



LIFE IS FOR SHARING.

An aerial night view of a city, likely Toronto, featuring the CN Tower as a prominent landmark. The city is illuminated with streetlights and building lights, and long-exposure light trails from traffic are visible on the roads. The sky is a deep blue with some clouds.

SMART SOLUTIONS FOR SUSTAINABLE CITIES

CONTENTS

SUSTAINABLE CITIES – THE IMPORTANCE OF BEING SMART	3
THE CENTURY OF CITIES	4
Making Cities smart – by Retrofitting	4
Making Cities smart – with Citizens	5
IOT PAVING THE WAY FOR SMART CITIES	6
NarrowBand IoT – a Game Changer for the Internet of Things	6
5G – the Network of Networks	8
Security within the Internet of Things	8
New data concepts: Privacy by Design	9
FROM SMART TOWNS TO SMART REGIONS	11
Connected Mobility	11
Energy Efficiency	14
Air Quality	16
FROM GATHERING DATA TO CREATING SMARTNESS	17
Smart City innovation stages	17
Navigating through a Smart City	18
New Insights with Big Data	19
EU FINANCING OF SMART CITY SOLUTIONS	21
Success factors for getting EU funds	23
OUTLOOK ON SMART SUSTAINABLE CITIES	24
The Friendly Skies: Drones and Air Taxis	24
5G in the Smart City	24
Blockchain Technology	24
BIBLIOGRAPHY	27

SUSTAINABLE CITIES – THE IMPORTANCE OF BEING SMART

Every week, three million people worldwide move into cities, therefore urban centers are gaining more and more importance. The urbanization, in combination with limited resources and tight budgets, is leading to a number of challenges that cities need to deal with. The Smart City concept provides solutions that can tackle these challenges on a local and regional level. By implementing ICT-based solutions, cities can not only save energy and resources, but also increase the quality of life for citizens, attract visitors, and support economic development.

On the way towards a Smart City, it is important to involve all parties that will be affected by this development – be it citizens, visitors, start-ups or industry players. An open and collaborative approach is the only way to successfully and sustainably drive the digital transformation of a city.

The current white paper provides insights about the underlying technologies enabling Smart Cities, and stresses the importance of IT security. Using international best practice examples, it demonstrates how all kinds of urban centers, from small towns to entire regions, can benefit from Smart City solutions. As smart solutions are created from smart data, the white paper highlights the need for open platforms and open standards as well as interdepartmental co-operation to fully utilize the potential of the available data, and benefit from it. The innovation stages of a Smart City are described, followed by a deep dive into funding opportunities for Smart City solutions. An outlook on how emerging trends and technologies will impact the further evolution of Smart Cities completes the white paper.

THE CENTURY OF CITIES

“The 19th century was a century of empires. The 20th century was a century of states. The 21st century will be a century of cities.” This quote by Wellington E. Webb, former mayor of the City of Denver, seems plausible when you look at the numbers: Although cities cover only a fraction of the Earth’s surface, they are already home to more than half of the world’s population.

Every week, three million people worldwide move into cities [1], which means that the number of urban residents will increase to 6.5 billion by 2050 – two out of three people will live in cities by then.

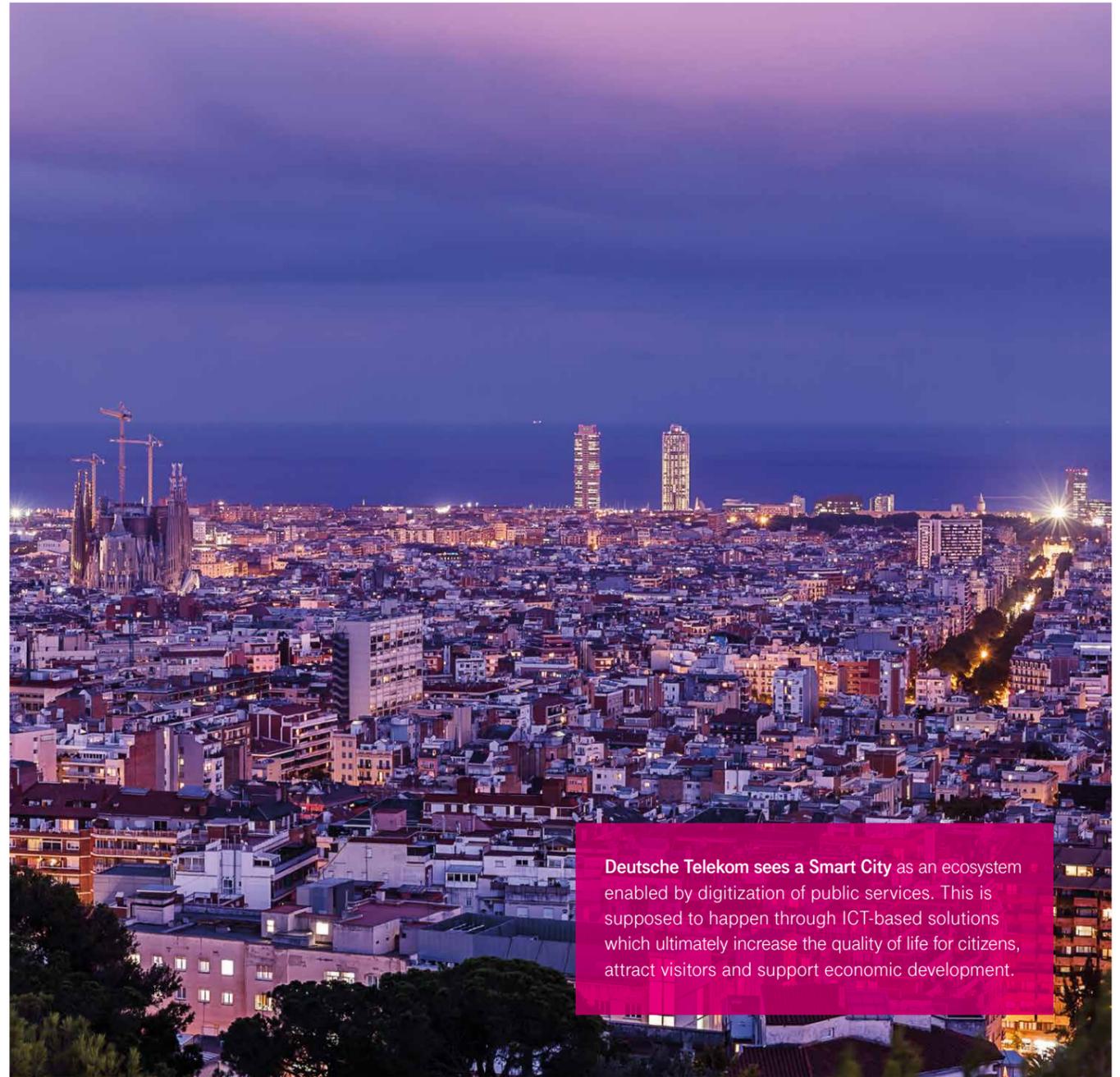
This influx of people brings opportunities for cities such as a rise in economic power and a skilled workforce. But it also brings economic and ecological challenges. More people mean, for example, more traffic, more energy consumption, more waste. According to the United Nations Habitat Program [2], urban areas create 75 percent of the Earth’s energy demands and carbon emissions. Cities need to gather data by using information and communication technology to both learn about these pain points and tackle them. Analyzing and interpreting the data as well as combining them with feedback from citizens will help turn urban areas into Smart Cities that

- improve the quality of life for the people who live there, and also enhance visitor experiences with smart services such as parking management, environmental monitoring, bike sharing offerings, and intelligent public transport systems.
- save energy and reduce costs due to intelligent lighting concepts, efficient waste collection routes or smart water metering.
- support the cities’ economic development by expanding infrastructures to enable more smart services and solutions.

