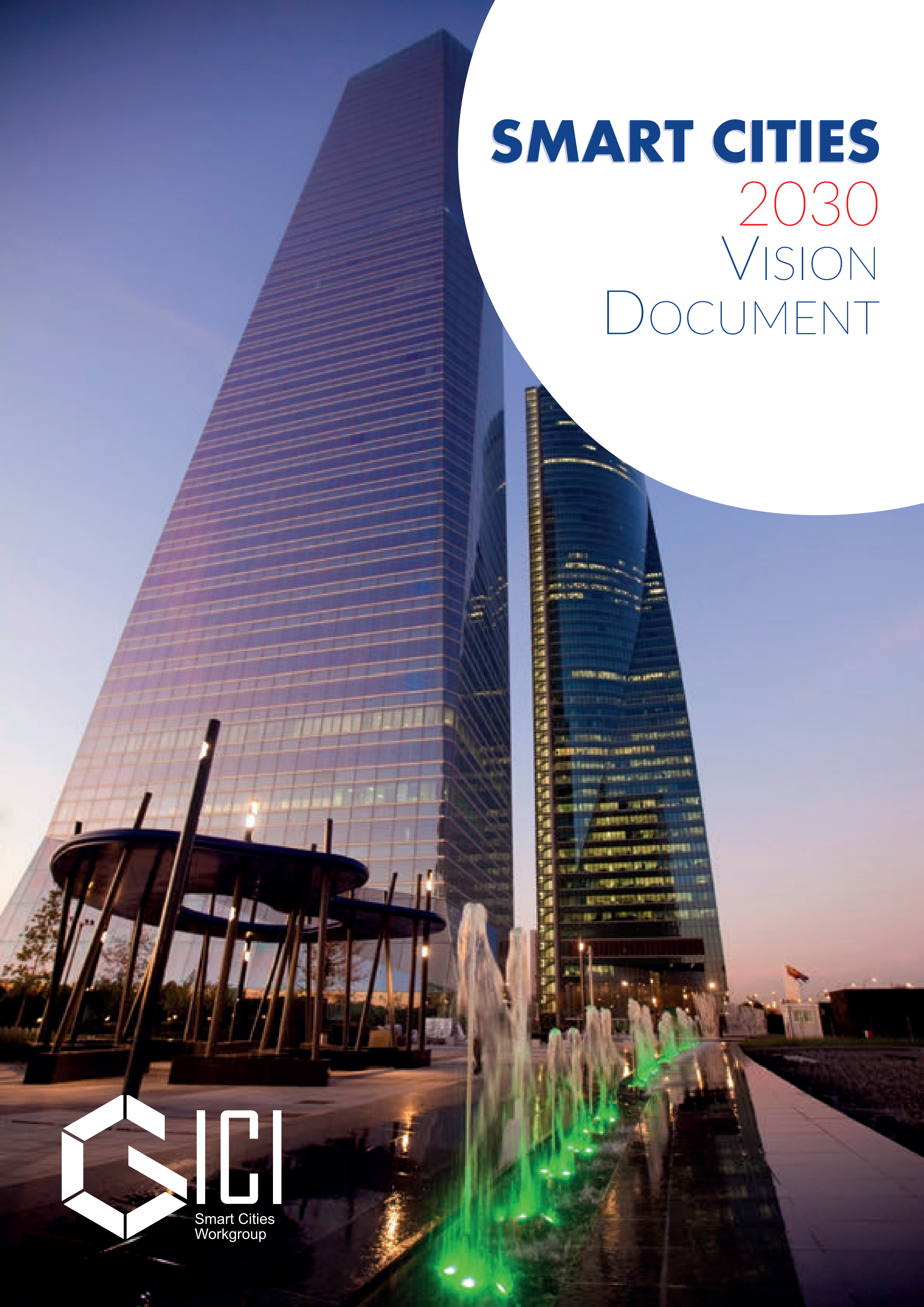
SMART CITIES
2030
VISION DOCUMENT



Smart Cities Workgroup

Table of contents

Elaborated by GICI in June 2015
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Design and layout by CIRCE

Nowadays, the cities already represent the place where more than half of the population lives, and that ratio will continue increasing, not only because of the migration from rural to urban areas, but also because of the population growing. In the following 25 years, global population will grow from 7.3 billion people up to 9.5 billion and that population will be more urban, going from the current 50% up to 66% in 2050. This urbanization process is more advanced in Europe and in Spain particularly, where more than two thirds of the population is urban and it is expected that 85% of it will be urban in 2050, headlining along with America this population change.

