1. Introduction

For thousands of years, human being have migrated to cities in search of better opportunities. According to the last population estimation, experts say that XXI century will be the century of cities and that this fact will take place in every country regardless of the stage of their development. In developed nations, this process has already started largely, and in the coming years it should finish. In developing countries, migration are moving large masses of people from rural areas to cities, in some cases true megalopolis, which are experiencing rapid population growth, in most of the cases messy and full of serious inequalities. In fact, in 2008, for the first time in history the urban population reached the rural population of the world.

In this scenario, future cities will concentrate most of population of the planet; will be the focus of cultural, artistic and economic activity; will consume most of the natural and energy resources; will generate most of the waste and will be responsible for the emission into the atmosphere of greenhouse gases. The cities, in sum, will be the focus of human activity, which will be located in a fraction of the planet's surface, with all the effects that this entails. Positive effects by leveraging human concentration to stimulate economic development, relationships, innovation, progress in general, to facilitate sustainable models of energy management to make available to the majority of the world's population access to basic services such as health and education; but also negative effects, such as a net increase in the urban population living in slums without tap water or electricity, an increased insecurity and air pollution.

Smart City stands as a great opportunity to manage in the most efficient way that eminently urban future. Extensive and intensive application of the Information and Communications Technology (ICT) to public services, such us management of supply and consumption of energy or water, the improvement of transport and mobility, public safety and civil protection. Obviously, the city government and transparency and citizen participation are the key to the transformation of the traditional city into a Smart city where everything could be offered with a high added value.

The Strategic Implementation Plan of the European Innovation Partnership on Smart Cities and Communities defines Smart Cities as:

> *Smart cities should be regarded as systems of people interacting with and using flows of energy, materials, services and financing to catalyze sustainable economic development, resilience, and high quality of life; these flows and interactions become smart through making strategic use of information and communication infrastructure and services in a process of transparent urban planning and management that is responsive to the social and economic needs of society.*

It has to be noted that Smart City is a broad concept, which fit definitions of varying scope, from the most restrictive to the most extensive, but in all cases the application of ICT is the true cornerstone that makes everything possible.

In this context, new devices, sensors, communications networks, storage and processing capacity, service management environments are required in order to improve the delivery of city services, such as energy, water, transport, waste management, trade, tourism and government. TIC Companies have to face a great challenge and a huge opportunity for growth and development.

The services that can offer a Smart City are associated with the technologies that can be employed for that purpose. These technologies, which range from wired and wireless communications networks to M2M (Machine to Machine) and Internet of Things, allow the management of sensors and actuators deployed throughout the city. In the same way, the large amount of monitoring data generated by these devices requires proper storage and processing capacities, and to this end, the

emerging Big Data technologies is the best option nowadays.
The Strategic Implementation Plan aforementioned establishes that, in order to achieve a decarbonisation of Europe's economy in line with the EU' 20/20/20 energy and climate goals today's ICT, energy (use), transport systems and infrastructures have to drastically change. The illustration below, taken from this document depictures the estimation of energy consumption and the goal aimed by the plan. The EU needs to shift to sustainable production and use of energy, to sustainable mobility, and sustainable ICT infrastructures and services.

