ICT INFRASTRUCTURE MANAGEMENT SOLUTION BOOKLET

Smart Cities Marketplace 2024

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ENERGY

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Author	Smart Cities Marketplace managed by the European Commission Directorate-General for energy smart-cities-marketplace.ec.europa.eu | European Commission | DG ENER
Written by	Mari Jose Alonso, Javier Alés, Jesús del Estad (Tower Automation Alliance), Alis-Daniela Torres, Xavier Casanova Colomé (ICLEI Europe)
Proofreading	Gabi Kaiser, Ariadne Dimakou Bertels (Steinbeis Europa)
Graphic design	Agata Smok (Th!nk E) for the Smart Cities Marketplace, European Commission DG ENER.
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WHAT IS THE SMART CITIES MARKETPLACE?

The Smart Cities Marketplace is an initiative supported by the European Commission bringing together **cities, industry, SMEs, investors, banks, research and other climate-neutral and smart city actors**. The Smart Cities Marketplace Investor Network is a growing group of investors and financial service providers who are actively looking for Climate-neutral and smart city projects.

WHAT ARE THE AIMS OF THE SMART CITIES MARKETPLACE?

The Smart Cities Marketplace has thousands of followers from all over Europe and beyond, many of which have signed up as a member. Their common aims are to **improve citizens' quality of life, increase the competitiveness of European cities and industry** as well as to **reach European energy and climate targets.**

WHAT CAN THE SMART CITIES MARKETPLACE DO FOR YOU?

Explore the possibilities, **shape** your project ideas, and close a **deal** for launching your Smart City solution! If you want to get directly in touch with us please use info@smartcitiesmarketplace.eu

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WHAT AND WHY

Madrid, Spain ©Getty images

What and why

The idea of a digitised, automated and smart city has become one of the most important challenges for local governments looking into the near future. It is now the right time to ask this question:

> ***Are telecom infrastructure and the network architecture ready for all the challenges smart cities want to achieve?***

In this booklet, we will tackle some of the topics related to infrastructures that should be able to support a consistent, sustainable and reliable smart city.

DIGITISED AUTOMATED SMART CITY

©Getty images

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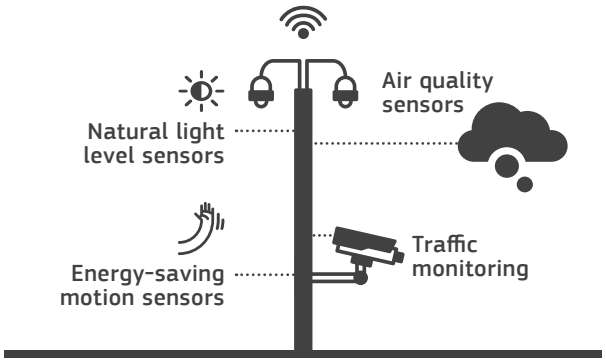
IoT infrastructure

The booming of the Internet of Things (IoT) signals a fundamental transformation.

When IoT is applied to the Smart City concept it normally refers to a network of sensors and actuators connected to a centralised server or cloud that collects data from the sensors and provides orders to the actuators.

The massive deployment of these devices is critical to making the vision of interconnectivity a reality.

However, this data flow requires a powerful and reliable telecommunications infrastructure capable of handling the vast volume of information while ensuring real-time responsiveness.



The IMAGINEXT project, co-funded by EIT Urban Mobility, is piloting an AI-driven Software as a Service solution to measure air quality in Lindau, Germany. Sensors installed in Lindau are assessing air quality changes before and after the reconstruction of cycling streets. ©EIT Urban Mobility

The connectivity network

The deployment and normalisation of information and communication technology (ICT) infrastructure lays the foundation for the smart city ecosystem. This implies a strategic expansion of telecom networks to ensure reliable and high-speed connectivity, the basis of a digitally enabled city.

Strong connectivity and telecom infrastructure are fundamental to smart city ecosystems. They act as the communication channels for the constant data flow between sensors, devices, and city management systems. This real-time data exchange is essential for powering applications like traffic management, energy optimisation, and citizen engagement, ultimately leading to a more efficient, sustainable, and liveable urban environment.

Today's city infrastructure is a complex group of technologies working together to handle the ever-increasing data flow of a smart city.

Fibre optic networks provide the backbone for reliable, high-speed data transmission, while mobile broadband like 4G and 5G keep us connected when on the move. Public Wi-Fi hotspots are popping up in urban areas, and emerging technologies are helping to connect low-power devices over long distances.

Despite this progress, challenges like cost and ensuring everyone has access remain. Cities are constantly innovating and expanding their networks to keep pace with the growing demands of a data-driven and smart urban future.

5G plays a key role in realising the vision of smart cities. Its high-speed, low-latency connectivity supports diverse applications such as autonomous vehicles or remote healthcare. A robust telecommunications infrastructure ensures a fluent network to handle the massive data exchanges essential for digital transformation and the efficient operation of smart cities. Not to mention other IoT technologies, equally reliable, although with lower bandwidth and higher latency, such as LoRaWAN (Long Range Wide Area Network) or NB IoT (Narrowband Internet of Things).

Telecommunication tower ©Matthieu Rochette, Unsplash

Urban furniture

The integration of smart furniture into the urban landscape is emerging as a new way to redefine functionality and utility. From benches with integrated solar panels to charging stations equipped with Wi-Fi connectivity, these innovations are prepared to increase citizen convenience while serving as nodes within the IoT network.

However, their effectiveness depends on reliable connectivity, which requires the expansion and optimisation of telecommunications networks to accommodate these distributed endpoints.

The role of public institutions

Legislation and the role of public institutions cannot be underestimated in shaping the course of smart city development.

Clear regulatory frameworks safeguard ordered telecom network rollout, promote innovation, and ensure equitable access to technology.

Public institutions, especially local governments play a key role in driving stakeholder collaboration and orchestrating initiatives.

Cyber Security

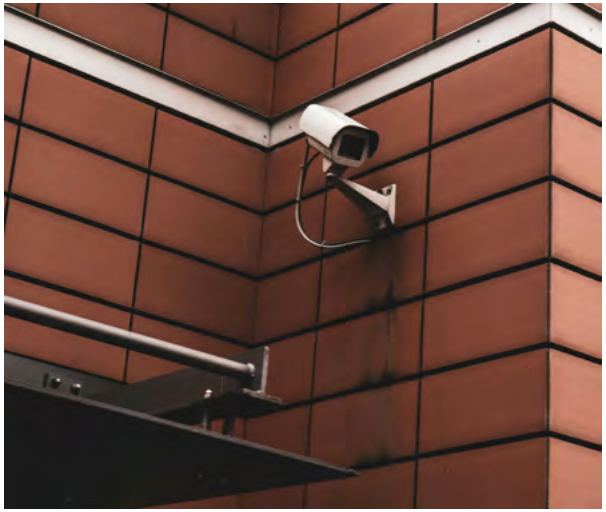
Security is a primary concern for the Smart Cities infrastructure. With an intricated network of interconnected devices and data streams , it is imperative to ensure robust cyber security measures.

Open APIs (application programming interfaces)[1] serve as a gateway to access and leverage data, promoting innovation and interoperability.

1 Kong Inc (2022, Mary 23). The API Mandate: How a mythical memo from Jeff Bezos changed software forever konghq.com/blog/enterprise/api-mandate

Cardmapr in the Netherlands provides an interactive map that shows the locations of businesses that accept Visa and Mastercard. Users can zoom in on specific areas to find, for example, card-friendly charging stations nearby. ©Cardmapr, Unsplash

©Albert Hu, Unsplash

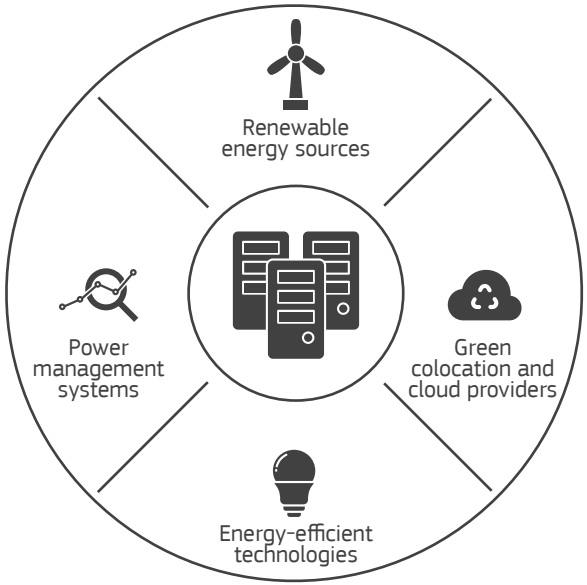


Security camera in Frankfurt, Germany ©Justus Menke, Unsplash

Energy

Energy requirements are crucial for ensuring service continuity and sustainability in smart cities.

As the demand for electricity increases with the rise of connected devices, renewable energy solutions, such as solar panels integrated into the infrastructure, must be adopted.



Sustainability

While telecom networks are crucial for smart city functions, their environmental impact can't be ignored. The vast network of cell towers and data centres contribute to the urban landscape, raising concerns about visual impact.

Additionally, the constant churn of mobile devices and network equipment generates electric and electronic waste (e-waste), requiring proper recycling strategies and programmes. Furthermore, ongoing discussions about the potential health effects of electromagnetic fields (EMF) emitted by these networks must be addressed and communicated to citizens in a timely and responsible manner.