MAKING CITIES SMART – BY RETROFITTING

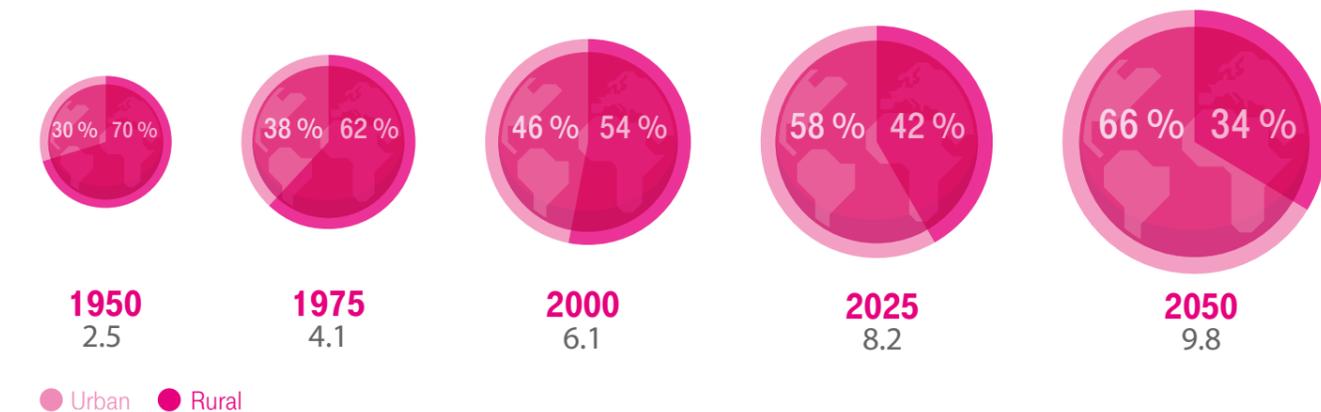
To have the opportunity to build a Smart City from the ground up like Tianjin Eco-city in China is an exception. Normally, cities have to work with their existing infrastructure, and implement smart solutions by retro-

fitting it. The Spanish city of Santander installed around 20,000 parking sensors in streets, introduced smart waste containers that are monitored, and measures air pollution, precipitation and traffic density. Up to 150,000 instances of data a day are collected in a central information system [3]. Using this data, Santander’s municipal administration can optimize the waste truck routes to save staff and fuel costs, or control the irrigation of the city parks to save water. Digital services benefit locals and tourists: Apps and signs guide drivers to a free parking space. The smartphone app “City Pulse” invites Santander’s citizens to report broken waste containers, unmaintained benches and potholes. Via the app they can afterwards follow the state of the incidents at any time. Signs at bus stops inform people in real time how long they have to wait or which line to catch to get to their destination.



Deutsche Telekom sees a Smart City as an ecosystem enabled by digitization of public services. This is supposed to happen through ICT-based solutions which ultimately increase the quality of life for citizens, attract visitors and support economic development.

WORLD POPULATION FROM 1950 TO 2050 (IN BILLIONS)



MAKING CITIES SMART – WITH CITIZENS

The Catalan metropolis Barcelona, housing ten times the number of inhabitants of Santander, has an even wider Smart City approach. The city not only implemented thousands of smart energy meters [4], LED streetlights, parking and rain sensors, Wi-Fi on buses as well as an innovative waste management system. Barcelona also changed its Smart City approach from top-down to bottom-up. The city motivates its citizens to participate in Smart City projects like the open network infrastructure Guifi.net [5], one of the

largest free networks in the world that started in Catalonia. Anyone is able to extend the network by adding a Wi-Fi access node after accepting an interconnection agreement. The approach of Guifi.net is to provide affordable broadband connections for everybody, and support collaborative economic activity based on proximity and sustainability.

Another bottom-up project is the Smart Citizen Kit [6], a little sensor box collecting data about environmental variables like air composition, temperature, light intensity, sound levels, and humidity. It can be purchased by anybody interested in the health

of their environment, and potentially concerned about the air quality and noise levels near their homes. The real-time data are sent via Wi-Fi to an open data platform, and are used to create maps visualizing the environmental conditions, thus raising awareness of issues that matter to citizens. Additionally, the open data can be used freely by public and private actors to develop applications or services for citizens.

IOT PAVING THE WAY FOR SMART CITIES

Within just a few decades, the Internet has revolutionized many aspects of our daily lives both in business and privately. Along with companies, cities are now using the Internet to create more convenient service offerings. Citizens can apply online for a residents' parking permit, reserve a place in a municipal kindergarten, or check the status of a building permission application. The Internet is increasingly also connecting things, evolving to the Internet of Things (IoT). The new paradigm is "everything that can be connected will be connected".

PATRAS: A EUROPEAN NB-IOT PIONEER

The City of Patras is the first in Greece and one of the first in Europe to use NB-IoT in its Smart City solutions. Cosmote, a subsidiary of Deutsche Telekom Group, partnered with the City of Patras to launch the technology for several city services. Specialized Smart Parking sensors were installed in existing parking spaces, and a mobile phone based parking app is available to guide drivers to free parking spaces, reducing congestion and improving its citizens' quality of life. Likewise, a Smart Lighting system was added, including sensors that adjust to different light levels at different times of the day and year, saving electricity. In addition environmental monitoring is being piloted with the data being made available to the city.

Cities and companies all over the world are equipping physical objects with software, sensors and connectivity to merge them into a global network. As things are becoming able to collect and exchange data, they emerge into new ecosystems across processes, industries and countries. This enables new services and entirely new business models to supplement and expand their current internet service offerings. Existing mobile (2G, 3G, 4G), wireless (Wi-Fi, Bluetooth, NFC) and fixed (Ethernet, fiber) networks feed many connectivity needs of IoT use cases, but they are not designed for every application. Given the specific requirements of some use cases in terms of longevity or latency, new communication technologies are essential to meet the wide spread deployment to Smart City devices. NarrowBand IoT (NB-IoT) and 5G will help address this.

NARROWBAND IOT - A GAME CHANGER FOR THE INTERNET OF THINGS

NarrowBand IoT is a new cellular communication technology specifically designed for many "simple" IoT and Smart City applications. The unique advantages of NB-IoT make it a perfect supplement to the existing networks:

- The low-cost factor of NB-IoT modules paves the way for a mass distribution of IoT devices.
- The extremely low energy consumption of the modules allows for smart devices to be deployed with a battery that will last for up to 10 years.
- The deep indoor penetration of NB-IoT enables data transmissions from cellars for Smart Metering, or underground parking garages for Smart Parking, where existing mobile networks have poor coverage.

NarrowBand IoT uses licensed spectrum and existing mobile network sites to provide highly reliable and secure connections with excellent coverage in a city. NB-IoT was specified and standardized in 2016. After this, network operators around the world are upgrading their mobile base stations to implement the new technology. Deutsche Telekom has already launched the first NB-IoT network in The Netherlands and is currently rolling out the technology across Germany with a further seven European markets to follow.

NB-IOT IN THE ENTERTAINMENT CAPITAL OF THE WORLD

T-Mobile US announced the first test of NB-IoT in North America, conducted with Qualcomm and Ericsson across multiple sites on T-Mobile's live commercial LTE network in Las Vegas. T-Mobile and the City of Las Vegas also announced a partnership to deploy IoT technology throughout the city using NB-IoT. They are jointly piloting several IoT projects like flood abatement, Smart Lighting and environmental monitoring. In 2018, the NarrowBand IoT network will be rolled out US-wide.

NB-IoT communication technology has a wide range of performance advantages like lower costs, low device power consumption and deep indoor penetration. NB-IoT addresses applications that are not cost efficiently served by existing networks and communication technologies, many of which are Smart City use cases like the ones shown below.



5G - THE NETWORK OF NETWORKS

In the future, all the networks like LTE, Wi-Fi, NB-IoT or fixed-line will be combined under a new roof: 5G. With this highly flexible network infrastructure, 5G will be able to serve all possible IoT and Smart City use cases, and provide the perfect connection depending on the individual demand for data rate, speed, and capacity. Furthermore, 5G offers new features the existing network technologies cannot provide:

- The extremely high transmission speed of up to 20 Gbit/s enables enhanced mobile broadband for ultra-fast downloads and uploads, everywhere and anytime.
- The low latency of less than one millisecond means signal transmissions are possible almost in real time: a necessity for the intelligent automatic control of important infrastructures such as energy supply, where an immediate reaction is needed in the event of fluctuations in the network and power failures. Or for autonomous driving, when cars not only communicate with other cars (Car-to-Car/C2C) but also with the infrastructure (Car-to-Everything/C2X).
- The high connection density allows the 5G network to supply one million devices per square kilometer at the same time with guaranteed quality of service. 5G can not only cope with large crowds at a concert or a sports event, when thousands of people want to phone, text, and send pictures at the same time. It will be able to connect all the networked devices and sensors in a Smart City at the same time.

SECURITY WITHIN THE INTERNET OF THINGS

As more areas of a city's operations benefit from and rely on ICT-based applications, the security aspect of all systems involved becomes increasingly important. Guaranteeing continuous services to citizens and protecting critical infrastructure from attack are essential requirements of a city.

