1547214.htm (using Google Translate); Tai Koo Li, "About Sino-Ocean Taikoo Li Chengdu", <http://www.soltklcd.com/zh-CN/AboutUs/ProjectSummary> (using Google Translate), viewed 25 August 2020.
- 118 REN21, op. cit. note 7; IEA, *Global EV Outlook 2020* (Paris: 2020), <https://www.iea.org/reports/global-ev-outlook-2020>; IEA, "New electric bus registrations in China, 2015-2019", <https://www.iea.org/data-and-statistics/charts/new-electric-bus-registrations-in-china-2015-2019>, updated 14 June 2020; IEA, "New electric bus registrations by country/region, 2015-2019", <https://www.iea.org/data-and-statistics/charts/new-electric-bus-registrations-by-country-region-2015-2019>, updated 14 June 2020; BloombergNEF, *Electric Buses in Cities: Driving Towards Cleaner Air and Lower CO₂* (London: March 2018), <https://assets.bbhub.io/professional/sites/24/2018/05/Electric-Buses-in-Cities-Report-BNEF-C40-Citi.pdf>; T. Kawakami, "'Hydrogen Valley' powers China's fuel cell industry", *Nikkei Asia*, 4 July 2020, <https://asia.nikkei.com/Business/China-tech/Hydrogen-Valley-powers-China-s-fuel-cell-industry>; Netease News, "Zhangjiakou is speeding up to build a 'Hydrogen Energy Capital', and the advantages of renewable energy hydrogen production are highlighted", 15 June 2020, <https://3g.163.com/dy/article/FF6AA8750534CY9P.html> (using Google Translate).
- 119 G. Zhang, J. Zhang and T. Xie, "A solution to renewable hydrogen economy for fuel cell buses – a case study of Zhangjiakou in North China", *International Journal of Hydrogen Energy*, vol. 45, no. 29 (2020), pp. 14603-13, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7173837>; S. Lewis, "N China hydrogen push led by hydrogen as by-product, renewables", S&P Global Platts, 11 June 2020, <https://www.spglobal.com/platts/en/market-insights/latest-news/metals/061120-n-china-hydrogen-push-led-by-hydrogen-as-by-product-renewables>; J. Zuid, "Hydrogen-powered cities: Who, where, how?", *WhatsOrb*, 18 December 2019, <https://www.whatsorb.com/community/building-hydrogen-powered-cities-who-where-how>.
- 120 Cedamia, op. cit. note 22.
- 121 Department of Heavy Industries, Government of India, "FAME INDIA II Scheme", <https://dhi.nic.in/UserView?mid=1378>, viewed 10 November 2020.
- 122 The developments are part of the visionary Chula Smart City Project, which seeks to sustainably rejuvenate and redevelop the Siam Square and Suan Luang – Sam Yan commercial areas. The plant is slated to be fully completed in 2027 and will be developed over three phases, with its first phase expected to be operational in late 2022. From Cool Coalition, "Consortium secures new \$329M contract for district cooling system in the heart of Bangkok", 30 July 2020, <https://coolcoalition.org/consortium-secures-new-329m-contract-for-district-cooling-system-in-the-heart-of-bangkok>; E. Dwi Putranto, "In Picture: Megahnya Wajah Baru Masjid Istiqlal Setelah Renovasi", *Republika*, 29 July 2020, <https://republika.co.id/berita/qe736p375/megahnya-wajah-baru-masjid-istiqlal-setelah-renovasi-11>.
- 123 REN21 Policy Database, op. cit. note 1. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and may not be exhaustive.
- 124 World Bank, *Poverty and Shared Prosperity 2018: Piecing Together the Poverty Puzzle* (Washington, DC: 2018), <https://www.worldbank.org/en/publication/poverty-and-shared-prosperity-2018>; M. Boule and A. Dane, *The Impacts of Covid-19 on the Power Sector in Sub-Saharan Africa, and the Role of*

- the Power Sector in Socio-economic Recovery* (Cape Town: Konrad-Adenauer-Stiftung, July 2020), https://www.kas.de/documents/282730/8327029/Covid_Energy_SSA_publication.pdf/efc74763-8f85-39c6-53e4-de16cb75f71d?t=1594778811782.
- 125 L. Tait and M. Euston-Brown, "What role can African cities play in low-carbon development? A multilevel governance perspective of Ghana, Uganda and South Africa", *Journal of Energy in Southern Africa*, vol. 28, no. 3 (2017), pp. 43-53, http://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S1021-447X2017000300004; S. Bawakyillenuo et al., "Sustainable energy transitions in Sub-Saharan African cities: The role of local government", *Urban Energy Transition* (2018), pp. 529-51, <https://www.sciencedirect.com/science/article/pii/B9780081020746000425>.
- 126 S. Bawakyillenuo et al., "Chapter 4.3. Sustainable energy transitions in Sub-Saharan African cities: The role of local government", in P. Droege, *Urban Energy Transitions: Renewable Strategies for Cities and Regions* (Amsterdam: Elsevier Ltd, 2018), <https://www.elsevier.com/books/urban-energy-transition/droege/978-0-08-102074-6>; Mini-Grids Partnership, Sustainable Energy for All (SEforALL) and BloombergNEF, *State of the Global Mini-Grids Market Report 2020: Trends of the Renewable Energy Hybrid Mini-grids in Sub-Saharan Africa, Asia and Island Nations* (London: Bloomberg Finance L.P., 2020), https://minigrids.org/wp-content/uploads/2020/06/Mini-grids_Market_Report-20.pdf.
- 127 See, for example, T. Smith, "Uganda: Boda boda e-bike on a pay as you go model", Green Building Africa, 25 September 2020, <https://www.greenbuildingafrica.co.za/uganda-boda-boda-e-bike-on-a-pay-as-you-go-model-to-boost-sector>.
- 128 van Staden, op. cit. note 21.
- 129 Mini-Grids Partnership, SEforALL and BloombergNEF, op. cit. note 126.
- 130 Covenant of Mayors in Sub-Saharan Africa (CoM SSA), "About", 2015, <https://comssa.org/about>; C40 Cities, "Climate Action Planning (CAP) Africa launch event and 1st Regional Academy", 15 May 2018, <https://www.c40.org/tags/cap-africa>; S. Bawakyillenuo et al., op. cit. note 126.
- 131 F. Jackson, "Latin America EV sales up 90% as transport transformation continues", Forbes, 4 July 2019, <https://www.forbes.com/sites/feliciajackson/2019/07/04/latin-americaev-sales-up-90-as-transport-transformation-continues>; Wartsila, "Latin America: The power of one", 23 August 2018, <https://www.wartsila.com/twentyfour7/energy/latin-america-the-power-of-one>.
- 132 REN21 Policy Database, op. cit. note 1. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and may not be exhaustive. UNFCCC, "The Race to Zero", op. cit. note 45; Global Covenant of Mayors for Climate & Energy, op. cit. note 45; New Climate Institute and Data-Driven EnvironLab, op. cit. note 45.
- 133 CDP, "The world's renewable energy cities", <https://www.cdp.net/en/cities/world-renewable-energy-cities>, viewed 10 December 2020.
- 134 CDP-ICLEI Unified Reporting System, "Cities Renewable Energy Targets", <https://data.cdp.net/browse?category=Renewable%20Energy>, viewed 4 January 2021; REN21, op. cit. note 7.
- 135 H. Rudnick and J. Zolezzi, "Electric sector deregulation and restructuring in Latin America: Lessons to be learnt and possible ways forward", *IEE Proceedings*, vol. 148, no. 2 (2001), pp. 180-84, https://digital-library.theiet.org/content/journals/10.1049/ip-gtd_20010230.
- 136 IRENA, *Renewable Energy Market Analysis Latin America* (Abu Dhabi: 2016), p. 35, <https://www.irena.org/publications/2016/Nov/Renewable-Energy-Market-Analysis-Latin-America>; F. Koop et al., "Chinese electric buses roll out across Latin America", *Diálogo Chino*, 29 June 2020, <https://dialogochino.net/en/climate-energy/36128-chinese-electric-buses-rollout-across-latin-america>.
- 137 Asian Development Bank, *Renewable Energy and Sustainable Development in Pacific Island Countries* (Manila: 2016), <https://www.adb.org/publications/renewable-energy-and-sustainable-development-pacific-island-countries>.
- 138 P. Taylor, "New Zealand declares a climate change emergency", 2 December 2020, *The Guardian* (UK), <https://www.theguardian.com/world/2020/dec/02/new-zealand-declares-a-climate-change-emergency>; REN21 Policy Database, op. cit. note 1. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and may not be exhaustive.
- 139 M. Maisch, "City of Adelaide switches to 100% renewable electricity", pv magazine, 1 July 2020, <https://www.pv-magazine-australia.com/2020/07/01/city-of-adelaide-switches-to-100-renewable-electricity>; A. Danigelis, "City of Adelaide powers operations with 100% renewable energy", Environment + Energy Leader, 2 July 2020, <https://www.environmentalleader.com/2020/07/adelaide-renewable-energy-operations>; City of Melbourne, "Melbourne Renewable Energy Project: A new generation of energy", <https://www.melbourne.vic.gov.au/business/sustainable-business/mrep/Pages/melbourne-renewable-energy-project.aspx>, viewed 17 December 2020; Energetics, "Melbourne Renewable Energy Project 2.0", July 2020, <https://www.energetics.com.au/projects/melbourne-renewable-energy-project-20>; S. Wray, "Sydney switches to 100 percent renewable energy", CitiesToday, 6 July 2020, <https://cities-today.com/sydney-switches-to-100-percent-renewable-energy>; City of Sydney, "5 things to know about our electricity deal", <https://news.cityofsydney.nsw.gov.au/articles/5-things-to-know-about-our-electricity-deal>, viewed 8 February 2021. See also S. Hanley, "City of Sydney goes 100% renewable", CleanTechnica, 3 July 2020, <https://cleantechnica.com/2020/07/03/city-of-sydney-goes-100-renewable>.
- 140 M. Bloch, "SA's first electric garbage truck doing the rounds", Sea Electric, 25 February 2020, <https://www.sea-electric.com/sas-first-electric-garbage-truck-doing-the-rounds>; B. Schmidt, "Australia's first fully electric rubbish trucks clean up in Casey", The Driven, 24 May 2019, <https://thedriven.io/2019/05/24/australias-first-fully-electric-rubbish-trucks-clean-up-in-casey>.
- 141 S. Vorrath, "Solar powered bushfire recovery initiative launched in Victoria", One Step Off the Grid, 23 September 2020, <https://onestepoffthegrid.com.au/solar-powered-bushfire-recovery-initiative-launched-in-victoria>.
- 142 F. Wehinger, FES, Jordan, personal communication with REN21, 31 August 2020.
- 143 REN21 Policy Database, op. cit. note 1. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and may not be exhaustive.

URBAN POLICY LANDSCAPE

- 1 S. Borbonus, *Generating Socio-economic Values from Renewable Energies: An Overview of Questions and Assessment Methods* (Potsdam: Institute for Advanced Sustainability Studies, July 2017), https://publications.iasa-potsdam.de/rest/items/item_2344893_6/component/file_2344894/content; Renewable Energy Network for the 21st Century (REN21) Policy Database (2020), available at www.ren21.net/cities/datapack. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and therefore may not be exhaustive.
- 2 International Renewable Energy Agency (IRENA), *Rise of Renewables in Cities* (Abu Dhabi: October 2020), https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Oct/IRENA_Renewables_in_cities_2020.pdf.
- 3 United Nations Development Programme, "Solar for health", <https://www.undp-capacitydevelopment-health.org/en/capacities/focus/solar-for-health>, viewed July 2020; B. Bungane, "Measuring embedded generation opportunities for municipalities", *ESI Africa*, 10 October 2019, <https://www.esi-africa.com/industry-sectors/generation/measuring-embedded-generation-opportunities-for-municipalities>.
- 4 REN21, *Renewables in Cities 2019 Global Status Report* (Paris: 2019), www.ren21.net/cities.
- 5 **City Snapshot: Orlando** based on the following sources: CDP, "2018-2019 City-Wide Emissions", CDP Open Data Portal, <https://data.cdp.net/Emissions/2018-2019-City-wide-Emissions/mkj4-km9s>; City of Orlando, "40 fun Orlando facts", 1 August 2014, www.cityoforlando.net/blog/40-fun-orlando-facts; Orlando Utilities Commission (OUC), "OUC's roadmap", www.oucroadmap.com, viewed 5 January 2021; OUC, "OUC's solar projects", www.ouc.com/environment-community/ouc-solar-solutions/solar-at-ouc, viewed 5 January 2021, viewed 5 January 2021; M. Inanc, "Major solar energy project begins operation in Central Florida", *Energy Central*, 30 June 2020, <https://energycentral.com/c/cp/major-solar-energy-project-begins-operation-central-florida>; Greenwood Energy, "Greenwood Energy attends the dedication ceremony of the Kenneth P. Ksionek Community Solar Farm", 1 January 2017, <https://www.greenwoodinfra.com/2018/01/17/greenwood-energy-attends-dedication-ceremony-kenneth-p-ksionek-community-solar-farm>.
- 6 H. Vandevyvere and S. Stremke, "Urban planning for a renewable energy future: Methodological challenges and opportunities from a design perspective", *Sustainability*, vol. 4, no. 6 (2012), pp. 1309-28, <https://www.mdpi.com/2071-1050/4/6/1309>.
- 7 REN21 Policy Database (2020), available at www.ren21.net/cities/datapack. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and therefore may not be exhaustive.
- 8 Ibid.
- 9 **Figures 3 and 4** from Ibid. Data on renewable energy targets include targets for municipal operations and for city-wide energy use, as well as sectoral and technology-specific targets; these targets are set either as a share of consumption or as specific capacity or generation goals. The data exclude targets for energy efficiency, carbon emission reduction and electric vehicles, unless these are coupled with renewable power targets. Some research is based on voluntary reporting and therefore may not be exhaustive.
- 10 Ibid.
- 11 Ibid.
- 12 Energy Cities, *How Cities Can Back Renewable Energy Communities* (Brussels: 2019), http://www.energy-cities.eu/wp-content/uploads/2019/06/EnergyCities_RNP_Guidebook_Web.pdf.
- 13 T. Gonçalves and Y. Liu, "How US cities and counties are getting renewable energy", *World Resources Institute (WRI) Blog*, 24 June 2020, <https://www.wri.org/blog/2020/06/renewable-energy-procurement-cities-counties>.
- 14 REN21, op. cit. note 7. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and therefore may not be exhaustive.
- 15 Ibid. **Figure 5** from REN21, op. cit. note 7. Data on renewable energy targets include targets for municipal operations and for city-wide energy use, as well as sectoral and technology-specific targets; these targets are set either as a share of consumption or as specific capacity or generation goals. The data exclude targets for energy efficiency, carbon emission reduction and electric vehicles, unless these are coupled with renewable power targets. Some research is based on voluntary reporting and therefore may not be exhaustive.
- 16 REN21, op. cit. note 7; IRENA, op. cit. note 2.
- 17 REN21, op. cit. note 4; G. Kieffer and T. Couture, *Renewable Energy Target Setting* (Abu Dhabi: IRENA, 2015), <https://www.irena.org/publications/2015/Jun/Renewable-Energy-Target-Setting>.
- 18 **Figure 6** from REN21, op. cit. note 7. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and therefore may not be exhaustive.
- 19 T. Veith, *Local Energy and Climate Roadmaps: 5 City Visions for 2050* (Brussels: Energy Cities, 2018), https://energy-cities.eu/wp-content/uploads/2019/02/local_energy_climate_roadmaps_final-1.pdf.
- 20 REN21, op. cit. note 7. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and therefore may not be exhaustive.
- 21 American Council for an Energy-Efficient Economy (ACEEE), "Scorecard: Leading U.S. cities grow clean energy efforts but many more lag far behind", press release (Washington, DC: 6 October 2020), <https://www.aceee.org/press-release/2020/10/scorecard-leading-us-cities-grow-clean-energy-efforts-many-more-lag-far>; ACEEE, *The 2020 City Clean Energy Scorecard* (Washington, DC: 2020), <https://www.aceee.org/research-report/u2008>.
- 22 Ibid.
- 23 All targets are for consumption except for Eliat (Israel) and Newstead (Australia) which have 100% generation targets. Some UK cities (part of UK100) have pledged "100% clean energy targets" that may include nuclear energy. **Figure 7** from REN21, op. cit. note 7. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and therefore may not be exhaustive.
- 24 Sierra Club, "Check out where we are Ready for 100", <https://www.sierraclub.org/ready-for-100/map?show=committed>, viewed 5 January 2021. **City Snapshot: Adelaide** based on the following sources: CDP, "2018-2019 City-Wide Emissions", CDP Open Data Portal, <https://data.cdp.net/Emissions/2018-2019-City-wide-Emissions/mkj4-km9s>; CNCA, "Adelaide", <https://carbonneutralcities.org/cities/adelaide>, viewed 5 January 2021; City of Adelaide, "Reducing Council emissions", www.cityofadelaide.com.au/about-adelaide/our-sustainable-city/reducing-council-emissions, viewed 5 January 2021; City of Adelaide and Government of South Australia, *Carbon Neutral Adelaide: Action Plan 2016-2021* (Adelaide: 2020), <https://s3-ap-southeast-2.amazonaws.com/cna-public-assets/general-downloads/Carbon-Neutral-Adelaide-Action-Plan-2016-2021.pdf>; City of Adelaide and Government of South Australia, *Carbon Neutral Adelaide Status Report* (Adelaide: 2019), <https://s3-ap-southeast-2.amazonaws.com/cna-public-assets/general-downloads/95637-BSA-Carbon-Neutral-Adelaide-Status-Report-FIN.pdf>; City of Adelaide, "How are we making the City of Adelaide carbon neutral?", Carbon Neutral Adelaide, <https://www.carbonneutraladelaide.com.au/about/how>, viewed 5 January 2021; Hornsdale Wind Farm, "Clean Energy for South Australia: Overview", <https://hornsdailewindfarm.com.au>, viewed 18 December 2020.
- 25 M. Lewis, "Texas leads the US in wind power — and now it's ramping up solar, too", *Texas Observer*, 21 February 2020, <https://electrek.co/2020/02/21/texas-leads-the-us-in-wind-power-and-now-its-ramping-up-solar-too>.
- 26 M. van Staden, ICLEI, personal communication with REN21, 30 October 2020; CDP-ICLEI Unified Reporting System,

- "Cities renewable energy targets", <https://data.cdp.net/browse?category=Renewable%20Energy>, viewed 4 January 2021.
- 27 CDP-ICLEI Unified Reporting System, op. cit. note 26.
- 28 REN21, op. cit. note 7. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and therefore may not be exhaustive.
- 29 CDP-ICLEI Unified Reporting System, op. cit. note 26.
- 30 B. Vad Mathiesen et al., "Towards a decarbonized heating and cooling sector in Europe", Aalborg University, December 2019, <https://vbn.aau.dk/da/publications/towards-a-decarbonised-heating-and-cooling-sector-in-europe-unloc>; REN21, op. cit. note 4; REN21, *Renewables 2020 Global Status Report* (Paris: 2020), <https://www.ren21.net/reports/global-status-report>.
- 31 CDP-ICLEI Unified Reporting System, op. cit. note 26.
- 32 Government of Mexico City, "Ciudad Solar: Estrategia de sustentabilidad energética 2019-2024", presentation (undated), <https://ciudad solar.cdmx.gob.mx/storage/app/media/presentacion-ciudad-solar.pdf>.
- 33 REN21, op. cit. note 7. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and therefore may not be exhaustive.
- 34 In 2014, Auckland set biofuel targets for 3% of fuels sold to be advanced biofuel by 2020, 7% by 2030 and 14% by 2040, from Auckland Council, *Low Carbon Auckland* (Auckland: July 2014), <https://www.aucklandcouncil.govt.nz/plans-projects-policies-reports-bylaws/our-plans-strategies/topic-based-plans-strategies/environmental-plans-strategies/docslowcarboncopy/low-carbon-strategic-action-plan-full.pdf>. In 2019, new targets for the production of biogas for use as a vehicle fuel were put in place in Helsingborg (Sweden) and Mexico City (Mexico). Helsingborg's 2019 target states that the use of locally produced biogas should increase 15% from 2018 levels. Mexico City has a new target for biogas production for 104 GWh per year. Both from REN21, op. cit. note 7. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and therefore may not be exhaustive.
- 35 **Box 1** based on the following sources: International Transport Forum, *Decarbonising Maritime Transport: Pathways to Zero-carbon Shipping by 2035* (Paris: 2018), <https://www.itf-oecd.org/sites/default/files/docs/decarbonising-maritime-transport.pdf>; DNV GL, *Ports: Green Gateways to Europe* (Oslo: 2020), https://download.dnvgl.com/ports_greengatewaysto europe_ty; City of Amsterdam, *Amsterdam Climate Neutral Roadmap 2050* (Amsterdam: February 2020), https://assets.amsterdam.nl/publish/pages/887330/roadmap_climate_neutral.pdf; T. Lindeman, "Oslo's ambitious plan to decarbonize its port", CityLab, 8 November 2019, <https://www.bloomberg.com/news/articles/2019-11-08/oslo-s-ambitious-plan-to-decarbonize-its-port>; International Energy Agency (IEA), *Global EV Outlook 2020* (Paris: 2020), <https://www.iea.org/reports/global-ev-outlook-2020>; J. Ovcina, "Port Esbjerg teams up with Honeywell on massive decarbonisation mission", Offshore Energy, 4 September 2020, <https://www.offshore-energy.biz/port-esbjerg-teams-up-with-honeywell-on-massive-decarbonization-mission>; L. H. Liang, "Rotterdam sets ambitious goal for shore-based power by 2030", Seatrade Maritime News, 15 October 2020, <https://www.seatrade-maritime.com/environmental/rotterdam-sets-ambitious-goal-shore-based-power-2030>; Port of Kiel, "Shore power terminals", <https://www.portofkiel.com/blue-port-en/shore-power-facility.html>, viewed 11 January 2021; Vancouver is Awesome, "Shore power: Here's how the Port of Vancouver plans to become the most sustainable port in the world", <https://www.vancouverisawesome.com/sponsored/vancouver-port-sustainability-shore-power-1944486>, viewed 11 January 2021; Port Houston, "Port Commission approves move on renewable energy", press release (Houston, TX: 23 October 2019), https://porthouston.com/wp-content/uploads/Port_Commission_October_Press_Release_revised_Roger_en-002.pdf; B. Hensel, Port Houston, personal communication with REN21, 21 January 2020.
- 36 REN21, op. cit. note 4.
- 37 D. Miller and M. Porter, "Electric vehicles are the next dominant class of renewable energy buyers", Rocky Mountain Institute, 18 March 2020, <https://rmi.org/electric-vehicles-are-the-next-dominant-class-of-renewable-energy-buyers>.
- 38 For countries with no power targets or for which the share of renewable power already surpasses the highest targets, the latest available shares of renewable power are considered. Brazil's target excludes all hydropower. Canada's share excludes all hydropower. India does not classify hydropower installations larger than 25 MW as renewable energy sources, so hydro >25 MW is excluded from national targets. De facto sub-national targets have been set through existing Renewable Portfolio Standard policies. The Russian Federation's targets exclude hydropower plants >25 MW. **Figure 8** from REN21, op. cit. note 7. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and therefore may not be exhaustive.
- 39 Based on Partnership for Sustainable, Low Carbon Transport (SLOCAT), Transport and Climate Change Global Status Report (TCC-GSR) Policy Database.
- 40 Ibid.
- 41 Additional targets include electrifying 10% of its taxi fleet by 2022, 100% of its municipal fleet by 2028 and 100% of its Metro and LADOT buses by 2030. Los Angeles also has plans to introduce 155 new electric buses into its fleet in 2021, install 10,000 publicly available EV chargers by 2022 and 28,000 chargers by 2028. Mayor E. Garcetti, *LA's Green New Deal: Sustainable City pLAn* (Los Angeles: 2019), https://plan.lamayor.org/sites/default/files/pLAn_2019_final.pdf.
- 42 Ministerio de Transporte de Chile, "Duplicaremos la flota de buses Red en los próximos dos meses y reasignamos el 41% de los recorridos de Express", 26 June 2020, <http://mtt.gob.cl/archivos/25575>.
- 43 Based on CDP data as received on October 2020.
- 44 SLOCAT, op. cit. note 39.
- 45 T. Ha, "5 trends this decade that will shape Singapore's switch to electric mobility", Eco-Business, 24 June 2020, <https://www.eco-business.com/news/5-trends-this-decade-that-will-shape-singapores-switch-to-electric-mobility>; S. Gupta, "Movin' towards eMobility – Singapore finally at the forefront!" Ingenuity, 8 July 2020, <https://ingenuity.siemens.com/2020/07/movin-towards-emobility-singapore-finally-at-the-forefront>. Out of a total of 5,153 public-sector diesel vehicles currently being used, 3,586 will be replaced with "green" vehicles. M. Lewis, "EGEB: Seoul to ban diesel public-sector cars by 2025", Electrek, 7 August 2020, <https://electrek.co/2020/08/07/egeb-seoul-bans-diesel-public-sector-cars-2025-newark-delaware-solar>; Z. Shahan, "Seoul: Dirty diesel vehicles banned from public fleets in 2025", CleanTechnica, 11 August 2020, <https://cleantechnica.com/2020/08/11/seoul-dirty-diesel-vehicles-banned-from-public-fleets-in-2025>.
- 46 P. Brewer, "ACT wants only to invest in 'green' hydrogen, and that's at odds with the federal government's view", *Canberra Times*, 11 May 2020, <https://www.canberratimes.com.au/story/6749655/acts-coal-power-rejection-risks-300m-in-federal-hydrogen-funding>; "San Francisco Mission Street hydrogen station opens", FuelCellsWorks, 14 February 2020, <https://fuelcellworks.com/news/san-francisco-mission-street-hydrogen-station-opens>; European Commission, "Hydrogen drives Europe towards emissions-free transport", 29 August 2016, <https://ec.europa.eu/programmes/horizon2020/en/news/hydrogen-drives-europe-towards-emissions-free-transport>.
- 47 L. Jin and H. He, "Ten cities, thousand fuel cell vehicles? China is sketching a roadmap for hydrogen vehicles", International Council on Clean Transportation (ICCT), 19 August 2020, <https://theicct.org/blog/staff/china-sketching-roadmap-hydrogen-vehicles-aug2020>.
- 48 NewClimate Institute, *Navigating the Nuances of Net-Zero Targets* (Cologne: October 2020), https://newclimate.org/wp-content/uploads/2020/10/NewClimate_NetZeroReport_October2020.pdf.
- 49 Global Covenant of Mayors for Climate and Energy, "Homepage", <https://www.globalcovenantofmayors.org>, viewed 3 November 2020.
- 50 NewClimate Institute, op. cit. note 48; REN21, op. cit. note 7.
- 51 Ibid.
- 52 Ibid.

- 53 C40, "Deadline 2020", <https://www.c40.org/other/deadline-2020>, viewed 20 November 2020.
- 54 NewClimate Institute, op. cit. note 48.
- 55 **Figure 9** from Ibid., and from REN21, op. cit. note 7. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and therefore may not be exhaustive.
- 56 Carbon Neutral Adelaide, "Renewable energy", <https://www.carbonneutraladelaide.com.au/take-action/renewable-energy>, viewed 20 November 2020.
- 57 NewClimate Institute, op. cit. note 48; REN21, op. cit. note 7. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and therefore may not be exhaustive.
- 58 NewClimate Institute, op. cit. note 48; REN21, op. cit. note 7. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and therefore may not be exhaustive. Global Climate Action NAZCA, "Climate Ambition Alliance: Net Zero 2050", <https://climateaction.unfccc.int/views/cooperative-initiative-details.html?id=94>, viewed 10 December 2020.
- 59 Global Climate Action NAZCA, op. cit. note 58; Energy and Climate Intelligence Unit (ECIU), "Net Zero Targets", <https://eciu.net/netzerotracker/map>, viewed 10 December 2020.
- 60 REN21, op. cit. note 7. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and therefore may not be exhaustive.
- 61 Mike, "Dublin City Council Awards Energy Performance Contract to Upgrade its Sports Centres", 8 August 2019, <https://www.industryandbusiness.ie/dublin-city-council-awards-energy-performance-contract-to-upgrade-its-sports-centres/>
- 62 IISD Knowledge Hub, "Investing in climate-resilient cities benefits national economic prosperity, report finds", Coalition for Urban Transitions, 15 October 2019, <https://sdg.iisd.org/news/investing-in-climate-resilient-cities-benefits-national-economic-prosperity-report-finds>.
- 63 City of Portland, "New solar battery storage system at Portland Fire Station 1 fuels emergency resiliency", <https://www.portlandoregon.gov/fire/article/749719>, viewed 5 November 2020.
- 64 S. Vorrath, "Solar drinking water for Adelaide, as Happy Valley Reservoir adds 5B array", One Step Off the Grid, 19 August 2020, <https://onestepoffthegrid.com.au/solar-drinking-water-for-adelaide-as-happy-valley-reservoir-adds-12mw-pv-array>.
- 65 A. Dane, "3 ways U.S. cities are investing in clean energy for resilience", WRI Blog, 16 June 2020, <https://www.wri.org/blog/2020/06/3-ways-us-cities-are-investing-clean-energy-resilience>; C40 Finance Facility, "Quezon City: Using solar power to promote clean energy", <https://www.c40cff.org/projects/quezon-city-solarizing-the-future-generation>, viewed 5 November 2020.
- 66 Chennai Smart City Limited, "About installation of solar rooftops in GCC buildings", <https://www.cscl.co.in/solar-rooftop-government-building>, viewed 5 November 2020; C40 Finance Facility, op. cit. note 65; S. Ikelá, "Windhoek plans N\$420m solar plants", *The Namibian*, 13 October 2020, [https://www.namibian.com.na/95577/read/Windhoek-plans-N\\$420m-solar-plants](https://www.namibian.com.na/95577/read/Windhoek-plans-N$420m-solar-plants); Wind Energy International, "Argentina", <https://library.windea.org/listing/argentina>, viewed 4 January 2021; Electricity Distribution Co, "Karak municipality invests in solar energy", <https://edco.jo/index.php/ar/163218218-acrr/268c76ymetalliding>, viewed 4 January 2021.
- 67 American Cities Climate Challenge, "Local Government Renewables Action Tracker", <https://cityrenewables.org/transaction-tracker>, viewed 4 November 2020; Gonçalves and Liu, op. cit. note 13.
- 68 American Cities Climate Challenge, op. cit. note 67.
- 69 Gonçalves and Liu, op. cit. note 13.
- 70 A. Best, "How this Colorado ski town will achieve 100% emissions-free electricity", Mountain Town News, 8 April 2020, <https://mountaintownnews.net/2020/04/08/solar-gardens>.
- 71 Ibid.
- 72 Ibid.
- 73 CEDEC, *An EU Heating and Cooling Strategy* (Brussels: undated), http://www.cedec.com/files/default/an%20eu%20heating%20and%20cooling%20strategy_final%20cedec%20paper-1.pdf; B. Richter, "New EU Directive: A renewable energy investment offensive in heating and cooling and in the generation of electricity for household self-consumption is on the horizon", Rödl and Partner EnEws, August 2018, <https://www.roedl.com/insights/renewable-energy/2018-08/new-eu-directive-renewable-energy-investment-heating-cooling>.
- 74 Gdynia, "Koniec z kopciuchami w Gdyni", <https://www.gdynia.pl/co-nowego,2774/koniec-z-kopciuchami-w-gdyni,547999>, viewed 10 January 2021.
- 75 M. Mazengarb, "ACT government to build first all-electric hospital, powered by renewables", RenewEconomy, 2 September 2020, <https://reneweconomy.com.au/act-government-to-build-first-all-electric-hospital-powered-by-renewables-76968>.
- 76 Biobio Chile, "Temuco contará con gran proyecto de calefacción distrital alimentado por biomasa", 3 February 2020, <https://www.biobiochile.cl/noticias/nacional/region-de-la-araucania/2020/02/03/temuco-contara-con-gran-proyecto-de-calefaccion-distrital-alimentado-por-biomasa.shtml>.
- 77 IRENA, op. cit. note 2; Agora Verkehrswende, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and World Economic Forum (WEF), *Transport for Under Two Degrees – The Way Forward. 10 Key Insights for the Decarbonisation of the Transport Sector* (Berlin: 2020), https://www.t4under2.org/pdf/T4under2_Global-foresight-study_FINAL.pdf.
- 78 REN21, *Renewables 2020 Global Status Report*, op. cit. note 30.
- 79 B. Osgood, "City's bus fleet to transition to renewable diesel", *Santa Barbara Independent*, 3 December 2019, <https://www.independent.com/2019/12/03/citys-bus-fleet-to-transition-to-renewable-diesel/>; R. Schorske, *Central Coast Alternative Fuel Vehicle Readiness Plan* (Santa Barbara, CA: EV Alliance, March 2016), https://www.c-5.org/images/cms/files/Final_Readiness%20Plan_Combined0.pdf; J. Parkinson, "The future of biofuels takes root in S.B.", *Santa Barbara Independent*, 21 February 2008, <https://www.independent.com/2008/02/21/future-biofuels-takes-root-s-b>.
- 80 M. Johnston, "Fueling trash trucks with RNG", BioCycle, 6 May 2019, <https://www.biocycle.net/fueling-trash-trucks-rng>.
- 81 M. Mace, "Liverpool City Council unveils biogas-powered refuse trucks", edie, 11 March 2020, <https://www.edie.net/news/6/Liverpool-City-Council-unveils-biogas-powered-refuse-trucks>.
- 82 In **North America**, the demand for electric buses continued to rise in 2019 and 2020, including in cities such as Brampton (Ontario, Canada), Gulfport (Mississippi, US) and Portland (Maine, US), which procured their first e-buses. See K. Tigue, "U.S. electric bus demand outpaces production as cities add to their fleets", Inside Climate News, 14 November 2019, <https://insideclimatenews.org/news/14112019/electric-bus-cost-savings-health-fuel-charging>, and L. Belmonte, "Electric buses are coming to this GTA city and the government's hoping it's a game changer", Narcity, 19 July 2019, <https://www.narcity.com/en-ca/news/toronto/brampton-electric-buses-aim-to-accelerate-plans-for-greener-canada>. Several cities in **Latin America** – such as Buenos Aires (Argentina), Bogota, Cali and Medellín (all Colombia), Montevideo (Uruguay), Santiago (Chile) and São Paulo and Volta Redonda (both Brazil) – made progress with integrating electric buses into public transport fleets and building EV charging stations. Santiago (Chile) has the largest electric urban bus fleet outside of China, with 452 in circulation in 2020 and plans for 1,160 more to enter operation during the year; see the following sources: Ministerio del Medio Ambiente de Chile, "Gobierno recibe 100 nuevos buses eléctricos que se sumarán a RED Metropolitana de Movilidad", 31 July 2019, <https://mma.gob.cl/gobierno-recibe-100-nuevos-buses-electricos-que-se-sumaran-a-red-metropolitana-de-movilidad>; Ministerio de Transporte de Chile, "RED sigue expandiéndose con 80 nuevos buses que comienzan a operar hoy en tres recorridos", 19 July 2020, <http://mtt.gob.cl/archivos/25794>; Ministerio de Transporte de Chile, "Duplicaremos la flota de buses Red en los próximos dos meses y reasignamos el 41% de los recorridos de Express", 26 June 2020, <http://mtt.gob.cl/archivos/25575>; Ministerio de Energía de Chile,

- "Santiago se convertirá en la región con la red de carga eléctrica pública más grande de Sudamérica", 24 June 2019, <https://www.energia.gob.cl/noticias/metropolitana-de-santiago/santiago-se-convertira-en-la-region-con-la-red-de-carga-electrica-publica-mas-grande-de-sudamerica>. Colombia from the following sources: Alcaldía de Santiago de Cali, "El MIO pone en servicio la primera flota eléctrica de un Sistema Integrado de Transporte Masivo en Colombia", 10 September 2019, <https://www.cali.gov.co/movilidad/publicaciones/149414/el-mio-pone-en-servicio-la-primer-flota-electrica-de-un-sistema-integrado-de-transporte-masivo-en-colombia>; Alcaldía de Medellín, "Los 64 buses eléctricos ya están en Medellín", 17 September 2019, <https://www.medellin.gov.co/movilidad/component/k2/los-64-buses-electricos-ya-estan-en-medellin>; Alcaldía de Bogotá, "Primer bus eléctrico del SITP ya se encuentra en Bogotá", <https://bogota.gov.co/mi-ciudad/movilidad/transmilenio/buses-electricos-del-sitp-en-bogota>, updated December 2019; Transmilenio S.A., "Supply and demand statistics of the Integrated Public Transport System – SITP" (Bogotá: February 2020), <https://www.transmilenio.gov.co/loader.php?Servicio=Tools2&ITipo=descargas&IFuncion=descargar&idFile=5778>. Uruguay from Intendencia de Montevideo, "Nuevas condiciones para la renovación o incremento de la flota", 1 October 2019, <https://montevideo.gub.uy/noticias/movilidad-y-transporte/nuevas-condiciones-para-la-renovacion-o-incremento-de-la-flota>, and from Intendencia de Montevideo, "El transporte colectivo sigue cambiando", 19 May 2020, <https://montevideo.gub.uy/noticias/movilidad-y-transporte/el-transporte-colectivo-sigue-cambiando>. Buenos Aires from Ministry of Transport of Argentina, "Resolución 284-2019", 13 May 2019, <https://www.boletinoficial.gob.ar/detalleAviso/primera/207542/20190515>, and from Government of the Republic of Argentina, "Ya circulan los primeros buses eléctricos en la Ciudad de Buenos Aires", 17 May 2019, <https://www.argentina.gob.ar/noticias/ya-circulan-los-primeros-buses-electricos-en-la-ciudad-de-buenos-aires>. Brazil from the following sources: Prefeitura Municipal de Volta Redonda, "Terceiro Ônibus Do Tarifa Comercial Zero É Entregue Em Volta Redonda", 1 January 2020, <https://new.voltaredonga.rj.gov.br/24-noticias-em-destaque/gabinete-do-prefeito/2230-terceiro-%C3%B4nibus-do-tarifa-comercial-zero-%C3%A9-entregue-em-volta-redonda>; City of São Paulo, "São Paulo passa a ter a maior frota de ônibus 100 % elétricos do país", 19 November 2019, <http://www.capital.sp.gov.br/noticia/sao-paulo-passa-a-ter-a-maior-frota-de-onibus-100-eletricos-do-pais>; "E-bus radar", <https://www.ebusradar.org>, viewed 23 September 2020. In **Europe**, following successful public procurement procedures, new electric buses were put into circulation in Gothenburg (Sweden), Lisbon (Portugal), London (UK), Milan (Italy), Paris (France) and many more cities. See the following sources: Biofuels International, "Volvo receives order for electric, biodiesel buses in Swedish city", 6 November 2019, <https://biofuels-news.com/news/volvo-receives-order-for-electric-biodiesel-buses-in-swedish-city>; Mayor of London, "London's electric bus fleet becomes the largest in Europe", 5 September 2019, <https://www.london.gov.uk/press-releases/mayoral/london-has-europes-largest-electric-bus-fleet>; P. Dzikiy, "Milan to receive 250 electric buses from Solaris in one of Europe's largest e-bus orders yet", *Electrek*, 10 July 2019, <https://electrek.co/2019/07/10/milan-250-electric-buses-solaris>; Groupe RATP, "RATP Group 2018 results: A year of profitable growth and investments to the benefit of passengers", press release (Paris: 29 March 2019), <https://www.ratpdev.com/sites/default/files/annexes/communiqués/RATP%20Group%202018%20results.pdf>. Some **Asian** cities procured electric buses with the stated goal of improving air quality, including Ahmedabad, Bangalore, Delhi, Gurugam and Pune (all India) and Nur-Sultan (Kazakhstan). In 2020, Pune's public transport service provider issued a tender for the supply, operation and maintenance of 150 electric buses and associated charging infrastructure. See the following sources: SLOCAT, op. cit. note 39; A. Parikh, "Delhi to shut Rajghat thermal power project, use land for 5 MW solar park", *Mercom India*, 15 July 2019, <https://mercomindia.com/delhi-rajghat-thermal-project-solar-park>; R. Nair, "Pune announces tender for 150 electric buses under FAME-II Program", *Mercom India*, 15 September 2020, <https://mercomindia.com/pune-tender-electric-buses>; "100 Yutong electric buses delivered in Kazakhstan's capital Nur-Sultan", *Sustainable Bus*, 16 April 2020, <https://www.sustainable-bus.com/electric-bus/100-yutong-electric-buses-delivered-in-kazakhstans-capital-city-nur-sultan>.
- 83 Supra-national, national and state mandates can put pressure on cities to accelerate the uptake of EVs and build-out of EV charging infrastructure as well as infrastructure for other zero-emission vehicles such as fuel cell vehicles, thus enabling the uptake of renewable electricity and fuels. For example, in 2019, members of the EU Parliament and EU Member State representatives agreed on a new "clean vehicles" directive and targets requiring that at least a quarter of new buses purchased by public authorities in cities across Europe be "clean" by 2025, and at least a third by 2030. A "clean" light-duty vehicle is defined as any car or van meeting the following emission thresholds: until 31 December 2025: no more than 50g/km of CO₂ and up to 80% of applicable real driving emission (RDE) limits for NOx and PN; from 1 January 2026: only zero-emission vehicles. "Clean" heavy-duty vehicle refers to any truck or bus fuelled by hydrogen, battery electric (including plug-in hybrids), natural gas (both CNG and LNG, including biomethane), liquid biofuels, synthetic and paraffinic fuels, LPG. F. Simon, "Europe agrees sales targets for 'clean' buses in cities", *Euroactiv*, 12 February 2019, <https://www.euractiv.com/section/electric-cars/news/europe-agrees-sales-targets-for-clean-buses-in-cities>; European Commission, "Clean Vehicles Directive", 8 December 2020, https://ec.europa.eu/transport/themes/urban/clean-vehicles-directive_en. In 2020, the governor of California (US) issued an Executive Order banning the sale of internal combustion engine vehicles in the state by 2035, and the California Air Resources Board announced that all commercial trucks and vans in the state must be zero emission by 2045. Washington, D.C., along with 15 US states, announced plans to follow California's lead in electrifying all heavy-duty trucks, vans and buses to reduce harmful diesel engine pollution. See J. St. John, "California to ban all internal combustion engine vehicles by 2035", *Greentech Media*, 23 September 2020, <https://www.greentechmedia.com/articles/read/california-to-ban-all-internal-combustion-engine-vehicles-by-2035>, and S. O'Kane, "15 states will follow California's push to electrify trucks and buses", *The Verge*, 14 July 2020, <https://www.theverge.com/2020/7/14/21324552/electric-trucks-buses-clean-air-zero-emissions-states>.
- 84 Prefecture of São Paulo, "São Paulo passa a ter a maior frota de ônibus 100 % elétricos do país", 19 November 2019, <http://www.capital.sp.gov.br/noticia/sao-paulo-passa-a-ter-a-maior-frota-de-onibus-100-eletricos-do-pais>; L. Antoniou, "Portland's new electric buses will be 100 per cent wind powered", *Intelligent Transport*, 17 April 2019, <https://www.intelligenttransport.com/transport-news/78639/portland-electric-buses-100-per-cent-wind-powered>.
- 85 Leeds Climate Commission, "Leeds City Council plans to more than halve carbon emissions by 2025", 13 January 2020, <https://www.leedsclimate.org.uk/news/leeds-city-council-plans-more-halve-carbon-emissions-2025>; Mayor's Office of Sustainability, "Maximizing New York City's renewable energy", <https://www1.nyc.gov/site/sustainability/codes/energy-supply.page>, viewed 23 September 2020; C. Howe, "New York gives big boost to renewable energy", *Natural Resources Defense Council*, 15 October 2020, <https://www.nrdc.org/experts/cullen-howe/new-york-lays-down-gauntlet-renewable-energy>; M. Bandyk, "New Jersey outlines sweeping plans to achieve 100% clean energy by 2050", *Utility Dive*, 28 January 2020, <https://www.utilitydive.com/news/new-jersey-outlines-sweeping-plans-to-achieve-100-clean-energy-by-2050/571195>; M. Bloch, "Blue Mountains City Council aiming for carbon neutrality", *SolarQuotes*, 1 October 2019, <https://www.solarquotes.com.au/blog/blue-mountains-carbon-neutral-mb1234>; "Chile's ambitious goals to lead renewable energy", *reve*, 13 September 2019, <https://www.evwind.es/2019/09/13/chiles-ambitious-goals-to-lead-renewable-energy/70837>.
- 86 R. Whitlock, "Leeds City Council adds over 120 all-electric Renault Kangoo Z.E.33 vehicles to its fleet and new EV trials scheme", *Renewable Energy Magazine*, 18 June 2020, https://www.renewableenergymagazine.com/electric_hybrid_vehicles/leeds-city-council-adds-over-120-allelectric-20200618.
- 87 B. Chang, "New York City will begin testing a new fully electric garbage truck – see the Mack LR Electric", *Business Insider*, 27 September 2020, <https://www.businessinsider.com/new-york-city-testing-its-first-fully-electric-garbage-truck-2020-9>; A. Redling, "Jersey City, New Jersey, invests in electric waste vehicles", *Waste Today*, 14 July 2020, <https://www.wastetodaymagazine.com/article/jersey-city-electric-waste-trucks>; "Blue Mountains City Council trials electric garbage truck", *Blue Mountains Gazette*, 18 September 2020, <https://www.bluemountainsgazette.com.au/story/6931778/blue-mountains-city-council-trials-electric-garbage-truck>.
- 88 A. Menon, Z. Yang and A. Bandivadekar, *Electric Vehicle Guidebook for Indian States* (Washington, DC: ICCT, 2019), https://theicct.org/sites/default/files/publications/India_EV_State_Guidebook.20191118.pdf.