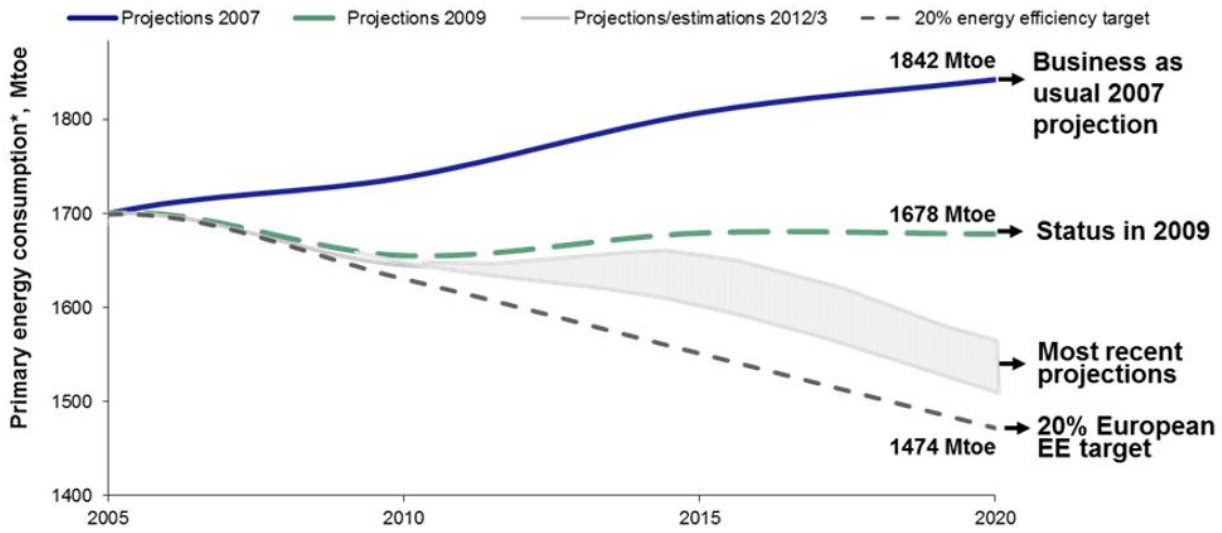


Figure 1. Primary energy consumption scenarios for 2020[1]

Cities and urban communities play the crucial role in this process. Three quarters of our citizens live in urban areas, consuming 70%5 of the EU's overall energy consumption and emitting roughly the same share of greenhouse gases. Of that, buildings and transport represent the lion's share (see illustration below). The trend towards urbanization continues at unprecedented pace at European and global scale and risks increasing traffic congestion and pollution which in turn risks rendering cities dysfunctional, undermine competitiveness and seriously affect quality of life. Furthermore, cities are a huge economic and purchasing power in Europe and account for 19% of the total expenditures in the EU. If combined and thought through in a smart way this could trigger a significant potential for economic growth and jobs by combining market pull and technology push, even without reliance on traditional funding mechanisms.

Whilst it is true that European cities and regions are different from each other, it is also true that they have many similar needs that can be tackled best through a common approach.

Among the specific actions that fall under the concept of Smart City that handles the European Commission, it can be include the following:

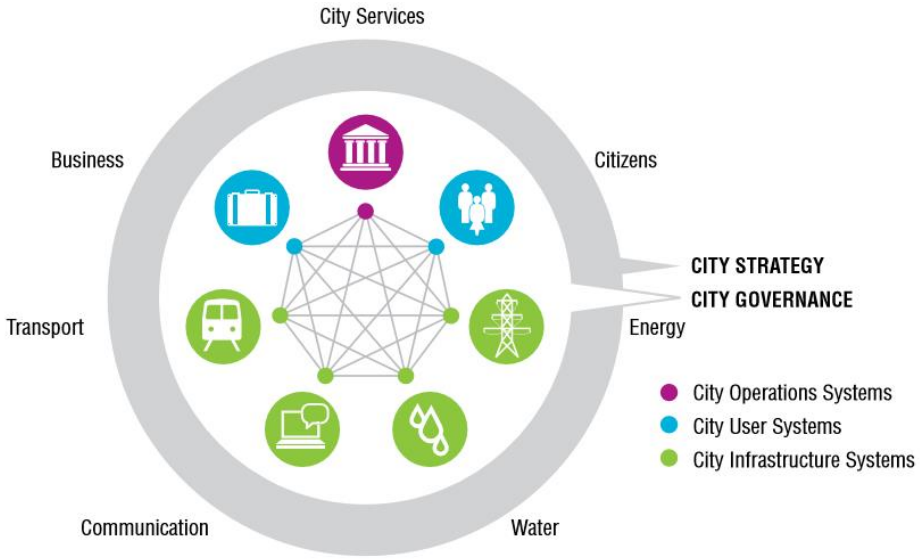
- Increasing the use of renewable energy sources and reducing energy consumption and green-house-gas emission.
- Use of smart heating, cooling, and ventilation systems.
- Smart lighting systems– both indoor and outdoor.
- Develop and deploy zero/plus energy buildings with innovative technical solutions and materials.
- Use of smart meters for energy and water.
- Real time energy management.