This includes determining the probability of certain attacks and estimating the possible damage they could cause. Existing examples of Smart City hacks call for appropriate mechanisms to detect and prevent attacks: In April 2016, for example, the security experts from Kaspersky Labs managed to hack roadside sensors in Moscow [7] that were used to manage traffic flows. The researchers were able to observe all data gathered by the devices, and to modify it.

In April 2017, unknown perpetrators intruded the tornado warning system of the city of Dallas [8]. At midnight, all 150 sirens across the city started to blare periodically – the whole night through. The city administration was not prepared and had no option other than to shut down the entire system.

To counter enormous risks like these, every single component of Smart City solutions has to be safeguarded – from the communication network and backend server to applications running on smart devices. Potential risks have to be constantly identified and assessed. Deutsche Telekom and its partners place the utmost importance on security, and implement preventative measures across the entire network and IoT ecosystem to safeguard customers and users.

In Germany, Deutsche Telekom is leading the way with its "5G:haus", an innovation laboratory for research institutes, start-ups and network technology manufacturers. The goal is to prepare the Telekom network for the commercial launch of 5G services in Europe by 2020.



5G COVERS IT ALL
A NERVOUS SYSTEM FOR SMART CITIES

BILLIONS OF DEVICES	DEEP INDOOR PENETRATION	LOW ENERGY CONSUMPTION	LOW COST
HIGH SECURITY	E2E SEAMLESS CONNECTIVITY	HIGH DATA VOLUMES	LOW LATENCY

NEW DATA CONCEPTS: PRIVACY BY DESIGN

In addition to handling IT security in general, cities must develop new concepts for handling data. A Smart City generates enormous amounts of data that must be stored securely. When information from smart homes, networked traffic systems and video surveillance solutions is merged, the privacy of citizens must not be breached. Legal issues must also be clarified: Who owns which data and who is entitled to access it? Which data can be made accessible to the general public in the context of an open data initiative, and which data must be kept under lock and key because it enables people to be identified, or constitutes a security risk? To answer questions like these, new processes, tools, and mechanisms are needed to manage data, and ensure its integrity.

Experts call for the protection of personal data to be integrated into smart applications from the outset as a fundamental development principle: Privacy by Design. To encourage acceptance of connected solutions, they must provide the greatest possible degree of transparency about the data collected, while maintaining the anonymity of users.

Deutsche Telekom successfully defends its infrastructure against 1.4 million external attacks per day. The company's Cyber Defense Center monitors, and analyzes cyber incidents worldwide, and develops countermeasures. Since it is essential to identify potential weaknesses at an early stage, Telekom also introduced the Privacy and Security Assessment (PSA). The PSA process guarantees that all development projects meet the strictest technical security and data privacy requirements. It has the following goals:

- a consistent and adequately high security and data privacy level in all products, systems and platforms
- an integrated and standardized process for technical security and data privacy as a deeply rooted element of product and system development processes
- a support level, adapted to project complexity and criticality through the introduction of categorization at the start of each development project

FROM SMART TOWNS TO SMART REGIONS

Small towns, big cities, regions and even states – they all face challenges that can be addressed by Smart City solutions. However, for a city to decide which solutions are best, it must take into account both its current requirements as well as its future needs. Traffic, for instance, may be at first sight a problem related more to a major city like Hamburg.

But even a small town can have specific traffic challenges: Heidelberg, for example, is an attractive tourist destination that needs to steer a massive influx of cars. In a 2017 survey [9], 50 percent of the respondents identified traffic as the biggest problem in Heidelberg.

Also cities of comparable size are going to have different issues and priorities – in the context of their respective histories and geographies as well as their main economic features like business center, tourism center or cultural metropolis. Smart City solutions must take each city's motivations, requirements, limitations, challenges and objectives into account. Often, these will be generated and guided by the dominant local political and economic groups, and solutions must support and complement a city's overall strategy for success. Being “smart” means something different for each city.

CONNECTED MOBILITY

A good example illustrating the different needs is parking: For smaller towns, the information how many free parking spaces are available might not be that important. However, Smart Parking solutions can be used to prevent illegal parking or to steer disabled drivers to free parking spaces and other specialty services that are both helpful and beneficial to citizens.

In bigger cities, parking has wider implications. According to the European Parking Association [10], surveys in concentrated urban areas found that approximately every third motorist in a city is just searching for an available space to park. In Germany, for

example, that adds up to 560 million hours of driving each year – an enormous waste of time for drivers and completely unnecessary fuel consumption, plus additional air pollution, noise and congestion. In this case, a complete service including infrastructure, sensors and mobile apps would be ideal to mitigate the corresponding problems.

Smart Parking in Hamburg

By 2018, the city of Hamburg and Deutsche Telekom will have implemented the Smart Parking service Park and Joy. Around 11,000 parking spaces in Hamburg will be equipped with sensors that will register when a spot is occupied or free, and transmit this information via NarrowBand IoT technology to the cloud. The new NB-IoT technology is a perfect fit for this use case, taking into consideration the small amounts of data that are transmitted, and the need for a long battery life in the on-street parking sensors. Additionally, other data sources can be used to calculate the probability of a free parking space in a certain area – as, for example, crowd-sourced data from mobile networks, or data from parking operators. Motorists can then see the current status of parking availability in the city via the Park and Joy smartphone app, which also navigates the driver to a vacant parking space. Park and Joy will not only spare drivers the tiresome search for a parking spot: Users can also pay any parking charges directly via the app, so they'll no longer need to search for small change and a parking meter.

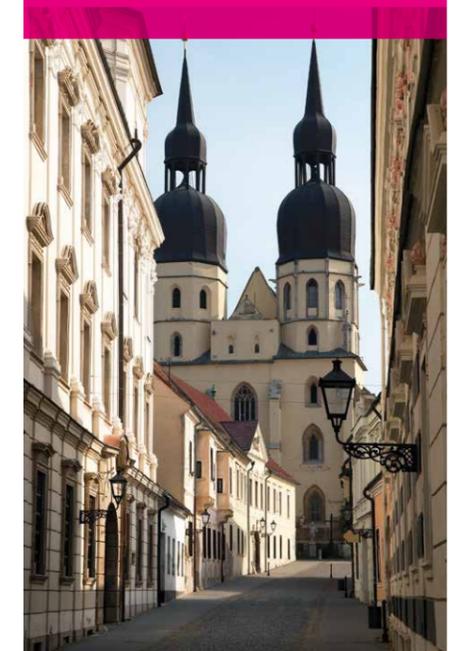
Combining the information about available parking spaces from different cities can create additional value on a regional level.

Smart Parking solutions can be extended to Park & Ride facilities at airports and train stations. And users of car-sharing services can receive information about vacant parking lots automatically when they enter their destination in a navigation device.

In the Slovakian town of Trnava, Deutsche Telekom's subsidiary Slovak Telekom has created a Smart Parking service. Parking bays in car parks in the town have been fitted with occupancy sensors to feed information to a cloud-based service. Disabled drivers can now use a mobile app and a web service to identify, and eventually drive to available handicapped parking spots in downtown Trnava.

Park and Joy is a full service product which provides all the necessary components and services from a single source:

- sensors
- communications
- management software
- mobile application
- users support
- optional installation
- integration services
- payment and billing systems





In Croatia, Deutsche Telekom's subsidiary Hrvatski Telekom created the largest pilot electric vehicle charging (EVC) network, consisting of 145 charging spots at 101 electric vehicle charging stations in 70 cities. The solution combines charging infrastructure with easy-to-use software helping electric vehicle drivers find, book and pay for vehicle charging. The solution is offered to public and private customers alike, and provides access to an international network of more than 10,000 publicly available charging locations. The cloud-based ICT management platform delivers information on the availability of EVC infrastructure in real-time. It also handles the billing of each charging transaction.

From Public Transportation to Personal Transportation Management

Small towns and villages don't need sophisticated Public Transportation solutions. Most of the time, the challenge is simply to inform passengers when the next bus will actually arrive, and if there is a delay. In a city, on the other hand, bus line schedules can be connected to the train schedules to show alternate connections. Additionally, outside of cities, departure times of buses, metros and railways can be combined with data from traffic jams and road works on the highways. This provides commuters with recommendations about the best way to get to work on time, and allows for the city to develop and implement multimodal transportation concepts.

