IRENA
International Renewable Energy Agency

THE POST-COVID RECOVERY

An agenda for resilience, development and equality

© IRENA 2020

CITATION

IRENA (2020), The post-COVID recovery: An agenda for resilience, development and equality, International Renewable Energy Agency, Abu Dhabi

ISBN 978-92-9260-245-1

ABOUT IRENA

The International Renewable Energy Agency (IRENA) serves as the principal platform for international co-operation, a centre of excellence, a repository of policy, technology, resource and financial knowledge, and a driver of action on the ground to advance the transformation of the global energy system. An intergovernmental organisation established in 2011, IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity. **www.irena.org**

DISCLAIMER

THE POST-COVID RECOVERY

An agenda for resilience, development and equality

ACKNOWLEDGEMENTS

The report was authored by Rabia Ferroukhi, Dolf Gielen and Elizabeth Press with valuable contributions from Michael Renner, Diala Hawila, Xavier Garcia-Casals, Michael Taylor and Ricardo Gorini (IRENA), and from David Jacobs (IET).

Different sections benefited from reviews and input by Gayathri Prakash, Costanza Strinati, Samah Elsayed, Bishal Parajuli, Celia García-Baños, Carly Leighton, Emanuele Bianco, Carlos Guadarrama, Jinlei Feng, Mirjam Reiner, Sufyan Diab and Abdullah Abou Ali (IRENA), along with Amir Lebdioui, Laura El-Katiri and Divyam Nagpal (IRENA consultants).

Steven Kennedy and Neil MacDonald edited the main chapters, while Caren Weeks produced the final report design.

FOREWORD

This year was supposed to have opened the Decade of Action on sustainable development and climate change, with the transformation of the global energy system at its heart. While 2020 has thus far brought tragic loss of life and sudden economic uncertainty, it could yet turn out to be a crucial year and a turning point in these defining challenges of our time.

The first *Global Renewables Outlook*, released by the International Renewable Energy Agency (IRENA) in April 2020, showed how to transform the global energy system in line with the Paris Agreement, bringing immense socio-economic benefits and welfare gains. The advantages of renewables to weather the rising economic storm were already apparent. A few months on, their resilience compared to the conventional energy industries based on fossil fuels has become even clearer.

Now is the time to be strategic and ambitious, and to take the decisive step towards the structural shift needed to fulfil the 2030 Agenda for Sustainable Development and keep global warming at 1.5°C degrees. The *Post-COVID Recovery: An Agenda for Resilience, Development and Equality* makes this connection clear. It points out how and where investments and policy measures focused on energy transitions can strengthen the economic recovery, bolster sustainable development, and set the course for a fully decarbonised system by the middle of this century.

Government policies and investment choices can create the self-perpetuating momentum to enact systemic change and deliver the energy transformation. The word “investment” is meaningful – these are not simply costs, but investments in our collective future and key enablers of economic growth, social resilience and welfare.

The agenda proposed here is achievable. The burden would not fall on public finances alone, particularly as technologies keep developing and costs fall further. Importantly, stimulus investments will result in rapid job creation. To support a sustained shift in local economies, industrial policies and targeted education and training programmes are needed to build tomorrow’s workforce and foster diverse segments of the value chain.

Investments to foster innovation for the energy transition will bring substantial local, as well as global, benefits. Technologies now exist with the potential to deliver a net zero energy system. By investing in their commercialisation, governments and businesses can create value and ensure sustained and long-term growth. Green hydrogen, with its associated production and logistical requirements, represents one of the major strategic opportunities in the coming years.

As the pandemic continues, its full impact is yet to be seen. IRENA's post-COVID recovery agenda does not seek to predict the future or speculate on how the current economic downturn will play out. Countries must follow their varied pathways, both in economic recovery and in their energy transitions. IRENA, as the agency supporting countries worldwide in their transition to a sustainable energy future, reflects the diversity of views, priorities, abilities and needs of 180 Members and States in Accession.

This report provides practical insights, options and recommendations for governments to consider. It can support informed policy-making as countries devise recovery measures specific to their circumstances. In suggesting how to navigate present times, it keeps a firm focus on the aims of inclusiveness and a just transition, while connecting short-term actions to medium- and long-term decarbonisation pathways.

The COVID-19 crisis has, in some ways, provided an unexpected foreshadowing of the mounting climate emergency. This is the right moment to reassess long-standing assumptions, perceived barriers, and default decisions. The pandemic has shown us how quickly all we are accustomed to can change. But it has also shown that collectively and with a common purpose, we are able to act decisively.

I hope this report helps to uphold such a vision. The world after COVID-19 can be more resilient, prosperous, just, and capable of tackling the challenges ahead of us.

Francesco La Camera
Director-General, IRENA

CONTENTS

Energy has become a crucial policy focus in the COVID-19 crisis

PART II

PART III

FIGURES

TABLES

BOXES

EXECUTIVE SUMMARY

The energy sector, always at the centre of the global economy, plays a crucial role amid the coronavirus (COVID-19) crisis. Response measures, including widespread lockdowns, have disrupted production and supply chains, shrunk demand for goods and services, depressed commodity prices and caused a massive economic contraction around the world. Alongside the health crisis, hundreds of millions of people have lost their jobs or seen their livelihoods threatened.

Renewable energy, while suffering along with the whole global economy, has proven to be more resilient than other parts of the sector. With energy demand for transport and industrial uses plunging, fossil fuels have been hit hard. Oil prices have fallen sharply, raising concerns about volatility and long-term viability even as fossil fuels begin to show signs of recovery, at least in the short-term. Meanwhile, electricity systems with high shares of renewables continue to operate effectively.

When incorporated into stimulus and recovery plans, the energy transition can represent a far-sighted investment. The crisis has further unveiled inadequacies of the current system, both in terms of reliance on fossil fuels and massive gaps in energy access, which in turn affect healthcare, water supply, information and communication technologies and other vital services. An investment package focused on the energy transition can help to overcome the economic slump and create much-needed jobs, both for the short-term and beyond.

SUMMARY

The International Renewable Energy Agency (IRENA), as the lead intergovernmental organisation for the global energy transition, supports countries in their pursuit of a sustainable energy future. The *Global Renewables Outlook* released by IRENA in April 2020 provides a comprehensive long-term strategy, which the present report adapts to the current situation and the decade until 2030. Governments have a profound opportunity to set in motion a lasting shift in the global energy mix and allow the world to reap the multiple benefits of a cleaner energy system. Drawing on IRENA's extensive knowledge and expertise on the technological, macroeconomic, and policy aspects of the energy transition, the present report offers decision-making advice at this critical time.

The moment for structural change

Linking the short-term recovery to medium and long-term strategies is paramount to achieving the Sustainable Development Goals (SDGs) and the Paris Agreement on Climate Change. The catalogue of post-COVID recovery measures outlined here aligns closely with the United Nations-backed 2030 Agenda for Sustainable Development and represents a crucial phase in the timely reduction of CO_2 emissions to avert catastrophic climate change. It instigates a fundamental shift in how we produce and consume energy, thereby delivering the long-term global energy transformation.

Policy measures and investments for stimulus and recovery can drive a wider structural shift, fostering national and regional energy transition strategies as a decisive step in building resilient economies and societies. The energy sector must be viewed as an integral part of the broader economy to fully understand the impact of the transition, and ensure it is timely and just.

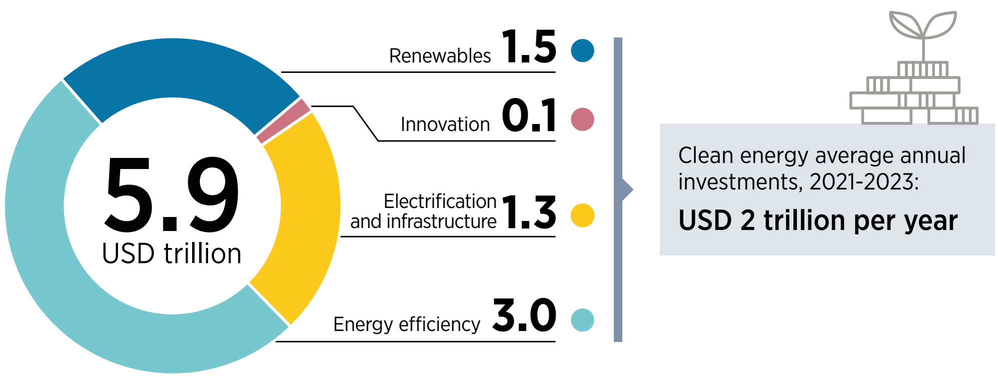
Recovery plans rooted in the energy transition represent a far-sighted investment

Energy transition investment can boost the economy over the 2021-23 recovery phase and create a wide range of jobs. Stimulus measures can accelerate positive ongoing tends. In 2019, renewables and other transition-related technologies attracted investments worth USD 824 billion. In the 2021-2023-recovery phase, the analysis conducted in this report shows that such investments should more than double to nearly USD 2 trillion (see ES Figure 1) and then continue to grow to an annual average of USD 4.5 trillion in the decade to 2030. Government funds can leverage private investments by a factor of 3-4 and should be used strategically to nudge investment decisions and financing in the right direction.

Institutional investment and green bonds will be vital, along with dedicated credit, investment and funding programmes. For now, the pandemic appears to have sharpened investor interest in sustainable assets. Institutional investors may opt to focus more on renewables in the recovery and beyond. By aligning their investment portfolios to a climate-safe future, investors can also be better prepared to anticipate new regulatory demand and evolving fiduciary standards.

Figure ES.1 Energy transition investment under the Transforming Energy Scenario, 2021-2023

Cumulative clean energy investments (USD_{2019} trillion)



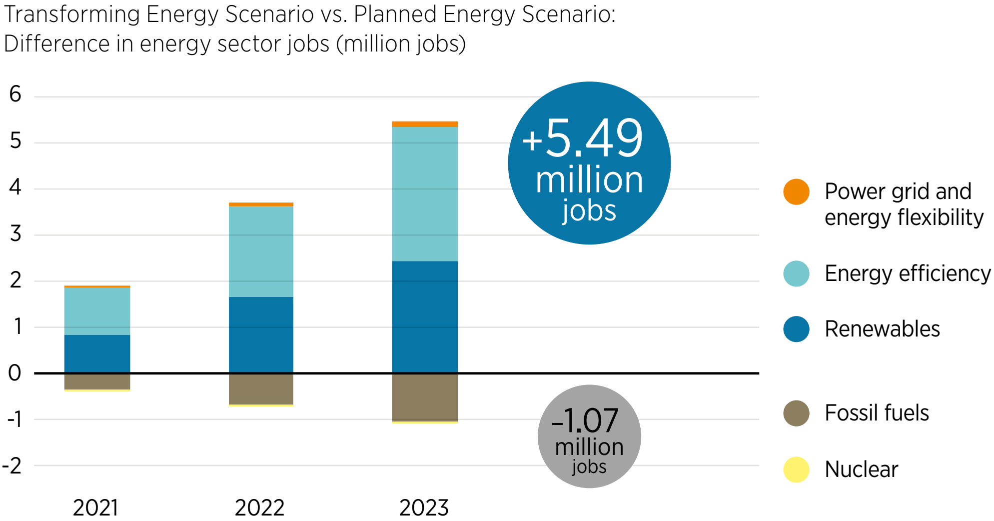
Source: Based on IRENA (2020), *Global Renewables Outlook: Energy Transformation 2050*.

Boosting GDP and employment

Socio-economic benefits would already accrue in the first three years of recovery programmes, while simultaneously accelerating the energy transition. If the required investment is mobilised and nimble recovery policies are put in place, the transition would boost GDP by 1% more, on average over three years, than current plans.

Each million dollars invested in renewables or energy flexibility would create at least 25 jobs, while each million invested in efficiency would create about 10 jobs. With the added investment stimulus under IRENA's Transforming Energy Scenario, energy transition-related technologies would add 5.5 million more jobs by 2023 than would be possible under the less ambitious Planned Energy Scenario. Renewables would account for 2.46 million of these additional jobs, energy efficiency for 2.91 million, and grids and energy system flexibility for 0.12 million. These gains far outweigh the loss of 1.07 million jobs in the fossil fuel and nuclear sectors (see ES Figure 2).

Figure ES.2 Changes in energy sector jobs resulting from transition-related investment, 2021-2023



Based on IRENA analysis

SUMMARY

The transition would achieve net job gains in all regions of the world, including those where fossil-fuel jobs are now concentrated. This creates meaningful options to switch from fossil-fuel employment and provides new opportunities for both skilled and unskilled workers from other industries. Such benefits hinge on leveraging and enhancing local industrial capacities, strengthening supply chains, putting in place adequate education and training programmes, and adopting suitable labour market policies. Forward-looking industrial policies can create green industries, in both developed and developing countries.

Investments starting now can put renewable power generation on track to grow five times faster than current plans would indicate. Such ramping up requires substantial upfront spending, as well re-evaluating the cost-effectiveness of existing assets. To start with, retiring the least competitive 500 gigawatts (GW) of coal-fired power capacity and replacing it with utility-scale solar PV and onshore wind could reduce annual system-wide generation costs by USD 23 billion and yield a far larger stimulus, according to IRENA's latest cost analysis.

What must happen in the short-term

Recovery measures over the next three years can either trigger a decisive shift toward resilient energy systems or ensure an enduring lock-in with unsustainable practices. A holistic policy approach – rooted in the climate-safe energy development, yet also focused on short-term imperatives – would reap multiple benefits and help set the stage for a just transition.

Renewable power projects – including existing utility-scale plants and those under construction, distributed generation investments and renewables-ready network infrastructure – must be safeguarded. Alongside renewable power generation, measures could stimulate supply industries (e.g. battery factories), enabling infrastructure (smart grids, grid reinforcements, EV charging, district heating and cooling, hydrogen), energy efficiency and increased electrification of end uses.

Energy investments undertaken as a short-term response to the pandemic's effects can support increasingly ambitious longer-term targets for renewables and efficiency in all sectors, as well as reinforce enhanced climate pledges. Current Nationally Determined Contributions (NDCs) under the Paris Agreement – as far as they set renewable power targets – lag compared to already-apparent market trends. If renewable power continues growing at the same rates as seen in 2015-18, the cumulative global targets now in place for 2030 could be met as soon as 2022. Market progress and renewable-based recovery aims could be reflected in updated NDCs.

Short-term measures can also drive the energy transition in end uses like heat and transport that account for a large share of total energy demand. The post-COVID stimulus package could encompass renewable-based heating and cooling systems combined with energy efficiency measures in buildings; electromobility based on renewable power sources; and transport fuels based on bioenergy or green hydrogen. Increased electrification of end-use infrastructure, including via electric vehicle (EV) charging and electrolysis for hydrogen production, is another requirement for a decarbonised energy system.

Investment decisions must go hand-in-hand with policies to ensure that industrial and other economic capabilities are aligned with recovery and transition objectives. Careful policy attention is needed to ramp up existing manufacturing capacity, building supply chains, and expanding the available pool of skilled labour in parallel with boosting investment.

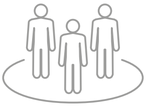
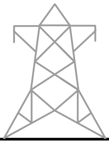
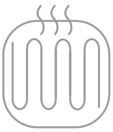
To foster a just transition, labour and social protection policies must be tailored to the specific needs of each region and country. Labour-market interventions can include employment services (matching jobs with qualified applicants; facilitating on- and off-job training; and providing safety nets), along with relocation grants and other measures to facilitate labour mobility where necessary. Programmes could also support the retention of fossil-fuel workers whose skills can be reoriented for the energy transition. Social equity considerations, in particular gender aspects, must be integrated into policy and programme design, in order to fully tap societal potential and to ensure that no one is left behind.

To ultimately succeed, the Agenda for Resilience, Development and Equality calls for full adherence to the principles of sustainability and human solidarity. Economic stimulus plans should be consistent with the 2030 Agenda on the SDGs, the Paris Agreement on Climate Change, and plans for their implementation such as those outlined in the Addis Ababa Action Agenda on financing for development. Short-term and longer-term opportunities can be sequenced, aiming to cascade investment flows into key areas. Beyond renewables and decarbonisation, investments in the energy system in the wake of the COVID-19 pandemic can pave the way for equitable, inclusive and resilient economies.

The table that follows outlines:

- *Short-term measures to stimulate recovery and accelerate the energy transition*
- *Measures to advance the transition through 2030 and beyond*

Table E.1 Short- and medium-term energy transition measures

	SHORT-TERM MEASURES TO STIMULATE RECOVERY AND ACCELERATE THE ENERGY TRANSITION
AMBITION	• Adopt ambitious renewable energy targets in the next round of NDCs in line with energy transition plans. • Set and align renewable energy targets in all end uses (electricity, heating and cooling, transport), related infrastructure and energy efficiency.
PUBLIC INTERVENTION 	• Provide risk-mitigation instruments (*e.g.*, guarantees) to mobilise private capital. • Shift public finance away from fossil fuels and towards energy transition-related investment. • Make energy industry bailouts conditional on meeting renewable energy targets. • Make financial support to carbon-intensive companies conditional on measurable climate action. • Implement carbon pricing to avoid distorted economic uptake as the pandemic recedes. • Mobilise public finance to trigger investment in enabling infrastructure for renewables (*e.g.*, smart grids, EV charging stations).
INVESTMENT **Power Sector** 	• Safeguard renewable energy projects facing construction delays: - Extend deadlines, waive penalties, and facilitate agreements with off-takers. - Speed up authorisation and permitting procedures. • Maintain investments in planned projects: - Reassure market players about commitments to existing plans. - Assert commitments to procurement plans and communicate revised plans with transparency. - Mitigate risks (e.g., curtailment, currency exchange) and allocate them more evenly between relevant parties.
INVESTMENT **Heating and Cooling** 	• Trigger transition-related heating and cooling investment: - Adopt ambitious targets and mandates in buildings and industry, together with financial and fiscal incentives to support the uptake of renewable/efficient solutions (e.g., heat pumps). - Tie stimulus packages to decarbonisation requirements (e.g., building codes for new construction and renovation).

MEASURES TO ADVANCE THE TRANSITION THROUGH 2030 AND BEYOND	
• Support NDC implementation via energy transition-related plans. • Support implementation of national energy transition-related targets.	**AMBITION**
• Set up comprehensive, supportive and clear policy frameworks to attract energy transition-related investment. • Create pipelines of bankable renewable energy projects. • Establish sustainability requirements for investors (*e.g.*, climate-risk analysis and disclosure). • Review investment restrictions and sustainability mandates for institutional investors. • Adopt standards for green bonds in line with global climate objectives. • Provide seed capital and capacity building to promote greater use of green bonds.	**PUBLIC INTERVENTION**
• Scale up power transition-related investment: - Fast track licensing, customised loans, long-term PPAs resulting from auctions for power plants. - Develop flexibility options, including grids and pumped hydro, through centralised planning, fast tracked licensing, and customised loans. - Introduce financial incentives for smart meters, batteries and other storage technologies. - Redesign the power market to provide stable long-term signals to renewable power generators while rewarding short-term flexibility. - Enhance cross-border electricity trading. - Expand R&D and provide subsidies and grants for emerging renewable electricity technologies.	**INVESTMENT** **Power Sector**
• Scale up transition-related heating and cooling investment: - Introduce renewable energy quotas and mandates for centralised heat (e.g., in district heating and cooling and green gas) and decentralised solutions (e.g., heat pumps) through, for example, building codes. - Provide financial incentives (e.g., grants or tax credits) to subsidise the higher capital costs of renewable heat options in buildings and industry. - Invest in innovation, R&D and demonstration projects to support less mature technologies (e.g., green hydrogen).	**INVESTMENT** **Heating and Cooling**

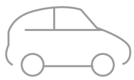
Table ES.1 (continued)

	SHORT-TERM MEASURES TO STIMULATE RECOVERY AND ACCELERATE THE ENERGY TRANSITION
INVESTMENT **Transport**	• Trigger transition-related transport investment: - Adopt ambitious targets and mandates in transport, together with financial and fiscal incentives to support uptake of renewable solutions (e.g., EVs). - Tie stimulus packages to decarbonisation requirements (e.g., collecting airline passenger taxes for cleaner transport). - Promote behavioural changes and curtail non-essential travel. - Adopt post-pandemic urban designs favourable for cyclists and pedestrians.
EMPLOYMENT	• Protect existing jobs and support new job creation: - Introduce social protection measures for workers affected by COVID-19. - Create employment benefits by investing in distributed generation. - Create new job opportunities by leveraging local capacity along the value chains of energy transition technologies. - Offer reskilling for workers who have lost or are at risk of losing employment, including fossil fuel workers. - Match skills demand and supply through active labour market policies.
INDUSTRY	• Diversify supply chains: - Reduce entry barriers for local firms seeking access to value chains. - Develop productive capabilities to feed into renewable energy supply chains. - Promote the shift to regional value chains to foster global resilience to exogenous shocks.
ACCESS	• Ensure reliable energy access amid disruptions: - Deploy distributed renewable energy solutions to support COVID-19 responses and strengthen health, sanitation and other critical infrastructure. - Engage cross-sector partnerships to mobilise rapid responses. - Ensure that vulnerable populations continue using modern decentralised solutions (e.g., with relief measures to energy providers to defer or restructure payments) rather than reverting traditional fuel use due to income shocks. - Meet the immediate financing needs of distributed energy enterprises for bridge loans, operating capital and grants. - Address logistical challenges faced by suppliers to service off-grid areas. - Mainstream gender in COVID-19 support programmes.

MEASURES TO ADVANCE THE TRANSITION THROUGH 2030 AND BEYOND

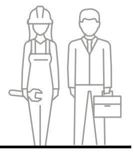
INVESTMENT
Transport

- Scale up transition-related transport investment:
  - Provide financial or fiscal incentives for the purchase of EVs, fuel-efficient vehicles and advanced biofuel use for aviation and shipping.
  - Introduce labelling, minimum standards for energy efficiency and emissions, and bonuses for cars exceeding standards.
  - Introduce blending mandates for ethanol and biodiesel, and offer customised loans for biofuel production.
  - Invest in innovation and R&D to support less mature solutions (e.g., hydrogen).



EMPLOYMENT

- Support the expansion of the workforce in energy transition-related fields:
  - Identify the occupations required and leverage existing skills.
  - Develop training and education programmes to minimise skills gaps and co-ordinate educational offerings with industry needs.
  - Support the integration of renewable energy and climate topics into all-level educational curricula for relevant technical and non-technical disciplines.
  - Provide financial support to enhance the quality of training by technical and vocational institutions.

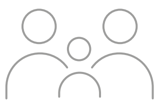


INDUSTRY

- Develop local industries:
  - Impose strict performance requirements on local suppliers in exchange for government support (e.g., subsidies and tax breaks).
  - Establish green financing programmes under national development banks to improve access to finance for industrial activities.
  - Set up supplier development programmes to promote learning-by-doing for local suppliers.
  - Establish industry clusters for energy transition-related technologies.

ACCESS

- Ensure universal energy access:
  - Allocate funding in national budgets for electrification and clean cooking, complemented by development finance.
  - Capitalise dedicated funding facilities to deliver financing tailored to utilities, enterprises and consumers.
  - Ensure that scarce public financing helps to mobilise private capital.
  - Build capacity in local financial institutions to expand financing for energy access and associated productive activities.
  - Support distributed energy-for-livelihood applications by identifying cross-sector opportunities.
  - Develop dedicated programmes to ensure modern energy access in schools, health care facilities and community centres.



INTRODUCTION

The COVID-19 pandemic has devastated people's lives around the world. On top of the tragic death toll, widespread lockdown measures have thrown the global economy into a severe crisis – one set to become the worst recession since the Great Depression of the 1930s.

The need to lock down economies to combat the virus has severely affected multiple sectors, caused massive job losses in many countries and slashed incomes and economic prospects around the world. Demand has tumbled in energy markets, to varying degrees, precipitating the steepest drop in oil prices in two decades. While some developments of recent months may prove temporary, the world after COVID-19 will clearly be different.

Shutting down large parts of the economy has led to significant, temporary, cuts in greenhouse-gas emissions, with global industrial emissions in 2020 expected to show their largest annual drop since the Second World War. However, if anything, this just serves to highlight how little progress in decarbonisation the world is making. Changes in production as well as consumer behaviour before this crisis, although notable, led to only a fraction of the reduction in emissions needed to meet key climate goals. Nor has the current reduction in economic activity put the world on track – specifically to keep the rise in average global temperature to within 1.5°C above pre-industrial levels.

INTRO

Yet the current period may contribute to a heightened understanding of what needs to be done next, underlining the urgent necessity of creating resilient economies and societies. Going forward, the world needs a fundamentally different energy system, fuelled primarily by renewable sources. Building such as system is technically viable and economically desirable.

Now is the time to reimagine the future, so that the economic recovery drives an acceleration in the decarbonisation of our societies. It can do so while also reducing some of the increasing inequalities driven by continued fossil fuel use (*e.g.*, health costs from local pollution disproportionately on the less well off). The health crisis has provided insights into the consequences of the climate crisis. The impacts of COVID-19 and climate change both know no borders; both put the poor and vulnerable at greater risk than the wealthy; and both demand government action on an unprecedented scale. Yet the response has also shown the feasibility of conducting, within a few weeks and at a global scale, decisive interventions to safeguard the public interest. Actions to accelerate the energy transition, however, offer the critical benefit of enhancing economic performance.

Policy makers now have a unique chance – to align short-term investments, regulations and policies with the long-term need for decarbonised economies and societies. By placing energy transitions at the centre of national recovery plans, governments can alleviate the current economic downturn and simultaneously tackle the climate crisis.

The Post-COVID recovery: An agenda for resilience, development and equality analyses the impacts of the pandemic and outlines holistic recovery options based on scaling up energy transition technologies. It outlines investment opportunities, along with policies and programmes for job creation, industrial development and energy access that could form the core of national stimulus policies. The analysis draws extensively on the recent *Global Renewables Outlook*, released by the International Renewable Energy Agency (IRENA) in April 2020.

The present report includes three main parts, examining different challenges and timeframes for the climate-aligned post-COVID recovery. **PART I** traces the effects of the pandemic in the broader economy, the energy sector and renewable energy. **PART II** outlines how medium-term investments in the decade to 2030, as outlined in the *Global Renewables Outlook* and consistent with the Paris Agreement, could form the basis for a plan to address both the economic damage of COVID-19 and the climate crisis in a holistic way.

PART III then zooms in on the immediate future and maps out in detail a possible short-term (2021-2023) recovery plan. This includes recommendations on investments and policies to create jobs and stimulate the private sector in line with the paradigm shift outlined in the *Global Renewables Outlook*. The report concludes with an overview of holistic policy-making and investment priorities, whereby the energy transition can help to create resilient and equitable economies and societies.

PART I

COVID-19 AND ITS IMPACT ON THE GLOBAL ENERGY LANDSCAPE

PART I

Because of the lockdowns needed to slow the spread of the virus, the COVID-19 pandemic has disrupted production and supply chains and slashed the demand for a wide range of goods and services around the world. This, in turn, has caused contractions in economic activity and depressing many commodity prices. Hundreds of millions of people have either lost their jobs or seen their live lihoods put at risk.[1]

With lockdowns, spending on leisure activities, restaurant dining, flights and other activities has plummeted. Consumers have stopped spending on many non-essential goods and services, while job or income losses have constrained even essential purchases for many. Businesses have delayed new investment, and economic activity in many sectors has been reduced or has slowed down severely.

This part of the report reviews the pandemic's impact on the global economy, on the energy sector and on renewable energy – all with a principal focus on employment.

01 | THE GLOBAL ECONOMY

Projections of the pandemic's impact on GDP vary widely, depending on assumptions about how long national shutdowns remain in effect, how far demand for goods and services falls, what and how fast fiscal and monetary policy support takes effect.[2] For example:

- The International Monetary Fund (IMF) in April predicted that global gross domestic product (GDP) would contract by 3% this year, triggering the most severe recession since the Great Depression.[3] However, more recent estimates from the World Bank suggest a contraction of 5%.[4]
- Cambridge Econometrics sees the pandemic reducing global GDP by 5–6% in 2020, depending on the effectiveness of government interventions.[5] The hardest-hit sectors would include transport, travel and retail, all of which are large consumers of energy.
- The Organisation for Economic Co-operation and Development (OECD) estimates a global GDP decline by 7.6% if a second outbreak occurs towards the end of 2020 and a 6% decrease if the second outbreak is avoided. Only in the second case would GDP almost regained its pre-crisis level at the end of 2021. Worst affected economies could contract by as much as 11-12% in 2020 and 13-14% in the two cases, respectively). Even so, the equivalent of at least five years of per capita real income growth could be lost by 2021.[6]

Asia-Pacific economies may do better, as a whole, than those in other parts of the world. Even so, the IMF expects zero growth there in 2020, the region's worst performance in almost 60 years.[7] China's economy contracted 6.8% in the first quarter.[8]

Elsewhere, GDP in the United States fell 5% year-on-year in the first quarter,[9] while the Federal Reserve Bank of Atlanta has estimated a 48.5% decline in the second quarter.[10] The European Union's GDP is expected to shrink 7.4% for the year.[11] The Latin American regional GDP could shrink 7.2%, the worst annual result in half a century. Sub-Saharan African GDP is expected to contract by 2.8% and Middle East and North Africa by 4.2%.[12]

Foreign direct investment, meanwhile, could decline by up to 40% globally in 2020, amid supply restrictions, demand shocks and slipping investor confidence.[13] Global trade values have fallen by about 3% in the first quarter, with this trend set to reach 27% in the second quarter.[14]

The crisis is bringing to the fore the weaknesses of complex global supply chains based on lean manufacturing.[15] Supply chain disruptions have reduced the availability of raw materials, intermediate goods and final products almost everywhere.[16] Some 436 million enterprises in the hardest-hit sectors face risks of serious disruption.[17]

Small and vulnerable economies will be hit harder in the long run, as the crisis compounds existing economic and social vulnerabilities and undoes years of progress in curbing global poverty. The number of people subsisting on less than USD 1.9 a day – which fell from 36% of the world's population in 1990 to just 10% by 2015 – is set to rise again for the first time since 1998.[18]

The outbreak could push between 40 million and 60 million people into extreme poverty, with sub-Saharan Africa bearing the brunt, according to the World Bank.[19] Acute hunger could double by the end of 2020, with the first month of the crisis alone cutting the incomes of informal workers by an estimated 60% globally. Remittances from migrant workers could drop 20% in 2020.[20]

Women are likely to be the hardest hit financially. They make up 70% of health workers globally and provide 75% of unpaid care, looking after children, the sick and the elderly. Women are also more likely to be employed in poorly paid, precarious jobs entailing higher virus exposure and health risk.[21]

Sharply reduced economic activity translates into job losses. Global working hours declined by an estimated 4.5% in the first quarter of 2020, equivalent to 130 million full-time jobs. By the secondquarter, the impact climbed to a 10.7% loss, equivalent to 305 million full-time jobs.[22]

China reported roughly 5 million job losses in the first two months of 2020.[23] Europe's five largest economies (France, Germany, Italy, Spain, and the United Kingdom) saw more than 30 million workers, or almost a fifth of the workforce, apply for government-supported short-term leave programmes.[24] In the United States, with a workforce of 156 million, more than 40 million unemployment claims were filed between mid-March and late-May.[25] The numbers appear similarly dire for India, Japan, Russia and Latin America.

People in precarious jobs or without access to social safety nets are the hardest hit everywhere. Some 1.6 billion informal workers, or 80% of the planet's total, have been let go, either amid closures in hard-hit sectors or simply due to lockdown constraints.[26]

02 | THE ENERGY SECTOR

As response measures took centre stage in many parts of the world, the impact of the economic slump started hitting the energy sector hard. By mid-April 2020, weekly energy demand had fallen 25% for countries in complete lockdown and 18% for those in partial lockdown.[27] Energy needs for transport plunged. Global energy demand could contract some 6% for the year, over seven times more than in the 2008-09 financial crisis.

Fossil fuels have taken the brunt of the demand reduction in transport and industry. Oil and coal use could fall by 8-9% in 2020.[28] Coal use, driven mainly by trends in China, was down nearly 8% in the first quarter, year on year. Oil consumption fell about 5%, amid 50–60% less ground and air travel compared to 2019 levels.

The drop in crude oil prices in April was the largest since 2002. Amid weakening demand, Brent crude prices fell to an 18-year low of USD 19/barrel in April 2020,[29] in the United States crumbling demand and storage constraints even resulted in a negative U.S. oil price for the first time in history as forward contracts came due.[30]

The effects of the crisis on the energy sector over the longer term remains to be seen. Governments could face pressure to bail out fossil-fuel companies and relax environmental standards, which could also slow advances in fuel efficiency for cars.[31] Countries not firmly committed to scaling up renewable energy may be tempted to take advantage of low-cost oil in end-uses such as transportation and heating and cooling.

Others suggest that 2019 could well turn out to be the peak year for oil consumption, as efficiency gains, inroads made by electric vehicles, and behavioural changes (*e.g.*, reduced air travel) continue pushing down demand.[32] The growing practice of working from home and expectations from citizens of cleaner air could also prove to be game changers.[33]

As a positive side-effect of the lockdown, carbon dioxide (CO_2) emissions growth is likely to have stopped and turned negative for 2020. Daily emissions worldwide in the first week of April were 17% lower than a year earlier. The International Energy Agency expects global industrial emissions to fall about 8% compared to 2019, their largest annual drop since the Second World War. The European Union's daily energy-related CO_2 emissions for transportation fell a staggering 88% in early April relative to pre-crisis levels, while its emissions across the energy sector were down 40% and those for the whole economy 58%.[34]

The oil and gas industry also slipped into the doldrums because of massive overproduction of oil before the onset of the pandemic. Rystad Energy (2020) projects that 21% of jobs in oilfield services – more than one million out of five million worldwide – are likely to be cut in 2020.[35]

Production at several North Sea oil fields in the United Kingdom has been abandoned to cut costs; new projects planned for the year have been postponed. Companies expect the crisis to result in 30 000 lost jobs, affecting 20% of the people employed directly or indirectly, in the UK oil and gas sector.[36] By late May U.S. oil production was down almost 20% from a peak of 13.2 million barrels a day in March, with about half of the cut representing shale-oil operations that had thrived on higher prices.[37] Unemployment in the mining, quarrying, and oil and gas extraction sector in the United States rose from 1.9% in January 2020 to 10.2% in April.[38]

In countries whose economies are highly dependent on the extraction and sale of oil, the impact of the pandemic reverberates far beyond the energy sector. In Nigeria, where oil revenues make up around 9% of GDP and 90% of exports, the crisis could increase unemployment – already directly affecting over 20 million people – by 25%.[39]

While the natural gas industry is less affected, the liquefied natural gas (LNG) segment is under pressure from falling prices and weak demand given that LNG is the swing supply for many netimporters of natural gas. LNG projects in North America and Australia have been delayed, while the construction workforce at LNG Canada's Kitimat site has been cut in half amid concerns about infections.[40]

The coal industry – with an oversized presence in power generation for decades in many countries – has also dipped amid the energy demand reductions and shifts triggered by the COVID-19 crisis. These changes come on top of long-standing dynamics, as renewables and natural gas continue taking larger shares of the electricity market. The shift away from coal intensified during the lockdown months, accelerating power plant closures in several countries. Coal-related power generation and employment is thus likely to continue its downward slide beyond 2020 in many markets. Lower demand for electricity, increased generation form renewables and natural gas, and declining export prospects led to the loss of 12% of US mining jobs in the first four months of 2020, even though coal mines were declared an essential business.[41] The United States is expected, for the first time in its history, to produce more electricity from renewables than from coal in 2020.[42]

In Europe, coal employment was already declining for decades due to automation, fuel switching and climate policy. Germany's largest power producer, RWE, already aimed to eliminate 6 000 jobs, nearly a third of its workforce, before the COVID-19 crisis, announcing this at the beginning of 2020 as part of a plan to exit the coal market. Of the world's 80 countries running coal-fired power plants, 19 plan a complete phaseout.[43] Worldwide, plant retirements amounting to 170 gigawatts (GW) in 2015-2019, concentrated in North America and Europe, were still surpassed by new additions, but much larger planned capacities (5 350 GW) have been cancelled.[44] The pandemic has reinforced these pressures. Sweden and Austria have closed their last coal-fired power plants this year, two years ahead of schedule in Sweden's case.

