UNLOCKING THE POTENTIAL OF SMART CITIES

Whitepaper

SUSTAINABILITY & IoT

JUNIPER RESEARCH

1.1 Introduction

In the last three decades, smart cities have evolved from an abstract concept to a technology-based and inclusive spatial concept, emphasising environmental considerations. The 'digital' element referring to the technology has now gained an underlying enabler role. As such, a smart city is a city that leverages technology and technological deployments to effectively meet inhabitants' needs, improve their experience, and engage them without compromising on basic considerations like data integrity and privacy protection. Therefore, an important element of smart cities is about efficient governance through empowerment of local administrators, who, in turn, are enabled to devise policies for enhancing citizens' quality of life.

1.2 Definitions and Scope

Juniper Research defines a smart city as follows:

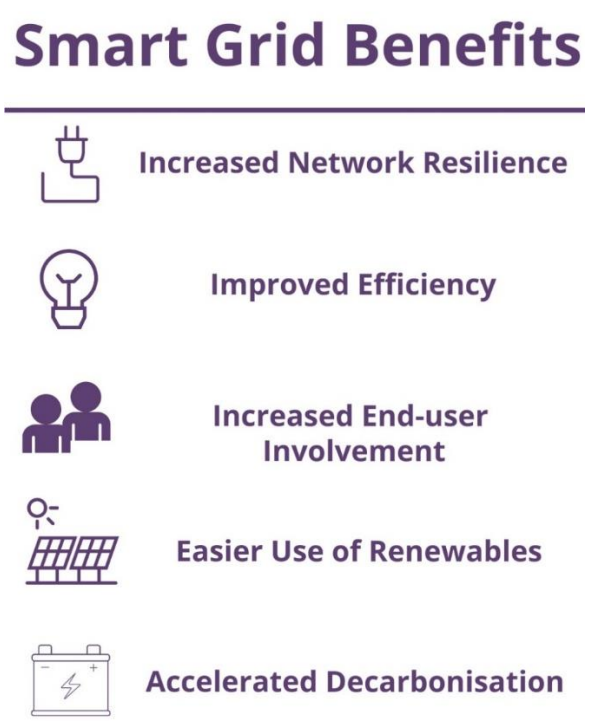
'A smart city is a place where traditional networks and services are made more efficient through the use of digital solutions for the benefit of its inhabitants and business. It means smarter urban transport networks, upgraded water supply and waste disposal facilities, and more efficient ways to light and heat buildings.'

This practical and goal-oriented view ultimately focuses on areas where industry applications can have visible contributions to both collective and individual lives, for instance, with regards to energy supply.

Components and segments of a smart city that allude to underlying technologies are numerous, stated as below.

- Smart Buildings: Smart buildings refer to where buildings use information and communications technology-based systems, services, and technology for optimisation of the facility's performance and operations to create a comfortable environment and improve sustainability. These systems and services often involve IoT devices and solutions, such as sensors, which are utilised to generate data to measure power and air quality, energy, and resource consumption, as well as occupancy, and to predict maintenance needs to achieve efficiency. Collectively, they contribute to the lowering of energy and operational costs and enable inhabitants to make informed decisions about changes or improvements they may want to undertake for buildings their own consumption habits. Smart buildings differ from 'connected' buildings, with the former referring to building operations connected to and run and/or managed by IT networks. On the other hand, smart buildings produce insights from the data collected, often enriched by AI/ML, and feed them into platforms for responsive and highly configurable solutions.
- Smart Grid: Smart grids can be broadly defined as an electricity supply network that uses digital communications technology to detect and react to local changes in usage, leveraging analytics and smart metering, and including elements such as microgeneration. Like smart buildings, smart grid leverages IoT and adapts to changing supply and demand patterns by ensuring communication throughout the value chain without overly relying on separate operators, as well as through data collection and analysis. It acts as an integrated management mechanism to coordinate demand and supply and oversee efficient and sustainable energy distribution. More importantly, since it is a foundational system, it lays the basis for the efficient functioning of all other smart city components, such as smart lighting, buildings, and interrelated systems such as EV charging.