The concentration of the population in urban centres, as a consequence of the efficiencies brought by the resources sharing implies, simultaneously, a centralization of the political, economic, cultural, social, etc. power that supports the growth in the cities. As a result, the cities are the economic driving force responsible for 80% of the European GDP, besides cultural, educative, ideological, etc. references that highlight the progress of our society.

To support this activity energy is needed, which means that cities in Europe are responsible for three fourths of the energy consumption and greenhouse gases. Therefore, working in energy optimization of the cities is justified and it is an important ally for the accomplishment of European environmental policies. As well as energy, and in a wider sense, the cities should face the challenges about circular economy supposing the use of resources and recycling, the logistic of people and goods movement, accessibility, citizen safety and, finally, the quality of life of its inhabitants.

The progress in the solution of these challenges, which are traditional in urban management, is being promoted by an important number of initiatives that accelerate the changes in the urban area. Mainly, these initiatives are intersectorial and public-private collaboration, searching for an increase in communication and knowledge transfer between cities and based on the Information and Communication Technologies like dinamization of innovative processes, highlighting the introduction of new tools or concepts such as hiperconectivity, BigData, collaborative ecosystems, etc. Nowadays, the innovation is increasingly taking place in collaboration and, for instance, the solutions adopted in a city are tried to be replicated and scaled in other cities or synergies are sought between sectors that have traditionally operated independently.

Spain has a wide ecosystem formed by different sized cities, an important productive, educative and experimental grid which, with institutional support in this topic, allows to have an international leadership position. This leadership implies double benefits, the increase in the sustainability of the cities adopting the solutions, which will enhance the appeal and also the quality of life of their citizens, and the improvement in the competitiveness of the productive and educative grid in the international market.

Proof of this leadership is the success achieved by this ecosystem in the H2020 funding programme, the celebration of the main Smart Cities international congress in Barcelona, the international positioning of several of our cities like Malaga, Barcelona or Santander, etc.

On the other hand it is highlighted that recently the highest level of the Industry, Energy and Tourism Ministry has banked on the creation of the Smart Cities National Plan that seeks to encourage the technological industry that supplies services and solutions to the Smart Cities and to support the local entities in their transforming processes. This initiative, formed by the Economy and Competitiveness Ministry, groups the different stakeholders in this field to help coordinate different activities suggested in the plan that, without a doubt, will ensure the efficiency of the developments and the national leadership in this topic.

Additionally, the Economy and Competitiveness Ministry is encouraging the INNPULSO Grid. This grid groups the cities which received the award, "innovation and science city" when demonstrating a special interest in favour of innovation. Through its workgroups, the grid tries to pave the way for the technological industry and for the Smart Cities to identify and tackle, through innovation, the needs and challenges not satisfied by the market and end up improving our Cities.

Eventually, within the Economy and Competitiveness Ministry an answer is given to this movement with the creation of Smart Cities Interplatform Group (GICI) which is formed by 20 representative technological platforms from different sectors along with other relevant organizations. This group unites and organizes the Spanish scientific-technological offer and tries to give a coordinated answer to several technological challenges raised in the area of the Cities. The consequence of the work made by GICI is this document, which describes, in technological development terms, the vision of the smart city until 2030, both from topic area point of view (energy and environment, buildings and infrastructures, mobility and intermodality, government and social services) as well as from other more cross-sectorial areas.

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1

EXECUTIVE SUMMARY

More than fifty per cent of the world's population, which continues to grow, lives in urban areas. This concentration of urban population implies several advantages in terms of efficiency that allows people to have more advanced services than in other environments, therefore becoming more relevant in the global governance regarding issues such as economic, social and political development. However, while cities keep growing they must face important challenges that must be addressed in order to ensure their future sustainability.

As an example, European cities host 68% of the population (they are expected to reach 85% by 2050), consume 70% of the energy, and are responsible for 75% of the greenhouse gas emissions and their economic activity represents 80% of the gross domestic product.