In Asia, while coal reliance remains strong, reduced power demand due to COVID-19 have led to significant overcapacity, reflected in job reductions in the sector in China and India. India's government has explicitly prioritised solar energy over coal,[45] but is also planning to provide assistance to the coal sector in its COVID-19 recovery package.[46] Prior to the pandemic, China's coal power capacity had already been capped at 1 100 GW for 2020, but utilisation rates are below 50%.[47] Yet there is pressure to allow more coal-fired power plants to be built.[48]

Apart from health and medical concerns, emergency measures in many countries initially focused on maintaining a secure energy supply, as well as extending support to energy consumers and hard-hit end-use sectors. Grid operators enhanced hygiene procedures, introduced protocols to mitigate staff absences, and adopted temporary technical measures to deal with lower demand. Many countries, aiming to safeguard basic services for affected citizens and businesses, have issued moratoria on disconnections due to unpaid bills, guaranteed utility supply for vulnerable citizens, or expanded benefits related to energy and other utilities for as long as the crisis continues. Some have reduced energy prices or frozen price increases to ensure affordability.[49]

As the pandemic continues, governments have moved on to addressing specific technical challenges and ensuring that ongoing national plans stay on track in the short- to medium-term. Several countries quickly sought to mitigate supply-chain risks for investors and developers. For example, many governments extended pre-existing deadlines for publicly funded renewable energy projects. In other cases, governments have softened force majeure provisions in existing contracts to keep renewable energy projects on track.

Energy supply companies, in parallel, saw that distress among their customers would hurt their own financial positions. In response, some governments have offered large-scale loans to utilities[50] or postponed payment deadlines for "green levies" on earlier government loans.[51] Others have taken a more targeted approach. India, for example, has asked its electricity distributors to keep paying renewable power generators,[52] despite a three-month moratorium on payments to non-renewable utilities. Interventions in the power sector have mostly sought to shield investors and developers through administrative measures rather than direct financial support.

03 | RENEWABLE ENERGY DEVELOPMENT

So far, the renewable energy sector has fared better than the rest of the energy sector. Still, the crisis has affected project schedules and industries considerably. Lockdown measures, along with dampening fuel and electricity demand, have caused delays opening new facilities or bringing new plants online. At the same time, the availability of finance has contracted and the risk appetite among investors has shrunk, affecting future investments and installations.

Yet not all effects of the economic slowdown are negative. As more governments pledge to build a better future, ambitions to decarbonise energy sector may be gaining ground. This would suggest faster deployment of renewables, both in the power sector and beyond.

The crisis has affected the ongoing global development of renewables in a variety of ways. This section examines impacts on: 1) existing and planned projects (in the power, heating and cooling, building and transportation sectors); 2) investment; 3) employment; 4) supply chains, and 5) energy access.

Climate-safe energy ambitions could rise as more governments pledge to build a better future

3.1 Impacts across the spectrum of renewables

■ Power generation

Impacts in the renewable power sector vary, with existing plants facing different challenges than projects that are still at the planning stage.

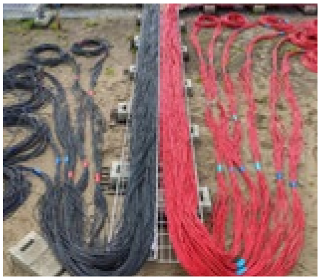
Existing plants. In several countries under lockdown, electricity demand has declined by 20% or more, given that higher residential usage is substantially outweighed by cuts in commercial and industrial demand.[53] As a result, Europe saw a record collapse in electricity prices. In Germany, the first trimester of 2020 registered 172 occurrences of negative wholesale prices, compared with 212 for the whole of 2019. In Spain, low demand led to the lowest average prices in four years. However, despite the slowdown in new capacity, renewable electricity generation is still expected to rise by nearly 5% in 2020.[54]

During the shutdown, the share of renewables in the electricity mix grew in many countries, since renewable power plants have close to zero marginal costs and thus make economic sense to be dispatched first. In, Europe, renewables' share of total power generation hit 41% in the first quarter of 2020, 16% higher than the first three months of the previous year.[55]

However, there has been some pain for renewables projects. Those operating in liberalised markets, without a price hedge are sometimes (partially) exposed to wholesale market risk and therefore were confronted with lower electricity prices. In other cases, even those with 100% price hedges in the form of power purchase agreements with fixed remuneration levels (shielding them from fluctuations in market prices) for all their output were sometimes unexpectedly curtailed – without compensation – as demand for electricity fell. In Mexico and South Africa, for example, reduction in demand was cited by authorities for curtailing variable renewable power producers.

Off-takers that assumed the burden of honouring contracts were strained, especially in countries where energy regulators and governments allowed consumers to put off paying their utility bills. Defaults on payments cascade throughout the energy sector.[56] Moreover, as distribution and transmission companies reduce their capital expenditures – delaying most initiated projects and suspending non-critical investments – the fulfilment of investment programmes may be put at risk.[57]

Planned power projects. In the power sector, some projects under development face delays, and some risk missing deadlines to qualify for support. Solar and wind power projects, as they are the most widely adopted renewable technologies, have absorbed the brunt of the pandemic's impact on the sector, primarily in the form of project delays. In India alone 3 GW of solar and wind energy projects face postponements, due to disruptions in supply chains and labour.[58]



In solar photovoltaics (PV), lockdown measures, permitting challenges, supply chain delays, the tightening of tax equity markets, and homeowners' reluctance to spend have placed pressure on the industry. Wood Mackenzie (2020) expects new capacity additions in 2020 to be about 106 GW worldwide; this is roughly on par with the 2019 level, but 18% below earlier expectations.[59] A similar degree of reduction is also expected by the International Solar Association (ISA), which lowered its initial forecast by 20%, from 130-135 GW to around 105 GW in 2020.[60]

In the United States, only 3 GW of solar capacity will likely be installed in Q2 2020 – a 37% decline from pre-COVID forecasts. The differential is equivalent to powering 288 000 homes and USD 3.2 billion in economic investment. The Solar Energy Industries Association estimated that out of a total of more than 260 000 solar jobs held in February 2020, some 72 000 had been lost by the end of May. Given that installations, and employment, had been expected to expand strongly before the onset of the pandemic, the solar job numbers in June were 114 000 lower than predicted.[61] Pandemic-related disruption also severely impacted solar installations in India. During the first three months of the year, the country added only 689 megawatts (MW) of utility scale PV, against the 1 864 MW that was scheduled to be commissioned.[62]

In China, the world's most important producer of solar technologies, solar module production declined 20-25% in January-February 2020.[63] Temporary factory closures translated into shortages of components and delays in projects in other regions. This has provoked a rethinking of just-in-time supply chains, including their centralisation in a few countries.

In the wind industry, supply chain disruptions, and restrictions on labour availability and construction activity affect primarily the onshore segment, leading analysts to revise their forecasts of global capacity additions in 2020. Wood Mackenzie, for example, estimates that global onshore wind capacity additions could be 15-20% lower than initially expected. The revised total of 66.3 GW will, however, still be somewhat higher than the 59 GW added in 2019.[64]

In the United States, 25 GW of wind projects representing USD 35 billion in investment have been put at risk, portending a potential loss of over USD 8 billion in revenues and lease payments for rural communities where projects are located, as well as the loss of over 35 000 jobs.[65]

In, France, Germany, Spain and the United Kingdom, expectations of 2020 onshore capacity additions have been reduced by around 10%. Siemens Gamesa Renewable Energy and Vestas, for example, were forced to halt production at their Spanish facilities, following a government ban on all nonessential activities.[66] The disruptions have affected revenues of some of the largest companies.

As for offshore wind, the impacts have not been significant, as most projects for 2020 and 2021 are already either partially commissioned or at an advanced stage of development, particularly in Europe, the largest offshore market. Wood Mackenzie forecasts global capacity additions in 2020 at 6.7 GW, surpassing the 2019 value.[67] However, impacts may be felt after 2021, if pre-development work, such as permitting and environmental approval, is delayed during the pandemic.

For most of the renewable energy power projects under development, delays have been the chief impact of the crisis; analysis indicates that capacity not installed in 2020 will be deferred to 2021. The delays become more problematic if projects are not built within a certain time frame and banks call for a renegotiation of terms or demand added guarantees. In China and Vietnam, delayed projects may lose their eligibility for a feed-in tariff. In the United States, projects not completed on time risked losing tax incentives. In many other countries with auctions in place, delays in project completion put developers at risk of penalties.

The situation highlights the importance of flexibility in policy implementation, as missing out on support could have implications beyond a simple deferral to 2021. Policy strategies and stimulus packages must be designed properly at the outset to ensure investor confidence in the months and years ahead.

Short-term recovery measures to address these impacts, in addition to medium-term policy measures to scale up transition-related investments in the power sector are discussed in sections 7.3 and 6.1 respectively.

Heating and cooling and transport

The impacts of the pandemic have been less pronounced outside the power sector, as renewables constitute only a small fraction of the energy mix in end-use sectors. In 2019, the share of renewables in global heat consumption (excluding the traditional uses of biomass) was less than 10%; in transport, it was just over 3%.[68] In short, the crisis has further slowed an already sluggish transition, and reaffirmed the need for more ambitious and stronger policy support to decarbonise heating and cooling through reduced fossil fuel consumption, increased energy efficiency and a switch to renewables.

In addition to low fossil fuel prices, the decarbonisation of heating and cooling has been affected by the financial situation of potential investors, reduced activity in construction and industry, and strained household and business finances. In the absence of supportive policies, some plans to switch to renewable or electric heating solutions (*e.g.*, solar water heaters or biomass boilers; heat pumps) could be postponed or cancelled. Moreover, lockdown measures and labour restrictions have caused delays in manufacturing, sales and installation of those solutions.

The ILO's Monitor on the labour impact of COVID-19 judges the impact of the crisis on activity in the construction industry (with about 33 million workers) to be of "medium" severity, compared with transport's medium-to-high ranking.[69] How the dynamics in the sector will affect opportunities for integrating renewable energy and energy efficiency solutions into buildings remains to be seen.

As personal mobility has come to a standstill in most of the world, the crisis has had significant impacts on the demand for biofuels, while the market for electric vehicles (EVs) has stalled as consumers defer large purchases. Global demand for gasoline has declined significantly, a development that by implication also limits biofuel consumption, depending on whether blending mandates are raised (as is the case, for instance, in the EU, where rising blending somewhat tempers a reduction in biodiesel demand, expected to fall by 10%).[70]

Meanwhile, the EV industry is facing interruptions in manufacturing. In China and South Korea, home to major manufacturers of EV batteries, lockdown measures significantly reduced production, affecting Nissan, Kia, BMW, Daimler, and Tesla. Most of these companies have shut down their automobile production facilities and shifted their focus to manufacturing of personal protective equipment.[71]

Lockdowns reduced sales of EVs in China by 79% in February. With 45% of the global EV fleet 2018, China is the largest market ahead of Europe (24%) and the United States (22%).[72] The slowdown depressed the stock prices of major Chinese battery and EV manufacturers.

However, when travellers return to the roads after lockdowns end, and if public transportation continues to be perceived as a health risk, more consumers may look to purchase new vehicles. With appropriate policy action, they might opt for EVs.

Short-term recovery measures to address these impacts, in addition to medium-term policy measures to scale up renewables in heating and cooling and transport are discussed in sections 7.3 and 6.1 respectively.

3.2 Investment

A transformation of the global energy system compatible with internationally agreed climate and development objectives will require a significant scale-up of energy investment. But instead of rising, renewable energy investment dropped slightly in the first quarter of 2020, down 2.6% from the same period in 2019.[73] New commitments further dropped in April and May – two-thirds lower than in the same period last year – indicating a considerable slowdown in activity in the second quarter of 2020.

The financial impact of the pandemic is even more severe in emerging markets and developing economies (EMDEs) than in developed countries. Following the onset of the crisis, increased risk aversion and a global liquidity crunch resulted in unprecedented capital outflows from EMDEs.[74] Foreign capital flows to emerging markets are forecast to decline by 53% in 2020.[75] In addition, the crisis is likely to be accompanied by a wave of credit downgrades, making it increasingly difficult for borrowers from EMDEs to access the international debt market.[76] With their reduced project financing options, EMDEs could see a decrease in new renewable energy projects.

Early data show that investments attuned to environmental, social and governance concerns are performing better and proving more resilient to the volatility caused by the COVID-19 crisis than conventional funds.[77] According to Bloomberg (2020), such funds experienced only half of the decline observed for the S&P 500, delivering better returns during the crisis.[78]

The pandemic has sharpened investors' interest in sustainable and resilient assets, including renewables. Institutional investors have been paying increasing attention to companies' environmental, social and governance practices, recognising their impact on long-term profitability and future value creation.[79] As they review their portfolio strategies, larger investment in renewable energy assets can be expected.

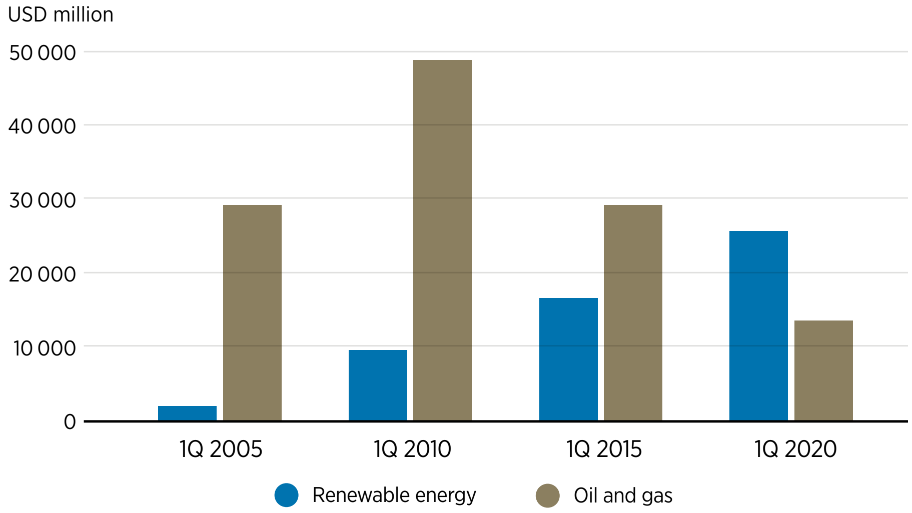
Amid the global crisis, investors are also calling for stimulus and recovery packages to be aligned with the transition to a low-carbon economy. More than 50 CEOs from the banking and insurance sectors have joined the "green recovery alliance", launched in April at the initiative of the chair of the Environment Committee of the European Parliament.[80] This announcement followed a statement signed by the seven founding partners of The Investor Agenda, including the Institutional Investor Group on

Climate Change, urging governments to align their economic response to the pandemic with the Paris Agreement.[81]

Despite the uncertainty caused by the pandemic, foreign direct investment in renewable energy reached an all-time high in the first quarter of 2020, while investments in fossil fuels plummeted. According to fDi Markets (2020), foreign investors have already announced over USD 23 billion of cross-border renewable energy investment this year, the highest quarterly performance recorded over the past decade (see Figure 3.1). Placing renewable energy at the core of green recovery plans can signal long-term public commitment to the industry, boosting investor confidence and attracting private capital.

Medium-term policy measures that aim to mobilise green investments, in addition to short-term recovery measures to ensure public finance is used strategically are discussed in sections 6.4 and 7.1 respectively.

Figure 3.1 Announced foreign direct investments in renewables and oil and gas sector, first quarter 2005 to first quarter 2020 (USD million)



Note: Renewable energy excludes hydropower.

Source: fDi Markets (2020), *Covid-19 accelerates energy investment shift to renewables*, 7 May, www.fdiintelligence.com/article/77658.

PART I

3.3 Employment

The pandemic-triggered lockdowns that have had a major impact on employment in many sectors of the economy. Within the energy sector, renewables jobs have been affected as well, but less so than fossil fuel jobs. Although the pace of new installations will be slower in 2020 than previously forecast, construction of large-scale utility projects will proceed, though with some delays.

Some job effects stem from temporary disruptions in the supply of pieces of equipment, components or raw materials, either because of factory shutdowns or border restrictions. Jobs appear less affected in operations of utility-scale wind and solar plants than in solar rooftop installation and off-grid solutions, where social distancing requirements and constrained household budgets have a significant impact.

The solar PV industry has been the largest employer among renewable energy technologies, with a third of the total renewable energy jobs in 2018.[82] In India, 70 000 people employed in solar plant construction and maintenance face uncertainties given delays of several months in project delivery.[83]

In the United States, the expected 37% decline in new solar capacity in Q2 2020, relative to pre-COVID forecasts, means there will be only 188 000 jobs by June 2020 instead of an expected 302 000.[84] More than 65 000 installer and technician jobs had been lost by mid-May.[85]

Job impacts in manufacturing have mostly been temporary, as in Bangladesh, where a 40-day industrial shutdown affected 10 000 solar workers.[86]

Renewables have weathered the crisis, so far, better than other energy industries

The COVID-19 crisis has brought severe disruptions in supply chains

In the onshore wind industry, pandemic-related disruptions stand to reduce capacity additions in 2020 from 62.5 GW to 58.4 GW, with delays more common than cancellations. Some 25 GW of projects at risk in the United States could mean the loss of over 35 000 jobs.[87] In major European markets, additions may be 10% lower than expected. Halting production of one of its turbine models, Vestas will cut 400 jobs in Denmark, around 10% of its workforce in the country.[88]

In the offshore segment, impacts have not been significant, given that most projects for 2020 and 2021 are partially commissioned or in advanced development. Impacts may be felt after 2021, as some pre-development work such as permitting and environmental approval is delayed.[89]

Jobs in the biofuel sector, accounting for up to 2.1 million worldwide in 2018, are at risk as demand for transport fuel has fallen drastically.[90] Global ethanol production could fall to 2013 levels and may not recover until 2022.[91] Sugarcane and ethanol producers in Brazil and the United States are seeking government support to stave off bankruptcy.[92] The closure of ethanol plants could have devastating ripple effects for farmers and agricultural equipment manufacturers.[93]

Short-term recovery measures to preserve livelihoods and maximise job creation, in addition to medium-term labour and educational policies are discussed in sections 7.5 and 6.3 respectively.

3.4 Supply chains

The COVID-19 crisis has brought severe disruptions to cross-border supply chains. While the renewable energy sector has generally been hit far less by the crisis than other energy sectors, factory shutdowns in China, which accounts for half of the global wind power supply chain,[94] have led to a global "ripple effect" slowing down renewable energy deployment in many parts of the world.

Similarly, the lockdown in Ecuador, which produces around 90% of global balsa supply,[95] has led to a shortage of this raw material that is a key component of many wind turbine blade cores.[96]

The crisis has affected renewable energy operations differently across segments of the value chain. Table 3.1 provides a broad characterisation of the relative magnitude of impacts in the different segments and some observations on what it means for jobs. Although the precise situation varies among countries, among individual renewables technologies, and over time, the magnitude of impact is generally seen as higher in transport of equipment, construction, and among distributed renewables projects than in project planning and in operations and maintenance.

Direct impacts on project planning are limited as staff can work remotely, but there is uncertainty surrounding the demand for new projects, component pricing, and the fate of tax credit and other incentive schemes - factors that could slow or hinder the development of new projects and have repercussions further down the supply chain. Uncertainty can lead to delays in investment and procurement. Announcements in several countries indicate the possible postponement or cancellation of renewable energy auctions in several countries but Germany and France modified tender schemes to offer greater flexibility.[97]

Manufacturing of equipment is more heavily impacted. Lockdown measures have resulted in the temporary closure of various manufacturing plants for renewable energy technologies around the world. Closures have come at different moments of

Table 3.1 COVID-19 effects on employment in segments of the renewable energy value chain

Segment of value chain	Magnitude of impact of COVID-19	Comments
Project planning	Low	Jobs in consulting, administration and research lend themselves to remote working arrangements. However, there are delays to activities that require the presence of foreign expertise as well as on-site assessments.
Manufacturing and procurement	High in short-term	Factory workers, technicians and engineers have been heavily affected.
Transport and logistics	High through medium term	Truck drivers and personnel responsible for shipping, delivery and loading have been significantly affected by a shortage of parts, social distancing measures and border controls.
Construction and installation	High	Engineers, technicians and workers have been strongly affected by shutdowns and delays in many locations. This has resulted in temporary and permanent job losses as well as slashed hours. Where countries have resumed construction and installation activities there are still limitations on the numbers of workers allowed on-site and requirements to observe stringent health protocols.
Operations and maintenance	Low	Because energy generation is an essential service, jobs in operations and maintenance have been relatively unaffected. The physical space available at wind and solar farms allows a degree of social distancing.
Distributed renewables	Very high	Job losses among rooftop solar installers and technicians are especially high owing to falling demand.
Biofuels	High	Many of the world's two million biofuels jobs are threatened by a cratering of demand caused by the pandemic and associated lockdown measures. This is true all along the biofuels value chain. Ethanol plants are facing closure in several countries,

Note: For more detail, see Annex 2: Impacts along the Renewable Energy Value Chain.

Based on IRENA literature review and adapted from SEIA, *COVID-19 Impacts on the U.S. Solar Industry*; Lavietes, M. (2020), *U.S. solar industry sheds five years of job growth amid the coronavirus, Reuters*, 19 May, www.reuters.com/article/us-healthcoronavirus-solar-trfn/u-s-solar-industry-sheds-five-years-of-job-growth-amid-the-coronavirus-idUSKBN22V059 time in different countries, rather than all at once, but along with border closures have nonetheless led to disruptions in increasingly globalised operations, especially in solar and wind. In China, factory closures in January and February led to a significant fall in solar module production, but production largely resumed in March.[98] Closures took place later elsewhere, such as in India and in parts of Europe. These challenges have given rise to calls for diversifying supply chain dependencies.

Transport and logistics are being impacted by a combination of lack of parts availability, social distancing measures and border controls. Logistics challenges associated with shipping and ground transportation can delay the timely delivery of parts in turn impeding the progress of activities further along the value chain.

Given that energy facility construction is not considered an essential activity in many countries, shutdowns and delays took place in locations heavily impacted by the virus. Small and medium enterprises (SMEs) in the solar sector are taking a hit. In the utility scale segment of the solar PV industry, the main impact on construction is one of delays in the timeline. Residential solar PV installers confront lower demand as households are faced with increasing financial challenges from job loss or uncertainty. As a result, many contractors have had to lay-off staff.

Operation and maintenance activities are relatively unaffected by the pandemic. Given that energy generation is considered essential, power plant workers are typically exempted from decrees to stay home.

Short-term recovery measures to diversify and develop supply chains, in addition to medium-term measures to develop renewable energy industries are discussed in sections 7.4 and 6.2 respectively.

Economic disruptions may slow down universal access to energy

3.5 Energy access

COVID-19 is affecting efforts to widen access to modern energy in developing countries in a variety of ways.

Most of the world's people who lack access to modern energy live in rural areas.[99] Their primary sources of income are agriculture, seasonal and migrant work, or remittances.[100] With pandemic-related disruptions in economic activity, rural populations in developing countries face an impending income shock.[101] Women are disproportionately affected by economic shutdowns, as they are more likely to be informal workers and entrepreneurs.[102] Vulnerable households whose incomes are strained are less likely to be able to pay for electricity or clean cooking services, thus risking expansion of new access and those with access falling back into energy poverty.

This will have a strong impact on the revenues of off-grid enterprises such as stand-alone solar system companies and mini-grid utilities.[103] A recent survey of over 80 such companies worldwide revealed that respondents expect to lose between 27% and 40% of their revenues in the coming months because of the crisis.[104]

Providing access to energy requires high capital investment. Even as global investment in energy access has been far-less than needed, the COVID-19 crisis has raised concerns over future financing in electricity and clean cooking. The crisis is already placing utilities and off-grid enterprises in financial duress. The cash positions of off-grid companies are extremely tight, with approximately 70% of companies having no more than two months of operating capital available.[105]

The off-grid supply chain has been affected at multiple levels. Shutdowns of ports and flights in many countries will mean that imported batteries, solar panels, inverters, and smart meters will not be as readily available as they had been. Even internally, movement restrictions have slowed servicing of existing customers in rural areas and delivery of projects.

Existing energy access programmes and initiatives may also experience delays in implementation because of the pandemic. As of 2019, over 4 000 mini grids were scheduled for development across Africa.[106]

Similar initiatives led by the private sector or by communities may face similar delays, if not cancellation. With hundreds of millions of people relying on off-grid solutions to meet their modern energy needs, urgent efforts will be needed to keep the lights on.

Short-term recovery measures to safeguard reliable energy access amid disruptions, in addition to medium-term measures to ensure universal access to energy are discussed in sections 7.6 and 6.5 respectively.

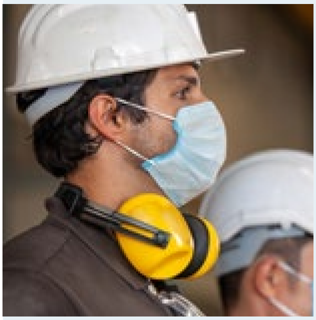
PART II

INVESTMENT AGENDA FOR 2030

Unprecedented government intervention has played a critical role in confronting the health crisis and related economic downturn. The shock of the pandemic has necessitated a kick-start, providing a rare and timely opportunity for structural changes that emphasise sustainability and deliver benefits with minimal negative effects. Governments must ensure that their recovery plans are sustainable, so that investments made now in people and infrastructure have longevity.

IRENA's *Global Renewables Outlook (GRO): Energy Transition 2050* presents ambitious but realistic global pathways to a future that is consistent with the goals of the 2015 Paris Agreement on Climate Change. Under the report's Transforming Energy Scenario, in which the rise in global temperatures is kept to well below 2°C, the goal is achieved by cutting 70% of the world's energy-related carbon dioxide emissions. The report also offers a "deeper decarbonisation perspective," with options to reduce energy-related carbon dioxide emissions to zero.

At a time when significant public and private investment is needed to aid economic recovery, IRENA's outlook offers 2.4% higher GDP growth than current plans through 2050. The cumulative gains between now and 2050 amount to



USD 98 trillion; a return of USD 3-8 for every dollar spent. There could be 100 million jobs in the energy sector globally by 2050; about 40 million more than today. This includes up to 42 million jobs in the renewable energy sector, compared to just over 11 million in 2018. The transition would result in 7 million more jobs economy-wide than under current plans.

The decade requires focused planning and an ambitious investment path

Recognising that pathways are varied, the *Global Renewables Outlook* scrutinises the needs of regions and emphasises the need for a holistic view of economic, environmental and societal considerations. Under any of the transition pathways laid out in the report, all would lead to cleaner living conditions, particularly improved air quality, and global welfare gains estimated at 13.5% by 2050.

The present report provides policy makers, as a medium-term perspective, a ten-year time horizon to set out where we need to be in 2030, in line with the path outlined in the *Global Renewables Outlook* and so with the Paris Agreement. This timeframe is also decisive for the achievement of the *2030 Agenda for Sustainable Development*. While it is too early to tell how quickly economies around the world will revive after the COVID-19 freeze, a decade appears sufficiently long for an ambitious investment path to unfold. At the same time, a decade is sufficiently near-term to permit focused planning.

The Transforming Energy Scenario set out in the *Global Renewables Outlook* requires significant investment. As argued below, that investment will generate substantial savings and help cushion the negative economic impacts of COVID-19. The key to achieving these powerful synergies is to harmonise short-term needs with medium- and long-term transition requirements and to move toward structures that increase socioeconomic resilience.

This part of the report starts by presenting the transformation pathways and technological choices laid out in the 2030 Transforming Energy Scenario. It then discusses medium-term investment opportunities by sector and technology. The analysis confirms significant job benefits and an additional boost in GDP - an outcome whose importance is pivotal in the current circumstance of layoffs and furloughs. The section concludes with a set of medium-term policy measures for the next decade that can help governments be where they need to be in 2030 to meet climate and sustainable development goals.

PART II

04 | INVESTMENTS TO ACCELERATE THE ENERGY TRANSITION

The Transforming Energy Scenario would reduce CO_2 emissions to levels consistent with global climate and energy objectives. But realising that goal will require a profound transition of energy supply and demand.

Scaling up electricity from renewables is a prerequisite for decarbonising the world's energy system. Under the Transforming Energy Scenario, renewables would provide 57% of global power generation by 2030, up from 25% in 2017 (and an expected 30% in 2020). Wind and solar PV would dominate, both in electricity generation and capacity additions, with one-third of the world's electricity coming from solar and wind power by 2030. With respect to end-use sectors (and including the share of renewables in upstream electricity and heat generation for consumption in end-use sectors), the buildings sector would show the highest share of renewable energy by 2030 (40%, with all traditional uses of biofuels phased out) (see Table 4.1). The next-highest renewables share would be in industry (including blast furnaces and coke ovens), where renewables would reach a 29% share by 2030. Transportation would have the lowest share but the greatest growth, climbing from 3% in 2017 to 16% of the sector's final energy consumption by 2030.[107] With such measures, the global energy system would be set on the climate-safe path envisaged in the *Global Renewables Outlook*.

To achieve climate objectives, the energy transition requires a substantial acceleration in three areas: 1) growth in renewables-fuelled power generation; 2) electrification of end-use sectors; and 3) improvements in energy efficiency. The share of renewables in total final energy use (considering the combined effect of renewables deployment, demand evolution and energy efficiency improvements) would have to grow at a rate of 1.2% per year, a five-fold increase from the 0.25% rate that can be achieved under the policies currently in place or under consideration.[108] This would yield a 28-29% global renewable energy share by 2030 (Table 4.1).

The recovery packages now being planned or implemented provide an opportunity to achieve the needed acceleration. In 2019, around USD 825 billion was invested in the renewables and transition-related technologies.

From the USD 300 billion invested in renewables, USD 253 billion went to power and the rest to direct-uses such as solar thermal, biofuels, electric vehicles charging infrastructure, heat pumps, etc., USD 249 billion to energy efficiency; and around USD 275 billion investment in grids and storage.[109] A fivefold increase from the recent growth rate to the necessary one implies investments on the order of USD trillions of dollars each year.

Table 4.1 Shares of emissions and use of renewables, by sector, 2017 and 2030

	Energy-related CO_2 emissions		Renewables share, by sector	
	2017	Transforming Energy Scenario 2030	2017	Transforming Energy Scenario 2030
	GT CO_2		in %	
Total	**32.6**	**24.9**	13% (TPES) 17% (TFEC)	29% (TPES) 28% (TFEC)
Power	13.4	6.4	25%	57%
District heat		1.6	8%	35%
Industry	6.17	6.5	13%	29%
Transport	8.04	6	3%	16%
Buildings/ other	2.9	2.1	35%	40%

Based on IRENA (2020), *Global Renewables Outlook: Energy Transformation 2050*.

Note: The renewables share in end-use sectors takes into account renewable heat and power supply.
TPES = total primary energy supply; TFEC = total final energy consumption.

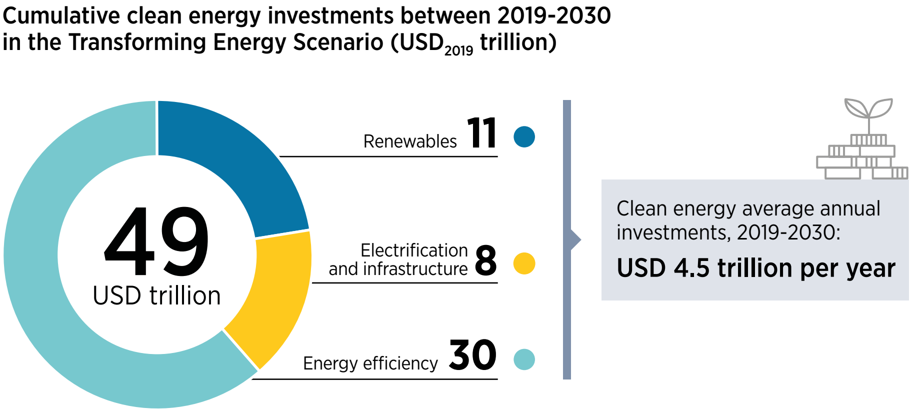
4.1 Renewables and efficiency as key investment focus

Investments in the energy transition can be an attractive part of a recovery package. They can boost the economy over the next three years and beyond, while creating good jobs in a wide range of professions. Investments can be scaled up rapidly in several areas, accelerating the recovery. Short-term and longer-term opportunities can be sequenced with an eye to cascading investment flows into the areas needed for the transition to succeed. Recovery programmes also offer opportunities to take a comprehensive approach that will ensure that supply chains, enabling infrastructure and skills are in place when certain investments are made. Such a holistic approach would allow governments to tailor investment to meet a range of domestic policy agendas.

The Transforming Energy Scenario suggests that cumulative energy sector investment in renewable energy and energy efficiency must rise to USD 49 trillion between now and 2030.[110] The simple average therefore represents annual investments of around USD 4.5 trillion per year in climate friendly investment in renewable energy, energy efficiency and low-carbon facilitating technologies over the period to 2030 – including enabling infrastructure such as power grids and storage (see Figure 4.1). This is more than five times greater than the amount USD 825 billion invested in 2019 in renewable energy technologies, energy efficiency and power grids, including storage.[111]

This will mean a change in the amount as well as the type of investment needs, as investments in the energy transition, enabling infrastructure and energy efficiency rise, while those in fossil fuel supply decrease.