- 89 "Dubai to raise electric, hybrid electric vehicles to 30% by 2030", Zawya, 9 September 2020, https://www.zawya.com/uae/en/business/story/Dubai_to_raise_electric_hybrid_vehicles_to_30_by_2030-SNG_184180646.
- 90 R. Ranjan, "Dubai's renewable energy share in its power mix exceeds target", Mercom India, 7 June 2020, <https://mercomindia.com/dubai-renewable-energy-share>.
- 91 Yuji, "China hydrogen policy: A summary of provincial plans", Energy Iceberg, 19 August 2020, <https://energyiceberg.com/china-hydrogen-policy-provincial-summary>; IRENA, *Hydrogen: A Renewable Energy Perspective* (Abu Dhabi: September 2019), https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Sep/IRENA_Hydrogen_2019.pdf.
- 92 "Zhangjiakou is speeding up to build a 'hydrogen energy capital', and the advantages of renewable energy hydrogen production are highlighted", Netease News, 15 June 2020, <https://3g.163.com/dy/article/FF6AA8750534CY9P.html> (using Google Translate); G. Zhang, J. Zhang and T. Xie, "A solution to renewable hydrogen economy for fuel cell buses – A case study of Zhangjiakou in North China", *International Journal of Hydrogen Energy*, vol. 45, no. 29 (2020), pp. 14603-13, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7173837>; S. Lewis, "N China hydrogen push led by hydrogen as by-product, renewables", S&P Global Platts, 11 June 2020, <https://www.spglobal.com/platts/en/market-insights/latest-news/metals/061120-n-china-hydrogen-push-led-by-hydrogen-as-by-product-renewables>.
- 93 3emotion, "North Denmark (Aalborg) prepares for the first hydrogen buses in Denmark", <https://3emotion.eu/news/north-denmark-aalborg-prepares-first-hydrogen-buses-denmark>, viewed 25 January 2021; 3emotion, "Three fuel cell buses have officially been inaugurated in Aalborg! 10 September 2020", <https://3emotion.eu/news/three-fuel-cell-buses-have-officially-been-inaugurated-aalborg-10-september-2020>, viewed 25 January 2021.
- 94 REN21, op. cit. note 7. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and therefore may not be exhaustive.
- 95 Ibid.
- 96 Ibid.
- 97 **Figure 10** from Ibid.
- 98 **Box 2** from the following sources: A2EI, "Putting an end to Nigeria's generator crisis: The path forward", presentation, Dalberg, June 2019, https://a2ei.org/resources/uploads/2019/06/A2EI_Dalberg_Putting_an_End_to_Nigeria%E2%80%99s_Generator-Crisis_The_Path_Forward.pdf; Power Africa, *Off-grid Solar Market Assessment: Tanzania* (Washington, DC: US Agency for International Development, 2019), https://www.usaid.gov/sites/default/files/documents/1860/PAOP-Tanzania-MarketAssessment-Final_508.pdf; RESET, "Solar power for Kitefu Primary School in Arusha", <https://en.reset.org/project/kitefu-primary-school>, viewed 13 January 2021; J. Lee and M. McCuskey Shepley, "Benefits of solar photovoltaic systems for low-income families in social housing of Korea: Renewable energy applications as solutions to energy poverty", *Journal of Building Engineering*, vol. 28 (March 2020), <https://www.sciencedirect.com/science/article/pii/S2352710219311635>; D. Broom, "Seoul is putting solar panels on all public buildings and 1 million homes", World Economic Forum, 12 November 2019, <https://www.weforum.org/agenda/2019/11/solar-power-seoul-south-korea>; GRID Alternatives, Vote Solar and the Center for Social Inclusion, *Low-Income Solar Policy Guide: A Road Map to Successful Policies and Programs That Are Creating Access to Solar Technology and Jobs Nationwide*, March 2017, https://www.lowincomesolar.org/wp-content/uploads/2017/03/Policy-Guide_3.7.17.pdf; S. Hirschmann, "Som Energia, Catalonia (Spain)", Energy Democracy, 14 November 2017, <https://energy-democracy.net/som-energia-the-first-energy-cooperative-which-provides-an-alternative-to-the-traditional-energy-suppliers>; Hackney Council, "100% of Hackney Council electricity now supplied by renewables", press release (Hackney, UK: 1 April 2020), <https://news.hackney.gov.uk/100-of-hackney-council-energy-now-supplied-by-renewables>; Hackney Council, "Green homes", <https://hackney.gov.uk/hlp-green-homes>, updated 31 March 2020; Greater London Authority, "Mayor announces 'London Power' – a new, fairer energy company", 18 September 2019, <https://www.london.gov.uk/press-releases/mayoral/mayor-announces-london-power>; City and County of Honolulu, "Rehabilitation loan – Solar installation", <http://www.honolulu.gov/cms-dcs-menu/site-dcs-sitearticles/1852-cad-solar-loan.html>, viewed 13 January 2021; Covenant of Mayors for Climate & Energy, *How to Alleviate Energy Poverty at the Local Level?* (Brussels: November 2018), https://www.eumayors.eu/index.php?option=com_attachments&task=download&id=617.
- 99 S. Carbone, "Lessons from down under: Ways to lower PV solar soft costs", Aurora, 17 April 2019, <https://blog.aurorasolar.com/lessons-from-down-under-ways-to-lower-pv-solar-soft-costs>.
- 100 J. Morris et al., *Reducing Solar PV Soft Costs: A Focus on Installation Labor* (Snowmass, CO: Rocky Mountain Institute, December 2013), https://rmi.org/wp-content/uploads/2017/05/RMI_Document_Repository_Public-Reprrts_2013-16_SimpleBoSRpt.pdf.
- 101 REN21, op. cit. note 7. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and therefore may not be exhaustive.
- 102 T. Alonso, "The green transition: buildings that will combat climate change", Tomorrow.City, 13 February 2020, <https://www.smartcitylab.com/blog/urban-environment/the-green-transition-buildings-that-will-combat-climate-change>.
- 103 City of Vancouver, *Renewable City Strategy 2015-2050* (Vancouver: 2015), <https://vancouver.ca/files/cov/renewable-city-strategy-booklet-2015.pdf>.
- 104 D. A. Pohoryles et al., "Energy performance of existing residential buildings in Europe: A novel approach combining energy with seismic retrofitting", *Energy and Buildings*, vol. 223 (15 September 2020), p. 110024, <https://www.sciencedirect.com/science/article/pii/S0378778819335510>.
- 105 European Commission, "Renovation wave", https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/renovation-wave_en, viewed 14 January 2021.
- 106 A. Segond, "Chauffages au fioul: comment continuer à les utiliser après 2022?" Actualité France, 5 August 2020, https://actu.fr/economie/chauffages-au-fioul-comment-continuer-a-les-utiliser-apres-2022_35347348.html.
- 107 REN21, op. cit. note 7. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and therefore may not be exhaustive.
- 108 REN21, *Renewables 2020 Global Status Report*, op. cit. note 30.
- 109 **Sidebar 3** based on the following sources: IRENA, *Synergies Between Renewable Energy and Energy Efficiency* (Abu Dhabi: August 2017), https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/Aug/IRENA_REmap_Synergies_REEE_2017.pdf; United Nations Economic and Social Council, Joint Task Force on Energy Efficiency Standards in Buildings, "Updated Framework Guidelines for Energy Efficiency Standards in Buildings" (Geneva: 13 July 2020), https://www.unece.org/fileadmin/DAM/energy/se/pdfs/geee/geee7_Sept2020/ECE_ENERGY_GE.6_2020_4e.pdf; REN21, op. cit. note 7; M. Shank, "Adopting a zero-emissions standard for new buildings", Carbon Neutral Cities Alliance (CNCA), 29 November 2018, <https://carbonneutralcities.org/adopting-a-zero-emissions-standard-for-new-buildings>; International Institute for Sustainable Development (IISD), "Energy efficiency for sustainable cities: Achieving SDGs 7 and 11", SDG Knowledge Hub, 21 September 2017, <https://sdg.iisd.org/commentary/guest-articles/energy-efficiency-for-sustainable-cities-achieving-sdgs-7-and-11>; M. Shank and J. Partin, *Game Changers: Bold Actions by Cities to Accelerate Progress Toward Carbon Neutrality* (Copenhagen: CNCA, 2018), <http://carbonneutralcities.org/wp-content/uploads/2018/09/CNCA-Game-Changers-Report-2018.pdf>; City of Vlorë, "SMENSWICT", <http://vlora.gov.al/2020/01/25/smenswict>, viewed 5 January 2021 (using Google Translate); UNEP, *2020 Global Status Report for Buildings and Construction: Towards a Zero-emission, Efficient and Resilient Buildings and Construction Sector* (Nairobi: 2020), https://globalabc.org/sites/default/files/inline-files/2020%20Buildings%20GSR_FULL%20REPORT.pdf; Stockholms stad, *Strategy for a Fossil-fuel Free Stockholm by 2040*

- (Stockholm: 2016), <https://international.stockholm.se/globalassets/rappporter/strategy-for-a-fossil-fuel-free-stockholm-by-2040.pdf>; 100% Renewable Energy Atlas, "Stockholm, Sweden", <https://www.100-percent.org/stockholm-sweden>, updated 8 March 2019; M. Gough, "California's cities lead the way to a gas-free future", Sierra Club, 21 December 2020, <https://www.sierraclub.org/articles/2020/12/californias-cities-lead-way-gas-free-future>; City of Palo Alto, "2019 Energy Reach Code", https://www.cityofpaloalto.org/gov/depts/ds/green_building/2019_energy_reach_code_study.asp, viewed 6 January 2021; City of San Jose, "San Jose Reach Code", <https://www.sanjoseca.gov/your-government/departments-offices/environmental-services/climate-smart-san-jos/2019-reach-code-initiative>, viewed 8 January 2021; Achieving Zero, "San Francisco 100% renewable electricity for large commercial", <https://achieving-zero.org/san-francisco-100-renewable-electricity-for-large-commercial>, viewed 13 January 2021; City of San Francisco, "Ordinance amending the Building Code to require new construction to utilize only electric power. Amended in board 11/10/2020" (San Francisco: 2020), <https://sfgov.registar.com/View.ashx?M=F&ID=8911593&GUID=A0CEC5DB-30DE-4576-AAAD-6BF8266CC67C>; Leuven, "Roadmap 2025.2035.2050: 13 programs to a climate-neutral future", <https://roadmap-en.leuven2030.be>, viewed 5 January 2021; CDP-ICLEI Unified Reporting System, op. cit. note 26.
- 110 REN21, op. cit. note 7. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and therefore may not be exhaustive.
- 111 Ibid.
- 112 T. Smith, "Latest list of municipalities with approved SSEG tariff structures", ESI Africa, 3 September 2020, <https://www.esi-africa.com/industry-sectors/future-energy/latest-list-of-municipalities-with-approved-sseg-tariff-structures>.
- 113 I. Tsagas, "Dubai utility clamps down on net metered commercial solar", pv magazine, 26 May 2020, <https://www.pv-magazine.com/2020/05/26/dubai-utility-clamps-down-on-net-metered-commercial-solar>; Los Angeles Department of Water and Power, "Feed-in Tariff (FiT) Program", <https://www.ladwp.com/ladwp/faces/ladwp/commercial/c-gogreen/c-gg-commsolarprograms/c-gg-csp-fit>, viewed 6 November 2020; L. Poruschi, C. L. Ambrey and J. C. R. Smart, "Revisiting feed-in tariffs in Australia: A review", *Renewable and Sustainable Energy Reviews*, vol. 82, Part 1 (February 2018), pp. 260-70, <https://www.sciencedirect.com/science/article/abs/pii/S1364032117312789>.
- 114 Solar Energy Industries Association, "Net metering", <https://www.seia.org/initiatives/net-metering>, viewed 23 December 2020.
- 115 REN21, op. cit. note 7. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and therefore may not be exhaustive.
- 116 M. Hansen, "Springfield adopts new solar rules", NPR Illinois, 8 January 2020, <https://www.nprillinois.org/post/springfield-adopts-new-solar-rules>.
- 117 O. Zinaman et al., *Grid-connected Distributed Generation: Compensation Mechanism Basics* (Golden, CO: National Renewable Energy Laboratory, 2017), <https://eta-publications.lbl.gov/sites/default/files/68469.pdf>; Quick Electricity, "2020 solar buyback programs and net metering in Texas", <https://quickelectricity.com/2018-solar-panel-incentives-texas-net-metering-buyback-programs>, viewed 23 December 2020.
- 118 L. King Magel, "Solar energy and Texas' municipally owned utilities", Texas Solar Energy Society, <https://txses.org/solar-energy-and-texas-municipally-owned-utilities>, viewed 23 December 2020.
- 119 In France, the new national Law on Energy and Climate adopted in November 2019 introduced an obligation to install solar PV or solar thermal collectors covering at least 30% of the available rooftop space available for all new buildings with a footprint larger than 1,000 m², from Floriane, "ICPE Photovoltaïque: Obligation, encadrement et sécurité", Terre Solaire, 4 June 2020, <https://terresolaire.com/Blog/batiment-solaire/icpe-photovoltaique>; South Australia, "Energy efficiency requirements for new homes", <https://www.sa.gov.au/topics/energy-and-environment/energy-efficient-home-design/Six-star-energy-efficiency-requirements>, viewed 6 November 2020; S. Roth, "California isn't requiring rooftop solar on every new home after all", *Los Angeles Times*, 20 February 2020, <https://www.latimes.com/environment/story/2020-02-20/california-backtracks-on-rooftop-solar-requirement>. The law included exemptions for new construction in highly shaded areas.
- 120 City of Davis, "City of Davis adopts solar standard for all new commercial buildings", Cool Davis, 29 May 2019, <https://www.cooldavis.org/2019/05/29/city-of-davis-adopts-solar-standard-for-all-new-commercial-buildings>.
- 121 E. Wesoff, "California solar mandate weakened by Commission's new definition of community solar", pv magazine, 23 February 2020, <https://pv-magazine-usa.com/2020/02/23/challenge-by-sacramento-municipal-utility-weakens-california-solar-mandate>.
- 122 K. M. Dayashankar, "Smart turn: Karimnagar looks to the sun", *The Hindu*, 25 February 2019, <https://www.thehindu.com/news/national/andhra-pradesh/smart-turn-karimnagar-looks-to-the-sun/article26358979.ece>.
- 123 Ibid.
- 124 **City Snapshot: Rajkot** based on the following sources: PopulationStat, "Rajkot India Population (2019)", <https://populationstat.com/india/rajkot>, viewed 12 December 2021; CapaCITIES India, "Climate Resilient City Action Plan – Rajkot", 31 July 2018, http://capacitiesindia.org/wp-content/uploads/2019/12/CRCAP_Rajkot_July-2018.pdf; WWF International, "Smart City of Rajkot declared the national winner of WWF's Global One Planet City Challenge 2020", 10 July 2020, <https://www.wfindia.org/?19482%2Fsmart-city-of-rajkot-declared-the-national-winner-of-wwfs-global-one-planet-city-challenge-2020>; CapaCITIES India, "Quick Win Project – Rajkot Solar PV Social Housing", 2018, http://capacitiesindia.org/wp-content/uploads/2018/08/Quickwin-Projects-Rajkot_Solar-PV-Social-Housing.pdf.
- 125 Lahore Development Authority, "Building Regulation 3.6.4" (Lahore: September 2019), https://www.lda.gov.pk/images/LDA_BR.pdf.
- 126 H.-J. Frey, "Solare Baupflicht in Amberg", Solarenergie Förderverein Deutschland, 10 January 2020, http://www.sfv.de/artikel/solare_baupflicht_in_amberg.html. **City Snapshot: Heidelberg** based on the following sources: Heidelberg.de, "Meilenstein zur klimaneutralen Stadt", https://www.heidelberg.de/hd/HD/service/23_07_2020+meilenstein+zur+klimaneutralen+stadt.html; Heidelberg.de, "Heidelberger Sonnenstrom", https://www.heidelberg.de/hd/HD/Leben/heidelberger+sonnenstrom+_+energie+vom+dach.html, viewed 15 January 2021; Heidelberg.de, "Elektromobilität in Heidelberg", https://www.heidelberg.de/hd/HD/Arbeiten+in+Heidelberg/22_10_2020+elektromobilitaet+in+heidelberg.html, viewed 15 January 2021.
- 127 Gough, op. cit. note 109.
- 128 City of Richmond California, "Energy Reach Code", <https://www.ci.richmond.ca.us/3951/Energy-Reach-Code>, viewed 5 January 2021.
- 129 REN21, op. cit. note 7; California Energy Codes and Standards, "Reaching beyond", 29 October 2020, <https://localenergycodes.com>.
- 130 Ibid.
- 131 Quick Electricity, op. cit. note 117.
- 132 City of Philadelphia, "Urging the City of Philadelphia to take measures to achieve fair and equitable transition to the use of 100% Clean Renewable Energy by 2050, Resolution No. 19072800" (Philadelphia: 26 September 2019), <https://phila.registar.com/LegislationDetail.aspx?From=RSS&ID=4142523&GUID=BA06CC3B-7B43-4743-A07E-515A145C4A2A>.
- 133 Solarbe, "Interpretation of Beijing Development and Reform Commission's 'Notice on Further Supporting the Promotion and Application of Photovoltaic Power Generation Systems'", 30 December 2020, <https://news.solarbe.com/202012/30/333530.html> (using Google Translate); Solarbe, "Up to 0.3 yuan/kWhx6 years, Guangzhou's three districts give high subsidies to distributed photovoltaics!", 4 December 2020, <https://news.solarbe.com/202012/04/332804.html> (using Google Translate); Shanghai Municipal Development and Reform Commission, "Notice on Printing and Distributing the 'Shanghai Renewable Energy and New Energy Development Special Fund Support Measures (2020 Edition)'", 8 June 2020, <http://fgw.sh.gov.cn/zgjil/20200608/e186fb40e413471eb32e3783c207f0f1.html> (using Google Translate); Xi'an Bureau of Industry and Information Technology, "Public solicitation of 'Opinions on Further Promoting the Sustainable and Healthy Development of the Photovoltaic Industry'", 25 December 2020, <http://gxj.xa.gov.cn/ywxx/jsjb/5fe5dd2cf8fd1c596657a645.html> (using Google Translate).

- 134 Gdynia, "Energia z odnawialnych źródeł w Gdyni", <https://www.gdynia.pl/co-nowego,2774/otrzymaj-dotacje-na-odnawialne-zrodla-energii,546348>, viewed 10 January 2021.
- 135 A. Stoppelkamp, "Speicherförderung in Bundesländern und Kommunen", 20 March 2019, http://www.sfv.de/artikel/speicherfoerderung_in_bundeslaendern_und_kommunen.htm.
- 136 REN21, op. cit. note 7. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and therefore may not be exhaustive.
- 137 **City Snapshot: Seoul** based on the following sources: Government of Seoul, "Seoul Statistics", <http://opengov.seoul.go.kr/stat>, viewed 5 January 2021; Seoul Metropolitan Government, "Seoul combats economic crisis and climate change with 'Green New Deal'", 9 July 2020, <http://english.seoul.go.kr/seoul-combats-economic-crisis-and-climate-change-with-green-new-deal>; I. Gerretsen, "South Korea formally commits to cutting emissions to net zero by 2050", Climate Home News, 28 October 2020, www.climatechangenews.com/2020/10/28/south-korea-formally-commits-cutting-emissions-net-zero-2050; E. Bellini, "Seoul launches 1 GW rooftop solar plan", pv magazine, 18 November 2019, <https://www.pv-magazine.com/2019/11/18/seoul-launches-1-gw-rooftop-solar-plan>; N. Eun-ju, "Solar City Seoul' aims to produce 1 GW of solar power annually", The Hankyoreh, 22 November 2017, http://english.hani.co.kr/arti/english_edition/e_national/820207.html.
- 138 S. Vorrath, "Solar powered bushfire recovery initiative launched in Victoria", One Step Off the Grid, 23 September 2020, <https://onestepoffthegrid.com.au/solar-powered-bushfire-recovery-initiative-launched-in-victoria>.
- 139 Ibid.
- 140 T. Szatow, "How a small town solved five key barriers to a 100 per cent renewable energy supply", One Step Off the Grid, 21 August 2020, <https://onestepoffthegrid.com.au/how-a-small-town-solved-five-key-barriers-to-a-100-per-cent-renewable-energy-supply>.
- 141 Ibid.
- 142 SA Power Networks, *2020-2025 Tariff Structure Statement: Part A* (Keswick, South Australia: June 2020), <https://www.sapowernetworks.com.au/public/download.jsp?id=9508>; M. Carabott, "Solar sponge tariffs could be the answer to the electricity industry's duck curve problem", Leading Edge Energy, 22 July 2020, <https://www.leadingedgeenergy.com.au/news/solar-sponge-tariffs>.
- 143 Environment America, "Ten ways your city can go solar", <https://environmentamerica.org/feature/ame/ten-ways-your-city-can-go-solar>, viewed 6 November 2020; City and County of Honolulu, "Rehabilitation Loan – Solar Installation", <http://www.honolulu.gov/cms-dcs-menu/site-dcs-sitearticles/1852-cad-solar-loan.html>, viewed 6 November 2020.
- 144 Sustainia, "Mendoza: Small Municipality With Big Renewable Energy Plans", Global Opportunity Explorer, 18 June 2018, <https://goexplorer.org/mendoza-small-municipality-with-big-renewable-energy-plans>.
- 145 PACE Nation, "PACE programs", <https://pacenation.org/pace-programs>, viewed 6 November 2020; D. Gabrielson, "PACE: Property Assessed Clean Energy", PACE Nation, presentation, 2017, https://ec.europa.eu/energy/sites/ener/files/documents/007_1a_david_gabrielson_seif_paris_11-12-17.pdf; ManagEnergy – Energy Agencies leading the energy transition, "Boosting integrated home renovation services in Europe", <https://www.managenergy.net/node/560>, viewed 21 November 2020.
- 146 PACE Nation, "Texas PACE", <https://pacenation.org/pace-programs/#!US-TX>, viewed 6 November 2020.
- 147 REN21, op. cit. note 7.
- 148 Globo.com, "Lancado nesta sexta iptu amarelo oferece descontos para quem adotar energia solar em Salvador", 20 December 2018, <https://g1.globo.com/ba/bahia/noticia/2018/12/20/lancado-nesta-sexta-iptu-amarelo-oferece-descontos-para-quem-adotar-energia-solar-em-salvador.ghtml>; IPTU Amarelo, "Certificação para residências que adotem o sistema de geração de energia solar fotovoltaica", <http://www.iptuamarelo.salvador.ba.gov.br/#what-is>, viewed 10 January 2021.
- 149 Carbons Center, "City of Boulder, CO, United States", https://carbons.org/city_profiles/City_of_Boulder_CO, viewed 10 January 2021.
- 150 REN21, op. cit. note 7. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and therefore may not be exhaustive.
- 151 Ibid.
- 152 L. F. Cabeza, A. de Graca and A. L. Pisello, "Integration of renewable technologies in historical and heritage buildings: A review", *Energy and Buildings*, volume 177 (15 October 2018), pp. 96-111, <https://doi.org/10.1016/j.enbuild.2018.07.058>; IRENA, op. cit. note 2.
- 153 Vikram Solar, "Delhi's new virtual net metering policy: A guideline for rooftop solar India should adopt nationally", 21 February 2019, <https://www.vikrimsolar.com/delhis-new-virtual-net-metering-policy-a-guideline-for-rooftop-solar-india-should-adopt-nationally>.
- 154 S. Vorrath, "Australia's biggest 'solar garden' opens for membership in NSW Riverina", One Step Off the Grid, 17 September 2020, <https://onestepoffthegrid.com.au/australias-biggest-solar-garden-opens-for-membership-in-nsw-riverina>.
- 155 Ibid.
- 156 UK Department of Energy and Climate, *Collective Purchasing and Switching: What Consumers Need to Know* (London: 2020), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/36699/5368-collective-purchasing--guidance-for-consumers.pdf.
- 157 Solar United Neighbors, "Solar for Municipalities", <https://www.solarunitedneighbors.org/go-solar/solar-for-municipalities>, viewed 6 November 2020.
- 158 REN21, op. cit. note 4.
- 159 K. Trumbull, J. Gattaciecceca and J. R. DeShazo, "The Role of Community Choice Aggregators in Advancing Clean Energy Transitions: Lessons from California", UCLA Luskin Center for Innovation (LCI), October 2020, https://innovation.luskin.ucla.edu/wp-content/uploads/2020/11/The_Role_of_CCAs_in_Advancing_Clean_Energy_Transitions.pdf.
- 160 Ibid.
- 161 Ibid.
- 162 C. Morehouse, "5 ballot initiatives poised to propel states, cities to 100% clean energy", Utility Dive, 5 November 2020, <https://www.utilitydive.com/news/5-ballot-initiatives-poised-to-propel-states-cities-to-100-clean-energy/588440>.
- 163 Renewable Newstead, "Bringing renewable energy to Newstead", <https://renewablenewstead.com.au>, viewed 14 January 2021.
- 164 Renewable Newstead, "How it works", <https://renewablenewstead.com.au/how-it-works>, viewed 14 January 2021.
- 165 **Box 3** from the following sources: B. Wehrmann, "Most German cities are wasting vast solar potential on their rooftops – analysis", Clean Energy Wire, 18 June 2020, <https://www.cleanenergywire.org/news/most-german-cities-are-wasting-vast-solar-potential-their-rooftops-analysis>; S. Castellanos et al., "Rooftop solar photovoltaic potential in cities: How scalable are assessment approaches?", *Environmental Research Letters*, vol. 12 (2017), p. 125005, <https://iopscience.iop.org/article/10.1088/1748-9326/aa7857/pdf>; L. Winkless, "The rise of the urban rooftop", *Forbes*, 10 August 2018, <https://www.forbes.com/sites/lauriewinkless/2018/08/10/the-rise-of-the-urban-rooftop/?sh=39d3dc9c273d>; LichtBlick, "14 Grossstädte im SolarCheck: Deutsche Metropolen hinken beim Solarausbau hinterher", 18 June 2020, <https://www.lichtblick.de/presse/14-grossstaedte-im-solarcheck-deutsche-metropolen-hinken-beim-solarausbau-hinterher>; Masterplan Solarcity, "Sonne von Berlins Dächern ernten – Senat beschliesst Masterplan Solarcity Berlin", press release (Berlin: 10 March 2020), <https://www.berlin.de/rbmskzl/aktuelles/pressemitteilungen/2020/pressemitteilung.904927.php>; American Planning Association, *Solar Mapping* (Chicago: 2012), https://planning-org-uploaded-media.s3.amazonaws.com/publication/download_pdf/Solar-Mapping.pdf; BUILD UP, "A new interactive map of municipal PV installations in Rome", 29 June 2018, <https://www.buildup.eu/en/explore/links/new-interactive-map-municipal-pv-installations-rome>; Durban, "Durban Solar Map", <http://gis.durban.gov.za/solarmapviewer>, viewed 8 January 2021; Mayor of London, "London Solar Opportunity Map", <http://london.gov.uk/what-we-do/environment/energy/energy-buildings/london-solar-opportunity-map>, viewed 8 January 2021; Calgary, "Solar Potential Map", <https://maps.calgary.ca/SolarPotential>, viewed 8 January 2021.

- 166 REN21, op. cit. note 7. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and therefore may not be exhaustive.
- 167 Ibid. **Sidebar 4** based on the following sources: REN21, *Renewables 2020 Global Status Report*, op. cit. note 30, Table R9; B. Epp, "Database of building codes: 24 Individual regulations", solarthermalworld.org, 25 July 2013, <https://www.solarthermalworld.org/news/database-building-codes-24-individual-regulations>; B. Epp, "Consider solar thermal systems as basic furniture", Sun & Wind Energy, September 2009, https://www.solrico.com/fileadmin/solrico/media/doc/Sun___Wind_Energy_Article/solar_Building_Codes_Worldwide_SWE_2008.pdf; F. Jiménez Castellanos, "Balance your solar mandate between what the market is ready for and what you want to achieve", solarthermalworld.org, 27 November 2020, <https://www.solarthermalworld.org/news/balance-your-solar-mandate-between-what-market-ready-and-what-you-want-achieve>; The national solar thermal mandate (SANS10400XA) came into force on 9 September 2011, per L. Sibanda, City of Cape Town, South Africa, personal communication with REN21, October 2020; J. Malaviya, "Successful solar energy bylaw in Bengaluru India", solarthermalworld.org, 17 August 2018, <https://www.solarthermalworld.org/news/successful-solar-energy-bylaw-bengaluru-india>; A. Diego Rosell, "Argentina: Other municipalities follow frontrunner city Rosario", solarthermalworld.org, 7 August 2013, <https://www.solarthermalworld.org/news/argentina-other-municipalities-follow-frontrunner-city-rosario>; E. Augsten, "Argentina: Rosario City plans public building solar obligation", solarthermalworld.org, 10 February 2012, <https://www.solarthermalworld.org/news/argentina-rosario-city-plans-public-building-solar-obligation>; V. Kriele, "Brazil: Impact of São Paulo solar obligation", solarthermalworld.org, 13 November 2015, <https://www.solarthermalworld.org/news/brazil-impact-sao-paulo-solar-obligation>; C. Alencar, "São Paulo feels the first effects of its solar building code", solarthermalworld.org, 21 May 2019, <https://www.solarthermalworld.org/news/sao-paulo-feels-first-effects-its-solar-building-code>; W. Giese, "Use mandates to boost established markets, but not to build up new ones", solarthermalworld.org, 23 October 2020, <https://www.solarthermalworld.org/news/use-mandates-boost-established-markets-not-build-new-ones>; B. Epp, "Israel: Front runner in solar building code with strong impact on market", solarthermalworld.org, 13 July 2015, <https://www.solarthermalworld.org/news/israel-front-runner-solar-building-code-strong-impact-market>; Ark Resources, *Evaluation of the Victorian 6-star Housing Standard* (Victoria, Australia: Department of Environment, Land, Water & Planning, July 2019), https://www.energy.vic.gov.au/__data/assets/pdf_file/0028/448534/Evaluation-of-Victorian-6-Star-Standard-Final-Report.pdf.
- 168 City of Carlsbad California, "Residential Water Heating Ordinance", <https://www.carlsbadca.gov/services/depts/pw/environment/cap/waterheat.asp>, viewed 10 January 2021.
- 169 Under the policy, the companies contracted to construct the buildings are responsible for the first-time instalment, while subsequent maintenance is left to the owner. See Government of Luanzhou City, "Special Plan for Green Buildings in Luanzhou City (2020-2025)", 16 July 2020, <http://www.gba.org.cn/h-nd-1394.html> (using Google Translate).
- 170 REN21, op. cit. note 7. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and therefore may not be exhaustive.
- 171 Kanton Basel-Stadt, "SG 772.100 – Energiegesetz (EnG)", https://www.gesetzessammlung.bs.ch/app/de/texts_of_law/772.100, viewed 10 January 2021.
- 172 REN21, op. cit. note 7.
- 173 This program is co-financed with Inter-American Development Bank and World Bank, among others. Government of Mexico City, *Ciudad Solar: Estrategia de sustentabilidad energética 2019-2024* (Mexico City: undated), <https://ciudadssolar.cdmx.gob.mx/storage/app/media/presentacion-ciudad-solar.pdf>.
- 174 Ibid.
- 175 Government of Jiaozuo City, "Interpretation of the Interim Measures for the Management of Special Funds for the City's Winter Clean Heating Finance, Jiaozuo Daily", 13 December 2018, http://www.jiaozuo.gov.cn/sitesources/jiaozuo/page_pc/zwgk/szfxxgk/zcjd/articled561ec90df6b4bdf80dc76f72868c193.html (using Google Translate).
- 176 Olsztyn EU, "WymienPiec.Olsztyn.eu", <https://olsztyn.eu/gospodarka/program-ograniczania-niskiej-emisji.html>, viewed 27 July 2020; Ministerstwo Środowiska, "Program Czyste Powietrze: Dofinansowanie nowych źródeł ciepła i termomodernizacji budynków jednorodzinnych", http://wfosigw.olsztyn.pl/wp-content/uploads/2018/09/Czyste_powietrze_ulozka.pdf, viewed 10 August 2020.
- 177 Berlin.de, "Raus mit dem Öl: Berliner Heizungs austausch-programm startet", 4 June 2019, <https://www.berlin.de/rbmskz/aktuelles/pressemitteilungen/2019/pressemitteilung.817029.php>.
- 178 Hackney, "Green homes", <https://hackney.gov.uk/hlp-green-homes>, viewed 10 January 2021; Leicester from Green BELLE, "About Green BELLE", <https://www.greenbelle.org.uk/about-green-belle>, viewed 10 January 2021.
- 179 Energia Barcelona, "We'll help you to develop your renewable-energy project", <https://energia.barcelona/en/well-help-you-develop-your-renewable-energy-project>, viewed 10 January 2021.
- 180 F. Green, "The logic of fossil fuel bans", *Nature Climate Change*, vol. 8 (May 2018), pp. 449-51, http://eprints.lse.ac.uk/88114/1/Green_Fossil%20Fuel%20Bans_Accepted.pdf; F. Green, "Anti-fossil fuel norms", *Climatic Change*, vol. 150 (1 February 2018), pp. 103-16, <https://link.springer.com/article/10.1007/s10584-017-2134-6>. **Figure 11** from REN21, op. cit. note 7. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and therefore may not be exhaustive.
- 181 M. Moench, "California approves natural gas limits on new buildings in nine Bay Area cities", *San Francisco Chronicle*, 20 February 2020, <https://www.sfchronicle.com/business/article/California-approves-natural-gas-limits-on-new-15071665.php>; City of Palo Alto, "City Council Staff Report: Energy Reach Code for Building Construction" (Palo Alto: 4 November 2019), <https://www.cityofpaloalto.org/civicax/filebank/documents/73790>; REN21, op. cit. note 7. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and therefore may not be exhaustive.
- 182 K. Stark, "San Francisco could ban natural gas in new buildings", KQED, 30 June 2020, <https://www.kqed.org/science/1966631/san-francisco-could-ban-natural-gas-in-new-buildings>; J. K. Dineen, "No more natural gas in new San Francisco building starting next year", *San Francisco Chronicle*, 12 November 2020, <https://www.sfchronicle.com/bayarea/article/No-more-natural-gas-in-new-San-Francisco-15717658.php>.
- 183 REN21, op. cit. note 7.
- 184 **City Snapshot: Vancouver** based on the following sources: City of Vancouver, *City of Vancouver 2020 Action Plan: 2018-2019 Implementation Update* (Vancouver: 2019), <https://vancouver.ca/files/cov/greenest-city-action-plan-implementation-update-2018-2019.pdf>; City of Vancouver, "Renewable City Strategy 2015-2050" (Vancouver: 2015), <https://vancouver.ca/files/cov/renewable-city-strategy-booklet-2015.pdf>; City of Vancouver, "Neighbourhood Energy Strategy", <https://vancouver.ca/green-vancouver/neighbourhood-energy-strategy.aspx>, viewed 5 January 2021; Energy Manager, "B.C. funding expansion of green district heating solution in Vancouver", 2 September 2020, <https://www.energy-manager.ca/b-c-funding-expansion-of-green-district-heating-solution-in-vancouver>; City of Vancouver, "Expansion of the False Creek Neighbourhood Energy Utility"; Plumbing and HVAC, "Vancouver to ban fossil fuel appliances for low-rise buildings", 17 June 2020, <http://plumbingandhvac.ca/vancouver-to-ban-fossil-fuel-appliances-for-low-rise-buildings>.
- 185 A. Stoyanov, "Hamburg imposes ban on oil heating", *The Mayor*, 3 May 2020, <https://www.themayor.eu/en/a/view/hamburg-imposes-ban-on-oil-heating-4896>.
- 186 A. Dimitrova, "Amsterdam becomes natural gas-free by 2040", *The Mayor*, 8 April 2020, <https://www.themayor.eu/de/a/view/amsterdam-becomes-natural-gas-free-by-2040-4732>.

