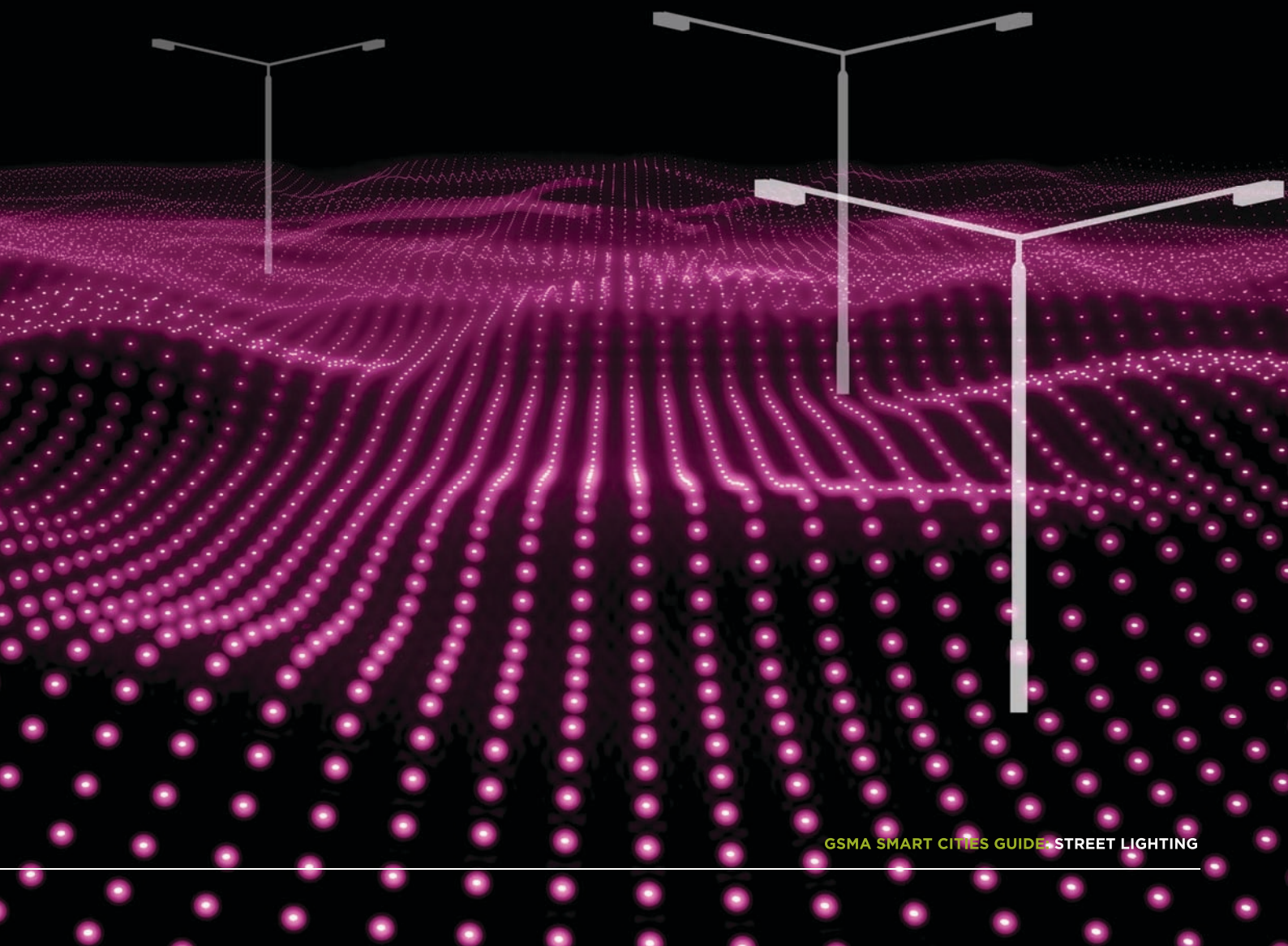
Internet of Things

GSMA SMART CITIES GUIDE
STREET LIGHTING

How mobile operators can help cities manage and control their streetlights and use them to provide new smart city services



Introduction

Street lighting is a core piece of urban and rural infrastructure. Lighting helps to create a safe environment for both pedestrians and drivers. Many streetlights around the world are now being updated to LED lighting, which uses less energy and is more reliable than traditional sodium lamps, significantly reducing the cost of keeping streets illuminated.