To promote sustainability, cities and telecom companies are exploring solutions like energy-efficient network equipment, using renewable energy sources, and implementing green building practices for data centres.

Automation

Process automation is emerging as a cornerstone in improving the efficiency and effectiveness of smart cities. From predictive maintenance systems that leverage Artificial Intelligence (AI) algorithms to optimise assets lifecycle to automated inventory management, these innovations streamline operations and zero-touch processes. However, the success of this automation depends on a reliable and well-maintained network infrastructure that facilitates instant communication between devices and central control systems.

At the intersection of these factors lie the essential components for the realisation of smart cities.

By tackling these challenges and seizing opportunities, cities can embark on a transformative journey toward a more connected, efficient, and habitable future for all.

Why telecom infrastructure is key for Smart Cities?

Telecommunications infrastructure is capable of handling the sheer volume of information while ensuring real-time responsiveness.

5G is essential for its high-speed, low-latency connectivity, making it compatible with various applications.

Innovations such as Wi-Fi equipped stations increase the comfort of citizens while serving as nodes within the IoT network.

Management of big data and sensors is critical to reducing crime and emergency response time.

The demand for electricity is increasing with the growth of connected devices and renewable energy solutions.

Process automation is emerging as a cornerstone in improving the efficiency and effectiveness of smart cities.

The deployment of fibre optics, is becoming indispensable. Optical fibre provides the backbone for reliable, high-speed data transmission.

Legislation and the role of public institutions are key to create regulatory frameworks that safeguard the deployment of telecommunications networks.

CITY CONTEXT

The Pixel building, designed by studio505, is Australia's first carbon-neutral office building, achieving a perfect 105 Greenstar rating. The building features an advanced water treatment system, a colourful facade with integrated planters, shading louvers, double-glazed windows, and solar panels. Pixel serves as a showcase of sustainable design and aims to set new environmental standards, being assessed by Greenstar, LEED, and BREEAM rating systems. © John Gollings

City context

Every day more people move to live in a city. The Organisation for Economic Co-operation and Development (OECD) predicts that by 2050 the world's population will rise to nine billion, 70% of which will live in urban centres. This means a great challenge at a global level that entails problems such as a lack of scarce resources like water or energy and population growth, among others.

To face this challenge, cities can harness the potential of smart city technologies from two perspectives. On the one hand, recognising that information and communication technology (ICT) and its infrastructure are part of the city realm and have to be efficient, reliable and sustainable. On the other hand, leveraging the potential of ICT technologies can help cities advance their climate and environmental goals by providing new and innovative services.

To this end, information and communication technologies (ICT) can be used to support efficient and sustainable management in cities, with the objectives of reducing energy consumption, reducing CO_2 emissions, and increasing the well-being of citizens.

Smart cities face increasing energy demands due to the massive deployment of IoT devices and associated telecommunications infrastructure. Sustainably deploying the ICT infrastructure is a major challenge, which is why smart cities are adopting innovative solutions to optimise energy use as well as the implementation of smart grids, energy-efficient buildings and advanced metering infrastructures to enable better energy management.

A good example is the Pixel building in Melbourne, Australia. This building is capable of generating its energy thanks to the solar panels on its roof. It also produces and stores the water it uses[2].

Collaboration between various industries, including mobility, telecommunications, and energy infrastructure, plays a key role in addressing complexities and ensuring sustainable infrastructure development at the local level. The interdependence of smart telecommunications and energy infrastructure highlights the need for a collaborative approach between private and public organisations to effectively manage this challenging ecosystem[3].

This way, Governments provide regulatory frameworks that encourage investment in sustainable energy and mobility solutions, while private organisations provide expertise in the deployment of innovative technologies. Together, they create an enabling environment for the development of smart energy grids and smart mobility systems such as traffic management, Mobility as a Service (MaaS), congestion taxes, etc.

An emerging concept is energy infrastructure solutions offered as a service (EaaS). This approach involves third-party providers offering energy solutions tailored to the specific needs of smart cities' telecommunications networks. Specialised energy infrastructure companies can partner with telecom operators to offer site-specific sustainable energy solutions. These service-oriented models ensure efficient energy use.

The deployment of new 5G infrastructure is another critical aspect to consider in the context of smart cities, given the increase in user traffic driven by a growing population and the rising number of applications and connected devices.

2 Green Source Magazine. (2012). Pixel Perfect. www.studio505.com.au/uploads/media/downloads/1093_120801_Green_Source_Magazine_Pixel_Perfect_spread_sm.pdf

3 Estrada, A. (2023, March 3). Hybrico Presentation. Automate Winter Camp, Seville, Spain.

The ICT Infrastructure Stakeholder Ecosystem in Cities

The world's cities are hubs of information exchange, powered by a complex web of telecommunications players. This ecosystem transcends borders, but within each city and country, different stakeholders support the development of the ICT and Telecommunications infrastructure development for smarter and more resilient cities.

The key players and their roles are described in the Table below:

	Key Role	Stakeholder
	**Building the Infrastructure**	**Telecom Network Providers (TNPs):** They build, maintain, and operate the physical infrastructure – the cables, towers, and data CENTRES that carry information across the city. (Deutsche Telekom, Telefonica, AT&T, etc) **Mobile Network Operators (MNOs):** MNOs lease access to the physical infrastructure from TNPs and use it to provide mobile network services to end users (individuals and businesses) – voice calls, text messages, and mobile data access. MNOs sell mobile phone plans, data packages, and other mobile services directly to consumers. **Tower Companies (TowerCos):** These specialists focus on cell sites and towers, leasing space to multiple mobile network operators (MNOs). This promotes wider network coverage and fosters competition among service providers, a concept echoed in the European Union's (EU) push for a unified digital market.

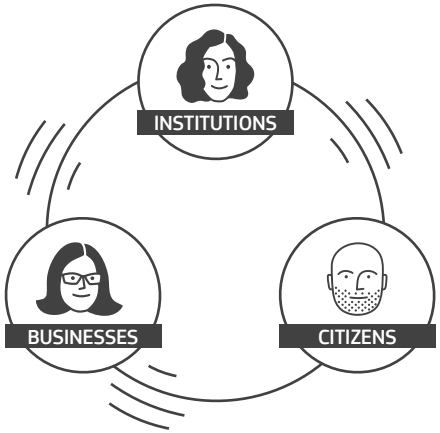
	Key Role	Stakeholder
	**Regulation and Policy**	**National Regulatory Bodies:** Each country has its own regulatory bodies, ensuring fair competition and spectrum allocation – the invisible resource for wireless communication. The EU acts as a guiding force, shaping regulations for a unified European approach. Cities: Local governments play a crucial role. They develop regulations for tower placement and infrastructure development, striking a balance between connectivity and aesthetics. Similar to some European cities, they can also partner with private companies to expand broadband access or spearhead innovative “smart city” initiatives.
	**Delivering Services**	**Content and Service Providers:** These companies offer the services we use every day – internet access, streaming platforms like Netflix, mobile apps, and social media. They drive demand for network capacity and contribute to the overall digital ecosystem.
	**Innovation and Development**	**Device Manufacturers:** These companies design and produce the hardware that connects us to the network – smartphones, tablets, computers, and networking equipment. They play a vital role in driving innovation and ensuring a seamless user experience. (Ericsson (Sweden) and Nokia (Finland)). **Research Institutions:** Research institutions across the globe are at the forefront of telecommunications technology development. They focus on areas like increased network capacity, efficiency, and future-proofing the infrastructure for emerging technologies like 5G and beyond.

	Key Role	Stakeholder
	**The Users**	**Residents:** Individuals living in the city are the end users. They rely on the network for communication, internet access, and online services, shaping the overall demand and influencing the direction of the ecosystem. **Businesses:** Businesses are major consumers, utilising networks for communication, operations, online platforms, and cloud-based applications. They are a significant driver of data traffic and contribute to the economic viability of the ecosystem. **Educational Institutions:** Schools and universities need reliable connections for learning, research, and online education platforms. They play a crucial role in developing future generations of users and innovators within the ecosystem. **Emergency Services:** Fire departments, police, and other first responders rely on the network for critical communication. A secure and reliable network ensures effective response to emergencies and safeguards public safety.
	**Additional Players**	**Infrastructure Investors:** Investment firms and pension funds can play a significant role by financing the development and maintenance of the physical network. Their support is crucial for infrastructure growth and modernisation. **Consumer Advocacy Groups:** These groups advocate for user privacy, fair access to the internet, and affordable pricing. They ensure consumer interests are represented and contribute to a balanced ecosystem,

The success of a city's telecommunications ecosystem hinges on effective collaboration.

By working together, stakeholders can address key challenges like bridging the digital divide, investing in future technologies, ensuring cyber security, and developing smart city initiatives.

This collaborative effort will ensure a robust and future-proof network that empowers citizens, businesses, and institutions to thrive in the digital age, reflecting the interconnected nature of our globalised world.



©Amelie Mourichon, Unsplash

©Fortytwo,Unsplash

Learning about the capacity of household appliances in a playful way during workshops in Oud-Heverlee, Belgium. ©Leen Peeters, Th!nk E

TECHNICAL SPECIFICATIONS

IMAGINEXT sensors installed in Lindau Germany ©EIT Urban Mobility

Technical specifications

5G network in cities

5G technology brings a new challenge compared to the previous version of mobile communication protocols 4G, 3G, 2G to local governments. It is affecting telecommunication (telco) infrastructure management and impacting city administration perspectives as well.