- 187 Foresight Climate & Energy, "Polish coal boiler phase-out: An inspiration for clean heat", 10 February 2020, <https://foresightdk.com/polish-coal-boiler-phase-out-an-inspiration-for-clean-heat>; ClientEarth, "Poland's top court upholds solid fuel ban for Krakow", 3 April 2020, <https://www.clientearth.org/latest/latest-updates/news/poland-s-top-court-upholds-solid-fuel-ban-for-krakow>; Networks, "Fossil fuel heating in new buildings to be phased out in 2020s", 13 October 2017, <https://networks.online/gas/fossil-fuel-heating-in-new-builds-to-be-phased-out-in-2020s>.
- 188 S. Vorrath, "All-electric, all-solar Canberra suburb set to launch unique home battery trial", One Step Off the Grid, 15 September 2020, <https://onestepoffthegrid.com.au/all-electric-all-solar-canberra-suburb-set-to-launch-unique-home-battery-trial>.
- 189 Ibid.
- 190 Urban Europe, "Driving urban transitions to a sustainable future (DUT)", <https://jpi-urbaneurope.eu/driving-urban-transitions-to-a-sustainable-future-dut>, viewed 20 November 2020; UNEP, *District Energy in Cities* (Paris: 2015), https://wedocs.unep.org/bitstream/handle/20.500.11822/9317/-District_energy_in_cities_unlocking_the_potential_of_energy_efficiency_and_renewable_ene.pdf.
- 191 City of Buenos Aires, "Viviendas nuevas en Containera", <https://www.buenosaires.gov.ar/jefaturadegabinete/secretaria-de-integracion-social-y-urbana/viviendas-nuevas-en-containera>, viewed 29 July 2020.
- 192 Zafrir Rinat, "Israeli cities take the lead in recycling and renewable energy", Renewables, 8 March 2018, <https://renewables.net/2018/03/08/israeli-cities-take-the-lead-in-recycling-and-renewable-energy>, viewed 20 November 2020.
- 193 Eilat Eilat, "Eilat – A Smart City", <http://www.eilateiloft.org/smart-city-eilat>, viewed 20 November 2020.
- 194 Smart Cities World, "Vienna phasing out fossil fuel use in new buildings", Euroheat & Power, 17 July 2020, <https://www.euroheat.org/news/vienna-phasing-out-fossil-fuel-new-buildings>.
- 195 AFP, "Vienna to ban oil and gas heaters for 80 percent of new homes", Yahoo News, 31 July 2019, <https://news.yahoo.com/vienna-ban-oil-gas-heaters-80-percent-homes-150040476.html>.
- 196 City of Vienna, "Climate protection areas: No more fossil fuel for new buildings", <https://www.wien.gv.at/english/environment/energy/climate-protection-areas.html>, viewed 20 November 2020.
- 197 A. Dimitrova, "First floating solar panel plant to spring up in Utrecht", The Mayor, 10 April 2020, <https://www.themayor.eu/en/a/view/first-floating-solar-panel-plant-to-spring-up-in-utrecht-4758>.
- 198 B. Pidoux, "Two Swedish cities explore collective self-consumption and new electricity market models", Energy Cities, 8 April 2020, <https://energy-cities.eu/two-swedish-cities-explore-collective-self-consumption-and-new-electricity-market-models>.
- 199 Urban Europe, "Positive energy districts (PED)", <https://jpi-urbaneurope.eu/ped>, viewed 20 November 2020.
- 200 S. Bossi, C. Gollner and S. Theierling, "Towards 100 Positive Energy Districts in Europe: Preliminary data analysis of 61 European cases", *Energies*, vol. 13, no. 22 (2020), p. 6083, <https://jpi-urbaneurope.eu/wp-content/uploads/2020/12/PED-Article-2020-energies-13-06083.pdf>.
- 201 Nantes Metropole, *Nantes European Green Capital 5 Years Report* (Nante: 2019), https://ec.europa.eu/environment/europeangreencapital/wp-content/uploads/2019/05/2019_05_24_rapport_EGC_5ans_EN_EXE3.pdf.
- 202 European Commission, "Positive Energy Districts and Neighbourhoods for urban energy transitions", <https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/lc-sc3-scc-2-2020>, viewed 20 November 2020.
- 203 Ecodistricts, "Rochester, NY, USA: High Falls Ecodistrict", August 2017, <http://ecodistricts.org/wp-content/uploads/2017/08/ed-case-study-high-falls-FINAL-august-3-2017.pdf>.
- 204 Ecodistricts, "Boston, MA, USA: Talbot-Norfolk Triangle Eco-Innovation District", June 2017, <http://ecodistricts.org/wp-content/uploads/2017/08/ed-case-study-TNT-EID-FINAL-august-3-2017.pdf>.
- 205 J. M. Takouleu, "Burkina Faso: Construction of the sustainable city of Yennenga launched", Afrik21, 20 July 2018, <https://www.afrik21.africa/en/burkina-faso-construction-of-the-sustainable-city-of-yennenga-launched>; N. Coulibaly, "Yennenga, les ambitions d'une ville nouvelle aux portes de Ouagadougou [4/8]", *Jeune Afrique*, 18 June 2020, <https://www.jeuneafrique.com/mag/989012/economie/yennenga-les-ambitions-dune-ville-nouvelle-aux-portes-de-ouagadougou-4-8>.
- 206 REN21, *Renewables 2020 Global Status Report*, op. cit. note 30.
- 207 REN21, op. cit. note 7.
- 208 Ibid.
- 209 Alcaldía de Bogotá, *Plan de Desarrollo Económico, Social y Ambiental de Bogotá 2020-2024* (Bogotá, Colombia: May 2020), pp. 2260-97, http://www.sdp.gov.co/sites/default/files/edici_n_3001_pa_123_sd_de_2020.pdf.
- 210 J. Gerdes, "UK proposes 'world first' EV charger mandate for new homes and offices", Greentech Media, 27 August 2019, <https://www.greentechmedia.com/articles/read/uk-proposes-world-first-ev-charger-mandate-for-new-homes-and-offices>.
- 211 Gough, op. cit. note 109; City of San Mateo, "Mandatory green building measures", <https://www.cityofsanmateo.org/3363/Mandatory-Green-Building-Measures>, viewed 1 August 2020; City of Vancouver, "Electric vehicles (EVs)", <https://vancouver.ca/streets-transportation/electric-vehicles.aspx>, viewed 30 September 2020.
- 212 A. Parikh, "Delhi Cabinet approves Electric Vehicle Policy", Mercom India, 26 December 2019, <https://mercomindia.com/delhi-cabinet-approves-electric-vehicle-policy>.
- 213 R. Walton, "Chicago requires new residential, commercial construction include EV charging capabilities", Utility Dive, 28 April 2020, <https://www.utilitydive.com/news/chicago-requires-new-residential-commercial-construction-include-ev-chargi/576885>.
- 214 J. Zuid, "Hydrogen-powered cities: Who, where, how?", WhatsOrb, 18 December 2019, <https://www.whatsorb.com/community/building-hydrogen-powered-cities-who-where-how>.
- 215 China SDG, "Guangzhou to develop hydrogen energy industry with RMB200 billion output by 2030", 30 June 2020, <https://www.chinasdg.org/article/guangzhou-to-develop-hydrogen-energy-industry-with-rmb200-billion-output-by-2030>; North Star Energy News, "Kunshan, Jiangsu releases hydrogen energy industry development plan (2020-2025)", 21 September 2020, <http://chuneng.bjx.com.cn/news/20200921/1105800.shtml>.
- 216 L. Jin and H. He, "Ten cities, thousand fuel cell vehicles? China is sketching a roadmap for hydrogen vehicles", ICCT, 19 August 2020, <https://theicct.org/blog/staff/china-sketching-roadmap-hydrogen-vehicles-aug2020>; Y. Sun and B. Goh, "Chinese automakers announce targets to raise hydrogen vehicle sales", *Reuters*, 15 September 2020, <https://www.reuters.com/article/china-autos-hydrogen-idUSKBN2650L0>.
- 217 REN21, op. cit. note 7.
- 218 Baden bei Wien, "Photovoltaikanlage und E-Auto – Baden fördert klimafreundliches Miteinander", https://www.baden.at/Photovoltaikanlage_und_E-Auto_-_Baden_foerdert_klimafreundliches_Miteinander_1, viewed 26 July 2020.
- 219 Empresas Públicas de Medellín, "Taxis Eléctricos EPM", <https://www.epm.com.co/site/taxis-electricos>, updated September 2019; Intendencia de Montevideo, "Nueva convocatoria para taxis 100% eléctricos", 3 September 2019, <https://montevideo.gub.uy/noticias/movilidad-y-transporte/nueva-convocatoria-para-taxis-100-electricos>; Intendencia de Montevideo Movilidad, *Estudio sobre el funcionamiento del sector de transporte por aplicaciones y sus consecuencias en el sector de transporte oneroso de pasajeros en la ciudad de Montevideo* (Montevideo: March 2019), p. 3, https://montevideo.gub.uy/sites/default/files/biblioteca/informefinal.neroso12032019_0.pdf; D. Adams, "Edinburgh councillors support proposals for fleet of electric taxis", Digit, 10 January 2019, <https://digit.fyi/electric-taxis-edinburgh-council>; Ayuntamiento de Vitoria-Gasteiz, "Solicitud de subvención para la adquisición de vehículos nuevos eléctricos puros destinados al Servicio de Taxi de Vitoria-Gasteiz", https://sedeelectronica.vitoria-gasteiz.org/j30-01s/contenidoAction.do?locale=es&uid=u4ca1cb05_16df6dcb32c__7d43, viewed 1 August 2020.
- 220 F. Jüdel, "Everything you need to know about EV incentives in the Netherlands", Wallbox, 25 June 2020, https://wallbox.com/en_catalog/netherlands-ev-incentives.
- 221 In 2020, China's NEV subsidy programme, which was supposed to expire at the end of the year, was extended to the end of 2022 in an effort to keep promoting e-mobility amid the COVID-19 pandemic. See IEA, "New Energy Vehicle (NEV) Mandate Policy", 5 December 2019, <https://www.iea.org/policies/3335-new-energy-vehicle-nev-mandate-policy>; H. Cui and H. He, "China announced 2020-2022 subsidies for new energy vehicles", ICCT, 13 July 2020, <https://theicct.org/publications/china-2020-22-subsidies-new-energy-vehicles-jul2020>.

- 222 H. He et al., *Assessment of Electric Car Promotion Policies in Chinese Cities* (Washington, DC: October 2018), https://theicct.org/sites/default/files/publications/China_city_NEV_assessment_20181018.pdf.
- 223 "Shanghai to subsidise NEV sales", Argus Media, 21 May 2020, <https://www.argusmedia.com/en/news/2107358-shanghai-to-subsidise-nev-sales>. In Shenzhen, if a citizen already owns an EV or plug-in hybrid and has it registered in their name, they can purchase another one (either a new EV or a new plug-in hybrid) and still qualify for the incentives. There is also support for new EV charging ports in the city. See J. Crider, "Shenzhen gives residents incentives to buy EVs – Tesla included", CleanTechnica, 15 June 2020, <https://cleantechnica.com/2020/06/15/shenzhen-gives-residents-incentives-to-buy-evs-tesla-included/>; Shenzhen Municipal Development and Reform Committee, "Subsidy for New Energy Vehicles 2019-2020", www.fgw.sz.gov.cn/zwgk/qt/tzgg/202002/t20200220_19018924.htm, updated 19 February 2020.
- 224 District of Columbia, "D.C. Law 22-257. CleanEnergy DC Omnibus Amendment Act of 2018" (Washington, DC: 2018), <https://code.dccouncil.us/dc/council/laws/22-257.html>; N. Riddle, "DC passed the most ambitious clean energy law in the US. Now what?" Greater Washington, 8 May 2019, <https://ggwash.org/view/71751/dc-passed-the-most-ambitious-clean-energy-law-in-the-us-now-what>; Government of the District of Columbia, "Excise tax exemption categories", 20 November 2020, <https://dmv.dc.gov/sites/default/files/dc/sites/dmv/publication/attachments/Amended-Excise-tax-exemption-categories-11-20-20.pdf>.
- 225 Ibid.
- 226 City of São Paulo, "Devolução do IPVA para veículos elétricos", February 2020, https://www.prefeitura.sp.gov.br/cidade/secretarias/meio_ambiente/inspecao_veicularold/index.php?p=246711.
- 227 A. Dimitrova, "Stimulus packages make driving a hydrogen vehicle in Arnhem more accessible", The Mayor, 4 August 2020, <https://www.themayor.eu/en/a/view/stimulus-packages-make-driving-a-hydrogen-vehicle-in-arnhem-more-accessible-5554>; H2-Drive, "De actie H2-Drive", <https://www.h2-drive.nl/de-actie-h2-drive>, viewed 25 September 2020.
- 228 Dimitrova, op. cit. note 227; H2-Drive, op. cit. note 227.
- 229 A. Hodges, North Central Texas Council of Governments, "Clean Fleets North Texas 2020 Call for Projects", Webinar, 5 November 2020, [https://www.nctcog.org/getattachment/trans/funds/cfpls/Clean-Fleets-North-Texas-2020/20201022_CFNT2020-\(1\).pdf](https://www.nctcog.org/getattachment/trans/funds/cfpls/Clean-Fleets-North-Texas-2020/20201022_CFNT2020-(1).pdf).
- 230 REN21, op. cit. note 7. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and therefore may not be exhaustive.
- 231 REN21 and FIA Foundation, *Renewable Energy Pathways in Road Transport* (London: 2020), <https://www.fiafoundation.org/media/791530/renewable-energy-pathways.pdf>; IEA, op. cit. note 35.
- 232 S. Wappelhorst, *The End of the Road? An Overview of Combustion Engine Car Phase-out Announcements in Europe* (Washington, DC: May 2020), <https://theicct.org/sites/default/files/publications/Combustion-engine-phase-out-briefing-may11.2020.pdf>.
- 233 D. Boffey, "Amsterdam to ban petrol and diesel cars and motorbikes by 2030", *The Guardian* (UK), 3 May 2019, <https://www.theguardian.com/world/2019/may/03/amsterdam-ban-petrol-diesel-cars-bikes-2030>; City of Amsterdam, *Amsterdam Climate Neutral Roadmap 2050* (Amsterdam: February 2020), https://assets.amsterdam.nl/publish/pages/887330/roadmap_climate_neutral.pdf.
- 234 Wappelhorst, op. cit. note 232.
- 235 P. Dzikiy, "Iceland moving away from ICE as capital Reykjavik aims to reduce gas stations by half by 2025", Electrek, 13 May 2019, <https://electrek.co/2019/05/13/iceland-reykjavik-gas-stations>.
- 236 **Figure 12** based on SLOCAT, op. cit. note 39; REN21, op. cit. note 7.
- 237 REN21, op. cit. note 7. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and therefore may not be exhaustive.
- 238 Oxford (UK) had plans to launch an inner-city zero-emission zone in December 2020, waiving road charges for drivers of zero-emission vehicles while charging for other vehicles. The launch was postponed amid the coronavirus pandemic. See Wappelhorst, op. cit. note 232, and Urban Access Regulations in Europe, "Corona: UK cities delay clean air zones and zero emission zones", <https://urbanaccessregulations.eu/news-and-press/1391-corona-uk-cities-delay-clean-air-zones-and-zero-emission-zones>, viewed 25 September 2020; C. Van-Ristell, "Large areas of London to be made 'car-free'", Climate Action, 19 May 2019, <http://www.climateaction.org/news/large-areas-of-london-to-be-made-car-free/>; Urban Access Regulations in Europe, "Corona: Barcelona suspends collection fines for LEZ", <https://urbanaccessregulations.eu/news-and-press/1372-corona-barcelona-suspends-collection-fines-for-lez>, viewed 26 September 2020; Urban Access Regulations in Europe, "Corona: City access regulations start to come out of lockdown", <https://urbanaccessregulations.eu/news-and-press/1383-corona-city-access-regulations-start-to-come-out-of-lockdown>, viewed 26 September 2020.
- 239 Wappelhorst, op. cit. note 232.
- 240 Y. Bernard et al., "Impacts of the Paris low-emission zone and implications for other cities", ICCT, 12 March 2020, <https://theicct.org/publications/true-paris-low-emission-zone>.
- 241 REN21, op. cit. note 7. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and therefore may not be exhaustive.
- 242 Ministry of Environmental Protection of Israel, "Low-Emission Zones", https://www.gov.il/en/departments/guides/lez_low_emission_zone, updated 1 September 2020.
- 243 For example, in Norway, since 2017, it has been up to the local governments to decide the incentives regarding access to bus lanes (which are usually off-limits to private vehicles) and free municipal parking. In 2019, the Norwegian Parliament set a 50% rule under which counties and municipalities cannot charge EV users more than 50% of the full price of fares on ferries, public parking and tolls. See Norsk elbilforening, "Norwegian EV Policy", <https://elbil.no/english/norwegian-ev-policy>, viewed 25 September 2020; K. Joshi, "The electric recipe of Norway's zero emissions transport boom", *The Driven*, 10 July 2020, <https://thedriven.io/2020/07/10/the-electric-recipe-of-norways-zero-emissions-transport-boom>.
- 244 Jüdel, op. cit. note 220; Transport Decarbonisation Alliance, *Zero Emission Urban Freight* (May 2019), <http://tda-mobility.org/wp-content/uploads/2019/05/TDA-Zero-Emission-Urban-Freight.pdf>.
- 245 For instance, Shenzhen exempts daily first-hour street parking fees for NEVs. In Hefei, NEV users get five hours of free parking, twice per day, in parking lots owned by the local government, and they can have up to two hours of free street parking and half of the regular rate for any extra time. See X. Li, S. Qiu and G. Shi, "3 lessons from China's rocket growth in electric vehicles", *The City Fix*, 5 August 2020, <https://thecityfix.com/blog/3-lessons-chinas-rocket-growth-electric-vehicles-xiangyi-li-shiyong-qiu-ge-shi>; Transport Decarbonisation Alliance, op. cit. note 244.
- 246 A. Moloney, "10 global cities charting a green recovery from coronavirus", Thomson Reuters Foundation News, 16 July 2020, <https://news.trust.org/item/20200716113048-9jhn0>; Parikh, op. cit. note 212.
- 247 E. O'Shaughnessy et al., *Community Choice Aggregation: Challenges, Opportunities, and Impacts on Renewable Energy Markets* (Golden, CO: National Renewable Energy Laboratory, February 2019), <https://www.nrel.gov/docs/fy19osti/72195.pdf>; J. St. John, "California's Community Choice Aggregators are filling the gaps in EV charger investment", Greentech Media, 14 August 2019, <https://www.greentechmedia.com/articles/read/california-cca-peninsula-clean-energy-launches-ev-charging-rollout>.
- 248 F. Wehinger, Friedrich-Ebert-Stiftung, Jordan, personal communication with REN21, 31 August 2020; Friedrich-Ebert-Stiftung, *Recommendations on E-Mobility in Jordan* (Amman: June 2019), <http://library.fes.de/pdf-files/bueros/amman/15635.pdf>.
- 249 Climate Mayors, "What is the Collaborative?", <https://driveevfleets.org/what-is-the-collaborative>, viewed 20 September 2020.
- 250 Wappelhorst, op. cit. note 232; C40 Cities, "Our Commitment to Green and Healthy Streets: Fossil Fuel Free Streets Declaration", <https://www.c40.org/other/green-and-healthy-streets>, viewed 20 September 2020.

MARKETS AND INFRASTRUCTURE

- 1 M. Motyka, "Renewables (em)power smart cities", Deloitte, 5 March 2019, <https://www2.deloitte.com/us/en/insights/industry/power-and-utilities/smart-renewable-cities-wind-solar.html>.
- 2 International Energy Agency (IEA), "The covid-19 crisis and clean energy progress", in *Tracking Clean Energy Progress* (Paris: 2020), <https://www.iea.org/reports/the-covid-19-crisis-and-clean-energy-progress/transport#abstract>.
- 3 Based on examples and sources cited throughout this chapter.
- 4 P. Droege, *Urban Energy Transition: Renewable Strategies for Cities and Regions* (Amsterdam: Elsevier, 2018), <https://www.elsevier.com/books/urban-energy-transition/droege/978-0-08-102074-6>; International Renewable Energy Agency (IRENA), *Rise of Renewables in Cities* (Abu Dhabi: 2020), https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Oct/IRENA_Renewables_in_cities_2020.pdf. See also examples and sources cited throughout this chapter.
- 5 Renewable Energy Policy Network for the 21st Century (REN21), *Renewables 2020 Global Status Report* (Paris: 2020), https://www.ren21.net/wp-content/uploads/2019/05/gsr_2020_full_report_en.pdf.
- 6 **Sidebar 5** from the following sources: S. Kaza *et al.*, *What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050* (Washington, DC: World Bank, 2018), https://datatopics.worldbank.org/what-a-waste/trends_in_solid_waste_management.html; M. Yan, J. Waluyo and P. Agamuthu, "Challenges for sustainable development of waste to energy in developing countries", *Waste Management & Research*, vol. 38, no. 3 (2020), pp. 229-31, <https://journals.sagepub.com/doi/pdf/10.1177/0734242X20903564>; European Biogas Association (EBA), *European Biogas Association Statistical Report: 2019 European Overview* (Brussels: January 2020), <https://www.europeanbiogas.eu/eba-statistical-report-2019-european-overview>; S. Jain, *Global Potential of Biogas* (London: World Biogas Association, June 2019), https://www.worldbiogasassociation.org/wp-content/uploads/2019/07/WBA-globalreport-56ppa4_digital.pdf; Bioenergy Insight, "EPA approves second biogas facility at Melbourne Regional Landfill", 17 September 2020, <https://www.bioenergy-news.com/news/epa-approves-second-biogas-facility-at-melbourne-regional-landfill>; A. Karidis, "Los Angeles to combine food waste, biosolids for massive energy project", *Waste360*, 11 March 2019, <https://www.waste360.com/anaerobic-digestion/los-angeles-combine-food-waste-biosolids-massive-energy-project>; L. Dawson, "How cities are turning food into fuel!", *Politico*, 21 November 2019, <https://www.politico.com/news/magazine/2019/11/21/food-waste-fuel-energy-sustainability-070265>; A. Sherrard, "Construction start for New Zealand's first large-scale food waste-to-bioenergy plant", *Bioenergy International*, 6 August 2020, <https://bioenergyinternational.com/biogas/construction-start-for-new-zealands-first-large-scale-food-waste-to-bioenergy-plant>; EBA, "The 'European Biomethane Map 2020' shows a 51% increase of biomethane plants in Europe in two years", press release (Brussels: June 2020), https://www.europeanbiogas.eu/wp-content/uploads/2020/06/Biomethane-map_Press-Release_EBA_GiE.pdf; Sustainable Bus, "Lille, the biomethane fleet by Keolis and Iveco Bus", 22 May 2018, <https://www.sustainable-bus.com/cng-Ing/lille-buses-cng-biomethane-iveco-bus-keolis>; Bioenergy Insight, "77 biomethane-powered buses launched in Bristol, UK", 18 February 2020, <https://www.bioenergy-news.com/news/77-biomethane-powered-buses-launched-in-bristol-uk>; Confederation of European Waste-to-Energy Plants, "First tonnes of CO₂ captured from residual waste supplied to greenhouse horticulture", 8 October 2019, <https://www.cewep.eu/avr-duiven-ccu>; D. T. Kearns, *Waste-to-Energy with CCS: A Pathway to Carbon-Negative Power Generation* (Melbourne: Global CCS Institute, 2019), https://www.globalccsinstitute.com/wp-content/uploads/2019/10/Waste-to-Energy-Perspective_October-2019-5.pdf; Aguas Andinas, *Integrated Report 2019*, https://www.aguasandinasinversionistas.cl/~/_media/Files/A/Aguas-IR-v2/annual-reports/en/integrated-report-aguas-andinas-2019-v1.pdf; City of Toronto, "Turning waste into renewable natural gas", <https://www.toronto.ca/services-payments/recycling-organics-garbage/solid-waste-facilities/renewable-natural-gas>, viewed 7 December 2020; Fortum, "A full-scale carbon capture and storage (CCS) project initiated in Norway", <https://www.fortum.com/media/2018/11/full-scale-carbon-capture-and-storage-ccs-project-initiated-norway>, viewed 26 January 2021.
- 7 Greenhouse Gas Protocol, "GHG Protocol for Cities – An Accounting and Reporting Standard for Cities", https://ghgprotocol.org/sites/default/files/standards/GHGP_GPC_0.pdf, viewed 23 January 2021.
- 8 Another trend that sources included is working with utilities to achieve shared goals, which this chapter discusses in the text focused on overcoming challenges. L. Shaver, "Watch these 4 clean energy trends in U.S. cities in 2020", World Resources Institute (WRI) Blog, 23 January 2020, <https://www.wri.org/blog/2020/01/watch-these-4-clean-energy-trends-us-cities-2020>; L. Shaver, "4 creative ways cities are transitioning to a clean energy future", WRI Blog, 26 February 2020, <https://www.wri.org/blog/2019/02/4-creative-ways-cities-are-transitioning-clean-energy-future>. See also information and sources cited throughout this chapter.
- 9 J. Duncan and C. Bonugli, "How cities and utilities can form partnership agreements to accelerate climate action", Institute for Market Transformation (IMT), 26 September 2019, <https://www.imt.org/how-cities-and-utilities-can-form-partnership-agreements-to-accelerate-climate-action>; IRENA, op. cit. note 4; IEA, *Status of Power System Transformation 2019* (Paris: 2019), <https://www.iea.org/reports/status-of-power-system-transformation-2019>.
- 10 K. Crandall, "Going for 100% renewables? Why partnerships between cities and utility regulators matter more than ever before", IMT, 17 October 2018, <https://www.imt.org/going-for-100-renewables-why-partnerships-between-cities-and-utility-regulators-matter-more-than-ever-before>; Shaver, "Watch these 4 clean energy trends in U.S. cities in 2020", op. cit. note 8; Duncan and Bonugli, op. cit. note 9.
- 11 **Box 1** based on the following sources: IRENA, *Renewable Energy in Cities* (Abu Dhabi: October 2016), https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2016/IRENA_Renewable_Energy_in_Cities_2016.pdf; R. Libatique, "Calls on councils to improve street lighting to prevent road crashes", *Insurance Business Australia*, 20 November 2020, <https://www.insurancebusinessmag.com/au/news/breaking-news/calls-on-councils-to-improve-street-lighting-to-prevent-road-crashes-239645.aspx>; SmartCitiesWorld, "Smart solar lighting deployed at Tampa's master-planned community", 19 October 2020, <https://www.smartcitiesworld.net/news/news/smart-solar-lighting-deployed-at-tampas-master-planned-community-5776>; D. Branco, "The city shines a light on a solar-powered street lamp", *CKPGToday*, 2 June 2020, <https://ckpgtoday.ca/2020/06/02/the-city-shines-a-light-on-a-solar-powered-street-lamp>; J. M. Takoueu, "Senegal: Fonroche completes 50% installation of 50,000 solar street lights", *Afrik21*, <https://www.afrik21.africa/en/senegal-fonroche-completes-50-installation-of-50000-solar-street-lights>; L. M. Sonpon III, "12 towns in rural Bong County get solar street lights", *Daily Observer*, 20 January 2020, <https://www.liberianobserver.com/news/12-towns-in-rural-bong-county-get-solar-street-lights>; J. M. Takoueu, "Cameroon: Fonroche installs solar street lamps in Yaoundé", *Afrik21*, 29 September 2019, <https://www.afrik21.africa/en/cameroon-fonroche-installs-solar-street-lamps-in-yaounde>; I. Magoum, "Nigeria: Lagos tries out solar-powered traffic lights", *Afrik21*, 1 April 2020, <https://www.afrik21.africa/en/nigeria-lagos-tries-out-solar-powered-traffic-lights>; L. Feukeng, "Benin: Start-up Alivo makes traffic light eco-friendly with solar energy", *Afrik21*, 22 January 2020, <https://www.afrik21.africa/en/benin-start-up-alivo-makes-traffic-light-eco-friendly-with-solar-energy>; A. Ojha, "Lalitpur to install 669 smart electric lamps on three routes", *Kathmandu Post*, 29 July 2020, <https://kathmandupost.com/national/2020/07/29/lalitpur-to-install-669-smart-electric-street-lamps-on-three-routes>; "Traffic, street lighting nightmare in Harare", *The Herald*, 12 December 2020, <https://www.herald.co.zw/traffic-street-lighting-nightmare-in-harare>; G. Mutegeki, "KCCA steps up plans to install lights on Kampala streets", *New Vision*, 19 November 2020, <https://www.newvision.co.ug/news/1532664/kcca-steps-plans-install-lights-kampala-streets>; F. Mthupha, "Fixing faulty street lights proves a challenge in Ekurhuleni", *Boksburg Advertiser*, 6 October 2020, <https://boksburgadvertiser.co.za/396016/fixing-faulty-street-lights-proves-a-challenge-in-ekurhuleni>.
- 12 T. Gonçalves and Y. Liu, "How US cities and counties are getting renewable energy", WRI Blog, 24 June 2020, <https://www.wri.org/blog/2020/06/renewable-energy-procurement-cities-counties>.
- 13 Ibid. See also the following: Office of the Mayor, "Mayor Cranley announces water works to go solar", press release (Cincinnati, OH: 28 June 2017), <https://www.cincinnati-oh.gov/mayor/news/mayor-cranley-announces-water-works-to-go-solar>; LA Mayor, "Mayor Garcetti announces completion of new rooftop solar project", press release (Los Angeles: 24 February 2016), <https://www.lamayor.org/mayor-garcetti-announces-completion-new-rooftop-solar-project>; J. Williams, "City Council approves first steps towards 'community solar' power program", *NOLA*, 21 June 2018,

- https://www.nola.com/news/article_04df5db1-f15f-5c41-a073-f0c65af300f8.html. In-city solar PV capacity was about 419.9 MW in Los Angeles, followed by San Diego (351 MW in 2018), Phoenix (235 MW) Honolulu (227 MW) and San Jose (201 MW), with 30 MW in Tallahassee as of 2018 and 19 MW in Santa Fe, all from Environment America and Frontier Group, *Shining Cities 2019: The Top U.S. Cities for Solar Energy* (Washington, DC: April 2019), https://environmentamerica.org/sites/environment/files/reports/WEB_AME_Shining-Cities_2019_040919-v1.pdf.
- 14 Environment America and Frontier Group, op. cit. note 13.
- 15 Ibid., p. 6. San Diego was second after Honolulu, with 247.5 watts (W) per inhabitant, from Ibid. For comparison, the top three countries at end-2019 were Germany (595 W), Australia (585 W) and Japan (497 W), from IEA Photovoltaic Power Systems Programme, *Snapshot of Global PV Markets 2020* (Paris: April 2020), p. 7, https://iea-pvps.org/wp-content/uploads/2020/04/IEA_PVPS_Snapshot_2020.pdf.
- 16 Other factors include relatively modest solar resources and less open land compared with other regions of the country. From Gonçalves and Liu, op. cit. note 12.
- 17 Metropolitan Transportation Authority, "MTA Solar", <https://new.mta.info/sustainability/mta-solar>, updated 16 December 2020; C. Splvack, "MTA looks to rooftop solar power to raise much-needed funds", *Curbed*, 23 April 2019, <https://ny.curbed.com/2019/4/23/18511589/mta-nyc-transit-leases-rooftop-solar-power-profits>; M. Bates, "NYPA, City of New York issue RFP for rooftop solar arrays", *Solar Industry Magazine*, 1 July 2020, <https://solarindustrymag.com/ny-pa-city-of-new-york-issue-rfp-for-rooftop-solar-arrays>; "NYPA and City of New York seek developersto install solar at dozens of NYC schools", *Renewable Energy Magazine*, 1 July 2020, https://www.renewableenergymagazine.com/pv_solar/ny-pa-and-city-of-new-york-seek-20200701.
- 18 J. Addison, "How the cleanest U.S. cities are progressing toward zero carbon", *GreenBiz*, 23 October 2019, <https://www.greenbiz.com/article/how-cleanest-us-cities-are-progressing-toward-zero-carbon>.
- 19 CDP, "Case studies: Fayetteville", <https://www.cdp.net/en/articles/cities/fayetteville>, viewed 17 December 2020; City of Fayetteville Arkansas, "Solar array project", <https://www.fayetteville-ar.gov/3536/Solar-Array-Project>, viewed 17 December 2020.
- 20 Energo, "Description of the power plant", https://www.energo.ua/ua/assets/tpp_na_biopalyvi_ayaks_dnipro_1_stage (using Google Translate), viewed 17 December 2020.
- 21 Glasgow City Council, "Glasgow Recycling and Renewable Energy Centre opens officially", press release (Glasgow: 20 August 2019), <https://www.glasgow.gov.uk/article/24884/Glasgow-Recycling-and-Renewable-Energy-Centre-opens-officially>.
- 22 M. Lempriere, "Exeter City Council's 1.2MW solar site takes a step forwards", *Solar Power Portal*, 7 July 2020, https://www.solarpowerportal.co.uk/news/exeter_city_councils_1.2mw_solar_site_takes_a_step_forwards.
- 23 A. Manos, "Photovoltaics in 50 schools in the municipality of Athens", *Ecopress*, 29 June 2020, <https://ecopress.gr/fotovoltaika-se-50-scholia-tou-dimou-athineon> (using Google Translate); Kaunas City Municipal Administration, "Kaunas green ambitions will receive financial support – solar power plants will be built not only on schools", press release (Kaunas: 19 May 2020), <http://en.kaunas.lt/news/kaunas-green-ambitions-will-receive-financial-support-solar-power-plants-will-be-built-not-only-on-schools>.
- 24 A. Dimitrova, "960 renewable energy installations will improve air quality in Tychy", *The Mayor*, 4 July 2020, <https://www.themayor.eu/en/a/view/960-renewable-energy-installations-will-improve-air-quality-in-tychy-5292>.
- 25 Z. Shahan, "First Solar's thin-film PV modules chosen for largest urban solar power plant in Europe", *CleanTechnica*, 25 September 2020, <https://cleantechnica.com/2020/09/25/first-solars-thin-film-pv-modules-chosen-for-largest-urban-solar-power-plant-in-europe/>; "Bordeaux: 59 MW PV plant on disused landfill", *PV Europe*, 28 September 2020, <https://www.pveurope.eu/installation/bordeaux-59-mw-pv-plant-disused-landfill>; JP Énergie Environnement, "[CONSTRUCTION] Centrale photovoltaïque de Labarde", 19 June 2020, <https://www.jpee.fr/construction-centrale-photovoltaïque-de-labarde>.
- 26 "Diu Smart City 1st in India to run on 100% renewable energy during day", *ETEnergyworld*, 24 April 2018, <https://energy.economictimes.indiatimes.com/news/renewable/diu-smart-city-first-in-india-to-run-on-100-pc-renewable-energy-during-daytime-official/63889099>. See also, for example, N. T. Prasad, "Karnataka's Tumakuru Smart City releases tender for 1.2 MW of rooftop solar projects", *Mercom India*, 21 July 2020, <https://mercomindia.com/tumakuru-smart-city-releases-tender>; N. T. Prasad, "Vellore Smart City issues tender for 1.2 MW of solar projects", *Mercom India*, 16 July 2020, <https://mercomindia.com/vellore-smart-city-tender-solar-projects>.
- 27 A. Parikh, "Delhi to shut Rajghat Thermal Power Project, use land for 5 MW solar park", *Mercom India*, 15 July 2019, <https://mercomindia.com/delhi-rajghat-thermal-project-solar-park>.
- 28 K. Singh, "Pune has stolen a march over other cities in India's rooftop solar energy race", *Quartz India*, 6 November 2019, <https://qz.com/india/1742584/pune-has-stolen-a-march-over-other-cities-in-indias-rooftop-solar-energy-race>.
- 29 Ibid.
- 30 A. Gupta, "Bespoke solar developer NEFIN installs the city's largest solar panel system at Hong Kong Disneyland Resort", *EQ International*, 16 January 2020, <https://www.eqmagpro.com/bespoke-solar-developer-nefin-installs-the-citys-largest-solar-panel-system-at-hong-kong-disneyland-resort>.
- 31 See, for example: "Xinyi launches 31MWp rooftop solar PV system project", *Borneo Post Online*, 7 January 2020, <https://www.theborneopost.com/2020/01/07/xinyi-launches-31mw-rooftop-solar-pv-system-project>; A. Aziz, "Solarvest wins rooftop solar project worth RM29.2 mil", *The Edge Markets*, 23 April 2020, <https://www.theedgemarkets.com/article/solarvest-wins-rooftop-solar-project-worth-rm292-mil>; "Mydin, first retail chain to go solar", *New Strait Times*, 19 September 2019, <https://www.nst.com.my/news/nation/2019/09/522652/mydin-first-retail-chain-go-solar>; A. C. Shankara, "Advanceon inks MoU to install solar power system at Mydin outlet in Bandar Seremban Utama", *The Edge Markets*, 6 August 2020, <https://www.theedgemarkets.com/article/advanceon-inks-mou-instal-solar-power-system-mydin-outlet-bandar-seremban-utama>.
- 32 The rooftops of the Secretariat of Economic Development (Sedeco) were fitted with solar PV systems of 47.3 kWp and 45.1 kWp with the main goal of curbing pollution in the Mexican capital. The PV arrays will generate around 140,000 kWh of renewable power, avoid the emission of 75 tonnes of CO₂ and help Sedeco save up to MXN 600,000 (USD 30,160) in electricity bills each year. The Ciudad Solar programme plans to support the installation of rooftop solar PV and other clean power schemes that will add up to 350 MW of renewable capacity in the 2019-2024 period. From S. Djunicic, "Mexico City kicks off Ciudad Solar programme with first PV arrays", *Renewables Now*, 4 February 2020, <https://renewablesnow.com/news/mexico-city-kicks-off-ciudad-solar-programme-with-first-pv-arrays-685973>.
- 33 This is part of Walmart's efforts to power all of its facilities with 100% renewable energy by 2035. K. Pickerel, "Walmart plans to go 100% renewable by 2035", *Solar Power World*, 21 September 2020, <https://www.solarpowerworldonline.com/2020/09/walmart-plans-to-go-100-renewable-by-2035/>; Ginlong Technologies, "Solis powers 4MWs of solar for Walmart in Mexico – high-efficiency Solis 60kW advances retail giant's green goals", 19 March 2020, <https://www.ginlong.com/conews/33079.html>.
- 34 Bancolombia, "Con paneles solares, Bancolombia dejará de emitir más de 420 toneladas de CO₂ cada año", 31 January 2020, <https://www.grupobancolombia.com/wps/portal/acerca-de/sala-prensa/noticias/responsabilidad-social-ambiental/paneles-solares-bancolombia>; GreenYellow, "Gracias a la alianza entre Diverplaza y GreenYellow el noroccidente de Bogotá respire un aire más limpio", 31 July 2020, <https://www.greenyellow.co/gracias-a-la-alianza-entre-diverplaza-y-greenyellow-el-noroccidente-de-bogota-respira-un-aire-mas-limpio>.
- 35 Agencia Nacional de Energia Eléctrica (ANEEL), "Geracao distribuida", <https://app.powerbi.com/view?r=eyJrIjoiZjM4NjM0OWYtN2IwZS00YjVlTlMjN2E5MzBkN2ZlMzVklwiidCI6IjQwZDZmOWI4LWVjYtctNDZhMio0MmQ0LWVhNGU5YzAxNzBIMS01slmMiOjR9>, viewed 12 January 2021; Prefeitura de Uberlândia, "Uberlândia volta a ser a 1ª do país em geração de energia fotovoltaica", 13 August 2020, <https://www.uberlandia.mg.gov.br/2020/08/13/uberlandia-volta-a-ser-a-1a-do-pais-em-geracao-de-energia-fotovoltaica>.