In this scenario, several initiatives have emerged looking for solutions that enable the optimization of cities operation and ensure their sustainability. This concern is embodied in the alignment of the defined social challenges both in Spain and Europe, the establishment of organizations at all levels on this topic, the allocation of specific resources on R&D aiming for development and presentation of applications in urban environments.

Common features of these initiatives include:

- Collaboration in the broadest sense between public administrations (also among themselves), research centres, enterprises and citizenship.
- Focus on innovation by developing near to market solutions.
- Exchange of experiences and solutions between cities that have already been applied in a successful way.

The Smart Cities workgroup (GICI) was created in 2013 with the purpose of meeting cities' challenges from a technological development perspective at national level.

Through the promotion of and in close collaboration with the Spanish Administration, **20 Spanish Technological Platforms** that represent different sectors are collaborating **in order to promote technological developments and solutions towards sustainability** in cities, in a shared view of what a smart city should be

This document **describes in an orderly and systematic way the smart city vision until 2030 in terms of technological development** (itself or its application) and from the point of view of the different platforms involved in its development. Several areas for action (energy and environment, buildings and infrastructures, mobility and intermodality, government and social services; and transversal areas, ICT, sensors, security and materials) are set out in this document elaborating the different technological elements that must exist in the cities of tomorrow.

A definition of a smart city is required prior to the brief description of the city model. Several definitions exist in which organizations emphasise the aspects they find more relevant. GICI has defined the smart city concept from an innovative point of view, focusing on sustainability and on improving citizens' quality of life. Therefore, **"a smart city is a city that ensures energy, environmental, economic and social sustainability in order to improve citizen's quality of life and encourage business activity by incorporating innovative technologies, processes and services".**

Future smart cities will produce an important share of the energy they finally consume (and a great percentage will come from renewable energies), citizens' capacity to participate in the energy market will be enhanced and efficiency will constitute a basic principle that will continuously reduce the energy consumption of buildings (insulation), electrical equipment, etc. Energy distribution grids, and particularly electric ones, will be the backbone of the energy transition.

Furthermore, the cities will take further advantage of the natural resources required for the activities performed within them by storing rainwater, totally valuing urban waste, etc.

Urban mobility will shift to alternative fuels in order to reduce pollution and greenhouse gas emissions. Besides, a more efficient management of the different methods of transport will be performed in order to optimize transport flows and avoid traffic, as well as logistical movements of materials and products in and out of the city.

City optimization also encompasses its **monitoring**, which will be increased both in the public sector with an advanced sensors' network enabling the collection of information from lighting, pollution, traffic situation, etc. and in the private sector by automatizing homes and buildings.

Not only will **Information and communication technologies** (ICT) play a crucial role in the transmission and processing of all this information, but they will also enable citizens and enterprises to access the public administration, promote the city as a tourist attraction, reduce trips by using communication technology, etc.

The quality of life is linked to **health and safety**. Therefore, advances in these areas will reduce the number of incidents and accidents in city activities and will reduce the degree of invasiveness of clinical interventions as well, while remote management for monitoring patients will improve patient autonomy and monitoring itself.