5G is the fifth evolution of wireless networking technology, with several defining characteristics including high bandwidth, fast data rates, broad connectivity, widespread coverage, and low latency (low latency describes a computer network that is optimised to process a very high volume of data messages with minimal delay)[4].

The way this technology is providing these advanced functionalities is by getting closer to the end user. It is a trade-off between performance and the coverage or reach of the antennas.

This turns into a need to densify the physical network which means a higher number of towers to cover the same area and, those towers need to be fed and provisioned with a fibre connection, which is the only way to deliver the bandwidth and latency levels 5G can provide. On the one hand, we have a higher demand for tower locations and the "fiberisation" – pulling underground fibre to feed the towers – of those towers.

In addition, to reach outdoor coverage, 5G technology is also quite demanding in terms of infrastructure for indoor coverage in large buildings. Operators need to spread more indoor antennas and the infrastructure companies need to provide more locations. This new paradigm has accelerated the need for municipalities to manage and budget their telco-suitable infrastructures.

But how can 5G infrastructure be deployed in an urban landscape without compromising sustainability and visual impact?

To do this, cities need to implement zoning regulations that guide the location of 5G infrastructure in a way that minimises visual impact, taking into account factors such as distance from residential areas, community spaces and historical landmarks.

Here are several considerations to achieve this balance:

Utilising small cells and micro infrastructure for 5G deployment as these smaller, less obtrusive devices can be integrated into existing street furniture, such as lampposts, traffic lights, or buildings, reducing the need for large tower sites.

Camouflaged designs encourage the development of aesthetically pleasing and visually subtle infrastructure. Designing 5G equipment to blend with the surroundings, resemble common urban elements or use materials that harmonise with the environment.

Shared infrastructure is also key, with the collaboration between utility providers or other telecommunication companies to share existing infrastructure like utility poles or buildings for installing 5G equipment. Utilising small cells and micro infrastructure for 5G deployment as these smaller, less obtrusive devices can be integrated into existing street furniture, such as lampposts, traffic lights, or buildings, reducing the need for large tower sites.

4 Informatica. What is Low Latency? www.informatica.com/services-and-training/glossary-of-terms/low-latency-definition.html

But how can we test innovative solutions within cities before going full-scale? The creation of sandbox environments or pilots could be a solution.

Examples of initiatives in Europe include the creation of a 5G testbed in Dublin or the Smart Urban Spaces project in Madrid.

Dublin Docklands 5G Testbed Case Study[5]

The Dublin case study consisted of a creation of a state-of-the-art 5G testbed in the Docklands. 20 outdoor small cells were mounted on street furniture such as poles and traffic lighting columns, and 10 indoor small cells in locations such as The CHQ Building. The challenges encountered were access to power, backhaul (fibre) and planning policies. Additionally, it was necessary to coordinate with third parties such as ESB Networks and Novegen. The network density that will be required in the future is immense, and small cell deployment models such as neutral hosts will be critical to reduce visual pollution and urban clutter. The testbed continues to inform the council's connectivity plans.

Smart Urban Spaces in Madrid Case Study[6]:

Madrid focuses on creating smart public spaces through technology.

This includes using sensors and digital technologies for adaptive features like lighting and irrigation, parking spaces, waste treatment, monitoring of green areas and parks, monitoring biodiversity and air quality, promoting pedestrian-friendly areas or offering citizen interaction through apps.

Smart litter containers ©tetuan30dias

Cabin service ©CabinPaq

5 Smart Docklands. (2024). Docklands 5G Testbed smartdocklands.ie/projects/docklands-5g-testbed/

6 Smart Urban Spaces. Smart Urban Spaces presentation iotmadlab.es/wp-content/uploads/2023/11/Smart-Urban-Spaces-Presentation.pdf

IoT massive deployment

Basic components of the infrastructure

IoT networks, encompassing an array of sensors and interconnected devices as actuators and network nodes, function as the vital infrastructure in a smart city setup.

Sensors collect and transmit data in real-time from the environment, e.g. a temperature sensor – or a connected thermometer – providing the air temperature with some periodicity or sending an alert message in case the temperature goes out of a certain range – less than 4ºC, to warn of the possibility of ice on the pavement.

Some commonly used sensors in a Smart City project are those related to environmental conditions, like weather – rain, wind, temperature, humidity, atmospheric pressure, air and water quality, or traffic control – to prevent or manage traffic jams – though there can be many more depending on the services that one wants to provide.

Actuators are those elements of the IoT network that can receive commands from another device or the central server and perform actions.

An actuator is usually equipped with an electric engine or relay and can open and close valves, to control the flow of water or gas through pipes, or start and stop electrical circuits, which can be used to turn lights on and off, control traffic by optimising the timing of traffic lights and many other different purposes.

Another element of the IoT network is the Network Nodes. The nodes provide wireless coverage to sensors and actuators spread along the city and are physically connected to a private or public network that allows the data to flow in and out of the server or the cloud. The best example of a public network is the Internet.

Weather station connected to a lamppost in Burkina ©Yoda Adaman, Unsplash

A network node is conceptually very similar to a domestic Wi-Fi router, on one end it is connected to the Internet and on the other it provides a wireless connection to electronic devices.

At the other end of the network from sensors and actuators is the Server or the Cloud. This element gathers the measurements from the sensor, runs applications and releases commands to the actuators based on those measurements and its programming.

IoT like 5G claims to occupy its own space in cities. The sensors, actuators and nodes of the IoT network are typically small in size, but large in number – a large Smart City project can involve several thousand of these devices – and need to be placed in specific locations.

Automating the massive deployment of IoT devices involves an end-to-end workflow encompassing purchase, logistics, configuration, setup, installation, commissioning, readings tracking, alerting, triggering actions and auditing for faults in the devices themselves. Streamlining these processes enhances efficiency and ensures a quick and effective deployment of IoT infrastructure[7].

©Planet Volumes

7 Atrebo. (2022, February 16). Use Case: IoT Massive Deployment and Assets Monitoring. www.atrebo.com/en/use-case-iot-asset-monitoring/

Functionalities

One of the key aspects of IoT deployment is the ability to anticipate incidents and events. By combining sensors with predictive algorithms, smart cities can detect patterns and anomalies. The presence of burglary detection, based on sensor data and pattern recognition, ensures public safety and security.

As an example, in Jaipur (India) to improve the quality of city services to make it a smarter and safer city, a smart street lighting solution has been implemented that includes award-winning motion sensors and wireless controllers capable of adjusting the brightness levels of streetlights based on human presence in real-time[8].

On the other hand, sustainable or smart mobility is another of the foundations of the smart city. Whether due to the high population density that many cities are beginning to accumulate or to optimise resources, the connection of electronic devices to the Internet of Things (IoT) allows the creation of a smart infrastructure.

The application of high-tech Smart Mobility is looking for solutions such as intelligent pedestrian control systems, bike lanes, specific weather conditions, charging stations, parking capacity control, traffic control and tourist saturation. Thanks to this technology bicycles are connected by sending real-time location and speed data, allowing for more efficient traffic management, adjusting traffic lights to ensure smooth and safe routes.

In addition, the IoT can also ensure pedestrian safety by detecting that a pedestrian is trying to cross the road when they shouldn't warning both the pedestrian and the driver, reducing the risk of an accident.

Another important aspect to consider is public transport. One of the applications of IoT is real-time information signalling. Nowadays, passengers can be provided with accurate, real-time updates on the arrival and departure of public transport services. This allows travellers to better plan their journeys and reduce waiting time.

However, electromobility is the most crucial aspect of sustainable mobility as it plays a pivotal role in the transformation towards smarter and more sustainable cities.

The introduction of electric vehicles (EVs) and the associated charging infrastructure contribute to reducing air pollution and decreasing dependence on fossil fuels.

This new infrastructure, gaining popularity in the electric vehicle market, also requires space within cities. EVCS such as the 5G require a specific space for their placement, on the pavement or in a car park, and they also need to be supplied with power. Charging stations are geographically dispersed, making on-site management difficult and expensive. IoT allows operations to be monitored and managed remotely and problems to be resolved quickly by providing real-time information on device usage and performance, including charger availability, fault monitoring and troubleshooting.

In Jaipur, India, smart streetlights with motion sensors and wireless controllers adjust brightness in real-time based on human presence, enhancing city services and safety. © tvilight.com

8 TVILIGHT. Largest Sensor-Based Smart Street Lighting Project in Indi. tvilight.com/case-study/largest-sensor-based-smart-lighting-project-in-india/

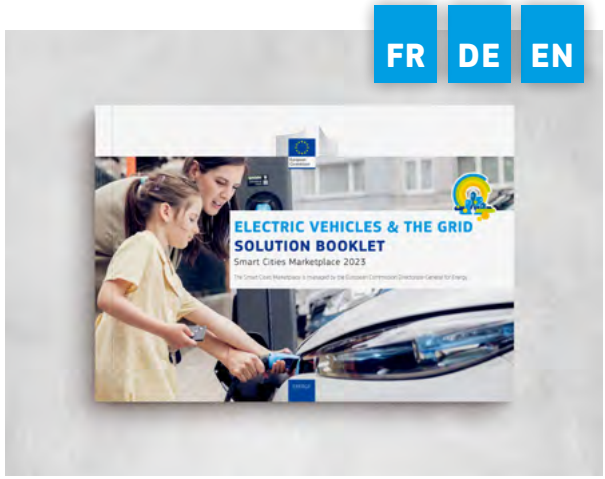
OPEN API

Implementing OPEN APIs in smart cities presents a wide range of possibilities, offering developers and stakeholders a gateway to create innovative solutions. An open API, as the name implies, is an openly (publicly) available application programming interface, which allows developers to have coding access to a proprietary system[9]. Open API opens up space for innovations.