It is now cost effective to add communications technology to streetlamps at the same time as LED upgrades take place. Mobile operators' Internet of Things (IoT) solutions can provide low cost, ubiquitous coverage across a city, and are designed specifically to connect city services and sensors, including streetlights. This connectivity enables the lights to be remotely monitored and controlled. Moreover, additional sensors can be added to the lighting infrastructure, offering a cost effective way of creating a citywide IoT sensor network and enabling the deployment of more smart services.

As they already have wireless networks and associated systems in place, mobile operators make ideal partners for municipalities looking to upgrade their streetlights or introduce other smart city services. Mobile operators can help public agencies make their services more efficient, obtain intelligence from raw data and ultimately improve the quality of life of their citizens. Harnessing their existing local assets, mobile operators can help to build a sustainable smart city that offers new services and new opportunities.

IoT-enabled street lights

Streetlights have long been a major cost for local government. Although they offer immediate benefits in terms of street safety, the cost of running thousands of streetlights for many hours of the day adds up. Historically, energy companies would charge for the electricity used by streetlights through an unmetered connection, meaning that governments just paid a flat fee. However, with the move to more dynamic energy supply, electric power for streetlights is now often metered, meaning that cities' lighting costs have generally risen. New technologies allow these costs to be reduced or controlled. By replacing traditional sodium lamps with energy efficient LED lamps, running costs can be cut by up to 60%, as well as providing a brighter street environment. These new bulbs also last much longer than traditional bulbs, reducing maintenance costs significantly. Streetlight provision and maintenance is a large part of any municipality's budget, and the introduction of LED technologies can help free up funds for other programmes.

However, replacing the lighting technology is only half the story. If the new street lamps are connected to a mobile network, they can be controlled remotely as an IoT device – they can be dimmed outside of peak hours, turned on or off as needed and faults identified quickly. These decisions can be made in real-time, either by a central control centre or on the device itself. This means that both maintenance costs and energy costs can be reduced significantly: Machina Research estimates that dimming lights when they are not needed can generate an additional 20% cost saving (on top of the savings from the installation of LED bulbs).

Of course, the connectivity used by street lights needs to be as cost effective as possible to maximise the savings. Mobile networks are well suited to connecting lights – they already have ubiquitous coverage across urban and rural areas, meaning no additional infrastructure needs to be installed. They offer a good quality of service, and are underpinned by mobile operators' customer support capabilities, which can resolve any issues. They also offer secured bandwidth in licenced spectrum, meaning flexibility is assured and there is no risk of interference from other services. Finally, it is straightforward to add mobile communications technology to the lighting unit itself - standard low-cost communications components can be integrated into the streetlamp using standardised connectors from a number of different manufacturers.

Now well established, IoT-enabled lighting is often used to light up major landmarks, such as the Eiffel Tower and the Empire State Building, in different colours every night. Lighting is increasingly being mounted directly onto bridges, buildings and stadiums to turn them into new city highlights. Even the Niagara Falls is now impressively lit up in multiple colour combinations at night by new IoT-enabled lighting techniques. These high profile feature lighting systems rely on a robust communications network to ensure that lamp control and colour changes can be conducted remotely.

CASE STUDY: Monheim am Rhein

One of Germany's picturesque cities along the river Rhine is benefitting from smarter street and festive lighting: The city of Monheim am Rhein, in cooperation with Deutsche Telekom and the municipal subsidiary Elektrizitäts- und Gasversorgung GmbH (MEGA), is using intelligent street lighting. Dimmable and remote-controlled, the streetlights in the heart of the city use less energy than their predecessors, and will report failures automatically. The same light management system can be used to remotely control the town's new LED Christmas decorations.

> *"With the digital expansion, we are increasing the quality of life of our inhabitants and Monheim's attractiveness as a location for business"*
>
> **Daniel Zimmermann,** Mayor of Monheim