- 36 "Op-Ed: DER much more than rural electrification in Africa", *ESI Africa*, 3 April 2020, <https://www.esi-africa.com/industry-sectors/renewable-energy/op-ed-der-much-more-than-rural-electrification-in-africa>; M. Hankins, "How green energy and new technologies will impact Kenya's power sector", *The Elephant*, 10 May 2019, <https://www.theelephant.info/ideas/2019/05/10/how-green-energy-and-new-technologies-will-impact-kenyas-power-sector>; United Nations Environment Programme (UNEP) DTU Partnership, *Clean Captive Power: Understanding the Uptake and Growth of Commercial and Industrial (C&I) Solar PV in Kenya* (Paris: 2020), p. 9, <https://unepdtu.org/wp-content/uploads/2020/05/temarin-kenya-report-web2.pdf>. **City Snapshot: Cocody** based on the following sources: Mairie de Cocody, "Cocody", <http://mairiecocody.com>, viewed 5 January 2021; CDP, "2018-2019 City-Wide Emissions", CDP Open Data Portal, <https://data.cdp.net/Emissions/2018-2019-City-wide-Emissions/mkj4-km9s>; United Nations Framework Convention on Climate Change, "Contributions prevues determinees au niveau national de la Côte d'Ivoire", 2015, https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/C%3C3%B4te%20d%27Ivoire%20First/INDC_CI_22092015.pdf; Maire de Cocody, *Climate Action Plan Cocody* (Santa Monica, CA: Earth Rights Institute, 2017), https://www.earthrightsinstiute.org/images/pubs/Climate_Action_plan_DEF_Englishfinal.pdf.
- 37 J. M. Takoueu, "Libya: Government launches construction of a solar power plant in Kufra", *Afriki21*, 16 April 2020, <https://www.afriki21.africa/en/libya-government-launches-construction-of-a-solar-power-plant-in-kufra>.
- 38 J. M. Takoueu, "DRC: Nuru connects 1.3 MW solar off-grid hybrid in Goma", *Afriki21*, 7 February 2020, <https://www.afriki21.africa/en/drc-nuru-connects-1-3-mw-solar-off-grid-hybrid-in-goma>.
- 39 J. M. Takoueu, "Egypt: Benha and Suntech to build solar power plants (18 MWp) in NAC", *Afriki21*, 23 July 2020, <https://www.afriki21.africa/en/egypt-benha-and-suntech-to-build-solar-power-plants-18-mwp-in-nac>.
- 40 J. M. Takoueu, "Kenya: Equator Energy provides 1 MW mini solar power plant in Tatu City", *Afriki21*, 2 October 2019, <https://www.afriki21.africa/en/kenya-equator-energy-provides-1-mw-mini-solar-power-plant-in-tatu-city>. Coca-Cola has installed 11 off-grid solar PV plants totalling 10.5 MW across its production plants in South Africa, from J. M. Takoueu, "Namibia: Coca-Cola sets up off-grid on rooftop at Windhoek plant", *Afriki21*, 30 September 2019, <https://www.afriki21.africa/en/namibia-coca-cola-sets-up-off-grid-on-rooftop-at-windhoek-plant>.
- 41 Overall, the surface area that will be exploited in the two Maroc Bureau factories is 9,820 m². The total power of the plants is expected to be around 800 kW per hour, which will meet 70% of the plants' electricity consumption. From B. Ngounou, "Morocco: Maroc Bureau installs photovoltaic systems at its factories", *Afriki21*, 12 June 2020, <https://www.afriki21.africa/en/morocco-maroc-bureau-installs-photovoltaic-systems-at-its-factories>.
- 42 Dubai Electricity & Water Authority, "DEWA's Shams Dubai connects 1,354 buildings totalling 125 MW of power", 8 October 2019, <https://www.dewa.gov.ae/en/about-us/media-publications/latest-news/2019/10/dewas-shams-dubai-connects-1354-buildings-totalling-125mw-of-power>.
- 43 Tel Aviv Government, "Smart City – environment & energy", <https://www.tel-aviv.gov.il/en/abouttheCity/Pages/SmartEnvironment.aspx>, viewed 2 October 2020.
- 44 In the UK, for example, around 5,500 churches were using 100% renewable energy to power their operations as of 2018, and in 2019 the first purpose-built eco mosque, the Central Mosque in Cambridge, opened with rooftop solar PV panels generating enough electricity to meet a third of the mosque's energy requirements. From S. Hanley, "5,500 churches in UK have switched to renewable energy", *CleanTechnica*, 5 August 2018, <https://cleantechnica.com/2018/08/05/5500-churches-in-uk-have-switched-to-renewable-energy/>; M. Teller, "Green mosques generate positive energy", *AramcoWorld*, July/August 2020, <https://www.aramcoworld.com/Articles/July-2020/Green-Mosques-Generate-Positive-Energy>. In the United States, seven Catholic communities in the Catholic Diocese of Richmond (Virginia) were completing solar projects (for a combined 1.3 MW) during 2020, from Renewable Energy World, "1.3 MW of solar capacity installed on churches and schools in Virginia", 27 August 2020, <https://www.renewableenergyworld.com/2020/08/27/1-3-mw-of-solar-capacity-installed-on-churches-and-schools-in-virginia>.
- 45 Teller, op. cit. note 44.
- 46 L. Feukeng, "Morocco: Hassan-II Mosque drastically reduces impacts (at zero cost)", *Afriki21*, 15 October 2019, <https://www.afriki21.africa/en/morocco-hassan-ii-mosque-dramatically-reduces-impacts-at-zero-cost>; Teller, op. cit. note 44.
- 47 Monash University, "Monash to become Australia's first 100 per cent renewable energy powered university", 9 October 2017, <https://www.monash.edu/news/articles/monash-to-become-australias-first-100-per-cent-renewable-energy-powered-university>; Monash University, *Monash Net Zero Initiative* (Melbourne: July 2019), https://bridges.monash.edu/articles/report/NetZero_Brochure/9189635.
- 48 Ibid., both references.
- 49 M. Mazengarb, "Melbourne airport's massive behind-the-meter solar farm nears completion", *One Step Off the Grid*, 4 August 2020, <https://onestepoffthegrid.com.au/melbourne-airports-massive-behind-the-meter-solar-farm-nears-completion>.
- 50 See, for example: "200 solar panels installed on Shoalhaven Entertainment Centre rooftop", *Australasian Leisure Management*, 14 October 2019, <https://www.ausleisure.com.au/news/200-solar-panels-installed-on-shoalhaven-entertainment-centre-rooftop>; "Solar panels installed on Aquamoves' rooftops", *Australasian Leisure Management*, 24 June 2020, <https://www.ausleisure.com.au/news/solar-panels-installed-on-aquamoves-rooftops>; "Mosman Sports Centre installs new solar panels while recycling the old", *Australasian Leisure Management*, 23 June 2020, <https://www.ausleisure.com.au/news/mosman-sports-centre-installs-new-solar-panels-while-recycling-the-old>.
- 51 RDT Pacific, "Foodstuffs to install NZ's largest array of solar panels", <https://www.rdtpacific.co.nz/news/foodstuffs-to-install-nzs-largest-array-of-solar-panels>, viewed 27 January 2021; Foodstuffs Limited, "Foodstuffs to install NZ's largest array of solar panels", press release (Auckland: 28 January 2020), <https://www.scoop.co.nz/stories/BU2001/S00191/foodstuffs-to-install-nzs-largest-array-of-solar-panels.htm>.
- 52 See, for example: American Cities Climate Challenge, "Procurement guidance: Green tariff", <https://cityrenewables.org/green-tariffs>, viewed 17 December 2020; US Environmental Protection Agency (US EPA), "Utility green tariffs", <https://www.epa.gov/greenpower/utility-green-tariffs>, viewed 17 December 2020. **Box 2** based on the following sources: L. Tawney, M. Sotos and E. Holt, *Describing Purchaser Impact in U.S. Voluntary Renewable Energy Markets* (Washington, DC: US EPA, April 2018), https://www.epa.gov/sites/production/files/2018-06/documents/gpp_describing_purchaser_impact.pdf; Urban Grid, "Achieving sustainability goals through additionality", <https://www.urbangridsolar.com/achieving-sustainability-goals-through-additionality>, viewed 16 December 2020; J. Bieller, "What you need to know about additionality", *Schneider Electric Perspectives*, 10 September 2018, <https://perspectives.se.com/renewable-energy/what-you-need-to-know-about-additionality>; T. Day et al., *Navigating the Nuances of Net-zero Targets* (NewClimate Institute and Data-Driven EnviroLab, October 2020), https://newclimate.org/wp-content/uploads/2020/10/NewClimate_NetZeroReport_October2020.pdf; REN21, *Renewables 2018 Global Status Report* (Paris: 2018), <https://www.ren21.net/wp-content/uploads/2019/08/Full-Report-2018.pdf>; J. Mühlenhoff, "Why most 'green' electricity in Europe isn't green", *Energy Post*, 27 October 2016, <https://energypost.eu/green-electricity-europe-isnt-green>; T. Juliani, *Renewable Energy, Additionality, and Impact* (Newport Beach, CA: Edison Energy, 2018), https://www.smartenergydecisions.com/upload/whitepapers/ee_wp_rea_faq_jan_2018.pdf; Bolt, "Belgian energy platform Bolt causes a stir in Reykjavik when 1000 guarantees of origin are returned to the Icelandic prime minister" press release (Reykjavik: 7 August 2020), <https://bolt.prezly.com/belgisch-energieplatform-bolt-veroorzaakt-ophef-in-reykjavik-bij-teruggave-van-1000-garanties-van-oorsprong-aan-ijslandse-premier> (using Google Translate); P. Arnjóltsdóttir, "Belgian company returns guarantees of origin", *RÚV*, 7 August 2020, <https://www.ruv.is/frett/2020/08/07/belgiskt-fyrirtaeki-skilar-upprunaabyrgdum> (using Google Translate); RE100, *Accelerating Change: How Corporate Users Are Transforming the Renewable Energy Market, Annual Report 2017* (London: 2017), <http://www.indiaenvironmentportal.org.in/content/439090/accelerating-change-how-corporate-users-are-transforming-the-renewable-energy-market/>; K-E. Stromsta, "Texas is the center of the global corporate renewable energy market", *Greentech Media*, 28 January 2020, <https://www.greentechmedia.com/articles/read/texas-is-the-center-of-the-global-corporate-renewable-energy>

- market; A. Shpitsberg, "Corporate renewable procurement pushing solar and wind deployment", HIS Markit, 27 September 2019, <https://ihsmarkit.com/research-analysis/corporate-renewable-procurement-pushing-solar-and-wind-deploy.html>; S. Dunlop, Senior Policy Adviser, SolarPower Europe/RE-Source Platform, "Companies going for 100% renewables in Europe", presentation, 2019, https://www.renewable-ei.org/pdfdownload/activities/Keynote_SoniaDunlop_EN.pdf; F. Simon, "Calls grow for EU-wide certificates to boost market for 'green gas'", Euractiv, 3 October 2019, <https://www.euractiv.com/section/energy/news/calls-grow-for-eu-wide-certificates-to-boost-market-for-green-gas>; Green Gas Certification Scheme, "Additionality", <https://www.greengas.org.uk/certificates/additionality>, viewed 16 December 2020.
- 53 United States from A. Rotatori and C. Bonugli, "Mapping out Charlotte's lead on green tariffs", GreenBiz, 5 March 2020, <https://www.greenbiz.com/article/mapping-out-charlottes-lead-green-tariffs>. In Europe, the market is focused almost entirely on corporate purchases, from Simon, op. cit. note 52.
- 54 US EPA, "Green power communities", <https://www.epa.gov/greenpower/green-power-communities>, updated 27 July 2020.
- 55 City of Charlotte, "Green Source Advantage Program – Solar Energy Project", https://charlottenc.gov/sustainability/seap/Pages/Green_Source_Advantage.aspx, viewed 17 December 2020; City of Charlotte, "Strategic Energy Action Plan", <https://charlottenc.gov/sustainability/seap/Pages/default.aspx>, viewed 17 December 2020.
- 56 Simon, op. cit. note 52.
- 57 Ibid.; M. Perez, "As demand for 'green' power soars utilities turn to Guarantees of Origin", S&P Global Platts, 7 August 2019, <https://blogs.platts.com/2019/08/07/eu-green-electricity-guarantees-of-origin>.
- 58 I. M. Poxton, "Borough buildings and street lights will switch to 100% renewable energy", Bedford Independent, 25 November 2020, <https://www.bedfordindependent.co.uk/borough-buildings-and-street-lights-to-run-on-100-green-renewable-energy-from-2021>.
- 59 See information and sources throughout this section.
- 60 Shaver, "Watch these 4 clean energy trends in U.S. cities in 2020", op. cit. note 8; S. Enkhardt, "Europe has now 8.4 GW of planned and built PV projects under PPAs", pv magazine, 29 January 2020, <https://www.pv-magazine.com/2020/01/29/europe-has-now-8-4-gw-of-planned-and-built-pv-projects-under-ppas>; M. Lempriere, "City of London Corporation signs first of its kind £40m PPA for Dorset solar site", Solar Power Portal, 18 November 2020, https://www.solarpowerportal.co.uk/news/city_of_london_corporation_signs_first_of_its_kind_40m_ppa_for_dorset_solar.
- 61 See, for example: N. Filatoff, "Solar auctions to spread PV over the commercial landscape", pv magazine, 28 September 2020, <https://www.pv-magazine.com/2020/09/28/solar-auctions-to-spread-pv-over-the-commercial-landscape>; S. Djunicic, "Iberdrola signs corporate PPA for 100 MW of PV for on-site consumption", Renewables Now, 29 July 2020, <https://renewablesnow.com/news/iberdrola-signs-corporate-ppa-for-100-mw-of-pv-for-on-site-consumption-708114>; Enel Green Power, "Enel Green Power connects a 51 MW wind farm to the grid in Cuenca", press release (Cuenca: 7 August 2020), <https://www.enelgreenpower.com/media/press/2020/08/enel-green-power-connects-a-51-mw-wind-farm-to-the-grid-in-cuenca>.
- 62 See information and sources throughout this section.
- 63 Data for beginning of 2015 through first quarter of 2020, from Gonçalves and Liu, op. cit. note 12.
- 64 Calculated based on data for transaction announcements made during 2019 and through 30 June 2020, including 56 off-site physical PPAs and one off-site virtual PPA, from S. Abbott et al., "Local Government Renewables Action Tracker", <https://cityrenewables.org/local-government-renewables-action-tracker>, viewed 6 October 2020. Transactions are defined as electricity purchases and deals linked to specific renewable energy projects; "local government" includes cities, counties and tribal governments.
- 65 City of Los Angeles, "Mayor Garcetti celebrates final approval of largest solar and energy storage project in America", press release (Los Angeles: 6 November 2019), <https://www.lamayor.org/mayor-garcetti-celebrates-final-approval-largest-solar-and-energy-storage-project-us>; E. Misbrenner, "8 Minute Solar Energy approved to build 400-MW solar+storage project for City of Los Angeles", Solar Power World, 10 September 2019, <https://www.solarpowerworldonline.com/2019/09/8minute-solar-energy-los-angeles-solar-storage>.
- 66 Shaver, "Watch these 4 clean energy trends in U.S. cities in 2020", op. cit. note 8; City of Cincinnati, "Cincinnati to construct nation's largest solar project", press release (Cincinnati, OH: 21 November 2019), <https://www.cincinnati-oh.gov/mayor/news/cincinnati-to-construct-nation-s-largest-city-led-solar-project>; W. Peischel, "The biggest municipal solar farm coming to...Cincinnati?", Mother Jones, 10 February 2020, <https://www.motherjones.com/environment/2020/02/the-biggest-municipal-solar-farm-in-the-us-is-coming-to-cincinnati>; "Alabama Municipal Electric Authority signs 100-MW solar PPA", Renewable Energy World, 29 May 2019, <https://www.renewableenergyworld.com/2019/05/29/alabama-municipal-electric-authority-signs-100mw-solar-ppa>; C. Shahan, "New Sun Tribe solar project will cover 10% of Pennsylvania borough's electricity use", CleanTechnica, 30 May 2020, <https://cleantechnica.com/2020/05/30/new-sun-tribe-solar-project-will-cover-10-of-pennsylvania-boroughs-electricity-use>.
- 67 G. Holmes, "Major solar energy project begins operation in Central Florida", Florida Municipal Electric Association, 30 June 2020, <https://www.publicpower.com/news/major-solar-energy-project-begins-operation-in-central-florida>; E. Rosen, "2 new solar farms to deliver power to 6 Florida cities, including Orlando and Kissimmee", MSN, 22 June 2020, <https://www.msn.com/en-us/news/us/2-new-solar-farms-to-deliver-power-to-6-florida-cities-including-orlando-and-kissimmee/ar-BB15Q0PF>.
- 68 Rosen, op. cit. note 67.
- 69 Tenders Electronic Daily, "Place of performance (Map)", <https://ted.europa.eu/TED/search/searchResult.do>, viewed 12 December 2020. CPV used: 09332000; 09331000; 09330000; 09331100; 09331200; 45261215.
- 70 London's solar PPA will help save the City Corporation of London around GBP 3 million (USD 4.1 million) in energy costs over its lifetime, and provide half of its electricity demand. The PPA will help power buildings such as the Corporation's historic Guildhall headquarters, three wholesale markets and the Barbican arts centre. From Lempriere, op. cit. note 60. Enel Green Power, op. cit. note 61; Reve, "Andberg wind farm finds power offtaker", Renew, 1 October 2019, <https://renews.biz/55606/andberg-wind-farm-finds-power-offtaker>; EV Wind, "Wind energy in Sweden, First wind farm to utilize Nordex N149/5.X wind turbines", 10 January 2020, <https://www.evwind.es/2020/01/10/wind-energy-in-sweden-first-wind-farm-to-utilize-nordex-n149-5-x-wind-turbines/73005>.
- 71 B. Coyne, "Bristol Airport switches to 100 per cent renewable power via Ørsted", The Energyst, 13 September 2019, <https://theenergyst.com/bristol-airport-switches-to-100-per-cent-renewable-power-via-orsted>; S. Djunicic, "Bristol Energy inks PPA with Thrive for 3.55 MW of wind turbines", Renewables Now, 24 July 2019, <https://renewablesnow.com/news/bristol-energy-inks-ppa-with-thrive-for-355-mw-of-wind-turbines-662749>; A. Durakovic, "German airport operator seeks offshore wind power", Offshore WIND, 8 June 2020, <https://www.offshorewind.biz/2020/06/08/german-airport-operator-seeks-offshore-wind-power>.
- 72 M. Maisch, "City of Adelaide switches to 100% renewable electricity", pv magazine, 1 July 2020, <https://www.pv-magazine-australia.com/2020/07/01/city-of-adelaide-switches-to-100-renewable-electricity>; A. Danigelis, "City of Adelaide powers operations with 100% renewable energy", Environment + Energy Leader, 2 July 2020, <https://www.environmentalleader.com/2020/07/adelaide-renewable-energy-operations>; City of Melbourne, "Melbourne Renewable Energy Project: A new generation of energy", <https://www.melbourne.vic.gov.au/business/sustainable-business/mrep/Pages/melbourne-renewable-energy-project.aspx>, viewed 17 December 2020; Energetics, "Melbourne Renewable Energy Project 2.0", July 2020, <https://www.energetics.com.au/projects/melbourne-renewable-energy-project-20>.
- 73 S. Wray, "Sydney switches to 100 percent renewable energy", CitiesToday, 6 July 2020, <https://cities-today.com/sydney-switches-to-100-percent-renewable-energy>; City of Sydney, "5 things to know about our electricity deal", <https://news.cityofsydney.nsw.gov.au/articles/5-things-to-know-about-our-electricity-deal>, viewed 8 February 2021. See also S. Hanley, "City of Sydney goes 100% renewable", CleanTechnica, 3 July 2020, <https://cleantechnica.com/2020/07/03/city-of-sydney-goes-100-renewable>.
- 74 See, for example: I. B. Ruiz "Cities leading the transition to renewables", DW, 9 March 2018, <https://www.dw.com/en/cities-leading-the-transition-to-renewables/a-42850621>; L. Shaver and

- H. House, "INSIDER: Beyond buying renewables: How cities can influence the energy system", WRI Blog, 27 July 2020, <https://www.wri.org/blog/2020/07/insider-beyond-buying-renewables-how-cities-can-influence-energy-system>; Duncan and Bonugli, op. cit. note 9.
- 75 Sustainable Energy Africa (SEA), *State of Energy in South African Cities Report 2020* (Cape Town: 2020), http://www.cityenergy.org.za/uploads/resource_508.pdf; Business Insider South Africa, "Big breakthrough: Some municipalities can now generate their own electricity", 16 October 2020, <https://www.businessinsider.co.za/some-municipalities-can-procure-their-own-electricity-2020-10>.
- 76 Ibid.
- 77 See, for example: J. Duncan, "A new era for local governments and public utility commissions: The city perspective", IMT, 9 July 2019, <https://www.imt.org/a-new-era-for-local-governments-and-public-utility-commissions-the-city-perspective>; Shaver and House, op. cit. note 74.
- 78 D. Ribeiro et al., *The 2020 City Clean Energy Scorecard* (Washington, DC: American Council for an Energy-Efficient Economy, October 2020), p. 29, <https://www.aceee.org/sites/default/files/pdfs/u2008.pdf>.
- 79 C. Etter-Wenzel and L. Shaver, "Despite challenges, Virginia cities envision a bold clean energy future", WRI Blog, 29 August 2019, <https://www.wri.org/blog/2019/08/despite-challenges-virginia-cities-envision-bold-clean-energy-future>.
- 80 M. Banker, S. Abbott and A. Rotatori, "The Clean Economy Act is a breakthrough for Virginia and the South", Rocky Mountain Institute (RMI), 15 April 2020, <https://rmi.org/the-clean-economy-act-is-a-breakthrough-for-virginia-and-the-south>.
- 81 See, for example, K. Uhlenhuth, "Kansas City clean energy goals could get a boost from utility partnership", Energy News Network, 3 May 2018, <https://energynews.us/2018/05/03/midwest/kansas-city-clean-energy-goals-could-get-a-boost-from-utility-partnership>.
- 82 S. Abbott, "What good are city clean-energy targets?" RMI, 12 August 2019, <https://rmi.org/what-good-are-city-clean-energy-targets>; Duncan and Bonugli, op. cit. note 9.
- 83 Minneapolis Clean Energy Partnership, "About the partnership", <https://mplscleanenergypartnership.org/about>, viewed 17 December 2020. In 2018, Kansas City (Missouri) was working with local utility to achieve several of its clean energy goals; the city aims to set example for local businesses and institutions to follow. From Uhlenhuth, op. cit. note 81. See also Abbott, op. cit. note 82.
- 84 Duncan and Bonugli, op. cit. note 9. Breckenridge, Colorado also entered into a memorandum of understanding with Xcel in 2018 to achieve its 100% renewable goal, from Town of Breckenridge, "Town of Breckenridge approves a Memorandum of Understanding with Xcel Energy", press release (Breckenridge, CO: 24 January 2018), <https://www.townofbreckenridge.com/Home/Components/News/News/1932>.
- 85 Salt Lake City, "Utah communities celebrate landmark renewable energy legislation", SLC Blog, 22 April 2019, <https://www.slc.gov/blog/2019/04/22/utah-communities-celebrate-landmark-renewable-energy-legislation>. Salt Lake City and Park City both set 100% clean energy commitments in 2016, from Abbott, op. cit. note 82. See also J. Van Horn, "Salt Lake City announces 100% clean energy goal", Sierra Club, 15 July 2016, <https://www.sierraclub.org/compass/2016/07/salt-lake-city-announces-100-clean-energy-goal>, and The Climate Reality Project, "Park City signs 100% renewable electricity pledge", EcoWatch, 11 October 2016, <https://www.ecowatch.com/park-city-utah-renewable-energy-2040100564.html>.
- 86 I. García and D. Khandke, *Cities and Civil Society as Allies for the Energy Transition* (Washington, DC: German Marshall Fund of the United States, 2019), <https://www.gmfus.org/sites/default/files/Energy%20Allies.pdf>; SWM, "SWM: A company for Munich", <https://www.swm.de/english/company>, viewed 15 December 2020.
- 87 Siemens Gamesa, "DanTysk for Munich", <https://www.siemensgamesa.com/en-int/explore/customer-references/dantysk-offshore-wind-farm>, viewed 15 December 2020.
- 88 Abbott, op. cit. note 82; J. Farrell, "Voices of 100%: Michigan city sets steady pace to a clean electricity goal", CleanTechnica, 4 May 2020, <https://cleantechnica.com/2020/05/04/voices-of-100-michigan-city-sets-steady-pace-to-a-clean-electricity-goal>.
- 89 M. Motyka, "Renewables (em)power smart cities", Deloitte, 5 March 2019, <https://www2.deloitte.com/xe/en/insights/industry/power-and-utilities/smart-renewable-cities-wind-solar.html>.
- 90 See Citizen Participation chapter for more information and sources. Cities that have debated municipalisation include, for example, Boulder (Colorado), from "'Municipalization' of the Boulder electric utility: What happens when aspirational policy goals and complex realities collide – and a lesson for others", Velocity Public Affairs, 3 April 2019, <https://velocitypublicaffairs.com/2019/04/03/municipalization-of-the-boulder-electric-utility-what-happens-when-aspirational-policy-goals-and-complex-realities-collide-and-a-lesson-for-others>, and Chicago (Illinois), from Office of the Mayor, "City of Chicago releases findings of preliminary municipal utility feasibility study: Study finds that municipalization of electric utility is not financially viable", press release (Chicago, IL: 28 August 2020), https://www.chicago.gov/city/en/depts/mayor/press_room/press_releases/2020/august/MunicipalUtilityFeasibilityStudy.html. See also L. Ambort, "Spreading like wildfire: An interest in making electric power public", Institute for Local Self-Reliance, 5 March 2020, <https://ilsr.org/municipalization-electric-utilities-update-2020>.
- 91 Barcelona Energia, "Barcelona Energia, the metropolitan electricity company", <https://energia.barcelona/en/barcelona-energia-municipal-electricity-company>, viewed 17 December 2020.
- 92 Ibid.; Transformative Cities, "Barcelona Energia", <https://transformativecities.org/atlas/atlas-013>, viewed 17 December 2020; Ajuntament de Barcelona, "Barcelona Energia flicks the switch", press release (Barcelona: 30 June 2018), https://www.barcelona.cat/infobarcelona/en/tema/environment-and-sustainability/barcelona-energia-flicks-the-switch_683855.html.
- 93 Barcelona Energia, op. cit. note 91; Ajuntament de Barcelona, op. cit. note 92.
- 94 S. Becker, M. Naumann and T. Moss, "Between coproduction and commons: Understanding initiatives to reclaim urban energy provision in Berlin and Hamburg", *Urban Research & Practice*, vol. 10, no. 1 (2017), pp. 63–85, <https://www.tandfonline.com/doi/abs/10.1080/17535069.2016.1156735>; D. Q. Ilkhani and E. Woertz, *Remunicipalisation of Local Energy Provision: The Role of Cities and Bottom-up Initiatives* (Barcelona: CIDOB, May 2019), https://www.cidob.org/en/publications/publication_series/cidob_policy_brief/remunicipalisation_of_local_energy_provision_the_role_of_cities_and_bottom_up_initiatives; Transnational Institute et al., *Reclaiming Public Services: How Cities and Citizens Are Turning Back Privatization* (Amsterdam and Paris: June 2017), https://www.tni.org/files/publication-downloads/reclaiming_public_services.pdf; C. Morehouse, "Chicago considers municipalizing ComEd", Utility Dive, 25 July 2019, <https://www.utilitydive.com/news/chicago-considers-municipalizing-comed/559505>; City of Chicago, Office of the Mayor, "City of Chicago releases findings of preliminary municipal utility feasibility study", press release (Chicago, IL: 28 August 2020), https://www.chicago.gov/city/en/depts/mayor/press_room/press_releases/2020/august/MunicipalUtilityFeasibilityStudy.html; G. Bade, "San Francisco considering municipal utility as PG&E prepares bankruptcy filing", Utility Dive, 15 January 2019, <https://www.utilitydive.com/news/san-francisco-considering-municipal-utility-as-pge-prepares-bankruptcy-fil/546087>.
- 95 Total electricity share based on estimated global electricity generation of 27,000 TWh in 2019, from REN21, op. cit. note 5, p. 47; K. C. Seto et al., "Human settlements, infrastructure and spatial planning", in O. Edenhofer et al., eds., *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge, UK and New York, NY: Cambridge University Press, 2014), https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_chapter12.pdf.
- 96 Estimate of 27.3% from Ibid., p. 47.
- 97 CDP-ICLEI Unified Reporting System, "Cities renewable energy targets", <https://data.cdp.net/browse?category=Renewable%20Energy>, viewed 4 January 2021.
- 98 Ibid.
- 99 Ibid.
- 100 US Department of Energy, Energy Information Administration, *Electric Power Monthly with Data for December 2020* (Washington, DC: February 2021), <https://www.eia.gov/electricity/monthly/archive/February2021.pdf>.
- 101 CDP, *CDP Cities 2017 Information Request: City of Houston*, 12 June 2017, www.greenhoustontx.gov/reports/CDP-Cities-2017.pdf; City of Houston, *Resilient Houston* (Houston, TX: February 2020), www.greenhoustontx.gov/reports/Resilient-Houston.pdf;

- City of Houston, "The City of Houston commits to 100% renewable energy", press release (Houston, TX: 30 April 2020), <http://www.greenhoustontx.gov/pressrelease20200430.html>.
- 102 Austin Energy, "Renewable power generation", <https://austinenergy.com/ae/about/environment/renewable-power-generation>, viewed 30 November 2020; 37.5% in 2018 from CDP data received October 2020.
- 103 REN21 Policy Database (2020), available at www.ren21.net/cities/datapack. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and therefore may not be exhaustive. See also M. Navarro, "City issues rule to ban dirtiest oils at buildings", *New York Times*, 21 April 2019, <https://www.nytimes.com/2011/04/22/nyregion/new-york-city-bans-dirtiest-heating-oils-at-buildings.html>.
- 104 Based on IRENA, op. cit. note 4.
- 105 Solvay, "One Planet: Solvay Asia is getting a renewable energy boost!" 27 February 2020, <https://www.solvay.com/en/article/one-planet-solvay-asia-getting-renewable-energy-boost>; Solvay, "Powering up with increasingly green energy", 21 February 2019, <https://www.solvay.com/en/article/increasing-green-energy>; B. Epp, "Demand for central solar water heating peaks in 2019", solarthermalworld.org, 23 March 2020, <https://www.solarthermalworld.org/news/demand-central-solar-water-heating-peaks-2019>.
- 106 B. Epp, "50 new solar hot water systems at Turkish prisons in three years", solarthermalworld.org, 22 August 2020, <https://www.solarthermalworld.org/news/50-new-solar-hot-water-systems-turkish-prisons-three-years>.
- 107 Sonnenhaus Institut, "Erstes Mehrfamilien-Sonnenhaus in Regensburg ist bezugsfertig", 4 December 2020, <https://www.sonnenhaus-institut.de/erstes-mehrfamilien-sonnenhaus-in-regensburg-ist-bezugsfertig.html>; Sonnenhaus Institut, "Ein Sonnensegel für das Mehrfamilien-Sonnenhaus", 4 December 2020, <https://www.sonnenhaus-institut.de/ein-sonnensegel-fuer-das-mehrfamilien-sonnenhaus.html>.
- 108 IEA, "Section updates heat pumps", <https://www.iea.org/reports/heat-pumps>, viewed 4 October 2020.
- 109 REN21, op. cit. note 5, Chapter 6.
- 110 Heat output from J. W. Lund and A. N. Toth, "Direct utilization of geothermal energy 2020 worldwide review", *Proceedings World Geothermal Congress 2020*, Reykjavik, Iceland, 26 April - 2 May 2020, <https://www.geothermal-energy.org/pdf/IGAstandard/WGC/2020/01018.pdf>.
- 111 CIBSE Journal, "Oxford's balancing act: city smart grid with ground source heat pumps", October 2020, <https://www.cibsejournal.com/technical/oxfords-balancing-act-city-smart-grid-with-ground-source-heat-pumps>.
- 112 Ibid.
- 113 D. Thorpe, "The town that saves millions on heating costs with a water source heat pump", Smart Cities Dive, <https://www.smartcitiesdive.com/ex/sustainablecitiescollective/town-saves-millions-heating-costs-water-source-heat-pump/1055631>, viewed 7 November 2020; Star Renewable Energy, "Star Renewable Energy provides Scotland's largest water source heat pump for district heating", 15 May 2019, <http://www.neatpumps.com/news/star-renewable-energy-provides-scotland%E2%80%99s-largest-water-source-heat-pump-for-district-heating.aspx>.
- 114 HeatSmart, "Commercial HeatSmart: Case studies", 2020, <https://sustainablewestchester.org/wp-content/uploads/2020/05/Heatsmart-case-studies-2020.pdf>.
- 115 V. Spasić, "Decarbonisation is next step in development of district heating, cooling systems", Balkan Green Energy News, 6 December 2019, <https://balkangreenenergynews.com/decarbonization-is-next-in-development-of-district-heating-cooling-systems>.
- 116 IRENA, IEA and REN21, *Renewable Energy Policies in a Time of Transition: Heating and Cooling* (Paris: 2020), https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Nov/IRENA_IEA_REN21_Policies_Heating_Cooling_2020.pdf.
- 117 IEA, *Renewables 2019: Market Analysis and Forecast from 2019 to 2024* (Paris: 2019), <https://www.iea.org/reports/renewables-2019>.
- 118 IEA, "How can district heating help decarbonize the heat sector by 2024?", 21 October 2019, <https://www.iea.org/articles/how-can-district-heating-help-decarbonise-the-heat-sector-by-2024>.
- 119 Ibid.
- 120 Association of European Renewable Energy Research Centers, <https://eurec.be>, viewed 4 January 2020.
- 121 S. Werner, "International review of district heating and cooling", *Energy*, vol. 137 (15 October 2017), pp. 617-31, <http://www.sciencedirect.com/science/article/pii/S036054421730614X>.
- 122 IEA, *World Energy Statistics and Balances, 2020 Edition* (Paris: 2020), <https://webstore.iea.org/world-energy-balances-overview-2020-edition>.
- 123 Euroheat & Power, "Country report Iceland", <https://www.euroheat.org>, viewed 30 September 2020; N. Calcea, "Europe makes progress integrating renewables in district heating", Energy Monitor, 16 September 2020, <https://energymonitor.ai/sector/heating-cooling/europe-makes-progress-integrating-renewables-in-district-heating>; Euroheat & Power, "District energy in Iceland", <https://www.euroheat.org/knowledge-hub/district-energy-iceland>, viewed 27 January 2021.
- 124 IEA, op. cit. note 122. **Figure 13** based on data from idem.
- 125 Calcea, op. cit. note 123; World Bioenergy Association (WBA), *Global Bioenergy Statistics 2019* (Brussels: 2019), https://worldbioenergy.org/uploads/191129%20WBA%20GBS%202019_HQ.pdf.
- 126 WBA, op. cit. note 125.
- 127 Smart Together, "The largest biomass power plant in France: An exemplary partnership between the Métropole de Lyon, ADEME and Dalkia", 28 May 2019, <https://www.smarter-together.eu/news/largest-biomass-power-plant-france-exemplary-partnership-between-metropole-de-lyon-ademe-and>; Dalkia, "La chaufferie biomasse de Surville: un partenariat exemplaire entre la Métropole de Lyon, l'ADEME et Dalkia", <https://www.dalkia.fr/fr/espace-presse-communiquede-presse/chaufferie-biomasse-surville>, viewed 22 December 2020.
- 128 B. Epp, "15 MW SDH plant inaugurated in Latvia", solarthermalworld.org, 27 October 2019, <https://www.solarthermalworld.org/news/15-mw-sdh-plant-inaugurated-latvia>.
- 129 IEA Solar Heating & Cooling Programme, *Solar Heat Worldwide 2020* (Paris: 2020), <https://www.iea-shc.org/solar-heat-worldwide>; Fortum, "District heating in Oslo", <https://www.fortum.com/district-heating-oslo>, viewed 27 January 2021.
- 130 REN21, op. cit. note 5.
- 131 IEA Solar Heating & Cooling Programme Task 55, *Solar Heat for Cities: The Sustainable Solution for District Heating* (Paris: 2019), <https://task55.iea-shc.org/Data/Sites/1/publications/Solar-Heat-for-Cities--The-Sustainable-Solution-for-District-Heating.pdf>.
- 132 IEA Solar Heating & Cooling Programme, "Germany country report", <https://www.iea-shc.org/countries/germany/report>, viewed 21 December 2020.
- 133 REN21, op. cit. note 5.
- 134 The cities are Samobor, Velika Gorica and Zaprešić, from B. Epp, "Three SDH plants under development in Croatia", solarthermalworld.org, 22 October 2020, <https://www.solarthermalworld.org/news/three-sdh-plants-under-development-croatia>.
- 135 Heat capacity and output from Lund and Toth, op. cit. note 110.
- 136 Ibid.
- 137 **City Snapshot: Malmö** based on the following sources: Malmö stad, "Population", <https://malmo.se/Fakta-och-statistik/Facts-and-statistics-in-english/Population.html>, viewed 5 January 2021; Swedish Environmental Protection Agency, *National Inventory Report Sweden 2019* (Stockholm: 2019), <https://www.naturvardsverket.se/upload/miljoarbete-i-samhallet/internationellt-miljoarbete/miljokonventioner/FN/nir-sub-15-april.pdf>; IRENA and ICLEI-Local Governments for Sustainability, *Integrating Ambitious Renewable Energy Targets in City Planning* (Abu Dhabi: 2013), <https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2013/Jan/IRENA-cities-case-7-Malmo.pdf>; European Commission, "European Green Capital Malmö Comments", <https://ec.europa.eu/environment/europeangreencapital/winning-cities/previous-finalists/malmo>, viewed 5 January 2021; L. Guevara-Stone, "How Malmö, Sweden is leading way on sustainability", *RenewEconomy*, 24 September 2014, <https://reneweconomy.com.au/malmo-sweden-leading-way-70597>; J. Kamleh, Strategist, City of Malmö, presentation at Daring Cities 2020 event "100% Renewable Energy Roadmaps – Contributing to the Global Energy Transition", 13 October 2020; E.ON, "E.ON builds