For example, future streetlights based on Open API will adapt the colour of an emergency vehicle's path, so that traffic ahead can start to clear before hearing the emergency vehicle's siren. Another example is the coupling of smart streetlights and electric vehicle chargers, which can help respond automatically to reduce peak loads and protect the grid from collapsing.

OPEN API applications serve as a hub for seamless communication between diverse systems and services within urban environments. This standardised interface facilitates the exchange of data and functionalities between various platforms, enabling the development of new applications for various urban services.

Through OPEN API, cities can leverage the collective expertise of developers and organisations to create customised applications, optimise urban operations and improve citizen experiences. This collaborative ecosystem enables smart cities to be agile, scalable and adaptable, allowing them to respond dynamically to changing needs and technological advances.



Further reading: Smart Cities Marketplace Solution Booklet Electric Vehicles and the Grid

FIWARE[10] is one of the leading examples of open APIs and plays a key role in shaping the future of intelligent solutions. As an initiative, FIWARE[11], in collaboration with its members and partners, is driving the establishment of critical open standards and their subsequent implementation in the form of open-source software. This collaborative initiative has been designed to streamline the development of portable and interoperable smart solutions, thereby reducing time to market, complexity and cost.

One of FIWARE's main objectives is to avoid vendor lock-in. By advocating open standards, FIWARE promotes an environment in which innovation thrives without relying on a single vendor. This approach reduces the risk of being tied to proprietary technologies, ensuring healthy competition among solution providers.

9 Humanes, D. (2023, March 3). ***Atrebo Presentation***. Automate Winter Camp, Seville, Spain.

10 FIWARE Foundation. (2023, October 19). FIWARE – Open APIs for Open Minds. www.fiware.org/

11 Projects Story. (2017, March 30). FIWARE – a European success story. digital-strategy.ec.europa.eu/en/news/fiware-european-success-story

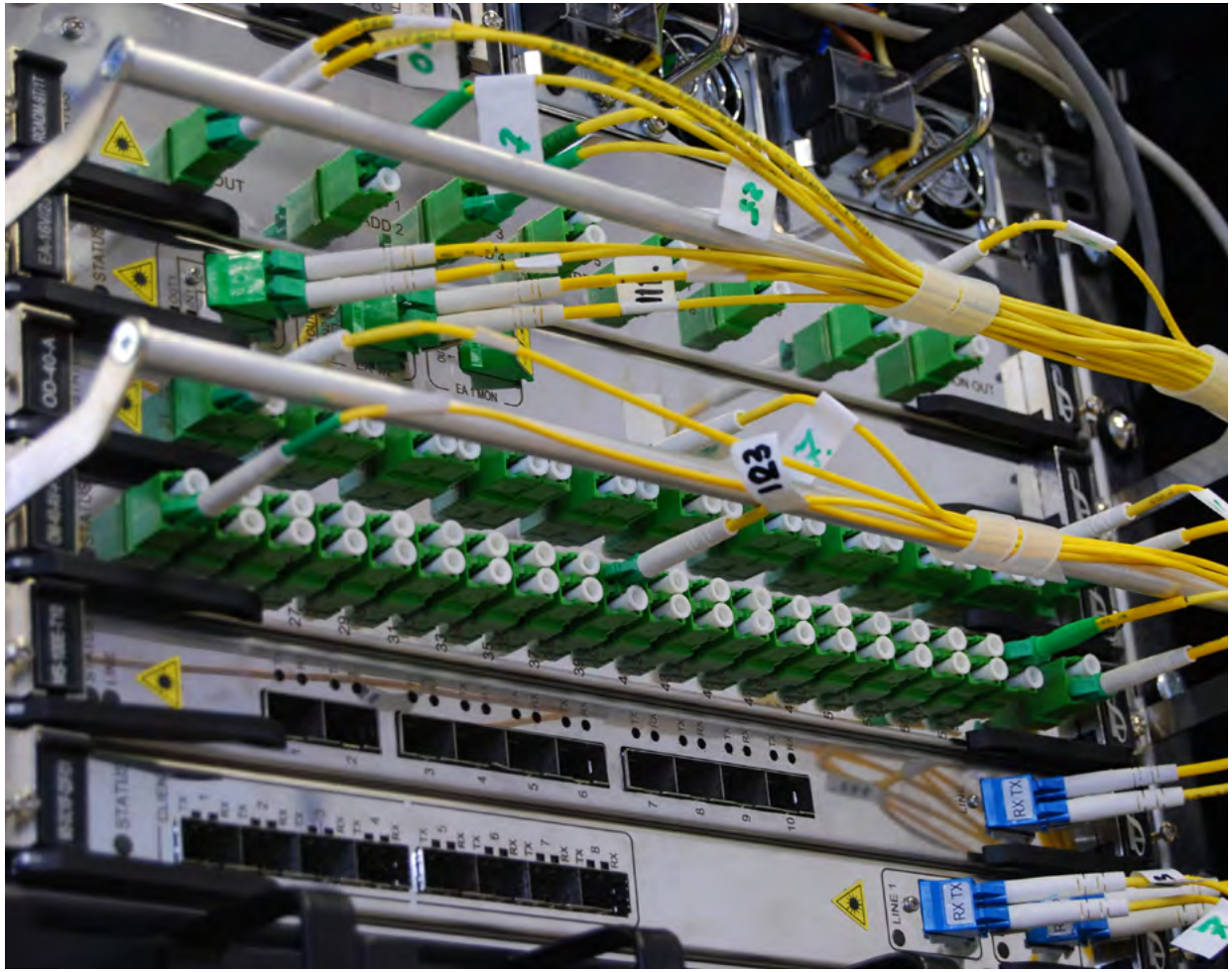
Telecom connectivity: Massive fibre rollout

Telecommunications connectivity, in particular using fibre optic networks, is the backbone of effective IT and communications management in smart cities.

Optical fibre offers unparalleled data transmission capacity, providing reliable and high-speed internet connectivity essential for various smart city applications. Close collaboration between local administrations, regulators, governments, and telecommunication companies is essential to facilitate this.In this way, cities, districts and neighbourhoods can benefit from all the advantages of fibre deployment for smart city infrastructures.

With its ability to handle vast amounts of data at lightning-fast speeds, fibre optics support the infrastructure necessary for IoT devices, smart sensors, and data-intensive services.

The massive deployment of fibre for widespread telecommunications connectivity denotes an expansive deployment of fibre optic cables to extend high-speed Internet access. This strategic infrastructure expansion involves laying extensive fibre optic cable networks across regions, cities, and rural areas.



Optic-fiber telecommunication equipment in rack ©Kirill Sh, Unsplash

Cyber security

Security within the telecommunications infrastructure for smart cities, especially when integrating Web3[12] and blockchain[13] technology is essential to ensure robust protection against cyber threats. Web3, with its decentralised nature, and blockchain, known for its immutable and transparent ledger, offer enhanced security measures.

Implementing blockchain in telecommunications infrastructure improves data integrity, preventing unauthorised tampering or manipulation. Despite its growing popularity, the world's most popular cryptocurrency is controversial, not least because of the large amount of energy it requires. A comparison by Visual Capitalist shows that it consumes far more energy than some of the world's largest technology companies.

Using decentralised networks in Web3 reduces the risk of single points of failure, improving the resilience of smart city communication systems against potential attacks.

This way, interconnected technologies such as drones, autonomous vehicles, energy appliances, robots or electric vehicle charging stations, establishing secure connectivity between diverse vendor platforms has become a key concern.

Centralised cloud-based services offer a convenient solution for managing large amounts of data. However, this scenario raises the question of ownership and management of encryption keys. Determining who owns the basic keys to encrypt data becomes crucial.

In contrast, decentralised secure communication technologies offer a different paradigm for securing complex collaborations involving numerous stakeholders. These technologies allow the creation of encrypted networks in which each participant owns and manages its encryption keys and security protocols. This approach promotes transparency and delineates clear lines of responsibility for data security. Each stakeholder takes responsibility for the encryption and protection of their data, eliminating uncertainties of ownership and ensuring a higher degree of trust between partners[14].