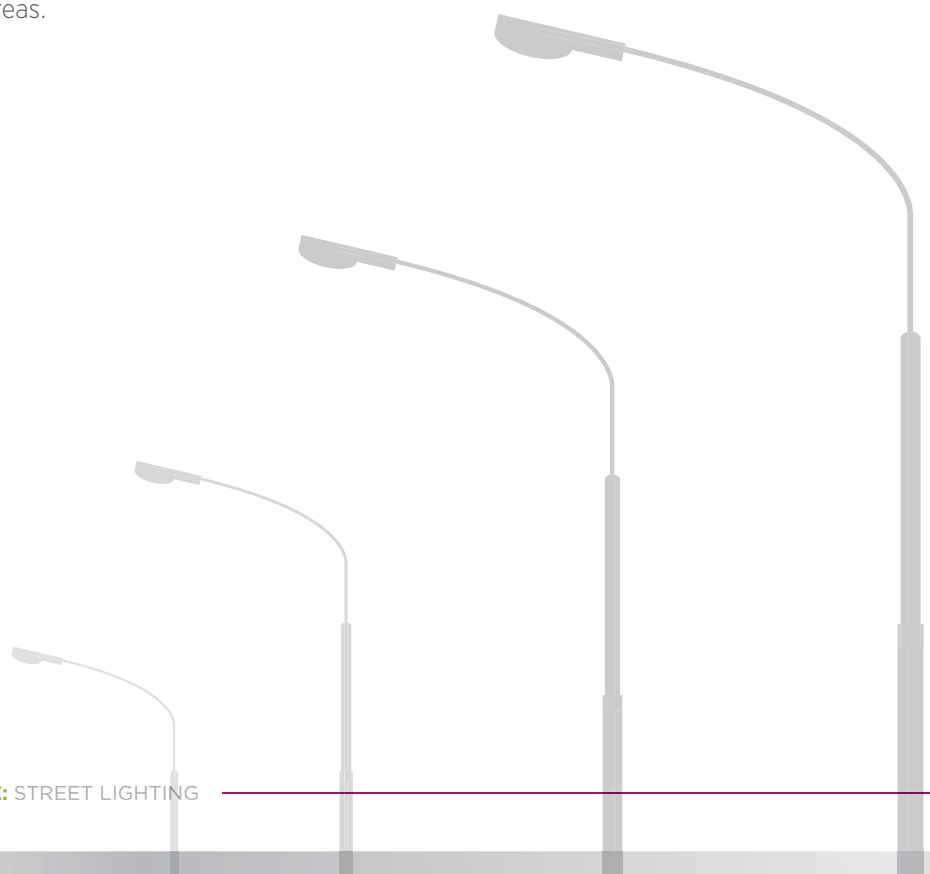
In the pilot project, the heads of the street lanterns were replaced and refitted with LED technology, connected to Deutsche Telekom's network. The new luminaries are optically the same as the previous old-town lanterns, but the power consumption per lantern drops from 70 watts to 22 watts per hour - a saving of nearly 70 per cent. As the lamps can be dimmed remotely using the light management system provided by Deutsche Telekom, the city saves additional energy at night when the traffic has come to a rest. Moreover, bulb failures are reported automatically, making maintenance easier for MEGA.

Under the motto "Monheim 4.0", the town on the Rhine is a pioneer of connected city technologies. For example, there is already an online reporting tool for local issues, such as pot holes or vandalized street signs, tablets for school lessons, a platform for discussion and voting on household proposals, as well as numerous WiFi hotspots in the urban area. "We will be the first city nationwide to complete broadband expansion by the end of 2018," says Daniel Zimmermann, Mayor of Monheim. "With the digital expansion, we are increasing the quality of life of our inhabitants and Monheim's attractiveness as a location for business."

Sustainable, connected street lighting

Urban street lights are densely-clustered, making it cost-effective to upgrade lighting with LED and connectivity. However, rural areas have a much lower density of street lighting, which can be more expensive to replace and maintain. The cost of connectivity and maintenance across all areas can be minimised by using new low power wide area Mobile IoT technologies from mobile operators. These new technologies, which are designed to offer low cost, wide area network coverage, are outlined in the next section.

To serve people living in remote communities in developing countries that lack reliable access to mains electricity, cellular-connected, solar-powered street lights are coming on to the market. Many governments in the developing world are exploring the use of connected solar-powered street lights as they can be run at very low cost. As the cost of installing an electricity grid for street lighting is very high, solar streetlights can be the right economic option in the right location. The solar power also provides enough electricity to enable connectivity through mobile and Mobile IoT networks, meaning that the lights' performance can be monitored and controlled remotely, if needed. The largest markets for solar streetlights are China and India, with African countries also investing heavily in solar streetlights, supported by World Bank initiatives. Use of solar-powered lighting is also growing quickly in the UK and Germany, driven by the significant cost savings these lights generate in hard to reach areas.



CASE STUDY: Telenor & Leading Light

Leading Light has partnered with Telenor Connexion to develop a connected lighting solution, called ActiveLights IQ. Municipalities, utilities and other companies use Leading Light's energy efficient solutions to help achieve environmental goals and create a safe environment. By partnering with Telenor Connexion, the IoT arm of the Telenor Group, Leading Light is providing an end-to-end service encompassing everything from the solution design to operations.