As a partner of the Kooperation Östliches Ruhrgebiet (KÖR), Deutsche Telekom helps to connect local public transport in the most populous German state of North Rhine-Westphalia. The co-operation includes 16 cities in 8 counties with more than 8 million inhabitants in the Ruhr Area. The Telekom solution enables municipal utilities and tramway companies to jointly monitor and control their urban transportation services. This does not only increase the satisfaction of passengers, who profit from increased transparency receiving real-time information about arrival times for busses and trains, but also serves the public transport authorities. They can benefit from economies of scale by sharing the same platform, and from efficiency gains by sharing certain tasks.

In Budapest, Deutsche Telekom installed a Public Transportation management and passenger information system to support the Center for Budapest Transport. It ranges from planning timetables, and optimizing routes to analyzing past and current data. The system has been extended to 13 counties across Hungary, connecting more than 4,000 vehicles. People who prefer to go by bike in Budapest can switch to a public bike-sharing system containing 1,200 bikes and 100 docking stations.

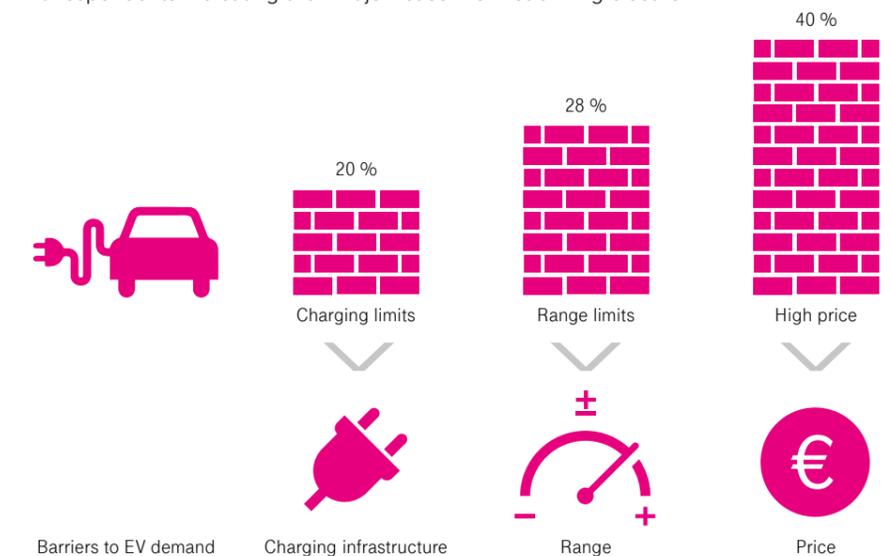


Getting further with Electric Vehicle Charging

Electric Vehicle Charging (EVC) is an integral part of the growing e-mobility value chain, and can further enhance local and regional mobility concepts. With e-mobility growing in the coming years, analysts fear that there will be a significant shortage of EVC stations [11]. To enable interregional mobility without "range anxiety", it is therefore essential to develop not only a local but also a regional and nationwide network of EVC. Initially, small towns probably only need a small number of charging stations, while larger cities need to think bigger, and provide access for entire car fleets of public busses. Implementing a convenient EVC infrastructure will furthermore expand the use of electric vehicles in a city. This, in turn, helps a city reduce its carbon footprint while helping policymakers and authorities pursue environmental protection goals with traceable information.

3 MAJOR BARRIERS TO EV DEMAND

% respondents indicating their major reason for not driving electric



Source: ING Question of the day – 47,000 respondents in the Netherlands (remaining 12 % chose other reasons)

ENERGY EFFICIENCY

Saving costs and improving energy efficiency are major goals of most municipalities. According to the report “The Future of Street Lighting” [12], street lighting constitutes up to 40 percent of a city’s overall electricity costs. Replacing conventional sodium lights with LED bulbs can reduce energy consumption by a minimum of 50 percent. These savings even increase to up to 80 percent (consumption and maintenance savings) when street lighting is connected with a central management system.

Smart Street Lighting is worthwhile for cities of all sizes. Monheim, a German town of 43,000 inhabitants between Düsseldorf and Cologne, has started just such an initiative together with Deutsche Telekom. New LED bulbs have been installed in the town’s street lamps, and connected to a central platform. Now the lights are easy to control, reducing energy consumption by up to 70 percent compared with the old ones, and they are smart: They automatically report various alarms and information to help speed up repair time when there is an issue.



THE DIFFERENT AREAS WITHIN A CITY

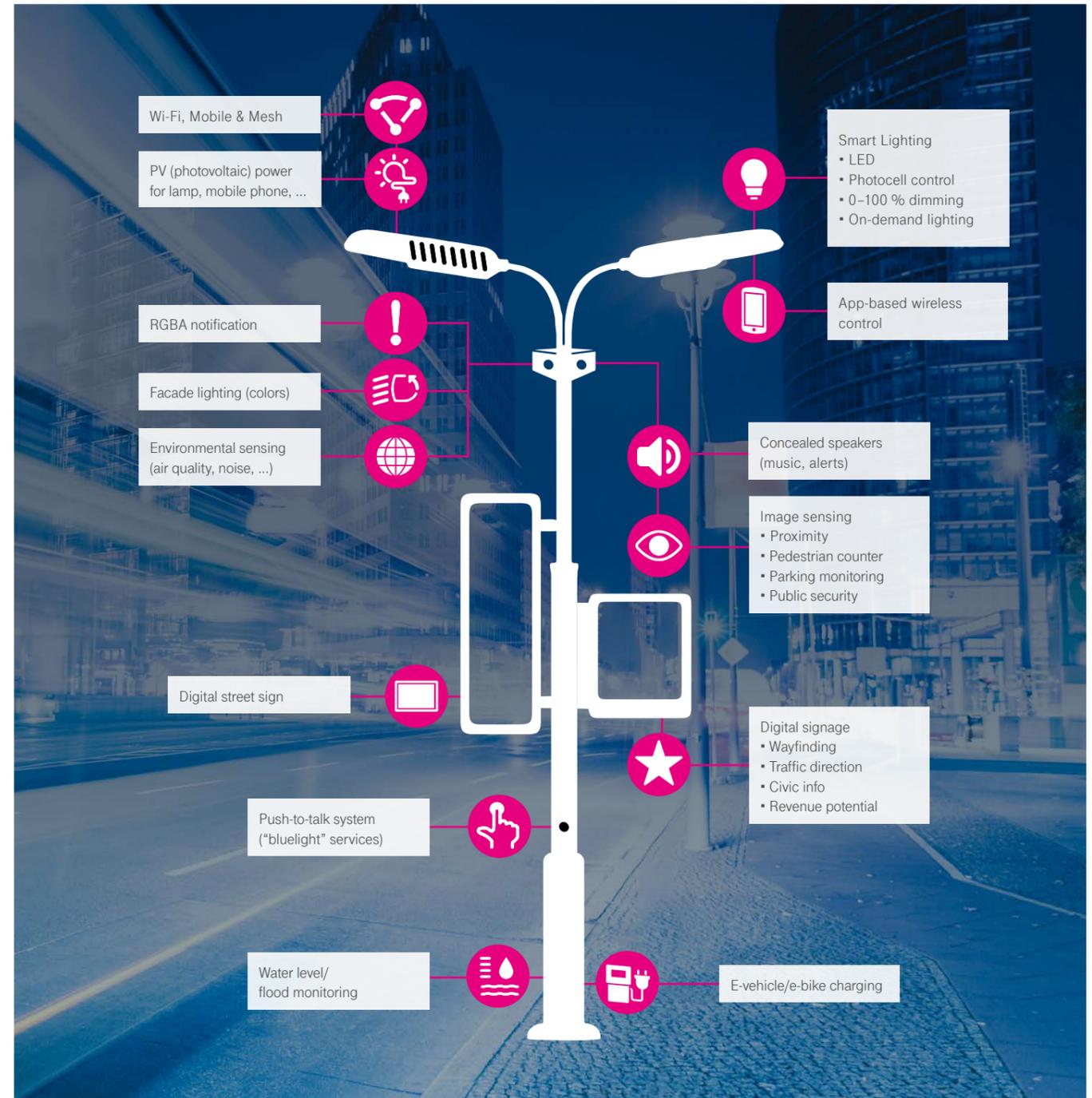


- Industrial area
- Commercial district
- Residential area
- City center
- Business district

Light only when it’s needed

Not every service enabled by a Smart City solution has to be evenly distributed across the whole municipal area. The needs are quite different in city centers compared to residential areas and the outskirts. Therefore, it is important to have a solution that can be configured flexibly. For example, street lighting in industrial areas needs to be fully lit only between 9 a.m. to 5 p.m. Before and after business hours, lights can be dimmed or shut off completely by using a combination of programmable timers and motion-sensor technology. Commercial districts need lighting in the evenings until stores close, after which it can be dimmed, while residential areas require street lighting from dusk till dawn to ensure public safety.