Decentralised secure communication technologies promote transparency and trust by allowing stakeholders to manage their own encryption keys and security protocols, ensuring clear responsibility for data security. Above ©Paul Hanaoka, Unsplash, Below ©David Dvoracek, Unsplash

12 Amazon Web Services (2024). Amazon Web Services. What is Web3? aws.amazon.com/what-is/web3/?nc1=h_ls

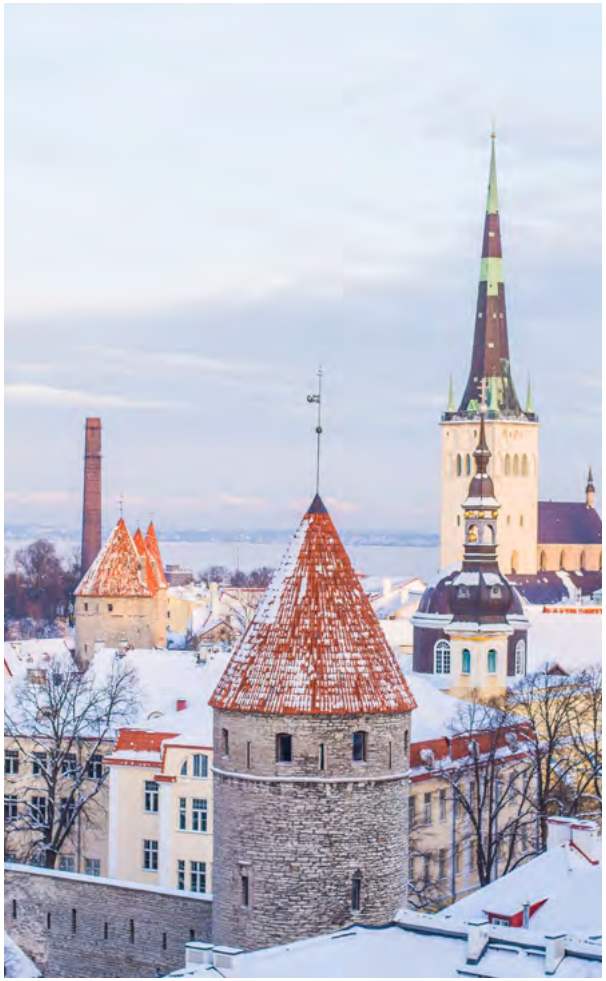
13 Telefónica What is Blockchain and what is this technology for? www.telefonica.com/en/communication-room/blog/what-is-blockchain-and-what-is-this-technology-for

14 Mikityuk, A.K. (2023, September 21). Tower Automation Alliance member Staex talk about smart cities. Automate Smart Cities Camp, Madrid, Spain. www.youtube.com/watch?v=QWBlXSBqdUE

The application of decentralised secure communication technologies in this varied ecosystem ensures that data security does not depend on a single entity. Instead, it distributes responsibility among multiple nodes, reducing the risk of a single point of failure and potential data breaches. In addition, these technologies encourage a sense of ownership among stakeholders, promoting proactive measures to maintain data integrity and security.

A good example of the use of these technologies is the case of Tallinn (Estonia). Around 99% of public services are digitised. Thanks to blockchain technology, all communications with the administration can be done through an electronic device. According to official studies, it saves 2% of the national GDP or the equivalent of 1,400 years of actual work[15].

For IoT technology, it is important to note that the data that is collected by IoT devices (atmospheric data, air quality, water pollution, state of traffic lights, etc.) are not considered "personal data" for data protection law and are following the European Regulation specifically Regulation (EU) 2018/1725[16] laying down the rules applicable to the processing of personal data. If certain devices collect personal data, they must be processed under the provisions of the aforementioned regulation.



Tallin, Estonia ©Ilya Orehov

15 Priit Martinson. (2019). Estonia – the Digital Republic Secured by Blockchain. www.pwc.com/gx/en/services/legal/tech/assets/estonia-the-digital-republic-secured-by-blockchain.pdf

16 European Comission. Data Protection in the EU. commission.europa.eu/law/law-topic/data-protection/data-protection-eu_en

Critical infrastructure

The European Union categorises the telecommunications infrastructure as critical infrastructure[17]. “Critical infrastructure is the collection of systems, networks and public works that a government considers essential to its functioning and safety of its citizens. Protecting it is becoming more and more important as malicious actors are increasingly targeting critical infrastructure.”[18]

Furthermore, IoT sensors provide real-time data for threat detection and enable automated security responses, significantly improving overall security posture.

Thanks to IoT, cities can improve energy distribution, optimise waste management, enhance safety, and even improve air quality. This is why it is important to maintain a massive IoT network over a wide area with multiple and diverse types of sensors, such as those measuring air and water quality.

All these sensors need regular maintenance and replacement of filters to ensure that the readings they provide are accurate.

A specialised ERP[19] for the operational management of the sensors and their network can reduce the cost of operation and maximise the availability of the overall system and for this to work properly it must be brought together in a centralised, single-source platform of truth.

The EU considers telecommunications infrastructure essential for government functionality and citizen safety, highlighting the need to protect it from increasing threats.

19 SAP. What is ERP? – www.sap.com/uk/products/erp/what-is-erp.html

Steps for massive IoT deployment automation. Atrebo. (2022, February 16). Use Case: IoT Massive Deployment and Assets Monitoring. Further reading: atrebo.com/en/use-case-iot-asset-monitoring

17 Joint Research Centre. Critical infrastructure protection. European Commission. joint-research-centre.ec.europa.eu/scientific-activities-z/critical-infrastructure-protection_en

18 Wright, G (August, 2023). Critical Infrastructure. Tech Target.www.techuk.org/resource/natsec2023-genetec-20jan23.html

These are the steps of a massive IoT deployment automation:

- IoT devises purchase and logistics: Scouting reliable IoT providers, defining accurate technical descriptions, to ideally create and manage a marketplace with these providers including:
  - ↳ Sensor list
  - ↳ Price
  - ↳ A regular and quick order process with tracking
- Logistics, if possible linked to an automatic inventory generation mechanism including these functionalities:
  - ↳ Delivery notes are checked via a scanner (QR).
  - ↳ Automatic payment release to the provider after verification.
    - ✓ Warehouse inventory management (inbound & outbound), both internal and external.
  - ↳ Inventory elements created on the reception of deliveries, capturing all the relevant information associated with each IoT asset:
    - ✓ Serial number
    - ✓ DevEUI
    - ✓ Type
    - ✓ Type of Readings (once the device is provisioned).
    - ✓ Location
    - ✓ Manufacturer
    - ✓ Etc.

IoT sensors provide real-time data for threat detection and automated security responses, significantly bolstering overall security.

© Jonas Leupe, Unsplash

- Configuration & set up automation – Over the Air (OTA)[20] (if allowed by the IoT device), for large deployments, it would be helpful to implement a tool that would ease these tasks by allowing:
  - ↳ Bulk or per-device configuration.
  - ↳ The use of config templates with dynamic fields based on:
    - ✓ Rules
    - ✓ Location
    - ✓ Region
    - ✓ Etc.
- IoT network and sensors – installation & commissioning, some tools in the market facilitate the management of these processes including:
  - ↳ End-to-end installation workflow and tracking.
  - ↳ Good reading confirmation after installation, automatically checking if:
    - ✓ The device is on
    - ✓ The central system is receiving readings from it
    - ✓ The device has been associated with its location with the right GPS coordinates
    - ✓ Inventory attribute location
  - ↳ A mobile app associated with the central tool for automatic commissioning performing:
    - ✓ Sensor – Site association via:
      - » QR or Serial # scanning
      - » GPS location
  - ↳ Installer tracking (who/when)

20 Over-the-air is any method of making data transfers or transactions wirelessly using the cellular network instead of a cable or other local connection.

IoT enhances energy distribution, waste management, safety, and air quality, necessitating a diverse and well-maintained sensor network, best managed by a specialised, centralised ERP system.

Telecommunication tower ©Nathan Anderson, Unsplash

- Real-time monitoring of sensor readings defining the expected operational range of every type or on a per-sensor basis as needed for the smart city service that wants to be implemented.
- Readings should be connected to an alerting system that should automatically generate events when:
  - ↳ Out-of-range readings are received.
  - ↳ A connection loss is detected.
  - ↳ The battery is down.

Alerting using:

- ↳ Presenting the alerts on a map.
- ↳ Sending notifications.
- ↳ Triggering corrective actions (processes).
- ↳ Alerting and notification.

A reliable IoT management platform should be capable of addressing all these functionalities described above, be service assurance oriented and provide an extra layer of quality and reliability to the IoT network. While managing, triggering, and tracking preventive and corrective maintenance, while collecting all the readings for third parties to develop smart city applications on top.

In the Netherlands, the city of Amsterdam uses an IoT management platform to enhance urban living. This platform integrates data from smart sensors placed throughout the city to monitor traffic flow, air quality, and energy usage, allowing the city to optimise traffic management, reduce pollution, and efficiently manage energy consumption in real-time. ©Fons Heijnsbroek, Unsplash

SOCIETAL, USER AND SUSTAINABILITY ASPECTS

Societal, user and sustainability aspects

The implementation of dedicated telecommunications infrastructure to serve smart cities poses a series of sustainability challenges for both institutions and telecommunications companies committed to providing connectivity for applications that benefit society as a whole.

Integration of infrastructure with the urban landscape ©Han Vandevyvere

Information to the society (EMF) ©Han Vandevyvere

Sustainability of the telecommunications industry ©Getty images

E-waste and circular economy © John Cameron, Unsplash

Integration of infrastructure with the urban landscape

The integration of the elements that make up the telecommunications network in such a way that it has the least visual impact within cities is something that infrastructure operators are already considering.

Small cells and antennas are adapted to the elements of the public space (newspaper kiosks, bus stops, traffic lights, lampposts, etc.), which means that they can be integrated into the urban landscape, making smart public furniture a solution for the deployment of networks in smart cities.

These devices significantly reinforce the reach of mobile networks, taking on a key role in large cities adopting cutting-edge technologies such as 5G. They complement conventional telecom towers on top of buildings and are emerging as a key component in the development of smart cities.