Telenor Connexion has worked together with Leading Light to optimise the hardware design, information management and the end user experience. This has helped reduce development time and provide a solid foundation for new services. The product has so far been installed in ten cities across Sweden.

ActiveLights IQ can be equipped with various sensors to enable smart services, such as traffic measurement, presence detection, light control, temperature and power consumption. The system can work offline, as well as online through 3G connectivity.

Leading Light's energy efficient solution, and the environmental goals it supports, are aligned with one of Telenor Connexion's core values: sustainability. By harnessing smart technology, sustainable solutions can be developed with minimal impact on the environment.

> *"ActiveLights IQ can be equipped with various sensors to enable smart services, such as traffic measurement, presence detection, light control, temperature and power consumption. The system can work offline, as well as online through 3G connectivity"*

Streetlights as multisensory gateways

Smart streetlights can support a range of sensors and services using the power and communications connections available on each light pole. As light poles are located throughout a city, they are the ideal hosts for a wide array of sensors. Sensors are critical to the functioning of a smart city. They can collect a wide range of data from across an urban area, much of which is relevant to the planning, utilisation and operation of city services.

Connected sensors can be used in many different ways by the municipality or citizens. They can signal when a parking space is free, what local weather conditions are, the number of vehicles queuing at a junction and identify noise issues. As sensors become increasingly diverse, more and more are being installed in cities, collecting more detailed data and yielding greater benefits.

Some of the use cases for sensors on light poles are outlined below:

MONITORING AIR QUALITY

A critical environmental factor that affects citizens' wellbeing, air quality can change rapidly and thus needs extensive, real-time monitoring.

Air quality monitoring is evolving from relying solely on large industrial units, which are expensive and are spread judiciously throughout a city, to a more blended approach combining local, low cost IoT sensors calibrated alongside industrial sensors, to give accurate air quality readings at many points throughout a city. These new flexible sensors also capture more detailed data from the road network across a city, highlighting when pollutants reach dangerous levels at precise locations.

Light poles provide a natural host for the new generation of small air quality sensors. They can be placed alongside roadways, and can be spread uniformly throughout a city. As the sensor can draw power from the light pole and use the communications equipment embedded in the smart street light, implementation of these air quality sensors can cost much less than finding and allocating dedicated sites to air quality measuring equipment.

MONITORING TRAFFIC AND PEDESTRIANS

Most light poles line roads, and so offer a natural place to mount sensors monitoring traffic. These sensors can easily count the number of vehicles, pedestrians and cycles passing underneath a streetlight and the resulting data can be tied to air quality measurements to provide greater analysis. Camera-based systems, infrared counters

CASE STUDY: AT&T and GE partner for smart street lighting deployments

AT&T and Current, powered by GE, are working together to connect cities across the United States and Mexico to the Internet of Things (IoT). Together, the companies will unlock a realm of possibilities to improve the way cities operate, communicate and meet the needs of citizens.

Since launching its Smart Cities organization in 2015, AT&T has been using its resources and IoT expertise to create impactful solutions for cities. By introducing GE's Predix-powered IoT platform, AT&T can use outdoor LED lighting in a city to create a digital infrastructure that helps address issues like traffic flow and parking optimization, gunshot detection on city streets, air quality monitoring and weather emergency alerts.

"Intelligent lighting plays a huge role in a smart city," said Chris Penrose, president, Internet of Things Solutions, AT&T. "Our collaboration with Current will enable us to use a city's existing lighting infrastructure to more securely connect sensor-enabled networks. This will put them on the path to becoming a smarter, more sustainable city."

Current recently announced a deal with the City of San Diego to upgrade thousands of the city's outdoor light fixtures to sensor-enabled LED technology, making it the world's largest smart city IoT platform. AT&T will act as the data carrier and provide highly secure connectivity for the San Diego deployment, which is expected to **save the city approximately $2.4 million in annual energy costs.**

> *"Our collaboration with Current will enable us to use a city's existing lighting infrastructure to more securely connect sensor-enabled networks. This will put them on the path to becoming a smarter, more sustainable city."*
>
> **Chris Penrose,** President, Internet of Things Solutions, AT&T

or microphones, which can pick up and analyse traffic and ambient noise in some detail, can all be used to monitor traffic volume.