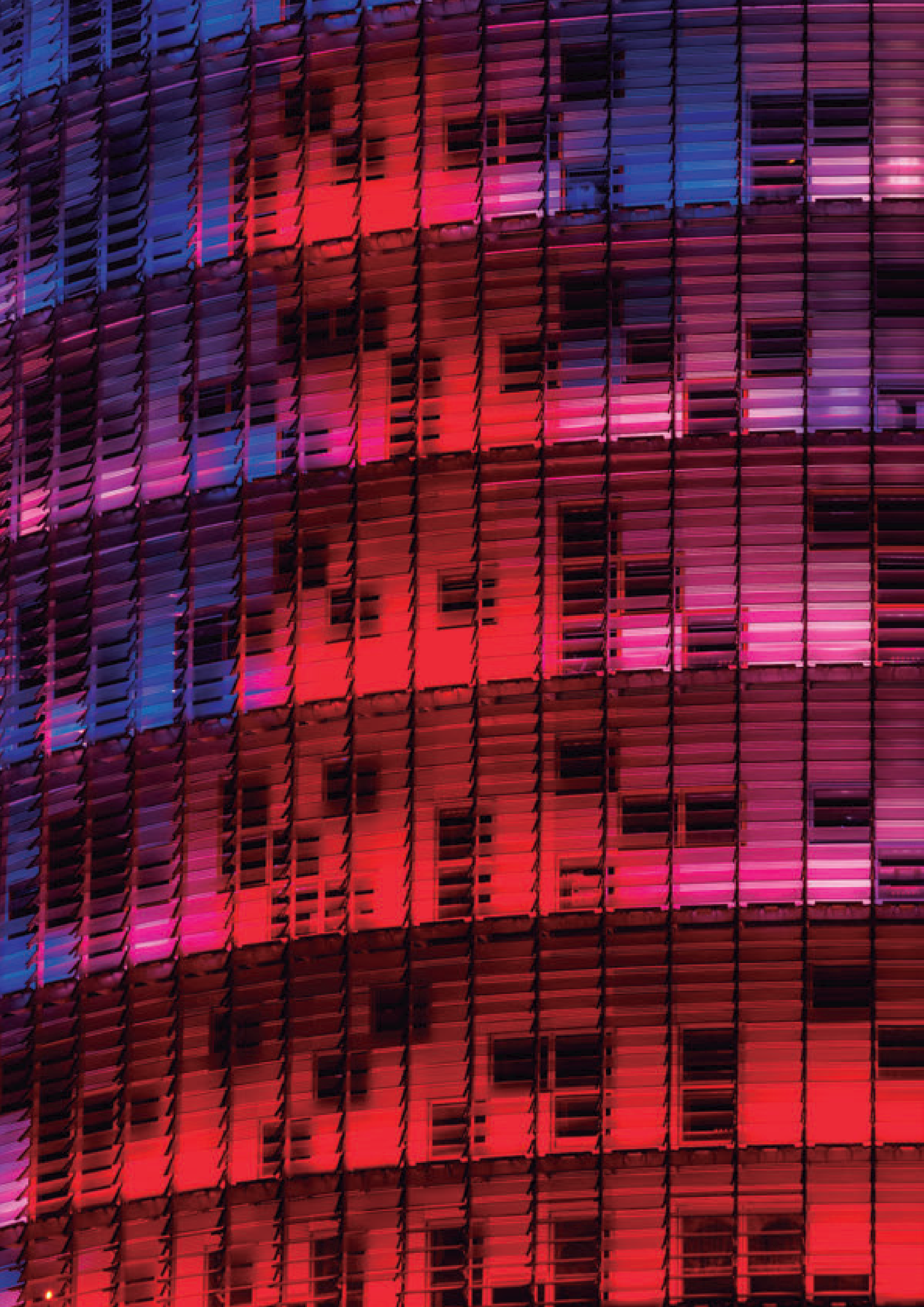
To sum up, **technological improvements will enable cities to become healthier, safer and more attractive environments for economic, cultural, educative and professional development, and will improve their energy and environmental sustainability**.

The work performed within GICI intends to promote those technical improvements although it cannot be achieved alone. As stated before, **collaboration is a key pillar, and GICI being focused on the supply side, it is necessary to complement it with the demand side, which is located mainly in the cities' governing bodies**.

In addition to technical developments, **advances in the smartness of cities need key factors such as standardisation and interoperability of the solutions that allow universalization and cost reduction, regulation at all levels that enables the development of an adequate framework for new solutions to reach the market and funding schemes for development and demonstration activities to reach pre-commercial level.**

Based on these factors, this vision document aims to address:

1. The members of the participating Technological Platforms, as providers of the technological solutions described here for smart cities.
2. The General State Administration, which is the promoter of initiatives for technological improvements to turn this vision into reality.
3. The cities' governing bodies, demanding environments that require the offer made in this document.