For example, a "system of Smart Lamp Poles will not only lead to a considerable reduction of energy costs – between 50% and 75% – but will also contribute to reducing CO_2 emissions by offering the possibility to host sensors, cameras, Wi-Fi, electric vehicle charging and other devices. It will also enable the hosting of both public and private 5G networks, thus enabling connected mobility. The suitability of this solution lies, among other aspects, in the fact that it favours the deployment of connectivity in areas such as parks, historic city centres and other urban areas where traditional towers are not allowed and where an antenna height of more than 10 metres is required. Additionally, there is a need to deploy more devices to meet the growing demand for connectivity".[21]

Multifunctional Street Furniture thus becomes an important asset due to the need for densification inside cities. With an increasing demand for connectivity access points and high frequencies, traditional deployment limitations often leave areas with residual coverage. This furniture offers innovative solutions by integrating various technologies while aligning with environmental compatibility, which is the condition for products or projects to have a reduced impact. Thanks to improved connectivity, new services emerge that take advantage of the capabilities of furniture, especially in emergencies.

These installations serve as connectivity hubs, equipped with sensors and cameras, amplifying surveillance and data collection for urban management. Moreover, they incorporate electric vehicle chargers, promoting sustainable transportation in city centres. By merging diverse technological functionalities, these installations significantly contribute to the advancement of smarter, more efficient urban spaces[22].

The urban furniture for information, also called MUPI and advertising totems are key components of indoor and outdoor telecommunications networks and drive integration in smart cities. These structures house a variety of devices while meeting strict regulatory standards. They span indoor and outdoor infrastructure and require specialised cabinets for optimal integration and control. These solutions, which require ample space, prioritise the reduction of environmental impact, ensuring minimal disruption while complying with regulatory standards[23].

21 Ceña, B. (2023, September 18). Farolas inteligentes (smart lamp poles), la forma nueva de comunicar nuestro mundo [Smart lamp poles, the new way of communicating our world]. Computing www.computing.es/opinion/farolas-inteligentes-que-son-para-que-sirven/

22 De Miguel, J. (2023, March 3). ***Vantage Towers Presentation***. Automate Winter Camp, Seville, Spain.

23 Gil, R. (2023, September 21). ***Berrade Presentation***. Automate Smart Cities Camp, Madrid, Spain.

Information to the society and electromagnetic fields (EMF)

Both public institutions and telecommunications operators should undertake communication actions to inform society as a whole of the potential impact of the deployment of telecommunications networks on the urban landscape and human health.

Possible concerns regarding health issues should be addressed via communication campaigns referring to the fact that exposure levels remain within safe limits to protect public health and the environment[24].

In cities around the world, concerns exist regarding the safety of electromagnetic fields (EMF) emitted by mobile network infrastructure. The mobile industry takes steps to address these concerns, but there's room for improvement.

Currently, most mobile network operators (MNOs) offer information on their websites and through downloadable materials. This information focuses on technical details and adherence to safety standards.

However, it might lack comprehensiveness and objectivity, potentially causing public distrust. Decades of research[25] have led to the establishment of safety measures and exposure limits for radio signals from mobile devices and mobile network antennas. These standards effectively mitigate any recognised health risks[26].

Major public health organisations, including the World Health Organization (WHO), have stated that the current understanding is that low-level radio signals used in mobile communications do not pose health risks.

Despite this, and to enhance transparency, the mobile industry could collaborate with independent research institutions and engage in open discussions with the public. Interactive tools and targeted community outreach programs can further educate residents and empower them with knowledge.

By working together and providing accessible, balanced information, the mobile industry can build trust and ensure a healthy relationship with technology in our increasingly connected cities.

24 European Commission (30 June 2020) The Commission adopts Implementing Regulation to pave the way for high capacity 5G network infrastructure. digital-strategy.ec.europa.eu/en/news/commission-adopts-implementing-regulation-pave-way-high-capacity-5g-network-infrastructure

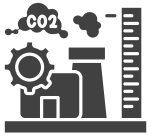
25 World Health Organization. Electromagnetic Fields. www.who.int/health-topics/electromagnetic-fields#tab=tab_2

26 GSMA | EMF and Health – Public Policy www.gsma.com/solutions-and-impact/connectivity-for-good/public-policy/regulatory-environment/emf-and-health

Sustainability of the telecommunications industry

Energy efficiency and greenhouse gases emissions management

Telecommunications systems can help to decrease GHG emissions in two ways: First, by cutting their emissions and secondly by enabling other sectors to do so.



Regarding cutting their emissions, operational emissions from telecommunications operators fell by 6% between 2019 and 2022, and in Europe, the decrease was 50% in the same period[27]. The increases in energy efficiency mean that even if the demand for telecommunications services has increased over the last years, energy consumption at a global level has decreased. Energy efficiency has been improved thanks to more efficient high-speed mobile networks with less use of less energy-efficient legacy technologies 2G/3G, and thanks to the deployment of fibre optic and the decommissioning of less-efficient copper networks.

Despite this positive trend, GHG emissions need to be closely monitored, as an increase in demand coupled with improvements in energy efficiency can lead to a rebound effect, an unintended consequence in which energy efficiency leads to increased energy consumption and thus, increased GHG emissions. In this sense, a study[28] conducted in 285 cities in China concluded that electricity consumption increased by 7% to 20% due to digital development.

Regarding the telecommunications industry's emissions, three-quarters of them are scope 3, and of those, 90% come from five categories: purchase goods and services, capital goods, fuel – and energy-related activities, use of sold products and investments[10].

International organisations such as GSMA (Global Mobile Telecom Industry Association) or ETNO are committed to decarbonising the telecommunications industry. GSMA, for example, has a climate action task force with 66 members (2023), with networks in most countries. Furthermore, the members of ETNO, the European Telecommunications Networks Operators Association, have committed to be carbon neutral before 2050 and to decrease scope 1 and 2 emissions and emissions per unit revenue generated[29].

> ***Telecommunications systems can help decrease GHG emissions by improving their energy efficiency and enabling other sectors to do the same, fostering a sustainable future for our increasingly connected world.***

27 GSMA Mobile Net Zero 2024 – State of the industry on climate action

28 Peng, H.-R., Zhang, Y.-J. and Liu, J.-Y. (2023). The energy rebound effect of digital development: Evidence from 285 cities in China. Energy, 270, p.126837. doi:doi.org/10.1016/j.energy.2023.126837.

29 ETNO Position Paper. EU Taxonomy and the European telecommunications sector.

About enabling other sectors to lower their emissions, the EU Taxonomy includes the telecom sector as one of the six relevant sectors that can support the mitigation of climate change in Europe by helping to decarbonise many other activities.

As an example, digital transformation in the transport sector could lead to a reduction in emissions of 30%. There are, however, remaining difficulties in accurately quantifying the impact of digitalisation in decarbonisation[12].

Additionally, energy management is a crucial aspect of smart city operations. IoT devices such as pulse/energy meters contribute to efficient energy usage and resource optimisation.

The city of Valencia has renewed more than 100,000 luminaires, and thanks to the new smart lighting system has reduced energy consumption by 74%, achieving savings of six million euros and reducing greenhouse gas emissions by 80%[30].

30 Microsoft Prensa. (2022, November 14th). Valencia ahorra energía y mejora la calidad de vida de sus habitantes y turistas gracias al control de iluminación inteligente basado en Azure IoT Hub. news.microsoft.com/es-es/2022/11/14/valencia-ahorra-energia-y-mejora-la-calidad-de-vida-de-sus-habitantes-y-turistas-gracias-al-control-de-iluminacion-inteligente-basado-en-azure-iot-hub/

In Barcelona using city lamppost networks supported COVID–19 response and recovery. Further reading: the Smart Cities Marketplace Humble Lamppost Initiative research identifing three groups of cities based on their implementation of smart equipment, highlighting untapped potential and the need for collaborative approaches to maximise benefits. ©Barcelona City Council

Replacing Europe's streetlight infrastructure with smart lampposts could save taxpayers up to €2.1bn a year, according to the leader of EU smart cities programme, Sharing Cities. Further reading: Smart lampposts are saving half of Burgas' energy ©Alexander Mils, Unsplash

E-waste and circular economy

Another aspect to consider is the management of e-waste, which according to the European Parliament[31] currently represents one of the fastest-growing waste streams in the EU.

One of the problems associated with e-waste is the degradation of the environment by throwing away equipment that could be reused or recycled. As a result, companies face regulatory, financial and consumer pressures to reduce the amount of e-waste they produce. Specifically for the telecom industry two main streams of e-waste are of relevance.

First, the generation of E-waste from legacy network equipment such as 2G, 3G, and on the other hand, the devices or equipment used by the final consumer (mobile phones, routers, etc).

Telecom industry experience shows that two key solutions to the problem have emerged: moving from a linear to a circular economy and promoting digital sustainability, including creating more efficient IT devices and equipment. .

The two solutions go hand in hand. In a circular economy, designers and manufacturers create products with end-of-life in mind, which means keeping products in use for as long as possible and recycling the materials they are made of. Digital sustainability means adopting ICT technologies that bring environmental, social and economic benefits.

In this regard, the waste management hierarchy establishes a prioritised framework for sustainable waste management practices, also applicable to e-waste management processes. Often depicted as an inverted pyramid, it ranks waste management options based on their environmental impact.