Analysing the big data captured by multiple sensor sets enables new services to be deployed. For example, the volume of traffic, combined with local temperature data, can be used to pinpoint routes for gritting trucks during freezing weather, while the number of pedestrians passing a light pole can be used to decide on the best locations for pedestrian crossings, bus stops and public transport routes.

PARKING SYSTEMS

Parking management is another service that can be hosted from connected lighting poles. Sensors or cameras can effectively identify vacant parking spots on the street below and inform the control centre, which can then direct a vehicle to the vacant spot. The same technology can be used to bill drivers for the length of time their vehicle occupies a space, highlight unlawful parking or identify abandoned vehicles.

This technology is particularly useful for the effective management of large parking lots, such as those in shopping malls or airports. Lights can also be dimmed out of opening hours to cut the cost of lighting such large areas.

CCTV/SECURITY

As well as creating safer environments by lighting dark routes, connected streetlights can support additional safety features that can both save money for the city and provide peace of mind for citizens. Connected light poles can host CCTV cameras and motion sensors to monitor the street environment. If a city decides to dim lights to save money, these motion sensors can be used to turn the light back up to full brightness if anyone is in the vicinity. These simple tools can create a safe environment, while potentially creating cost savings for city planners.

SMALL CELL BASE STATIONS

There is a growing trend towards using light poles to host small cell base stations to meet consumers' growing bandwidth requirements and to support the 5G networks of the future. Small cells offer the same functions as a traditional, larger cell, but the technology can now offer a better consumer experience in dense urban areas: A dense network of small base stations is generally better suited to meeting users' bandwidth requirements than a traditional macro network.

The small cell base station equipment is small enough to fit on the street light or pole. Embedding these small cells into streetlights and other street furniture keeps the visual clutter on the street to a minimum whilst opening up a new revenue stream for the street light owner. It also means that cities can improve the network coverage and bandwidth available to their citizens and sensors in densely populated areas.

STREETLIGHT USE CASES

RETAIL

Retail centres, supermarkets, shopping malls and associated parking lots need smart street and outdoor lighting. Whether they be outdoors, underground or multi-storey, shopping mall and supermarket car parks are often large areas in which connected lighting can support safety, security and parking management.

The cost of running lighting across a large parking lot can be high, especially if the lights need to be

kept on outside of store opening hours to provide safety and security for staff and local residents. Installing smart lighting enables the retail site manager to reduce its maintenance and management costs for lighting, whilst also improving the customer experience through accurate highlighting of empty parking spaces, improved security across the site and the ability to use lighting to guide customers to points across the retail park.

A smart lighting system can also be used for feature lighting of buildings and other amenities, such as fountains, outdoor eating areas and passageways lit and managed in a cost-effective, but customer-friendly way.

RURAL

Rural areas have a low density of street lighting, making it expensive to maintain each individual light. These features can make the business case for connecting rural streetlights very strong, as connectivity can significantly reduce the operating and maintenance costs associated with remote, hard-to-access street lighting. Moreover, the use of motion detectors means that even lights that are in the most remote location can be operated in a much more cost-effective manner. New Mobile IoT technologies from mobile operators are well suited to connecting these remote street lights, creating a safer, more secure rural road network, and giving the municipality more information about where best to locate new lights based on road and pedestrian traffic in the vicinity.

INDUSTRIAL

Industrial zones and industrial parks require lighting that is reliable, continuously available and able to meet the specific requirements of the on-site industrial activities. Roads to and from industrial zones also need to be well lit to ensure safety when large trucks and vans are coming and going throughout the day.

Connectivity allows for industrial lights to be managed continually. Industrial site owners are able to adjust the brightness of lighting based on activities through the day, and safety can be improved by ensuring hazardous areas are well lit and use sophisticated fault detection systems that can alert managers of imminent failures and enable timely maintenance.

RESIDENTIAL

New LED lights are significantly brighter than the previous generations of sodium lamps, and some residents complain that the brightness of nearby lights shining into their homes is interfering with their sleep. Smart streetlights can be remotely programmed to be dimmed during off-peak hours. This removes any issues that local residents might have with bright lights, whilst retaining street safety during peak hours. The use of motion detectors also means that street safety can be maintained outside of peak hours, as people passing by during the night will still benefit from a bright street environment.

Moreover, sensors attached to smart light poles in residential areas can help to improve the quality of life of local residents, by highlighting issues with air quality, traffic management or noise pollution that can be dealt with by the local government directly.