Figure 1: Smart Grid Benefits



Source: Juniper Research

- Smart Lighting: Smart lighting is one of the earliest applications of smart cities, where analytics and sensors are leveraged to optimise how lighting is used; helping reduce emissions compared to traditional lighting systems. With the help of sensors, pedestrian traffic is monitored and adapted to traffic and control systems, which also allowed remote diagnostics and visualisation. Smart lighting also has a role in ensuring public safety. Adoption of smart lighting technologies have also paved the way for the use of other sensors leveraging poles for uses in air quality monitoring and parking, Wi-Fi connectivity, EV charging, and more. In this sense, smart lighting is a precursor to smart city solutions employed.
- Smart Traffic Management and Parking: These concepts involve the use of digital technologies to manage vehicular traffic for the purpose of driving efficiencies, reducing congestion, and/or minimising harmful emissions. Smart traffic management holds a great potential to reduce GHG (Greenhouse Gas) emissions by optimising the traffic flow, especially when complemented or supported by other mobility solutions such as congestion surcharges and carpooling/ride hailing. They also contribute to the prevention of accidents and improve road safety. Likewise smart parking solutions aim to reduce fuel and time consumption caused by parking efforts and optimise these activities through data collected by PMS (Parking Management Systems) that include sensor-based solutions.
- MaaS: MaaS is a type of service which enables users to plan, book, and pay for multiple types of urban mobility services through a joint digital channel. The channel is often a platform that collates different transport modes, as well as parking facilities to deliver the most efficient and seamless route to journeys. MaaS has gained in popularity within the last decade thanks to increased adoption of local governments and transit authorities/agencies worldwide of the mobility platform solutions to provide unified approaches to transport that encompasses products and services in interconnected industries such as digital ticketing and mobile payments. MaaS, concurrent to smart city developments, is an area that continues to grow and increasingly adapts alternative modes of transport such as ride sharing/carpooling.

i. Technological Developments

Modern smart city deployments are intertwined with IoT connections and solutions. IoT use cases are mostly linked to smart city-related ones, along with a few others expected to increase consistently (ie, lighting, building automation).

Enhanced by the growing and ubiquitous connectivity and data processing capabilities, advancement of IoT industrial applications has been a game changer for smart cities. Edge computing is a good example. As a concept, it refers to a distributed information technology architecture in which client data is processed at the periphery of the network, as close to the originating source as possible. This entails moving data partially from data centres closer to the data source, as well as enabling computing and storage at the same point as the data source at the network edge; alleviating the pressures on data centres when transferring massive amounts

of information. In addition, the data processed via edge computing can be sent to real-time analytics platforms enabling the foundations of central server applications. The integration of edge computing into sensor networks enabled the use of AI-powered video technology, and led cameras to becoming part of the sensor network itself. This is part of the phenomenon which is referred to as Edge AI that helps to provide real-time insights, thanks to AI's self-training and continuous learning capabilities supported by edge computing's local data processing and analysis. Edge AI also claims to respond to the several challenges involving localisation of data processing, network connectivity/capability, data sovereignty and security. Offline data processing capabilities and local data analysis for enhanced privacy are the two solutions these technologies present for capability and data security problems.

Connectivity and capability are closely interwoven with limitations of networks and data resources, which current 5G deployments aim to largely address. Successful 5G deployments are expected to facilitate automation capabilities by resolving network and capability limitations, to be achieved via critical IoT and mobile and mass IoT deployments. The latter already exists within current 4G networks, while the former refers to time-critical IoT applications which currently use the URLLC (Ultra-reliable Low-latency Communication) standard that will be introduced with more advanced 5G deployments. Automation IoT is another layer to be built on critical IoT and enable integration of 5G systems with real-time Ethernet and TSN (Time-sensitive Networking) used in wired industrial automation networks. Critical IoT's use cases are numerous and cut across industries such as transportation and automotive, with potentially yielding most benefits for smart city applications.