But it’s not only about street lights: The lighting concept can, for example, be extended to public buildings which can reduce the city’s energy bill even more. Furthermore, the light pole infrastructure can be used for additional Smart City use cases like video surveillance or public Wi-Fi to help a city expand its service offering. Finally, once a city has control of its streetlights, and understands the IT behind it, it can move on to creating more innovative energy concepts including renewable energies, energy storage and self-sufficient micro grids.



STREET LIGHT POLES – DESIGNED FOR MORE THAN JUST LIGHTING

Today, a street lamp’s main purpose is to provide lighting when it’s dark. In a Smart City, the street lamp will increase in importance, as cities start to see the light pole as a multiuse object that enables various aspects of a Smart City. The city could easily and quickly deploy additional sensors or cameras to support, for example, traffic surveillance, air quality monitoring and public safety measures. Equipped with communication technology and 24/7 electricity, the light post will increasingly become a valuable asset as part of the city’s Smart City concept. Some of the uses cases that can benefit from this infrastructure include:

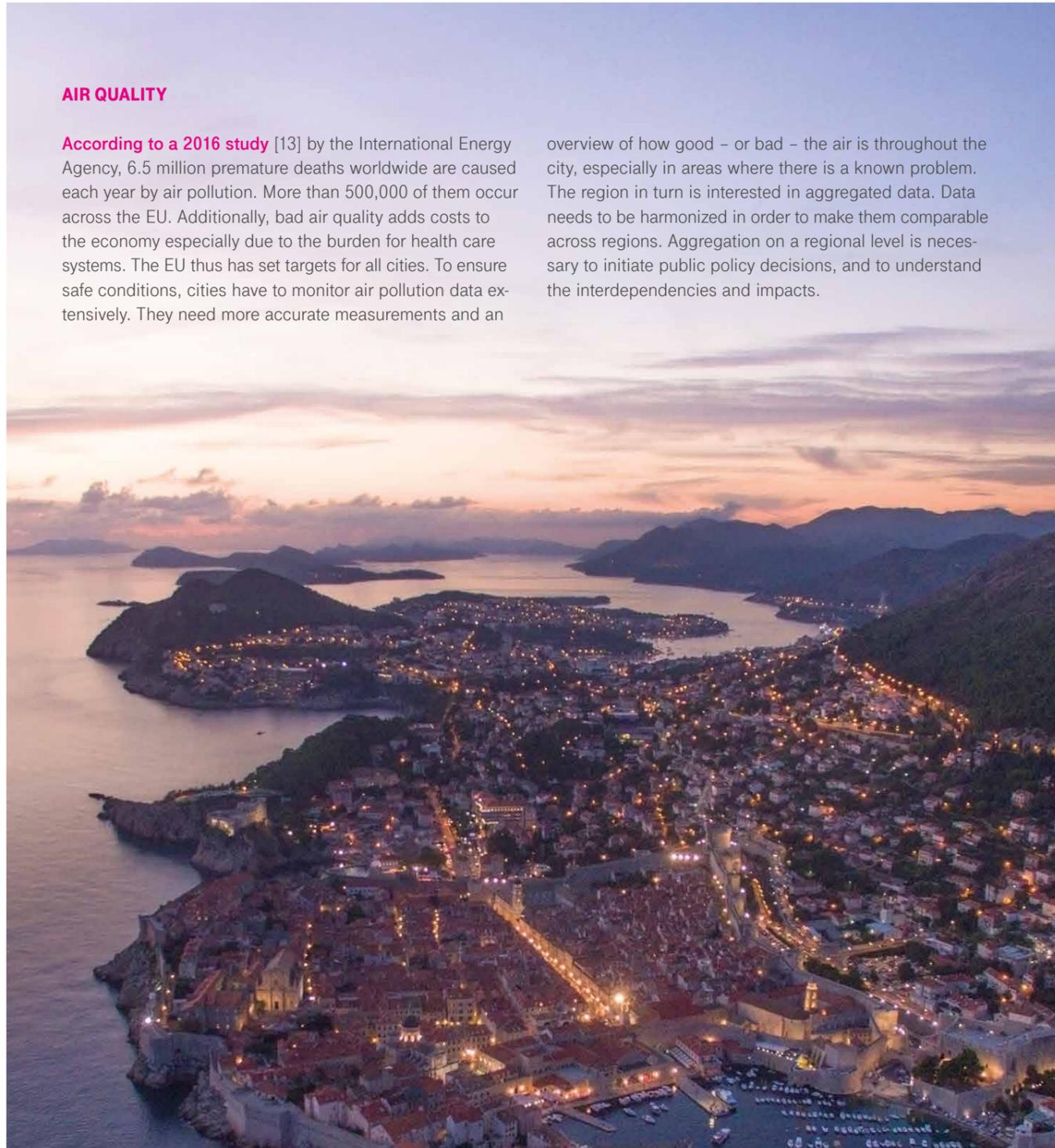
- Public Wi-Fi
- Environmental sensing (air quality, noise, etc.)
- Emergency call button
- Public security/video surveillance
- Parking – poles serve as an aggregation and data transport point for parking information
- Digital signage – information points for citizens and tourists
- E-bike charging station (depending on technical requirements)

As cities move towards smartness, and increasingly use the data generated by smart solutions for data driven business models, the utilization of the smart street light as an enabling infrastructure and revenue source will become very attractive.

AIR QUALITY

According to a 2016 study [13] by the International Energy Agency, 6.5 million premature deaths worldwide are caused each year by air pollution. More than 500,000 of them occur across the EU. Additionally, bad air quality adds costs to the economy especially due to the burden for health care systems. The EU thus has set targets for all cities. To ensure safe conditions, cities have to monitor air pollution data extensively. They need more accurate measurements and an

overview of how good – or bad – the air is throughout the city, especially in areas where there is a known problem. The region in turn is interested in aggregated data. Data needs to be harmonized in order to make them comparable across regions. Aggregation on a regional level is necessary to initiate public policy decisions, and to understand the interdependencies and impacts.



SMART AIR QUALITY MONITORING IN DUBROVNIK

In 2015, Deutsche Telekom installed the first Smart Air Quality units in the historic Croatian city of Dubrovnik. The units can be easily mounted on existing street lighting posts or on public buildings. The full turnkey cloud-based solution supports a wide range of sensors that can provide measurement of temperature, atmospheric pressure, or relative humidity – all from one remote monitoring terminal. High-quality calibrated electrochemical sensors measure gases. In addition, laser-based optical sensors detect the concentration of airborne particles; this became obvious when an exceptionally strong sandstorm hit the city in March 2016 [14]. The solution showed the amount of sand attacking the premises.

FROM GATHERING DATA TO CREATING SMARTNESS

Smart City is one aspect of the Internet of Things, and in order to realize the full potential of it and create synergies, the initiatives of individual departments within a city need to be viewed holistically.

Cities must have a common approach with all departments to understand how different infrastructure like street lights, cloud services and data sets can be commonly shared and utilized to solve problems. In addition, cities must bring in industry partners as well as their citizens to take part in innovation processes to ensure that solutions are practical and scalable in a cost-effective manner. To enable such innovation and results, it is essential to use open platforms and open standards. This is an important way to ensure that a city not only controls its data but also supports access to the data in a way that drives innovation and expansion of business and citizen-oriented applications.

SMART CITY INNOVATION STAGES

A Smart City in most cases starts with implementing basic solutions that solve the currently addressable pain points. This includes reducing electricity costs for street lighting, expanding free city Wi-Fi and working towards a more advanced parking solution. We call this stage **Smart City 1.0**. In this stage of evolution a city is in a basic data gathering stage, characterized by implementing basic stand-alone solutions. The solutions are mostly implemented by single departments and do not require too much interdepartmental co-operation. This first stage is an easy step that helps to get a city acquainted with the potential of a Smart City. While there is already some industry involvement, e.g. via local start-ups, there is hardly any citizen involvement. A key result of this stage is that first data sets are gathered and the city starts to think of how to use its massive amounts of existing non-digital data.