- deep heat power plants in Sweden", 3 March 2020, <https://www.eon.com/en/about-us/media/press-release/2020/2020-03-03-eon-builds-deep-heat-power-plants-in-sweden.html>.
- 138 A. Richter, "City in Shaanxi Province, China launches innovative large-scale geothermal district heating system", Think GeoEnergy, 8 December 2019, <https://www.thinkgeoenergy.com/city-in-shaanxi-province-china-launches-innovative-large-scale-geothermal-district-heating-system>.
- 139 G. Dias, DTU, personal communication with REN21, 12 October 2020.
- 140 A. Richter, "SWM complete drilling campaign pushing forward with three week test run at heat plant in Munich", Think GeoEnergy, 15 March 2020, <https://www.thinkgeoenergy.com/swm-complete-drilling-campaign-pushing-forward-with-three-week-test-run-at-heat-plant-in-munich>.
- 141 M. Kulmicht, "The geothermal heating network in Champs-sur-Marne launches", ENGIE, 30 October 2019, <https://www.engie-solutions.com/en/news/geothermal-site-geomarne>; GéoMarne, "Le réseau de chaleur GéoMarne, le futur réseau géothermique", 2 December 2019, <http://geomarne.reseau-chaleur.com/le-reseau-de-chaleur-geomarne-le-futur-reseau-geothermique>; Lumo SAS, "Géothermie de Champs-sur-Marne et Noisiel", <https://www.lumo-france.com/projets/geothermie-dela-marne>, viewed March 2020.
- 142 La Ville de Drancy, "La géothermie à Drancy", <https://www.drancy.fr/la-ville-s-engage-pour-lenvironnement/energies-renouvelables-drancy-s-engage-pour-un-avenir-vertueux-et-durable/la-geothermie-a-drancy-525.html>, viewed March 2020; Sipperec, "Gényo: Un futur réseau de chaleur écologique pour Bobigny-Drancy", <https://sipperec.fr/developper/produire-localement-les-energies-de-demain/geothermie/genyo-un-futur-reseau-dechaleur-ecologique-pour-bobigny-drancy>, viewed March 2020.
- 143 REN21, *Renewables 2019 Global Status Report* (Paris: 2019), https://www.ren21.net/wp-content/uploads/2019/05/gsr_2019_full_report_en.pdf.
- 144 Wandschneider + gutjahr ingeniergesellschaft mbh, "Design of chillers HW2 (plant half 2) – District Cooling City Nord", <https://www.wg-ing.de/en/projects/district-cooling-city-nord-hamburg-fernkaelte-geschaefsstadt-nord-gbr>, viewed 10 January 2021; Sustainable Cities Vattenfall, "Berlin's biggest refrigerator", <https://sustainablecities.vattenfall.com/en/berlin>, viewed 10 January 2021; Bayut, "Chiller-free vs district cooling in Dubai", <https://www.bayut.com/mybayut/chiller-free-district-cooling-dubai>, viewed 21 December 2020; City of Toronto, "District energy", <https://www.toronto.ca/services-payments/water-environment/environmentally-friendly-city-initiatives/district-energy>, viewed 21 December 2020; IRENA, *Renewable Energy in District Heating and Cooling: A Sector Roadmap for REmap* (Abu Dhabi: 2017), https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/Mar/IRENA_REmap_DHC_Report_2017.pdf.
- 145 A. Richter, "Geothermal heat to also fuel district cooling network in Munich, Germany", Think GeoEnergy, 18 April 2020, <https://www.thinkgeoenergy.com/geothermal-heat-to-also-fuel-district-cooling-network-in-munich-germany>.
- 146 Enwave, "Enwave and Toronto Water tap into innovative energy source", <https://www.enwave.com/case-studies/enwave-and-toronto-water-tap-into-innovative-energy-source>, viewed 18 December 2020; ESEMAG, "Enwave to expand Toronto's deep lake water cooling system", 11 January 2019, <https://esemag.com/water/expand-torontos-deep-lake-water-cooling-system>.
- 147 This system makes use of the temperature difference of the river water, and can save up to 30% of energy compared with conventional air conditioning. From Z. Huan, "China's largest 'water air conditioning system' saves 30 percent energy", EN People, 13 July 2017, <http://en.people.cn/n3/2017/0713/c90000-9241306.html>.
- 148 IEA, "Renewable energy in transport 2018 and 2024", <https://www.iea.org/data-and-statistics/charts/renewable-energy-in-transport-2018-and-2024>, updated 25 November 2019.
- 149 IEA, *World Energy Outlook 2019* (Paris: 2019), <https://www.iea.org/reports/world-energy-outlook-2019>.
- 150 IRENA, op. cit. note 4; Agora Verkehrswende, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and World Economic Forum (WEF), *Transport for Under Two Degrees – The Way Forward. 10 Key Insights for the Decarbonisation of the Transport Sector* (Berlin: 2020), https://www.t4under2.org/pdf/T4under2_Global-foresight-study_FINAL.pdf.
- 151 IEA, *World Energy Outlook 2020* (Paris: 2020), <https://www.iea.org/reports/world-energy-outlook-2020>.
- 152 Campaign for Better Transport, *Covid-19 Recovery: Renewing the Transport System* (London: July 2020), https://bettertransport.org.uk/sites/default/files/research-files/Covid_19_Recovery_Renewing_the_Transport_System.pdf.
- 153 IEA, *The Covid-19 Crisis and Clean Energy Progress* (Paris: 2020), <https://www.iea.org/reports/the-covid-19-crisis-and-clean-energy-progress/transport>.
- 154 J. Swira, "Creative destruction: The COVID-19 economic crisis is accelerating the demise of fossil fuels", African Mining Brief, 7 August 2020, <https://africanminingbrief.com/creative-destruction-the-covid-19-economic-crisis-is-accelerating-the-demise-of-fossil-fuels>; B. Chen, "E-bikes are having their moment. They deserve it", *New York Times*, 3 June 2020, <https://www.nytimes.com/2020/06/03/technology/personaltech/e-bikes-are-having-their-moment-they-deserve-it.html>; IEA, op. cit. note 151.
- 155 See REN21, op. cit. note 5.
- 156 IEA, *Oil 2020* (Paris: 2020), <https://www.iea.org/reports/oil-2020>; IEA, *Renewables 2019* (Paris: 2019), <https://www.iea.org/reports/renewables-2019>.
- 157 For the location of US biodiesel and ethanol production facilities, see US National Renewable Energy Laboratory, "AFDC TransAtlas", <https://maps.nrel.gov/transatlas/?aL=fjBW9%255Bv%255D%3Dt%26OgJeqs%255Bv%255D%3Dt%26OgJeqs%255B5Bd%255D%3D1&bL=clight&cE=0&IR=0&mC=39.45316112807394%2C-98.06396484375&zL=5>, viewed 15 December 2020.
- 158 According to IEA estimates, transport biofuel production was expected to contract 13% in 2020, its first drop in two decades. From IEA, op. cit. note 153.
- 159 Government of Mexico City, "Nueva planta productora de biodiésel en Central de Abasto", 4 August 2020, <https://www.cdmx.gob.mx/portal/articulo/inaugura-gobierno-capitalino-e-ipn-planta-productora-de-biodiesel-en-central-de-abasto>.
- 160 C40 Cities, "Case study: The circular economy in Venice: Green fuel for the city's boat fleet", 8 January 2020, https://www.c40.org/case_studies/the-circular-economy-in-venice-green-fuel-for-the-city-s-boat-fleet. **Box 3** based on the following sources: The Explorer, "Moving public transport onto waterways", <https://www.theexplorer.no/solutions/urban-water-shuttle--moving-public-transport-onto-waterways>, viewed 29 October 2020; A. Matua, "City passes Queens councilman's bill to study how to power NYC ferries with renewable fuel", QNS, 2 January 2018, <https://qns.com/2018/01/city-passes-queens-councilmans-bill-study-power-nyc-ferries-renewable-fuel>; A. Danigelis, "Copenhagen receives five zero-emissions ferries for public transport", Environment + Energy Leader, 7 July 2020, <https://www.environmentalleader.com/2020/07/copenhagen-zero-emissions-ferries>; ALT Energy Stocks, "Biofuels rocking the boats (and ships)", 24 July 2018, <http://www.altenergystocks.com/archives/2018/07/biofuels-rocking-the-boats-and-ships>; S. Six, "Bunker biofuel pilot projects launch in Asia", Argus Media, 18 December 2020, <https://www.argusmedia.com/en/news/2170286-bunker-biofuel-pilot-projects-launch-in-asia>; PR Newswire, "Red and White Fleet's long awaited plug-in vessel, 'The Enhydra', is available for use in San Francisco Bay", 13 September 2018, <https://www.prnewswire.com/news-releases/red-and-white-fleets-long-awaited-plug-in-vessel-the-enhydra-is-available-for-use-in-san-francisco-bay-300711900.html>; G. Han, "Hari Pontoon: The solar powered bamboo water taxi", Design Milk, 29 October 2020, <https://design-milk.com/hari-pontoon-the-solar-powered-bamboo-water-taxi>; 0Bills, "Solar panel powered water taxi plan for Cardiff to Bristol ferry", <https://www.zerohomebills.com/solar-panel-powered-water-taxi-plan-for-cardiff-to-bristol-ferry>, viewed 29 October 2020; M. Meisenzahi, "A solar-powered boat will transport guests to an ultra-luxury resort in Bora Bora — see how it works", Business Insider, 13 June 2020, <https://www.businessinsider.com/soel-yachts-soel-shuttle-14-solar-powered-luxury-water-taxi-2020-6>; V. Varma, "India's first solar-powered ferry Aditya wins global honour", Indian Express, 27 July 2020, <https://indianexpress.com/article/india/indias-first-solar-powered-ferry-aditya-wins-gustave-trouve-award-6525729>; D. Bönninghausen, "Launch of the first e-car ferry Sankta Maria II", Electrive, 24 October 2017, <https://www.electrive.net/2017/10/24/stapellauf-der-ersten-e-autofaehre-sankta-maria-ii>; M. Teliska, "Passenger ferries are going electric", AXIOS, 29 May 2019, <https://www.axios.com/passenger-ferries-are-going-electric-cb70b29f-fb19-4a10-bf53-24df0d9985bd.html>; "Electric ferries

- may become a major force on Bangkok's busy rivers", The Maritime Executive, 10 January 2020, <https://www.maritime-executive.com/article/electric-ferries-may-become-a-major-force-on-bangkok-s-busy-rivers>; J. Butler, "Bangkok becoming electric ferry capital of the world", Plugboats, 24 August 2020, <https://plugboats.com/bangkok-becoming-electric-ferry-capital-of-the-world>; J. Butler, "Norway leads an electric ferry revolution", Plugboats, 27 January 2019, <https://plugboats.com/norway-leads-an-electric-ferry-revolution>; World Maritime News, "Norled picks Westcon to build world's 1st hydrogen ferry", Offshore Energy, 29 May 2019, <https://www.offshore-energy.biz/norled-picks-westcon-to-build-worlds-1st-hydrogen-ferry>; E. Dudley, "Green-powered passenger ferries made by Brisbane-based small businesses", Dynamic Business, 16 November 2020, <https://dynamicbusiness.com.au/topics/news/green-powered-passenger-ferries-made-by-brisbane-based-small-businesses.html>; DFDS, "Partnership aims to develop hydrogen ferry for Oslo-Copenhagen", press release (Copenhagen: 26 November 2020), <https://www.dfds.com/en/about/media/news/hydrogen-ferry-for-oslo-copenhagen>.
- 161 R. Kotrba, "Eni opens its 2nd large-scale renewable diesel facility in Italy", Biodiesel Magazine, 26 September 2019, <http://www.biodieselmagazine.com/articles/2516794/eni-opens-its-2nd-large-scale-renewable-diesel-facility-in-italy>.
- 162 "Neste, McDonald's Netherlands and HAVI promote circular economy", Petrol Plaza, 25 June 2020, <https://www.petroplaza.com/news/24993>.
- 163 IEA, *Outlook for Biogas and Biomethane: Prospects for Organic Growth* (Paris: March 2020), <https://www.iea.org/reports/outlook-for-biogas-and-biomethane-prospects-for-organic-growth/an-introduction-to-biogas-and-biomethane>.
- 164 Ibid. In 2019, there were 89 total operational biomethane plants in the United States, producing 49 petajoules. Of these, more than 60% (54 confirmed operational plants) were producing biomethane for use as a vehicle fuel, with 30 more planned for this purpose. In the United States and Canada, in early 2020, there were 110 operational biomethane facilities transforming waste into fuel, 40 under construction and 58 in development. In Europe, the number of biomethane plants increased from 483 in 2018 to 729 in mid-2020, of which at least 19% were producing biomethane as vehicle fuel. See the following sources: M. Mintz and P. Voss, "Database of Renewable Natural Gas (RNG) Projects: 2019 Update", Argonne National Laboratory, October 2019, <https://www.anl.gov/es/reference/renewable-natural-gas-database>; NGV America, *Decarbonize Transportation with Renewable Natural Gas* (Washington, DC: April 2020), <https://www.ngvamerica.org/wp-content/uploads/2020/04/NGV-RNG-Decarbonize-FINAL-April-2020.pdf>; Gas Infrastructure Europe and European Biogas Association, *European Biomethane Map: Infrastructure for Biomethane Production 2020* (Brussels: June 2020), https://www.gie.eu/maps_data/downloads/2020/GIE_EBA_BIO_2020_A0_FULL_471.pdf.
- 165 "CalBioGas produces first RNG with Kern County dairy farms", Bioenergy Insight, 28 September 2020, <https://www.bioenergy-news.com/news/calbiogas-produces-first-rng-with-kern-county-dairy-farms>.
- 166 A. Dimitrova, "The Hague opens its largest solar-power plant to date", The Mayor, 20 July 2020, <https://www.themayor.eu/de/a/view/the-hague-opens-its-largest-solar-power-plant-to-date-5409>.
- 167 A. Dimitrova, "Poznan wants to power its buses with electricity from waste", The Mayor, 10 July 2020, <https://www.themayor.eu/de/a/view/poznan-wants-to-power-its-buses-with-electricity-from-waste-5350>.
- 168 The waste material will be supplied by Inverhouse Distillery at Pulteney in Wick (Caithness County, Scotland), from "Whisky by-product could help power electric cars", BBC News, 2 July 2020, <https://www.bbc.com/news/uk-scotland-highlands-islands-53249366>.
- 169 IRENA, *Hydrogen: A Renewable Energy Perspective* (Abu Dhabi: 2019), https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Sep/IRENA_Hydrogen_2019.pdf; IEA, "Hydrogen – fuels & technologies", <https://www.iea.org/fuels-and-technologies/hydrogen>, viewed 20 September 2020; IEA, *Hydrogen* (Paris: June 2020), <https://www.iea.org/reports/hydrogen>; REN21, op. cit. note 5.
- 170 Toshiba, "The world's largest-class hydrogen production, Fukushima Hydrogen Energy Research Field (FH2R) now is completed at Namie town in Fukushima", press release (Tokyo: 7 March 2020), https://www.toshiba-energy.com/en/info/2020_0307.htm.
- 171 M. Mace, "Danish groups team up to deliver green hydrogen for transport fuel", Euractiv, 27 May 2020, <https://www.euractiv.com/section/energy/news/danish-groups-team-up-to-deliver-green-hydrogen-for-transport-fuel>.
- 172 FuelCellsWorks, "Development of the FuelCell Energy project at Toyota's Port of Long Beach facility to proceed", FuelCell Energy, 5 March 2020, <https://fuelcellsworks.com/news/development-of-the-fuelcell-energy-project-at-toyotas-port-of-long-beach-facility-to-proceed>.
- 173 SEAFUEL plans to use renewable resources to demonstrate the feasibility of using hydrogen as fuel in isolated regions, promoting a sustainable transport system that can be adopted by other regions. Its innovative approach is based on the connection of filling stations to solar PV, wind and ocean energy installations, generating hydrogen depending on the availability of resources. From "Island of Tenerife plans to become a renewable hydrogen hub for mobility", NGV Journal, 5 August 2020, <http://www.ngvjournals.com/s1-news/c7-Ing-h2-blends/the-island-of-tenerife-plans-to-be-a-renewable-hydrogen-hub-for-transportation>, and from SEAFUEL, "SEAFUEL project arouses interest from new associate partners in Tenerife", 29 July 2020, <http://www.seafuel.eu/seafuel-project-arouses-interest-from-new-associate-partners-in-tenerife>.
- 174 A final investment decision is expected in 2021, from E. Bellini, "Renewable-powered hydrogen for Oman", pv magazine, 5 March 2020, <https://www.pv-magazine.com/2020/03/05/renewable-powered-hydrogen-for-oman>.
- 175 Calculations based on Organisation for Economic Co-operation and Development and International Transport Forum, *ITF Transport Outlook 2019* (Paris: 2019), https://read.oecd-ilibrary.org/transport/itf-transport-outlook-2019_transp_outlook-en-2019-en#page30.
- 176 IRENA, op. cit. note 11; REN21 and FIA Foundation, *Renewable Energy Pathways in Road Transport* (Paris: November 2020), <https://www.fiafoundation.org/media/791530/renewable-energy-pathways.pdf>.
- 177 D. Ainsley (Lewis Silkin), "Smart cities and renewable energy", Lexology, 14 May 2018, <https://www.lexology.com/library/detail.aspx?g=1756875e-7331-468f-90a9-36657c875d44>.
- 178 **Figure 14** from the following sources: IEA, *Global EV Outlook 2020* (Paris: 2020), <https://www.iea.org/reports/global-ev-outlook-2020>; REN21, op. cit. note 5; IEA, *Rail* (Paris: June 2020), <https://www.iea.org/reports/rail>; International Association of Public Transport (UITP), *Light Rail and Tram: The European Outlook* (Brussels: November 2019), <https://cms.uitp.org/wp/wp-content/uploads/2020/09/Statistics-Brief-LRT-Europe2.pdf>.
- 179 IEA, *World Energy Statistics and Balances, 2019 Edition* (Paris: 2019), <https://webstore.iea.org/world-energy-statistics-and-balances-2019>; IEA, *Rail*, op. cit. note 178.
- 180 IEA, *Rail*, op. cit. note 178.
- 181 Ibid.
- 182 Ibid.
- 183 REN21, op. cit. note 5.
- 184 "Chile's largest metro network to be powered by solar and wind", Climate Action, 21 June 2017, <http://www.climateaction.org/news/chiles-largest-metro-network-to-be-powered-by-solar-and-wind>; TeleMedellín, "Metro de Medellín Trabaja Completamente con Energías Renovables en 2021", 30 December 2019, <https://telemedellin.tv/metro-de-medellin-trabajara-completamente-con-energias-renovables-en-2021/370826>; R. Meier, "Metrol de São Paulo estuda implantação de sistema próprio de geração de energia limpa", Metro CPTM, 23 July 2020, <https://www.metrocptm.com.br/metro-de-sao-paulo-estuda-implantacao-de-sistema-proprio-de-geracao-de-energia-limpa>; Mayor of London, "Mayor moves forward with plans to power TfL Tube with green energy", 17 July 2020, <https://www.london.gov.uk/press-releases/mayoral/plans-to-power-tfl-network-with-green-energy>; Seattle from M. Luczak, "Sound transit light rail running on 'clean energy'", Railway Age, 2 December 2020, <https://www.railwayage.com/passenger/light-rail/sound-transit-light-rail-running-on-clean-energy>; "Greenest metro' in Nagpur sets new standards", New Indian Express, 11 June 2019, <https://www.newindianexpress.com/nation/2019/jun/11/greenest-metro-in-nagpur-sets-new-standards-1988521.html>; Delhi from P. V. Lal, "750 MW Rewa solar project starts supplying power", pv magazine, 9 July 2018, <https://www.pv-magazine-india.com/2018/07/09/750-mw-rewa-solar-project-starts-supplying-power>; Utrecht from A. Dimitrova, "The Hague opens its largest solar-power plant to date", The Mayor, 20 July 2020, <https://www.themayor.eu/de/a/view/the-hague-opens-its-largest-solar-power-plant-to-date-5409>.

- 185 Agence France-Presse, "Germany launches world's first hydrogen-powered train", *The Guardian* (UK), 11 September 2018, <https://www.theguardian.com/environment/2018/sep/17/germany-launches-worlds-first-hydrogen-powered-train>; "Hydrogen train tests in the Netherlands successfully meets objectives", *Global Railway Review*, 30 September 2020, <https://www.globalrailwayreview.com/news/110138/hydrogen-train-tests-netherlands-successful>.
- 186 "18 new biodiesel fueled trains coming to the Netherlands", *Biofuels International*, 13 July 2017, <https://biofuels-news.com/news/18-new-biodiesel-fuelled-trains-coming-to-the-netherlands>.
- 187 B. Nielsen, "Next generation clean local transport – Birmingham City University's IDEA think tank a lead partner in developing the UK's first biomethane-powered tram", *Centre for Brexit Studies Blog*, 24 July 2020, <https://centreforbrexitstudiesblog.wordpress.com/2020/07/24/next-generation-clean-local-transport-birmingham-city-universitys-idea-think-tank-a-lead-partner-in-developing-the-uks-first-biomethane-powered-tram>; J. Corser, "Railcars powered by manure on their way", *Express & Star*, 2 January 2021, <https://www.expressandstar.com/news/environment/2021/01/02/railcars-powered-by-manure-on-their-way>.
- 188 J-P. Rodrigue, "Urban transport challenges", in *The Geography of Transport Systems* (New York: Routledge, 2017), https://transportgeography.org/?page_id=4621; Agora Verkehrswende, GIZ and WEF, op. cit. note 150; World Bank, "Urban Transport Data Analysis Tool (UT-DAT)", <https://www.worldbank.org/en/topic/transport/publication/urban-transport-data-analysis-tool-ut-dat>, viewed 29 October 2020.
- 189 "How electric buses are hailing the future of city transport", *Bloomberg*, 2 November 2020, https://sponsored.bloomberg.com/news/sponsors/features/enel-x/discover-enel-xs-plan-for-cleaner-city-transport/?adv=31683&prx_t=bzkgAGCIIAXyKPA.
- 190 UITP, *Global Bus Survey* (Brussels: 2019), https://cms.uitp.org/wp/wp-content/uploads/2020/07/Statistics-Brief_Global-bus-survey-003.pdf.
- 191 Shanghai (China) produces over 30,000 metric tonnes per year of discarded cooking oil that is locally refined to make B5 and sold at 247 gas stations in the city, from H. Jing, "Over 2,000 Shanghai buses to run on biodiesel made from gutter oil", *Shine*, 7 May 2019, <https://www.shine.cn/news/metro/1905074258>; "Norwegian city rolls out biogas, biodiesel buses to reduce carbon footprint", *Biofuels International*, 11 September 2019, <https://biofuels-news.com/news/norwegian-city-rolls-out-biogas-biodiesel-buses-to-reduce-carbon-footprint>.
- 192 "64 buses in Tartu, Estonia to run on biomethane", *Bioenergy Insight*, 16 January 2020, <https://www.bioenergy-news.com/news/64-buses-in-tartu-estonia-to-run-on-biomethane>.
- 193 Columbia from Central Midlands Regional Transit Authority, "The Comet now uses biodiesel in its 39 diesel buses", *Mass Transit*, 5 August 2019, <https://www.masstransitmag.com/bus/vehicles/gas-diesel-cng-lng/press-release/21091398/central-midlands-regional-transit-authority-cmrta-the-comet-the-comet-now-uses-biodiesel-in-its-39-diesel-buses>; North Dakota Soybean Council, "City buses in Grand Forks, North Dakota, running on B20 biodiesel", *Biodiesel Magazine*, 16 July 2020, <http://biodieselmagazine.com/articles/2517082/city-buses-in-grand-forks-north-dakota-running-on-b20-biodiesel>.
- 194 REN21, op. cit. note 5; IEA, *Global EV Outlook 2020*, op. cit. note 178; IEA, "New electric bus registrations in China, 2015-2019", 14 June 2020, <https://www.iea.org/data-and-statistics/charts/new-electric-bus-registrations-in-china-2015-2019>; IEA, "New electric bus registrations by country/region, 2015-2019", 14 June 2020, <https://www.iea.org/data-and-statistics/charts/new-electric-bus-registrations-by-country-region-2015-2019>; BloombergNEF, *Electric Buses in Cities: Driving Towards Cleaner Air and Lower CO₂* (London: March 2018), <https://assets.bbhub.io/professional/sites/24/2018/05/Electric-Buses-in-Cities-Report-BNEF-C40-Citi.pdf>. **Figure 15** based on data from IEA, *Global EV Outlook 2020*, op. cit. note 178, as reported in REN21, op. cit. note 5, and updated based on IEA, "New electric bus registrations by country/region, 2015-2019", op. cit. this note, and on IEA, "New electric bus registrations in China, 2015-2019", op. cit. this note.
- 195 IEA, "New electric bus registrations by country/region, 2015-2019", op. cit. note 194; IEA, "New electric bus registrations in China, 2015-2019", op. cit. note 194. In 2019, the Polish bus manufacturer Solaris Europa claimed to have concluded the most contracts for the construction of electric buses. Some 800 electric-powered Solaris buses are now circulating in 72 cities, including Berlin (90 buses), Milan (250) and Warsaw (130); 47% of the buses built by Solaris are powered by an alternative propulsion system. Worldwide, more than 120,000 Yutong electric buses are operating in more than 380 cities, resulting in a global market share of 15% for Yutong. For nine consecutive years, Yutong was the largest seller of new energy buses. From Busworld, "Increasingly more electric buses", 19 October 2019, <https://www.busworld.org/articles/detail/4813/increasingly-more-electric-buses>.
- 196 R. Whitlock, "Forsee Power to equip electric buses in the city of London", *Renewable Energy Magazine*, 26 July 2019, https://www.renewableenergymagazine.com/electric_hybrid_vehicles/forsee-power-to-equip-electric-buses-in-20190726; Mayor of London, "London's electric bus fleet becomes the largest in Europe", 5 September 2019, <https://www.london.gov.uk/press-releases/mayoral/london-has-europes-largest-electric-bus-fleet>; P. Dzikiy, "Milan to receive 250 electric buses from Solaris in one of Europe's largest e-bus orders yet", *Electrek*, 10 July 2019, <https://electrek.co/2019/07/10/milan-250-electric-buses-solaris>; C. Randall, "Daimler delivers 16 electric buses to Hamburg", *Electrive*, 27 January 2020, <https://www.electrive.com/2020/01/27/daimler-delivers-16-electric-buses-to-hamburg>.
- 197 IRIS Smart Cities, "55 new electric busses in Utrecht", 25 April 2019, <https://irissmartcities.eu/content/55-new-electric-busses-utrecht>; "First of 130 Solaris electric buses deployed in Warsaw", *Green Car Congress*, 28 March 2020, <https://www.greencarcongress.com/2020/03/20200328-solaris.html>.
- 198 E. Chung, A. Hopton and T. Reid, "What cities can learn from the biggest battery-powered electric bus fleet in North America", *CBC*, 2 December 2020, <https://www.cbc.ca/news/technology/electric-buses-transit-1.5823166>; US PIRG Education Fund, *Electric Buses in America: Lessons from Cities Pioneering Clean Transportation* (Denver, CO: October 2019), https://uspirg.org/sites/pirg/files/reports/ElectricBusesInAmerica/US_Electric_bus_scrn.pdf; P. Dzikiy, "Portland's new electric buses run on wind energy, a first in US transit", *Electrek*, 22 April 2019, <https://electrek.co/2019/04/22/portland-electric-buses-wind>; K. Tigue, "U.S. electric bus demand outpaces production as cities add to their fleets", *Inside Climate News*, 14 November 2019, <https://insideclimatenews.org/news/14112019/electric-bus-cost-savings-health-fuel-charging>; D. Lefler, "Wichita, Kan., is state's first city to use electric buses", *GT*, 13 December 2019, <https://www.govtech.com/transportation/Wichita-Kan-is-States-First-City-to-Use-Electric-Buses.html>; J. Sensiba, "Wyoming gets its first electric bus", *CleanTechnica*, 29 November 2020, <https://cleantechnica.com/2020/11/29/wyoming-gets-its-first-electric-bus>; L. Belmonte, "Electric buses are coming to this GTA city and the government's hoping it's a game changer", *Narcity*, 19 July 2019, <https://www.narcity.com/en-ca/news/toronto/brampton-electric-buses-aim-to-accelerate-plans-for-greener-canada>.
- 199 City of São Paulo, "São Paulo passa a ter a maior frota de ônibus 100 % elétricos do país", November 2019, <http://www.capital.sp.gov.br/noticia/sao-paulo-passa-a-ter-a-maior-frota-de-onibus-100-eletricos-do-pais>; Mayor of Bogotá, "Primer bus eléctrico del SITP ya se encuentra en Bogotá", December 2019, <https://bogota.gov.co/mi-ciudad/movilidad/transmilenio/buses-electricos-del-sitp-en-bogota>; Transmilenio S.A., "Estadísticas de oferta y demanda del Sistema Integrado de Transporte Público SITP Febrero 2020", April 2020, <https://www.transmilenio.gov.co/publicaciones/151672/estadisticas-de-oferta-y-demanda-del-sistema-integrado-de-transporte-publico-sitp-febrero-2020/>.
- 200 This includes 563 standard e-buses, 624 trolley buses, 41 midi e-buses and 1 articulated e-bus, from E-bus Radar, <https://www.ebusradar.org>, viewed 23 September 2020.
- 201 IEA, *Global EV Outlook 2020*, op. cit. note 178; E-bus Radar, op. cit. note 200.
- 202 Based on SLOCAT Partnership on Sustainable Transport, *Transport and Climate Change Global Status Report (TCC-GSR) Policy Database*; A. Parikh, "Delhi to shut Rajghat thermal power project, use land for 5 MW solar park", *Mercom India*, 15 July 2019, <https://mercomindia.com/delhi-rajghat-thermal-project-solar-park>; R. Nair, "Pune announces tender for 150 electric buses under FAME-II Program", *Mercom India*, 15 September 2020, <https://mercomindia.com/pune-tender-electric-buses>.
- 203 Sustainable Energy for All, *Switching Gears: Enabling Access to Sustainable Urban Mobility* (Washington, DC: February 2020), https://www.seforall.org/system/files/2020-02/SEforALL-Switching_Gears.pdf; S. Meniano, "Modernization transforms Tacloban's commuting experience", *Philippine News Agency*, 17 July 2019, <https://www.pna.gov.ph/articles/1075086>.

- 204 J. M. Takouleu, "Egypt: Government launches first electric bus service", Afrik21, 14 November 2019, <https://www.afrik21.africa/en/egypt-government-launches-first-electric-bus-service>; "Mwasalat Misr announces launching X-Bus", Egypt Today, 5 February 2020, <https://www.egypttoday.com/Article/1/81306/Mwasalat-Misr-announces-launching-X-Bus>.
- 205 "Volvo receives order for electric, biodiesel buses in Swedish city", Biofuels International, 6 November 2019, <https://biofuels-news.com/news/volvo-receives-order-for-electric-biodiesel-buses-in-swedish-city>; Groupe RATP, "RATP Group 2018 results: A year of profitable growth and investments to the benefit of passengers", press release (Paris: 29 March 2019), <https://www.ratpdev.com/sites/default/files/annexes/communiqués/RATP%20Group%202018%20results.pdf>.
- 206 IEA, *Global EV Outlook 2020*, op. cit. note 178; M. Burgess, "1,000 new hydrogen-powered buses planned for European roads", H2-View, 17 September 2020, <https://www.h2-view.com/story/1000-new-hydrogen-powered-buses-planned-for-european-roads>; Fuel Cells and Hydrogen Joint Undertaking, *Fuel Cells and Hydrogen for Green Energy in European Cities and Regions* (Brussels: May 2018), https://www.fch.europa.eu/sites/default/files/180515_FCH2JU_BC%20Regions%20Cities_Stakeholder%20Communication%20Package_English_OUT%20%28ID%203520090%29.pdf; Fuel Cell Electric Buses, "Demos in Europe: Bus locations", <https://www.fuelcellbuses.eu/category/demos-europe>, viewed 23 September 2020; T. Kawakami, "'Hydrogen Valley' powers China's fuel cell industry", Nikkei Asia, 4 July 2020, <https://asia.nikkei.com/Business/China-tech/Hydrogen-Valley-powers-China-s-fuel-cell-industry>; "Zhangjiakou is speeding up to build a 'Hydrogen Energy City', the advantages of renewable energy hydrogen production are highlighted", Netease News, 15 June 2020, <https://3g.163.com/dy/article/FF6AA8750534CY9P.html> (using Google Translate).
- 207 G. Zhang, J. Zhang and T. Xie, "A solution to renewable hydrogen economy for fuel cell buses – a case study of Zhangjiakou in North China", *International Journal of Hydrogen Energy*, vol. 45, no. 29 (2020), pp. 14603-13, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7173837>; S. Lewis, "N China hydrogen push led by hydrogen as by-product, renewables", S&P Global Platts, 11 June 2020, <https://www.spglobal.com/platts/en/market-insights/latest-news/metals/061120-n-china-hydrogen-push-led-by-hydrogen-as-by-product-renewables>.
- 208 R. Whitlock, "The world's first hydrogen-powered double decker bus arrives in Aberdeen", Renewable Energy Magazine, 9 October 2020, <https://www.renewableenergymagazine.com/miscellaneous/the-world-s-first-hydrogenpowered-double-decker-20201009>.
- 209 S. Gössling, "Why cities need to take road space from cars – and how this could be done", *Journal of Urban Design*, vol. 25, no.4 (2020), pp. 443-48, <https://www.tandfonline.com/doi/full/10.1080/13574809.2020.1727318>.
- 210 Sales of electric cars topped 2.1 million globally in 2019, surpassing 2018 – already a record year. China remains the world's largest market for electric cars, followed by Europe and the United States. Battery electric cars (comprising battery electric cars and plug-in hybrid electric cars) made up a larger portion of electric car sales (almost three-quarters) in 2019. From IEA, *Global EV Outlook 2020*, op. cit. note 178.
- 211 IEA, *Global EV Outlook 2020*, op. cit. note 178.
- 212 H. Cui, D. Hall and N. Lutsey, *Update on the Global Transition to Electric Vehicles Through 2019* (Washington, DC: International Council on Clean Transportation (ICCT), July 2020), <https://theicct.org/sites/default/files/publications/update-global-EV-stats-20200713-EN.pdf>.
- 213 N. Kampouris, "Greece's Trikala to offer electric vehicles for public use inside the city", Greek Reporter, 17 April 2019, <https://greece.greekreporter.com/2019/04/17/greeces-trikala-to-offer-electric-vehicles-for-public-use-inside-the-city>; Bristol City Council, "New electric vehicle fleet for hire in Bristol following funding boost", 29 May 2019, <https://news.bristol.gov.uk/news/new-electric-vehicle-fleet-for-hire-in-bristol-following-funding-boost>; BlueLA, <https://www.bluela.com>, viewed 20 September 2020.
- 214 MOVMI, "Carsharing market & growth analysis 2019", 10 July 2019, <https://movmi.net/carsharing-market-growth-2019>; H. Lardier, "Video: In Utrecht, carsharing is being powered by solar energy", Groupe Renault #easyelectricle, 14 August 2019, <https://easyelectricle.groupe.renault.com/en/day-to-day/shared-mobility/video-in-utrecht-carsharing-is-being-powered-by-solar-energy>; R. Whitlock, "Volkswagen WeShare launched in Berlin as full-electric service", Renewable Energy Magazine, 28 June 2019, https://www.renewableenergymagazine.com/electric_hybrid_vehicles/volkswagen-weshare-launched-in-berlin-as-fullelectric-20190628; REN21, op. cit. note 5.
- 215 A. Ingram, "BYD e6 electric taxi fleet launched in Hong Kong to cut pollution", Green Car Reports, 23 March 2013, https://www.greencarreports.com/news/1084356_byd-e6-electric-taxi-fleet-launched-in-hong-kong-to-cut-pollution; J. Ayre, "Macao gets its first electric taxi fleet thanks to partnership with BYD", CleanTechnica, 18 February 2018, <https://cleantechnica.com/2018/02/13/macao-gets-first-electric-taxi-fleet-thanks-partnership-byd>; "Giving up gas: China's Shenzhen switches to electric taxis", Phys.org, 8 January 2019, <https://phys.org/news/2019-01-gas-china-shenzhen-electric-taxis.html>; LEVC, "London's largest electric taxi fleet expands to over 70 new TX taxis", 21 September 2018, <https://www.levc.com/corporate/news/largest-taxi-fleet-expands>; B. Schmidt, "Thousands of electric taxis in London have saved 6800 tonnes of CO2", The Driven, 2 August 2019, <https://thedriven.io/2019/08/02/thousands-of-electric-taxis-in-london-have-saved-6-8-tonnes-of-co2>; A. Hirschfeld, "Taxis go electric: Tesla joins cab fleets in New York City", Observer, 15 November 2019, <https://observer.com/2019/11/tesla-taxi-electric-vehicles-cab-fleets>; F. Lambert, "A fleet of Tesla cars are being deployed as taxis in Columbus", Electrek, 2 August 2019, <https://electrek.co/2019/08/02/tesla-fleet-taxi-columbus>; EkoRent, "Landmark development as first full electric mobility company launches in Nairobi", 9 August 2018, <https://ekorent.fi/en/news-en/landmark-development-as-first-full-electric-mobility-company-launches-in-nairobi>; UITP, *Global Taxi Benchmarking Study 2019* (Brussels: November 2020), https://cms.uitp.org/wp/wp-content/uploads/2020/11/Statistics-Brief-Taxi-Benchmarking_NOV2020-web.pdf.
- 216 ETAuto, "India offers its unused electric vehicles to taxi fleets", 1 August 2019, <https://auto.economicstimes.indiatimes.com/news/aftermarket/india-offers-its-unused-electric-vehicles-to-taxi-fleets/70478371>.
- 217 The Moving Rwanda Initiative provides for the collection and analysis of data on aspects such as the performance of electric cars, consumer acceptance, consumption trends and appropriate traffic conditions, maintenance and above all charging for cars. To improve the reliability of data collected during the pilot phase, an increase in the operational capacity is planned. The number of cars was expected to increase from 4 to around 50, while the number of charging stations across the city should increase from 1 to 15. From B. Ngounou, "Rwanda: Volkswagen launches electric car pilot project in Kigali", Afrik21, 31 October 2019, <https://www.afrik21.africa/en/rwanda-volkswagen-launches-electric-car-pilot-project-in-kigali>.
- 218 Driving, "Téo Taxi returns to Quebec streets after withdrawing from the province in 2019", 31 October 2020, <https://driving.ca/kia/auto-news/news/teo-taxi-returns-to-quebec-streets-after-withdrawing-from-the-province-in-2019>.
- 219 Practically all of the fuel cell EVs (FCEVs) in the United States, Japan and the Republic of Korea are passenger cars. Similarly, the European FCEV stock is dominated by cars (almost 95%), although in this case, there are also a few buses (80 units) and trucks (28 light-commercial vehicles and 8 heavy-duty trucks). From IEA, *Global EV Outlook 2020*, op. cit. note 178.
- 220 California Air Resources Board, *2020 Annual Evaluation of Fuel Cell Electric Vehicle Deployment & Hydrogen Fuel Station Network Development* (Sacramento, CA: September 2020), p. 14, https://ww2.arb.ca.gov/sites/default/files/2020-09/ab8_report_2020.pdf; J. Cart, "California's 'hydrogen highway' never happened. Could 2020 change that?", Cal Matters, 9 January 2020, <https://calmatters.org/environment/2020/01/why-california-hydrogen-cars-2020>; European Commission, "Hydrogen drives Europe towards emissions-free transport", 29 August 2016, <https://ec.europa.eu/programmes/horizon2020/en/news/hydrogen-drives-europe-towards-emissions-free-transport>.
- 221 FuelCellsWorks, "Taking a taxi in Paris: Now with hydrogen!" 29 March 2019, <https://fuelcellsworks.com/news/taking-a-taxi-in-paris-now-with-hydrogen>. More recent plans mention the possibility to convert 50,000 taxis or "taxi-like vehicles" to FCEVs running on "green" and "blue" hydrogen in the French capital. From M. Hall, "Plans for 50,000 hydrogen-powered taxis in Paris", pv magazine, 12 November 2020, <https://www.pv-magazine.com/2020/11/12/plans-for-50000-hydrogen-powered-taxis-in-paris/>.