2

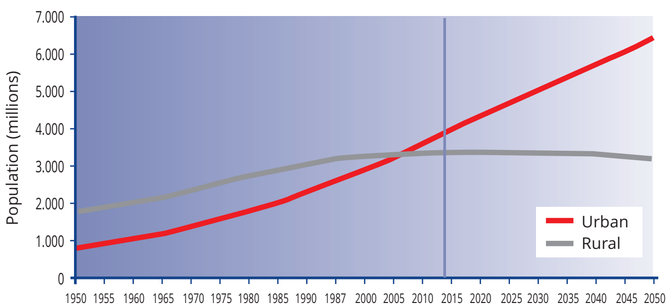
INTRODUCTION

Barcelona, Agbar Tower.

Cities are densely populated urban areas that entail an increasing consumption of water, energy and other resources, as well as an increase in waste generation, transport needs, land use, etc.

According to the United Nations 2014 report,[1] nowadays 54% of the world's population lives in urban areas and by 2050, this ratio is expected to be increased up to 66% while Earth population will be over 9 billion by then.

Urban and rural population of the world (1950-2050)



Source: United Nations, 2014.

Meanwhile, according to data coming from the European Commission, 68% of Europe's population was living in urban areas in 2012 and will reach 85% by 2050. This population is responsible for 70% of the energy consumption of cities and 75% of greenhouse gas emissions.

However, cities hold most of the economic activity, being responsible of 80% of the gross domestic product in the case of Europe. Such a capacity for creation of wealth results in cities competing for attracting new talent and investment, which is linked to concepts such as quality of life, good infrastructures and public services, stable regulation, incentives, etc.

Currently, cities are facing challenges related to global strategies such as the decarbonisation of the economy, the development of a circular economy, the reduction in waste generation and polluting substances, the establishment of limits to over-exploitation of resources, the protection of natural and productive biodiversity, the reduction of inequalities, etc. Lately, cities are looking for solutions that guarantee their sustainability and the improvement in citizens' quality of life.

Likewise the strategy 'Europe 2020', in which smart cities constitute a reference environment, makes suggestions of priorities for a sustainable growth based on three concepts: **intelligence**, through the development of knowledge and innovation (education, innovation and digital society); **sustainability**, based on a greener economy, more effective in managing resources and more competitive (fight against climate change, clean and efficient energy); and **integration**, aimed to boost employment, social and territorial cohesion (employment creation, capacities and fight against poverty).

A smart city represents a crossed concept, which implies that solutions and technologies from several sectors must be applied in a specific environment. For this reason, in 2013 the Smart Cities workgroup (GICI) was born as a group to coordinate actions and develop a common vision, therefore being able to give a response to the challenges from different sectors arising around this topic represented by the Spanish technological platforms. These platforms appeared 10 years ago as tools from the Ministry of Economy and Competitiveness (back then the Ministry of Science and Innovation) with the final aim of identifying the most adequate research and technical development strategies for improving competitiveness of the sectors addressed by each platform. All the relevant actors of science, technology and business fields participate in these platforms to define long-term objectives for each sector, as well as the strategic set of actions required to achieve them.

At the time when this document was written, GICI was composed of 20 Spanish Technological Platforms (PTE) and one group of reference bodies that ensures the connection of the work performed within GICI with other existing initiatives about smart cities.

1. United Nations: World Urbanization Prospects, Ed. 2014.

The 20 PTEs integrated within the group are the following:

BIOPLAT
Spanish Biomass Technology Platform
www.bioplat.org

eVIA
Spanish Technological Platform for eHelath, eWellness and Social Cohesion
www.ametic.es/es/innovacion/plataformas-tecnologicas/evia

FOTONICA21
Spanish Technology Platform of Photonics
www.fotonica21.org

FOTOPLAT
Spanish Photovoltaic Technology Platform
www.fotoplat.org

FutuRed
Spanish Technological Platform of Electrical Grids
www.futured.es

GEOPLAT
Spanish Geothermal Technology Platform
www.geoplat.org

Logistop
Spanish Technology Platform in Logistics, Intermodality and Mobility
www.logistop.org

M2F
Move to Future - Spanish Automotive Technology Platform
www.move2future.es

MANU-KET
Spanish Technological Platform for Advanced Manufacturing
www.manufacturing-ket.com

MATERPLAT
Spanish Technological Platform on Advanced Materials and Nanomaterials
www.materplat.es

PESI
Spanish Technology Platform on Industrial Safety
www.pesi-seguridadindustrial.org