As the city gets more comfortable with the Smart City concept, and understands the financial requirements and benefits it moves towards **Smart City 2.0**. In this stage the city starts to realize the benefits of combining data from multiple solutions to create new uses for the data. Dashboards or visualization layers help to provide a more holistic view of the city. These dashboards require a data harmonization layer to ensure that the data generated is in a format that can be shared easily. Larger industry players can now get involved, and the city starts communicating and sharing more information with the citizens, thus creating public interest.

Smart City 3.0 is an expansion and larger scale engagement of industry players, universities and other groups towards innovation to improve the use of the data. In this stage, the city encourages citizen participation, for example, by introducing citizen reporting applications that enable citizens to

take pictures of maintenance issues around the city, and send these to the city for action. Solutions such as this may not be a city's first priority, but in general, such apps improve the perception of the city's services. Another characteristic of this stage is that the gathered data is provided via a data market place, enabling different types of data to be shared with different users – based on a city's defined data access policies. At this stage more detailed analytics, machine learning, software development kits and API's will be introduced, and existing data and legacy information from other city systems will be integrated.

Smart City 4.0 finally integrates direct interaction and participation of the citizens in the Smart City. The biggest change in the 4.0 scenario is that it connects everyday collaborative acts with broader goals like social inclusion, democracy and enterprise.

SMART CITY DEVELOPMENT



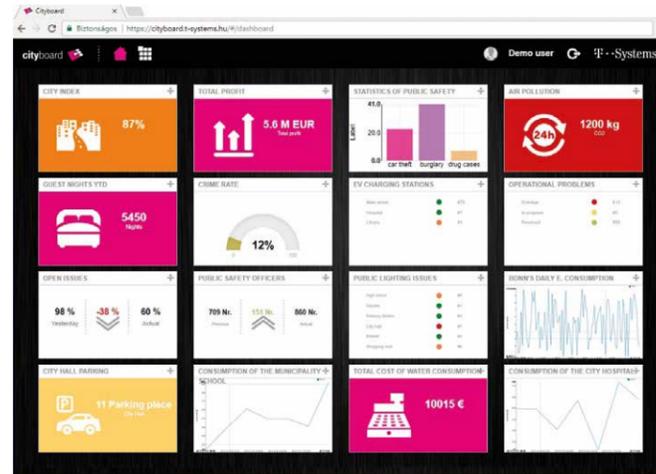
NAVIGATING THROUGH A SMART CITY

One of the big challenges on the path to becoming a Smart City is figuring out the business models and engagement models for businesses and citizens. Therefore, it is essential to introduce visualization layers/dashboards which allow decision makers to view all available data points, see correlations in the data, synergies in activities, and implement corrective measures. The dashboard can also be used to share selected data with citizens so that they can participate and interact with the developments within their city. Dashboards and some basic analytics also start to give citizens and mayors a first glimpse into the benefits generated by Smart City use cases.

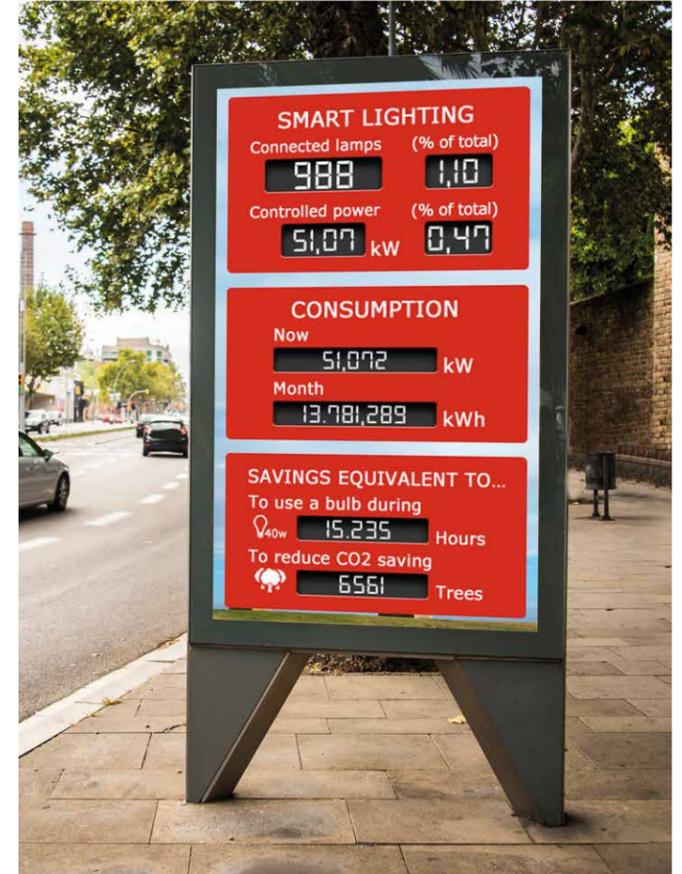
The cities of Liverpool [15], Boston [16] and Los Angeles [17] have implemented similar dashboards that provide a simple overview of key figures to everybody (from mayors to citizens) to judge the performance and efficiency of city services. The information is gathered from various sources and provides information on:

- the number of bus journeys
- the levels of air pollution compared with the national average
- the number of police officers currently on force
- the average waiting time for emergency calls
- the percentage of graffiti cleaned within the last 48 hours
- community center visits per month
- the street light outages in the last 12 months
- missed trash collections in the last 12 months

Obviously, a mayor or city department needs more information and details than a citizen to manage the new smart services, so data access and requirements need to be defined. But in the end this transparency increases the citizens' comprehension of the mayor's work, and can lead to more participation and high approval ratings for the mayor.



In Gijón, the largest city of the province of Asturias in the north of Spain, Deutsche Telekom installed a Smart Street Lighting system and a Smart City platform. The Smart Lighting solution saves the city council about 100,000 Euros each year from energy consumption, but the problem was that the citizens had no visibility of this great accomplishment. So the city installed a citizen board with live statistics to enable the city to showcase the impacts on publicly viewable video screens. Citizens can now view the most up to date statistics and savings generated by the city's Smart Street Lighting solution.



Eventually, the city will also be able to improve the satisfaction of citizens with its administrative services. Citizens will soon be able to follow the status of applications and city processes exactly the same way we currently track an order from an online shop. So, slowly but surely, cities will embrace the same transparency when renewing bus passes, parking permits or any other basic administrative process.



NEW INSIGHTS WITH BIG DATA

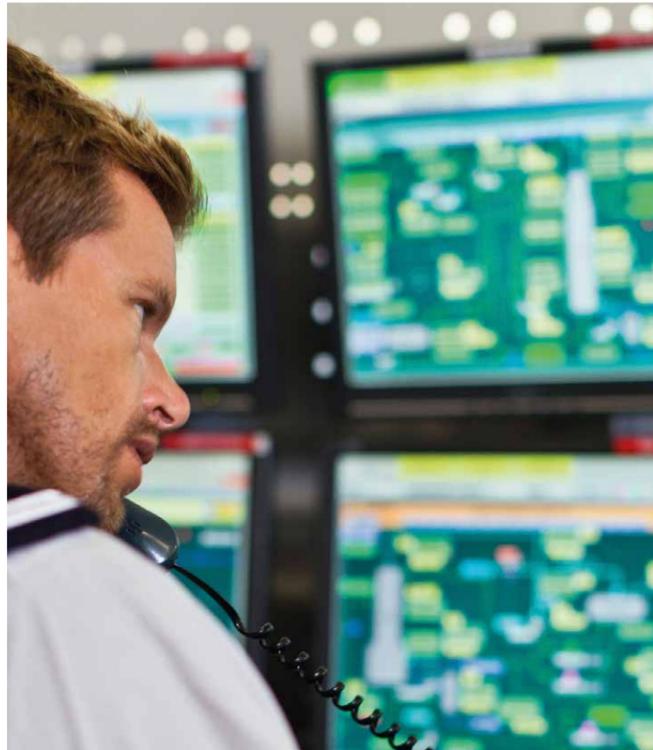
As Smart Cities grow, their solutions and business processes will generate more data than other enterprises around the world, for example, sensor data of buildings and traffic infrastructure, or traditional digitized services for citizens (applications, permits, licenses, etc.). A crucial step in creating actionable results and information from the urban data will be the analysis and evaluation in a Smart City platform. The platform must be able to deal with and process data that vary in frequency, type and volume – so-called Big Data. Technologies like machine learning, data mining and statistical modelling help to predict certain events, actions or conditions. So Big Data is about taking the step from identifying problems by gathering data to solving problems by combining data.