- pv-magazine.com/2020/11/12/plans-for-50000-hydrogen-powered-taxi-in-paris; State of Green, "Hail a hydrogen-powered taxi on the streets of Copenhagen", 14 May 2019, <https://stateofgreen.com/en/partners/state-of-green/news/hail-a-hydrogen-powered-taxi-on-the-streets-of-copenhagen>.
- 222 IEA, *Global EV Outlook 2020*, op. cit. note 178; IEA, *Global EV Outlook 2019* (Paris: 2019), <https://www.iea.org/publications/reports/globalevoutlook2019>.
- 223 In 2019, the stock of electric two-wheelers in China was close to 300 million units and the stock of three-wheelers was around 50 million units. India is home to around 1.5 million battery-powered electric three-wheelers/e-rickshaws and 0.6 million electric two-wheelers. From IEA, *Global EV Outlook 2020*, op. cit. note 178; New Urban Mobility Alliance, "New Mobility Atlas", <https://www.numo.global/new-mobility-atlas#2/20.7/-0.48>, viewed 30 March 2020.
- 224 R. Halder, "Solar rickshaws make debut on IIT-Delhi campus", *Times of India*, 20 July 2019, <https://timesofindia.indiatimes.com/city/delhi/solar-rickshaws-make-debut-on-iit-d-campus/articleshow/70299940.cms>.
- 225 "Uganda's motorbikes go green", DW, 12 May 2020, <https://www.dw.com/en/ugandas-motorbikes-go-green/a-53359578>; "A sunny future for e-bikes in Namibia", DW, 22 March 2019, <https://www.dw.com/en/a-sunny-future-for-e-bikes-in-namibia/av-48013690>.
- 226 C. Lewis, "Logistics hotspots: Nine that shine", *Inbound Logistics*, 20 September 2016, <https://www.inboundlogistics.com/cms/article/logistics-hotspots-nine-that-shine>.
- 227 IEA, *Global EV Outlook 2020*, op. cit. note 178.
- 228 Ibid.
- 229 B. Schmidt, "Sendle rolls out solar-powered electric delivery vehicles in Australia", *The Driven*, 9 June 2020, <https://thedriven.io/2020/06/09/sendle-rolls-out-solar-powered-electric-delivery-vehicles-in-australia>.
- 230 R. Cooper, "Royal Mail trials electric taxi van for parcel and letter deliveries", *Climate Action*, 9 July 2020, <http://www.climateaction.org/news/royal-mail-trials-electric-taxi-van-for-parcel-and-letter-deliveries>; J. Barrie, "John Lewis and Waitrose will start rolling out a new electric van delivery fleet next year", *iNews*, 29 July 2020, <https://inews.co.uk/news/environment/john-lewis-waitrose-new-electric-van-delivery-fleet-2021-564927>.
- 231 Transport Decarbonisation Alliance, *Zero Emission Urban Freight* (May 2019), <http://tda-mobility.org/wp-content/uploads/2019/05/TDA-Zero-Emission-Urban-Freight.pdf>.
- 232 A. Zaleski, "Cities seek deliverance from the e-commerce boom", *Bloomberg CityLab*, 20 April 2017, <https://www.bloomberg.com/news/articles/2017-04-20/how-cities-are-coping-with-the-delivery-truck-boom>; CIVITAS, *Smart Choices for Cities: Making Urban Freight Logistics More Sustainable* (no date), https://civitas.eu/sites/default/files/civ_pol-an5_urban_web.pdf.
- 233 nFront Consulting LLC, *Orlando Utilities Commission 2019 Ten-Year Site Plan* (Orlando, FL: April 2019), <http://www.psc.state.fl.us/Files/PDF/Utilities/Electricgas/TenYearSitePlans/2019/Orlando%20Utilities%20Commission.pdf>; "Shell partners with Maxim's Group, turning waste into energy to power commercial fleets", *Markets Insider*, 11 March 2019, <https://markets.businessinsider.com/news/stocks/shell-partners-with-maxim-s-group-turning-waste-into-energy-to-power-commercial-fleets-1028017961>.
- 234 C. Sølvsten, "22 nye skraldebiler i Esbjerg kører på biogas fra affald og gylle", *TVS*, 21 September 2020, <https://www.tvsvd.dk/ esbjerg/22-nye-skraldebiler-i-esbjerg-koerer-paa-biogas-fra-affald-og-gylle> (using Google Translate); "Neste, McDonald's Netherlands and HAVI promote circular economy", op. cit. note 162.
- 235 "Garbage collection trucks market benefits from steady sales of refuse trucks", *Recycling Magazine*, 24 September 2019, <https://www.recycling-magazine.com/2019/09/24/garbage-collection-trucks-market-benefits-from-steady-sales-of-refuse-trucks>. See also information and sources used throughout this section.
- 236 The official data submitted for sales of medium- and heavy-duty (with greater than 3.5 tonnes gross vehicle weight) electric trucks in China report 6,112 vehicles in 2019, 60% more than the previous sales spike in 2017. From IEA, *Trucks and Buses* (Paris: 2020), <https://www.iea.org/reports/trucks-and-buses>.
- 237 K. Field, "BYD lands deal for 500 electric refuse trucks with two companies in Shenzhen", *CleanTechnica*, 16 May 2018, <https://cleantechnica.com/2018/05/16/byd-lands-deal-for-500-electric-refuse-trucks-with-two-companies-in-shenzhen>.
- 238 J. Gitlin, "Seattle makes history with electric garbage truck", *ARS Technica*, 22 May 2019, <https://arstechnica.com/cars/2019/05/seattle-makes-history-with-electric-garbage-truck>.
- 239 M. Bloch, "SA's first electric garbage truck doing the rounds", *Sea Electric*, 25 February 2020, <https://www.sea-electric.com/sas-first-electric-garbage-truck-doing-the-rounds>; B. Schmidt, "Australia's first fully electric rubbish trucks clean up in Casey", *The Driven*, 24 May 2019, <https://thedriven.io/2019/05/24/australias-first-fully-electric-rubbish-trucks-clean-up-in-casey>.
- 240 IEA, *Global EV Outlook 2020*, op. cit. note 178.
- 241 R. Cooper, "World first' full-electric delivery vehicle to be trialled in London", *Climate Action*, 4 August 2020, <http://www.climateaction.org/news/world-first-full-electric-delivery-vehicle-to-be-trialled-in-london>.
- 242 A. Stoyanov, "Manchester waste collection goes eco-friendly", *The Mayor*, 7 June 2020, <https://www.themayor.eu/en/a/view/manchester-waste-collection-goes-eco-friendly-5124>.
- 243 City Logistics, "European demonstration programme on hydrogen garbage trucks: LIKE 'N Garb HY!", 13 August 2020, <http://www.citylogistics.info/projects/european-demonstration-programme-on-hydrogen-garbage-trucks-life-n-garb-hy>; Interreg North-West Europe HECTOR, "Project summary", 4 October 2019, <https://www.nweurope.eu/projects/project-search/hector-hydrogen-waste-collection-vehicles-in-north-west-europe>.
- 244 N. B. Groth, C. Fertner and J. Grosse, "Urban energy generation and the role of cities", *Journal of Settlements and Spatial Planning*, Special Issue no. 5 (2016), pp. 5-17, https://geografie.ubbcluj.ro/ccau/jssp/arihiva_si5_2016/02JSSPSI052016.pdf.
- 245 See, for example, K. Appunn, "Energiewende hinges on unblocking the power grid", *Clean Energy Wire*, 10 April 2018, <https://www.cleanenergywire.org/dossiers/energy-transition-and-germanys-power-grid>.
- 246 See, for example, K. A. Alboaouh and S. Mohagheghi, "Impact of rooftop photovoltaics on the distribution system", *Journal of Renewable Energy* (2020), pp. 1-23, <https://doi.org/10.1155/2020/4831434>.
- 247 K. Cleary and K. Palmer, "Renewables 101: Integrating renewable energy resources into the grid", *Resources for the Future*, 15 April 2020, <https://www.rff.org/publications/explainers/renewables-101-integrating-renewables>.
- 248 **City Snapshot: Oxford** based on the following sources: Oxford City Council, *Climate Emergency Strategy Support Report September 2019* (Oxford: 2020), https://www.oxford.gov.uk/downloads/file/6660/climate_emergency_strategy_support_report_2019; Edie, "Oxford City Council targets net-zero by end of 2020", 16 December 2019, <https://www.edie.net/news/9/Oxford-City-Council-targets-net-zero-by-end-of-2020>; Oxford City Council, "£41m project to support Oxford on journey to zero carbon", 3 April 2019, https://www.oxford.gov.uk/news/article/1049/41m_project_to_support_oxford_on_journey_to_zero_carbon.
- 249 REN21, op. cit. note 5.
- 250 T. Stevens, "At least 24 Utah cities, counties pledge to use renewable energy by 2030", *Salt Lake Tribune*, 13 January 2020, <https://www.sltrib.com/news/politics/2020/01/13/least-utah-cities>.
- 251 Salt Lake City, "100% Renewable Energy Community Goal", <https://www.slc.gov/sustainability/100-renewable-energy-community-goal>, viewed 15 December 2020; "Utah communities celebrate landmark renewable energy legislation", *slcgreen*, 23 April 2019, <https://slcgreenblog.com/2019/04/23/community-renewable-energy-act>.
- 252 Los Angeles Department of Water and Power (LADWP), "Green hydrogen & the Intermountain Power Project", presentation, https://www.cpuc.ca.gov/uploadedFiles/CPUC_Website/Content/Utilities_and_Industries/Energy/Energy_Programs/Gas/Natural_Gas_Market/Nov13LADWP.pdf, viewed September 2020.
- 253 Ibid.
- 254 N. S. Malik, "L.A. aims to be the first to power U.S. city with renewable hydrogen", *Bloomberg*, 10 March 2020, <https://www.bloomberg.com/news/articles/2020-03-10/l-a-aims-to-be-first-to-power-u-s-city-with-renewable-hydrogen>.
- 255 LADWP, op. cit. note 252; Malik, op. cit. note 254.
- 256 Malik, op. cit. note 254.
- 257 City of Sydney, "5 things to know about our electricity deal", <https://news.cityofsydney.nsw.gov.au/articles/5-things-to-know-about-our-electricity-deal>, viewed 15 December 2020.
- 258 Ibid.

- 259 S. Hanley, "City of Sydney goes 100% renewable", CleanTechnica, 3 July 2020, <https://cleantechnica.com/2020/07/03/city-of-sydney-goes-100-renewable>.
- 260 E. Chidley, "London pioneers the city's first 'virtual power station'", Climate Action, 10 March 2020, <http://www.climateaction.org/news/london-pioneers-the-citys-first-virtual-power-station>.
- 261 Energy Sector Management Assistance Program (ESMAP), *Mini Grids for Half a Billion People: Market Outlook and Handbook for Decision Makers* (Washington, DC: World Bank, June 2019), https://esmap.org/mini_grids_for_half_a_billion_people; IRENA, *Innovation Landscape Brief: Renewable Mini-Grids* (Abu Dhabi: 2019), https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Sep/IRENA_Renewable_mini-grids_2019.pdf.
- 262 EMSD Energy Land, "Building – DCS in other countries", https://www.emsd.gov.hk/energyland/en/building/district_cooling_sys/dcs_countries.html, viewed 15 December 2020.
- 263 Building Energy Conservation Research Center and IEA, *District Energy Systems in China: Options for Optimization and Diversification* (Paris: 2017), https://www.researchgate.net/publication/335978479_District_Energy_Systems_in_china_options_for_Optimization_and_Diversification.
- 264 Euroheat & Power, "Country by country 2019", https://www.euroheat.org/cbc_publications/cbc2019/sweden, viewed 22 December 2020.
- 265 State of Green, "Supplying cities with energy through collective heating and cooling", <https://stateofgreen.com/en/creating-smart-green-liveable-cities/heating-and-cooling-the-city>, viewed 3 January 2020.
- 266 West Dunbartonshire Council, "Pioneering district heating network now heating Clydebank", 9 December 2020, <https://www.west-dunbarton.gov.uk/council/newsroom/news/2020/dec/district-heating-network>; R. Dixon, "Scotland is about to hit its 100% renewable electricity target. It must go further", The Scotsman, 25 May 2020, <https://www.scotsman.com/news/opinion/columnists/scotland-about-hit-its-100-renewable-electricity-target-it-must-go-further-richard-dixon-2864016>.
- 267 D. Mavrokefalidis, "Leeds injects £24m to develop six new district heating networks", Energy Live News, 12 October 2020, <https://www.energylivenews.com/2020/10/12/leeds-injects-24m-to-develop-six-new-district-heating-networks>.
- 268 DHC News, "Montauban: Installation des canalisations du réseau de chaleur", 2 December 2020, <https://www.dhcnews.com/montauban-installation-canalisation-reseau-chaaleur>.
- 269 HOFOR, "District cooling reduces CO₂ emissions in central Copenhagen", State of Green, <https://stateofgreen.com/en/partners/hofor-utility-company/solutions/district-cooling-reduces-co2-emissions-in-central-copenhagen>, viewed 22 December 2020; DBDH, "District cooling", <http://www.e-pages.dk/dbdh/77>, viewed 22 December 2020; Smart City Sweden, "Gothenburg smart district cooling", <https://smartcitysweden.com/best-practice/386/gothenburg-smart-district-cooling>, viewed 22 December 2020; Celsius City, "District cooling Helsingborg, Sweden", 14 February 2020, <https://celsiuscity.eu/district-cooling-in-helsingborg-sweden>; Euroheat & Power, "Country by country 2019", op. cit. note 264; EMSD Energy Land, op. cit. note 262.
- 270 IRENA, op. cit. note 144.
- 271 The developments are part of the visionary Chula Smart City Project, which seeks to sustainably rejuvenate and redevelop the Siam Square and Suan Luang – Sam Yan commercial areas. Expected to be fully completed in 2027, the plant will be developed over three phases, with its first phase expected to be operational in late 2022. From Cool Coalition, "Consortium secures new \$329m contract for district cooling system in the heart of Bangkok", <https://coolcoalition.org/consortium-secures-new-329m-contract-for-district-cooling-system-in-the-heart-of-bangkok>, viewed 7 November 2020.
- 272 Tractebel, "District Cooling System at Amaravati Government Complexes in India", <https://tractebel-engie.com/en/news/2019/district-cooling-system-at-amaravati-government-complexes-in-india>, viewed 10 January 2021.
- 273 Cool Coalition, op. cit. note 271.
- 274 M. G. Fernández et al., *Efficient District Heating and Cooling Systems in the EU: Case Studies Analysis, Replicable Key Success Factors and Potential Policy Implications* (Luxembourg: Publications Office of the European Union, 2016), https://publications.jrc.ec.europa.eu/repository/bitstream/JRC104437/study%20on%20efficient%20dhc%20systems%20in%20the%20eu%20-dec2016_final%20-%20public%20report6.pdf.
- 275 Ibid.
- 276 B. Radowitz, "Stockholm plans world's first carbon-negative district heating", Recharge, 28 January 2020, <https://www.rechargenews.com/transition/stockholm-plans-world-s-first-carbon-negative-district-heating/2-1-745582>; Smart City Sweden, "Stockholm innovates district heating with new solutions and renewable sources", <https://smartcitysweden.com/best-practice/401/stockholm-innovates-district-heating-with-new-solutions-and-renewable-sources>, viewed 20 January 2021.
- 277 A. Mishra, "Data science: The key tool cities need to reduce carbon emissions", *Forbes*, 13 July 2020, <https://www.forbes.com/sites/ankitmishra/2020/07/13/data-science-the-key-tool-cities-need-to-reduce-carbon-emissions>; European Automobile Manufacturers Association, *Review of the Alternative Fuels Infrastructure Directive* (Brussels: June 2020), https://www.acea.be/uploads/publications/ACEA_Position_Paper-Review_of_Alternative_Fuels_Infrastructure_Directive.pdf.
- 278 Around 6.5 million EV chargers were private, light-duty vehicle slow chargers in homes, multi-dwelling buildings and workplaces. The number of publicly accessible slow chargers was 598,000 (52% in China), while public fast chargers totalled 272,000 (82% in China). From IEA, *Global EV Outlook 2020*, op. cit. note 178.
- 279 Based on information and sources used throughout this section.
- 280 Adelaide City Council, *Carbon Neutral Adelaide Action Plan 2016-2021* (Adelaide: 2016), <https://d31atr86jnrq2.cloudfront.net/docs/action-plan-carbon-neutral.pdf>.
- 281 Chargefox, "Chargefox opens South Australia's first ever ultra-rapid EV charging station in Keith", 10 March 2020, <https://www.chargefox.com/chargefox-opens-south-australias-first-ever-ultra-rapid-ev-charging-station-in-keith>.
- 282 **Table 2** from the following sources: 2,354 EV chargers in Los Angeles as of March 2020, from PlugShare, "Best EV charging stations in Los Angeles", <https://www.plugshare.com/directory/us/california/los-angeles>, viewed 29 October 2020; Los Angeles population of 3.98 million as of 1 July 2019, from US Census Bureau, "Population estimates, July 1, 2019", <https://www.census.gov/quickfacts/table/US/PS7045219>, viewed 29 October 2020; Los Angeles renewable electricity share in 2018 from LADWP, *2018 Power Content Label* (Los Angeles: July 2019), https://www.energy.ca.gov/sites/default/files/2020-01/2018_PCL_LADWP.pdf; San Jose EV chargers per million population from A. Bui, P. Slowik and N. Lutsey, *Update on Electric Vehicle Adoption Across U.S. Cities* (Washington, DC: ICCT, August 2020), <https://theicct.org/sites/default/files/publications/EV-cities-update-aug2020.pdf>; San Jose renewable electricity share in 2018 from San José Clean Energy, *2018 Power Content Label* (San Jose: July 2019), <https://sanjosecleanenergy.org/wp-content/uploads/2020/05/SJCE-2018-Power-Content-Label.pdf>; EV chargers per million population for Amsterdam, Beijing, London, Oslo, Paris and Stockholm from D. Hall and N. Lutsey, *Electric Vehicle Charging Guide for Cities* (Washington, DC: ICCT, 2020), p. 8, https://theicct.org/sites/default/files/publications/EV_charging_guide_03162020.pdf; country-level data on renewable shares for 2019 based on IEA, "Countries and regions", <https://www.iea.org/countries>, viewed 29 October 2020; Chinese cities from Hall and Lutsey, op. cit. this note; D. Hall, H. Cui and N. Lutsey, *Electric Vehicle Capitals: Showing the Path to a Mainstream Market* (Washington, DC: ICCT, November 2019), https://theicct.org/sites/default/files/publications/EV_Capitals_2018_20191121.pdf; Statista, "Number of public electric vehicle charging stations in Shanghai China 2019, by type", <https://www.statista.com/statistics/1035822/china-shanghai-public-electric-vehicle-charging-station-number-by-type>, updated 19 May 2020; Stockholm renewable electricity share based on CDP data received October 2020.
- 283 A. Krok, "Oslo will build wireless chargers for electric taxis in zero-emissions push", RoadShow CNET, 22 March 2019, <https://www.cnet.com/roadshow/news/oslo-wireless-chargers-electric-taxi-fleet/>; B. Harvorson, "World's first high-power wireless charging for taxis uses Jaguar I-Pace, in Oslo", Green Car Reports, 24 June 2020, <https://www.greencarreports.com/news/1128628-first-high-power-wireless-charging-jaguar-i-pace-taxis-oslo>.

- 284 S. Hanley, "NYC adds 50 Envision off-grid solar EV charging stations", *CleanTechnica*, 27 December 2018, <https://cleantechnica.com/2018/12/27/nyc-adds-50-envision-off-grid-solar-ev-charging-stations>.
- 285 In 2019, EDP (Energias de Portugal) announced the installation of 30 ultra-fast charging stations for EVs in the state of São Paulo. Audi, Porsche and Volkswagen partnered with EDP on this project, contributing to the vehicles testing and homologation of the infrastructure. The project costs an estimated USD 6 million and will include 29 stations of 150 kW (DC), 1 station of 350 kW (DC) and 30 devices of 22 kW (AC). From Energias de Portugal (EDP), "EDP anuncia a primeira rede de recarga ultrarrápida de veículos elétricos do Brasil", November 2019, <https://www.edp.com.br/noticias/edp-anuncia-a-primeira-rede-de-recarga-ultrarrapida-de-veiculos-eletricos-do-brasil>, and from EDP, "EDP announces electric mobility project with Audi, Porsche and VW for Brazil", 23 October 2019, <https://www.edp.com/en/news/2019/10/23/edp-announces-electric-mobility-project-audi-porsche-and-vw-brazil>. In 2019, the Metropolitan Regional Council of Santiago, along with Copec (Compañía de Petroleos de Chile), launched a public-private partnership to develop the largest charging infrastructure for EVs in South America with 104 charging points. Each point has a capacity of 22 kW, and the project cost around USD 2.5 million. From Gobierno de Santiago de Chile, "Santiago estrena nueva red de carga pública para vehículos eléctricos", October 2019, <https://www.gobiernosantiago.cl/nueva-red-de-carga-vehiculos-electricos>, and from Empresas COPEC, "COPEC launches new EV public charging network", 25 October 2019, <https://www.empresascopec.cl/en/noticia/copec-launches-new-ev-public-charging-network>.
- 286 Everoze, *V2G Global Roadtrip: Around the World in 50 Projects* (Bristol, UK: 2018), <http://everoze.com/app/uploads/2018/10/UKPN001-S-01-H-V2G-global-review-compressed.pdf>; IRIS Smart Cities, "More than just mobility... an 'e-revolution': Utrecht installs world's first public charge and discharge electric vehicle stations", 31 January 2019, <https://irissmartcities.eu/content/more-just-mobility%E2%80%A6-%E2%80%98e-revolution%E2%80%99-utrecht-installs-world%E2%80%99s-first-public-charge-and-discharge-electric-vehicle-stations>; The Mobility House, "Johan Crujff Arena in Amsterdam and The Mobility House set the pace for the future of electric mobility", press release (Amsterdam: 9 December 2019), https://www.mobilityhouse.com/int_en/magazine/press-releases/the-mobility-house-amsterdam-arena-v2g-project.html; Arnhem from Elaadnl, "Testing vehicle to grid (V2G) possibilities in the INVADE project, with surprising results", 20 December 2019, <https://www.elaad.nl/news/testing-vehicle-to-grid-v2g-possibilities-in-the-invade-project-with-surprising-results>; Cranfield from E.ON, "Parking up to power business: E.ON and Nissan announce major V2G project milestone", 6 August 2020, <https://www.eonenergy.com/About-eon/media-centre/eon-nissan-v2g-milestone>.
- 287 Such collaborative initiatives are key to ensuring that EV charging does not burden the grid but instead provides an opportunity to smoothly integrate high shares of renewable energy (particularly variable solar and wind power) by coupling the electricity and transport sectors. From M. Motyka, "Renewables (em)power smart cities", *Deloitte*, 5 March 2019, <https://www2.deloitte.com/xe/en/insights/industry/power-and-utilities/smart-renewable-cities-wind-solar.html>; M. Kane, "Nuvve announces vehicle-to-grid (V2G) pilot programs", *InsideEVs*, 3 January 2019, <https://insideevs.com/news/341858/nuvve-announces-vehicle-to-grid-v2g-pilot-programs>.
- 288 See, for example, National Commission on Energy Policy, *Task Force on Biofuels Infrastructure* (Washington, DC: 2019), <https://bipartisanpolicy.org/wp-content/uploads/2019/03/biofuels-taskforce.pdf>; US Department of Energy (DOE), Office of Energy Efficiency & Renewable Energy, "Hydrogen delivery", <https://www.energy.gov/eere/fuelcells/hydrogen-delivery>, viewed 29 October 2020; IRENA, op. cit. note 4.
- 289 As of 2019, the United States had at least 613 biodiesel (B20 or above) fuelling stations and more than 3,777 ethanol (E85) fuelling stations, from Alternative Fuels Data Center, "U.S. alternative fueling stations by fuel", <https://afdc.energy.gov/data/10332>, viewed 20 September 2020; D. DeRamus and C. Cain, *Biodiesel Distribution in the U.S. and Implications for RFS2 Volume Mandates* (Washington, DC: Bates White Economic Consulting, July 2016), https://www.bateswhite.com/media/publication/116_2016.07.11%20Biodiesel%20paper%20final.pdf. In Europe, at least 457 stations were selling pure (100% biomethane), and more than 500 additional stations were selling blended biomethane, in 2019, from NGV Europe, "NGVA Europe marks the 200th European LNG fuelling station with a revamp of its stations map", press release (Brussels: 14 May 2019), https://www.ngva.eu/wp-content/uploads/2019/05/PRESS-RELEASE_NGVA-Europe_200LNGstations_map-update_20190514.pdf; European Biogas Association, *Biomethane in Transport* (Brussels: April 2016), <https://www.europeanbiogas.eu/wp-content/uploads/2019/07/Biomethane-in-transport.pdf>.
- 290 Jing, op. cit. note 191.
- 291 R. Kotrba, "Targray opens new biodiesel terminal in Antwerp, Belgium", *Biodiesel Magazine*, 7 October 2019, <http://www.biodieselmagazine.com/articles/2516809/targray-opens-new-biodiesel-terminal-in-antwerp-belgium>.
- 292 M. Sapp, "Eco-Energy's ethanol distribution facility in Phoenix enters into final stage of construction", *Biofuels Digest*, 6 February 2020, <https://www.biofuelsdigest.com/bdigest/2020/02/06/eco-energys-ethanol-distribution-facility-in-phoenix-enters-into-final-stage-of-construction>.
- 293 US DOE, op. cit. note 288.
- 294 Japan remained the leader with at least 113 hydrogen filling stations, followed by Germany (81 stations) and the United States (64). In China, the number of hydrogen refuelling stations increased three-fold in 2019 (from 20 to 61). From IEA, *Global EV Outlook 2020*, op. cit. note 178.
- 295 H2Stations, "Hydrogen refuelling stations worldwide", <https://www.h2stations.org>, viewed 29 October 2020.
- 296 Shell, "Hydrogen fuel", <https://www.shell.com/energy-and-innovation/new-energies/hydrogen.html>, viewed 12 October 2020.
- 297 The station will have the capacity to supply up to 1,600 kilograms of hydrogen per day. From 2022 (when it is expected to become operational), the station will serve the region's fleet of 14 Alstom Coradia iLint hydrogen trains, following the announcement that the region's initial two trains successfully completed an 18-month, 180,000-kilometre test phase at the end of February 2020. From O. Cuenca, "Construction launched for Bremervörde hydrogen train filling station", *International Railway Journal*, 28 July 2020, <https://www.railjournal.com/technology/construction-launched-for-bremervorde-hydrogen-train-filling-station>.

FINANCING AND INVESTMENT IN CITIES

- 1 Frankfurt School – United Nations Environment Programme (UNEP) Collaborating Centre for Climate & Sustainable Energy Finance (FS-UNEP Centre) and BloombergNEF, *Global Trends in Renewable Energy Investment 2020* (Frankfurt: 2020), <http://www.fs-unep-centre.org>.
- 2 BloombergNEF, "Clean Energy Investment Trends, 1H 2020" (London: 13 July 2020), <https://data.bloomberglp.com/professional/sites/24/BNEF-Clean-Energy-Investment-Trends-1H-2020.pdf>.
- 3 Knowledge Lab for Public-Private Partnerships, www.pppKnowledgeLab.org, viewed 18 September 2020.
- 4 CDP and C40 Cities, *The Demand for Financing Climate Projects in Cities* (London: 2018), https://www.transparency-partnership.net/system/files/document/C40_CFF_CDP_Infrastructure_projects_report.pdf.
- 5 **Box 1** from the following sources: B. Buchner et al., *Global Landscape of Climate Finance 2019* (London: Climate Policy Initiative, 2019), <https://www.climatepolicyinitiative.org/publication/updated-view-on-the-global-landscape-of-climate-finance-2019>; J. Hogg, "Financing sustainable cities: How we're helping Africa's cities raise their credit ratings", World Bank, 24 October 2013, <https://www.worldbank.org/en/news/feature/2013/10/24/financing-sustainable-cities-africacreditworthy>; Cities Climate Finance Leadership Alliance, <http://www.citiesclimatefinance.org>, viewed 20 January 2021.
- 6 **City Snapshot: Palmas** from Institut Brasileiro de Geografia e Estatística, "Palmas: Panorama", <https://cidades.ibge.gov.br/brasil/to/palmas/panorama>, viewed 10 December 2020, and from International Urban Cooperation Program, "Programa Palmas Solar", 2018, http://iuc-la.eu/wp-content/uploads/2020/03/POR_Palmas__TO_-_Programa_Palmas_Solar.pdf.
- 7 ICLEI – Local Governments for Sustainability, "Climate finance decision-making tree", <https://www.iclei.org/en/publication/climate-finance-decision-making-tree>, viewed 10 October 2020.
- 8 M. Campbell et al., *Land Value Capture to Fund Transport Investment in Cities* (Wellington, New Zealand: BRANZ, 2016), https://www.researchgate.net/publication/303995861_Land_value_capture_to_fund_transport_investments_in_cities.
- 9 **Box 2** and **Figure 16** based on the following sources: Gofossilfree.org, "Divestment commitments overview", <https://gofossilfree.org/divestment/commitments>, viewed 14 December 2020; C40 Cities Climate Leadership Group, *Divesting from Fossil Fuels, Investing in Our Future: A Toolkit for Cities* (London: 2020), <https://c40.my.salesforce.com/sfc/p/#36000001Enhz/a/1Q00000MmBe/OsK2VDoRdYwGyPuXNGTakGB47EnJKXFUE5qWGpJ Eawg>; DivestInvest.org, "Commitments to DivestInvest", <https://www.divestinvest.org/commitments>, viewed 27 December 2020; J. C. Figueira, "12 major cities commit to divest from fossil fuel companies", Climate Action, 25 September 2020, <http://www.climateaction.org/news/12-major-cities-commit-to-divest-from-fossil-fuel-companies>; M. Rowling, "Cities promise to divest from fossil fuels to boost green recovery", Thomson Reuters Foundation News, 22 September 2020, <https://news.trust.org/item/20200922131602-u2ee2>.
- 10 ICLEI, op. cit. note 7.
- 11 E. Ahmad, *Infrastructure Finance in the Developing World: Public Finance Underpinnings for Infrastructure Financing in Developing Countries* (Washington, DC: Intergovernmental Group of Twenty-Four and Global Green Growth Institute, 2015), <http://www.g24.org/wp-content/uploads/2016/05/MARGGK-WP05.pdf>.
- 12 CORENA, "Citizens own renewable energy network Australia Inc.", <https://corenafund.org.au>, viewed 11 December 2020; Asia from Indiegogo, "Coffee for biogas energy & farmer's climate school", <https://www.indiegogo.com/projects/coffee-for-biogas-energy-farmer-s-climate-school>, viewed 15 October 2019, and from Indiegogo, "PAYG community solar pumps for marginal farms", <https://www.indiegogo.com/projects/payg-community-solar-pumps-for-marginal-farms>, viewed 15 October 2019; Europe from S. Mikulcic, "Crowd investing for solar roofs in Križevci" (Brussels: EU Mayors, 2020), https://www.eumayors.eu/index.php?option=com_attachments&task=download&id=932; North America from Start Engine, "Sun Fund", <https://www.startengine.com/sun-fund-dc>, viewed 15 October 2019, from Start Engine, "Solar Direct", <https://www.startengine.com/solar-direct>, viewed 15 October 2019, and from Start Engine, "Power2Peer", <https://www.startengine.com/power2peer>, viewed 15 October 2019.
- 13 Neighborly, "Fiber broadband infrastructure to connect communities: A full-service solution for open access networks", <https://neighborly.com/learn/history-of-municipal-bonds-chapter-2>, viewed 15 October 2019; Invesco, *Primer on Municipal Bonds: What Investors Need to Know* (Atlanta, GA: September 2019), <https://www.opiniopro.com/2019/05/invesco-primer-on-municipal-bonds-what-investors-need-to-know-pdf-2>.
- 14 R. Nallathiga, "Municipal bonds as a source of finance for urban infrastructure development in India", prepared for the 23rd Thinkers and Writers Forum of Skoch Summit, 11-12 June 2015, pp. 1-15, https://www.researchgate.net/publication/278302216_Municipal_Bonds_as_a_Source_of_Finance_for_Urban_Infrastructure_Development_in_India; J. Hudson, "How to invest in municipal bonds: Making cities smarter with municipal bonds", MunicipalBonds.com, 3 August 2017, <https://www.municipalbonds.com/investing-strategies/making-smarter-cities-with-municipal-bonds>.
- 15 **Table 3** from Climate Bonds Initiative (CBI), personal communication with REN21, 28 September 2020. **Sidebar 6** based on the following sources: International Energy Agency (IEA), *Renewable Energy Market Update* (Paris: 2020), <https://www.iea.org/reports/renewable-energy-market-update>; S. Trivedi, I. Ray and G. Vulturius, *Scaling Up Rooftop Solar Power in India: The Potential of Solar Municipal Bonds* (New Delhi: Climate Policy Initiative, Indian Council for Research on International Economic Relations and Stockholm Environment Institute, 2018), <https://climatepolicyinitiative.org/wp-content/uploads/2018/02/Scaling-up-Rooftop-Solar-Power-in-India-The-Potential-of-Solar-Municipal-Bonds.pdf>; R. Gillard et al., *Affordable and Clean Energy for All: Lessons on Rooftop Solar from Delhi, India* (Washington, DC: Coalition for Urban Transitions, 2018), <http://newclimateeconomy.net/content/cities-working-papers>; S. Graber, P. Sachiko and J. Sherwood, *Under the Grid: Improving the Economics and Reliability of Rural Electricity Service with Undergrid Minigrids* (Basalt, CO: Rocky Mountain Institute, 2018), www.rmi.org/insight/under-the-grid.
- 16 J. Chen, "Revenue bond", Investopedia, <https://www.investopedia.com/terms/r/revenuebond.asp>, updated 6 March 2018.
- 17 S. Brand and J. Steinbrecher, "Green bonds – a sustainable alternative for municipal infrastructure finance?", *KfW Research Focus on Economics*, no. 245 (2019), <https://www.kfw.de/PDF/Download-Center/Konzernthemen/Research/PDF-Dokumente-Fokus-Volkswirtschaft/Fokus-englische-Dateien/Fokus-2019-EN/Fokus-No.-245-March-2019-Green-Bonds.pdf>.
- 18 Ibid.
- 19 United Nations Framework Convention on Climate Change, "Gothenburg Green Bonds Sweden", 2020, <https://unfccc.int/climate-action/momentum-for-change/financing-for-climate-friendly/gothenburg-green-bonds>.
- 20 The United States issued USD 51.3 billion in 2019, an increase of 44% over 2018. China issued USD 31.3 billion in 2019, up only 1% from the previous year. Europe, however, experienced the highest growth, with a USD 50 billion increase equivalent of 57% over 2018. CBI, *Green Bonds: Global State of the Market 2019* (London: 2020), <https://www.climatebonds.net/resources/reports/green-bonds-global-state-market-2019>.
- 21 International Finance Corporation (IFC), *Climate Investment Opportunities in Cities. An IFC Analysis* (Washington, DC: 2018), <https://www.ifc.org/wps/wcm/connect/875afb8f-de49-460e-a66a-dd2664452840/201811-CIOC-IFC-Analysis.pdf?MOD=AJPERES&CVID=mthPzYg>.
- 22 CCFLA, *State of City Climate Finance 2015* (New York: 2015), <http://ccfla.wpengine.com/wp-content/uploads/2015/12/CCFLA-State-of-City-Climate-Finance-2015.pdf>.
- 23 T. Vinod, "Infrastructure lending must be based on environmental and social safeguards", Brookings, 1 June 2015, <https://www.brookings.edu/blog/future-for-development/2015/06/01/infrastructure-lending-must-be-based-on-environmental-and-social-safeguards>.
- 24 CCFLA, op. cit. note 3.
- 25 V. Bennet, "Green Climate Fund makes Eur87 million available to EBRD Green Cities", European Bank for Reconstruction and Development, 2 July 2019, <https://www.ebrd.com/news/2019/green-climate-fund-makes-87-million-available-to-ebrd-green-cities.html>.
- 26 United Nations Conference on Trade and Development (UNCTAD), *Supporting Infrastructure Development to Promote Economic Integration: The Role of Public and Private Sectors* (Geneva: March 2013), https://unctad.org/meetings/en/SessionalDocuments/cimem6d2_en.pdf.

- 27 ICLEI, op. cit. note 7; World Bank, "Main financing mechanisms for infrastructure projects", Public-Private Partnership Legal Resource Center, 2016, <https://ppp.worldbank.org/public-private-partnership/financing/mechanisms>.
- 28 World Bank, op. cit. note 27.
- 29 **City Snapshot: North Lombok** from Marlion LLC, "Jumlah Penduduk dan Rasio Jenis Kelamin Menurut Kabupaten/Kota di Provinsi NTB Tahun 2008", 21 August 2017, <https://web.archive.org/web/20170821170139/http://marlionllc.com/jumlah-penduduk-dan-rasio-jenis-kelamin-menurut-kabupatenkota-di-provinsi-ntb-tahun-2008>, and from B. Z. E. Cedrick and W. Long, "Investment motivation in renewable energy: A PPP approach", *Energy Procedia*, vol. 115 (June 2017), pp. 229-38, <https://www.sciencedirect.com/science/article/pii/S1876610217322208>.
- 30 ICLEI, op. cit. note 7.
- 31 Ibid.
- 32 UNCTAD, op. cit. note 26.
- 33 P. Dumas and T. Garabetian, "Financing deep geothermal: Innovating schemes for new business models", presented at European Geothermal Congress 2019, <http://europeangeothermalcongress.eu/wp-content/uploads/2019/07/105.pdf>.
- 34 I. Granoff, J. R. Hogarth and A. Miller, "Nested barriers to low-carbon infrastructure investment", *Nature Climate Change*, vol. 6 (December 2016), <https://www.nature.com/articles/nclimate3142>.
- 35 World Bank, *Private Participation in Infrastructure (PPI) 2019 Annual Report* (Washington, DC: 2020), <https://ppi.worldbank.org/content/dam/PPI/documents/private-participation-infrastructure-annual-2019-report.pdf>.
- 36 Ibid.
- 37 C40 Cities, *Establishing a City Green Bank: Best Practice Guide* (London: 2020), <https://www.c40knowledgehub.org/s/article/Establishing-a-City-Green-Bank-Best-Practice-Guide>.
- 38 Ibid.
- 39 Ibid.
- 40 World Bank, "Power purchase agreements (PPAs) and energy purchase agreements (EPAs)", 9 October 2019, <https://ppp.worldbank.org/public-private-partnership/sector/energy/energy-power-agreements/power-purchase-agreements>.
- 41 Urban Grid, "Types of power purchase agreements for offsite renewable energy projects", 21 January 2019, <https://www.urbangridsolar.com/types-of-power-purchase-agreements-for-offsite-renewable-energy-projects>.
- 42 Dumas and Garabetian, op. cit. note 33.
- 43 Center for Climate and Energy Solutions (C2ES), *Buying Clean Electricity: How Cities Benefit from Power Purchase Agreements* (Arlington, VA: 2018), <https://www.c2es.org/site/assets/uploads/2018/09/how-cities-benefit-from-ppas.pdf>.
- 44 Ibid.
- 45 Ibid.
- 46 C40 Knowledge, "How cities can create demand for large-scale clean energy generation", March 2019, <https://www.c40knowledgehub.org/s/article/How-cities-can-create-demand-for-large-scale-clean-energy-generation>.
- 47 L. Shaver and H. B. Ratz, "4 creative ways cities are transitioning to a clean energy future", WRI Blog, 26 February 2019, <https://www.wri.org/blog/2019/02/4-creative-ways-cities-are-transitioning-clean-energy-future>; City of Melbourne, "Melbourne renewable energy project: A new generation of energy", <https://www.melbourne.vic.gov.au/business/sustainable-business/mrep/Pages/melbourne-renewable-energy-project.aspx>, viewed 15 October 2019.
- 48 Shaver and Ratz, op. cit. note 47; City of Melbourne, op. cit. note 47.
- 49 Projects include all renewable energy types, a majority of which are solar PV and wind power. These numbers do not represent actual investment flows, but rather project costs, for which some cities are still in need of financing. As such it can be seen as a demand for financing. Dataset is not comprehensive and misses key countries such as China (except Hong Kong) and the United Arab Emirates. CDP Matchmaker Data, personal communication with REN21, 5 November 2020.
- 50 First launched in 2015, the Transformative Actions Program (TAP), led by ICLEI and supported by its 14 partners, aims to catalyse and improve capital flows to cities, towns and regions by strengthening their capacity to access climate finance and attract investment. Since its launch, the majority of the applications have come from the energy sector, representing a significant and growing part of the TAP project portfolio. Most applications come from Africa and Latin America and the Caribbean, followed by Asia. ICLEI, "Transformative Actions Program", <https://www.iclei.org/en/TAP.html>, viewed 19 December 2020; E. Mogyorósy, ICLEI, personal communication with REN21, 1 December 2020.
- 51 FS-UNEP Centre and BloombergNEF, op. cit. note 1.
- 52 Asian Development Bank, "Cambodia: Cambodia Solar Power Project", <https://www.adb.org/projects/50248-001/main#project-overview>, viewed 11 December 2020; "Cambodia Solar Energy Profile", *Solar Magazine*, 21 October 2019, <https://solarmagazine.com/solar-profiles/cambodia>.
- 53 J. S. Bunachita, "Renewable energy: Cebu companies go green", *Cebu Daily News*, 20 June 2018, <https://cebudailynews.inquirer.net/180705/renewable-energy-cebu-companies-go-green>.
- 54 FS-UNEP Centre and BloombergNEF, op. cit. note 1.
- 55 Ibid.
- 56 Y. Nishida, Renewable Energy Institute, personal communication with REN21, 19 October 2020.
- 57 Ibid.; General Incorporated Association Green Finance Promotion, <http://greenfinance.jp>, viewed 19 October 2020 (in Japanese).
- 58 Nishida, op. cit. note 56.
- 59 Ibid.
- 60 Ibid.; Japan for Sustainability, "Small hydropower brings possibility of locally generated electricity for local consumption", *JFS Newsletter*, no. 95 (July 2010), https://www.japanfs.org/en/news/archives/news_id030154.html.
- 61 Institute for Global Environmental Strategies (IGES), *Involvement of the Local Government in the Local Production for Local Consumption of Energy* (Kitakyushu City, Japan: 2016), https://www.iges.or.jp/en/publication_documents/pub/issue/en/5487/Involvement_of_the_Local_Government_in_the_Local_Production_for_Local_Consumption_of_Energy_EN.pdf.
- 62 IGES, op. cit. note 61.
- 63 FS-UNEP Centre and BloombergNEF, op. cit. note 1.
- 64 Ibid.
- 65 Y. Zhang, US National Renewable Energy Laboratory, personal communication with REN21, 9 October 2020.
- 66 International Institute for Sustainable Development, *Public Finance for Renewable Energy in China: Building on International Experience* (Winnipeg, Canada: 2014), <https://www.iisd.org/publications/public-finance-renewable-energy-china-building-international-experience>.
- 67 Zhang, op. cit. note 65.
- 68 Ibid.
- 69 Ibid.
- 70 M. Jing and C. Qian, eds., "River water is pumped ashore to construct a river water source heat pump project in Nanjing Jiangbei New District", *Nanjing Daily*, 28 May 2018, <http://js.cri.cn/20180528/ad398848-fd63-b4da-dacc-c1e05f3a665e.html> (using Google Translate).
- 71 Zhang, op. cit. note 65; Shanghai Municipal Development and Reform Commission, "Notice of the Shanghai Municipal Development and Reform Commission on doing a good job in the construction of photovoltaic power generation projects in 2020", 14 April 2020, <http://fgw.sh.gov.cn/zgjil/20200414/8b2fae3a7da34be7acc062c4ff599cbb.html> (using Google Translate); EcoHZ, "Beijing Yanqing low wind speed in China", <https://www.ecohz.com/renewable-energy-solutions/powerplants/beijing-yanqing-low-wind-speed-in-china>, viewed 10 December 2020; Guangzhou and Shenzhen from Guangdong Provincial Development and Reform Commission, "Notice of the Guangdong Provincial Energy Administration on promoting the development and construction of decentralized wind power", 29 April 2019, http://drc.gd.gov.cn/ywtz/content/post_2286523.html (using Google Translate).
- 72 Zhang, op. cit. note 65.