TRANSPORT NETWORKS

National road networks are critical infrastructure that need to be lit in order to improve safety, especially on busy stretches and at junctions. However, lighting at these sites is often difficult to access, being located in central reservations or across busy junctions. The maintenance cost of this lighting is particularly high, making a strong financial case for an upgrade to connected LED lighting. As well as creating a brighter, safer road environment, these lights can be remotely dimmed outside of peak hours. Moreover, they can alert transport engineers to potential faults before they occur, meaning the maintenance of these lights can be properly planned in advance, avoiding costly road closures that may otherwise be necessary.

Connected street lights can also be equipped with air quality sensors to monitor pollution, cameras to monitor traffic and sensors to count the volume of traffic through the day, giving transport and environmental planners accurate data they can use to improve their planning activities.

CASE STUDY: Vodafone & Philips

Vodafone is a global IoT managed connectivity partner for Philips Lighting, the global leader in street lighting. Together, the two companies enable city authorities worldwide to implement smart street lighting systems that can be connected wirelessly, saving energy and making maintenance easier and more efficient.

The Philips CityTouch street lighting management system uses Vodafone's M2M network to connect individual light points. Each connected street lamp contains a Vodafone M2M SIM. City authorities can then monitor and manage lighting through a user-friendly and flexible system, while engineers are able to check performance, identify faults and control the lighting remotely.

The joint offering is designed to enable city authorities to roll out infrastructure that is easily scalable, and will be able to support other smart city applications in future.

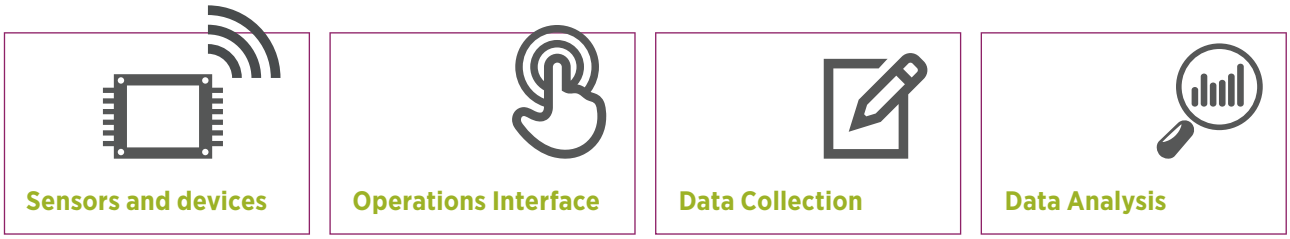
> *"City authorities can then monitor and manage lighting through a user-friendly and flexible system, while engineers are able to check performance, identify faults and control the lighting remotely"*

The technologies mobile operators use to provide connected lighting

Mobile operators and their partner ecosystems are a key resource for cities looking to deploy smart street lighting services. They are able to:

- Connect multiple sensor types through a single, consistent network designed for IoT sensors,
- Combine multiple data sources from multiple sensors to perform predictive analysis using their data management platforms,
- Directly manage IoT assets and sensors at scale around a city without the need for any additional infrastructure.

The diagram below shows the primary mobile operator and partner capabilities for smart street lighting.



Sensors and devices

- Sensor Deployments
- Sensor Intergration
- Low cost Operations

Operations Interface

- Real time remote control
- Group and connect
- Quality of Service analysis

Data Collection

- Collection network
- Data security & privacy
- Real-time analysis
- Urban & rural coverage

Data Analysis

- Data Aggregation
- Data Visualisation
- Predictive Analysis

The sections below outline some of the ways in which smart street lighting users can obtain value from mobile network operators.

DATA PRIVACY & SECURITY

Mobile operators have a track record of providing secure products and services to their customers. Mobile operators have very clear policies on how they collect and use data to enable new services and ensure that trust is retained.

Mobile operators' policies cover the collection and use of identifiable data, storage of this data and access to this data, among other privacy issues. Operators are aware that even data that is not personally-identifiable needs to be treated with care, as any breach of data or trust could seriously damage an organisation's reputation.

The GSMA has published both IoT Security Guidelines and Mobile Privacy Guidelines, which can be applied to smart street lighting implementations. The guidelines can be found at:

http://www.gsma.com/connectedliving/future-iot-networks/iot-security-guidelines/ and **http://www.gsma.com/publicpolicy/mobile-and-privacy/mobile-privacy-principles.**

MOBILE IOT NETWORKS

Mobile operators are beginning to deploy new networks specifically designed for IoT solutions, such as connected street lights.