By combining data from air quality monitoring sensors, for example, cities gain an overview of the air pollution, and take necessary actions. In Germany, cities ban cars with certain emission-class tags from entering the city center. Furthermore, data from city road work information systems and even municipal waste collection routes can be used to better steer urban traffic flows, hence having an impact on air pollution.

Open Data

Municipal authorities are currently undergoing a digital transformation based on an EU requirement to provide “open data”. The goal is to share data with citizens, industry players and entrepreneurs to promote opinion forming, co-operation and engagement. However, open data does not mean giving away data forever or free use. A city must carefully consider what data can be made available, what data is privacy protected, what data can be simply released and what data must be tracked. This is another key factor why cities need a Smart City platform to monitor and control such features and functionalities related to open data.

These days, improvement of public services based on digitization and smartness is evident. A survey by the consulting company Accenture [18] found out that from 2014 to 2016 the satisfaction of U.S. citizens doubled to 58 percent when the government implemented digital services. While this improvement is impressive, there is still a long way to go, because as services improve so do the expectations of the citizens. In the same survey 85 percent of the respondents expect the government’s digital services to be better than or equal to those from a commercial enterprise. This expectation is setting new goals and requirements for cities to remain competitive.



EU FINANCING OF SMART CITY SOLUTIONS

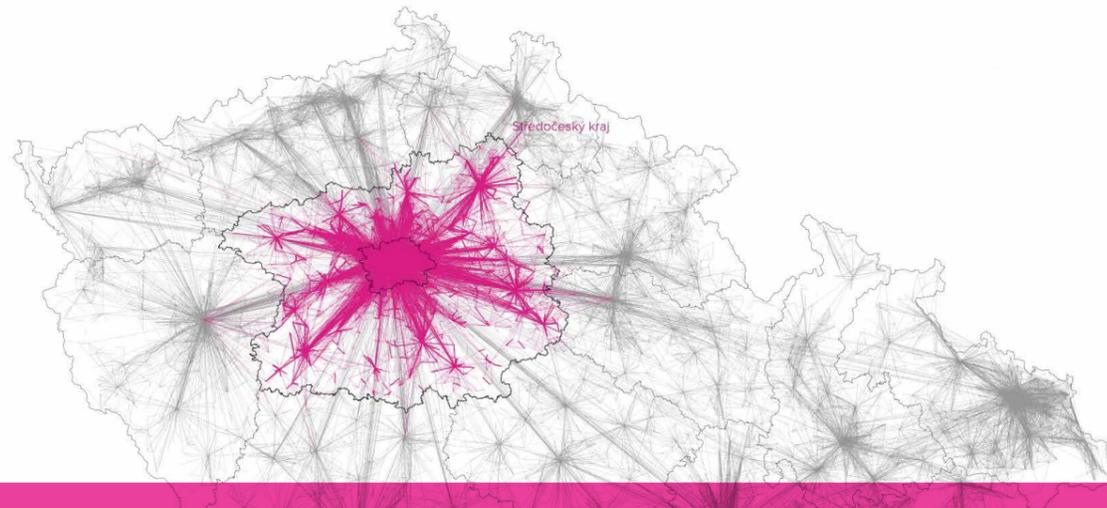
Municipal administrations often face limited public budgets when considering the implementation of Smart City services for their citizens. Therefore, the European Union has established several funding programs which aim to enhance the development of smart sustainable solutions.

EU funds for infrastructure-related Smart City solutions, such as Smart Lighting, are covering between 40 to 80 percent of the investment needed to complete these projects. Therefore, it is important for cities to know about the availability of funds and the process to get funds, so they can maximize the benefits for their citizens while minimizing their own investment.

The European Structural and Investments Funds (ESIF) [19] represent a viable means to address funding gaps. ESIF focuses on funding projects to reduce disparities in economic development between EU countries and regions. This is a very large program, as the EU has set aside a total budget of 450 billion euros for the period between 2014 and 2020. Of this amount more than 10 billion euros are allocated to specific issues that can be solved with Smart City solutions. The process to get granted parts of these funds is straight forward but requires time, effort, patience and focus for cities to be successful.

SMART STREET LIGHTING IN GRAZ – FUNDED BY THE EU

The Austrian city of Graz has reduced energy costs of street lighting by more than 60 percent due to the use of innovative Smart Street Lighting technology. The project, initiated in 2014, also introduced street lights which were able to change lighting intensity based on movement, such as passing cars. This system enabled reduced energy consumption driven by demand. The total investment for the project [20] was about 650,000 euros of which the EU’s European Regional Development Fund contributed 300,000 euros.

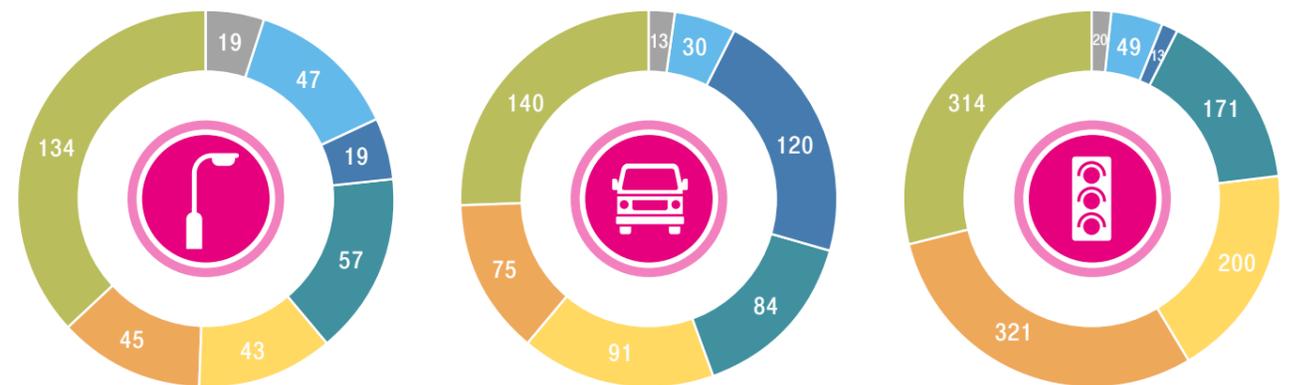


BIG DATA PROJECT: MOBILITY MONITORING

When it comes to **detailed and extensive models** based on huge amounts of data, co-operation is key and the RODOS Transport Systems Development Centre is a good example for this. The initiative is led by the Czech National Supercomputing Center and assembles several Czech universities, industry players and public authorities. T-Mobile Czech Republic acts as a strategic partner. By combining data from mobile networks and traffic monitoring, the participants have been able to build a complex mobility model. It has been used in several projects throughout the Czech Republic already.

For example, the RODOS team monitored 40 locations for Czech Tourism and provided the governmental agency with valuable insights about visitation patterns. During major events the model supports the police, fire brigades and ambulances in crisis management. By giving an overview of the actual distribution of people, and detecting deviations in real time, the mobility model provides important information for decision making in critical situations. In Prague’s metropolitan area, mobility information generated by the RODOS initiative is used for optimizing the city’s integrated public transport system.

FUNDS FOR SMART CITY PROJECTS
IN SELECTED CENTRAL AND EASTERN EUROPEAN COUNTRIES



364 million EUR for smart energy efficiency investments in public infrastructures

533 million EUR for smart clean urban transport infrastructure

1,088 million EUR for intelligent transport systems

- Croatia
- Greece
- Romania
- Poland
- Slovak Republic
- Czech Republic
- Hungary



The allocation of funds is usually made through competitive procedures known as calls for proposals. Cities are invited to submit their projects. The best ones are selected for financing and will receive the grant to start the implementation of their project.

Horizon 2020

While European Structural and Investment Funds are allocated to member states, and managed by national or regional authorities, the European Union also supports urban communities to test and deploy state-of-the-art innovative solutions through programs and initiatives, managed directly from Brussels, such as Horizon 2020, Urban Innovative Actions or Life.

Through its Smart Cities and Communities stream, Horizon 2020 supports urban communities to develop and test integrated innovative solutions to tackle energy transition challenges.

mySMARTLife in Hamburg

The EU defined several lighthouse projects in the areas of mobility, energy-neutral housing, and information and communication technology (ICT). One of the Horizon 2020 lighthouse projects is mySMARTLife which will be implemented in the cities of Hamburg, Helsinki and Nantes. Key topics of this flagship project include increased use of renewable energy sources, zero-carbon-footprint living and environmentally-friendly mobility in the Hamburg-Bergedorf project region. The project also includes

- provision of electric bicycles
- expansion of car sharing concepts
- new purchase of electric buses

- new charging stations for electric cars
- development of a local heating concept based on heat pumps and ice storage tanks
- intensification of energy-efficient building refurbishment
- planning of local cogeneration plants

These and other intelligent technical solutions, such as Smart Street Lights, will be combined on an open urban platform. As a result, all existing and new data can be utilized more efficiently and be provided to the public. The Hamburg project is supported by Deutsche Telekom and T-Labs. Telekom's main focus in this project is to provide a true Smart City platform.