[1] Source: European Commission 2013

- Energy storage systems.
- Sustainable Urban Mobility by means of alternative energies, public transport, efficient logistics, planning.
- Electrical vehicles charging system integrated in the Smart Grid
- Reduce energy use, environmental impact and carbon footprint of the data centers and ICT equipment.

2. Technologies and services in the Smart City

In the model of Smart City, a city can be seen as a set of systems that consume resources to provide a variety of services, and where an appropriate technology platform can optimize all processes, providing these services with higher quality and more efficient use of those resources. The following figure shows an example of interaction among the different systems that can be considered in the city, according to the vision of IBM:



Source: IBM Center for Economic Development analysis.

Figure 2. Cities systems and their interrelationships within the larger framework of the city's strategy and governance.[2]

2.1. Smart city Services

As already mentioned throughout the previous paragraphs, a Smart City has to provide its citizens and businesses with efficient services by means of ICT. These services fall within any of the following categories, which in turn relate to the six characteristics of City Smart3[3] (Smart Economy, Smart People, Smart Governance, Smart Mobility, Smart Environment, Smart Living):

a) Energy and environmental sustainability.
b) Management of urban infrastructure and public buildings.
c) Transport and mobility.
d) Waste management.
e) Healthcare services.
f) Trade.
g) Security.

[2] Source: IBM Institute for Business Value - A vision of smarter cities
[3] http://www.smart-cities.eu/download/smart_cities_final_report.pdf

h) City government and relationship with citizens.
i) Education.
j) Culture.
k) Tourism.

a) Energy and environmental sustainability

Improving energy management in the Smart City can be performed under several perspectives. It can be carried out in the generation, in the distribution and in the use of that energy.

In the power generation, the use of renewable energies such as wind energy or photovoltaic energy contributes to reduce the emissions of greenhouse gases, typical of fossil fuels.

In the power distribution, the use of ICT to add intelligence to the electricity grid, allowing two-way communication between the points of power generation and consumption points, is the key to the concept called Smart Grid[4]. The use of the Smart Grid makes possible an efficient use of the generated electricity, flattening the demand curve and maximizing the utilization of the assets of the grid. The Smart Grids also increase the efficiency of the distribution networks by means of reducing energy losses.

Finally, in the consumption of the energy, an essential element of the Smarts Grids are the smart meters or advanced metering Infrastructures (AMI. The combination of Smart Grids and smart meters allow electricity system operators to establish prices more in line with the real costs of energy production and the time of consumption (peaks or valleys). Real time knowledge of consumption facilitates the smart meters to adapt the user consumption curve at times when rates are lower.

b) Management of urban infrastructure and public buildings

Buildings are important points of energy consumption whose energy efficiency as to be improved. Public buildings, in particular, can be equipped with systems management of lighting, heating and air conditioning to reduce these inefficiencies, which in some cases can reach 50%. Public lighting services also have significant potential for improvement through management of lighting and the use of lower consumption technologies such as LED technology.

c) Transport and mobility

In large cities, the mobility of citizens and goods constitutes one of the main services provided by the government. Traffic management, public and private, is one of the main applications of the Smart City, because of its impact on improving the productivity of the city, reducing energy consumption and associated costs, control emissions of greenhouse gases, and the overall quality of life of the city, as the traffic is the main cause of air pollution and noise pollution. Additionally, the costs associated with traffic accidents in Europe amounting to two percent of gross domestic product of the European Union as well as being responsible for the loss of 40,000 lives a year.

Intelligent Transport Systems (ITS Intelligent Transportation Systems), as well as communication between vehicles (V2V Vehicle to Vehicle) and between these vehicles and urban infrastructure (V2I Vehicle to Infrastructure) allow substantially improve urban transport management and mobility. The electric vehicle, meanwhile, is a low-emission alternative to combustion engines, and their integration into the Smart Grid also allows more effectively manage of electricity demand.