Figure 4.1 Energy transition investment under the Transforming Energy Scenario, 2019-2030



Based on IRENA (2020), *Global Renewables Outlook: Energy Transformation 2050*.

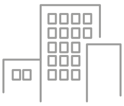
Note: "Electrification and infrastructure" includes investment in power grids, energy flexibility, electrification of heat and transport applications, and renewable hydrogen. "Energy efficiency" includes efficiency measures deployed in enduse sectors (industry, buildings and transport) and investments needed for building renovations and structural changes (excluding a modal shift in transport). "Renewables" include investments needed for deployment of renewable technologies for power generation as well as direct end-use applications (*e.g.*, solar thermal, geothermal). The investments are estimated considering historical levels of investment and needed cumulative investment from 2020 to 2030 to align ith the Transforming Energy Scenario 2030 outlook presented in IRENA's Global Renewables Outlook. The investment excludes the supply chain investments for electric vehicles and battery factories.

4.2 Investment opportunities by sector and technology

In the context of the post-COVID recovery, the energy transformation pathway provides a clear direction for targeting investment over the next decade. A renewables-based energy system, supplemented by measures to promote energy efficiency and energy flexibility, has the potential to create significantly more socio-economic benefits than the current fossil-fuel based energy system.

This section explores the relative weight of investments in various technologies and sectors, as well as their regional importance, and suggests how energy transition investments might figure in stimulus packages.

Table 4.2 breaks down the required global investment in renewable energy and energy efficiency into its main components. The annual sum of USD 4 486 billion between 2019 and 2030 would be equal to nearly 5.4% of global estimated 2019 GDP.



The **buildings sector** requires investment in a wide range of renewable and energy efficiency technologies. The solutions are varied, from LED lamps to more efficient appliances, and from efficiency-oriented retrofits of building shells to heat pumps and smart home systems.

The USD 2.2 trillion per year of investment needed in the buildings sector is dominated by energy efficiency investment (USD 2.1 trillion), the remainder being in heat pumps and use of other renewables, mostly solar thermal. Box 4.1 discusses the investment needs for building renovation in Europe. Overall, the buildings sector represents almost half (49%) of the total investment required for the energy transition.

Table 4.2 Energy transition investment under the Transforming Energy Scenario, annual averages, 2019-2030

		Average annual investments	
		USD billion/yr	Shares of total
		2019–2030	
Power	Generation capacity	851	19%
	Power grids and storage	334	7%
End uses and district heat	Buildings	2 187	49%
	District heat	18	0.4%
	Industry	423	9%
	Transport	652	15%
	Electrolysers	20	0,4%
Total clean energy	**Total**	**4 486**	

Based on IRENA (2020), *Global Renewables Outlook: Energy Transformation 2050.*

Box 4.1 Investment needs for building renovation in Europe

The energy renovation rate of the building stock in the European Union and the United Kingdom is not yet at the level needed to achieve a climate-neutral building stock by 2050, either in terms of speed or structure and investment levels.

For residential buildings in the EU-27 and the United Kingdom, the average energy renovation rate, which is the sum of all types of energy renovation from "below threshold" to "deep renovation," was around 12% for the period 2012-2016. The same rate for non-residential buildings was around 10%. The annual weighted energy renovation rate was about 1%. for both groups.

More than 90% of residential energy renovations are done in combination with non-energy renovation measures. The average of all energy renovations yielded annual primary energy savings of just 9%, "one-off" deep renovations occur only occasionally. These yield 66% savings, on average.

Within the EU-27 and the United Kingdom, heating savings from energy efficiency measures yielded a 1% primary energy reduction per year considering all energy uses covered by the Energy Performance of Buildings Directive. Light and moderate renovations contributed the bulk of savings during that period.

For the total building stock, for the period 2012-2016, annual investments in energy renovation amounted to EUR 280 billion. More than EUR 200 billion were spent each year for energy renovations in residential buildings and more than EUR 73 billion per year in non-residential buildings. The average annual energy renovation investment stayed constant during this period.

To achieve a decarbonised building stock by 2050, renovation activities would have to grow considerably from present levels. To close to triple the current weighted energy renovation rate would require energy renovation investments on the order of EUR 800 billion.

With respect to employment, the number of full-time equivalent employees engaged in renovating residential buildings (energy and non-energy) is estimated to be about 4.6 million. The same number for non-residential buildings is about 1.9 million. These numbers give a sense of the additional employees who would be needed if the pace and depth of energy renovations were to increase significantly in the next few years. Additional spill-over effects would be generated amongst manufacturers.

Source: European Commission (2019), *Comprehensive study of building energy renovation activities and the uptake of nearly zero-energy buildings in the EU*, www.ec.europa.eu/energy/sites/ener/files/documents/1.final_report.pdf.

USD 49 trillion should be invested in renewables and efficiency over the decade until 2030

Accelerated investment in the **power sector** of USD 1.2 billion would account for 26% of the total needed. Investments can be directed toward additional renewable power generation capacity, grid extension and resiliency, and other grid flexibility measures (from better renewable power generation forecasting to integrating demand-side flexibility and stationary battery storage). Key generation technologies are solar PV (rooftop and utility scale), with annual average investment needs of USD 318 billion per year to 2030; onshore wind with USD 273 billion per year; and power grids including smart meters, close to USD 300 billion.

Off-grid renewable energy solutions, which have long been rapidly deployable and reliable, are also becoming the most economical option to widen access to energy. 2018 was a record year for the off-grid energy access sector, with total annual investment of more than USD 511 million. Average equity investment doubled, and debt increased nearly 5.5-fold compared with previous years. By the end of 2018, cumulative investments added up to almost USD 1.7 billion since 2007.[112] Despite progress over the past decade, the world will fall short of ensuring universal access to affordable, reliable and clean energy by 2030 unless efforts are scaled up significantly. *Tracking SDG-7: The Energy Progress Report*[113] shows that electricity and clean cooking fuels require around USD 45 billion per year between 2019 and 2030, USD 40 billion of which is needed to attain universal access to electricity and USD 5 billion for clean cooking technologies.

Transport investments would rise to USD 652 billion per year (15% of total transition-related investment), excluding the incremental costs of electric vehicles (EVs). Energy efficiency would account for almost half of the total (47%). Charging infrastructure would represent 40% and biofuel supply 13%. With the full cost of EV batteries taken into account, the investment requirement would increase by USD 306 billion (Box 4.2).

Box 4.2 Investment opportunities in the electric vehicle supply chain

Today around 8 million electric vehicles (EVs) are in use worldwide – around 1% of all vehicles on the road. The share of EVs in new vehicle sales is higher, at around 3%. Rapid growth is foreseen in the coming years. The IRENA Transforming Energy Scenario foresees a stock of close to 380 million electric cars by 2030. That implies average sales of close to 34 million units per year, a fifteen-fold increase. Substantial investment is needed in several parts of the value chain if sales are to ramp up to that level, and those investments could have strong stimulus effects.

One of the challenges is that the upfront investment cost of EVs is still higher than for vehicles with internal combustion engines. The cost of electric vehicles is determined by the battery cost (about half of the total vehicle cost). A 60 kWh battery, fairly typical for new passenger vehicles, costs USD 9 000. Sales of close to 34 million vehicles per year until 2030, would require an investment of around USD 303 billion per year into batteries alone. Government subsidies can help to overcome the initial investment barrier and so increase sales over the next few years and help battery cost continue to fall.

Battery manufacturing capacity needs to grow substantially from the 300 GWh in place or under construction today to 2 023 GWh, close to a seven-fold increase. Battery factories will require an annual investment of USD 120 million per GWh, implying a total new investment in battery production of USD 207 billion These investments must occur before car sales can increase, so they are needed in the next five years.

The implications for mining and mineral supply chains require attention, too. Mining investment will be limited to those countries that have the natural resources, but the need for the resources is global and growing.

Lastly, new charging infrastructure will be needed. Thirty-seven million public charging stations will be needed over the period to 2030, supplemented by 250 to 500 million private charging stations. The associated investment needed in the coming decade is in the range of USD 0.9-2.4 trillion, with the majority for private charging stations.

Local grid reinforcements may be needed in some neighborhoods with large numbers of electric vehicles. While grid issues are likely to be some years away, the grids will have to be reinforced ahead of time to ensure smooth operation.

In the short-term to 2023, an estimate of annual investments of USD 100 billion on top of the investments in charging infrastructure and grid reinforcement mentioned above could be feasible and scaled up further from the second half of the decade to meet the energy transition needs in mobility sector. The sector as such is a job-intensive industry of the future that requires government intervention to become profitable and economically viable.

Source: Fitzgerald, B. (2019), *EV's will make nickel a once-in-a-generation investment opportunity, says BHP*, Live Wire, 16 August; McKinsey (2019), Recharging economies: The EV-battery manufacturing outlook for Europe, McKinsey, 3 June.

Industry sector investments would rise to USD 423 billion per year, 9% of the total, with the largest amount (USD 357 billion) going for energy efficiency measures (*e.g.*, more efficient electric motor systems and measures to reduce requirements for process heat and steam) and the rest predominantly in the direct use of renewables (*e.g.*, solar thermal for process heat) and heat pumps.

District heating and cooling systems offer the opportunity to integrate bioenergy, geothermal and solar heat. Such systems can provide thermal energy storage over short-time horizons or on a seasonal basis to use heat pumps efficiently by accessing hot/cool energy sources (depending on the season), such as rivers, lakes, and geothermal bores, among others. Other important efficiency opportunities exist in better insulation, flow regulation and time-of-use energy pricing to increase the economic viability of district energy systems. This field of investment can be combined with building renovation. Investments could be increased to around USD 18 billion per year.

Innovations will be needed in the end-use sectors and for sector coupling. Investments in electrolysers to produce **green hydrogen** and hydrogen supply infrastructure and deployment could be increased to around USD 20 billion per year, with significantly greater needs after 2030. Because of the early stage of development of green hydrogen, supply chain investments of around USD 5 billion would be required to produce a gigawatt of supply (representing around 15-20 petajoules/year, enough to make 2 million tons of iron and steel or to heat half a million energy-efficient homes). Today only 0.3 GW of hydrogen electrolyser capacity is in place and manufacturing capacity is below 2 GW per year. Significant scaling up of this capacity will be needed in coming years, along with expansion of capacity for hydrogen transportation and logistics (dedicated pipelines and upgrades to existing natural gas pipelines, refuelling stations, hydrogen storage facilities, hydrogen shipping). The focus should be on replacing hydrogen produced from fossil fuels in existing applications with renewably produced hydrogen and investing to drive down the costs of electrolysers. Over time, as the need for green hydrogen grows, a significant expansion of renewable power capacity will also be needed to produce it.

IRENA analysis suggests excluding CO_2 capture and storage (CCS) for power generation from investment projections for the stimulus package, as CCS technologies are uneconomical and can only play a minor role in the energy transition. Given the technology's capital-intensive nature and long project development time, CCS for power does not fit well with stimulus objectives.

CCS today is mainly linked to CO_2 use for enhanced oil recovery. If the energy transition causes oil demand to dwindle and oil prices to fall, this driver will disappear. A longer-term need may remain in specific industrial processes, such as cement clinker kilning. Elsewhere, CCS would mainly be applied as a transition solution to keep existing plants alive.

With CO_2 capture and use (CCU) technologies, various estimates suggest limited net CO_2 mitigation. By 2030, all combinations of CCU and CCS represent less than 1% of total CO_2 emission reduction. Early stage innovations, such as biomass CCS (BECCS) and direct air capture, as well as PtX synfuel production, may be considered. However, the investment needs for these technologies in the next few years represent a small volume compared to the overall stimulus size. This option, therefore, is not discussed in further detail.

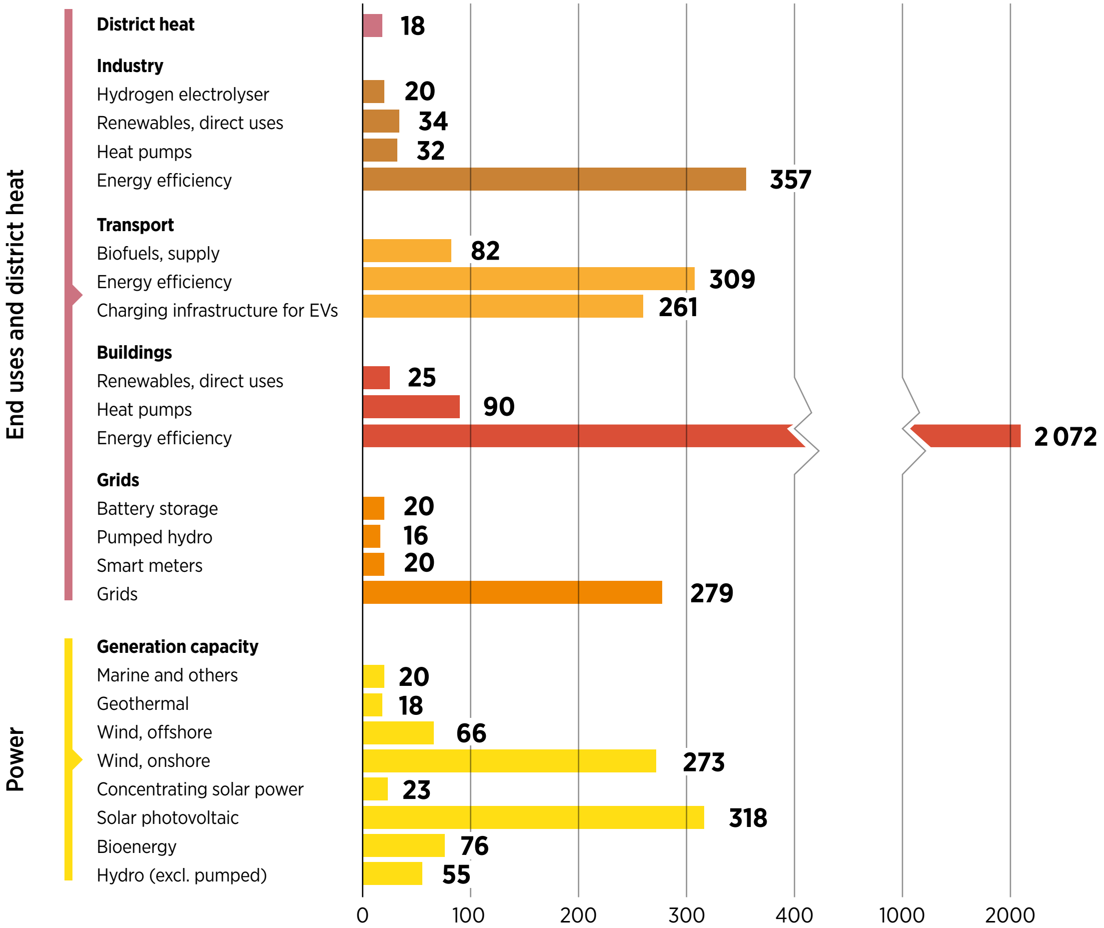
Figure 4.2 provides a further breakdown of investment needs by technology. In addition to solar PV and wind investment, the substantial requirements for transmission and distribution grids are notable, as are the needs for energy efficiency investment across all end-use sectors and for substantial investment in EV charging infrastructure.

Renewable and energy efficiency deployment must accelerate significantly across all regions if internationally agreed climate and energy goals are to be met (see Figure 4.3). East Asia (including China) accounts for almost a third of annual investment needs (32%) followed by North America (18%), the European Union and the United Kingdom (over 12%), the rest of Asia (12%), the rest of Europe (7%), the Middle East and North Africa (6%), Latin America and Caribbean (5%), South-east Asia (4%), Sub-Saharan Africa (3%) and Oceania (1%).

The energy transition must accelerate everywhere to meet climate goals

PART II

Figure 4.2 New investment needs for renewable energy and grids by sector and technology group, annual averages, 2019-2030



District heat: Renewable heating, fuels (solar thermal, modern bioenergy. etc.)

Hydrogen electrolyser: Electrolyser capacity (alkaline and polymer electrolyte membrane) for the production of green hydrogen.

Energy efficiency in industry: Improving processes efficiency, demand-side management solutions, highly efficient energy and motor systems and improved waste processes.

Energy efficiency in transport: All passenger and freight transport modes, notably road, rail, aviation and shipping. Key efficiency measures include lightweight materials, low friction designs, aerodynamic improvements among others.

Renewables, direct uses: Renewables in direct end-use applications (e.g., solar thermal, modern bioenergy)

Energy efficiency in buildings: Improving building thermal envelopes (insulation, windows, doors etc.,), deploying efficient lighting and appliances, equipping smart homes with advanced control equipment, replacing less efficient buildings with energy efficient buildings.

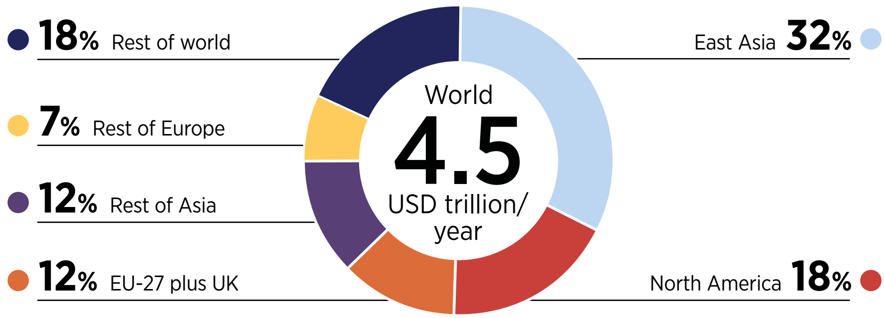
Grids: Transmission and distribution networks, smart meters, pumped hydropower, decentralised and utility-scale stationary battery storage (coupled mainly with decentralised PV systems), and retrofitted and new power generation capacity.

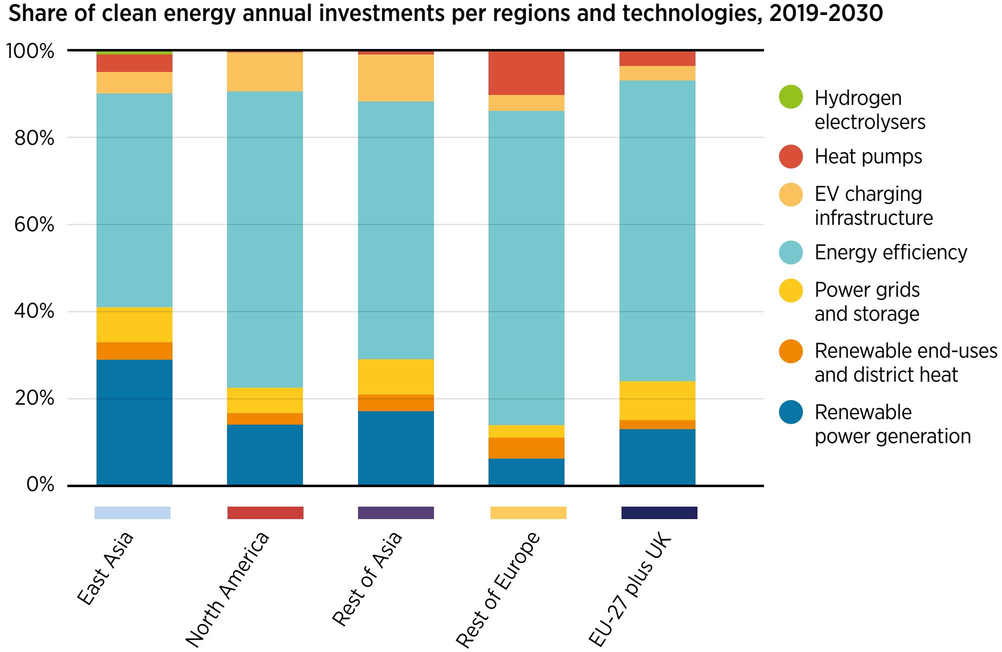
Renewables generation capacity: Deployment of renewable technologies for power generation.

Based on IRENA (2020), *Global Renewables Outlook: Energy Transformation 2050.*

Note: PV = photovoltaic; CSP = concentrated solar power; EV = electric vehicle.

Figure 4.3 Energy transition investment under the Transforming Energy Scenario, annual averages, 2019-2030





Based on IRENA (2020), *Global Renewables Outlook: Energy Transformation 2050*.

Note: "Power grids and storage" includes investment in power grids and energy flexibility measures such as energy storage. "Energy efficiency" includes efficiency measures deployed in end-use sectors (industry, buildings and transport) and investment needed for building renovations and structural changes (excluding modal shift in transport). "Renewable power" includes investment needed for the deployment of renewable technologies for power generation; "Renewables end-uses and district heat "includes investment needed for renewable energy technologies in direct end-use and district heat applications (solar thermal, geothermal). The bar chart includes the data for the five regions with the largest investment needs. "Rest of the World" includes the Middle East and North Africa, Latin America and Caribbean, South-east Asia, Sub-Saharan Africa and Oceania. Country groupings are defined in Annex I.

05 | EMPLOYMENT AND GROWTH BENEFITS TO 2030

Spurred by the need to overcome the COVID-19 pandemic with a green recovery investment push, an acceleration of the energy transition can bring substantial socio-economic benefits, specifically the creation of much-needed jobs and economic benefits. This section discusses the employment intensity of renewables and the opportunities for job creation, particularly in solar and bioenergy. The analysis shows that job gains from the transition outpace job losses in fossil fuels globally and in all regions. The discussion also covers the benefits along the value chain, distributed across different occupational groups.

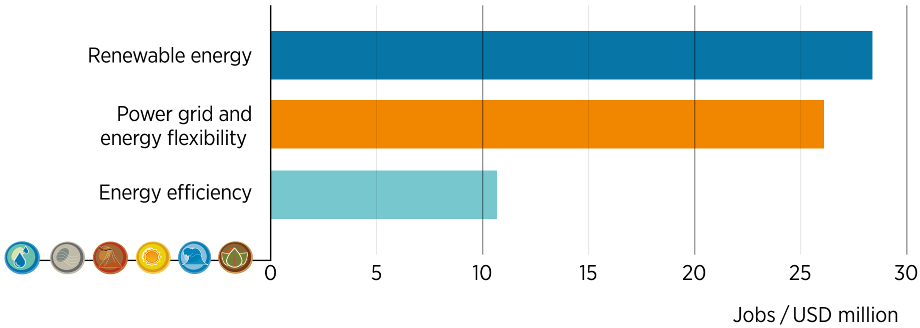
5.1 Employment intensity in transition-related investment

The so-called employment intensity of investment, meaning the employment generated for each unit of investment, varies from one technology to the next. Investing in energy transition technologies creates close to three times more jobs than fossil fuels do, for each million dollars of spending.[114] Figure 5.1 shows that both renewables and energy flexibility have an intensity of more than 25 jobs/USD million, with energy efficiency at about 10 jobs per million U.S. dollars invested.[115]

At the same time, significant regional differences (Figure 5.2) reflect specific country conditions, such as the depth and characteristics of local value chains, energy and commodity dependencies, and trade relationships[116]. The global employment intensity of all energy transition-related technologies is about 16.5 jobs/USD million, but regional values range from as high as about 30 jobs/USD million in Latin America and the Caribbean and countries of the Association of Southeast Asian Nations (ASEAN) to around 10 in EU-27 plus UK and North America (and 5 in Oceania).

Policy makers have an opportunity currently to raise the ambition of their energy transition plans and to strengthen the associated value chains by merging those transition plans with COVID-19 recovery programmes. Doing so will leverage the positive employment impact of the energy transition.

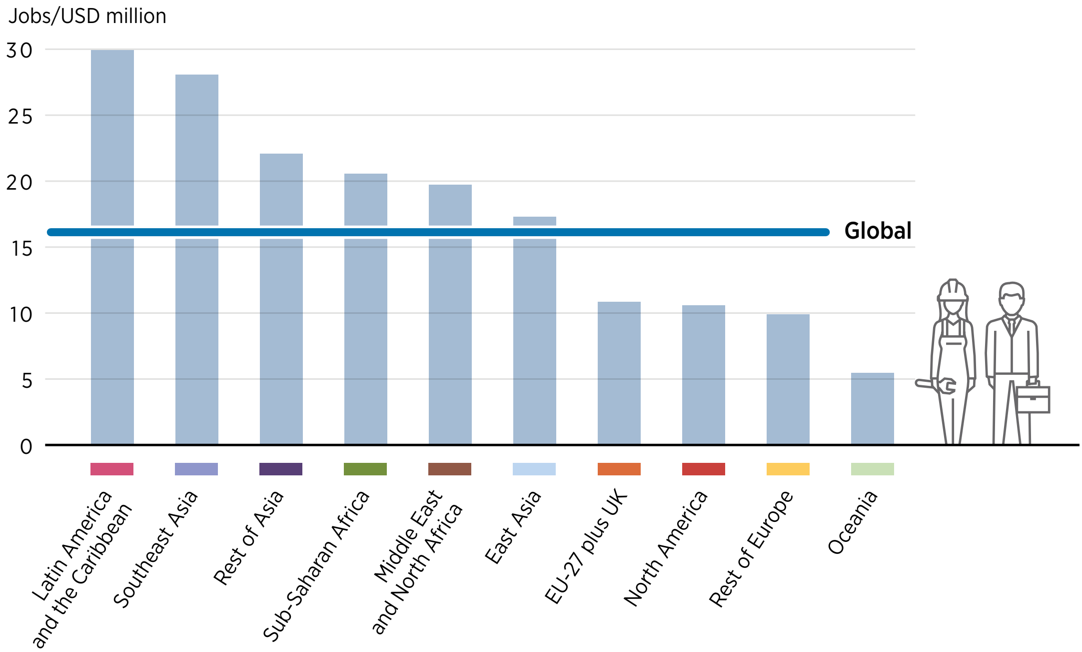
Figure 5.1. Global average employment intensities of investments in renewable energy, energy efficiency and energy flexibility



Based on IRENA (2020), *Global Renewables Outlook: Energy Transformation 2050*.

Note: The ratio is obtained from the average investment and jobs up to 2030.

Figure 5.2. Employment intensity of transition-related investments (renewables, efficiency and flexibility), by world region



Based on IRENA (2020), *Global Renewables Outlook: Energy Transformation 2050*.

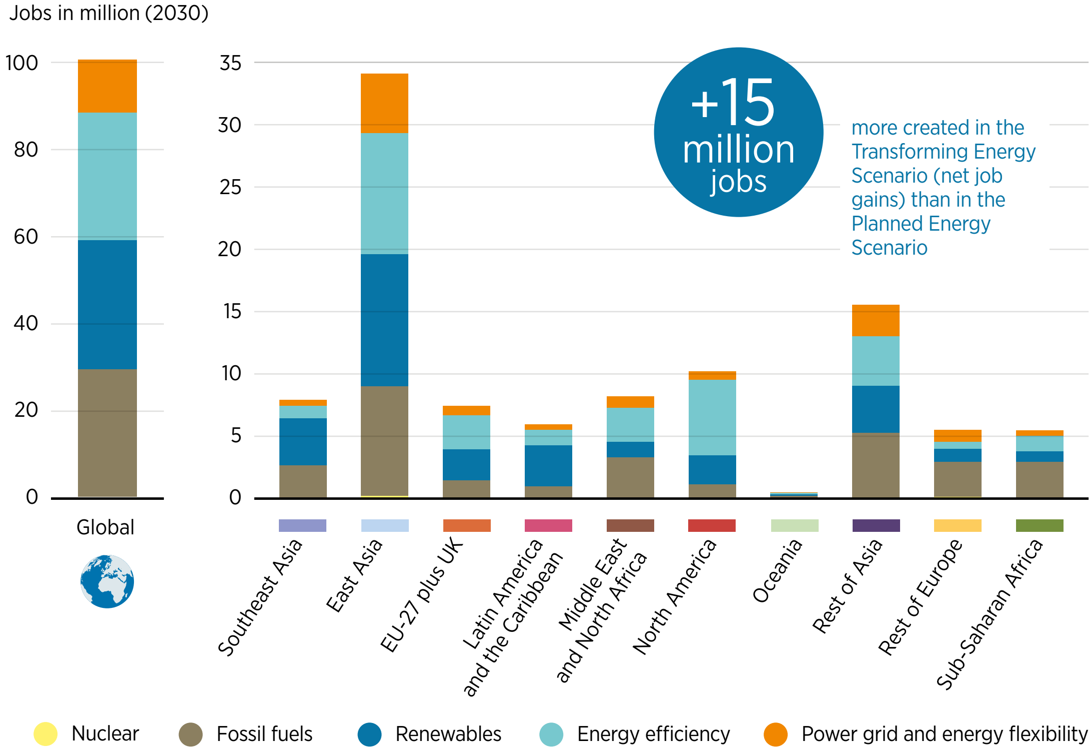
Note: Data on average jobs and investment to 2030 were used to create the figure. Country groupings are defined in Annex I.

5.2 Potential for medium-term job creation

The pathways to the energy transition analysed in IRENA's *Global Renewables Outlook: Energy Transformation 2050* reveal the considerable employment potential of green recovery programmes. Investing in the energy transition would lead to 100 million people being employed in the energy sector by 2030 under the Transforming Energy Scenario, up 74% from today's 58 million – and 15 million more than under the Planned Energy Scenario, which is based on nations' current plans and commitments.

Jobs in renewables would grow to almost 30 million in 2030 from about 12 million in 2017. Employment in energy efficiency would expand from under 10 million to 29 million, while grids and energy system flexibility would likely see an increase from 7.4 million to 12 million workers. In each case, the more ambitious Transforming Energy Scenario offers significant gains over the Planned Energy Scenario. Figure 5.3 shows the global results and how each region would fare.[117]

Figure 5.3. Energy sector jobs in 2030 under the Transforming Energy Scenario, globally and by region



Based on IRENA (2020), *Global Renewables Outlook: Energy Transformation 2050.*

5.3 Net gains in employment

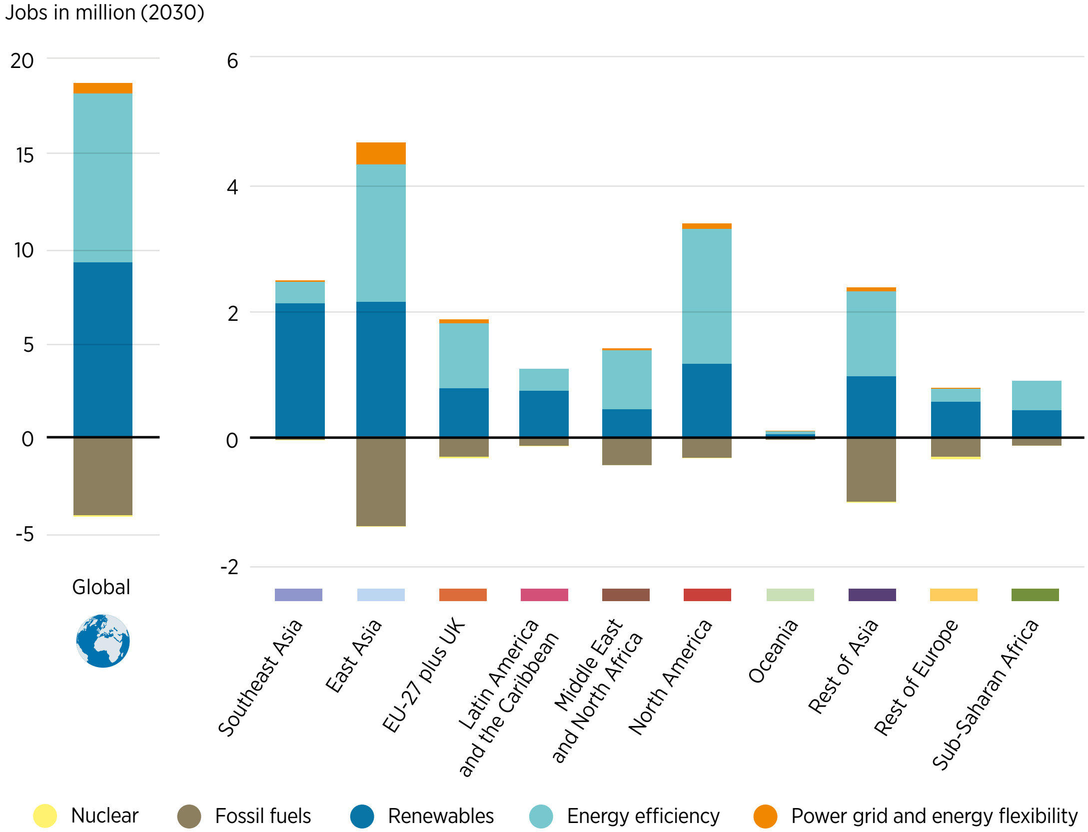
The new jobs created in transition-related technologies would substantially outweigh the job losses in the fossil fuel and nuclear sectors under both scenarios. But the gains would be far more pronounced under the Transforming Energy Scenario, *i.e.*, with greater ambition. Examining the difference in energy sector jobs between the two scenarios in 2030, Figure 5.4 presents job gains and losses for different energy technologies, globally and by region.

Globally, transition-related technologies create almost 19 million jobs more than under the Planned Energy Scenario. Although the fossil fuel and nuclear industries lose 4 million jobs, the Transforming Energy Scenario still yields a gain of almost 15 million jobs.

The balance of overall energy sector jobs is also positive in all individual regions, although the loss of fossil fuel jobs is concentrated in a few (East Asia, the rest of Asia, Middle East and North Africa, EU-27 plus UK and North America). This circumstance allows for meaningful employment in the transition-related energy sector for workers transitioning from the fossil fuel sector, as well as new opportunities for both skilled and unskilled workers from other industries across all the segments of the value chain. Given the current crisis and potential misalignments that occur in labour market dynamics (sectoral, temporal, spatial and educational) in any transition, a holistic approach needs to be pursued in labour market policy-making.