Citizens and visitors in Budapest who prefer to go by bike can use a public bike-sharing system implemented by T-Systems Hungary. It is comprised of 76 docking stations and 1,100 bikes. Around 3 million euros of the project costs have been financed by the EU Regional Development Fund. The Transport Challenge of Horizon 2020 provides more than 6 billion euros funding for smart, green and integrated transport.



Deutsche Telekom is a trusted partner with a proven track record of enabling decision-makers to understand the potential of Smart City solutions with EU funding. With an established network of partners all over Europe, Deutsche Telekom is ideally placed to offer in-depth advice and guidance to give cities the best chance at understanding the funding options for their innovation plans.

SUCCESS FACTORS FOR GETTING EU FUNDS

- 1. Plan ahead**
Develop coherent and integrated funding strategies based on the needs of your city. Prioritize the projects for which EU funding can be obtained in line with the funding programs in your country.
- 2. Make your investments smart**
Public transport, hospitals, schools and public lighting are all strategic investments with direct impact on the quality of life of your citizens. Rendering these investments smart through Smart City solutions can significantly contribute to a sustainable and comprehensive approach to your development projects.
- 3. Ensure your teams are up to the job**
Build solid teams for the management and implementation of EU-funded projects. External teams can also be sub-contracted to deliver the projects.
- 4. Involve partners and the private sector to identify the best solutions for your city**
The transparent and open involvement of partners and the industry will only give more legitimacy to your projects, and ensure the best solutions are found and proposed for EU financing.

OUTLOOK ON SMART SUSTAINABLE CITIES

THE FRIENDLY SKIES: DRONES AND AIR TAXIS

Smart City requires constant evolution, like a wave, with an increasing use of digital assets. One area where this will become increasingly important is in the skies, since in the near future the sky will be used by an increasing number of objects. The development of new technologies, like drones or airtaxis, requires a constant evaluation of cities' needs as well as a review of current laws and regulations.

5G IN THE SMART CITY

Current advances will soon bring major changes to mobility. With the increasing electrification of cars and the introduction of driverless vehicles, communication will become increasingly important. These new services require an extremely fast and secure

network to ensure safe operation. This is why telco operators are currently developing the 5th generation communication network: 5G. To provide this fast network connectivity and reaction time, the processing of information is shifted close to the access point – the “edge” of the network.

BLOCKCHAIN TECHNOLOGY

Blockchain is actually a way to structure data, and the foundation of cryptocurrencies like Bitcoin. This coding breakthrough – which consists of concatenated blocks of transactions – allows competitors to share a digital ledger across a network of computers without need for a central authority. No single party has the power to tamper with the records: The math keeps everyone honest. 40 of the world's top financial firms are experimenting with the technology including Deutsche Telekom.

In 2016, Deutsche Telekom, DFS Deutsche Flugsicherung, Deutsche Post DHL Group and RWTH Aachen University launched a joint research project on drones. In the future, the mobile network could be used for the surveillance and monitoring of unmanned aircraft, and this technology will be tested for delivery purposes. The first trial in the Ruhr region of Germany examined the use of drones for delivery and also for firefighting and agriculture purposes. In the case of firefighting, researchers investigate if drones can be sent to fires at the same time as other firefighting vehicles, to provide aerial photos even before firefighters arrive on location.



These are very futuristic aspects of a Smart City. Having said this, in the short to medium term, the actual work is to implement real-life solutions which help city administrations and benefit citizens in their daily lives. Developing a clear vision and starting with small steps will be the way forward.

Deutsche Telekom has developed an innovative concept of a blockchain solution that maps the complete value-added chain of a production process from the raw material to the delivery of a product. In the model, the information of the production process is stored transparently and unambiguously in a blockchain. This enables digital capacity management. The application leverages the benefits of blockchain technology for a trusted relationship between business partners without using a central platform. As a result, transactions will be handled faster, more cost-efficiently and transparently. For example, in the event of a breach of contract, all parties involved can follow the process via the entries in the blockchain. Subrogation or recovery receivables can be uniquely identified and addressed.



BIBLIOGRAPHY

[1] International Organization for Migration, WORLD MIGRATION REPORT – <https://www.iom.int/sites/default/files/country/docs/syria/IOM-World-Migration-Report-2015-Overview.pdf>

[2] United Nations Habitat Program, Urban themes/energy – <https://unhabitat.org/urban-themes/energy/>

[3] Das Erste, “Spanien: Die intelligenteste Stadt Europas”, by Stefan Schaaf, October 2017 – <http://www.daserste.de/information/politik-weltgeschehen/weltspiegel/sendung/santander-spanien-smart-100.html>

[4] Digital Trends, “Tech is making life in Barcelona better, even if you don’t know it’s there”, by Jenny McGrath, July 2017 – <https://www.digitaltrends.com/home/barcelona-smart-city-technology/>

[5] Guifi.net, Homepage – <https://guifi.net/>

[6] Smart Citizen, Homepage – <https://smartcitizen.me/>

[7] The Register, “Guess what’s ‘easily hacked’? Yes, that’s right: Smart city transport infrastructure”, by John Leyden, April 2016 – https://www.theregister.co.uk/2016/04/22/smart_transport_hackable/

[8] Dallas News, “Culprit broadcast signal that triggered Dallas’ emergency sirens Friday night”, by Robert Wilonsky, April 2017 – <https://www.dallasnews.com/news/news/2017/04/10/hacker-broadcast-signal-triggered-dallas-emergency-sirens-friday-night>

[9] Rhein-Neckar-Zeitung, “Der Verkehr bleibt das größte Sorgenkind der Heidelberger”, by Micha Hörnle, March 2017 – https://www.rnz.de/nachrichten/heidelberg_artikel,-Heidelberg-Der-Verkehr-bleibt-das-groesste-Sorgenkind-der-Heidelberger-_arid,264657.html

[10] European Parking Association, Homepage – <http://www.europeanparking.eu/>

[11] The Guardian, “Electric cars to account for all new vehicle sales in Europe by 2035”, by Adam Vaughan, July 2017 – <https://www.theguardian.com/environment/2017/jul/13/electric-cars-to-account-for-all-new-vehicle-sales-in-europe-by-2035>

[12] iot UK, The Future of Street Lighting Report, April 2017 – <https://iotuk.org.uk/future-street-lighting-report/>

[13] International Energy Agency, World Energy Outlook Special Report 2016: Energy and Air Pollution – <https://www.iea.org/publications/freepublications/publication/weo-2016-special-report-energy-and-air-pollution.html>

[14] the dubrovnik times, “VIDEO – Dubrovnik chokes as African sand blots out sun”, March 2016 – <http://thedubrovniktimes.com/news/dubrovnik/item/432-dubrovnik-chokes-as-african-sand-blots-out-sun>

[15] Centre for Cities, Multimedia/Liverpool City Region Metro Mayor Dashboard – <http://www.centreforcities.org/multimedia/liverpool-city-region-metro-mayor-dashboard/>

[16] City of Boston, Mayor’s Dashboard – <https://www.cityofboston.gov/mayorsdashboard/>

[17] City of Los Angeles, Mayor’s Dashboard – <http://dashboard.lamayor.org/>

[18] Accenture, Newsroom, “Citizen satisfaction with digital government services doubles in two years, Accenture report shows”, February 2017 – <https://newsroom.accenture.com/news/citizen-satisfaction-with-digital-government-services-doubles-in-two-years-accenture-report-shows.htm>

[19] European Commission, Funding/Tenders/European Structural and Investment Funds – https://ec.europa.eu/info/funding-tenders/european-structural-and-investment-funds_en

[20] European Commission, Regional Policy/Projects, “Energy-efficient street lighting in Graz area” – http://ec.europa.eu/regional_policy/en/projects/austria/energy-efficient-street-lighting-in-graz-area





LIFE IS FOR SHARING.

PUBLISHED BY

Deutsche Telekom AG
Friedrich-Ebert-Allee 140
53113 Bonn

For further information, please
contact us at smartcity@telekom.de