Further reading: Smart Cities Marketplace Solution Booklet Why Circular Cities?

Responsible management of electric and electronic appliances

In Luxemburg, Ecotrel is a non-profit association of producers and importers of electrical and electronic equipment that was founded in 2004 to ensure the legal obligations of the sector are met. Nowadays it manages and funds the electronic and electric waste processing in the country and ensures the future recycling of products currently on the market. Its operations are financed by the consumer via a recycling fee imposed on sold appliances. Ecotrel implements the concept of extended producer responsibility and contributes to the circular economy by not only recycling material but also by promoting repairing and reuse. More than 750 companies are affiliated with Ecotrel, and it is estimated that 6,300 tonnes of appliances are collected each year, with recovery rates reaching 90%.

Further reading: www.ecotrel.lu/en

31 Topics European Parliament. (2020, December 23). European Parliament "E-waste in the EU: facts and figures (infographic)". www.europarl.europa.eu/topics/en/article/20201208STO93325/e-waste-in-the-eu-facts-and-figures-infographic

Moving from a linear to a circular economy. Adapted by ©Agata Smok from Byström, J. (2018). The 15 circular steps for cities. European Investment Bank. www.eib.org/circular-economy

Waste Prevention

This tier represents the most preferable approach, emphasising strategies to minimise waste generation from the outset. This may involve acquiring fewer goods, utilising reusable products, or designing products that inherently generate minimal waste.

Energy Recovery

When waste cannot be prevented, reused, or recycled, extracting energy through processes like incineration can, in certain scenarios, be preferable to final disposal.

Reuse

This tier prioritises extending the life cycle of products by giving them a second life for their originally intended purpose. Examples include the use of refillable water bottles or the donation of clothing in good condition.

Disposal

Landfilling and incineration without energy recovery represent the least desirable options within the hierarchy due to their detrimental environmental consequences. These methods should only be employed as a last resort.

Recycling

This tier focuses on diverting waste from disposal by processing it into new materials. This necessitates the segregation of waste streams like paper, plastic, and glass to facilitate their inclusion in recycling programs.

Conducting a Life Cycle Assessment (LCA) of the telecom equipment and devices is an important step towards the implementation of a circular economy model for the industry.

However, ETNO warns that the definition of the LCA used in the EU Taxonomy is not specific enough, which means that the results are often not comparable across companies.

On another level, GSMA, representing the mobile telecom industry, announced its circularity targets in June 2023 with emphasis also on the consumer products[32]:

- By 2030, the number of used mobile devices collected through operator take-back schemes amounts to at least 20% of the number of new mobile devices distributed directly to customers.
- By 2030, 100% of used mobile devices collected through operator take-back schemes will be repaired, reused or transferred to controlled recycling organisations.

Cities need to take action to ensure that e-waste, used in telecommunications and other areas, is properly managed and if possible, follows a circularity model. In this sense, cities could work to ensure that electronic devices bought by the municipality via public procurement follow this circularity model. In addition, the cities should provide citizens with access to recycling facilities for their electronic devices.

Regarding public procurement, several factors must be considered by cities to define the criteria for selecting what devices are bought and from which companies[33]:

- Take into account changes in corporate sustainability policies to understand what criteria are used by different private companies.
- Demand decent working conditions by requiring it in your procurement contract.
- Recognise that supply chains do not end at the factories. Circularity and ethical treatment of workers must be required throughout the whole supply chain.
- Prioritise manufacturers that sell devices with a long product life cycle.
- Prioritise manufacturers that sell devices that are designed to be repaired so they can be reused once they start malfunctioning.

©Clint Bustrillos, Unsplash

32 GSMA | Mobile industry eyes five billion 'dormant' phones sitting in desk drawers for reuse or recycling www.gsma.com/newsroom/press-release/mobile-industry-eyes-five-billion-dormant-phones-sitting-in-desk-drawers-for-reuse-or-recycling/

33 ICLEI Europe, Electronics Watch, Procura+and Make ICT Fair. How to procure fair ICT. iclei-europe.org/fileadmin/templates/iclei-europe/lib/resources/tools/push_resource_file.php?uid=xM24nmb6

GOVERNANCE AND REGULATION

Governance and regulation

Legislation and public institutions play a key role in shaping the trajectory of smart cities, establishing regulatory frameworks and governance models that guide their development.

Public institutions, including local governments and regulators, drive the adoption of smart city initiatives by creating policies that promote innovation, sustainability, and inclusion.

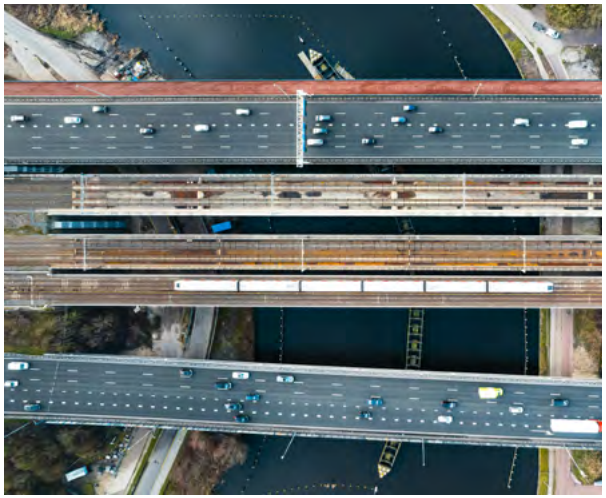
Collaborative efforts between these institutions and stakeholders help address challenges such as infrastructure deployment, funding mechanisms and citizen participation.

Facilitating the availability of resources for network hosting requires a multi-faceted strategy, especially when it comes to deploying infrastructure securely and efficiently in a diverse regulatory environment. It is vital to consider the different regulatory competencies at local, regional, national, and European levels, covering urban planning or telecommunications.

In highly populated cities, finding new locations to accommodate all these new ICT and telecom infrastructures is a significant challenge.

Municipalities have a significant role to play in this regard as managers of the public space. Cities should foster and facilitate an organised network development in their territory. In addition, as owners of potential locations to be used as telco sites (5G and IoT), or EVCS, whether buildings, urban furniture, sidewalks, parking lots, or any premise that is subject to allocated equipment, cities should explore different alternatives to develop infrastructures in selected locations addressing two demands:

- The sharing or renting of municipalities' space as a telco or EVCS infrastructure to TowerCos, telcos, smart city project (IoT) service providers, and electricity companies.
- The deployment of fibre and power lines involves civil works throughout the city to make these spaces suitable for their new use.



Amsterdam, the Netherlands ©Lennart Schulz, Unsplash

Municipalities play a crucial role in managing public spaces for ICT and telecom infrastructures. ©Okeykat, Unsplash

Public administrations should implement measures to ensure an organised deployment, creating discussion forums involving stakeholders to harmonise standards, stimulate collaboration and facilitate licensing procedures. These platforms harmonise regulations, optimise administrative procedures and speed up deployment[34].

Administrations may use the authority to encourage innovative site selection, integrating telecommunications infrastructure with street furniture while ensuring safety and functionality.

The rapid densification of 5G networks in smart cities poses a major challenge for local administrations as ensuring public acceptance of this wide deployment in urban areas requires considerable awareness-raising efforts[35]. However, such deployment is essential to transform cities into smart and efficient ecosystems. These infrastructures are crucial for the delivery of essential public services. Encouraging such deployment by the public sector not only benefits citizens but also supports the entrepreneurial ecosystem[36].

Regulation plays a key role, mainly focused on ensuring legal certainty and also facilitating the search for funding for these large deployments.

Regulatory frameworks also incorporate sandbox test environments, which allow for the testing of deployments and new technologies in a controlled environment before widespread implementation[37].

Technical standardisation is key, providing a clear framework for action and ensuring secure implementation, resulting in uniform deployments in all territories[38].

Further reading: Smart Cities Marketplace Solution Booklet Citizen Engagement

Co-creation workshops ©Cities-4-People Consortium, 2020

34 Maya, J. (2023, September 21). Initiatives for the use of public and private infrastructure for smart city services. Automate Smart Cities Camp, Madrid, Spain.
35 Portilla-Figueras, A. (2023, September 21). Initiatives for the use of public and private infrastructure for smart city services. Automate Smart Cities Camp, Madrid, Spain.
36 Pérez-Batlle, M. (2023, September 21). Initiatives for the use of public and private infrastructure for smart city services. Automate Smart Cities Camp, Madrid, Spain.

37 Fernández, M.A. (2023, September 21). Initiatives for the use of public and private infrastructure for smart city services. Automate Smart Cities Camp, Madrid, Spain.
38 Maya, J. (2023, September 21). Initiatives for the use of public and private infrastructure for smart city services. Automate Smart Cities Camp, Madrid, Spain.

ICT infrastructure deployment and normalisation

Deploying telecom networks in smart cities requires regulatory compliance, collaborative management practices, automated inventory control, efficient network-sharing processes, and continuous field operations and maintenance. By adopting these principles, cities can establish resilient and scalable networks that form the basis for technological advances.

In relation to regulatory compliance, under the EU overarching directives for telecom networks, every country defines its regulation to framework how operators can install mobile access radiant equipment (2G, 3G, 4G, 5G...). In most countries, the use of the radioelectric spectrum by mobile operators is granted by a public auction, for a fixed number of years and with mandatory requirements to be complied with in relation to the quality of the service, the coverage, etc.