New jobs in transition-related technologies would outweigh job losses in fossil fuel and nuclear energy

Figure 5.4. Energy sector job differentials between the Planned Energy and Transforming Energy scenarios in 2030, globally and by region



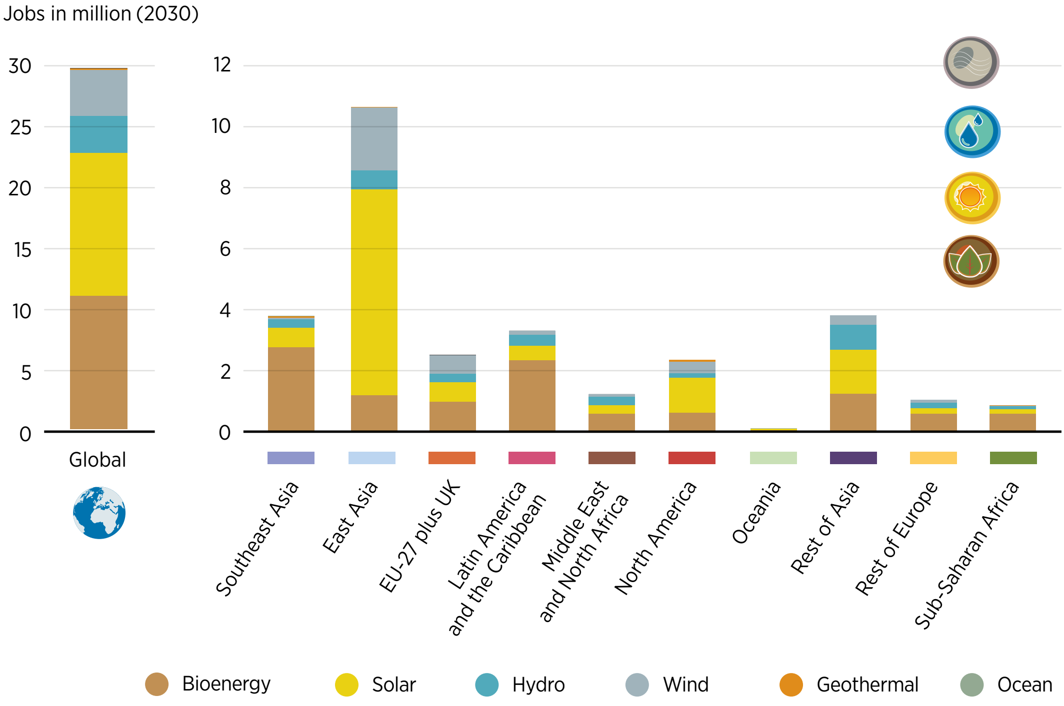
Based on IRENA (2020), *Global Renewables Outlook: Energy Transformation 2050*.
Note: Country groupings are defined in Annex I.

5.4 Solar and bioenergy labour demand

Addressing the unprecedented scale of unemployment resulting from the global pandemic calls for government intervention, both to save existing jobs and create new ones. Renewables can create 29.5 million jobs by 2030 under the Transforming Energy Scenario. Among renewable technologies, solar energy and bioenergy have the greatest potential – 11.7 and 10.9 million jobs, respectively, followed by wind energy jobs, at 3.7 million, and hydro at 3 million.

Among all regions, East Asia can expect the highest number of renewable energy jobs by 2030 under the Transforming Energy Scenario. The total of almost 11 million jobs is dominated by solar technologies. Figure 5.5 illustrates the distribution of renewable energy jobs by region and technology under the Transforming Energy Scenario through 2030.

Figure 5.5. Renewable energy jobs in 2030 under the Transforming Energy Scenario, globally, by region, and by technology



Based on IRENA (2020), *Global Renewables Outlook: Energy Transformation 2050*.

Note: Country groupings are defined in Annex I.

Increasing the ambition from the Planned Energy Scenario to the Transforming Energy Scenario produces more than 9 million additional jobs in renewable energy. Almost 56% of the new jobs are located in Asia, driven mainly by the increase in solar jobs in East Asia and bioenergy jobs in Southeast Asia.

Leveraging local capacity can create considerable job opportunities

5.5 Stronger value chains and job creation

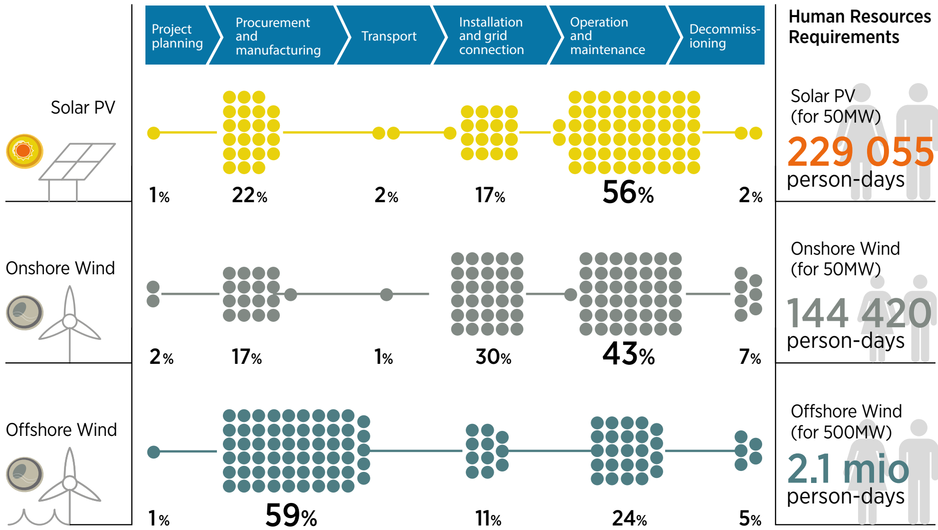
Policy makers need to recognise how many renewable energy jobs can be created along each segment of the value chain, so they can design green recovery programmes that maximise regional and national value creation. Renewable energy draws on a wide variety of occupational groups and skill sets and thus is a boon to many people. From project planning and development to the manufacturing of equipment and components, from construction and installation to operations and maintenance, renewable energy projects entail a broad range of activities and thus offer considerable potential (Box 5.1).

Box 5.1 Employment requirements across the segments of the value chain for three renewable energy technologies

Figure 6.6 illustrates the human resource requirements of segments of the value chain for solar photovoltaic (PV) plants and onshore and offshore wind farms.[118]

- A large-scale 50 MW solar PV project provides a total of 230 000 person-days of employment along all segments of the PV value chain. The highest concentration is in operation and maintenance (O&M), which requires 56% of the total human resources, followed by manufacturing (22%), and construction and installation (17%).
- For a 50 MW onshore wind project, a total of 144 000 person-days is needed. In this case, again, O&M is the leading segment, accounting for 43% of the total employment, followed by construction and installation (30%), and manufacturing (17%).
- Similarly, the analysis for a 500 MW offshore wind farm yields a total of 2.1 million person-days of employment, with manufacturing and procurement representing the largest segment (59%). This is followed by O&M (24%) and installation and grid connection (11%).

Figure 5.6. Employment along several important renewable value chains



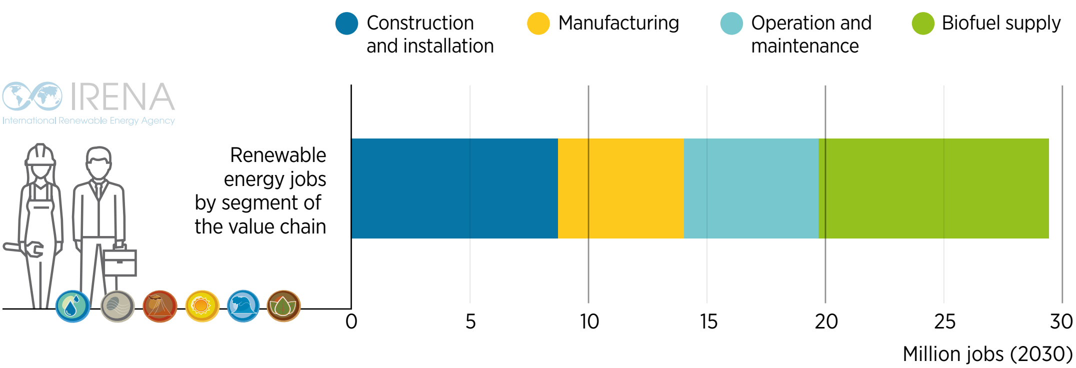
IRENA (2017), *Renewable Energy Benefits: Leveraging local capacity for onshore wind*, International Renewable Energy Agency, Abu Dhabi; IRENA (2017), *Renewable Energy Benefits: Leveraging local capacity for solar PV*, International Renewable Energy Agency, Abu Dhabi; IRENA (2018), *Renewable Energy Benefits: Leveraging local capacity for offshore wind*, International Renewable Energy Agency, Abu Dhabi.

Note: the values are averages that vary depending on location and labour-intensity over time.

PART II

Figure 5.7 shows how the 29.5 million renewable energy jobs expected under the Transforming Energy Scenario for 2030 are distributed by segment of the value chain.[119] The employment intensity of biofuel supply is very high, accounting for 33% of all renewable energy jobs, followed by construction and installation (30%), operation and maintenance (19%), and manufacturing (18%).

Figure 5.7 Distribution of the 29.5 million jobs in renewable energy by segment of the value chain: Transforming Energy Scenario in 2030

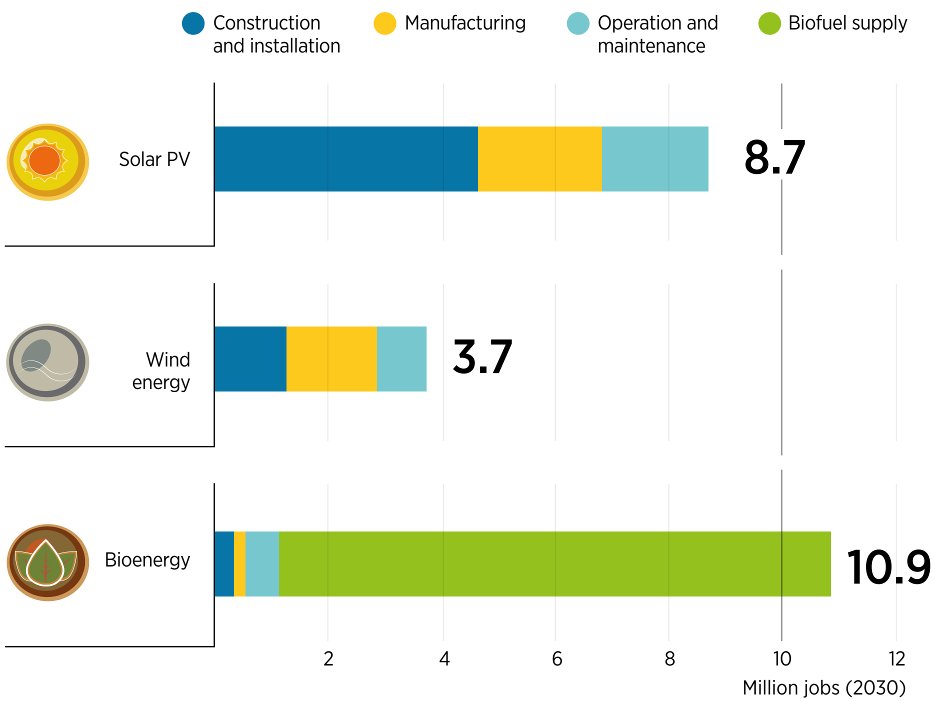


Based on IRENA (2020), *Global Renewables Outlook: Energy Transformation 2050.*

Renewables create jobs with a wide range of skill sets along the value chain

The distribution of jobs across segments of the value chain depends on both technology and location. Figure 5.8 shows this distribution for solar PV, wind and bioenergy. The almost 9 million solar PV jobs are dominated by construction and installation (53%), with manufacturing and O&M accounting for 25% and 22%, respectively. The largest share of wind energy jobs is in the manufacturing segment (43%), followed by construction and installation (34%), with the remaining quarter in O&M. Bioenergy jobs are heavily concentrated in biofuel supply (90%), with O&M (5%), construction and installation (3%) and manufacturing (2%) rounding out the job requirements.

Figure 5.8 Distribution of jobs in solar PV, wind and bioenergy by segments of the value chain: Transforming Energy Scenario 2030



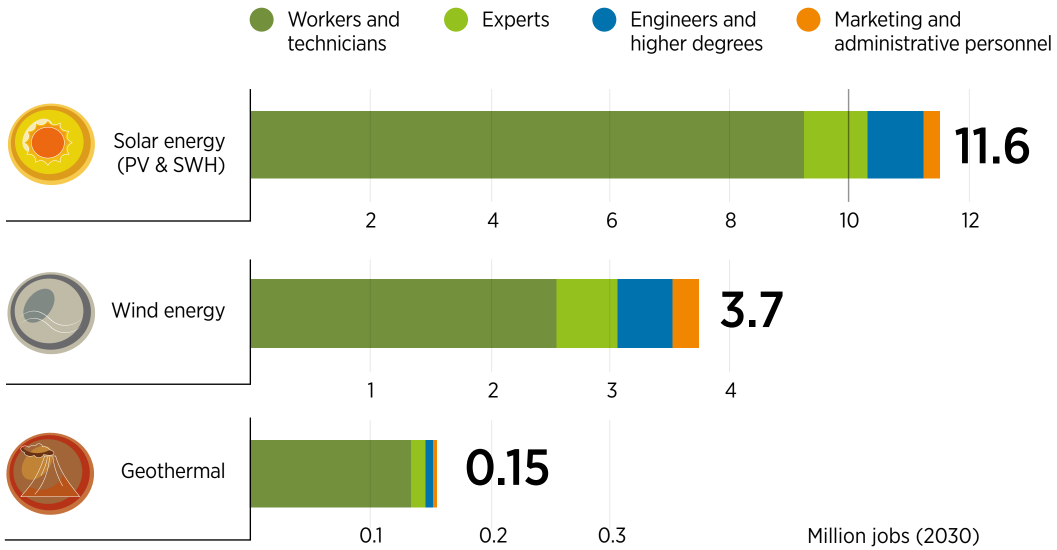
Based on IRENA (2020), *Global Renewables Outlook: Energy Transformation 2050.*

5.6 Demand for key skills and job types

The design of green recovery programmes must also take into account existing skills and potential skill gaps. Figure 6.8 shows what sort of jobs are likely to be created, classified into broad occupational requirements. Information is provided for a subset of renewable energy technologies (solar PV, solar water heaters, onshore wind, offshore wind and geothermal) in 2030 under the Transforming Energy Scenario. Overall, the 15.5 million jobs in these technology segments can be broken down into workers and technicians (77%), experts (10%), engineers and others with advanced degrees (9%), and marketing and administrative personnel (3%). For the two solar technologies (PV and solar water heaters), 80% of jobs are for workers and technicians, 9% for experts, 8% for engineers and others with advanced degrees, and less than 3% for marketing and administrative personnel. There are significant differences between the two solar technologies, with workers and technicians accounting for 95% of jobs related to solar water heaters and 76% for PV.

The share of workers and technicians for wind and geothermal is 68% and 86%, respectively. When comparing wind with solar PV, we find a lower share of workers and technicians (68% versus 76%), and higher shares in experts (14% versus 11%), engineers and higher degrees (12% versus 11%) and marketing and administrative personnel (6% versus 3%).

Figure 5.9 Distribution of solar (PV and solar water heaters), wind (onshore and offshore) and geothermal jobs in 2030 under the Transforming Energy Scenario, by occupational requirements

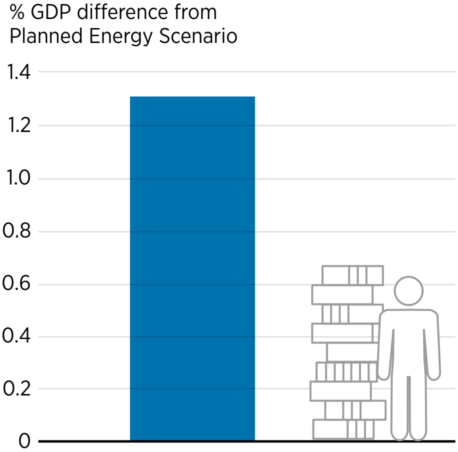


Based on IRENA (2020), *Global Renewables Outlook: Energy Transformation 2050.*

5.7 Triggering additional GDP growth

The *Global Renewables* Outlook documents the potential of an ambitious energy transition to produce economic growth. Across the global economy, the Transforming Energy Scenario has a consistently positive effect compared with the Planned Energy Scenario, boosting global GDP by an additional average 1.3% per year between 2020 and 2030. The cumulative GDP gain would therefore amount to USD 16 trillion. The additional growth is initially driven by investment in the power sector and in energy efficiency. The impacts of investment would remain positive through 2030. Other factors at play would result from changes in consumer spending in response to changes in fiscal policy, price effects, other indirect and induced effects, and trade.

Figure 5.10 Additional boost in GDP under the Transforming Energy Scenario, 2020-2030 (average per year)



IRENA (2020), *Global Renewables Outlook: Energy Transformation 2050.*

06 | MEASURES NEEDED THROUGH 2030 AND BEYOND

Mobilising the finance needed to scale up investments in renewable energy and energy efficiency, as outlined in this report, requires swift and decisive policy measures in a number of areas. Policy measures are also required to maximise socio-economic impacts, enhance the institutional and economic system capacity to manage this high level of investments, and distribute the benefits in an equitable manner.

Underpinning is the development of domestic industrial capacities and supply chains through local content requirements, domestic capacity development, the involvement of national development banks in green financing, the adoption of proper price signals, and adequate support for research and development. To build the needed workforce and meet skills requirements, a comprehensive set of labour and educational policies are needed. Mobilising the necessary green investment requires greater engagement on the part of institutional investors and the use of green bonds. Finally, to achieve the goal of universal access to modern forms of energy, financing for electrification and clean cooking must be increased.

Institutional investors represent vast potential for renewable energy finance

6.1 Scaling up renewables across the board

As demonstrated earlier, investment in renewables has a significant impact on both recovery and decarbonisation. To exploit that potential, the following policy measures are recommended in the medium term.

Invest in the power sector

A well-functioning power sector with high shares of renewables will be the backbone of future energy markets. The electrification of transport and heating and cooling will trigger additional demand for power, which should be met with renewables. For mature technologies (solar PV, hydro, on- and off-shore wind, biomass), fast-tracked licensing, streamlined permitting, customised loans and long-term power purchase agreements (resulting from auctions) are among the measures needed. For less-mature technologies, such as tidal energy, subsidies and project grants are needed.

Investment decisions for the power sector need to account for a balanced mix of variable and dispatchable renewable energy technologies. Investment in other flexibility options can pave the way to full decarbonisation. Flexible grids and pumped hydro are among the technologies that should be facilitated through centralised planning, fast-tracked licensing and customised loans, while smart meters, batteries and other storage technologies require incentives such as subsidies and tax exemptions.

Improve market design and offer financial incentives

The pandemic's impact on energy markets provides a practical demonstration of some of the challenges that high shares of variable renewable energy can generate. A resilient power system characterised by flexible demand and variable generation requires a market design that is able to signal demand for stable, long-term renewable generation while rewarding flexibility in the short-term through appropriate price signals.[120] Also desirable is cross-border trading of electricity.

In addition, measures must enable the electrification of end uses with renewable-based power. These include synchronising the expansion of renewable power plants with plans and measures to deploy electric solutions for transport and heating and cooling (*e.g.*, targets for EVs and heat pumps as well as fiscal measures to incentivise their adoption). Public funds must provide investment subsidies, in addition to grants and tax exemptions, to stimulate the market.

Scale up renewable heating and cooling solutions and energy efficiency

Mandates, incentives and fiscal inducements are needed to trigger the additional renewables-related investment identified in the heating and cooling sectors. Grants or tax incentives could be used to subsidise the higher capital costs of renewable heat options. Ambitious solar thermal targets, in addition to reduced system prices and customised loans, could also promote the deployment of heat pumps and solar water heaters. Mandating these solutions in buildings would also be effective.

In buildings, energy efficiency must be promoted through subsidised assessment of potential; cash incentives and tax rebates for householders, customised loans for retrofitting; tax exemptions and customised loans for efficient appliances; and minimum standards for appliances. Consumers connected to a district heating and cooling or gas network should be required to use the heat provided by the network. This would ensure the demand that is needed to render the fuel switching economically attractive. Buildings not connected to a grid should be required to adopt solutions such as heat pumps or solar water heaters.

In industry, energy efficiency needs to be promoted through subsidies for the assessment and implementation of energy management systems (ISO 50001); cash incentives, tax deductions, and customised loans; and accelerated depreciation of efficiency investment. Heat pumps and the direct use of renewables require cash incentives and customised loans for new installations.

Policies should promote investment into the development of hydrogen electrolysers and innovative zero-carbon process technologies for industry and other hard-to-abate sectors. Possible policy measures include subsidies, customised loans, R&D policies to cut costs, feed-in tariff schemes (or the like) that support the construction of prototype plants, as well as new, dedicated policy measures to create a green hydrogen market. Certification systems and regulations for carbon-free hydrogen supply are critical to ensure that future hydrogen supply is compatible with climate change goals, even if transported from afar. Finally, facilitating access to curtailed renewable electricity is crucial for the production of green hydrogen.

Invest in renewable-based transport

The decarbonisation of the transport sector will require strong policies as well as structural and behavioural changes.

Fiscal and financial incentives for EVs are crucial, but they promote decarbonisation only when accompanied by renewables-based power generation. Stimulus packages supporting the automobile industry can be tied to the industry's commitments to invest in EVs and higher-efficiency cars. Labelling and minimum standards for energy efficiency and emission should be considered, along with bonuses for cars that exceed fuel efficiency and emissions standards.

Depending on the country context, biofuels could be supported through blending mandates for ethanol and biodiesel, customised loans for biofuel production, and fiscal incentives (or mandates) for the use of advanced biofuels in aviation and shipping.

Hydrogen could also be used in the transport sector via fuel cells. This would require dedicated investment in R&D and demonstration projects and in supply infrastructure, in addition to mandates and incentives for hydrogen and hydrogen-derived synthetic fuels.

Electric vehicle uptake must be matched with renewable power generation

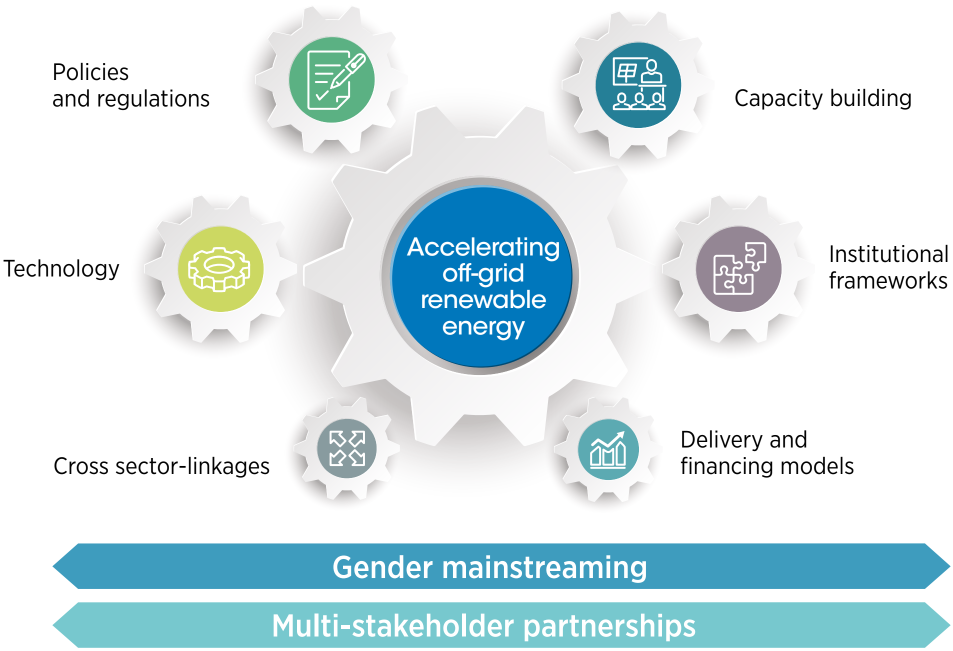
Keep expanding off-grid renewables

Investments in energy access must remain a central priority of energy policies in the medium term. Aligned with the time frame of Sustainable Development Goal 7, countries are advised to develop comprehensive electrification and clean cooking plans based on an optimum, yet dynamic, mix of centralised and decentralised solutions to deliver universal access.[121] Energy access plans should embrace the principles of inclusivity, permanence, viability, integration[122] and a focus on development outcomes for end users.[123]

National plans will have to be complemented by enabling policies and regulations to attract the new investments needed across all energy access solutions.[124] Policy needs vary according to local conditions and the access solutions proposed. The specific case of renewable energy mini-grids, for instance, usually requires dedicated policies and regulations to address legal and licensing questions, tariff setting, access to financing, and what happens once the main grid reaches the area.[125]

In addition to policies and regulations, other elements of the enabling environment are also needed to accelerate off-grid renewable energy solutions, including tailored delivery models and financing for end-users and enterprises, appropriate institutional approaches, capacity building and skills, cross-sector linkages and adapted technologies (see Figure 7.1).[126] Gender considerations must be integrated into the design of policies and programmes, capacity-building initiatives, technology applications, and delivery and financing models.

Figure 6.1 Elements of an enabling environment for off-grid renewable energy solutions



IRENA (2019), *Off-grid renewable energy solutions to expand electricity access: An opportunity not to be missed*, International Renewable Energy Agency, Abu Dhabi.

Millions of people rely on off-grid solutions for modern energy access

PART II

To realise the energy transition-related investments, policy makers need to:

Scale up power transition investment by:

- Fast-tracking licensing, customised loans, and long-term power purchase agreements resulting from auctions to support the deployment of mature renewable electricity technologies.
- Expanding R&D and providing subsidies and grants for emerging renewable electricity technologies (such as tidal energy).
- Developing flexibility options, including grids and pumped hydro, through centralised planning, fast tracked licensing, and customised loans; and smart meters, batteries and other storage technologies through financial incentives.
- Redesigning the power market to provide stable and long-term signals to renewable generators while rewarding short-term flexibility.
- Enhancing cross-border trading of electricity.
- Supporting the electrification of end-uses by synchronising renewable power plants with plans and measures to electrify transport and heating and cooling (*e.g.*, investment subsidies and time of use tariffs).

Scale up heating and cooling transition investment by:

- Introducing renewable energy quotas for suppliers (*e.g.*, in district heating and cooling and green gas) and mandating the use of renewable heat when connected to a network.
- Introducing renewable energy quotas and mandates for decentralised heat (*e.g.*, heat pumps) through building codes.
- Providing financial incentives (*e.g.*, grants or tax credits) to subsidise the higher capital costs of renewable heat options in buildings and industry.
- Investing in innovation, R&D and demonstration projects to support less mature technologies (*e.g.*, green hydrogen).

Scale up transport transition investment by:

- Providing financial or fiscal incentives for the purchase of electric vehicles and fuel-efficient vehicles.
- Introducing labelling, minimum standards for energy efficiency and emissions, and bonuses for cars that exceed standards.
- Introducing blending mandates for ethanol and biodiesel, and offer customised loans for biofuel production.
- Introducing mandates and fiscal incentives for the use of advanced biofuels for aviation and shipping, and for the use of hydrogen and hydrogen-derived synthetic fuels.
- Investing in innovation and R&D to support hydrogen via fuel cells, in addition to supply infrastructure.

Scale up energy access by:

- Allocating funding for national electrification and clean cooking plans in national budgets complemented further by development finance.
- Capitalising dedicated funding facilities to deliver financing tailored to utilities, enterprises, and consumers.
- Ensuring that scarce public financing is effectively deployed by promoting solutions, such as results-based financing, that can improve viability and mobilise private capital.
- Building adequate capacity among local financial institutions and intermediaries to expand access to financing for energy access and linked productive activities.
- Identifying energy gaps across sectors that could be addressed through distributed energy solutions.
- Ensuring inclusivity in access to financing for energy enterprises and end users.
- Ensuring adequate and reliable supply of modern energy to schools, health care facilities and community centres through dedicated programmes.

6.2 Developing renewable energy industries

COVID-19 recovery packages need to be integrated into forward-looking industrial policies focused on energy transition technologies. Industrial policies will play a vital role in transforming the productive structures that underpin green industries, especially in developing countries that lack pre-existing related capabilities, where market forces may detract from welfare-optimal outcomes and where the broader trends dominating anti-poverty and recovery policies have favoured consumption jobs over production jobs.[127]

The financial resources now mobilised to address the social and economic repercussions of the COVID-19 pandemic have altered perceptions of what governments can and must do. The necessary government efforts could be channelled into accelerating the energy transition.

Individual countries are embarking on the energy transition from different starting points, defined largely defined by their existing socio-economic structures, supply chains and human expertise. Countries must nevertheless acknowledge that policy interventions underlie the accumulation of productive capabilities. This section will outline policy interventions capable of stimulating the investments needed to promote a post-COVID recovery.

Support national manufacturing via local content requirements

Local content requirements can be helpful in providing local firms with opportunities for learning-by-doing and incremental innovation, especially in the context of consolidated international supply chains with high barriers to entry. This is particularly relevant to renewable energy, which in many markets is still a newcomer. Renewable energy also offers favourable prospects for localised inputs because of the comparative ease of technology transfer and the labour intensiveness of its low- and medium-skilled work segments.

In the past, the use of local content requirements for industrial development and job creation has sometimes been found to violate World Trade Organization rules. The post-COVID landscape presents an opportunity to rethink these rules and the policy space for using local content requirements, including the possibility of granting special status for renewable energy technologies, given the nature and urgency of climate change.

At the same time, local content requirements are not a stand-alone solution. They do not suffice for building productive capabilities that are oriented toward international competitiveness in the long run.[128] In fact, they have often failed to achieve desired outcomes. Quotas have often been either too high, scaring away investors, or too broad, enabling investors to exploit ambiguities.[129] More importantly, government have often enforced local content quotas without investing in parallel processes to build capabilities, leading to a costly trade-off between local content and competitiveness. The accumulation of productive capabilities required for integrating renewable energy supply chains should therefore go far beyond local content requirements and be combined with genuine investment in human resource development to fit local content ambitions.

Establish capacity development programmes

Programmes to develop suppliers can enhance the industrial capabilities of local actors by allowing domestic firms to benefit from more stable intra-industry relationships, exposing them to international best practices and quality standards, and giving them access to information on quality requirements and evolving market needs. In Malaysia, for example, vendor development programmes were set up across several sectors with the objective of developing a competitive domestic industrial base and local technologies. Firms participating in such programmes have strengthened their capabilities, increased sales, gained exposure to international markets, and stabilised their contracts, enabling them to plan better.[130]

Technical skills are also essential for the adoption and diffusion of renewable technology. When institutions for training specialised personnel are lacking, or when specific skills (or at least the means for acquiring such skills) are not provided nationally and locally, private firms struggle to increase local content.[131] Therefore, strategies for entering renewable energy value chains need to be supported by targeted labour policies, as discussed further on.

Through gradual accumulation of capabilities, local firms can develop the scale and capacity to meet the demand for increasingly sophisticated inputs and services in green technology manufacturing. This strategic and holistic approach implies that even though countries would eventually phase out local content requirements as part of their international trade commitments, they would have built a competitive supplier base that would no longer need protection.[132] This approach would also enable countries to integrate renewable value chains without potentially slowing down the global energy transition.

Offer green financing via development banks

Green national development banks, or green financing programmes under national development banks, can help improve access to credit, investment and funding to undertake industrial activities that feed into renewable energy value chains. Credits for activities that aim to increase local content in renewable energy sector could also benefit from lower interest rates (*e.g.* clean-tech interest rates versus the standard interest rate).

In Brazil, for example, the Brazilian National Development Bank played an important role in supporting the wind turbine manufacturing industry by offering competitive financing for wind power installations (at rates well below market levels) while requiring local content. In the U.S. market, electric car makers benefitted from guaranteed loans (of more than USD 1 billion in total) from the U.S. Department of Energy.[133]

Provide price signals and fiscal tools

Price control mechanisms are industrial policy tools that use prices to achieve desired socio-economic outcomes. For instance, fiscal incentives can be offered to companies and suppliers that contribute to the local economy through industrial linkages and knowledge transfer. Governments can also alter market signals by increasing the cost of alternatives to green technologies. For example, besides carbon taxes, the progressive phasing out of fossil fuel subsidies can incentivise local consumers and firms to shift to renewables, creating a mass market in which private firms can exploit scale economies to produce goods at lower cost.

Industrial policies can help to ensure positive socio-economic outcomes

In the U.S. market, Tesla and other makers of electric cars have benefitted from federal tax credits for purchases of electric cars, as well as from fuel efficiency standards that favoured energy-efficient vehicles, further boosting the productivity of manufacturers through economies of scale. The European Union's gradual phasing out of incandescent bulbs between 2009 and 2012 enabled LED costs to fall by 85% because the shifting consumer demand created a mass market that enabled firms to produce LED goods more competitively.[134]

Support R&D, new strategies and industry clusters

Increased R&D for energy transition technologies can become an essential ingredient for COVID-19 recovery programmes. Innovation-driven industrial policies have a key role to play in addressing climate change because innovation along the value chain depends on public institutions that incentivise firms to perform in-house R&D, quality certification, standard setting, incubation, technology transfer and diffusion.[135] Government action is essential because financing tends to skew toward the deployment phase of incumbent dominant technologies rather than early-stage R&D.[136] As a result, in order to stimulate a low-carbon revolution and green technology development, the state should consider providing long-term, patient capital and R&D grants.

The European Union has been a frontrunner in supporting renewable energy industries. Of the EU's sizeable public funding for green tech R&D, around EUR 5.9 billion (about USD 7 billion) goes towards energy research and innovation projects under the Horizon 2020 programme.[137] These projects create and improve transition-related technologies such as smart energy networks, tidal power and energy storage.

To further promote technology diffusion, governments can establish industry clusters for emerging energy transition technologies. Several renewable energy technologies – notably onshore wind and solar PV, which have become least costly technologies for power generation[138] – have reached market maturity in the past years, but other technologies that will be crucial for the long-term energy transition and full decarbonisation of energy systems, are not yet cost-competitive. Examples include battery storage, hydrogen, synthetic fuels, electric vehicles, tidal power and kite power. Recovery programmes can help to bring emerging technologies closer to technological maturity.

Although these technologies can be supported individually under COVID-19 recovery programmes, policy makers might consider forming industry clusters to further develop them. By adopting national or regional strategies for emerging technologies, countries should be able to localise or regionalise many of the expected socio-economic benefits of industry development and job creation. The Netherlands[139] and Germany, for instance, have developed a national hydrogen strategy aimed at creating a national hydrogen supply chain. Policies and regulation, infrastructure investment and support policies are all parts of the strategy.

To develop a renewable energy industry, policy makers need to:

- Provide investment incentives for green R&D, patient capital, and grant funding.
- Design and set up training programmes to build skilled human capital.
- Consider local content requirements, incentives, skills development, R&D support and state-led investment.
- Impose strict performance requirements on local suppliers in exchange for government support (such as subsidies and tax breaks).
- Establish green financing programmes through national development banks to improve access to credit, investment and funding for industrial activities.
- Set up supplier development programmes to promote learning-by-doing for local suppliers.
- Increase R&D for energy transition technologies to trigger innovation and spillover effects.
- Establish energy transition strategies and industry clusters for emerging technologies, *e.g.*, hydrogen and batteries.
- Phase out local content requirements as international trade resumes and as a competitive supplier base outgrows protections for infant industries.
- Certify quality, set standards, offer incubation, and support technology transfer and diffusion.