- 73 CBI, *China Green Bond Market: 2019 Research Report* (London: 2020), https://www.climatebonds.net/files/releases/joint_release-cbi_ccdc_hsbcc-china-green-bond-market-report2019_en_29062020-final-.pdf.
- 74 Ibid.
- 75 CBI, "Green Bond Fact Sheet" (London: 2020), https://www.climatebonds.net/files/files/2020-08_CN_Datang_Henan_Power_Generation.pdf.
- 76 GIZ China, "Transport & Power-to-X (PtX) in China", 17 August 2020, <https://www.sustainabletransport.org/archives/7846>; "Zhangjiakou speeds up to build a Hydrogen Energy City, Renewable energy production highlights the advantages", 16 June 2020, <http://guangfu.bjx.com.cn/news/20200616/1081324.shtml> (using Google Translate).
- 77 Guyuan Rong Media Center, "With a total investment of 2.03 billion yuan, the equipment installation of the Hebei Guyuan Hydrogen Generation Project has been completed!", 8 December 2020, <https://wind.in-en.com/html/wind-2396041.shtml> (using Google Translate).
- 78 B. Finamore and H. M. Kim, "How EV charging can clean up China's electricity grid", Natural Resources Defense Council, 23 June 2020, <https://www.nrdc.org/experts/barbara-finamore/how-ev-charging-can-clean-chinas-electricity-grid>.
- 79 FS-UNEP Centre and BloombergNEF, op. cit. note 1.
- 80 A. Bhardwaj, New York University, personal communication with REN21, 17 September 2020.
- 81 Trivedi, Ray and Vulturius, op. cit. note 15.
- 82 Bhardwaj, op. cit. note 80; A. Bhardwaj, F. de Lorenzo and M-H. Zerah, *New Powers: How India's Smart Cities Are Governing and Transitioning to Low Carbon Energy* (New Delhi: Centre for Policy Research, July 2019), <http://www.indiaenvironmentportal.org.in/files/file/New%20Powers.pdf>.
- 83 Bhardwaj, de Lorenzo and Zerah, op. cit. note 82.
- 84 Ibid.
- 85 Ibid. Kalyan had invested INR 192 crore (USD 26.2 million) and Surat INR 155 crore (USD 21.2 million) in waste-to-energy.
- 86 Ibid. Pune had invested INR 126 crore (USD 17.2 million) and Dharamshala INR 63.06 crore (USD 8.6 million) in e-mobility.
- 87 FS-UNEP Centre and BloombergNEF, op. cit. note 1.
- 88 Ibid.
- 89 Dedicated funds available for renewable energy projects across the continent include but are not limited to: the Renewable Energy Program for Sub-Saharan Africa (RFP), the Sustainable Energy Fund for Africa (SEFA), the Green Enterprise Finance Accelerator (GEFA), Global Innovation Lab for Climate Finance, Off-Grid Market Development Fund (OMDF), the Dutch Fund for Climate and Development, the Urban and Municipal Development Fund for Africa and the Beyond the Grid Fund for Africa.
- 90 NS Energy, "Benban Solar Park", <https://www.nsenergybusiness.com/projects/benban-solar-park>, viewed 8 January 2021.
- 91 J. M. Takouleu, "Rwanda: Kigali Green City project receives Eur9.6m grant from KfW", Afrik21, 14 February 2020, <https://www.afrik21.africa/en/rwanda-kigali-green-city-project-receives-e9-6m-grant-from-kfw>.
- 92 I. Magoum, "Ghana: Elecnor delivers a 6.5 MWp photovoltaic solar power plant in Lawra", Afrik21, 13 October 2020, <https://www.afrik21.africa/en/ghana-elecnor-delivers-a-6-5-mwp-photovoltaic-solar-power-plant-in-lawra>.
- 93 FS-UNEP Centre and BloombergNEF, op. cit. note 1.
- 94 K. Fullerton, "South Africa's REIPP", Sense and Sustainability, 2 April 2019, <https://www.senseandsustainability.net/2019/04/02/south-africas-reipp>.
- 95 A. Eberhard, J. Kolker and J. Leigland, *South Africa's Renewable Energy IPP Procurement Program: Success Factors and Lessons* (Washington, DC: World Bank, 2014), <https://www.ee.co.za/wp-content/uploads/2014/06/southafrica-reipp-report-6-5.pdf>.
- 96 A. Richter, "Open Mountain Energy secures 15 MW PPA for two geothermal projects under construction", Think GeoEnergy, 27 February 2020, <https://www.thinkgeoenergy.com/open-mountain-energy-secures-15-mw-ppa-for-two-geothermal-projects-under-construction>.
- 97 NS Energy, "Siraj-1 Solar Power Project", <https://www.nsenergybusiness.com/projects/siraj-1-solar-power-project>, viewed 8 January 2021.
- 98 C40 Cities, "C40 Good Practice Guides: Johannesburg – Green Bond", 15 February 2016, https://www.c40.org/case_studies/c40-good-practice-guides-johannesburg-green-bond.
- 99 D. Barbuscia and A. Ramnarayan, "Egypt becomes first Arab country to issue green bonds with \$750 million deal", Reuters, 29 September 2020, <https://www.reuters.com/article/idUSKBN26K1MJ>.
- 100 FS-UNEP Centre and BloombergNEF, op. cit. note 1.
- 101 Ibid.
- 102 J. M. Vassallo, *Afrontando el reto de conectar y mejorar las ciudades* (Caracas: CAF, 2019), <http://scioteca.caf.com/handle/123456789/1376>.
- 103 World Bank, op. cit. note 35; Gobierno Regional Metropolitano de Santiago, "Santiago estrena nueva red de carga pública para vehículos eléctricos", 18 October 2019, <https://www.gobiernosantiago.cl/nueva-red-de-carga-vehiculos-electricos>.
- 104 Piauí Governo do Estado, "Governo retoma licitação da PPP das Miniúsinas de Energia Solar", 23 June 2020, <https://www.pi.gov.br/noticias/ppp-das-miniúsinas-de-energia-solar-tem-licitacao-retomada>.
- 105 CanalEnergia, "Prefeitura de São Paulo estuda investir R\$ 32,6 milhões em energia solar", 21 August 2020, <https://www.canalenergia.com.br/noticias/53144542/prefeitura-de-sao-paulo-estuda-investir-r-326-milhoes-em-energia-solar>; L. Morals, "Brazil's Copel to build 5-MW solar, biomass hybrid in Parana", Renewables Now, 5 March 2020, <https://renewablesnow.com/news/brazils-copel-to-build-5-mw-solar-biomass-hybrid-in-parana-689695>.
- 106 Norton Rose Fulbright, *Renewable Energy in Latin America* (London: 2017), <https://www.nortonrosefulbright.com/-/media/files/nrf/nrfweb/imported/renewable-energy-in-latin-america.pdf>.
- 107 Iberdrola Mexico, "Grupo Modelo e Iberdrola anuncian acuerdo de suministro de energía eléctrica removable", 28 March 2017, <https://www.iberdrolamexico.com/grupo-modelo-e-iberdrola-anuncian-acuerdo-de-suministro-de-energia-electrica-renovable>.
- 108 Inter-American Development Bank (IDB), *Expansión de las energías renovables no convencionales en América Latina y el Caribe: el rol de las instituciones financieras de Desarrollo* (Washington, DC: 2016), <https://publications.iadb.org/publications/spanish/document/Expansión-de-las-energías-no-convencionales-en-América-Latina-y-el-Caribe-el-rol-de-las-instituciones-financieras-de-desarrollo-es-es.pdf>.
- 109 Bancoldex, "Bancoldex será pionero en financiar inversiones verdes en negocios de micros y pequeños empresarios", 9 October 2019, <https://www.bancoldex.com/noticias/bancoldex-sera-pionero-en-financiar-inversiones-verdes-en-negocios-de-micros-y-pequenos-empresarios-3403>.
- 110 São Paulo Governo do Estado, "Governo de SP assina acordo para incentivo de energia solar", 13 June 2018, <https://www.desenvolvesp.com.br/comunicacao/noticias/governo-de-sp-assina-acordo-para-incentivo-de-energia-solar>.
- 111 IDB, "IDB Invest financia la expansión de la energía solar en Brasil junto a Sicredi", 12 February 2020, <https://www.idbinvest.org/es/medios-y-prensa/bid-invest-financia-la-expansion-de-la-energia-solar-en-brasil-junto-a-sicredi>.
- 112 Ciudad Luz, "¿Qué es el modelo ESCO?", 27 April 2020, <https://ciudadluz.cl/2020/04/27/auto-draft/>; Ciudad Luz, "Energía Solar", <https://www.greenyellow.co/energia-solar>, viewed 12 December 2020; GarperEnergy, "Financiación y Modelo ESCO en Colombia", <http://www.garperenergy.com/ahorrar-energia-servicios/financiacion-esco>, viewed 12 December 2020; EscogD, "Proyecto Solar", <https://escogd.com.br/solucoes/3-projeto-solar>, viewed 12 December 2020.
- 113 B. Bastit, "Resurgen los bonos verdes latinoamericanos", World Bank, 30 September 2019, <https://blogs.worldbank.org/es/voices/resurgen-los-bonos-verdes-latinoamericanos>.
- 114 C40 Cities, *Clean Energy Business Model Manual* (London: November 2018), https://c40-production-images.s3.amazonaws.com/other_uploads/images/2008_C40_Clean_Energy_Business_Model_Manual_-_Ezgi_Kelleher.original.pdf.
- 115 FS-UNEP Centre and BloombergNEF, op. cit. note 1.
- 116 Ibid.
- 117 Brand and Steinbrecher, op. cit. note 17.
- 118 Ibid.
- 119 CBI, op. cit. note 20.
- 120 CBI, *The Green Bond Market in Europe 2018* (London: 2019), https://www.climatebonds.net/files/reports/the_green_bond_market_in_europe.pdf.

- 121 European PPP Expertise Center, *Market Update: Review of the European PPP Market in 2019* (Luxembourg: 2020), https://www.eib.org/attachments/eppec/eppec_market_update_2019_en.pdf.
- 122 V. Spasic, "Ljubljana contracts third PPP project for energy renovation of public buildings", *Balkan Green Energy News*, 29 July 2020, <https://balkangreenenergynews.com/ljubljana-contracts-third-ppp-project-for-energy-renovation-of-public-buildings>.
- 123 "Commission for PPP helping municipalities adopt strategic approach", *Balkan Green Energy News*, 26 February 2018, <https://balkangreenenergynews.com/commission-for-ppp-helping-municipalities-adopt-strategic-approach>; B. Jovičić, "GGE puts into operation environmentally biomass boilers in school in Pirot", *Balkan Green Energy News*, 8 November 2017, <https://balkangreenenergynews.com/gge-puts-into-operation-environmentally-friendly-biomass-boilers-school-pirot>.
- 124 European Commission, "EU funding possibilities in the energy sector", https://ec.europa.eu/energy/funding-and-contracts/eu-funding-possibilities-in-the-energy-sector_en, viewed 2 October 2020.
- 125 The Celsius Project, "Riga, making a difference in the Baltic countries", <https://celsiuscity.eu/riga-making-a-difference-in-the-baltic-countries>, viewed 20 September 2020.
- 126 European Bank for Reconstruction and Development (EBRD), "EBRD puts on the heating in Banja Luka", 13 November 2017, <https://www.ebrd.com/news/2017/ebdr-puts-on-the-heating-in-banja-luka.html>.
- 127 B. Epp, "SDH prefeasibility studies for Serbian cities", [solarthermalworld.org](http://solarthermalworld.org/news/sdh-prefeasibility-studies-serbian-cities), 19 February 2020, <https://www.solarthermalworld.org/news/sdh-prefeasibility-studies-serbian-cities>.
- 128 T. De Atholia, G. Flannigan and S. Lai, *Renewable Energy Investment in Australia* (Sydney: Reserve Bank of Australia, 2020), <https://www.rba.gov.au/publications/bulletin/2020/mar/pdf/renewable-energy-investment-in-australia.pdf>.
- 129 M. Mazengarb, "Rooftop solar already a pioneer in 'buy now, pay later' Bright founder says", *One Step Off the Grid*, 11 September 2020, <https://onestepoffthegrid.com.au/rooftop-solar-already-a-pioneer-in-buy-now-pay-later-brighte-founder-says>.
- 130 Ibid.
- 131 Off Grid Energy Independence, "Sydney switches to 100% renewable energy", 8 July 2020, <https://www.offgridenergyindependence.com/articles/21165/sydney-switches-to-100-renewable-energy>.
- 132 C40 Knowledge, op. cit. note 46.
- 133 IFC, "Cleaner, cheaper power fuels a better future for Solomon Islanders", December 2019, https://www.ifc.org/wps/wcm/connect/news_ext_content/ifc_external_corporate_site/news+and+events/news/impact-stories/cleaner-cheaper-power-fuels-better-future-solomon-islanders.
- 134 Ibid.
- 135 FS/UNEP Centre and BloombergNEF, op. cit. note 1.
- 136 S. Abbott et al., "Local Government Renewables Action Tracker" (Washington, DC: Rocky Mountain Institute and World Resources Institute, 2020), <https://cityrenewables.org/local-government-renewables-action-tracker>.
- 137 See, for example: New Braunfels (Texas, US), from E. F. Merchant, "Texas municipal utility signs new super-low solar PPA", *Greentech Media*, 14 December 2018, <https://www.greentechmedia.com/articles/read/utility-signs-new-low-solar-ppa-in-texas>; Philadelphia (Pennsylvania, US), from Philadelphia Energy Authority, "Mayor signs legislation for large-scale purchase of renewable energy", 19 December 2018, <https://philaenergy.org/philadelphia-mayor-signs-legislation-for-large-scale-purchase-of-renewable-energy>; Washington, D.C. (US), from C40 Cities Climate Leadership Group, "How cities can create demand for large-scale clean energy generation", https://www.c40knowledgehub.org/s/article/How-cities-can-create-demand-for-large-scale-clean-energy-generation?language=en_US, viewed 15 October 2020.
- 138 Abbott et al., op. cit. note 136.
- 139 J. Jeuch, *Case Study: Cincinnati's Path to A 100 MW Solar Deal* (Cincinnati, OH: American Cities Climate Challenge, 2020), https://cityrenewables.org/wp-content/uploads/2020/08/CRA_Cincinnati_Case-Study.pdf.
- 140 A. Danigelis, "RBC becomes first Canadian bank to sign renewable energy deal", *Environment + Energy Leader*, 31 July 2020, <https://www.environmentalleader.com/2020/07/rbc-renewable-energy-deal>.
- 141 Energy Northwest, "Horn Rapids Solar, Storage & Training Project", <https://www.energy-northwest.com/energyprojects/horn-rapids/Pages/default.aspx>, viewed 8 January 2021.
- 142 CBI, *Green Bond Fact Sheet: Sacramento Municipal Utility District* (London: July 2020), https://www.climatebonds.net/files/files/2020-05_US_Sacramento_Municipal_Utility_District.pdf.
- 143 Climate Mayors Electric Vehicle Purchasing Collaborative, "What is the Collaborative", <https://driveevfleets.org/what-is-the-collaborative>, viewed 8 January 2021; ChargePoint, Inc., "Cities and towns", <https://www.chargepoint.com/solutions/cities-and-towns>, viewed 8 January 2021; EVgo, "Utility and government agencies", <https://www.evgo.com/ev-charging-business/utility-companies>, viewed 8 January 2021.
- 144 Los Angeles Cleantech Incubator, "Zero Emissions Mobility and Community Pilot Program Fund", <https://laincubator.org/mobility-pilots>, viewed 8 January 2021.
- 145 Granoff, Hogarth and Miller, op. cit. note 34; T. S. Schmidt, "Low-carbon investment risks and de-risking", *Nature Climate Change*, vol. 4 (April 2014), <https://www.nature.com/articles/nclimate2112>.
- 146 Granoff, Hogarth and Miller, op. cit. note 34; G. Floater et al., *Global Review of Finance for Sustainable Urban Infrastructure* (London and Washington, DC: Coalition for Urban Transitions, 2017), pp. 1-60, https://newclimateeconomy.report/workingpapers/wp-content/uploads/sites/5/2018/01/NCE2017_CUT_GlobalReview_02012018.pdf; G. C. Unruh, "Understanding carbon lock-in", *Energy Policy*, vol. 28, no. 12 (2000), pp. 817-30, <http://www.sciencedirect.com/science/article/pii/S0301421500000707>.
- 147 Granoff, Hogarth and Miller, op. cit. note 34; Floater et al., op. cit. note 146; Unruh, op. cit. note 146.
- 148 Granoff, Hogarth and Miller, op. cit. note 34.
- 149 ICLEI, op. cit. note 50; Mogorósy, op. cit. note 50.
- 150 Hudson, op. cit. note 14.
- 151 Granoff, Hogarth and Miller, op. cit. note 34.
- 152 European Committee of the Regions, "Financing climate action: opportunities and challenges for local and regional authorities" (Brussels: European Union, 2017), <https://cor.europa.eu/en/engage/studies/Documents/Financing-climate-action.pdf>.
- 153 Ibid.
- 154 B. Petrie et al., *Multi-level Climate Governance in South Africa. Catalysing Finance for Local Climate Action* (Berlin / Cape Town: OneWorld, Sustainable Energy Africa and adelphi, 2018), <https://www.adelphi.de/en/system/files/mediathek/bilder/Multi-level%20climate%20governance%20in%20South%20Africa%20-%20adelphi.pdf>.
- 155 Organisation for Economic Co-operation and Development (OECD), "Challenges for infrastructure investment at subnational level", *OECD Regions at a Glance 2016* (Paris: 2016), https://www.oecd-ilibrary.org/docserver/reg_glance-2016-en.pdf.
- 156 IFC, op. cit. note 21.
- 157 Ibid.; Floater et al., op. cit. note 146.
- 158 Granoff, Hogarth and Miller, op. cit. note 34; Schmidt, op. cit. note 145.
- 159 Granoff, Hogarth and Miller, op. cit. note 34; Schmidt, op. cit. note 145.
- 160 CCFLA, op. cit. note 22.
- 161 Ibid.
- 162 World Bank, "City Creditworthiness Initiative: A partnership to deliver municipal finance", <https://www.worldbank.org/en/topic/urbandevelopment/brief/city-creditworthiness-initiative>, viewed 30 December 2020.

CITIZEN PARTICIPATION

- 1 See A. Rüdinger, "What is the citizen participation in the energy transition?" IDDRI, 26 April 2017, <https://www.iddri.org/en/publications-and-events/blog-post/what-citizen-participation-energy-transition>.
- 2 D. Bidwell, "Thinking through participation in renewable energy decisions", *Nature Energy*, vol. 1 (May 2016), www.nature.com/articles/nenergy201651.
- 3 Ö. Yildiz, "Financing renewable energy infrastructures via financial citizen participation – The case of Germany", *Renewable Energy*, vol. 68 (August 2014), pp. 677–85, <https://www.sciencedirect.com/science/article/abs/pii/S0960148114001293>.
- 4 M. S. Henry, M. D. Bazilian and C. Markuson, "Just transitions: Histories and futures in a post-COVID world", *Energy Research and Social Science*, vol. 68 (October 2020), p. 101668, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7351418>.
- 5 S. R. Arnstein et al., "Being a 'citizen' in the smart city: Up and down the scaffold of smart citizen participation in Dublin, Ireland", *GeoJournal*, 1 January 1969, <https://link.springer.com/article/10.1007/s10708-018-9845-8>.
- 6 M. Islar and H. Busch, "'We are not in this to save the polar bears!' – The link between community renewable energy development and ecological citizenship", *Innovation: The European Journal of Social Science Research*, vol. 29, no. 3 (2016), pp. 303–19, <https://www.tandfonline.com/doi/abs/10.1080/13511610.2016.1188684>.
- 7 S. Haf and R. Robison, *How Local Authorities Can Encourage Citizen Participation in Energy Transitions* (London: UK Energy Research Centre, 2020), https://energy-cities.eu/wp-content/uploads/2020/05/HafRobison_LAs-and-citizen-participation_published.pdf.
- 8 Islar and Busch, op. cit. note 6.
- 9 T. F. Luna et al., "The influence of e-carsharing schemes on electric vehicle adoption and carbon emissions: An emerging economy study", *Transportation Research Part D: Transport and Environment*, vol. 79 (February 2020), p. 102226, <http://www.sciencedirect.com/science/article/pii/S1361920919309460>.
- 10 Accenture, *The New Energy Consumer: Unleashing Business Value in a Digital World* (Dublin: 2020), https://www.accenture.com/_acnmedia/centric/content/next-gen/insight-unlocking-value-of-digital-consumer/pdf/accenture-new-energy-consumer-final.pdf.
- 11 Ibid.
- 12 D. Litvine and R. Wüstenhagen, "Helping 'light green' consumers walk the talk: Results of a behavioural intervention survey in the Swiss electricity market", *Ecological Economics*, vol. 70, no. 3 (2011), pp. 462–74, <https://www.sciencedirect.com/science/article/abs/pii/S0921800910004234?via%3Dihub>.
- 13 Deloitte, *Deloitte Resources 2020 Study* (Stamford, CT: 2020), https://www2.deloitte.com/content/dam/insights/us/articles/6655_Resources-study-2020/DI_Resources-study-2020.pdf; M. N. Conte and G. D. Jacobsen, "Explaining demand for green electricity using data from all US utilities", *Energy Economics*, vol. 60 (November 2016), pp. 122–130, <https://www.sciencedirect.com/science/article/pii/S0140988316302353>.
- 14 Deloitte, op. cit. note 13.
- 15 Ofgem, *Household Consumer Perceptions of the Energy Market* (London: 2020), https://www.ofgem.gov.uk/system/files/docs/2020/09/consumer_perceptions_of_the_energy_market_q2_2020_pdf_1.pdf.
- 16 World Resources Institute, "Utility green tariffs", <https://www.wri.org/our-work/project/clean-energy/utility-green-tariffs>, viewed 23 December 2020.
- 17 M. S. Barry and A. Creti, "Pay-as-you-go contracts for electricity access: Bridging the 'last mile' gap? A case study in Benin", *Energy Economics*, vol. 90 (August 2020), p. 104843, <https://www.sciencedirect.com/science/article/pii/S0140988320301833?via%3Dihub>.
- 18 **Sidebar 7** from the following sources: M. Mazengarb, "Power Ledger partners with French utility to certify renewables with blockchain", One Step Off the Grid, 8 April 2020, <https://onestepoffthegrid.com.au/power-ledger-partners-with-french-utility-to-certify-renewables-with-blockchain>; Brooklyn Energy, "Brooklyn Microgrid", <https://www.brooklyn.energy>, viewed 16 December 2020; AsiaOne, "Senoko Energy, Electrify and Engie Factory team up to launch Singapore's first pilot project in peer-to-peer renewable trading", 21 July 2020, <https://www.asiaone.com/business/senoko-energy-electrify-and-engie-factory-team-launch-singapore%E2%80%99s-first-pilot-project-peer>; P. Maloney, "Green Mountain Power, LO3 pilot utilizes blockchain", American Public Power Association, 27 November 2019, <https://www.publicpower.org/periodical/article/green-mountain-power-lo3-pilot-utilizes-blockchain>; P. Lague, "Indian electricity distributor to trial P2P solar trading", Power Engineering International, 16 November 2020, <https://www.powerengineeringint.com/digitalization/indian-electricity-distributor-to-trial-p2p-solar-trading>; Smart Energy International, "Bringing blockchain to India's power consumers", 3 April 2020, <https://www.smart-energy.com/industry-sectors/policy-regulation/bringing-blockchain-to-indias-power-consumers>; EIA University, "Could Colombia Lead the Peer-to-Peer Energy Revolution?" (Medellin: 2020), http://www.transactive-energy.co/wp-content/uploads/2020/01/PolicyBriefingP2P_Colombia.pdf; The European Consumer Organisation (BEUC), *The Future of Energy Consumers: Bright or Burdensome?* (Brussels: 2019), https://www.beuc.eu/publications/beuc-x-2019-055_the_future_of_energy_consumers.pdf; International Renewable Energy Agency (IRENA), *Innovation Landscape Brief: Net Billing Schemes* (Abu Dhabi: 2019), https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Feb/IRENA_Net_billing_2019.pdf.
- 19 C. Zhang et al., "Review of existing peer-to-peer energy trading projects", *Energy Procedia*, vol. 105 (May 2017), pp. 2563–68, <https://www.sciencedirect.com/science/article/pii/S1876610217308007>; F. Huneke and S. Nitzsche, *Impulspapier Energy Sharing* (Berlin: Energy Brainpool, June 2020), <https://publikationen.windindustrie-in-deutschland.de/impulspapier-energy-sharing/63148775>.
- 20 S. Liccardo and S. Kuehl, "California's three big utility companies stand in the way of consumer choice", *San Francisco Chronicle*, 1 September 2020, <https://www.sfchronicle.com/opinion/openforum/article/California-s-three-big-utility-companies-stand-15528929.php>.
- 21 M. J. Kotchen, *Climate Policy and Voluntary Initiatives: An Evaluation of the Connecticut Clean Energy Communities Program* (Cambridge, MA: National Bureau of Economic Research, 2020), <https://environment.yale.edu/kotchen/pubs/CCEC.pdf>.
- 22 S. MacDonald and N. Eyre, "An international review of markets for voluntary green electricity tariffs", *Renewable and Sustainable Energy Reviews*, vol. 91 (August 2018), pp. 180–92, <https://www.sciencedirect.com/science/article/abs/pii/S1364032118301084?via%3Dihub>.
- 23 K. Trumbull, J. Gattaciecchia and J. R. DeShazo, *The Role of Community Choice Aggregators in Advancing Clean Energy Transitions: Lessons from California* (Los Angeles: UCLA Luskin Center for Innovation, 2020), https://innovation.luskin.ucla.edu/wp-content/uploads/2020/11/The_Role_of_CCAs_in_Advancing_Clean_Energy_Transitions.pdf; I. Todorović, "Electricity consumers in Turkey to get renewables-only tariff option", *Balkan Green Energy News*, 8 July 2020, <https://balkangreenenergynews.com/electricity-consumers-in-turkey-to-get-renewables-only-tariff-option>.
- 24 Deloitte, op. cit. note 13.
- 25 R. Wait, "All you need to know about green energy tariffs", *Forbes*, 6 November 2020, <https://www.forbes.com/sites/advisoruk/2020/05/15/all-you-need-to-know-about-green-energy-tariffs>.
- 26 IRENA, *Innovation Landscape Brief: Pay-as-you-go Models* (Abu Dhabi: 2020), https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Jul/IRENA_Pay-as-you-go_models_2020.pdf.
- 27 Ibid.
- 28 Empresas Públicas de Medellín, "Servicio de Energía Prepago", https://www.epm.com.co/site/clientes_usuarios/clientes-y-usuarios/hogares-y-personas/energia/tramites/energia-prepago, viewed 10 January 2021.
- 29 Renewable Energy Policy Network for the 21st Century (REN21), *Renewables 2020 Global Status Report* (Paris: 2020), www.ren21.net/gsr.
- 30 T. Couture et al., *Residential Prosumers: Drivers and Policy Options (RE-Prosumers)* (Paris: International Energy Agency, Renewable Energy Technology Deployment, 2014), <https://www.osti.gov/servlets/purl/1163237>.
- 31 P. Pavanelli, *Pesquisa de Opinião Pública: Energia Elétrica* (Brasília: Abraceel, 2020), https://abraceel.com.br/wp-content/uploads/post/2020/08/JOB-20_0211_Energia-El%C3%A9trica_2020_Abraceel-Apresenta%C3%A7%C3%A3o-2.pdf.
- 32 S. Hall and D. Brown, *Business Models for Prosumers in Europe*, Deliverable 4.1 of the Horizon 2020 PROSEU project (Brussels: 2020), https://www.researchgate.net/profile/Donal_Brown/publication/338595423_Business_Models_for_Prosumers_in_Europe/links/5e6b890aa6fdccf321d99717/Business-Models-for-Prosumers-in-Europe.pdf.

- 33 Ciudad Solar, "Estrategia de sustentabilidad", presentation, <https://ciudad-solar.cdmx.gob.mx/storage/app/media/presentacion-ciudad-solar.pdf>, viewed 10 January 2021.
- 34 A. Hobbs et al., *Improving Solar Policy: Lessons from the Solar Leasing Boom in California* (San Francisco: Climate Policy Initiative, July 2013), <https://www.climatepolicyinitiative.org/publication/improving-solar-policy-lessons-from-the-solar-leasing-boom-in-california>.
- 35 HES Solar, "The evolution of solar leasing", 1 September 2016, <https://www.hessolar.com/blog/2016/sepember/the-evolution-of-solar-leasing>; S. Bajaj, "Kerala set to develop 200 MW of rooftop solar projects under Soura Program", Mercom India, 9 September 2019, <https://mercomindia.com/kerala-soura-program-200mw-solar>; T. Z. Yun, "Solutions: Getting financing for your solar power system", The Edge Markets, 22 January 2020, <https://www.theedgemarkets.com/article/solutions-getting-financing-your-solar-power-system>.
- 36 S. Hanley, "Western Australia trials Tesla PowerBank community storage system", CleanTechnica, 26 July 2019, <https://cleantechnica.com/2018/11/06/western-australia-trials-tesla-powerbank-community-storage-system>.
- 37 G. Walker and P. Devine-Wright, "Community renewable energy: What should it mean?", *Energy Policy*, vol. 36, no. 2 (2008), pp. 497-500, <https://www.sciencedirect.com/science/article/abs/pii/S0301421507004739>.
- 38 A. L. Berka and E. Creamer, "Taking stock of the local impacts of community owned renewable energy: A review and research agenda", *Renewable and Sustainable Energy Reviews*, vol. 82, Part 3 (February 2018), pp. 3400-19, <https://www.sciencedirect.com/science/article/abs/pii/S1364032117314247>.
- 39 Islar and Busch, op. cit. note 6.
- 40 K. Szulecki, "Conceptualizing energy democracy", *Environmental Politics*, vol. 27, no. 1 (2018), pp. 21-41, <https://www.tandfonline.com/doi/abs/10.1080/09644016.2017.1387294>.
- 41 See, for example, the following: German Cooperation, "2nd Thai-German Community-based Renewable Energy Conference 2016", https://www.thai-german-cooperation.info/en_US/2nd-thai-german-community-based-renewable-energy-conference-2016; The Beam, "The community power movement is on the rise in Japan", Medium, 13 February 2017, <https://medium.com/thebeammagazine/community-power-gears-up-global-renewable-energy-movement-dccb184fea6>; Community Energy Association Canada, "About us", <https://www.communityenergy.ca/about-us>, viewed 8 January 2021. See also examples cited throughout this chapter.
- 42 A. Bolle, *How Cities Can Back Renewable Energy Communities* (Brussels: Energy Cities, 2019), <https://energy-cities.eu/publication/how-cities-can-back-renewable-energy-communities>.
- 43 European Committee of the Regions, *Models of Local Energy Ownership and the Role of Local Energy Communities in Energy Transition in Europe* (Brussels: 2018), <https://cor.europa.eu/en/engage/studies/Documents/local-energy-ownership.pdf>.
- 44 Haf and Robison, op. cit. note 7.
- 45 Bolle, op. cit. note 42.
- 46 Ibid.
- 47 Ibid.
- 48 REScoop, "Council finalizes Clean Energy for All Europeans Package, empowering citizens energy communities", 23 May 2019, <https://www.rescoop.eu/news-and-events/press/council-finalises-clean-energy-for-all-europeans-package-empowering-citizens-energy-communities>.
- 49 G. Willmer, "Homemade energy gets boost to go mainstream", Horizon, 6 May 2019, <https://horizon-magazine.eu/article/homemade-energy-gets-boost-go-mainstream.html>.
- 50 REScoop, <https://www.rescoop.eu>, viewed 7 January 2021.
- 51 A. Caramizaru and A. Uihlein, *Energy Communities: An Overview of Energy and Social Innovation* (Luxembourg: European Commission, 2020), https://publications.jrc.ec.europa.eu/repository/bitstream/JRC119433/energy_communities_report_final.pdf.
- 52 C. Pons-Seres de Brauwier and J. J. Cohen, "Analysing the potential of citizen-financed community renewable energy to drive Europe's low-carbon energy transition", *Renewable and Sustainable Energy Reviews*, vol. 133 (November 2020), p. 110300, <https://www.sciencedirect.com/science/article/pii/S1364032120305888>.
- 53 Cooperatives Europe, *The COVID-19 Crisis and Its Economic and Social Impact on Cooperatives Across Europe* (Brussels: 2020), https://coopseurope.coop/sites/default/files/Covid19%20Report_CoopsEurope-compressed.pdf.
- 54 E. Barbiroglio, "1,000 solar roofs boost recovery and citizen engagement in Croatia", *Forbes*, 4 August 2020, <https://www.forbes.com/sites/emanuelbarbiroglio/2020/08/04/1000-solar-roofs-boost-recovery-and-citizen-engagement-in-croatia>.
- 55 Som Energia, "La Cooperativa D'Energia Verda", <https://www.somenergia.coop>, viewed 9 November 2020; Goiener, S. Coop. "Goiener Taldea: Empowering citizens through energy", Transformative Cities, 3 September 2020, <https://transformativecities.org/atlas/atlas-034>.
- 56 A. G. Valdivia, "Renewable energy in Spain: From the 'Sun Tax' to the promotion of collective self-consumption", *Forbes*, 15 April 2019, <https://www.forbes.com/sites/anagarciavaldivia/2019/04/15/renewable-energy-in-spain-from-the-sun-tax-to-the-promotion-of-collective-self-consumption>; P. S. Molina, "Spain's new rules for self-consumption come into force", pv magazine, 8 April 2019, <https://www.pv-magazine.com/2019/04/08/spains-new-rules-for-self-consumption-come-into-force>.
- 57 Resilience, "Girona, Spain: Cooperative breaks the mould to provide renewable energy", 25 September 2018, <https://www.resilience.org/stories/2018-09-25/girona-spain-cooperative-breaks-the-mould-to-provide-renewable-energy>; Energy Cities, "Community energy from scratch", <https://energy-cities.eu/inspiring-mind/community-energy-from-scratch>, viewed 18 January 2021; Energy Democracy, "Energética Cooperative challenges energy poverty by supplying clean energy", 21 December 2020, <https://energy-democracy.net/energetica-cooperative-challenges-energy-poverty-by-supplying-clean-energy>.
- 58 Caramizaru and Uihlein, op. cit. note 51; World Wind Energy Association (WWEA), "German government clearly misses all three self-imposed goals associated with auctions", 2 September 2019, <https://wwindea.org/blog/2019/09/02/german-government-clearly-misses-all-three-self-imposed-goals-associated-with-auctions>; Deutscher Genossenschafts- und Raiffeisenverband e.V., *Energy Cooperatives in Germany. State of the Sector Report 2020* (Berlin: 2020), https://www.dgrv.de/wp-content/uploads/2020/07/20200708_State-of-the-sector-2020.pdf.
- 59 WWEA op. cit. note 58; Deutscher Genossenschafts- und Raiffeisenverband e.V., op. cit. note 58.
- 60 Agentur für Erneuerbare Energien e.V. 2020, *Energiegenossenschaften im Auf- und Abschwung* (Berlin: 2020) https://www.unendlich-viel-energie.de/media/file/4051.AEE_RK_Energiegenossenschaften_jul20.pdf.
- 61 Agentur für Erneuerbare Energien e.V., *Community Energy in Germany* (Berlin: 2019), https://www.unendlich-viel-energie.de/media/file/3591.89_Renews_Spezial_Community_energy_LECo.pdf.
- 62 Bürgerenergie Jena, <https://www.buergerenergie-jena.de>, viewed 18 January 2021.
- 63 B. Epp and M. Oropeza, eds., *Solar Heat for Cities: The Sustainable Solution for District Heating* (Paris: International Energy Agency Solar Heating & Cooling Programme, 2019), https://www.solarthermalworld.org/sites/default/files/news/file/2019-12-19/solar_heat_for_cities_screen_optimised_task_55_iaea_shc_november_2019.pdf; Plan Energi, "One GW solar heating in Denmark", <https://planenergi.eu/activities/district-heating/solar-district-heating/1-gw-sdh-in-dk>, viewed 21 December 2020; Co2mmunity, "Community energy cases", <http://co2mmunity.eu/outputs/community-energy-cases>, viewed 9 November 2020.
- 64 Epp and Oropeza, eds., op. cit. note 63; Co2mmunity, op. cit. note 63.
- 65 S. Robinson and D. Stephen, *Community Energy: State of the Sector 2020 (Sheffield: 2020)*, https://communityenergyengland.org/files/document/385/1592215769_CommunityEnergy-StateoftheSector2020Report.pdf.
- 66 Ibid.
- 67 Ibid.
- 68 Community Energy London, <https://www.communityenergy.london>, viewed 18 January 2021.
- 69 Edinburgh Community Solar Co-operative, <https://www.edinburghsolar.coop>, viewed 31 December 2020.
- 70 Brighton Energy Cooperative, <https://brightonenergy.org.uk>, viewed 8 January 2021; Sustainable Dorset, "Community Energy Team Dorset Energy Council", <https://www.sustainabledorset.org/item/community-energy-team-dorset-county-council>, viewed 8 January 2021; Bristol Energy Cooperative, <http://bristolenergy.coop/about/>, viewed 8 January 2021; Cardiff Community Energy, <http://www.cardiffcommunityenergy.co.uk>, viewed 8 January 2021.