Network sharing, in particular over radio access networks (RANs), involves complex request, verification and execution processes. Efficient procedures ensure collaboration between several operators is transparent, optimising the use of resources and improving network coverage and capacity while reducing costs.

Practical recommendations for better management for the deployment of telecommunications networks:

- **The use of standardised protocols and technologies enables the integration of diverse systems, facilitating compatibility and scalability.** It ensures that disparate components from multiple vendors can communicate effectively, reducing complexities and improving efficiency.
- **Managing telecom sites in a dynamic and personalised way is essential for complete coverage and real-time information.** Being able to visualise sites on maps provides a holistic view that facilitates strategic location and resource allocation.
- **Promoting access to real-time information** for decision-making and rapid response to changes or problems, thereby improving network performance
- **Optimising inventory assets is crucial to avoid obsolescence and improve operational efficiency.** Real-time updates and geo-positioning of inventory items streamline management processes. Configuration of inventory fields, attributes and items allows customised tracking and quick retrieval of information through interactive dashboards.

Open RAN (Radio Access Network) for smart cities revolutionises traditional telecommunications infrastructure by separating hardware and software components, encouraging interoperability between different vendors[39].

This approach promotes flexibility, scalability and innovation, enabling cities to deploy and manage networks efficiently. Open RAN's open standards foster competition, reduce costs and accelerate the adoption of advanced technologies. Its agile architecture allows cities to quickly adapt to changing connectivity needs. By adopting Open RAN, smart cities can cultivate resilient, vendor-neutral networks, enabling rapid development and improved connectivity.

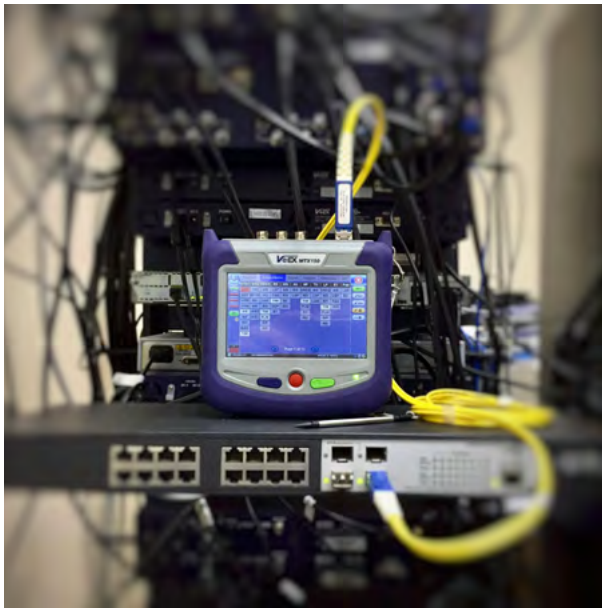
Edge computing in telecommunications networks refers to the decentralised processing of data closer to its source or endpoint, typically at the edge of the network, rather than relying on a centralised data processing infrastructure. In telecommunications networks, edge computing involves deploying computing resources closer to where data is generated, enabling faster processing, reduced latency and increased data security.

Applied to smart cities, edge computing facilitates the efficient operation of multiple interconnected devices and systems by enabling real-time data analysis and decision-making at the edge of the network, enabling smart cities to respond quickly to changing conditions.

Field operations and maintenance are integral components in ensuring the reliability and longevity of telecommunications networks in smart cities. Applying predictive, preventive, and corrective maintenance strategies minimises downtime and maximises uptime. Monitoring every step of the process facilitates proactive identification and resolution of potential problems, thereby improving network reliability.

On fixed telecommunications infrastructure, and more specifically referring to fibre infrastructure, a new figure is erected to enable the sharing of the fixed network to any operator. This new figure is the so-called fibres.

These companies are neutral fibre infrastructure companies that own the physical infrastructure (the fibre cable) from datacentres to the end user premise and rent it to the operator that is eventually providing the Internet access service. By owning and sharing their infrastructure they minimise the need for overlapping networks, in a scenario where every single operator would need to deploy its fibre cable down to every single end user.



A telecommunication test set connected to a network switch, to perform some data transmission quality measurements. ©Polo Ildefonso, Unsplash

39 De Miguel, J. (2023, March 3). Vantage Towers Presentation. Automate Winter Camp, Seville, Spain.

Automation process

The automation of the processes required to manage smart cities has transformed urban governance, using technology to improve various elements of city functions. This change includes many key sectors to ensure efficiency, sustainability, and safety.

Creating and keeping updated an IoT device inventory is essential to managing a smart city, especially when it comes to large deployments in a city, with tens or hundreds of thousands of devices deployed. Automation simplifies this procedure through the use of centralised systems to collect the relevant inventory information of these devices and keep them tracked throughout their lifecycle. Leveraging smart software, these systems monitor the location, performance, and health status of IoT devices, ensuring efficient maintenance and management.

For the deployment of telecommunications networks, automation plays a key role in the deployment and management of these networks for smart cities. It facilitates the efficient installation, configuration and monitoring of network infrastructure. Through automated processes, cities can rapidly deploy telecommunications equipment, optimise network performance, and quickly resolve any connectivity issues that may arise.

Predictive maintenance mechanisms should be implemented with the help of AI technology to proactively address smart cities' infrastructure issues before they happen. Automation integrates sensors and data analytics to monitor the condition of various systems and predict potential failures. Algorithms analyse historical data and real-time information to forecast maintenance needs, minimising downtime and reducing overall maintenance costs.

Automated access control systems reinforce security measures in smart cities. These systems manage and regulate entry points to critical infrastructure, public facilities, and restricted areas.

Using biometric authentication, smart cards or mobile apps, automated access control ensures secure entry while maintaining efficient flow within the city. It is important to highlight that personal information should be lawfully obtained (usually through freely given consent) for a specific purpose, and not be used for unauthorised surveillance or profiling by governments or third parties or used for unconnected purposes without consent (unless otherwise required under the law)[40].

40 The World Bank. (2024). Data Protection and privacy laws. id4d.worldbank.org/guide/data-protection-and-privacy-laws

Incident alerts from sensors and action triggers are based on the flux of continuous readings received from the sensors installed throughout the city. Automation processes this influx of sensor data, identifying anomalies or potential problems in real-time. When irregularities are detected or predefined thresholds are exceeded, automatic alerts are generated that trigger immediate actions or responses.

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Faouzi Achbar, Vice Mayor of Rotterdam, at the Eurocities Digital Forum 2024, emphasising that technology should serve people.
Further reading: European cities place people at the heart of digitalisation (Eurocities) ©Eurocities

Lessons learnt

- Cities should leverage the power of ICT infrastructure, to develop smart city services that create a more efficient, sustainable, and liveable urban environment for their citizens
- **Smart cities provide value in many aspects:** reducing pollution, improving citizen safety, traffic management, improving environmental sustainability[41], and ultimately improving the quality of citizens. Its development needs to be based on a sustainable and reliable network infrastructure.

- For the deployment of a smart city and all the technology that goes with it (IoT, 5G, sensors, AI), it is necessary to seek common standards from all public and private actors involved in the process.
- It is essential that cities build a technological ecosystem where digital transformation is the link between public and private administration. To materialise this ecosystem, 5G and optical fibre becomes a key factor since currently, this technology is the one that can support and satisfy the demand generated by the challenging ecosystem of a Smart City.

- Smart cities aren't just about technology or infrastructure – they are about people. Municipalities should actively involve citizens in the planning and development of smart city initiatives and ICT infrastructure developments, especially when this infrastructure is linked to the public space.
- By investing in a robust ICT infrastructure and nurturing a vibrant ecosystem, cities can create a fertile ground for smart city development. This collaborative effort, with a strong emphasis on infrastructure and enabling the ecosystem, paves the way for efficient, sustainable, and liveable urban environments for the future.

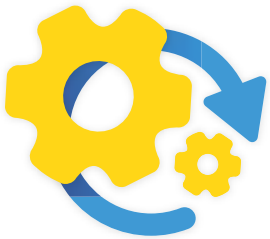
41 Barrachina, M. (01/01/2024). Tecnologías inteligentes para aspirar a ciudades más sostenible. BIT. bit.coit.es/tecnologias-inteligentes-para-aspirar-a-ciudades-mas-sostenibles/

Smart Cities Marketplace

The Smart Cities Marketplace is a major market-changing initiative supported by the European Commission bringing together cities, industries, SMEs, investors, researchers and other smart city actors.

The Marketplace offers insight into European smart city good practice, allowing you to explore which approach might fit your smart city project.

Discover our digital brochure here.



Matchmaking

The Smart Cities Marketplace offers services and events for both cities and investors on creating and finding bankable smart city proposals by using our Investor Network and publishing calls for projects.

Investor network

Call for Applications – Matchmaking Services

Project finance masterclass

Focus and Discussion groups

Focus groups are collaborations actively working on a commonly identified challenge related to the transition to smart cities. Discussion groups are fora where the participants can exchange experience, cooperate, support, and discuss a specific theme.

Focus and Discussion groups

Community

Scalable Cities

A city-led initiative providing a large-scale, long-term support for the cities and projects involved in the Horizon 2020 Smart Cities and Communities projects.

Scalable Cities

ICT INFRASTRUCTURE MANAGEMENT

SOLUTION BOOKLET

Smart Cities Marketplace 2024

The Smart Cities Marketplace is managed by the European Commission Directorate-General for Energy