6.3 Designing appropriate labour and educational policies

Well-designed labour market policies and forward-looking education and training programmes are needed to support the growth of a skilled renewable energy workforce and to address skills gaps that may emerge as the sector expands and evolves. Policies can facilitate the process in a number of ways, such as enhancing the quality not only of university curricula but also of technical and vocational education and training (TVET) programmes; incorporating information technologies for remote learning (of great significance in the wake of the COVID-19 crisis); ensuring continuity of education and training for current students through improved use of information technology; and integrating energy and climate education in primary, secondary and tertiary education.

Adopt comprehensive labour policies

While the energy transition offers many opportunities for job creation, labour market policies must also address structural changes, notably temporal, spatial, educational or sectoral misalignments. As the energy transition unfolds, altered occupational and skills patterns will be just as critical as changes in employment numbers. Because labour challenges are context-specific, labour policies for a just transition will depend on the specific circumstances of each region and country. Effective labour market interventions include adequate employment services (matching jobs with qualified applicants; facilitating on- and off-job training; and implementing job safety nets), along with measures to facilitate labour mobility where necessary, such as relocation grants.

The renewable energy sector will also benefit from labour policies that embrace and encourage best practices in worker safety, remuneration, and workplace rights and quality standards. The desire to ensure that jobs are of high quality should be reflected in both short-term stimulus packages and longer-term policy responses. Flexible work arrangements, voluntary forms of part-time work, and work-from-home with the help of video-conferencing software are important ways to recruit and retain talent, not only in the immediate aftermath of COVID-19 but also in the long term.

Enhance education and training, including technical and vocational programmes

Developing adequate education and training programmes can help avoid or minimise skills gaps. This requires monitoring how skills profiles evolve, identifying potential skills gaps, and working with educational institutions and the renewable energy industry to address any mismatches between skill-building profiles and the inventory of skills required by the energy transition.

TVET institutions need financial and technical support to ensure a high degree of training quality. Curriculum standards must keep pace with the skills needed in a continuously evolving renewable energy sector; instructors must receive training as needed; equipment must be kept up to date; and information and communications technologies must figure prominently. To ensure that skills development meets the needs of the renewable energy sector, TVET training in manufacturing, in particular, should move beyond skills such as metal working and welding to train workers in areas such as advanced material development and digital design.[140]

Accreditation of programmes and certification of graduates will play a key role. Workplace learning opportunities such as apprenticeships should also be integrated into TVET programmes. Targeted scholarships, outreach and mentoring can all be deployed to attract more women and girls to programmes focused on renewable energy.

Support renewable energy education from an early age

Building local professional capacity to develop, manage and execute renewable energy projects will require close partnerships among universities, governments and firms to ensure that energy curricula prepare students for renewable energy careers in engineering, management and policy, and other fields. Education policies also need to build the capacity of teachers.

Exposing young people to renewable energy–related topics and careers early in their schooling is a good way to build their interest and understanding. This can be done by including energy and climate education in primary, secondary and tertiary education. Such integration into national curriculum frameworks could focus not only on science and technology but also include social and environmental dimensions of the energy transition.

To implement appropriate labour and educational policies, policy makers need to:

- Analyse and understand the country-specific employment potential along the value chain of energy transition technologies.
- Examine the labour market impacts of the structural changes brought about by the transition, particularly by studying temporal, spatial, educational or sectoral misalignments.
- Analyse occupational patterns and requirements for all energy transition technologies.
- Provide adequate employment services (matching jobs with qualified applicants), facilitate labour mobility where necessary (through relocation grants), and co-ordinate skill-matching efforts by facilitating collaboration between industry and educational institutions.
- Provide support for education and training programmes for careers in the renewables sector, ranging from university courses to TVET, to ensure high-quality training.
- Provide funding for remote-learning (online) opportunities for students and trainees.
- Support the integration of renewable energy and climate topics into primary, secondary and tertiary education curricula.

6.4 Mobilising green energy investments

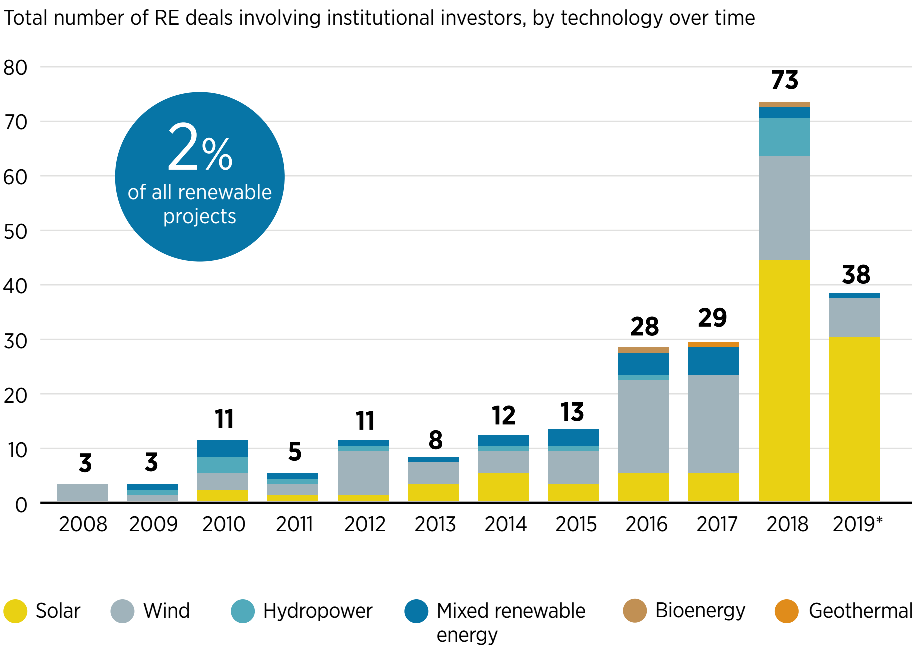
A global energy transition, as outlined in the *Global Renewables Outlook*, will require a massive reallocation of capital away from fossil fuels and a considerable scale-up of investment in green infrastructure assets such as renewables. This will require tapping into all available capital sources, especially institutional and other large investors.

Encourage institutional investment in renewables

With about USD 87 trillion of assets under management, institutional investors (*i.e.*, pension plans, insurance companies, sovereign wealth funds, endowments and foundations) command one of the largest capital pools in the world. They are indispensable to the investment required for the energy transition.

Although direct institutional investment in renewable energy projects has increased over time, it remains minimal, amounting to only about USD 6 billion in 2018 – or 2% of total direct investment in renewables that year (see Figure 7.2). Similarly, institutional investment in renewables-focused funds is estimated at about USD 6 billion per year.[141]

Figure 6.2 Renewable energy project transactions involving institutional investors, by technology, 2009–Q2 2019



Source: IRENA (forthcoming), Mobilising institutional capital for renewable energy, International Renewable Energy Agency, Abu Dhabi; based on Preqin (2019), "Global infrastructure data" (database) (subscription required, last accessed September 2019).

Institutional investors are increasingly seeking investments with good environmental, social and governance attributes. By aligning their investment portfolios to a climate-safe future, institutional investors can also be better prepared to anticipate new regulatory demands and evolving fiduciary standards.[142] Many are likely to boost their capital allocations to renewable energy infrastructure as a way to hedge their climate exposure. Renewable energy assets can provide institutional investors with stable, bond-like returns that match their liabilities, while reducing their exposure to the risk of stranded assets.

But combined efforts on multiple fronts will be needed to scale up institutional capital in renewables. Among those fronts are regulations and policies, capital market solutions, and a host of internal changes on the part of institutional investors.[143] Policy makers and regulators can surmount the macroeconomic and regulatory barriers to greater institutional investment by taking the following steps:

- **Policies to support renewable energy deployment**. Policy makers and regulators have a critical role to play in setting up comprehensive, supportive and clear policies that attract investors to the renewable energy sector and accelerate the energy transition. This includes a combination of direct policies and instruments, integrative policies and enabling policies.[144]

- **Sustainable finance principles**. Policy makers and regulators can work to align the financial system with sustainability objectives. Examples include adopting new investment principles that incorporate environmental, social and governance aspects and establishing new requirements for investors, including climate risk analysis and disclosure.[145]

- **Regulation of institutional investors and investment mandates**. Policy makers and regulators can review investment restrictions and capital adequacy rules that might adversely affect the ability of institutional investors to invest in long-term green projects. In addition, they can establish new sustainability mandates for institutional investors. These might include explicit provisions in investment guidelines concerning risk-and-return considerations related to environmental sustainability, long-term risk assessment and minimum-asset allocation targets for green sectors.[146]

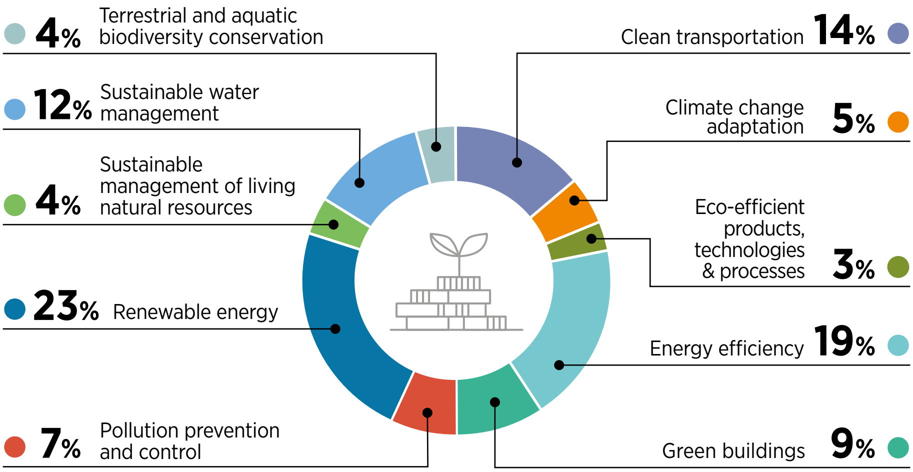
PART II

Promote green bonds for renewables

Green bonds can be an important instrument to mobilise financial resources in support of a global low-carbon economic recovery aligned with climate and sustainable objectives. Green bonds are particularly attractive to institutional investors and have the potential to channel considerable additional private capital into renewable energy.[147]

The global green bonds market was not immune to the shock triggered by the pandemic at the beginning of 2020. Before that, however, annual global green bond issuances experienced considerable growth, from USD 44 billion in 2015 to USD 271 billion in 2019.[148] Renewables are the largest recipient of green bond proceeds, followed by energy efficiency projects and clean transport (see Figure 7.3). Annual green bond issuances dedicated to renewable energy grew rapidly from USD 2 billion in 2013 to USD 21 billion in 2018.[149]

Figure 6.3 Breakdown of green bond issuances by use of proceeds, cumulative volume, 2010-2019



Source: IRENA analysis based on Environmental Finance (2019), "Bond Database" (database) www.bonddata.org (subscription required, last accessed December 2019).

Note: 2019 includes data up to and including November 2019.

The green bond market can be a bridge between providers of capital, such as institutional investors, and sustainable assets, including renewable energy. Although progress to date has been impressive, cumulative issuances of green bonds are still below 1% of global bond issuances, leaving significant opportunity for further growth.[150]

Stimulating the recovery of the green bond market and boosting further growth, particularly with respect to renewable energy, will require co-ordinated measures among stakeholders, including policy makers, public capital providers, and institutional investors.[151]

Policy makers and public financial institutions, in particular, can support green bond issuances and strengthen their credibility among market participants by 1) adopting green bond standards in line with global climate objectives (*e.g.*, the Climate Bonds Standard); 2) reviewing investment restrictions for institutional investors and mandating a minimum allocation to green assets, such as renewables; 3) providing technical assistance and economic incentives (*e.g.*, grants, seed capital and funding of demonstration issuances); and 4) creating pipelines of bankable renewable energy projects (*e.g.*, via risk mitigation instruments, documentation standardisation and aggregation).[152]

To mobilise green investment, policy makers need to:

- Boost the participation of institutional investors in the green sector by lowering macroeconomic and regulatory barriers hampering their investment.
- Set up comprehensive, supportive and clear policy frameworks (including direct policies, integrative policies and enabling policies) to attract further investment in renewable energy and accelerate the energy transition.
- Establish sustainability requirements for investors, such as climate-risk analysis and disclosure.
- Review investment restrictions and capital adequacy rules and establish long-term sustainability mandates for institutional investors, including long-term risk assessment and minimum asset allocation targets for green sectors, such as renewables.
- Adopt green bond standards in line with global climate objectives (*e.g.*, the Climate Bonds Standard).
- Review investment restrictions and sustainability mandates for institutional investors and mandate a minimum allocation to green assets.
- Create pipelines of bankable renewable energy projects.
- Support green bonds through seed capital, demonstration issuances and capacity building.

6.5 Ensuring universal access

Raise large-scale finance for electrification and clean cooking

Funding to expand people's access to modern forms of energy will have to be strengthened if the world is to meet the goal of universal access by 2030, as articulated in SDG-7. Investments in electrification and clean cooking should be scaled up to become a central pillar of the global recovery package. The socio-economic dividends of reliable, sustainable and affordable energy access are substantial and underpin a just and inclusive recovery process while contributing to multiple Sustainable Development Goals.

With an estimated need for more than USD 45 billion annually to meet the target of universal energy access,[153] governments, utilities, off-grid enterprises and consumers will need tailored financing. And that financing will have to be aligned with an integrated strategy that leverages all electrification and clean cooking solutions and ensures that no one is left behind. Public financing will continue to play a fundamental role, even as new models to leverage private capital are tested and implemented. Fiscal support for off-grid renewable energy technologies could prove to be an effective tool for boosting technology diffusion. Support measures could be enshrined in national planning; they might include specific financial support to enable low-income consumers to afford connection fees, stand-alone systems or energy-efficient appliances. Building adequate capacity along the value chain – by upgrading financing institutions, for example – will yield valuable returns for the energy access sector.

Welcome developments include planned funding facilities, such as the Universal Energy Facility[154] (a multi-donor, results-based financing facility to scale up electricity access set up by the Sustainable Energy for All initiative) and the Clean Cooking Fund (a USD 500 million fund planned by the World Bank's Energy Sector Management Assistance Program to scale up public and private investment in clean cooking).[155] Drawn up prior to the onset of the COVID-19, these funding facilities must be operationalised immediately and scaled up to support national energy access efforts.

Strengthen links between energy supply, livelihoods and public infrastructure

Vulnerable segments of the population will need a recovery path that includes an energy safety net, resilient livelihoods and long-term social security. While expanding modern energy access more broadly, careful attention must also be paid to distributed renewable energy solutions that deliver reliable and affordable energy for productive applications.

Distributed renewable energy sources can support diverse livelihoods in rural communities

A more resilient and inclusive economy depends on more local economic opportunities and jobs, improved public infrastructure (healthcare and education),[156] and better market linkages. Such improvements will also discourage rural-urban migration over the long-term.

Several livelihood applications supported by distributed renewables already exist in many sectors – including textiles, agriculture, animal husbandry, food processing, carpentry, pottery, cottage industry, services and retailing.[157] In India, for example, decentralised solar-powered milling and milking machines have been a boon for rural communities; they have been cut off by the travel restrictions and logistics breakdowns brought on by the pandemic.[158] To strengthen rural livelihoods, governments and international partners might consider measures to scale up the adoption of reliable and affordable distributed renewable energy solutions, including energy-efficient appliances.

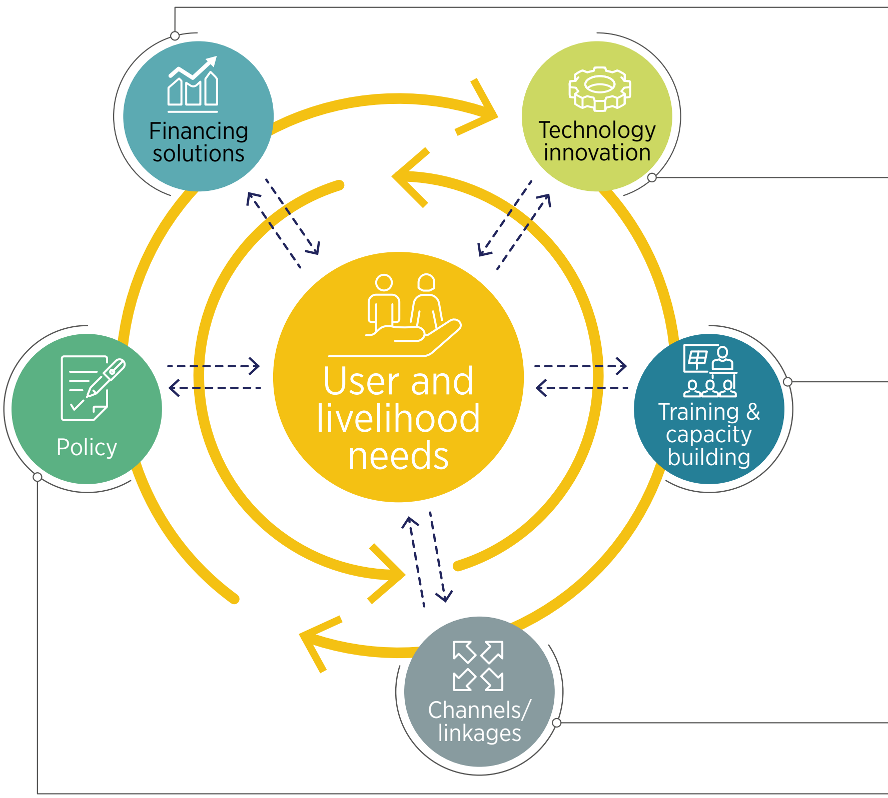
Building on regional experiences, IRENA and the SELCO Foundation[159] have partnered to assess the ecosystem needed to forge linkages between energy supply from distributed renewable energy sources and diverse livelihoods in rural areas (see Box 6.1). Crucially important in this regard are cross-sector policies and financing focused on households and enterprises along the value chain for various goods and services. Core policy measures include fiscal stimuli to spur demand among rural consumers and to kickstart industries, as well as financial support for distributed renewables and for households seeking to connect to the grid or to a mini-grid. Concessional financing for productive equipment and appliances could, in addition, encourage local economic activities, create employment and reduce dependence on polluting, unhealthful traditional fuels.[160]

Efforts to support livelihoods with distributed renewables must ensure equitable access to, and control over, sustainable energy services for both men and women to maximise socio-economic development.[161] Women-owned enterprises should be encouraged in the energy access sector, as in other sectors that depend on distributed energy solutions; financing and skills-development programmes should be accessible to all (see Box 6.1).[162]

Box 6.1 Ecosystem for supporting rural livelihoods with distributed renewable energy solutions

Traditional approaches to energy access involving distributed renewable energy solutions have focused on achieving a certain number of connections or deploying a given number of systems. The need to encourage productive end uses and to link them with livelihoods is often an afterthought. An alternative approach is to identify energy needs that, if met, might transform people's livelihoods by increasing productivity and incomes, enhancing value creation and access to markets, reducing drudgery, and offering a pathway toward long-term social security.

Figure 6.4 Ecosystem needs for supporting livelihoods with distributed renewable energy solutions



Source: SELCO Foundation, 2018.

There are key differences between an ecosystem that supports off-grid renewable energy solutions for energy access and one that specifically supports users and their livelihoods. Rather than focusing on a specific technology solution (solar home systems, mini-grids, biogas plants), why not focus on users and livelihoods? The ecosystem of users and livelihoods can assume additional dimensions (market linkages, sector-specific skills upgrades, couplings of energy technology with livelihood equipment), which in turn may help maximise the value of improved energy access. Building on case studies across regions, IRENA and the SELCO Foundation have joined forces to improve decision-making on deploying distributed renewables to support livelihood applications (Figure 6.4).

- Financing based on perceived cash flows
- Partnerships with local financial institutions
- Affordable cost of capital
- Appropriate repayment mechanisms
- Appropriate ownership models (individual, operator, rental, community owned)

- Access to efficient technologies which will build long term assets/investments
- Technologies which cater to the actual need and capacity/market of the entre preneur/cooperative
- Last mile supply chains and after sales service

- Awareness of alternatives to sustain/improve efficiency in existing vulnerable business
- Training to begin new sustainable business
- Knowledge transfer on best/worst practices

- Access to stable input sources (backward linkages)
- Access to existing or new market linkages to sell end products

- Awareness of informal/livelihoods in micro and small enterprise financial schemes
- Sustainable energy recognition in cross sector specific schemes (agri, artisan/craftmen, manufacturing etc.)
- De risking tools to unlock financing

To reach universal access, policy makers need to:

- Scale up and ensure ring-fenced allocations in national budgets for national electrification and clean cooking plans, complemented by development finance.
- Capitalise funding facilities dedicated to expanding access to electricity and clean cooking technologies to deliver financing tailored to utilities, enterprises, and consumers.
- Support the development of a pipeline of energy access projects and programmes run by the private sector, government entities, utilities, non-governmental organisations and communities that can tap into available public and private capital.
- Ensure that scarce public financing is effectively deployed by promoting solutions, such as results-based financing, that can improve viability and mobilise private capital.
- Build adequate capacity among local financial institutions and intermediaries to expand access to financing for energy access and linked productive activities, especially in rural areas.
- Ensure inclusivity in access to financing for energy enterprises and end users.
- Assess cross-sector opportunities for linking distributed renewable energy solutions with livelihood applications in rural and peri-urban areas that show a high potential for catalysing local economies and employment generation.
- Adopt a value-chain approach to identify energy gaps across sectors that could be addressed through distributed energy solutions.
- Invest in the entire ecosystem of resilient enterprise development through renewable energy – including market linkages, skills and capacity building.
- Provide inclusive financing options to enable households and enterprises to adopt renewable energy solutions and acquire productive appliances.
- Consider dedicated programmes that will ensure adequate and reliable supplies of modern energy for schools, health care facilities and community centres.
- Address barriers to inclusiveness, including those related to gender, faced by enterprises and households in accessing financing for grid and off-grid connections and clean cooking technologies.

Clean cooking and electricity access require dedicated finance tailored for utilities, enterprises and consumers

PART III

OPPORTUNITIES TO STIMULATE ECONOMIC RECOVERY

PART III

This report has made a case for a decade of action on the global energy transformation. It has shown that ambitious investment in the energy transition through 2030, underpinned by targeted policies, can bring about a much-needed shift toward decarbonised energy systems. The involuntary pause that COVID-19 imposed on the global economy offers a unique opportunity to recalibrate the role of energy policies in strategic economic decision making.

Recovery efforts can and should be consistent with the trajectory of an ambitious energy transition, building on the principles of sustainability and human solidarity expressed in the Agenda 2030 for Sustainable Development, in the 2015 Paris Agreement on Climate Change, and in plans made for the implementation of those agreements (notably the Addis Ababa Action Agenda[163] on financing for development).

The energy transition does not yet feature prominently in governments' recovery plans, even though transition-focused recovery measures could correct the pandemic-induced economic downturn while addressing climate and development imperatives in the medium and long term. Rooted in IRENA's 2050-focused *Global Renewables Outlook*, the previous part of the present report has focused on the key decade until 2030. This provides a context for specific, practical recommendations to policy makers on post-COVID recovery strategies.

Much is still unknown about the impact of COVID-19 on lives and livelihoods; similarly, government interventions to promote recovery remain a work in progress. What is already evident, however, is that the recovery phase can either trigger a decisive shift toward a sustainable future or serve to lock in the past.

Given the leading role of governments,this next part of the report details policy measures that, if taken now, could instigate systemic change for the better. The last segment surveys the potential impact on employment and GDP of policy measures and investments aimed simultaneously at recovery from the pandemic and hastening the energy transition on which the health and wealth of humanity depends.

07 | SHORT-TERM ENERGY TRANSITION MEASURES

Transitions are best managed through holistic planning. From the onset, policies should drive outcomes toward sustainability and resilience. Such policies are the subject of the six sections of this chapter.

A comprehensive package of policy measures to produce recovery in the short term necessarily includes the use of public funds to direct investment – ideally into areas that will also contribute to the energy transition. Accomplishing both requires strict conditions to ensure that any bailouts contribute to sustainability goals, reforms of fossil fuel pricing, and assurances that no new fossil fuel assets will be funded as old ones are retired. The short-term policy package should be aligned with the renewable energy targets and Nationally Determined Contributions (NDCs) defined under the 2015 Paris Agreement on Climate Change.

Further, measures are needed to safeguard renewable energy facilities already in operation or under construction while stimulating additional investment in energy efficiency and renewables-based end uses (notably heating and transport). Success will also depend on diversifying and regionalising renewable energy supply chains in response to the COVID-19 crisis through industrial policy. Investment is needed not only in physical assets but also in people. This means providing social protection for workers affected by the pandemic-induced recession, seizing opportunities for urgent job creation, reskilling fossil fuel workers for careers in renewables, efficiency and other transition-related technologies, and realising the employment potential of investment in energy efficiency. No less important are steps to ensure reliable access to electricity and clean cooking fuels in this time of disruption, through support of vulnerable communities and their healthcare facilities.

7.1 Using public finance strategically

The COVID-19 pandemic provides governments and investors with a historic opportunity to accelerate the energy transition. Now more than ever, countries need to place energy transition solutions at the centre of their stimulus and recovery measures. Governments and development finance institutions should consider shifting public finance away from fossil fuels and other polluting and harmful activities toward sustainable infrastructure assets, such as renewables.

International co-operation, together with financial assistance from the industrialised world, will be required to sustain developing countries, hit hard by the pandemic, as they respond to the crisis and develop economic resilience. Compared with developed countries, emerging economies have lacked the resources needed to respond to pandemic-induced economic disruptions. International co-operation and assistance will be crucial to securing their financial well-being, both now and over the long haul.[164]

Investment is needed not only in physical assets but also in people

In the renewable energy sector, international public financial flows to developing countries have surged in recent years, from USD 3.8 billion in 2009 to USD 21.4 billion in 2017.[165] For the post-pandemic recovery period, these flows will have to be scaled up so that developing countries have the infrastructure they need to accelerate the energy transition and achieve sustainable development.

To emerge from the pandemic with new strength and chart a path toward a climate-safe energy system, policy makers should consider encouraging investment in green assets, conditioning non-sustainable bailouts on further investment in the energy transition, reforming energy subsidies and retiring fossil-fuel assets.

Promote investment in green assets: renewable energy and energy efficiency

The economic and fiscal disruptions caused by the pandemic have caused fiscal deficits and public debt ratios to balloon.[166] Now more than ever, strategic use of public finance could leverage infusions of private capital to support the energy transition. The growing interest of private financiers in sustainable assets was underscored by the global pandemic, because these assets have proven more resilient to the global turmoil than their traditional counterparts. Early data shows that so-called environmental, social and governance investments are performing better and proving more resilient to the volatility caused by the COVID crisis than are conventional funds.[167] While such funds were also hit by the financial turmoil, they have experienced only half of the decline observed for the S&P 500, delivering better returns during the crisis.[168]

Public resources can promote green assets, including renewable energy and related infrastructure as well as energy efficiency, by lowering risks and barriers for investors. Risk-mitigation instruments (*e.g.*, guarantees, currency hedging instruments and liquidity reserve facilities) can mobilise private investment in renewables while easing public capital requirements.[169] Risk mitigation will be important, especially as the pandemic and its disruptions have made investors more risk averse. Moreover, risk-mitigation instruments will attract investment in the hard-hit developing and emerging markets.

Condition bailouts on further investment in the energy transition

Conditional bailouts are an effective tool for governments to restore economic activity while also moving closer to international climate commitments and development objectives. When the U.S. government bailed out the automobile industry in 2008 during the global financial crisis, it attached requirements mandating the production of more energy-efficient fleets. This was the impetus needed for the industry to become more competitive and innovative, catalysing the deployment of electric vehicles.[170]

In the wake of the global pandemic, many companies are seeking bailouts and other forms of financial assistance. Governments around the world can choose to impose conditions on measurable climate action when offering financial lifelines to companies in carbon-intensive industries. For instance, the French government attached environmental conditions to its EUR 7 billion bailout for Air France.[171] The airline is required to reduce its carbon emissions by 50% by 2030 against 2005 levels, to renew its fleet with more efficient aircraft and to commit to sourcing 2% of its fuel requirements from sustainable sources by 2025.[172]

Alternatively, bailouts for carbon-intensive companies could require the setting of climate- and sustainability-related targets and, if such targets are not met, bailout funding could be converted to equity, creating strong incentives for companies to deliver on their stated targets.[173]

In the energy industry, governments could also condition bailouts on the replacement of fossil fuel plants with new renewable energy facilities or mandate targets for renewables-based power generation targets.[174]

Governments can condition financial lifelines to carbon-intensive industries on meaningful climate action

Reform fossil fuel prices

Global energy subsidies remain large, consuming enormous fiscal resources in some countries. The global total of direct energy sector subsidies – including those to fossil fuels, renewables and nuclear power – are estimated to have been at least USD 634 billion in 2017, of which USD 447 billion were for fossil fuels. Subsidies of petroleum products dominated the total, at USD 220 billion, followed by electricity-related support to fossil fuels at USD 128 billion. Subsidies to natural gas and coal in 2017 were estimated at USD 82 billion and USD 17 billion, respectively.[175]

These estimates do not include the unpriced externalities of fossil fuel use. In 2017, health costs arising from outdoor pollution generated by fossil fuel use were USD 2 260 billion, accompanied by climate change costs of around USD 370 billion (at USD 11/tonne of CO_2). The costs of unpriced externalities and the direct subsidies for fossil fuels (USD 3.1 trillion) exceeded support for renewable energy by a factor of 19.[176] The International Monetary Fund put the subsidies to fossil fuels at USD 5.2 trillion in 2017.[177] It also calculated that if fuel prices had been set at fully efficient levels in 2015, estimated global CO_2 emissions would be 28% lower, fossil fuel-related air pollution deaths 46% lower, tax revenues higher by 3.8% of global GDP, and net economic benefits (environmental benefits less economic costs) at 1.7% of global GDP.[178]

The G7 and many European countries have pledged to phase out inefficient fossil fuel subsidies by 2025.[179] Government interventions in the post-COVID recovery could accelerate this process, in concert with measures for greater energy efficiency and structural changes in the economy to prevent demand for fossil fuels from returning to pre-pandemic levels.

The collapse in oil prices during the crisis has undermined investors' confidence. This may be an opportune moment to account for the full costs of carbon. Before the crisis, there was reluctance to institute carbon taxes or similar measures for fear of making industries uncompetitive or of triggering public opposition. But such measures might now be justified on the grounds of stabilising oil prices and making them better reflect the ecological cost of fossil fuels.

The primary purpose of carbon taxes is to absorb the negative external effects of carbon emissions. In other words, pricing in the cost of carbon can level the field for low-carbon technologies. If low oil prices cause the post-pandemic economic recovery to be distorted in favour of carbon-intensive technologies, future economies will be less resilient and carbon emissions could be locked in for many decades. IRENA's latest costing report[180] indicates that as much as 1 200 gigawatts (GW) of coal-fired power will be generated next year, displacing generation of the same quantity of energy by more economical, new, clean plants using renewables. A further advantage of carbon taxes is to raise revenues that policy makers can use to finance the green recovery and a just energy transition.[181]

Retire existing fossil fuel assets (and avoid building new ones)

The pandemic and its global disruptions offer opportunities to rethink the ways in which public financial resources are used to support industries. Any future support for fossil fuel industries should come with strings attached – that is, with stringent sustainability conditions. This might include more demanding regulations to lower emissions of air pollutants and mandates to transform fossil fuel companies to be compatible with the energy transition.

Consideration should be given to using public resources to take over fossil fuel assets while they can be bought at discounted prices, retiring them under a thoroughly planned, accelerated energy transition strategy.[182] For example, replacing the costliest 500 GW of coal with solar PV and onshore wind next year would cut power system costs by up to USD 23 billion each year and reduce annual emissions by around 1.8 gigatons (Gt) of CO_2, equivalent to 5% of total global CO_2 emissions in 2019.[183]

Trigger investment in energy network infrastructure

Investment in physical infrastructure is at the core of economic recovery programmes. It can exert a far-reaching economic stimulus while signalling commitment to the energy transition.[184] Public finance can also be used to attract private investment in the needed infrastructure. These investments should be aligned with long-term plans and other enabling and integrative policies, such as research and development (R&D).

Power sector infrastructure. Investment must be steered into grid enhancement and upgrades at both the distribution and transmission levels. The electricity grid is already in need of modernisation to enable it to handle growing amounts of variable renewable energy (VRE) and related technologies. Network development plans should include deployment targets for renewables in the mid- and long term. Moreover, additional investment in cross-country interconnectors, smart grids, smart devices, demand-side management, and digitalisation can pave the way toward better integration of high shares of renewables. Smart charging of electric vehicles (EVs), for example, can significantly facilitate the integration of VRE by leveraging storage capacity and the growing potential for flexibility in consumption patterns.[185]

Heating and cooling and transport infrastructure. For heating and cooling, investment should target the integration of direct renewable heat (*e.g.*, geothermal) and green gases (*e.g.*, green hydrogen). Refurbishing existing networks for district heating and cooling, for example, or developing new ones will require financial support and incentives, such as subsidies, grants and tax credits for private-sector utility providers; debt guarantees to minimise risk for potential investors; and concessional finance.

The same kind of support is needed to facilitate the development of the infrastructure needed to deploy renewable gas (such as green hydrogen) for heating.

Risks associated with the delivery of such networks must be proactively identified and eliminated. For example, mandates are needed to guarantee a demand anchor load for project developers. Permitting procedures must be streamlined. Such measures are normally undertaken at the city level.

For transport, putting more electric and alternative-fuel vehicles on the streets will depend on the rollout of infrastructure for charging and fuelling.

When designing response measures, policy makers need to use public finance strategically. They should:

- Provide risk-mitigation instruments (*e.g.*, guarantees, currency hedging instruments and liquidity reserve facilities) to mobilise private capital.
- Shift public finance away from fossil fuels towards energy transition-related investment.
- Make financial support to carbon-intensive companies conditional on measurable climate action.
- Make energy industry bailouts conditional on the replacement of fossil fuel plants with new renewable energy facilities or on meeting targets for renewable energy generation.
- Implement carbon pricing to avoid a distorted economic uptake as the pandemic recedes.
- Mobilise public financing to trigger investment in enabling infrastructure for renewable power (*e.g.*, smart grids, cross-country interconnectors), heat (district heating and cooling networks), and transport (*e.g.*, charging stations for EVs). Instruments include capital grants, public-private partnerships, loan guarantees, soft loans from development banks and fiscal incentives.
- Identify and eliminate risks associated with the delivery of renewable heat and gas projects, such as mandating zones to guarantee demand and streamlining permitting procedures.

7.2 Increasing national climate ambitions and raising renewable energy targets

As they devise their recovery programmes, governments have an immense opportunity to pair recovery with more ambitious plans to transform the energy system. A more resilient future depends on governments making ambitious pledges to accelerate energy transitions.