- 71 REScoop, "The LICHT Approach", 19 October 2020, <https://www.rescoop.eu/toolbox/the-licht-approach>.
- 72 Hageland Stroomt, "Pilot Project", <https://hagelandstroomt.be/wat-doen-we/pilootprojec>, viewed 9 November 2020.
- 73 Noordlicht, "Zonnepanelen Op Kinderkribbe Jannemieke in Zaventem Officieel in Gebruik Genomen", 7 October 2020, <https://www.noordlicht.be/nieuws/nieuws-nieuws/zonnepanelen-kinderkribbe-zaventem-in-gebruik.html>; A. Dimitrova, "A large cooperative project on renewable energy starts in Leuven", The Mayor, 15 July 2020, <https://www.themayor.eu/en/a/view/a-large-cooperative-project-on-renewable-energy-starts-in-leuven-5388>.
- 74 Covenant of Mayors, Database, <https://www.eumayors.eu/support/library.html>, viewed 23 December 2020.
- 75 Carbon Co-op, "Our visit to EcoPower, the brilliant Belgian energy coop", 15 September 2016, <https://carbon.coop/2016/09/our-visit-to-ecopower-the-brilliant-belgian-energy-coop>; Ecopower, "Eeklo 2 Wind", <https://www.ecopower.be/over-ecopower/productie-installaties/eeklo-2>, viewed 23 December 2020.
- 76 Pajopower, "Adopteer je straatlamp: investeren in duurzame energie in Halle", <https://www.pajopower.be/projecten/adopteer-je-energiezuinige-led-lamp>, viewed 23 December 2020.
- 77 Windpark Zeewolde, "What is Zeewolde Wind Park?" <https://windparkzeewolde.nl/wat-is-windpark-zeewolde>, viewed 9 November 2020.
- 78 S. Giovannini, "Slavutych, Ukraine – The community energy story you need to hear!", Energy Cities, 10 December 2019, <https://energy-cities.eu/slavutych-ukraine-the-community-energy-story-you-need-to-hear>.
- 79 Friends of the Earth Europe, REScoop.eu and Energy Cities, *Community Energy. A Practical Guide to Reclaiming Power* (Brussels: October 2020), <https://energy-cities.eu/wp-content/uploads/2020/10/13-FoEE-Community-Energy-Guide-mr.pdf>.
- 80 EnCES – Citizen Energy of the Eurometropolis, <https://www.brassersdenergie.eu>, viewed 31 December 2020.
- 81 J. Heeter, "Sharing the Sun Community Solar Project Data" (Golden, CO: National Renewable Energy Laboratory, May 2020), <https://data.nrel.gov/submissions/131>.
- 82 Ibid.
- 83 City of Portland, "About PCEF", <https://www.portland.gov/bps/cleanenergy/about>, viewed 23 December 2020.
- 84 S. Furuya, "The community power movement is on the rise in Japan", The Beam, 13 February 2017, <https://medium.com/thebeammagazine/community-power-gears-up-global-renewable-energy-movement-dccbc184fea6>.
- 85 Y. H. Kang and L. Joubert, "Grassroots solar energy in South Korea", Energy Transition, 27 September 2018, <https://energytransition.org/2018/09/south-koreas-grassroots-energy-transition>.
- 86 Heeter, op. cit. note 81.
- 87 Ibid.
- 88 Kang and Joubert, op. cit. note 85; H. Kim, "A community energy transition model for urban areas: The energy self-reliant village program in Seoul, South Korea", *Sustainability*, vol. 9, no. 7 (2017), <https://www.mdpi.com/2071-1050/9/7/1260>.
- 89 Inter-American Development Bank, Latin American Energy Organization (OLADE) and Energy Technology Working Group, *Energy Access and Affordability – Voluntary Action Plan for Latin America and the Caribbean* (Washington, DC: 2018), <http://biblioteca.olade.org/opac-tmpl/Documentos/old0418.pdf>.
- 90 Red Girasol, "Empresa Dedicada Al Crowdfunding De Proyectos De Energía Solar Para Hogares", <https://www.redgirasol.com>, viewed 9 November 2020.
- 91 K. Schneider et al., "Shared solar cooperatives in Brazil: Context, overcoming barriers and lessons to be drawn from previous European countries experiences", paper presented at 36th EU PVSEC European Photovoltaic Solar Energy Conference and Exhibition, Marseille, France, September 2019, https://www.researchgate.net/publication/335989100_SHARED_SOLAR_COOPERATIVES_IN_BRAZIL_CONTEXT_OVERCOMING_BARRIERS_AND_LESSONS_TO_BE_DRAWN_FROM_PREVIOUS_EUROPEAN_COUNTRIES_EXPERIENCES.
- 92 E. Araujo, "Brasil terá primeira cooperativa de energia solar em favela do RJ", Canal Solar, 18 June 2020, <https://canalsolar.com.br/noticias/item/616-brasil-tera-primeira-cooperativa-de-energia-solar-em-favela-do-rj>.
- 93 Department of Environment, Land, Water and Planning of Victoria State, "Community energy", <https://www.energy.vic.gov.au/renewable-energy/community-energy>, viewed 9 November 2020.
- 94 S. Vorrath, "Australia's biggest 'solar garden' opens for membership in NSW Riverina", One Step Off the Grid, 17 September 2020, <https://onestepoffthegrid.com.au/australias-biggest-solar-garden-opens-for-membership-in-nsw-riverina>.
- 95 Totally Renewable Yackandandah, <https://totallyrenewableyackandah.org.au>, viewed 23 December 2020; G. Parkinson, "Yackandandah takes another step closer to 100% renewable energy", RenewEconomy, 3 October 2019, <https://reneweconomy.com.au/yackandandah-takes-another-step-closer-to-100-renewable-energy-94764>.
- 96 M. Mazengarb, "Independent MP launches \$483m local power plan to boost community energy", One Step Off the Grid, 23 September 2020, <https://onestepoffthegrid.com.au/independent-mp-launches-483m-local-power-plan-to-boost-community-energy>.
- 97 African Development Forum, *Electricity Access in Sub-Saharan Africa* (Washington, DC: 2019), <https://openknowledge.worldbank.org/bitstream/handle/10986/31333/9781464813610.pdf>.
- 98 World Bank, "Lighting up Africa: Bringing renewable, off-grid energy to communities", 13 August 2020, <https://www.worldbank.org/en/news/feature/2020/08/13/lighting-up-africa-bringing-renewable-off-grid-energy-to-communities>.
- 99 Sun Exchange, "Crowd Sale: Own and Earn", presentation, <https://d1tsx6lhcafpu4.cloudfront.net/production/6f499ca7b629406e9a7c571c02eabba5.pdf>, viewed 23 December 2020.
- 100 Energy Cities, *Guidelines for Local and Regional Policy Makers* (Brussels: 2019), https://energy-cities.eu/wp-content/uploads/2019/06/EnergyCities_RNP_Guidebook_Web.pdf. **City Snapshot: Jakarta** based on the following sources: Energy Cities, op. cit. this note; ICLEI–Local Governments for Sustainability, "City Profile: National Capital Region of Jakarta (Indonesia)", 12 December 2017, <https://acp.iclei.org/wp-content/uploads/2019/10/Jakarta-profile.pdf>; CDP, "2018-2019 City-Wide Emissions", CDP Open Data Portal, <https://data.cdp.net/Emissions/2018-2019-City-wide-Emissions/mkj4-km9s>; Provincial Government of DKI Jakarta, "Regional Medium-Term Development Plan (RPJMD) of DKI Jakarta 2017-2022", 16 April 2018, https://bappeda.jakarta.go.id/uploads/document/2019-07-17/65/65__RPJMD_2017-2022.pdf; ICLEI Indonesia, "DKI Jakarta stakeholders prioritize low emission development options for implementation", 13 December 2019, <https://icleiseas.org/index.php/2019/12/13/formulation-workshop-towards-ghg-emissions-reduction-in-jakarta>; D. R. Meilanova, "6 Provinsi Telah Selesaikan Rancangan Umum Energi Daerah: Ekonomi", *Bisnis.com*, 27 March 2018, <https://ekonomi.bisnis.com/read/20180327/44/754937/6-provinsi-telah-selesaikan-rancangan-umum-energi-daerah>; Governor of Jakarta, "Instruction of The Governor of Jakarta 66/2019: Air Quality Control" (Jakarta: 2019), https://jdih.jakarta.go.id/uploads/default/produkhukum/INGUB_NO_66_TAHUN_2019.pdf.
- 101 Based on examples cited throughout this chapter.
- 102 G. Nanrah, "Plans revealed for huge new solar farm in Notts", Nottinghamshire Live, 28 April 2020, <https://www.nottinghampost.com/news/local-news/plans-revealed-huge-new-solar-4082868>.
- 103 Edinburgh Talks Climate, <https://edinburghtalksclimate.dialogue-app.com>, viewed 9 November 2020.
- 104 Renewable Networking Platform, "Best Practice: Co-Designing Low Carbon Public Services", <https://www.renewables-networking.eu/documents/FI-li.pdf>, viewed 9 November 2020.
- 105 Municipality of Li, "Climate action and renewable energy", <https://www.ii.fi/en/climate-actions-and-renewable-energy>, viewed 18 January 2020.
- 106 Energy Cities, *Local Energy and Climate Roadmaps* (Brussels: 2018), https://energy-cities.eu/wp-content/uploads/2019/02/local_energy_climate_roadmaps_final-1.pdf.
- 107 Smart City EU, *Roadmap 2025: 50 Steps Towards a Carbon Neutral Sonderborg* (Brussels: 2020), https://smartcity.eu/media/roadmap2025_eng.pdf.
- 108 A. Dimitrova, "Amsterdam becomes natural gas-free by 2040", The Mayor, 9 April 2020, <https://www.themayor.eu/en/amsterdam-becomes-natural-gas-free-by-2040>.
- 109 Gent municipality, "#ALSGETMIJVRAAGT Dampoort", <https://stad.gent.nl/mobiliteit-openbare-werken/mobiliteit/plannen-projecten-subsidies-cijfers-scholenwerking/wijkmobiliteitsplan/wijkmobiliteitsplan-dampoort>, viewed 23 December 2020.

- 110 WSAV, "Savannah leaders, community members discuss shift to clean energy at town hall", 19 February 2020, https://www.newsbreak.com/georgia/savannah/news/1512139149211/savannah-leaders-community-members-discuss-shift-to-clean-energy-at-town-hall?s=samsung_daily.
- 111 CalCCA, <https://cal-cca.org>, viewed 8 January 2021.
- 112 eThekweni Municipality, "Public encouraged to comment on Draft Energy Policy", 24 November 2020, http://www.durban.gov.za/Resource_Centre/new2/Pages/Public-encouraged-to-comment-on-Draft-Energy-Policy-.aspx.
- 113 Ibid.
- 114 iShack, <https://www.ishackproject.co.za>, viewed 23 December 2020.
- 115 GreenCape, "Witsand Informal Settlement: Building resilient urban communities through innovation and partnership" (Cape Town: 2020), https://www.greencape.co.za/assets/GreenCape_Resilience_Case_Study_Witsand_29_6_20.pdf.
- 116 Y. Cabannes, "Participatory budgeting in Paris: Act, reflect, grow", in Y. Cabannes, ed., *Another City Is Possible with Participatory Budgeting* (Montreal/New York/London: Black Rose Books, 2017), pp. 179-203, https://budgetparticipatif.paris.fr/bp/plugins/download/PB_in_Paris.pdf.
- 117 Renewables Networking Platform, "Best Practice: Mouscron's Community Energy Model", <https://www.renewables-networking.eu/documents/BE-Mouscron.pdf>, viewed 9 November 2020.
- 118 A. Fortes, "Participatory budgeting in Porto Alegre: An experience in democratic innovation and its historical background", *Moving the Social*, vol. 49 (2013), pp. 113-32, <https://moving-the-social.ub.rub.de/index.php/MTS/article/view/7518/6690>.
- 119 Fridays for Future, "Strike statistics", <https://fridaysforfuture.org/what-we-do/strike-statistics>, viewed 18 January 2021.
- 120 Lochem Energie, "Burger-Energiecoöperatie Lochem Energie", <https://www.lochemenergie.net/je-eigen-energie>, viewed 9 November 2020.
- 121 Friends of the Earth, "Communities fighting climate breakdown", <https://friendsoftheearth.uk/climate/communities-fighting-climate-breakdown>, viewed 23 December 2020; Climate Action Leicester and Leicestershire, <http://www.climateactionleicesterandleicestershire.org.uk>, viewed 23 December 2020.
- 122 Electricidad, "AES Gener's Ventanas 1 thermoelectric plant in Puchuncaví will close in December", 28 October 2020, <https://www.revistaei.cl/2020/10/28/en-diciembre-cerrara-termoelectrica-ventanas-1-de-aes-gener-en-puchuncavi>.
- 123 V. C. Broto and M. S. Calvet, "Sacrifice zones and the construction of urban energy landscapes in Concepción, Chile", *Journal of Political Ecology*, vol. 27, no. 1 (2020), pp. 279-99, https://www.researchgate.net/publication/340615212_Sacrifice_zones_and_the_construction_of_urban_energy_landscapes_in_Concepcion_Chile; Chile Sustentable, "Cierre de termoeléctricas: Región del Bío Bío sólo quedará con una central a carbón en 2022", 1 June 2020, <http://www.chilesustentable.net/2020/06/cierre-de-termoelectricas-region-del-bio-bio-solo-quedara-con-una-central-a-carbon-en-2022>.
- 124 S. Becker, M. Naumann and T. Moss, "Between coproduction and commons: Understanding initiatives to reclaim urban energy provision in Berlin and Hamburg", *Urban Research & Practice*, vol. 10, no. 1 (2017), pp. 63-85, <https://www.tandfonline.com/doi/abs/10.1080/17535069.2016.1156735>.
- 125 H. Busch and K. McCormick, "Local power: Exploring the motivations of mayors and key success factors for local municipalities to go 100% renewable energy", *Energy, Sustainability and Society*, vol. 4, art. 5 (2020), <https://link.springer.com/article/10.1186/2192-0567-4-5>; Energy Cities, op. cit. note 100.
- 126 Transnational Institute, "Public Futures. Global database of de-privatised public service", <https://publicfutures.org>, viewed 18 January 2021.
- 127 S. Kishimoto, L. Steinfort and O. Petitjean, *The Future Is Public – Towards Public Ownership of Public Services* (Amsterdam and Paris: New Europe, 2020), https://www.tni.org/files/publication-downloads/futureispublic_online_def.pdf.
- 128 Ibid.
- 129 Eau de Paris, "Eau de Paris présente son plan climat énergie", 9 November 2016, <http://www.eaudeparis.fr/nc/ac/lespace-culture/actualites/actualite/news/eau-de-paris-presente-son-plan-climat-energie>.
- 130 Renewables Networking Platform, "Best Practice: Active citizenship for Renewable Energy, Wolfhagen, Germany", <https://www.renewables-networking.eu/documents/DE-Wolfhagen.pdf>, viewed 23 December 2020.
- 131 M. Bunn, "Robin Hood Energy hit with £9.5m green tax payment threat by Ofgem", Nottinghamshire Live, 1 October 2019, <https://www.nottinghampost.com/news/nottingham-news/robin-hood-energy-threatened-losing-3379637>; "Bristol Energy was 'wrong market', says city mayor", BBC News, 21 July 2020, <https://www.bbc.com/news/uk-england-bristol-53485283>.
- 132 Mpower, "A democratic transition to renewable energy in Cádiz", 2 June 2020, <https://municipalpower.org/articles/a-democratic-transition-to-renewable-energy-in-cadiz>.
- 133 S. Burgen, "Renewable energy in Cádiz and Barcelona, Spain", *AltEnergyMag*, 30 May 2019, <https://www.altenergymag.com/article/2019/05/renewable-energy-in-c%3%A1diz-and-barcelona-spain/31052>.
- 134 D. Q. Ilkhani and E. Woertz, *Remunicipalisation of Local Energy Provision: The Role of Cities and Bottom-up Initiatives* (Barcelona: CIDOB, May 2019), https://www.cidob.org/en/publications/publication_series/cidob_policy_brief/remunicipalisation_of_local_energy_provision_the_role_of_cities_and_bottom_up_initiatives.
- 135 Climate Emergency Declaration, "Climate emergency declarations in 1,830 jurisdictions and local governments cover 820 million citizens", 5 November 2020, <https://climateemergencydeclaration.org/climate-emergency-declarations-cover-15-million-citizens>.
- 136 Cedamia, "Climate Emergency Declaration", <https://www.cedamia.org/global>, viewed 9 November 2020.
- 137 Climate Emergency Declaration, op. cit. note 135.
- 138 Ibid.
- 139 **City Snapshot: Recife** based on the following sources: CDP, "2018-2019 City-Wide Emissions", CDP Open Data Portal, <https://data.cdp.net/Emissions/2018-2019-City-wide-Emissions/mkj4-km9s>; ICLEI, "Recife becomes first Brazilian city to declare climate emergency", 20 November 2019, <https://iclei.org/en/media/recife-becomes-first-brazilian-city-to-declare-climate-emergency>; CELPE, "O Futuroa Gente Faz Agora", <https://servicos.celpe.com.br/a-celpe/Paginas/Efici%C3%Aancia%20Energ%C3%A9tica/Como-participar-EE.aspx>; ANEEL, "Programa De Eficiência Energética – ANEEL", <https://www.aneel.gov.br/programa-eficiencia-energetica>, viewed 5 January 2021.
- 140 Climate Emergency Declaration, op. cit. note 135.
- 141 Ibid.
- 142 Ibid.
- 143 Ibid.; REN21 Policy Database (2020), available at www.ren21.net/cities/datapack. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and therefore may not be exhaustive.
- 144 Climate Emergency Declaration, op. cit. note 135. **Figure 17** from REN21 op. cit. note 143. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, C40, ICLEI, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and therefore may not be exhaustive.
- 145 Ibid.

FEATURE

- 1 World Bank, "Population total – Sub-Saharan Africa", <https://data.worldbank.org/indicator/SP.POP.TOTL?locations=ZG>, viewed 30 October 2020; United Nations (UN), *World Urbanization Prospects, Volume 12* (New York: 2018), <https://population.un.org/wup>.
- 2 World Bank, *Poverty and Shared Prosperity 2018: Piecing Together the Poverty Puzzle* (Washington, DC: 2018), <https://www.worldbank.org/en/publication/poverty-and-shared-prosperity-2018>.
- 3 Ibid.
- 4 UN, op. cit. note 1.
- 5 International Energy Agency (IEA), *Africa Energy Outlook 2019 – Analysis Scenarios*, World Energy Outlook Special Report (Paris: 2019), p. 288, <https://www.iea.org/reports/africa-energy-outlook-2019>.
- 6 Ibid., p. 288; IEA, *World Energy Outlook 2020* (Paris: 2020), <https://www.iea.org/reports/world-energy-outlook-2020>.
- 7 IEA, *World Energy Outlook 2020*, op. cit. note 6, IEA, op. cit. note 5, p. 288.
- 8 International Renewable Energy Agency (IRENA), *Global Renewables Outlook: Energy Transformation 2050* (Abu Dhabi: 2020), https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Apr/IRENA_Global_Renewables_Outlook_2020.pdf.
- 9 IRENA, *Renewable Energy in National Climate Action* (Abu Dhabi: 2018), https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Dec/IRENA_COP24_NDC_update_2018.pdf.
- 10 IRENA, *Scaling Up Renewable Energy Deployment in Africa: Impact of IRENA's Engagement* (Abu Dhabi: 2019), https://www.irena.org/cleanenergycorridors/-/media/Files/IRENA/Agency/Publication/2019/Jan/IRENA_Africa_impact_2019.ashx; Z. Gebrehiwot, "The EAPP Master Plan and Renewable Energy Options", presentation at Executive Strategy Workshop to Map Out Priorities for IRENA's Africa Clean Energy Corridor Initiative, Abu Dhabi, 22-23 June 2013, https://www.irena.org/-/media/Files/IRENA/Agency/Events/2013/Nov/9_1/Afriac-CEC-session-2_EAPP_Gebrehiwot_220613.pdf; IRENA, op. cit. note 9.
- 11 L. Tait and M. Euston-Brown, "What role can African cities play in low-carbon development? A multilevel governance perspective of Ghana, Uganda and South Africa", *Journal of Energy in Southern Africa*, vol. 28, no. 3 (2017), pp. 43-53, http://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S1021-447X2017000300004; S. Bawakyillenuo et al., "Sustainable energy transitions in Sub-Saharan African cities: The role of local government", *Urban Energy Transition* (2018), pp. 529-51, <https://www.sciencedirect.com/science/article/pii/B9780081020746000425>.
- 12 Covenant of Mayors in Sub-Saharan Africa (CoM SSA), "About", 2015, <https://comssa.org/about>; C40 Cities, "Climate Action Planning (CAP) Africa launch event and 1st Regional Academy", 15 May 2018, <https://www.c40.org/tags/cap-africa>.
- 13 ESI Africa, "The big question: The future skyline of energy generation in cities", 11 May 2020, <https://www.esi-africa.com/industry-sectors/future-energy/the-big-question-the-future-skyline-of-energy-generation-in-cities>.
- 14 Ibid.
- 15 Ibid.
- 16 CoM SSA, op. cit. note 12; Supporting African Municipalities in Sustainable Energy Transitions (SAMSET), <https://samsetproject.net>, 2014.
- 17 **Figure 18** from the following sources: Sustainable Energy Africa (SEA), *State of Energy in South African Cities Report 2020* (Cape Town: 2020), http://www.cityenergy.org.za/uploads/resource_508.pdf; J.N. Yongoua, S. Sambou and L. Nicholson, *Rapport d'inventaire Des Émissions de Gaz à Effet de Serre de La Ville de Dakar*, 2016 (Dakar: C40 Cities, 2019); SEA, *Data and Scenario Modelling Technical Report for Kampala, Uganda* (Kampala: 2019); SEA, *Rapport Technique Sur La Modélisation Des Scénarios Pour La Commune d'Arrondissement de Yaoundé IV, Cameroun* (Yaoundé: 2019); SEA, *Data and Scenario Modelling Technical Report, Tsévié City, Togo* (Tsévié City 2019).
- 18 SEA, *State of Energy in South African Cities Report 2020*, op. cit. note 17.
- 19 Ibid.
- 20 IEA, op. cit. note 5, p. 288; A.K. Amegah and S. Agyei-Mensah, "Urban air pollution in Sub-Saharan Africa: Time for action", *Environmental Pollution*, vol. 220, part A (January 2017), pp. 738-43, <https://www.sciencedirect.com/science/article/abs/pii/S0269749116312933>.
- 21 SEA, *Data and Scenario Modelling Technical Report, Tsévié City, Togo*, op. cit. note 17.
- 22 IEA, op. cit. note 5, p. 288.
- 23 **Figure 19** from the following sources: SEA, *State of Energy in South African Cities Report 2020*, op. cit. note 17; Yongoua, Sambou and Nicholson, op. cit. note 17; SEA, *Data and Scenario Modelling Technical Report for Kampala, Uganda*, op. cit. note 17; SEA, *Rapport Technique Sur La Modélisation Des Scénarios Pour La Commune d'Arrondissement de Yaoundé IV, Cameroun*, op. cit. note 17; SEA, *Data and Scenario Modelling Technical Report, Tsévié City, Togo*, op. cit. note 17.
- 24 Western Cape Government, *2017 Socio-economic Profile: City of Cape Town* (Cape Town, South Africa: 2017), https://www.westerncape.gov.za/assets/departments/treasury/Documents/Socio-economic-profiles/2017/city_of_cape_town_2017_socio-economic_profile_sep-lg_-_26_january_2018.pdf.
- 25 Ibid.
- 26 Department of Energy of the Republic of South Africa, *The South African Energy Sector Report 2019* (Pretoria: 2019), <http://www.energy.gov.za/files/media/explained/2019-South-African-Energy-Sector-Report.pdf>.
- 27 Department of Mineral Resources and Energy of the Republic of South Africa, *Integrated Resource Plan (IRP 2019)* (Pretoria: 2019), <http://www.energy.gov.za/IRP/2019/IRP-2019.pdf>.
- 28 SEA, *State of Energy in South African Cities Report 2020*, op. cit. note 17.
- 29 Ibid.
- 30 Ibid.
- 31 SEA and City of Cape Town, *Cape Town State of Energy 2015 Report* (Cape Town: 2015), https://africacityenergy.org/uploads/resource_22.pdf.
- 32 SEA, *State of Energy in South African Cities Report 2020*, op. cit. note 17.
- 33 Ibid.
- 34 Ibid.
- 35 Cape Town's local sustainable energy approach mirrored that of the national Energy White Paper of 1998, with a strong emphasis on energy poverty, environmental protection (including climate mitigation) and energy security towards much-needed economic development. This early work was located within the Environmental Resources Management Department, and the City employed a single Energy Officer in 2006. This grew to a fully established and staffed Energy and Climate Change Unit over the next 10 years and was given impetus by the inclusion of the energy and climate goals in the Integrated Development Plan from as early as 2008. SEA, *State of Energy in South African Cities Report 2020*, op. cit. note 17.
- 36 SEED, a 13-year, award-winning capacity-building programme born at the time of the democratic transition in South Africa, became the genesis of the country's local energy movement. SEED was designed to help the government tackle the urban crisis from an energy perspective, through fostering individuals and programmes and growing the critical skills to plan and manage energy. The first *State of Energy in South African Cities* report was produced under this programme. From SEA, *State of Energy in South African Cities Report 2020*, op. cit. note 17.
- 37 SEA and City of Cape Town, op. cit. note 31.
- 38 SEA, *State of Energy in South African Cities Report 2020*, op. cit. note 17.
- 39 Ibid.
- 40 City of Cape Town, "Rooftop PV: Guidelines for safe and legal installations in Cape Town" (Cape Town: 2018), <https://www.westerncape.gov.za/energy-security-game-changer/files/atoms/files/Energy-PV-Brochure.pdf>.
- 41 South African Local Government Association (SALGA), *Status of Small Scale Embedded Generation in South African Municipalities* (Pretoria: 2020), p. 13, <https://www.sseg.org.za/status-of-sseg-2020>.
- 42 Ibid.
- 43 This was achieved through initiatives such as the GIZ South African-German Energy Programme (GIZ SAGEN) Municipal Sustainable Energy Transition Support Programme, which aims to promote sustainable energy in municipalities, with a focus on renewables and energy efficiency. SEA, *State of Energy in South African Cities 2020*, op. cit. note 17, pp. 67-69.

- 44 Between 2008 and 2010, the City of Cape Town implemented two major solar water heater roll-out programmes in low-income households, both of which were grant-funded, in the communities of Kuyasa (2,000 units) and Joe Slovo (1,500 units). SEA and City of Cape Town, op. cit. note 31; GlZ-SAGEN and SEA, *Review of Best Practice Solar Water Heating Implementation by Local Government* (Pretoria: GlZ, 2015), http://www.cityenergy.org.za/uploads/resource_351.pdf.
- 45 SEA, *Sustainable Energy Solutions for South African Local Government: A Practical Guide* (Cape Town: 2017), pp. 38-40, http://www.cityenergy.org.za/uploads/resource_434.pdf.
- 46 SEA, *State of Energy in South African Cities Report 2020*, op. cit. note 17.
- 47 SEA and City of Cape Town, op. cit. note 31.
- 48 SEA, *State of Energy in South African Cities Report 2020*, op. cit. note 17.
- 49 Ibid.
- 50 Business Insider South Africa, "Big breakthrough: Some municipalities can now generate their own electricity", 16 October 2020, <https://www.businessinsider.co.za/some-municipalities-can-procure-their-own-electricity-2020-10>.
- 51 SEA, *State of Energy in South African Cities Report 2020*, op. cit. note 17.
- 52 Ibid.
- 53 City of Cape Town, *Draft City of Cape Town Climate Change Strategy* (Cape Town: 2020), http://www.capetown.gov.za/councilonline/_layouts/OpenDocument/OpenDocument.aspx?DocumentId=509d02cf-c744-4aba-b913-6fc05e2dfeea.
- 54 Ibid.
- 55 This plan is further broken down in sectoral plans such as the Comprehensive Integrated Transport Plan, the Cape Town Metropolitan Spatial Development Framework, and the Cape Town Energy and Climate Change Strategy, among others. City of Cape Town, *Comprehensive Integrated Transport Plan 2018-2023* (Cape Town: 2018) <https://tdacontenthubstore.blob.core.windows.net/resources/fd3ddc0d-b459-4d26-bb01-7f689d7a36eb.pdf>.
- 56 Ibid.
- 57 Urban Electric Mobility Initiative, *Cape Town EV Readiness Assessment* (Cape Town: 2018), http://www.uemi.net/uploads/4/8/9/5/48950199/ev_r_sa.pdf.
- 58 City of Cape Town, *City of Cape Town EV Framework* (Cape Town: 2019), http://www.cityenergy.org.za/uploads/resource_471.pdf.
- 59 Ibid. The renewable energy can be purchased through a renewable energy certificate or directly from a renewable energy IPP and wheeled through the grid. Wheeling is the term for the transport of electric energy from within an electrical grid from one party (the seller) to another party (the buyer). Wheeling deals with the use of the network and the cost of delivering the energy.
- 60 Yongoua, Sambou and Nicholson, op. cit. note 17.
- 61 100 Resilient Cities, *Dakar Resilient Strategy* (Dakar: 2016), <https://resilientcitiesnetwork.org/networks/dakar>.
- 62 Power Africa, "Senegal Power Africa Fact Sheet" (Washington, DC: US Agency for International Development, 2020), <https://www.usaid.gov/powerafrica/senegal>.
- 63 Ministry of Petroleum and Energy of the Republic of Senegal, "Lettre de Politique de Développement du Secteur de l'Énergie" (Dakar: 2012).
- 64 Republic of Senegal, *Plan Sénégal Emergent* (Dakar: 2014), https://www.sec.gouv.sn/sites/default/files/Plan%20Senegal%20Emergent_0.pdf.
- 65 Ministry of Urban Renewal, Housing and the Living Environment of the Republic of Senegal, *Plan Directeur d'Urbanisme de Dakar et ses Environs Horizon 2035* (Dakar: 2016), http://www.pdudakar.gouv.sn/IMG/pdf/eijr16003_da2875.pdf.
- 66 City of Dakar, personal communication with SEA, November 2020.
- 67 Ibid.
- 68 Yongoua, Sambou and Nicholson, op. cit. note 17.
- 69 Ibid.; US Energy Information Administration, "How much electricity does an American home use?" <https://www.eia.gov/tools/faqs/faq.php?id=97>, viewed 27 September 2020.
- 70 Yongoua, Sambou and Nicholson, op. cit. note 17.
- 71 National Agency of Statistics and Demography of the Republic of Senegal, *Situation Economique et Sociale de la Région de Dakar*, 2016 edition (Dakar: 2019), <http://www.ansd.sn/ressources/ses/SES-Dakar-2016.pdf>.
- 72 Ibid.
- 73 Executive Council of Urban Transport in Dakar (CETUD), *Plan de Déplacements Urbains de Dakar* (PDUD), 2008-2025 (Dakar: 2008).
- 74 City of Dakar, *Atelier de planification climat* (Dakar: November 2019).
- 75 Uganda Bureau of Statistics, *The National Population and Housing Census 2014 – Area Specific Profile Series* (Kampala: 2017), <https://www.ubos.org/wp-content/uploads/publications/2014CensusProfiles/KAMPALA-KCCA.pdf>.
- 76 Kampala Capital City Authority (KCCA), *Energy and Climate Profile* (Kampala: 2016), <https://www.kcca.go.ug/uDocs/Energy%20and%20Climate%20Profile.pdf>.
- 77 Ibid.
- 78 Ibid.
- 79 Ministry of Energy and Mineral Development of the Republic of Uganda, *Draft National Energy Policy* (Kampala: 2019), https://www.energyandminerals.go.ug/site/assets/files/1081/draft_revised_energy_policy_-_11_10_2019-1_1.pdf.
- 80 KCCA, op. cit. note 76.
- 81 Ibid.
- 82 Ibid.
- 83 World Bank, *Role of City Governments in Economic Development of Greater Kampala* (Washington, DC: 2017), https://development-data-hub-s3-public.s3.amazonaws.com/ddhfiles/143567/119806-revised-public-the-wb-book-2017-report-web-individual-page-layout_0.pdf.
- 84 Ibid.
- 85 KCCA, *Kampala Strategic Plan 2020/21 to 2024/25* (Kampala: 2020), <https://www.kcca.go.ug/uDocs/Kampa-City-Strategic-Plan-2020-2025.pdf>.
- 86 KCCA, op. cit. note 76.
- 87 T. Smith, "Uganda: Boda boda e-bike on a pay as you go model", Green Building Africa, 25 September 2020, <https://www.greenbuildingafrica.co.za/uganda-boda-boda-e-bike-on-a-pay-as-you-go-model-to-boost-sector>.
- 88 SEA, *Data and Scenario Modelling Technical Report, Tsévié City, Togo*, op. cit. note 17.
- 89 Ibid.
- 90 World Bank, *Revue des Politiques du Secteur de l'Énergie. Revue du Sous-Secteur de l'Électricité* (Washington, DC: 2013), <https://openknowledge.worldbank.org/bitstream/handle/10986/16263/ACS4990WP00FRE0x0379826B000PUBLIC0.pdf>.
- 91 ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE), *Plan Actions National d'Efficacité Énergétique (PANEE)* (Praia: 2015), http://www.se4all.ecreee.org/sites/default/files/plan_actions_national_defficacite_energetique_panee_-_togo.pdf; ECREEE, *Plan d'Actions National Des Énergies Renouvelables (PANER)* (Praia: 2009), https://www.se4all-africa.org/fileadmin/uploads/se4all/Documents/Country_PANER/Togo_Plan_d_Actions_National_des_Energies_Renouvelables.pdf.
- 92 ECREEE, *Plan d'Actions National Des Énergies Renouvelables (PANER)*, op. cit. note 91.
- 93 SEA, *Data and Scenario Modelling Technical Report, Tsévié City, Togo*, op. cit. note 17.
- 94 Ibid.
- 95 Ibid.
- 96 Ibid.
- 97 City of Tsévié, *Plan en faveur d'un accès à une énergie durable et du climat (PAAEDC). Convention des Maires d'Afrique Sun Saharienne* (Tsévié: 2020).
- 98 Ibid.
- 99 H. Michel, City of Tsévié, personal communication with SEA, 2020.
- 100 Ibid.

- 101 SEA, *Rapport Technique Sur La Modélisation Des Scénarios Pour La Commune d'Arrondissement de Yaoundé IV, Cameroun*, op. cit. note 17.
- 102 Wikipedia, "Yaoundé", <https://en.wikipedia.org/wiki/Yaound%C3%A9#Economy>, viewed 28 October 2020.
- 103 GIZ, *Analyse Nationale Cameroun* (Brussels: CoM SSA, 2020).
- 104 IRENA, *Cameroon Energy Profile* (Abu Dhabi: 2020), https://www.irena.org/IRENADocuments/Statistical_Profiles/Africa/Cameroon_Africa_RE_SP.pdf.
- 105 Ministry of the Economy, Planning and Regional Development of the Republic of Cameroon, *Cameroun Vision 2035* (Yaoundé: 2009), <http://extwprleg1.fao.org/docs/pdf/cmr145894.pdf>; *Republic of Cameroon, CPDN Du Cameroun* (Yaoundé: 2017), <https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Cameroon%20First/CPDN%20CMR%20Final.pdf>.
- 106 GIZ, op. cit. note 103.
- 107 SEA, *Rapport Technique Sur La Modélisation Des Scénarios Pour La Commune d'Arrondissement de Yaoundé IV, Cameroun*, op. cit. note 17.
- 108 Ibid.
- 109 Ibid.
- 110 Commune de Yaoundé IV, *Plan d'Action Communal en faveur d'un Accès à une Energie Durable et du Climat (PACAEDC)* (Yaoundé: 2020).
- 111 Ibid.
- 112 SEA, *Rapport Technique Sur La Modélisation Des Scénarios Pour La Commune d'Arrondissement de Yaoundé IV, Cameroun*, op. cit. note 17.
- 113 J-J. Belinga, City of Yaoundé IV, personal communication with SEA, 2020.
- 114 Ibid.
- 115 IRENA, *Scaling Up Renewable Energy Deployment in Africa*, op. cit. note 10; RES4Africa Foundation, *Scaling Up Africa's Renewable's Power: The Need for De-risking Investments and the Case for RenewAfrica* (Rome: 2020), <https://www.res4africa.org/wp-content/uploads/2020/07/RES4Africa-Foundation-Scaling-up-Africas-renewable-power.pdf>.
- 116 IRENA, *Scaling Up Renewable Energy Deployment in Africa*, op. cit. note 10; RES4Africa Foundation, op. cit. note 115.
- 117 African Development Bank, Sustainable Energy for All (SEforALL) Africa Hub and Sustainable Energy Fund for Africa, *Green Mini-Grids in Sub-Saharan Africa: Analysis of Barriers to Growth and the Potential Role of the African Development Bank in Supporting the Sector* (Abidjan: 2016), <https://energy4impact.org/file/1818/download?token=j67HKZEy>; RES4Africa Foundation, op. cit. note 115.
- 118 SEA, *State of Energy in South African Cities Report 2020*, op. cit. note 17.
- 119 S. Bawakyillenuo et al., "Chapter 4.3. Sustainable energy transitions in Sub-Saharan African cities: The role of local government", in P. Droege, *Urban Energy Transitions: Renewable Strategies for Cities and Regions* (Amsterdam: Elsevier Ltd, 2018), <https://www.elsevier.com/books/urban-energy-transition/droege/978-0-08-102074-6>.
- 120 T. Paulais, *Financing Africa's Cities: The Imperatives of Local Investment* (Washington, DC: 2012), <https://www.afd.fr/en/ressources/financing-africas-cities-imperative-local-investment>; African Centre for Cities, University of Cape Town and Pinsent Masons LLP, *African Thought Leadership Programme, Roundtable 5: Urban Governance and Decentralisation* (Pinsent Masons LLP, 2019), <https://www.pinsentmasons.com/thinking/special-reports/african-cities-thought-leadership-programme>.
- 121 African Centre for Cities, University of Cape Town and Pinsent Masons LLP, op. cit. note 120.
- 122 Ibid.
- 123 Mini-Grids Partnership, SEforALL and BloombergNEF, *State of the Global Mini-Grids Market Report 2020: Trends of the Renewable Energy Hybrid Mini-grids in Sub-Saharan Africa, Asia and Island Nations* (London: Bloomberg Finance L.P., 2020), https://minigrids.org/wp-content/uploads/2020/06/Mini-grids_Market_Report-20.pdf.
- 124 IEA, op. cit. note 5, p. 145; Mini-Grids Partnership, SEforALL and BloombergNEF, op. cit. note 123; RES4Africa Foundation, op. cit. note 115.
- 125 M.P. Blimpo and M. Cosgrove-Davies, *Electricity Access in Sub-Saharan Africa: Uptake, Reliability, and Complementary Factors for Economic Impact* (Washington, DC: World Bank, 2019), <https://openknowledge.worldbank.org/bitstream/handle/10986/31333/9781464813610.pdf>.
- 126 SEA, op. cit. note 45.
- 127 Mini-Grids Partnership, SEforALL and BloombergNEF, op. cit. note 123.
- 128 S. Sambou, Dakar C40 City Advisor, personal communication with J. Nana, SEA, September 2020.
- 129 S. Bawakyillenuo et al., op. cit. note 119.
- 130 Ibid.; C40 Cities Climate Leadership Programme, *Strategies to Increase the Deployment of Distributed Renewables in Sub-Saharan African Cities* (London: November 2020), http://cityenergy.org.za/uploads/resource_510.pdf; SEA, *State of Energy in South African Cities Report 2020*, op. cit. note 17.
- 131 Bawakyillenuo et al., op. cit. note 119; SEA, op. cit. note 45; M. Borchers et al., "Sustainable energy transitions: Changing the 'business as usual' trajectory in Sub-Saharan African urban areas", *International Journal of African Development*, vol. 5, no. 1 (2018), pp. 13-30, <https://scholarworks.wmich.edu/cgi/viewcontent.cgi?article=1094&context=ijad>.
- 132 Bawakyillenuo et al., op. cit. note 119; SEA, *State of Energy in South African Cities Report 2020*, op. cit. note 17; Tait and Euston-Brown, op. cit. note 11.

RENEWABLES IN CITIES

2021 GLOBAL STATUS REPORT



REN21 Secretariat

c/o UN Environment Programme
1 rue Miollis
Building VII
75015 Paris
France

www.ren21.net

ISBN 978-3-948393-01-4