[4] -http://www.smartgrids.eu/

d) Waste management

Waste management in big cities is a first-rate logistics process that consumes large amounts of public resources. The control of containers (fill level) using sensing systems, the design of efficient waste collection routes based on the captured information about the status of the containers and control of the fleets of vehicles dedicated to garbage collection can be considered as essential services for intelligent management of waste generated in cities.

e) Healthcare services

In large cities, especially in the developed countries where the population is aging rapidly, the provision of healthcare services and social health is a major public benefits received by citizens. Technical monitoring devices and the application of ICT to the protection and care of vulnerable persons increases the quality of these services.

f) Trade

Trade is undoubtedly one of the central activities of cities. In the Smart City, the traditional trade has to evolve and to adapt, offering e-commerce services and facilitating the use of means of payment such as payment by mobile phone.

g) Security

Public safety and civil protection services are provided by most large municipalities. For instance, in Spain, civil protection is a municipal responsibility in all cities of over twenty thousand inhabitants. The integration of emergency services, combining networks of sensors and surveillance cameras, as well as the collection and processing of large volumes of information generated by the citizens, for example through their mobile phones, allows a more effective response of the authorities to emergencies.

h) City government and relationship with citizens

The Widespread of eGovernment in the relationship between citizens or businesses and municipal authorities is one of the services of the Smart City. The use of ICT by the Administration to inform citizens and to develop policies of transparency, Open Data and Open Government in municipal management is another service that Smart City can offer.

i) Education

A Smart City ICT infrastructure can be leveraged to provide educational services based on ICT. Broadband networks facilitate widespread access to applications and educational content and e-learning.

j) Culture

The Smart City can provide cultural services through Internet, thus providing access to information on the cultural program of the city, including providing access to digitized cultural and heritage data.

k) Tourism

Tourism is one of the main sectors of many large cities. The application of ICT in this sector, both for tourism promotion to managing reserves, and access to tourist services of all kinds, especially through mobile devices is essential in the Smart City model, especially in cities with greatest tourism potential.[5]

2.2. Technologies for Smart City

[5] http://smartcitiescouncil.com/article/4-creative-ways-cities-are-using-smart-technologies-promote-tourism

As described before in this section, the Smart City can offer a wide range of services to its citizens and companies by means of an intensive use of technologies. The range of technologies that can be developed in the Smart City is large, thus, here are just the most important or representative.

Sensor technologies
Sensors allow us to collect information from several facets of the city, information that can later be processed and used for management decisions.

For instance, sensors can provide information related to traffic conditions, energy consumption, etc. These sensors can be used to measure energy and water consumptions or flows. They can measure quantities associated with security levels. They capture information of temperature, humidity, wind speed and direction, atmospheric pressure, also they can measure speed or traffic intensities, levels of occupation of roads, means of transport, etc. All these sensors can be located in the city infrastructure, public transport, private vehicles or systems, or on mobile phones or any other fixed or mobile element that is connected in somehow to Internet.

Communication networks.
Communication networks of Smart City allow the interconnection of all systems that integrate and facilitate the collection of data through sensors, for further processing and management decisions. Communications infrastructure of the city includes both fixed and mobile broadband networks. Mobile or wireless networks are particularly important in the Smart City because they allow the connection of vehicles, mobile devices and people. Among others, the main technologies that can be used for this purpose are the well-know ZigBee, WiFi, Wimax, PLC, LTE/UMTS/GSM/GPRS, etc.[6]

Furthermore, M2M (machine to machine) technologies allow the integration of devices that connect to the network using M2M gateways or by direct interconnection with other devices.

Storage and processing of information.
Storing the data (in some cases during a long period of time) and the processing capability allow to exploit the large volumes of information generated by the sensor networks. Big Data technologies allow to aggregate this huge flow of information coming from the sensors network of the city, and to transform it into a useful and applicable knowledge for management decisions of the Smart City services.

[6]Evolution of Communication Technologies for Smart Grid applications
http://www.academia.edu/4049261/Evolution_of_Communication_Technologies_for_Smart_Grid_applications