Besides autonomous technologies, and interwoven with data collection and processing, the concept of digital twinning is becoming increasingly popular in smart city deployments. This approach enables duplication of entire cities, infrastructures, buildings, and other assets as digital representations. Accessing the digital representation or twin online, or through a software, allows users to test and plan deployments based on real-time data, and thereby gives local authorities a comprehensive understanding of smart city data and operations, particularly for effective management and maintenance of infrastructure assets. This is achieved through various technologies (ie, AI-powered sensors) and solutions, such as geospatial data, and data imaging/mapping. Changes or inconsistencies in usage of systems can be viewed, automatically detected or projected based on real-time data and AI-powered analysis.

As illustrated by cross-cutting edge computing capabilities and digital twinning use case, the role of AI has been visible in several areas of smart city applications:

- Applications in Smart Grid: AI-powered digital technologies and sensors allow all the devices and assets within the grid to communicate better, predict grid imbalance and improve automated switching. These applications also improve security of the grid and improve demand-side energy management.
- Applications in Smart Buildings: AI-powered building applications allow for better communication with smart grids and increase their participation in distributed energy sources through data-driven analytics. At the granular level, these applications lead to better automation capabilities to reduce energy use.
- Applications in Smart Lighting: As will be analysed in depth in the next chapter, AI-enabled smart lighting solutions advance applications to go beyond lighting and evolve to smart poles.
- Applications in Smart Urban Mobility: Besides future uses of AVs, current applications of AI in urban mobility include operations management, intelligent digital ticketing, and customer analytics for public transport. As discussed briefly, AI also assists in multi-modal journey planning in urban settings.

Tying all these applications together is a smart city data platform as was conceptualised by large tech companies. A smart data platform is an open, secure, and city-wide platform, with a data warehouse (in-house or on cloud) to store, manage, and report smart city data from IoT sensors and other open data sources, about energy, population, traffic, buildings, and infrastructure. Coupled with dashboards and powered by AI and analytics, the platform allows the government to manage and optimise the city's system for the benefit of businesses and inhabitants. Most popular examples of these platforms are those led by large IT companies and big tech, such as Cisco's Kinetic for Cities software (abandoned in 2020), and Google's Sidewalk Lab experiment in Toronto (abandoned in 2020 citing COVID-19's impact and economic uncertainty), and more recently, Amazon's new Sidewalk project which will connect a range of devices to build more connected communities.

1.3 Market Forecast Summary: Total Value of Digital Prepaid Card Transactions

Juniper Research found that Shanghai is the leading smart city in 2023, ranked first for the second year in a row.

The top 5 smart cities ranked by Juniper Research are:

- Shanghai
- New York
- Toronto
- Seoul
- Shenzhen

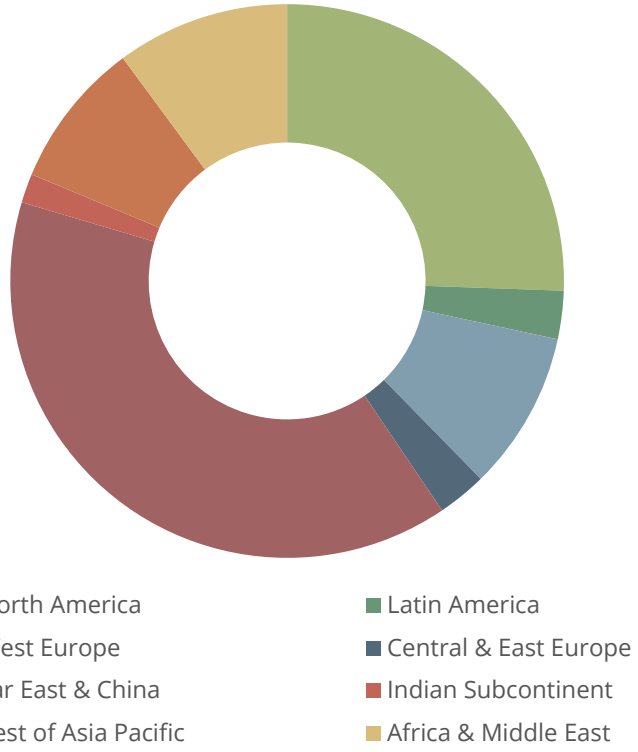
The ranking of 50 world cities is based on an evaluation of many different smart city aspects, covering transportation and infrastructure, energy and lighting, city management and technology, and urban connectivity.