These Mobile IoT networks can support low cost, long battery life, low bandwidth, and high volume connections in licensed spectrum. By connecting to a module in a light pole, these networks can enable multiple services ranging from simple lamp on/off type controls to collecting data from multiple sensors monitoring environmental conditions, such as air quality and weather conditions. Basic status updates from many types of sensors can also be accommodated. These networks are ideally suited to minimising the maintenance of sensors in inaccessible places, such as light poles. In addition to street lighting, Mobile IoT networks are ideally suited to connecting parking sensors, traffic lights, weather stations and many other devices that enable smart city services, meaning that a single network operator can meet all of a smart city's network communications and data collection needs. Mobile operators' Mobile IoT networks can also provide coverage deep indoors and underground, enabling rich and pervasive smart city services.

Standards body 3GPP has finalised three different variants of Mobile IoT technologies for use in licenced spectrum. They will be ready for commercial deployments in 2017. Further information on these technologies can be found at: **http://www.gsma.com/connectedliving/mobile-iot-initiative/**

BIG DATA ANALYTICS

Harvesting the data from connected sensors can give many insights into a city's status, how planning can meet citizens' needs, and what information can be shared with citizens to enhance their quality of life. By combining multiple sources of data, such as air quality and traffic information, complex analysis can be undertaken. This in turn can enable the development of adaptive services, and the introduction of predictive and planning tools that allow the city to adapt over time based on forecasts derived from real-time environmental, traffic, and other related data.

This data analysis can be used to improve the street lighting environment across a city. For example, monitoring of pedestrian footfall underneath a streetlight can dictate what hours it is switched on for, or how dense the lighting in certain areas needs to be. Additionally, the integration of data from streetlights with data from other city sources, such as transport networks, can be used to inform the dynamic control of the infrastructure, so street lights around a bus stop can be set to be brighter than those further away, or lights around pedestrian crossings can switch to a brighter setting when pedestrians are crossing the road.

EMBEDDED SIM

The GSMA Embedded SIM Specification provides a single, standard way to provision and manage SIM-based connections over the air, without the need for any physical maintenance. The embedded SIM specification allows for the initial provision to a mobile operators network, but also a change of network provider over the air at the end of a contract period, without the need to physically swap out the SIM card.

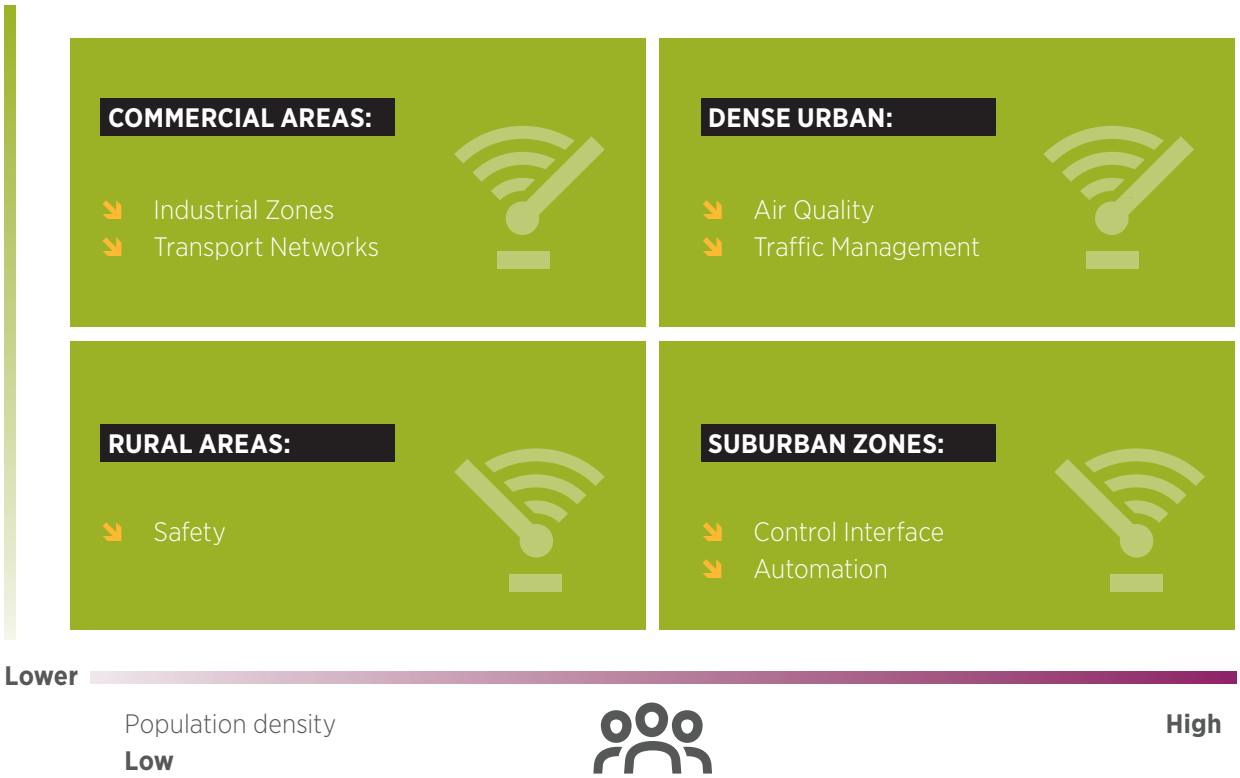
Changing SIM cards can be problematic for businesses and organisations. Many IoT devices, such as streetlights, are remotely located, often hermetically sealed, and their after-sale location is not known during production. Moreover, their product life cycles can be lengthy. The GSMA Embedded SIM Specification addresses these challenges by providing a global product for global manufacturing processes that can be remotely provisioned once the product is deployed in the field. This reduces the cost of operation and also solves the challenge of managing those devices in the field. Many of the interfaces and processes needed to make the remote provisioning of SIMs work are virtually identical to the SIM personalisation processes and interfaces used by mobile operators today.