IRENA estimates that if all national renewable power targets are implemented in the first round of NDCs under the Paris Agreement, global renewable power capacity would reach just 3.2 terawatts by 2030 – well below the 7.7 terawatts of installed capacity projected under IRENA's Transforming Energy Scenario, which fulfils the Paris Agreement objectives and yields considerable socio-economic benefits.[186]

Furthermore, the current NDCs do not reflect the rapid growth experienced by renewables over the past decade. If renewable energy deployment were to grow at the same rate experienced from 2015 to 2018 (*i.e.*, at 8.6% per year), global NDC renewable power targets for 2030 would be met by 2022.[187]

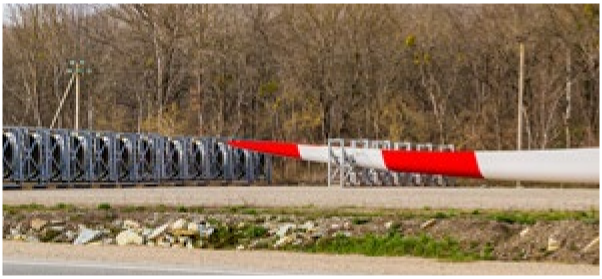
Therefore, the time seems right to raise our ambition. IRENA analysis shows, for example, that by simply aligning the next round of NDCs to other national energy plans, governments could increase their renewable electricity pledges by 64% and reach 5.2 terawatts of renewable power capacity in 2030.[188] Setting ambitious renewable energy targets consistent with long-term national energy strategies and plans can send a strong signal to investors and help attract additional capital.

Renewable energy targets also need upward adjustment to take account of additional short-term procurement of new capacity. If policy makers decide to deploy more renewables-fuelled capacity post-COVID to generate employment and economic growth, then targets should be raised commensurately. Otherwise, there is the risk of stop-and-go procurement cycles, which could have detrimental effects on national renewables industries.[189]

National targets have so far been focused on the power sector, but long-term targets for all end uses will be needed to ensure that reductions in emissions and air pollution during the crisis persist after the economy recovers. By reviewing NDCs in 2020, countries can re-evaluate their targets and adopt more ambitious ones, both for the power sector and beyond.

When designing response measures, policy makers need to increase national climate ambitions and raise energy transition-related targets. They should:

- Adopt ambitious energy transition-related targets in the next round of NDCs.
- Align NDCs with energy transition plans and recovery measures.
- Set and align renewable energy targets in all end uses (electricity, heating and cooling, transport).
- Increase short- and medium-term targets to account for additional short-term procurement of new renewable capacity in 2020 and 2021.



7.3 Maintaining existing projects and investment plans

Safeguard power plants in operation or under construction

For renewable energy power plants now being planned or built, governments should consider relaxing project milestones and compliance rules where necessary to prevent project failure (Box 7.1). The swift recovery of the renewable energy sector depends on government authorisations. Local governments would be well advised 1) to shorten delays in the issuance of permits that weaken confidence in the market and 2) to ease project approvals, especially for small and new players (to encourage their participation).[190] Projects should nevertheless be evaluated with the usual rigour before licenses are issued.

Box 7.1 Relaxing rules in extraordinary circumstances increases market confidence

The COVID-19 pandemic has disrupted supply chains, delaying the delivery of essential components and equipment needed for renewable projects. Lockdown rules have closed manufacturing operations for weeks. Looming deadlines are therefore a major concern for developers. Governments should consider easing administrative and permitting procedures, prolonging support schemes (such as feed-in tariffs or tax breaks), waiving penalties, and extending deadlines for projects that have been disrupted.

Extending deadlines for support. The U.S. Treasury may modify tax credit rules for wind and solar energy. At issue are the investment tax credit for solar and the production tax credit for wind.[191] China and Viet Nam are also considering the extension of their feed-in tariffs.

Waiving penalties. Policy makers may also want to relax compliance rules. Germany and France, for example, are extending deadlines for submission of auction bids.[192] Elsewhere, deadlines are being extended for project completion to accommodate unavoidable delays. Relaxing penalties (*e.g.*, the confiscation of commitment bonds) is another option that may help to ease developers' financial situation. Countries could revisit developers' contractual obligations during the delay, particularly, in markets where the developer is required to purchase compensatory products in lieu of undelivered electricity.[193]

Provision of assets in the short run. Despite these efforts, the crisis may push some developers into severe difficulties. In cases where an asset is partly developed, public provisions for commissioning may be a wise choice.

As for renewable power plants currently operating in liberalised markets, certain support mechanisms that are meant to trigger more system-friendly operation have exposed generators to substantially lower wholesale market prices resulting from reduced electricity demand. Specific tax reductions for renewables-based electricity could be implemented under such circumstances. Existing surcharges or taxes could be reduced, either temporarily or for a longer period, to increase demand for renewables-based power. Higher demand for electricity could prevent wholesale market price reductions, assuring renewable energy producers of sufficient revenues. For instance, Germany's recovery package includes measures to reduce one component of the electricity price, the renewable energy surcharge (EEG surcharge), financing it in part out of the general budget. Cuts in electricity prices will also incentivise the use of electricity in the heating and cooling and transport sectors.[194]

Continue investments in distributed generation

For distributed generation technologies (rooftop solar PV, biomass and small-scale hydro), investment incentives are a critical part of any COVID-19 recovery programme. In the short term, the pandemic is likely to affect the ability of households and commercial activities to invest in distributed generation, and reduced electricity prices are likely to lengthen installation payback periods, deferring investment.

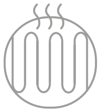
Governments can avoid a sectoral crisis, by investing in distributed generation in public buildings and taking steps that make distributed generation more appealing. For example, well-designed net metering/billing schemes could support solar PV deployment, without incurring the expenditures required by feed-in tariff (FiT) schemes. Investment subsidies can also help reduce upfront costs.

Keep up investments in planned power projects

To attract investment in any project, the allocation of market risks must be clearly laid out from the outset, including explaining what force majeure clauses entail and sharing responsibility for allocating risks. In certain contexts, for example, take-or-pay contracts may, in times of crisis, pose strains on utilities and distribution companies, making them unsustainable in the long run. Instruments to mitigate investment risk (so-called de-risking policies) become even more essential at such times. Similarly, in some economies, exposing developers to inflation and currency risks should be minimised, especially where contract prices are not already indexed to inflation or are denominated in local currency.[195]

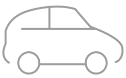
Attracting investment into the sector also requires reassurance to market players regarding commitments to existing plans. Delays or cancellations must be avoided in procurement programmes designed for the transition of the power sector to renewables and efficiency. If such programmes or auctions are postponed for the duration of the pandemic, any revised plans need to be transparent to maintain market confidence.

Trigger investments in efficiency and in renewables for key end uses



Renewable and efficient heating and cooling. Significant decarbonisation can be achieved through electrification of heating and cooling, but only if powered by renewables. Ambitious plans for the deployment of combined energy efficiency and renewable heating and cooling solutions must be announced through targets and mandates affecting buildings and industry. These targets and mandates can be supported by the financial incentives discussed in section 6.1. In addition, stimulus packages should be tied to decarbonisation requirements (*e.g.*, building codes for new construction and renovation, higher efficiency for appliances such as cookstoves or boilers).

In industry, the need for continuous operation is often a barrier to investment in efficiency. The involuntary idling of industrial installations thus offers a good opportunity to make efficiency retrofits that can increase competitiveness upon recovery. Especially for small and medium enterprises, important opportunities remain, and a combination of energy audits and fiscal support measures can achieve significant process within a short time. Awareness and implementation can be heightened through more widespread implementation of energy management standards.



Renewable and efficient transport. Significant decarbonisation can be achieved through electrification of the sector, but only if powered by renewables. Phasing out fossil fuel subsidies would also make investment in EVs more attractive. Either way, systemic shifts in the transport sector will require target-setting, as well as fiscal and financial incentives.

Recovery packages for the automobile industry can be tied to commitments to invest in EVs and higher-efficiency cars. In addition, depending on the country context, fuel blending mandates can be introduced or made more ambitious in support of biofuels. Green hydrogen can also be used directly via fuel cells (for road vehicles) or as feedstock for production of ammonia, methanol or other synthetic fuel for the shipping and aviation sector. Dedicated investment will be required in R&D and demonstration projects to evolve these solutions faster, to benefit from the abundance of cost-competitive renewable power.

Decarbonisation of the transport sector will depend on policies as well as structural and behavioural changes. To sustain the reductions in emissions and air pollution brought about by the pandemic and its economic disruptions, lessening traffic will be key. Policy makers, especially in cities, have a crucial role to play in proposing measures to change travel patterns and habits, especially if public transportation becomes less attractive for fear of contagion. Candidate measures include promoting alternative mobility services, *e.g.*, by widening biking and walking paths, prioritising cyclists and pedestrians, and reducing automobile speed limits to ensure safety. As for air travel, bailouts could be linked to a transition requirement favouring more fuel-efficient carriers and greener fuels, curtailing short-haul flights, reducing non-essential travel, and directing airline investment to railways.

When designing response measures, policy makers need to maintain existing projects and investment plans. They should:

- Support operating renewable energy plants in the context of falling electricity demand.
- Safeguard renewable energy projects facing construction delays:
  - Extend deadlines and waive penalties or facilitate agreements with off-takers.
  - Speed up authorisation procedures, remove bureaucratic barriers, and facilitate co-ordination between levels of government.
- Safeguard investment in distributed generation by installing systems in public buildings and introducing supporting instruments (*e.g.*, capital subsidies, net metering/billing).
- Maintain investment in planned projects
  - Provide reassurance to market players regarding commitments to existing plans.
  - Avoid cancelling procurement programmes. If such programmes or auctions are postponed for the duration of the pandemic, the revised plans need to be transparent.
  - Reduce market risks by clearly laying of responsibilities from the outset.
  - Introduce measures to reduce risks, including those related to curtailment or project finance.
- Trigger investment in renewables for end uses
  - Adopt ambitious deployment plans by announcing future targets and mandates in buildings, industry and transport, together with financial and fiscal incentives to support the uptake of solutions (*e.g.*, heat pumps and EVs).
  - Invest in innovation and R&D to support nascent solutions (*e.g.*, hydrogen)
  - Tie stimulus and recovery packages to decarbonisation requirements (*e.g.*, building codes for new construction and renovation; collecting airline passenger taxes and investing in railways over airlines).
  - Promote behavioural changes and reduce non-essential travel.
  - Adopt post-pandemic urban design (wider biking and walking paths), prioritising cyclists and pedestrians, and reducing automobile speed limits to ensure the safety of cyclists and pedestrians.

7.4 Diversifying and developing supply chains

This section addresses the diversification and regionalisation of renewable energy supply chains and outlines the role of industrial policy in achieving such objectives.

Regionalise renewable energy supply chains

The COVID-19 crisis has severely disrupted cross-border supply chains.[196] While most of the renewable energy sector has been hit by the crisis far less than other energy sectors, it has still been significantly affected.

Against this backdrop, to improve the long-term resilience of renewable energy deployment against exogeneous shocks, a further diversification of supply chains may be needed. In developing countries, leveraging domestic capacities by training local personnel and developing local suppliers would also help reduce dependence on foreign expertise.

The expansion and diversification of supply chains for energy transition technologies is particularly important given their role in surmounting the threats posed by climate change. The current momentum for policy makers to consider ways to "build back better"[197] offers a historic opportunity to pursue ambitious structural measures that will boost the economy and create jobs while achieving energy transition goals.

Ease entry into the value chain for renewables

The imperative of expanding global production networks in renewable energy sectors calls for efforts to facilitate the integration of newcomers in renewable energy value chains. Easing entry barriers will also spread the socioeconomic benefits of the energy transition. The gradual development of the scale and capacity of local firms to meet demand for increasingly sophisticated inputs and services in green technology manufacturing will go far in releasing the enormous potential of renewable energy to drive localised socio-economic development, notably through job creation.[198]

The use of industrial policy tools requires further attention because the development of internationally competitive local suppliers (particularly in developing economies) has been hindered by the existence of high barriers to entry, which reflect the capital- or technology-intensive nature of many value-added activities, and of internationally consolidated supply chains designed to ensure quality and reliability.

Such market obstacles can be largely overcome by industrial policies aimed at spurring innovation, the accumulation of skilled human capital, and learning-by-doing.[199]

When designing response measures, policy makers need to diversify supply chains. They should:

- Reduce entry barriers for local firms seeking access to value chains.
- Develop productive capabilities that can feed into renewable supply chains.
- Promote the shift to regional value chains, thereby fostering global resilience to exogenous shocks.

7.5 Preserving livelihoods and maximising job creation

Many medium-term policies will be continuations of policies initiated in the short term. Labour policies are a good example, given the importance of job creation in a world that suddenly confronted a massive cratering of the economy. Social protection programmes, as well as education and skills training, are critical in securing the longer-term benefits of an investment-driven recovery and transition strategy.

Provide social protections to energy sector workers

As in other parts of the economy, the energy sector has been deeply affected by the lockdowns in response to the pandemic, with layoffs and job insecurity affecting millions. Responding to massive job losses, governments have already adopted a series of broad social protections. Of short duration, these will have to be extended until the recovery is clearly under way. Measures also need to recognise that women are much more likely than men to be in temporary work arrangements, and thus at higher risk of losing their job and income.

Government interventions must consider the dynamics of the energy sector, not only because it is deeply affected by the pandemic but because it must undergo a profound transformation that is vital to the economic and environmental survival of the planet.

Social protection measures must consider both short- and longer-term needs. One objective is to minimise social and economic dislocation and limit the suffering of affected workers and communities. The other is to prevent the fabric of the energy sector – its skilled workforce, supply chains and complex web of relationships – from unravelling as it undergoes epochal change. The costly consequence of such an unravelling would be the need to recreate the sector's capabilities from scratch.

Governments should consider ongoing, conditional payments to energy sector employers to enable them to retain workers. This could entail direct salary subsidies or support payments to stem companies' costs (rents, interest on debt, health insurance premiums, etc.) and thus to withstand the severe contraction caused by COVID-19 without shedding jobs. Priority could be accorded to programmes that support the retention of workers who participate in – or whose skills can be reoriented toward – the energy transition.

Where layoffs do occur, governments can ensure income stability through traditional unemployment insurance (expanding and extending eligibility), by providing special support programmes, or by designing guaranteed basic-income schemes. These efforts can be more successful if they also incorporate economic stabilisation programmes for communities that depend on the fossil fuel industry. Such measures in support of a just transition are relevant both during the pandemic recovery and as the energy transition accelerates.

Seize renewable energy job-creation opportunities

Existing knowledge and skills can be leveraged to meet the occupational requirements of emerging jobs.

The renewable energy sector offers employment prospects for people with a wide range of experiences and backgrounds, with many of the required skills typically available domestically. While there is a demand for professionals with training in fields such as science, technology, engineering and mathematics (STEM), as well as other highly qualified individuals (such as lawyers, logistics experts, marketing professionals, financial analysts, and experts in regulation and standardisation), most jobs (*e.g.*, construction and factory work) do not require a university degree.

The greatest demand from the renewable energy sector will be for factory workers and technicians. In solar PV and onshore wind facilities, for example, IRENA's analysis shows that over 60% of the workforce requires only minimal training (though often high manual dexterity). This includes construction and factory workers (see Figure 7.1). Individuals with degrees in STEM fields are needed in smaller numbers (around 30%). Non-STEM professionals account for roughly 5%, while administrative personnel make up the smallest share (1-4%). In offshore wind, the proportion is similar: those with lower formal skills and training again represent the largest share of employment (47%). The low threshold of skills for many of these jobs opens doors to employment for many people, particularly where on-the-job training is available. Furthermore, some skill sets can be leveraged from other domestic industries, with some retraining.

These skill and occupational patterns are important markers that can guide governments as they allocate public investment budgets, shape the contours of industrial policy measures, and undertake efforts to match skills demand and supply through labour market policies – all to speed post-COVID recovery and accelerate the energy transition.

Industrial policies can take account of skill-set compatibility between industries

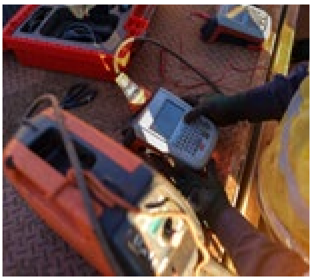
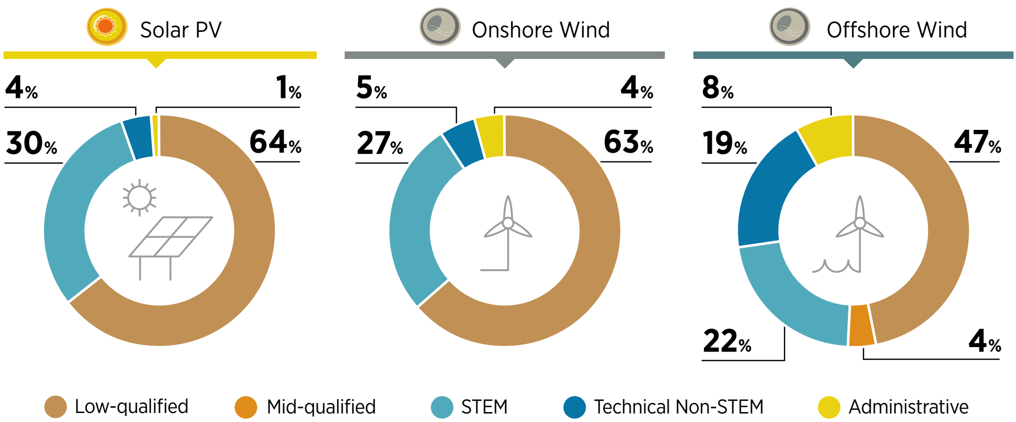


Figure 7.1 Human resource requirements for workers in solar PV and wind energy



Source: IRENA (2017), *Renewable energy benefits: Leveraging local capacity for solar PV*, International Renewable Energy Agency, Abu Dhabi; IRENA (2018), *Renewable energy benefits: Leveraging local capacity for onshore wind*, International Renewable Energy Agency, Abu Dhabi; IRENA (2018), *Renewable energy benefits: Leveraging local capacity for offshore wind*, International Renewable Energy Agency, Abu Dhabi.

Note: STEM = science, technology, engineering, and mathematics.

Reskill fossil fuel workers for jobs in renewables

The pandemic is hitting the fossil fuel sector harder than renewable energy, a prelude to the profound changes the energy transition will bring. While the energy transformation will have an overall net-positive impact on employment, millions of fossil fuel workers will need to find new jobs.[200]

Policies for a just transition can facilitate the process of retraining fossil fuel workers at risk. But for this to happen, the reskilling needs of fossil fuel workers must be evaluated so that financial support can be provided to help them acquire new skills. This evaluation should include assessments of the skills transferable from fossil fuel industries to the renewable energy sector to determine how many workers may be able to switch careers within the energy sector (as opposed to leaving it for another sector or choosing early retirement). Some skills are readily transferrable (such as from offshore oil and gas to offshore wind), but reskilling assistance may be needed.

The Scottish regional government's "Transition Training Fund"[201] for retraining and certification of oil and gas workers at risk of redundancy has already benefitted more than 4 000 people. Partnerships between governments and industry can be built to finance reskilling and to ensure that training content meets the evolving needs of the sector. The European Union is working on a fund of up to USD 111 billion for its coal-dependent countries.[202] Germany is considering a USD 55 billion package for regions and companies that rely on coal.[203]

Realise the job-creation potential of energy efficiency measures

Building renovation constitutes a big part of the overall stimulus package proposal. Its parts include building insulation, electrification, low-temperature heating systems, and domestic heat and electricity generation using renewables, as well as energy audits of homes and offices. Retrofits and other efficiency measures can be employment-intensive, as studies from several countries have shown.[204] These projects can be quite complex both conceptually and in execution. The project design component requires special expertise, while implementation requires skills that are more widely available. Still an important effort is needed in vocational training and learning on the job.

Best practices in France and Belgium have shown how to scale up and industrialise efficiency renovation efforts. France's national Grenelle Buildings Plan offered a role for local authorities organised as the City Jobs Alliance, which generated local action plans for training, awareness raising and the devising of local development strategies. In Belgium's Brussels capital region, the construction sector, trade unions and public authorities established the Professional Reference Centre for Construction to address skills shortages in renovation and retrofitting. The organisation brings together educational institutions and the construction sector, targeting low-skilled workers for integration in the labour market.[205]

In many developing and emerging countries, the building stock is expanding rapidly. The challenge there is less in retrofitting existing buildings, and more in integrating green technologies from the outset. This, too, creates many jobs and requires that workers are given opportunities for acquiring adequate skills.

When designing COVID-19 recovery programmes, policy makers need to preserve livelihoods and seize job-creation opportunities. They should:

- Introduce social protection measures for energy workers affected by the pandemic-induced recession.
- Create new job opportunities by leveraging local capacities for energy transition technologies all along the value chain.
- Provide reskilling opportunities for workers who have lost or are at risk of losing employment, including fossil fuel workers.
- Enhance online remote-learning opportunities to ensure continuity of education in renewable energy for students and trainees.

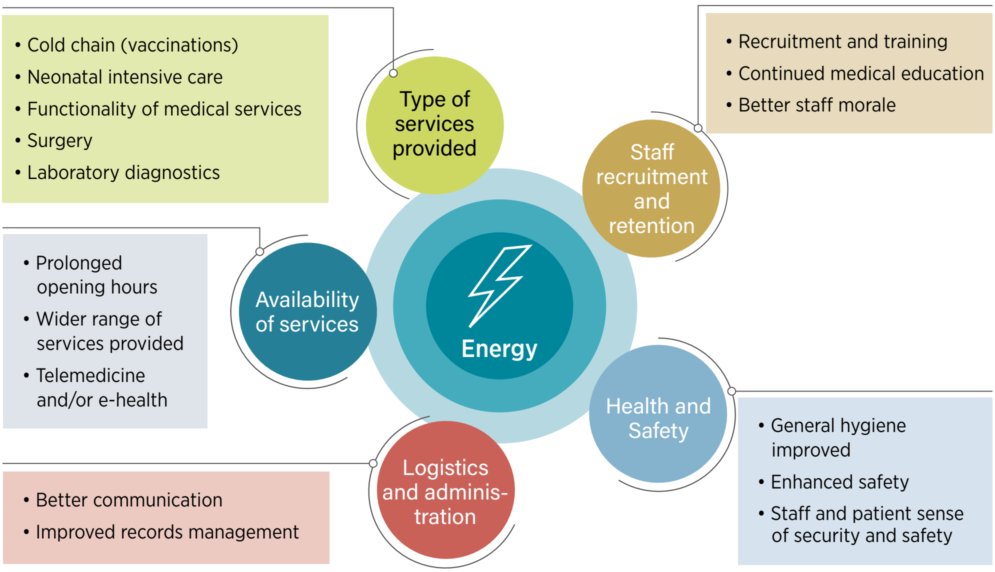
7.6 Ensuring reliable energy access amid disruptions

In the short term, adequate energy provision to critical infrastructure must be a special focus in any effective COVID-19 response. Support measures for vulnerable energy consumers (rural and urban) as well as for enterprises will protect those who have recently gained access from falling back into energy poverty.

Strengthen healthcare and other critical public infrastructure

There is an immediate short-term need to support ongoing efforts to strengthen healthcare and other critical public infrastructure in developing countries to tackle the pandemic. Reliable and sufficient energy ensures basic amenities (*e.g.*, lighting, ventilation, water supply) and powers vital medical appliances such as vaccine refrigerators and ventilators (see Figure 7.2).[206] A great many primary healthcare centres in sub-Saharan Africa operate without access to electricity or resort to unreliable and costly diesel backup generators. Distributed renewable energy solutions can permit healthcare centres to improve their level of care; they should be rapidly deployed. Such solutions also ensure access to water and sanitation services and continued operation of critical infrastructure such as mobile testing centres and laboratories, as well as the cold supply chains (*e.g.*, for vaccines) on which so many healthcare services rely.

Figure 7.2 Energy for health services



Source: IRENA (n.d.), *Off-grid renewables supply life-saving power to rural health centres*, International Renewable Energy Agency, Abu Dhabi.

Distributed renewables can supply energy for hospitals, health centres and other public services

Many emerging countries host a robust, dynamic ecosystem of distributed renewable energy technologies that can be leveraged too improve energy supply for urban and rural hospitals, in addition to isolation centres, rural health centres, and other critical public infrastructure.[207] Nigeria's Rural Electrification Agency, over a span of two weeks, installed four solar-hybrid mini-grids to power isolation centres across the country, each with over 100 beds.[208] India and other countries have developed and deployed solar-powered, mobile COVID-19 testing facilities.

Several initiatives and dedicated funding programmes are already in place to support scale-up. All On has operationalised a N180 million fund in Nigeria, while Power Africa/USAID has launched a grant competition known as Solar Electrification of Healthcare Facilities to support projects that improve readiness and resilience in rural, peri-urban and urban areas of sub-Saharan Africa. Under the Health and Energy Platform for Action, the World Health Organization (WHO) is working with Gavi, the Vaccine Alliance to leverage an existing programme of solar refrigeration of vaccines (officially called the Cold Chain Equipment Optimization Platform) to power other healthcare equipment. Working with the World Bank, IRENA, and SEforALL, WHO is also leading a global assessment to establish a baseline of data on rural clinic electrification.[209]

Programmes designed to scale up the adoption of energy solutions for the health sector must strike a balance between urgency and long-term sustainability. Public health facilities have limited budgets, so an adaptable delivery model must be identified to meet the growing energy needs of health facilities and ensure operational sustainability. In particular, the capital and recurring expenses related to electricity should be budgeted as part of healthcare facility operations from the outset. This has also been a key finding of IRENA's ongoing work on the energy-health nexus in partnership with WHO, the United Nations Foundation, SEforAll, and the UN Development Programme, among others.[210]

Support vulnerable consumers and energy enterprises

In countries with many vulnerable, low-income energy consumers, demand-side support will be needed to address reductions in citizens' ability to pay for energy services. To avoid being disconnected from electricity service for non-payment of tariffs (especially for critical institutions), off-grid service companies and utilities may want to consider deferred or flexible payment measures that ease burdens in the short term. Several pay-as-you-go operators are now offering grace periods for reliable customers, rescheduling payment plans by extending the term, reducing payment amounts and imposing a moratorium on repossessions.[211] Similar measures are also needed for vulnerable consumers who may otherwise return to using traditional fuels if they can no longer afford clean cooking fuel.

Energy service providers offering consumer relief will need to be backed by governments for effective implementation of support measures within their service areas.[212] Such measures will complement income support and other social protection measures already announced by several governments (*e.g.*, rural employment guarantee schemes, direct benefits transfer). With government and energy service providers co-ordinating their efforts, the population segments having access to modern energy can be preserved for the duration of the crisis; done right, access can also be expanded to more of those still lacking it, particularly for critical infrastructure.

Hardest hit in the developing countries are micro, small and medium-enterprises. As important generators of employment, these firms will require support during and in the aftermath of the pandemic. Such support measures include dedicated concessional credit lines, financial support for wages, payment of short-term allowances, tax cuts and direct financial support, and restructurings of existing loans. The many off-grid companies falling into these categories are likely to benefit from economy-wide measures introduced by governments.[213]

The cause of expanding access to modern forms of energy requires dedicated and tailored financing solutions focused on energy service companies. Enterprises working to expand access – such as companies that provide solar home systems, manage mini-grids, or manufacture and distribute appliances – need grants, bridge loans, and operating capital.[214] Governments are encouraged to consult with local actors and other sector stakeholders and to introduce dedicated funding facilities.

Several dedicated funding facilities for off-grid companies have already been announced. Donors, foundations and other financing institutions are making them operational to ensure that the lights stay on for the 470 million people who depend on off-grid solar solutions. The COVID-19 Energy Access Relief Fund, managed by SunFunder, is designed as a EUR 100 million concessionary debt fund to support off-grid energy companies facing a liquidity crunch due to the ongoing crisis.[215]

In Kenya, the REACT Relief Fund, operated by the Annie E. Casey Foundation, has set aside USD 2 million for emergency grants to support locally registered and operated businesses in the off-grid sector. Funding must be fully inclusive, so both local and international enterprises can benefit.[216]

In addition to the support described above, pre-pandemic measures for the renewable energy sector should be continued. Several countries – among them Indonesia, Kenya, Nigeria and Rwanda – have introduced fiscal incentives such as exemptions from value-added taxes and import duties for renewable energy equipment.[217]

When designing response measures, policy makers need to ensure reliable energy access amid disruptions. They should:

- Deploy distributed renewable energy solutions to support COVID-19 responses and strengthen the scale and resilience of health, sanitation and other critical infrastructure.
- Devise a sustainable delivery and financing model that balances immediate needs with long-term sustainability.
- Engage cross-sector partnerships through platforms and programmes, such as the Health and Energy Platform for Action and GAVI, to mobilise rapid responses.
- Ensure that vulnerable populations with access to electricity and clean cooking fuels do not fall back on traditional fuels due to income shocks.
- Support utilities and distributed energy enterprises to introduce relief measures for vulnerable energy consumers, such as deferred or restructured payments.
- Meet the immediate financing needs of distributed energy enterprises for bridge loans, operating capital and grants.
- Address logistical challenges faced by energy enterprises to service existing customers in off-grid areas.
- Maintain and strengthen fiscal incentives and support mechanisms for expanding access to modern forms of energy.
- Ensure that traditional gender-based inequalities, including barriers to access to financing, are considered in COVID-19 support programmes for vulnerable consumers and enterprises.

08 | ENERGY TRANSITION INVESTMENTS DRIVING SHORT-TERM RECOVERY

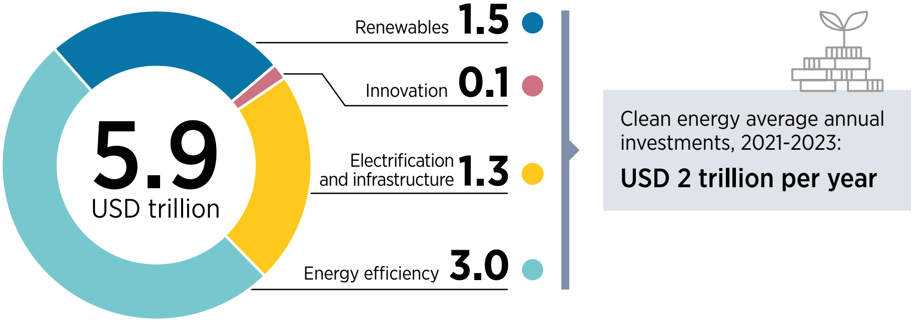
Underpinned by the policy measures discussed above, investment in the energy transition could become a vital enabler of recovery efforts in the coming three years. In the short term, priorities may be slightly different from the medium and long-term goals of the transition (*e.g.*, in prioritising investments that are easy to scale up). Similarly, in the short term, the maturity of a given technology becomes much more important, owing to the greater availability of equipment and expertise, a larger pipeline of projects, and easier access to finance at the regional and country levels.

Considering the practical constraints on the rapid increase in investment in the energy transition, and based on IRENA's Transforming Energy Scenario, global investment in transition-related technologies[218] could reach an annual average of nearly USD 2 trillion per year between 2021 and 2023 (Figure 8.1). This would be more than double the amount invested in 2019,[219] with cumulative investment of USD 5.9 trillion over the next three years. And this would be just the start, as annual investment would have to re-join the path toward the 2030 horizon and ramp up to an average of USD 4.5 trillion per year for the rest of the decade to ensure consistency with the long-term perspective of IRENA's *Global Renewables Outlook*.

Government interventions will be critical in coming years both to react to the disruption caused by the pandemic and to set the energy transition on track to achieve internationally agreed goals. The next three years need to bridge the recent shortfall of investment and then continue to grow at the levels necessary for the energy transition to occur. Importantly, interventions must be persuasive enough to raise investor confidence to the levels needed to mobilise the massive amounts of private sector funding required to achieve the 2030 targets of the Paris Agreement and IRENA's Transforming Energy Scenario.

Figure 8.1 Energy transition investment under the IRENA Transforming Energy Scenario, 2021-2023

Cumulative clean energy investments between 2021 and 2023 in the Transforming Energy Scenario (USD_{2019} trillion)



Based on IRENA (2020), *Global Renewables Outlook: Energy Transformation 2050*.

Note: "Electrification and infrastructure" includes investment in power grids, energy flexibility, electrification of heat (heat pumps) and transport applications (EVs, charging infrastructure for EVs and battery facilities); "Energy efficiency" includes efficiency measures deployed in end-use sectors (industry, buildings and transport) and investment needed for building renovations and structural changes (excluding a modal shift in transport); "Renewables" include investment needed for deployment of renewable technologies for power generation as well as direct end-use applications (e.g., solar thermal, geothermal); "Innovation" includes investment needed for renewable hydrogen production and deploying innovative industrial processes. The investment figures are estimated considering historical investment and needed cumulative investment from 2021 to 2023 to align with the Transforming Energy Scenario 2030 outlook presented in IRENA's *Global Renewables Outlook*. The USD values are 2019 dollars.

In the **power sector** alone, average investment of around USD 729 billion per annum over the next three years would set the sector onto a path consistent with meeting the global climate goals (Table 8.1). This is 26% higher than the average investment in renewable power generation technologies and the grid between 2017 and 2019 (USD 519 billion per year). The target is achievable but would require double-digit growth rates for all energy transition technologies. Most of the investment would be in new renewable power generation capacity (58%), with investment in electricity transmission and distribution grids (both grid expansion and flexibility measures) accounting for the balance (42%). Solar PV (USD 167 billion per year), onshore wind (USD 115 billion per year), hydro (USD 55 billion per year) and offshore wind (USD 43 billion per year) offer the greatest stimulus potential, but national circumstances will obviously affect such choices.

Table 8.1 New investment needs for renewable energy and grids by sector and technology group, annual averages, 2017-2019 and 2021-2023

			Average annual investments		
			Historical	Projections	
			USD billion/yr	USD billion/yr	Share of total
			2017-2019	2021-2023	
Power	Power generation capacity	Hydro (excl. pumped)	22	55	7.6%
		Bioenergy	13	35	4.8%
		Solar photovoltaic	115	167	23.0%
		Concentrating solar power	3	4	0.5%
		Wind, onshore	80	115	15.8%
		Wind, offshore	18	43	5.9%
		Geothermal	3	3	0.4%
		Marine and others	0.02	0.02	0.0%
	Grids and flexibility	Electricity network	271	287	39.4%
		Storage	4	20	2.7%
End uses and district heat	Renewables end uses and district heat	Biofuels, supply	2	9	12.5%
		Renewables, direct uses and district heat	31	61	87.5%
	Energy efficiency	Buildings	139	693	68.6%
		Industry	45	182	18.0%
		Transport	65	136	13.5%
	Electrification	Charging infrastructure for Electric Vehicles	2	20	14.4%
		Electric Vehicles and battery manufacturing		100	72.2%
		Heat pumps	12	19	13.4%
	Innovation	Green hydrogen – Electrolysers	0	8	28.6%
		Industrial processes		20	71.4%
		Total	**824**	**1 975**	

Note: Historical investment in power generation capacity is based on IRENA findings; other historical investment figures are based on IRENA analysis and IEA (2020), *World Energy Investments 2020*, International Energy Agency, Paris. Future projections are based on IRENA analysis.