Shanghai is leading due to its Suishenban Citizen Cloud, which provides access for over 1,000 different services for city residents, as well as its strong deployment of 5G, and its use of innovative technologies including digital twins. The leading cities in this ranking have all rolled out services that are effectively harnessing data and connectivity to improve citizen experiences.

Shanghai has taken a joined-up approach to data, building not only a robust and all-encompassing data platform, but also the connectivity to underpin every aspect of this. This joined-up approach is the biggest takeaway for rival cities wanting to emulate Shanghai's success, and should be a part of any smart city initiative to ensure success.

- Cost savings from smart city deployments are forecast to reach $249 billion by 2028 globally, from $96 billion in 2023; representing growth of 158%.
- Cost savings represent the monetary impacts of reduced energy usage and emissions from the deployment of smart grid, smart traffic management and smart street lighting.
- These massive savings are a major driver of smart city deployments, and will equate to almost three times the spend on smart city software and hardware by 2028, showing a clear path to return on investment for cities.

Figure 2: Total Cost Savings from Smart City Deployments in 2028 ($m): $249 Billion



Source: Juniper Research

Order the Full Research

Discover a ranking of the best examples of urban innovation in the world through this latest smart cities report. Featuring extensive forecasts on key smart city areas; this invaluable research delivers coverage of important technologies and trends within this evolving market.

Key Features

- **Market Dynamics:** Detailed assessment of market drivers and the key trends within the smart cities market, as well as an in-depth evaluation of the future growth of the industry and readiness for further disruption. This enables readers to understand the critical innovations driving this market forward.
- **Key Takeaways & Strategic Recommendations:** Featuring major opportunities and crucial factors for smart cities development highlighted across the landscape; making for important reading for key stakeholders, including smart cities platforms, city authorities and others.
- **Ranking:** Scoring of the capabilities and features of the world's leading smart cities; showcasing the best innovations in this area. This report presents a ranking of the top 20 smart cities in the world today, scored and ranked from a wider list of 50 innovative cities. For each of the top 20 cities, a full profile is provided of the city's initiatives and what future developments we anticipate.
- **Benchmark Industry Forecasts:** 5-year forecasts for deployments of smart city technologies; covering the installed base, market value, shipments and environmental impact of the following technologies: smart lighting, maas, smart traffic management, smart parking and smart grid. These are split across 60 countries, and by our 8 key regions.

What's in this Research?

1. **Market Trends & Opportunities:** Detailed analysis and strategic recommendations for key stakeholders, including smart cities platforms, city authorities and others for further innovation within the smart cities market.
2. **Strategic Analysis & Ranking:** Examines the future outlook for the ecosystem and provides comprehensive analysis of the key trends and market disruptions, including an analysis of a range of different technologies, and assessment of business models for players across the value chain.
3. **Interactive Forecast Excel:** Highly granular dataset comprising over 51,600 datapoints; allied to regional and sector analysis tools. Includes regional and country-level analysis, together with 5-year forecasts for the market, covering the installed base, market value, shipments and environmental impact of the following technologies: smart lighting, MaaS, smart traffic management, smart parking and smart grid.
4. ***harvest* Online Data Platform:** Visualises all the data in easy to use and exportable graphs, tables and charts, and features continuous data updates for 12 months.

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