Putting a smart street lighting service into action

To implement a connected street light service effectively, the street light provider needs to understand the financial benefits of integrated mobile connectivity and LED lighting, in addition to the maintenance and control benefits from connected smart street lighting. Mobile connected streetlights lower running and maintenance costs by a significant magnitude, while providing much greater flexibility. Through data analytics, mobile operators can also improve existing services and generate new revenue streams using the data collected by sensors hosted throughout a city, making mobile operators a strong partner for cities deploying connected streetlights.

IoT-enabled street lighting is a core part of any smart city strategy, offering benefits to both the city and its citizens. To maximise these benefits, the city should consider what other services, sensors and safety features it may want to deploy in future before beginning any smart street lighting programme. Retrofitting sensors to light poles later is an expensive move. By being clear about the data that the city wants to collect to solve the challenges that it faces, a smart lighting implementation can be planned effectively, and bring major benefits to the city.

Urban and rural areas may require different approaches, and solar street lighting may be appropriate in some locations. Different locations will have different profiles, which will dictate how streetlights are deployed and the types of service the city will need to support (see graphic).



If a municipality and its partners focus on the needs of the local community, they can determine the appropriate mix of lights, sensors and services. Different areas of the city will need different solutions, with some areas focused more on the safety benefits of smart street lighting, and other areas on the ability to dynamically control lighting. Industrial zones will need continuous lighting to support shift work and despatch centres, while transport networks can benefit from the low maintenance requirements of connected streetlights. Moreover, residential areas will prioritise a safe environment, enabled by flexible, bright lighting with low running costs.

Using the street lighting as a sensor 'hub' enables a range of services that can improve the operation and attractiveness of a city across all of these use cases and urban districts.

Conclusions

Installation of smart, connected street lighting enables a city to make significant cost savings, whilst opening up opportunities to transform into a smart city. Ideally, the upgrade to LED lighting and connectivity should be made in tandem to reduce installation, maintenance and management costs. Installing light poles equipped with multiple sensors allows a wide range of data to be collected, new services to be introduced without any further disruption, and air quality and other metrics to be recorded in line with legal requirements.

Mobile operators are the best partners for cities looking to deploy smart street lighting. Mobile operators already offer ubiquitous coverage across both urban and rural areas, eliminating the need for additional capital expenditure on network equipment. New Mobile IoT networks provide a low cost solution to managing street lighting, enabling advanced lighting and associated services to be installed across a city, bringing benefits to all zones – commercial, residential and industrial.

About GSMA Smart Cities

Cities are getting smarter every day, using information and communications technologies to enrich and enhance city life. The growth of the Internet of Things will have a fundamental impact on the development of smart cities, helping to drive efficiencies and delivering rich new services. However, without effective strategies in place, cities will be unable to capitalise on these benefits. As part of the GSMA Connected Living programme, the Smart Cities project is working with mobile operators and cities to create real, long term benefits for businesses and citizens through IoT technologies.

To find out more visit: www.gsma.com/smartcities
To contact us email: smartcities@gsma.com