Rising solar and wind use require increasing power-system flexibility

The accelerated growth in variable renewable electricity needs to be accompanied by investment in the enablers of flexible systems, such as generation flexibility (*e.g.*, storage), transmission and distribution grid operation, and smart power systems. National and regional circumstances will have to be taken into account, which means investment levels will inevitably differ from the overall global average.

Buildings would receive the greatest share of energy efficiency investment, at USD 693 billion per year.[220] Construction companies (large and small), heating and cooling equipment producers, and manufacturers of energy efficiency products (from insulation to windows), as well as their supply chains, would all benefit from this investment. In addition to its stimulus value, investment in energy efficiency can help support the low-income groups hardest hit by the pandemic effects by reducing their ongoing utility bills. Many energy efficiency improvements pay back quickly.

Transition-related investment in the industry sector could provide a stimulus of USD 234 billion per year from 2021 to 2023. More than 70% of such investment would go to improve efficiency in industrial processes and applications, with the balance directed to direct uses of renewables, such as solar thermal water heaters and heat pumps.

Investments in **transport** represent nearly 13% of global clean energy investment potential over the coming three years. The EV public charging infrastructure could support investment of nearly USD 20 billion per year – nearly ten-fold more than current levels.[221] If home charging and office charging points are included, this number can multiply. For electric vehicles themselves (and in the supply chains for these vehicles), a further investment of nearly USD 100 billion per year is needed.

Stimulus and recovery plans present an opportunity to kick-start several innovative technology solutions that are integral to the energy transition over the medium to long term, but which are presently at an early stage of deployment. Investments now in green hydrogen production and innovative, carbon-free industrial processes could yield handsome dividends by hastening progress toward these crucial energy transition solutions. On the other hand, a limited role of CCS in the energy transitions, totalling less than 1% in 2030, as well as the complexity of these projects, make it a less attractive investment option.

8.1 Aligning short-term measures with domestic policy priorities

Policy makers can multiply benefits by aligning their choices for short-term investment support under recovery packages with domestic policy priorities. The options for investment in the energy transition are varied across sectors and in scale, maturity, geographic relevance, ownership, soundness of local and global supply chains, and in how they would be financed and operated. This heterogeneity allows policy makers a great deal of latitude when considering the balance of energy transition components in recovery packages.

To assist policy makers in identifying the best policy options for a recovery package, IRENA has undertaken a quantitative and qualitative assessment of energy transition investment, together with a range of criteria that are relevant to domestic economic, social and environmental policy priorities.

None of the investment recommended under the Transforming Energy Scenario is optional over the long term, in the sense that the overall carbon budget must be respected if the Paris Agreement goals are to be met. Meeting the Paris Agreement goals requires policy makers to commit to all the recommended energy transition investment. Options may be substitutable, but they must achieve the same emissions reductions in each investment area.

Nevertheless, given the purpose of government interventions in support of economic recovery over the next few years, there is significant scope for flexibility in the short-term balance of investment priorities chosen at the country level. The criteria described in Box 8.1 address the most important considerations in the current environment and show how they pertain to energy transition investment.

In Table 8.2, these criteria are applied to the global potential for short-term energy transition investment for 2021-2023, drawing on the data contained in IRENA's *Global Renewable Outlook* and related analysis by the agency. The range of colour – from dark blue to violet, through to green to yellow – represents a scale of increasing compatibility with the criteria. A dark blue colour for timeliness, for instance, means that investment could be accelerated rapidly, while orange would signal that little additional investment could be accelerated in the short term. Orange hues are not warning signs, but markers on a relative scale.

The qualitative assessment of some of the criteria might change if the assessment were conducted at the country level, rather than at the global level. For instance, countries with domestic manufacturing hubs for some technologies would score higher in jobs, balance of payments and local content. The analysis presented here should therefore be considered indicative.

Though a mix of quantitative and qualitative assessments at the global level, the analysis highlights the crucial point that different investment areas may be suited to specific policy goals. The criteria therefore help identify how each of the investment areas in the energy transition may be suited to a greater or lesser extent to an individual country's recovery measures, depending on the immediate and unique challenges the country faces over the coming three years. For policy makers having to choose what investment area to prioritise in their packages, this high-level analysis provides insights into what areas to investigate more closely in light of their recovery goals and their government's existing economic, social and environmental policies.

Box 8.1 Criteria for assessing the recovery value of various investment areas over the period 2021-2023

- **Economic value of the stimulus.** This refers to the power of a given investment to boost the economy in the short term. A larger overall investment potential in a given area results in a higher score (considering that the investments must be replicable and scalable). A higher rating means that investment that can be ramped up significantly without inflating costs if appropriate policies are implemented.

- **Timeliness.** How quickly an investment can flow into the real economy is a crucial criterion for accelerating recovery. Timeliness relates to the lead times for major expenditure. For example, a utility-scale solar PV project can often be completed in a year following the initial investment decision, while rooftop solar PV can go from customer contact to completion in a matter of months. In contrast, offshore wind tends to have lead times measured in years. This criterion also considers the barriers to widespread implementation, whether due to stakeholder co-ordination (*e.g.*, principal-agent problems) or to regulatory, permitting and policy barriers that must be overcome.

- **Job creation.** This refers to the overall employment-creation potential of energy transition technologies, as well as their greater labour intensity relative to fossil fuel technologies. With unemployment numbers rising because of the global pandemic, prioritising investment that supports job creation most effectively is a key objective of recovery efforts.

- **Local value creation.** This refers to the share of local and national inputs into economic activity along the value chain of renewable energy technologies. It is based on efforts to leverage and enhance domestic capabilities and results in socio-economic benefits for the domestic economy, including job creation.

- **Environmental benefits.** This criterion highlights the economic and societal benefits of addressing the often-hidden costs of environmental damage, local pollution and ill health. Market costs also fail to account for the intergenerational issues of local and global ecosystems services. Investing in technologies that mitigate these failures would bring immediate and long-term benefits over and above their impact on economic recovery. For instance, better air quality and health benefits are by-products of technologies that reduce fossil fuel combustion.

Governments can consider multiple criteria in setting energy transition priorities

- **Innovation push.** This criterion rates investment areas on their potential to increase the adoption of innovative technologies and their spill-overs on other technologies. It rates a short-term investment for its relevance in supporting the development and accelerated adoption of innovative technology solutions necessary for the energy transition (*e.g.*, electrolysers, novel storage concepts, clean industrial production processes, etc.). Investments that scored high on this measure would accelerate the adoption of innovative technologies through economies of scale and technology learning investments to reduce unit costs. Accelerating innovative technology solutions in recovery packages can align near-term investment with the long-term energy transition and create a multiplier effect in the medium to long term.

- **Leveraging private capital.** To provide the greatest benefit to the economic recovery stimulated by public spending for the energy transition, public funds will have to be efficient in leveraging private capital. Thus, public spending for technologies or measures which have a high potential to leverage private investment spending should be prioritised.

- **Structural change.** Some investments address the structural barriers to the energy transition. This is particularly true for critical infrastructure. Investments designed to enable the grid to accommodate very high shares of VRE, electric vehicle charging, and green hydrogen supply infrastructure are some examples. Investment areas that score higher on this criterion are contributing proportionately more to achieving structural changes.[222]

- **Energy access.** This is an indicator of opportunities to accelerate rural electrification based on mini-grids and other off-grid energy solutions. Distributed generation solutions can trigger socio-economic development in off-grid and remote areas.

Table 8.2 Short-term criteria results

Sector	Investment	Criteria: Stimulus value	Timeliness	Job creation	Local value creation	Environ-mental benefits
Power generation capacity	Hydro (excl. pumped)					
	Solar PV (Utility and rooftop)					
	Wind onshore					
	Wind offshore					
	Biomass (total)					
	CSP					
	Geothermal					
	Marine and others					
Grids & flexibility	Electricity network					
	Pumped hydro					
	Smart meters					
	Storage					
Buildings	Energy efficiency					
	Heat pumps					
	Renewables direct use					
District heating	District heating					
Transport	Biofuel supply					
	Energy efficiency					
	EV charging infrastructure					
Industry	Energy efficiency					
	Heat pumps					
	Hydrogen electrolysers					
	Renewables in direct uses					
Innovation	Zero-carbon industrial processes					

Lower to higher value/contribution

0.1 — 5.0

	Fostering innovative technologies	Leveraging private capital	Infrastructure for structural change	Electricity access	**Investment**	**Sector**
					Hydro (excl. pumped)	**Power generation capacity**
					Solar PV (Utility and rooftop)	
					Wind onshore	
					Wind offshore	
					Biomass (total)	
					CSP	
					Geothermal	
					Marine and others	
					Electricity network	**Grids & flexibility**
					Pumped hydro	
					Smart meters	
					Storage	
					Energy efficiency	**Buildings**
					Heat pumps	
					Renewables direct use	
					District heating	**District heating**
					Biofuel supply	**Transport**
					Energy efficiency	
					EV charging infrastructure	
					Energy efficiency	**Industry**
					Heat pumps	
					Hydrogen electrolysers	
					Renewables in direct uses	
					Zero-carbon industrial processes	**Innovation**

Lower to higher value/contribution

0.1 5.0

The analysis of the short-term stimulus potential of investment in the energy transition yields some broad conclusions:

- The deployment of small, modular technology solutions (from rooftop solar PV to solar home systems and heat pumps) can be scaled up relatively quickly and boost employment and GDP in a timely manner.
- Utility-scale solar PV, onshore wind and offshore wind score well across the criteria, given their maturity, expanding supply chains and relative ease of deployment.
- Energy efficiency could be a major part of recovery packages, but the broad category subsumes easy-to-accelerate options (like appliance efficiency) with big-ticket programmes such as deep energy efficiency retrofits for existing buildings, where the complex task of engaging stakeholders and scaling up programmes rapidly are challenging in the short term even though the changes would provide large multi-year volumes of investment.
- Investments in transport, industry and buildings are quite heterogenous, but there are common elements in direct uses of renewable energy (such as solar thermal water heaters and heat pumps) and energy efficiency for industry and buildings that could yield useful synergies. Because addressing end uses is essential for decarbonisation in the long term, an early acceleration over the medium term using green stimulus funds could yield large benefits.
- With progress on the decarbonisation of power generation, certain electrification investments – in EV-charging infrastructure and heat pumps in residential and commercial buildings and for low-temperature heat in industry – could play a key role in accelerating sector coupling benefits.

Renewable-based power, end-uses and electrification all help to reduce emissions

Investments can often be accelerated at little additional cost

In all cases, the deployment of a given technology may have to contend with market, regulatory and policy barriers. Removal of such barriers is often a low-cost way to accelerate investment. For instance, streamlining permitting and environmental procedures or accelerating timelines could unlock many gigawatts of projects stuck in pipelines around the world.[223]

A range of investments in innovative technologies (from electrolysers to new low-carbon industrial processes) could be used to scale up recovery efforts. In some cases, this could occur rapidly, though from low starting points; the importance of such investments in unlocking greater emissions reductions in the future could be significant. But more immediate synergies might be more tempting, ones yielding immediate economic and decarbonisation benefits. For instance, if investment paired stationary battery storage with distributed and utility-scale solar PV, thereby supplying business models for flexible provision to the grid, this could have a major economic impact.

Large infrastructure projects to expand grids and build large hydropower projects may not yield large volumes of investment over the next six months. But over the medium term they could absorb a great deal of investment and create many jobs.

Some countries could easily expand existing deployment programmes or extend support premiums for projects that can deliver in 2020 and 2021. Where speed is essential, this will be the best approach. Where additional support policies need to be enacted, however, longer time horizons must be anticipated. In leveraging public funds to elicit private investment, governments may have to trade off the generosity of the incentive against the timeliness of the investment. There will be many opportunities, especially for wind and solar technologies, to accelerate investment at little or no incremental cost, given that they are already the most competitive choice for new power generation in many countries.

09 | IMMEDIATE EMPLOYMENT AND GROWTH BENEFITS

The 2030 energy transition pathway (IRENA's Transforming Energy Scenario) clearly promises significant benefits in support of a reinvigorated economy and employment creation. It would boost GDP by an average pf 1.3% annually over the 2020-2030 period and create an additional 19 million transition-related jobs by 2030 compared to current plans and policies (IRENA's Planned Energy Scenario).[224]

The economic devastation following the pandemic leaves no doubt about the need for immediate benefits, which are essential to counteract large job losses and heightened uncertainties. An investment package tied to the energy transition can help to overcome the unprecedented economic slump and create numerous, much-needed jobs in the short-term.

As IRENA analysis confirms, socio-economic benefits would already accrue in the first three years of recovery programmes, while simultaneously accelerating the needed energy transition, assuming the required investment can be mobilised and nimble recovery policies put in place. Indeed, recovery investment linked to the energy transition would boost GDP by an additional 1% on average.

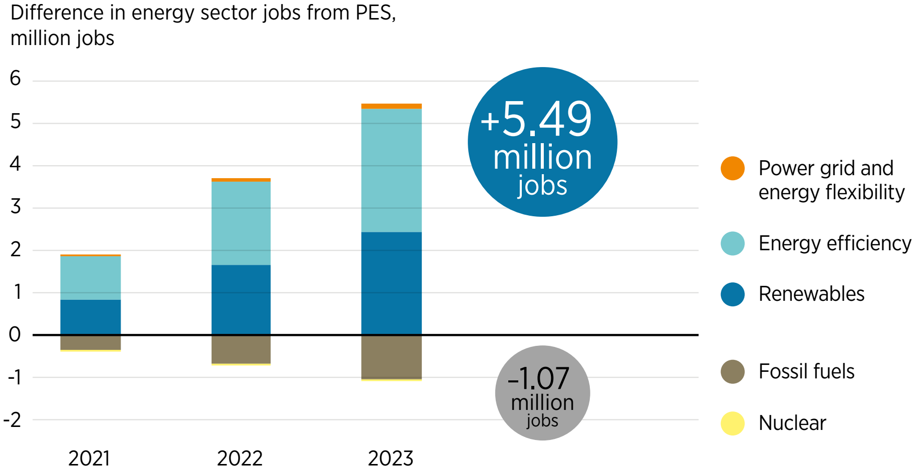
The employment analysis, like the GDP analysis, builds on the results from a global macro-econometric model with high regional and sectoral resolution.[225] The results presented for employment in the energy sector include direct and indirect jobs through all segments of the value chain (manufacturing, construction, installation, and operation and maintenance). Induced jobs due to resulting economic activity are also evaluated and reported in the economy-wide employment results (see Global Renewables Outlook, 2020). The jobs presented for each year represent all those resulting from former or current investment as well as labour market dynamics.[226]

The benefits of the transition would increase with time (see Figure 9.1), so that by the third year the additional jobs created in the Transforming Energy Scenario over the Planned Energy Scenario in transition-related technologies would substantially exceed the three-year average. Specifically, the annual total for 2023 could reach 5.49 million, including 2.46 million in renewables, 2.91 million in energy efficiency and 120 000 in grids and system flexibility, while conventional energy jobs would fall by 1.07 million. Investment in transition-related technologies would, therefore, provide a net positive balance of 4.42 million jobs.

These estimates refer to the additional jobs created through the investment stimulus linked to the Transforming Energy Scenario, on top of those already set to be created the Planned Energy Scenario.[227] Notably, the total increase in transition-related jobs compared to current employment levels would be higher. Compared to 2020, the Transforming Energy Scenario would create 12.19 million additional transition-related jobs by 2023.

The specifics vary from region to region and country to country – whether in terms of underlying structural conditions, the specific opportunities that can be pursued, or the likely scope of policy ambition. Yet what emerges very clearly are the energy transition's contributions to annual GDP and welfare. Looking more deeply, these benefits reflect the comparatively high employment intensities of renewables and other transition-related technologies; the vast potential for short-term employment; the opportunity for a net gain in jobs across the energy sector; the specific role that solar energy and biofuels can play in expanding employment; and the positive employment effects seen across different segments of the value chain.

Figure 9.1 Changes in energy sector jobs resulting from transition-related investment, 2021-2023
(Transforming Energy Scenario compared to Planned Energy Scenario)



Based on IRENA analysis

PART III

WAY FORWARD

This Post-COVID recovery agenda offers a comprehensive set of investment and policy responses to the combined challenges of a global health and economic crisis and climate change. Recovery measures after COVID-19 come at a unique moment. The pandemic has forced a dramatic break with business as usual. It has exposed the vulnerabilities inherent in an economic system that puts relentless stress on the natural world and leaves many people behind.

The situation also exposes structural connections between the current COVID-19 crisis and the less immediate, but no less urgent climate crisis. Piecemeal responses will not suffice in either case. The global agenda needs to be comprehensive, systemic, and transformative.

WAY FORWARD

To address the hopes and aspirations of people around the globe, post-COVID policies must aim for greater social justice, economic equality and a better quality of life for all. This implies fostering sustainable economic development; rediscovering the true value of essential activities and services; and learning to live in accord with nature.

Many of the technologies already at hand can help to create a cleaner and safer world. The necessary financial resources could also be marshalled. Yet the transformation of the energy system cannot be left to markets alone. It will take visionary government action and an empowered citizenry, driving sustained and inclusive public dialogue that sets core objectives and informs co-ordinated transition strategies.

Robust, dedicated institutions are essential to drive change at the required scale and pace. Governments must find ways to harness the technical, economic, social and environmental expertise available across all parts of society – whether in ministries academia, or non-governmental organisations – and ensure cohesion and unity of purpose. True solutions demand wisdom and a holistic view as much as they require nuts-and-bolts technical understanding.

The crisis underlines the axiom that no country exists in isolation. Resolving the COVID-19 crisis, like resolving the climate crisis, requires strong international co-operation. Through a vigorous multilateral approach, the response can draw on the capabilities and resources of countries around the world; make certain that lessons and solutions are shared; and ensure that no region, country or community is left behind. The entire world now needs to act in solidarity.

The pursuit of perpetual economic growth has stretched the boundaries of the planet's carrying capacity. This increasingly brings humanity in conflict with the natural world, causing continual disruption of the ecosystems that make our planet habitable.

The investments and policy measures proposed in this agenda can move humanity closer to a much cleaner energy future. Along the way, we may need to keep asking ourselves how much energy, and what sort of economic activity, is necessary to provide adequate incomes and sufficient quality of life for everyone.

As much as COVID-19 has imposed unforeseen suffering and risks, this unique moment may also be understood as a gift. The time-out forced upon us affords the opportunity to evaluate how we can move forward into a sustainable and equitable future.

ENDNOTES | PART I

Chapter 01

1 ILO (International Labour Organization) (2020), *ILO Monitor: COVID-19 and the World of Work. Fourth edition*, Geneva, 27 May, www.ilo.org/wcmsp5/groups/public/@dgreports/@dcomm/documents/briefingnote/wcms_745963.pdf.

2 OECD (2020), *Evaluating the initial impact of COVID-19 containment measures on economic activity*, OECD, 14 April, www.oecd.org/coronavirus/policy-responses/evaluating-the-initial-impact-of-covid-19-containment-measures-on-economic-activity-b1f6b68b/ (accessed 23 May).

3 Gopinath, G. (2020), *The Great Lockdown: Worst Economic Downturn Since the Great Depression, IMF Blog*, www.blogs.imf.org/2020/04/14/the-great-lockdown-worst-economic-downturn-since-the-great-depression/.

4 World Bank (2020), *Global Economic Prospects*, World Bank Group, June, Washington, D.C., www.worldbank.org/en/publication/global-economic-prospects.

5 Kiss-Dobronyi (2020), *Coronavirus: initial results from economic modelling, Cambridge Econometrics*, e3me, 16 April, www.e3me.com/developments/economic-impacts-coronavirus-e3me/.

6 OECD (2020), *OECD Economic Outlook, Volume 2020 Issue 1: Preliminary version*, www.oecd-ilibrary.org/economics/oecd-economic-outlook/volume-2020/issue-1_0d1d1e2e-en.

7 Rhee, C.Y. (2020), *COVID-19 Pandemic and the Asia-Pacific Region: Lowest Growth Since the 1960s, IMF Blog*, 15 April, www.blogs.imf.org/2020/04/15/covid-19-pandemic-and-the-asia-pacific-region-lowest-growth-since-the-1960s/.

8 Cheng, E. (2020), *Roughly 5 million people in China lost their jobs in the first 2 months of 2020*, CNBC, 16 March, www.cnbc.com/2020/03/16/china-economy-millions-lose-their-jobs-as-unemployment-spikes.html.

9 BEA (Bureau of Economic Analysis, US Department of Commerce) (2020), *Gross Domestic Product, 1st Quarter 2020 (Second Estimate); Corporate Profits, 1st Quarter 2020 (Preliminary Estimate)*, 28 May, www.bea.gov/news/2020/gross-domestic-product-1st-quarter-2020-second-estimate-corporate-profits-1st-quarter.

10 Federal Reserve Bank of Atlanta (2020), *GDPNow*, 9 June, www.frbatlanta.org/cqer/research/gdpnow.

11 Stevis-Gridneff and Ewing (2020), *E.U. Is Facing Its Worst Recession Ever. Watch Out, World, New York Times*, 6 May, www.nytimes.com/2020/05/06/business/coronavirus-europe-reopening-recession.html.

12 World Bank (2020), *The Global Economic Outlook During the COVID-19 Pandemic: A Changed World*, www.worldbank.org/en/news/feature/2020/06/08/the-global-economic-outlook-during-the-covid-19-pandemic-a-changed-world.

13 UNCTAD (United Nations Conference on Trade and Development) (2020), *Impact of the Covid-19 Pandemic on Global FDI and GVCs, Investment Trends Monitor*, March 2020, www.unctad.org/en/PublicationsLibrary/diaeiainf2020d3_en.pdf.

14 CCSA (Committee for the Coordination of Statistical Activities) (2020), *How COVID-19 Is Changing the World: A Statistical Perspective*, www.unstats.un.org/unsd/ccsa/documents/covid19-report-ccsa.pdf.

15 Lin, J., and C. Lanng (2020), *Here's how global supply chains will change after COVID-19, World Economic Forum*, 6 May, www.weforum.org/agenda/2020/05/this-is-what-global-supply-chains-will-look-like-after-covid-19/.

16 Qiang, C.Z, Y. Liu, M. Paganini, and V. Steenbergen (2020), *Foreign direct investment and global value chains in the wake of COVID-19, World Bank Blogs*, 1 May, www.blogs.worldbank.org/psd/foreign-direct-investment-and-global-value-chains-wake-covid-19.

17 ILO (2020), *ILO Monitor.*

18 World Bank (n.d.), "Poverty", www.worldbank.org/en/topic/poverty/overview.

19 Mahler, D.G., C. Lakner, R.A. Castaneda Aguilar, and H. Wu (2020), *The impact of COVID-19 (Coronavirus) on global poverty: Why Sub-Saharan Africa might be the region hardest hit, World Bank Blogs*, 20 April, www.blogs.worldbank.org/opendata/impact-covid-19-coronavirus-global-poverty-why-sub-saharan-africa-might-be-region-hardest.

20 World Bank (2020), *Poverty and Distributional Impacts of COVID-19: Potential Channels of Impact and Mitigating Policies*, Washington, DC, www.pubdocs.worldbank.org/en/980491587133615932/Poverty-and-distributional-impacts-of-COVID-19-and-policy-options.pdf.

21 Staab, S. (2020), *COVID-19 sends the care economy deeper into crisis mode, UN Women*, 22 April, www.data.unwomen.org/features/covid-19-sends-care-economy-deeper-crisis-mode; Moreira da Silva, J. (2020), *Why you should care about unpaid care work*, OECD Development Matters, 18 March, www.oecd-development-matters.org/2019/03/18/why-you-should-care-about-unpaid-care-work/.

22 ILO, *ILO Monitor.*

23 Cheng (2020), *Roughly 5 million people.*

24 Arnold, M. (2020), *Over 30m workers in Europe turn to state for wage support, Financial Times*, 28 April.

25 Cohen, P. (2020), *'Still catching up': Jobless numbers may not tell full story, New York Times*, 28 May, www.nytimes.com/2020/05/28/business/economy/coronavirus-unemployment-claims.html.

26 ILO (2020), *ILO Monitor*.

Chapter 02

27 IEA (International Energy Agency) (2020), *Global Energy Review 2020*, www.iea.org/reports/global-energy-review-2020.

28 IEA (2020), *Global Energy Review 2020*.

29 Wearden, G. (2020), *Brent crude plunges to 18-year low as oil slump rattles markets – as it happened, The Guardian*, 21 April, www.theguardian.com/business/live/2020/apr/21/markets-oil-slump-ftse-uk-unemployment-rises-covid-19-business-live.

30 Sheppard, D. et al. (2020), *US oil price below zero for first time in history, Financial Times*, 21 April, www.ft.com/content/a5292644-958d-4065-92e8-ace55d766654 (subscription required).

31 Bond, K. (2020), "Was 2019 the peak of the fossil fuel era?", Carbon Tracker Initiative, 1 May, www.carbontracker.org/was-2019-the-peak-of-the-fossil-fuel-era/.

32 Lewis, M. (2020), *Why we may have already seen the peak in oil demand, Financial Times*, 17 April, www.ft.com/content/bea183be-779c-491b-8ec6-f05da9fa5337 (subscription required).

33 Horowitz, J. (2020), *The world may never recover its thirst for oil, CNN Business*, 29 April, www.edition.cnn.com/2020/04/29/economy/oil-demand-peak/index.html.

34 Mallet, V. (2020), *EU carbon emissions tumble during lockdowns, Financial Times*, 8 April, www.ft.com/content/4c59fd16-6020-4798-b8f1-5df686bbd97a (subscription required).

35 Rystad Energy (2020), *Above a million OFS jobs will likely be cut in 2020 as COVID-19 and low oil price take toll*, 25 March, www.rystadenergy.com/newsevents/news/press-releases/above-a-million-ofs-jobs-will-likely-be-cut-in-2020-as-covid-19-and-low-oil-price-take-toll/.

36 Keane, K. (2020), *Coronavirus: 'Thousands' of North Sea oil and gas jobs under threat, BBC News*, 28 April, www.bbc.com/news/uk-scotland-scotland-business-52446555.

37 Brower, D. (2020), *US oil production drop steeper than expected, Financial Times*, 22 May.

38 US Bureau of Labor Statistics (2020), *Industries at a Glance: Mining, Quarrying, and Oil and Gas Extraction: NAICS 21*, www.bls.gov/iag/tgs/iag21.htm (accessed 23 May).

39 Zogopoulos, E. (2020), *Negative oil prices: 'There will be blood', Energy Industry Review*, 27 April, www.energyindustryreview.com/analysis/negative-oil-prices-there-will-be-blood/.

40 Middle East Oil and Gas (2020), *COVID-19 triggers delays in projects and investment decisions in global LNG liquefaction sector*, www.oilandgasmiddleeast.com/products-services/36660-covid-19-triggers-delays-in-projects-and-investment-decisions-in-global-lng-liquefaction-sector.

41 Meyer, G. (2020), *Trump campaign for US coal undermined by industry slump, Financial Times*, 18 May, www.ft.com/content/39909dd4-7c6c-425e-8f05-4f6e63b60c43.

42 Watts, J. and Ambrose, J. (2020), *Coal industry will never recover after coronavirus pandemic, say experts, The Guardian*, 17 May, www.theguardian.com/environment/2020/may/17/coal-industry-will-never-recover-after-coronavirus-pandemic-say-experts.

43 Carbon Brief (2020), "Mapped: The world's coal power plants", 26 March, www.carbonbrief.org/mapped-worlds-coal-power-plants.

44 Shearer, C., et al. (2020), Boom and bust 2020: Tracking the global coal plant pipeline.

45 Watts and Ambrose, *Coal industry will never recover*.

46 Rowlatt, J. (2020), "Could the coronavirus crisis finally finish off coal?", BBC News, 9 June, www.bbc.com/news/science-environment-52968716.

47 Baxter, T. and Y. Zhe (2019), "The 14th Five Year Plan: what ideas are on the table?", *China Dialogue*, 7 August, www.chinadialogue.net/article/show/single/en/11434-The-14th-Five-Year-Plan-what-ideas-are-on-the-table-.

48 Myllyvirta, L., S. Zhang and X. Shen (2020), "Will China build more Coal to stimulate the economy?", EnergypostEU, 6 April, https://energypost.eu/will-china-build-more-coal-to-stimulate-the-economy/.

49 As governments aim to contain the economic fallout, IRENA has set out to responses in the energy sector. The data collected thus far spans 50 countries.

50 Reuters (2020), *Article: Brazil weighs $2 billion in coronavirus relief loans to power sector: sources*, Reuters, 15 May, www.reuters.com/article/us-health-coronavirus-brazil-energy/brazil-weighs-2-billion-in-coronavirus-relief-loans-to-power-sector-sources-idUSKBN22Q3CU.

51 Petrova, V. (2020), *UK govt seeks input on postponing CfD payment increase*, Renewables Now, 14 May, www.renewablesnow.com/news/uk-govt-seeks-input-on-postponing-cfd-payment-increase-698778/.

52 MNRE (Ministry of New and Renewable Energy) (2020), *Office Memorandum: MUST RUN for Renewable Energy Generating Stations*, MNRE, 4 April, www.mnre.gov.in/img/documents/uploads/file_f-1586142405322.pdf.

Chapter 03

53 IEA, *Global Energy Review 2020*.

54 IEA, *Global Energy Review 2020*.

55 Renewable Energy World (2020), "Renewables achieve clean energy record as COVID-19 hits demand", 6 April, www.renewableenergyworld.com/2020/04/06/renewables-achieve-clean-energy-record-as-covid-19-hits-demand/.

56 Energy Community (2020), *Energy Community DSOs committed to keeping lights on during COVID-19 crisis*, 21 April, www.energy-community.org/news/Energy-Community-News/2020/04/21.html.

57 Mylenka and Bohdan (2020), *Impact of Covid-19 on the global energy sector, PV Magazine*, 24 April.

58 ETEnergyWorld (2020), *3,000 MW of solar and wind energy projects face delays on Coronavirus lockdown*, 6 April, www.energy.economictimes.indiatimes.com/news/renewable/3000-mw-of-solar-and-wind-energy-projects-face-delays-on-coronavirus-lockdown/75002601.

59 Wood Mackenzie (2020), *Coronavirus: Disruption will reduce 2020 global solar PV additions by 18%*, 3 April, www.woodmac.com/reports/power-markets-coronavirus-disruption-will-reduce-2020-global-solar-pv-additions-by-18-401150 (subscription required).

60 Bridge to India (2020), *Covid-19: Impact on Global Solar Market*, www.bridgetoindia.com/report/covid-19-impact-on-global-solar-market/.

61 SEIA (Solar Energy Industries Association) (2020), "COVID-19 & the U.S. solar industry", Factsheet, 6 June, www.seia.org/sites/default/files/2020-06/2020-June-SEIA-COVID-Factsheet.pdf.

62 Gupta, U. (2020), "Covid-19 delayed 63% of India's planned big solar in first quarter", *PV Magazine*, 3 June, www.pv-magazine.com/2020/06/03/india-added-989-mw-of-pv-in-the-first-quarter/.

63 GlobalData, *Coronavirus (COVID-19) – Executive Briefing*.

64 Wood Mackenzie (2020), *Coronavirus impact update: Week of May 25*, 28 May, www.woodmac.com/reports/power-markets-coronavirus-impact-update-power-and-renewables-and-the-energy-transition-week-of-may-25-395424 (subscription required).

65 AWEA (American Wind Energy Association) (2020), *COVID 19 Impacts on American Wind Industry and Mitigation Proposals*, 18 March, www.awea.org/Awea/media/Resources/COVID-19ImpactsonWindIndustryandMitigationProposalsforHill.pdf.

66 Carr, D. (2020), *Covid-19 lockdowns hit onshore predictions, Windpower Monthly*, 1 May, www.windpowermonthly.com/article/1682056/covid-19-lockdowns-hit-onshore-predictions.

67 Wood Mackenzie (2020), *Coronavirus impact update: Week of May 25*.

68 IEA, IRENA, UNSD, World Bank and WHO (2020), *Tracking SDG 7: The Energy Progress Report 2020*, www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/May/SDG7Tracking_Energy_Progress_2020.pdf.

69 ILO (International Labour Organization) (2020), *ILO Monitor: COVID-19 and the World of Work. Fourth edition*, Geneva, 27 May, www.ilo.org/wcmsp5/groups/public/@dgreports/@dcomm/documents/briefingnote/wcms_745963.pdf.

70 IHS Markit (2020), *Article: How COVID-19 will affect global biofuels demand*, 6 April, www.ihsmarkit.com/research-analysis/how-covid19-will-affect-global-biofuels-demand.html.

71 Businesswire (2020), *Impact of COVID-19 on the Electric Vehicle Industry, 2019-2025: Deviation & Trends Analysis*, 17 April, www.businesswire.com/news/home/20200417005390/en/Impact-COVID-19-Electric-Vehicle-Industry-2019-2025-Deviation.

72 Businesswire, Impact of COVID-19 on the Electric Vehicle Industry, 2019-2025: Deviation & Trends Analysis.

73 BNEF (BloombergNEF) (2020), "Transactions" (database), BloombergNEF, Available at: www.bnef.com/fundscommitted/search (subscription required).

74 IMF (International Monetary Fund) (2020), *Regional Economic Outlook – Sub-Saharan Africa: COVID-19, An Unprecedented Threat to Development*, Washington, DC.

75 IIF (Institute of International Finance) (2020), *Capital Flows Report Sudden Stop in Emerging Markets*, IIF, Washington, D.C.

76 World Bank, *Poverty and Distributional Impacts*.

77 Morningstar (2020), *Sustainable Funds Weather the First Quarter Better Than Conventional Funds, Morningstar*, 3 April, www.morningstar.com/articles/976361/sustainable-funds-weather-the-first-quarter-better-than-conventional-funds.

78 Bloomberg (2020), *Older ESG Funds Outperform Their Newer Rivals in Market Tumult*, 13 March, www.bloomberg.com/news/articles/2020-03-13/older-esg-funds-outperform-their-newer-rivals-in-market-tumult?sref=6K2T7rH3.

79 GSIA (Global Sustainable Investment Alliance) (2018), *Global Sustainable Investment Review 2018*, Brussels,

www.gsi-alliance.org/wp-content/uploads/2019/06/GSIR_Review2018F.pdf; EY (2020), *Renewable energy sector is expected to bounce back quickly despite the impact of COVID-19*, 19 May, www.ey.com/en_gl/news/2020/05/renewable-energy-sector-is-expected-to-bounce-back-quickly-despite-the-impact-of-covid-19.

80 Euractiv (2020), Financiers join EU 'green recovery alliance', 5 May, www.euractiv.com/section/energy-environment/news/financiers-join-eu-green-recovery-alliance/.

81 IGCC (Investor Group on Climate Change) (2020), *The Investor Agenda: A Sustainable Recovery from The Covid-19 Pandemic*, IGCC, www.iigcc.org/download/ia-a-sustainable-recovery-from-the-covid-19-pandemic/?wpdmdl=3289&masterkey=5eac65344452a.

82 IRENA (2019), Renewable Energy and Jobs – Annual Review 2019, International Renewable Energy Agency, Abu Dhabi.

83 CEEW (Council on Energy, Environment and Water in India) (2020), "How could Covid-19 Dampen India's Solar Ambitions? CEEW Analysis", 16 April, www.youtube.com/watch?v=nyQr7QQIDnA.

84 SEIA (Solar Energy Industries Association) (2020), *COVID-19 Impacts on the U.S. Solar Industry*, SEIA.

85 Lavietes, M. (2020), *U.S. solar industry sheds five years of job growth amid the coronavirus*, Reuters, 19 May.

86 Islam, S. (2020), *Bangladeshi solar module companies seek Covid-19 stimulus package, PV Magazine*, 4 May, www.pv-magazine.com/2020/05/04/bangladeshi-solar-module-companies-seek-covid-19-stimulus-package/.

87 AWEA (2020), *COVID 19 Impacts on American Wind Industry and Mitigation Proposals*.

88 Vestas (2020), "To ensure strong focus on execution in 2020 and sustain long-term competitiveness, Vestas will optimise its product portfolio", news release, 20 April, www.vestas.com/en/media/company-news?l=22&n=3639268#!grid_0_content_0_Container.

89 Wood Mackenzie (2020), *Coronavirus impact update: Week of May 25*.

90 IRENA (2019), *Renewable Energy and Jobs – Annual Review 2019*.

91 Reidy, S. (2020), *Global ethanol production could drop to 2013 levels*, World Grain, 1 May, www.world-grain.com/articles/13635-global-ethanol-production-could-drop-to-2013-levels.

92 Guerra, C. (2020), *Brazil sugarcane producers seek government aid, Argus Media*, 3 April, www.argusmedia.com/en/news/2093595-brazil-sugarcane-producers-seek-government-aid; Growth Energy (2020), *Mayors across 10 states urge EPA to protect biofuel and farm jobs amid COVID-19*, 11 May, www.growthenergy.org/2020/05/11/mayors-across-10-states-urge-epa-to-protect-biofuel-farm-jobs-amid-covid-19/.

93 Growth Energy (2020), *COVID-19's impact on ethanol production: Frequently Asked Questions*, 15 May, www.growthenergy.org/2020/05/15/covid-19s-impact-on-ethanol-production-frequently-asked-questions/.

94 Dempsey, H. (2020), "Wind power boom under threat as coronavirus hits supply chains", *Financial Times*, 29 April.

95 Cañadas-López, Á., Rade-Loor, D., Siegmund-Schultze, M., Moreira-Muñoz, G., Vargas-Hernández, J. J., & Wehenkel, C. (2019), Growth and yield models for balsa wood plantations in the coastal lowlands of Ecuador. *Forests*, 10(9), 733.

96 Dempsey, H. (2020), "Wind power boom under threat as coronavirus hits supply chains".

97 Enkhardt, S. and C. Bollet (2020), "Germany and France modify solar tenders because of Covid-19", *PV Magazine*, 25 March, www.pv-magazine.com/2020/03/25/germany-and-france-modify-solar-tenders-because-of-covid-19/.

98 Wood Mackenzie (2020), *Power and Renewables Insight: The coronavirus outbreak in China will negatively affect global solar supply chain and project deployment*.

99 IEA, IRENA, UNSD, World Bank and WHO, *Tracking SDG 7: The Energy Progress Report 2020*.

100 World Bank, "Poverty and Distributional Impacts".

101 FAO (Food and Agriculture Organization) (2020), *COVID-19 and rural poverty: Supporting and protecting the rural poor in times of pandemic*, www.reliefweb.int/sites/reliefweb.int/files/resources/CA8824EN.pdf.

102 ENERGIA (2020), *Gender and energy at center stage in COVID-19 battle: Powering a more gender-equal recovery*, www.energia.org/cm2/wp-content/uploads/2020/05/covid-position-paper_FINAL.pdf.

103 Peters, K., D. Waldron and J. Winiecki (2020), *Keeping the Lights On: How PAYGo Solar Can Offer Customer Relief During COVID-19, Next Billion*, 1 May, www.nextbillion.net/paygo-solar-customer-relief-covid19/?utm_sq=gechgb1v1f&utm_source=twitter&utm_medium=social&utm_campaign=nextbillion&utm_content=nbdailyposttweets.

104 SEforALL (2020), *Identifying options for supporting the Off-Grid sector during COVID-19 crisis*, SEforALL, www.seforall.org/sites/default/files/2020-04/SEforALL-survey-findings-20200417.pdf.

105 Schutzeichel, H. (2020), *Relief needs of African solar companies – Survey results from East Africa, Sun-connect news*, 29 April, www.sun-connect-news.org/articles/business/details/relief-needs-of-african-solar-companies-survey-results-from-east-africa/.

106 Puliti, R. (2020), *Energy access takes center stage in fighting COVID-19 (Coronavirus) and powering recovery in Africa, World Bank*, Washington, DC, www.worldbank.org/en/news/opinion/2020/04/22/energy-access-critical-to-overcoming-covid-19-in-africa.

ENDNOTES | PART II

Chapter 04

107 IRENA (2020), *Global Renewables Outlook: Energy Transformation 2050*, International Renewable Energy Agency, Abu Dhabi.

108 Considering the combined effect of renewables deployment, demand evolution and energy efficiency improvements.

109 Efficiency investments are highly uncertain and dependent on assumptions and definitions. The example of European building energy efficiency investments discussed in this section amounted to nearly USD 300 billion per year in recent years, will above this total global efficiency estimate. More transparency and more precise definitions can improve the policy relevance of efficiency numbers. The numbers for investment in renewables are better defined.

110 The USD values cited in this report are 2019-level.

111 Based on IEA (2020) and IRENA data. www.iea.org/reports/world-energy-investment-2019.

112 Wood Mackenzie (2019), *Strategic investments in off-grid energy access*, www.woodmac.com/news/feature/how-off-grid-energy-access-is-shaping-the-energy-transition/

113 IEA, IRENA, UNSD, World Bank, WHO. (2020), *Tracking SDG 7: The Energy Progress Report*, World Bank, Washington DC.

Chapter 05

114 Garrett-Peltier, H. (2017), "Green versus brown: Comparing the employment impacts of energy efficiency, renewable energy, and fossil fuels using an input-output model", *Economic Modelling*, Vol. 61, February, pages 439-447. A McKinsey report came to a very similar finding. McKinsey & Company (2020), "How a post-pandemic stimulus can both create jobs and help the climate", 27 May, www.mckinsey.com/business-functions/sustainability/our-insights/how-a-post-pandemic-stimulus-can-both-create-jobs-and-help-the-climate#.

115 The employment intensity of investment presented in Figures 6.1 and 6.2 has been computed as the ratio of average employment to average investment in the period to 2030. Note that this indicator falls between the 'jobs-year/USD million' and the 'jobs/USD million' for a specific technology along its life-cycle.

116 The employment intensity of economic sectors and its historical evolution vary across countries. Supply chains of transition-related technologies are linked to these economic sectors; hence the resulting employment intensities of these technologies also vary across countries. Trade relationships also affect overall job intensities, since investment in one country can be linked to imports (and hence jobs) from another country.

117 The distribution of energy sector jobs shows significant regional variations, with energy-related employment in some regions (sub-Saharan Africa and non-EU Europe) still dominated by fossil fuel jobs in 2030, while in others transition-related technologies already account for the bulk of jobs. In terms of total energy sector jobs, the regional distribution is clearly dominated by Asia, which accounts for over 57% of the 100 million jobs.

118 IRENA (2017), *Renewable Energy Benefits: Leveraging local capacity for onshore wind*, International Renewable Energy Agency, Abu Dhabi; IRENA (2017), *Renewable Energy Benefits: Leveraging local capacity for solar PV*, International Renewable Energy Agency, Abu Dhabi; IRENA (2018), *Renewable Energy Benefits: Leveraging local capacity for offshore wind*, International Renewable Energy Agency, Abu Dhabi.

119 These renewable energy jobs correspond to the Transforming Energy Scenario from GRO.

Chapter 06

120 IRENA (2020), *Power system organisational structures for the renewable energy era*, International Renewable Energy Agency, Abu Dhabi.

121 SEforALL (2019), *Integrated electrification pathways for universal access to electricity: A primer*, www.seforall.org/sites/default/files/2019-06/SEforALL_IEP_2019.pdf.

122 The integration must occur at several levels: technology (involving the use of grids, mini-grids, standalone systems), actors (involving public, private, communities), and end uses (electricity supply linked with productive uses).

123 Global Commission to End Energy Poverty (2019), *Inception Report*, MIT Energy Initiative, Cambridge, MA, www.endenergypoverty.org/reports.

124 IRENA (2019), *Off-grid renewable energy solutions to expand electricity access: An opportunity not to be missed*, International Renewable Energy Agency, Abu Dhabi.

125 IRENA (2018), *Policies and Regulations for Renewable Energy Mini-Grids*, International Renewable Energy Agency, Abu Dhabi.

126 IRENA (2019), *Off-grid renewable energy solutions to expand electricity access: An opportunity not to be missed.*

127 Amsden, A. (2012), "Grass roots war on poverty", *World Social and Economic Review*, No.1, p.114.

128 Lebdioui, A. (2019), "Local content in extractive industries: Evidence and lessons from Chile's copper sector and Malaysia's petroleum sector", The Extractive Industries and Society, www.doi.org/10.1016/j.exis.2019.05.001.

129 Grunstein, M. and C., Diaz-Wionczek (2017), Local Content in the Petroleum Industry – Mexico, Baker Institute.

130 Lebdioui, A. (2019), "Local content in extractive industries".

131 Lebdioui, A. (2019), "Local content in extractive industries".

132 Lebdioui, A. (2019), "Local content in extractive industries".

133 Hochstetler, K. (forthcoming), Political Economies of Energy Transition: Wind and Solar Power in Brazil and South Africa, Cambridge University Press.

134 Mazzucato M. (2016), "From market fixing to market creating: a new framework for innovation policy", Industry and Innovation, Vol. 23, Issue (2), pp. 140-156.

135 Anadón, L. D., G. Chan, A. G. Harley, K. Matus, S. Moon, S. L. Murthy, and W. C. Clark, (2016), "Making technological innovation work for sustainable development", Proceedings of the National Academy of Sciences 113(35): 9682–9690; Anzolin, G., and A. Lebdioui (forthcoming), "The green trinity: Climate change"; Barrett, S. (2009), "The coming global climate-technology revolution", Journal of Economic Perspectives, 23(2) 53–75; Conchado, A., L. Díaz Anadón, P. Linares Llamas, and Á. López-Peña Fernández (2016), "Benefits of investing in energy R&D and portfolio optimization: The case of Spain"; Mercure, J. F. A., F. Knobloch, H. Pollitt, R. Lewney, K. Rademakers, L. Eichler, and L. Paroussos (2016), "Policy-induced energy technological innovation and finance for low-carbon economic growth. Study on the macroeconomics of energy and climate policies", Brussels: European Commission.

136 Zenghelis D. (2016), "Decarbonisation, innovation and the economics of climate change", in Redefining Capitalism: Economics and Policy for Sustainable and Inclusive Growth (Political Quarterly Monograph Series), edited by M. Mazzucato and M. Jacobs. Wiley Blackwell: Oxford.

137 European Commission (2020), "Horizon 2020 programme", www.ec.europa.eu/programmes/horizon2020/en/area/energy.

138 IRENA (2020), *Renewable Power Generation Costs in 2019, International Renewable Energy Agency*, Abu Dhabi.

139 Government of the Netherlands (2020), Government Strategy on Hydrogen", 6 April, www.government.nl/documents/publications/2020/04/06/government-strategy-on-hydrogen.

140 Swearer, R. (2016), *Why Manufacturing Education Needs to Advance, Just Like You Have*, Industry Week, 23 August, www.industryweek.com/talent/education-training/article/22005837/why-manufacturing-education-needs-to-advance-just-like-you-have.

141 IRENA (forthcoming), *Mobilising institutional capital for renewable energy*, International Renewable Energy Agency, Abu Dhabi.

142 IRENA (forthcoming), *Mobilising institutional capital for renewable energy*.

143 IRENA (forthcoming), *Mobilising institutional capital for renewable energy*.

144 IRENA, IEA and REN21 (Renewable Energy Policy Network for the 21st Century) (2018), *Renewable Energy Policies in a Time of Transition*, IRENA, OECD/IEA and REN21.

145 IRENA (forthcoming), *Mobilising institutional capital for renewable energy*.

146 IRENA (forthcoming), *Mobilising institutional capital for renewable energy*.

147 IRENA (2020), *Renewable energy finance: Green Bonds*, International Renewable Energy Agency, Abu Dhabi; IRENA and CPI (forthcoming), *Global Landscape of Renewable Energy Finance 2020*, International Renewable Energy Agency, Abu Dhabi.

148 Environmental Finance (2019), "Bond Database" (database) www.bonddata.org (subscription required, last accessed December 2019).

149 Environmental Finance (2019), "Bond Database".

150 Environmental Finance (2019), "Bond Database"; SIFMA (Securities Industry and Financial Markets Association) (2019), *Capital markets fact book 2018*, Securities Industry and Financial Markets Association, www.sifma.org/resources/research/fact-book/.

151 IRENA (2020), *Renewable energy finance: Green Bonds*.

152 IRENA (2020), *Renewable energy finance: Green Bonds*.

153 IEA, IRENA, UNSD, World Bank, WHO. (2020), *Tracking SDG 7: The Energy Progress Report*, World Bank, Washington DC.

154 Philips, J., G. Davies and V. Plutshack (2020), *An off-grid energy future requires learning from the past*, Brookings,4 May, www.brookings.edu/blog/future-development/2020/05/04/an-off-grid-energy-future-requires-learning-from-the-past/.

155 World Bank (2019), *Clean cooking: Why it matters*, World Bank, 4 November, www.worldbank.org/en/news/feature/2019/11/04/why-clean-cooking-matters.

156 A 2018 survey conducted of nearly 1,600 educational facilities in Cambodia, Myanmar, Nepal, Kenya, Ethiopia and Niger found that 31% of the facilities are electrified through an on-grid source, 9% through off-grid systems; and 60% with no access. IEA, IRENA, UNSD, World Bank and WHO (2020), *Tracking SDG-7: The Energy Progress Report 2020*, www.irena.org/publications/2020/May/Tracking-SDG7-The-Energy-Progress-Report-2020.

157 SELCO Foundation (2019), *Sustainable energy and livelihoods: A collection of 65 livelihood applications*, www.selcofoundation.org/wp-content/uploads/2019/05/SELCO-Foundation-Sustainable-Energy-Livelihoods-65-Appliances.pdf; IRENA (2016), *Renewable Energy Benefits: Decentralised Solutions in the Agri-Food Chain*, International Renewable Energy Agency, Abu Dhabi.

158 SELCO Foundation (2020), *Decentralised milling services during COVID-19*, www.drive.google.com/file/d/1rwi8HHy1NEDaamnP_ndoBo2zc2mghy7n/view; SELCO Foundation (2020), *Solar Powered Digital Service Centres supporting Communities during COVID-19*, www.drive.google.com/file/d/1uAI81vma2x4CdXHhwnWedahCxVpge057/view.

159 SELCO is a public charitable trust for sustainable development.

160 IRENA and ICIMOD have established an action-oriented partnership to accelerate adoption of distributed renewables for strengthening resilient enterprises in the Hindu Kush Himalayas region. In the first phase of the project, primary data have been gathered on energy needs for three economic value chains—bamboo, dairy and tourism. IRENA (2019), "Renewable energy solutions for enterprise development in the Hindu Kush Himalaya", www.irena.org/events/2019/Nov/Regional-Initiative-on-Renewable-Energy-for-Hindu-Kush-Himalayas.

161 ENERGIA (2020), *Gender and energy at center stage in COVID-19 battle: Powering a more gender-equal recovery*, www.energia.org/cm2/wp-content/uploads/2020/05/covid-position-paper_FINAL.pdf.

162 Matser E., S. Oparaocha. and K. Yumkella (2020), *Energy access and clean cooking solutions must be part of COVID-19 economic recovery plans*, African Business Magazine, 15 May, www.africanbusinessmagazine.com/sectors/health-sectors/covid-19/energy-access-and-clean-cooking-solutions-must-be-part-of-covid-19-economic-recovery-plans/.

ENDNOTES | PART III

Chapter 07

163 UN (United Nations) (2015), *Addis Ababa Action Agenda*, www.un.org/esa/ffd/wp-content/uploads/2015/08/AAAA_Outcome.pdf.

164 International Monetary Fund (IMF) (2020), *Global Financial Stability Report*, IMF, Washington, D.C.

165 IRENA (forthcoming), *Mobilising institutional capital for renewable energy*, International Renewable Energy Agency, Abu Dhabi.

166 IMF (2020), *Fiscal Policies for the Recovery from COVID-19*, IMF Blog, Washington, D.C.

167 Morningstar (2020), *Sustainable Funds Weather the First Quarter Better Than Conventional Funds*, www.morningstar.com/articles/976361/sustainable-funds-weather-the-first-quarter-better-than-conventional-funds.

168 Bloomberg (2020), *Older ESG Funds Outperform Their Newer Rivals in Market Tumult*, www.bloomberg.com/news/articles/2020-03-13/older-esg-funds-outperform-their-newer-rivals-in-market-tumult?sref=6K2T7rH3.

169 IRENA (2016), Unlocking Renewable Energy Investment: The Role of Risk Mitigation and Structured Finance, International Renewable Energy Agency, Abu Dhabi.

170 Climate Policy Initiative (CPI) (2020), *Bailouts for a better world, CPI*, www.climatepolicyinitiative.org/2020/04/01/bailouts-for-a-better-world/.

171 Bloomberg (2020), *Air France KLM Wins EU Approval for $7.7 Billion Bailout*, Bloomberg, 4 May, www.bloomberg.com/news/articles/2020-05-04/air-france-wins-eu-approval-for-eu7b-french-guarantee-and-loan.

172 Business Green (2020), *Air France coronavirus bailout package to demand steep emissions cuts*, www.businessgreen.com/news/4014617/air-france-coronavirus-bailout-package-demand-steep-emissions-cuts.

173 Environmental Journal (2020), *Destination: green airline bailouts*, www.environmentjournal.online/articles/destination-green-airline-bailouts/.

174 CPI (2020), *India's lightbulb moment: Not using this crisis for meaningful energy sector reform would be a waste*, CPI, 12 May, www.climatepolicyinitiative.org/author/mahua-acharya/.

175 Taylor, M. (2020), *Energy Subsidies: Evolution in the Global Energy Transformation to 2050*, International Renewable Energy Agency, Abu Dhabi.

176 Taylor, M. (2020), *Energy Subsidies*.

177 Coady, D. et al. (2019), *Global Fossil Fuel Subsidies Remain Large: An Update Based on Country-Level Estimates*, IMF Working Paper No.19/89, International Monetary Fund, Washington, D.C.

178 Coady, D. et al. (2019), *Global Fossil Fuel Subsidies*.

179 Dixson-Declève, S. et al., (2020), "A green reboot after the pandemic", Project Syndicate, 24 March, www.project-syndicate.org/commentary/covid19-green-deal-by-sandrine-dixson-decleve-et-al-2020-03.

180 IRENA (2020), *Renewable Power Generation Costs in 2019*, International Renewable Energy Agency, Abu Dhabi.

181 Burke, Josh, Sam Fankhauser, and Alex Bowen (2020), *Pricing carbon during the economic recovery from the COVID-19 pandemic*, Policy brief published by the Grantham Research Institute on Climate Change and the Environment, and Centre for Climate Change Economics and Policy, www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2020/05/Pricing-carbon-during-the-recovery-from-the-COVID-19-pandemic.pdf.

182 Michael Liebreich of BNEF, for example, has argued that "Another smart way to stimulate investment in clean energy would be to buy down the closure of aging fossil fuel plants – but only on condition that they are replaced with renewable-plus-battery combinations (which can be packaged with concessional debt or debt guarantees), not just as largesse for shareholders of assets that would anyway soon be stranded".

183 IRENA (2020), *Renewable Power Generation Costs in 2019*.

184 Hepburn, C., B. O'Callaghan, N. Stern, J. Stiglitz and D. Zenghelis (2020), "Will COVID-19 fiscal recovery packages accelerate or retard progress on climate change?", Smith School Working Paper 20-02, www.smithschool.ox.ac.uk/publications/wpapers/workingpaper20-02.pdf.

185 IRENA (2019), *Innovation landscape for a renewable-powered future*, International Renewable Energy Agency, Abu Dhabi.

186 IRENA (2019), *NDCs in 2020: Advancing renewables in the power sector and beyond*, International Renewable Energy Agency, Abu Dhabi.

187 IRENA (2019), *NDCs in 2020*.

188 IRENA (2019), *NDCs in 2020*.

189 Jacobs, D. (2020), *Making societies more resilient - The role of renewables in COVID19 packages*, Policy Brief for the Global Renewable Congress, www.renewablescongress.org/wp-content/uploads/GRC_Policy_Brief_Renewables_in_COVID19.pdf.

190 IRENA (2019), *Renewable Energy Auctions: Status and Trends Beyond Price*, International Renewable Energy Agency, Abu Dhabi.

191 Runyon, J. (2020), *US Treasury says it may modify tax credit rules for wind and solar energy*, Renewable Energy World, 11 May.

192 Rollet, C. and Enkhardt, S. (2020), *Germany and France modify solar tenders because of Covid-19*, PV Magazine, 25 March.

193 IRENA (2020), *Call to Action in Response to COVID-19: Renewable Energy is a Key Part of the Solution*, International Renewable Energy Agency, Abu Dhabi.

194 Agora Energiewende and Agora Verkehrswende (2020), *Dual Benefit Stimulus for Germany – A Proposal for a Targeted 100 Billion Euro Growth and Investment Initiative*, www.agora-energiewende.de/fileadmin2/Projekte/2020/2020-05_Doppelter-Booster/A-EW_A-VW_Dual-Benefit_Stimulus_for_Germany.pdf.

195 IRENA (2016), *Unlocking Renewable Energy Investment: The role of risk mitigation and structured finance*, International Renewable Energy Agency, Abu Dhabi.

196 Seric, A. et al. (2020), *Managing COVID-19: How the pandemic disrupts global value chains*, UNIDO Industrial Analytics Platform, www.iap.unido.org/articles/managing-covid-19-how-pandemic-disrupts-global-value-chains.

197 UNEP (United Nations Environment Programme) (2020), "UNEP Statement on COVID-19", UNEP, 6 April.

198 IRENA (2017), *Renewable energy benefits: Leveraging local capacity for solar PV*, International Renewable Energy Agency, Abu Dhabi; IRENA (2018), *Renewable energy benefits: Leveraging local capacity for onshore wind*, International Renewable Energy Agency, Abu Dhabi; IRENA (2018), *Renewable energy benefits: Leveraging local capacity for offshore wind*, International Renewable Energy Agency, Abu Dhabi.

199 Chang, H. J., and A. Andreoni, (2020), "Industrial policy in the 21st century", Development and Change, 51(2): 324–351; Lebdioui, A. (2020), "Economic diversification and development in resource-dependent economies: Lessons from Chile and Malaysia", Doctoral thesis, University of Cambridge.

200 IRENA (2020), *Global Renewables Outlook: Energy transformation 2050*, International Renewable Energy Agency, Abu Dhabi.

201 Skills Development Scotland (2019), "Transition Training Fund", www.transitiontrainingfund.co.uk/.

202 Krukowska, E. (2019), *Race for climate-neutral continent comes with $111 billion boost*, Bloomberg Green, 4 December, www.bloomberg.com/news/articles/2019-12-04/eu-chief-eyes-111-billion-tool-to-spur-green-transition?sref=HOPZPtg9.

203 Parkin, B., B. Jennen and P. Donahue (2020), *German $55 billion plan to scrap coal clears cabinet hurdle*, Bloomberg Green, 29 January, www.bloomberg.com/news/articles/2020-01-29/merkel-cabinet-approves-coal-exit-bill-setting-rwe-compensation?sref=HOPZPtg9; Rathi, A. (2020), *The Pandemic Is Accelerating Coal's Demise*, Bloomberg, 28 April, www.bloombergquint.com/business/the-coronavirus-pandemic-is-accelerating-coal-s-demise.

204 Poschen, P. (2015), *Sustainable development, decent work and green jobs*, Greenleaf Publishing, Sheffield, UK.

205 Global Green Growth Best Practice Initiative (2014), *Green Growth in Practice: Lessons from Country Experiences*, Seoul.

206 IRENA (n.d.), *Off-grid renewables supply life-saving power to rural health centres*, International Renewable Energy Agency, Abu Dhabi.

207 Puliti, R., and D. Ogunbiyi (2020), *Africa: Energy access takes center stage in COVID-19 fight, powering Africa's recovery*, All Africa, 21 April, www.allafrica.com/stories/202004210827.html.

208 Takouleu, J.-M. (2020), *Nigeria: REA urgently installs mini-grids for Covid-19 care centres*, Afrik21: Green Economy and Sustainable Growth in Africa, 21 April, www.afrik21.africa/en/nigeria-rea-urgently-installs-mini-grids-for-covid-19-care-centres/.

209 Brent, W. (2020), *Roundup: COVID-19 sector response*, Power for All, 7 May, www.powerforall.org/insights/dre-technologies/covid-19-roundup.

210 In 2018, IRENA organised the first International Conference on Renewable Energy Solutions for Healthcare Facilities. Its presentation and findings are available here: https://iorec.irena.org/Home/Healthcare. In 2019, IRENA also partnered with Sustainable Energy for All and the United Nations Foundation to organise a conference on Clean Energy for Health Care in Kenya (https://poweringhc.org/conference/).

211 Peters, K., D. Waldron and J. Winiecki (2020), Keeping the Lights On: How PAYGo Solar Can Offer Customer Relief During COVID-19, Next Billion, 1 May, www.nextbillion.net/paygo-solar-customer-relief-covid19/?utm_sq=gechgb1v1f&utm_source=twitter&utm_medium=social&utm_campaign=nextbillion&utm_content=nbdailyposttweets.

212 Puliti and Ogunbiyi (2020), *Africa: Energy access*.

213 ILO (2020), *COVID-19 and the world of work: Impact and policy responses*, ILO Monitor 1st Edition, 18 March, www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/documents/briefingnote/wcms_738753.pdf.

214 Brent, W. (2020), *Roundup: COVID-19 sector response*.

215 Energy Access Relief (2020), "COVID-19 Energy Access Relief Response", www.energyaccessrelief.org/?platform=hootsuite.

216 GOGLA (2020), Our response to *"Dangerously insufficient: COVID-19 Energy Access Relief Fund"*, SunConnect: East Africa News, 29 April, www.sun-connect-ea.org/our-response-to-dangerously-insufficient-covid-19-energy-access-relief-fund/.

217 IRENA (2018), *Policies and Regulations for Renewable Energy Mini-Grids*, International Renewable Energy Agency, Abu Dhabi.

Chapter 08

218 Includes renewable energy and energy efficiency along with enabling infrastructure such as power grids and energy storage.

219 USD 825 billion was invested in renewable energy technologies, energy efficiency and power grids, including storage.

220 The assumed cost and energy savings of energy efficiency measures in end-use applications are based on IRENA's assessment, which in turn combines various datasets from the literature. The sources are listed in the annex of IRENA's background paper on methodology, www.irena.org/-/media/Files/IRENA/REmap/Methodology/IRENA_REmap_Decarbonisation_Pathway_Methodology_2017.pdf?la=en&hash=ADC8F7D359F5C23A3F50744E66D8E3E163ED97C4.

221 This is only the direct charging equipment costs, the additional investment in strengthening distribution networks and in solar and wind power technologies to supply the electricity is included under grids and the individual power generation technologies investment values.

222 Note, the entire energy transition can be considered a structural change, but this criteria refers specifically to some of the areas where critical infrastructure needs to change or be built form the ground up to facilitate different areas of the transition, (*e.g.*, electrification of transport with a smart charging network scaled in-step with EV sales growth).

223 Barrier removal should proceed from consensus around the national interest and the role of new technologies. Otherwise a project's legitimacy might be questioned mitigation might be blocked. In short, weakening environmental protections is not a solution to a sustainable stimulus.

Chapter 09

224 The GDP metric reported by IRENA is the difference of GDP between the Transforming Energy Scenario and the Planned Energy Scenario. GDP for both scenarios has been evaluated with a non-equilibrium macroeconomic model that has high sectoral and geographical resolution (E3ME from Cambridge Econometrics) and corresponds to the resulting outcome from the different dynamics developing within the economy. In addition to the energy sector investment differential between TES and PES, other drivers influence the resulting economy-wide GDP impact. These include: changes in investment in other economic sectors; changes in spending due to tax effects, royalty losses and aggregate price effects; changes in trade (fossil fuels and other); indirect and induced effects. A partial crowding out of investment in other sectors of the economy resulting from the increase in energy sector investment is also taken into account.

225 E3ME from Cambridge Econometrics

226 For instance, some of the jobs linked to investment in years 2021 and 2022 will still be active in year 2023. Operation and maintenance jobs are a typical example, but jobs from other segments of the value chain may still be active due to the lifetime of the project.

227 IRENA's assumption is that the Planned Energy Scenario would unfold as expected, and hence, create transition-related jobs resulting from the currently planned policies. The increased ambition in the Transformation Energy Scenario would generate additional jobs.

ABBREVIATIONS

°C	degrees Celsius
ASEAN	Association of Southeast Asian Nations
BECCS	biomass carbon capture and storage
CCS	carbon capture and storage
CCU	carbon capture and use
CEO	chief executive officer
CO_2	carbon dioxide
COVID-19	Coronavirus disease: an infectious disease caused by a newly discovered coronavirus
CSP	Concentrated solar power
EMDEs	emerging markets and developing economies
EU	European Union
EU-27	The 27 European Union countries
EUR	Euro
EV	electric vehicle
FiT	Feed-in Tariff
G7	the Group of Seven
GDP	gross domestic product
GRO	Global Renewables Outlook: Energy Transition 2050
Gt	gigaton
GW	gigawatt
GWh	gigawatt-hour
IMF	International Monetary Fund
IRENA	International Renewable Energy Agency
ISA	International Solar Association
ISO	International Organization for Standardization
kWh	kilowatt-hour
LED	light-emitting diode
LNG	liquefied natural gas
MW	megawatt
NDC	Nationally Determined Contribution
O&M	operation and maintenance
OECD	Organisation for Economic Co-operation and Development
PES	Planned Energy Scenario
PtX	power-to-X
PV	photovoltaics
Q	quarter
R&D	research and development
RE	renewable energy
SDG	Sustainable Development Goal
SME	small and medium enterprise
STEM	science, technology, engineering and mathematics
TES	Transforming Energy Scenario
TFEC	total final energy consumption
TPES	total primary energy supply
TVET	technical and vocational education and training
UK	United Kingdom of Great Britain and Northern Ireland
U.S.	United States of America
USD	United States Dollar
VRE	variable renewable energy
WHO	World Health Organization

PHOTO CREDITS

page 6 © APChanel
page 6 © Natascha Kaukorat
page 11 © Sirisak_baokaew
page 11 © The Drone Zone
page 14 © Tong_stocker
page 14 © Sahara Frost
page 23 © Paul Appleyard
page 25 © Manoej Paateel
page 25 © M2020
page 30 © Xiangli Li
page 30 © Alex N Varga
page 31 © Tsetso Photo
page 31 © Tsetso Photo
page 32 © Igor Hotinsky
page 32 © elmar gubisch
page 33 © Akella Srinivas Ramalingaswami
page 33 © malgosia janicka
page 36 © Aiman Khair
page 36 © Mike Mareen
page 37 © Chakrit Thongkhundam
page 37 © Mario Hagen
page 38 © fanjianhua
page 38 © fanjianhua
page 40 © Funtay
page 40 © Francisco Javier Diaz
page 41 © Anca Milushev
page 41 © Yupa Watchanakit
page 43 © I AM NIKOM
page 43 © fanjianhua
page 44 © FrameStockFootages
page 46 © petrmalinak
page 46 © khemmathat mensuwan
page 50 © Thorsten Schier
page 50 © anatoliy_gleb
page 52 © goodluz
page 53 © EVGEIIA
page 53 © NavinTar
page 59 © Im_rohitbhakar
page 59 © ChameleonsEye
page 62 © thirawatana phaisalratana
page 62 © humphery
page 64 © Rifa Abidin
page 67 © ronemmons
page 68 © Noushad Thekkayil
page 68 © M2020
page 70 © Gorlov-KV
page 70 © AxOst
page 71 © fanjianhua
page 71 © HeimatPlanet
page 72 © Tofan Singh Chouhan
page 72 © Anton_Ivanov
page 74 © Try my best
page 75 © Heinz Trebuth
page 77 © angus reid
page 77 © mirzavisoko
page 78 © Ivo Antonie de Rooij
page 78 © BlurryMe
page 80 © taka1022
page 83 © Sallehudin Ahmad
page 89 © Fly_and_Dive
page 89 © SweetHour
page 93 © Flightseeing-Germany
page 93 © Juan Alberto Casado
page 93 © Davdeka
page 93 © Red_Shadow
page 95 © Zanna Lecko
page 97 © M2020
page 97 © Viewfoto studio
page 98 © ShDrohnenFly
page 98 © Sugrit Jiranarak
page 103 © Pachai Leknettip
page 103 © Alexander Denisenko
page 105 © Roel Slootweg
page 105 © sandis sveicers
page 110 © AS photo studio
page 110 © King Ropes Access
page 114 © People Image Studio
page 114 © roibu
page 117 © 42nd Street in Manhattan
page 117 © kim7
page 120 © vaalaa
page 120 © zstock
page 123 © ShDrohnenFly
page 123 © Casezy idea
page 126 © Vladimka production
page 126 © elmar gubisch
page 127 © Milleflore Images
page 127 © Keitma

International Renewable Energy Agency

THE POST-COVID RECOVERY

IRENA Headquarters

Masdar City
P.O. Box 236, Abu Dhabi
United Arab Emirates

www.irena.org

ISBN 978-92-9260-245-1