Planetic
PSpanish Technology Platform for the Adoption and Promotion of the Electronic, Communication and Information Technologies
www.planetic.es

PTC
Spanish Road Technology Platform
www.ptcarretera.es

PTE-EE
Spanish Energy Efficiency Platform
www.pte-ee.org

PTE-HPC
Spanish Hydrogen and Fuel Cell Technology Platform
www.ptehpc.org

PTEA
Spanish Water Technological Platform
www.plataformaagua.org

PTEC
Spanish Construction Technology Platform
www.plataformaptec.com

PTFE
Spanish Railways Technological Platform
www.ptferroviaria.es

SmartLivingPlat
Home Automation and Smart Cities Technological Platform
www.smartlivingplat.com

Thinktur
Spanish Tourism Technology Platform
www.thinktur.org

The reference bodies contributing to the production of this document are the following ones:

Ministry of Economy and Competitiveness (MINECO)
through the Sub-Directorate General of Public-Private Collaboration, promoter of the group and manager of the tools for innovation funding

Centre for the Development of Industrial Technology
(CDTI)

Institute for the Diversification and Saving of Energy
(IDAE)

Spanish Association for Standardisation and Certification
(AENOR)

European Innovation Partnership on Smart Cities and Communities
(Marketplace of the European Innovation Partnership on Smart Cities and Communities, EIP-SCC)

Es.Internet
as Spanish Platform of Convergence towards the Internet of the Future, managed by AMETIC and promoted by the Ministry of Industry, Energy and Tourism (MINETUR)

This document intends to establish a vision of the city around 2030 from a technological point of view. It is not intended to supplant nor to replicate the various documents related to smart cities that have already been published at both the national or European level, but to offer the joint vision of the Spanish Technological Platforms represented in the GICI Smart Cities workgroup.

The methodology applied for developing this vision document is the characterization of technological elements, technologies descriptions or functions that need to be developed and implemented in order to improve the economic and social sustainability of cities.

These technological elements are based on the identification of unitary elements taken from the vision documents of the sectorial technological platforms belonging to GICI. Such unitary elements can be found in Annex 1. Based on these, the macro technological elements, gathered and unified by multiple unitary elements identified by each platform are synthesised. These macro elements represent a higher description level and relevance for the city.

Finally, the macro elements are grouped into different lines, which in turn are grouped into areas to facilitate its organization. The description of these elements, lines and areas can be found later in chapters 4 and 5.

In the preparation of the document an effort to maintain a link between the contributions of each technology platform with the final macro elements has been made to facilitate the interest connection or synergies between different platforms at the time of participating and developing solutions in the smart cities field.

3

SMART CITY AND SOCIAL CHALLENGES

Bilbao, Iberdrola Tower.

[3.1] Smart City definition

Currently different definitions of a Smart City are available depending on its origin. Thus, the following definitions can be found as references:

Red Española de Ciudades Inteligentes (Spanish Network of Smart Cities) (RECI):

"Smart Cities are those which have an innovation and networking system to provide cities with an economic and politic efficiency improvement model allowing social, cultural and urban development. Supporting this growth, they encourage creative industries with high technology that allows this urban growth based on boosting capabilities and network, articulated through participatory strategic plans to improve the local innovation system."

Comité de Normalización (Standards Committee) CTN 178 (AENOR):

"A Smart City is the holistic view of a city that applies ICT's to improve the quality of life and accessibility of its inhabitants and ensures a sustainable economic, social and environmental development in continuous improvement. A smart city allows its citizens to interact with it in a multidisciplinary way and is adapted in real time to their needs, in an efficient manner in terms of quality and costs, offering open data, solutions and services oriented to citizens as individuals, to address the growth effect of cities, in public and private domains, through the innovative integration of infrastructures with intelligent management systems."

European Innovation Partnership on Smart Cities and Communities:

"Smart cities should be regarded as systems of people interacting with and using flows of energy, materials, services and financing to catalyse sustainable economic development, resilience, and high quality of life; these flow 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."

As it is shown, each definition emphasizes different aspects of the city having the citizen and the sustainable economic development as the common denominator.

The following definition has been agreed by all the platforms participating in the GICI Smart Cities Workgroup under the premise of understanding the citizen at the cities centre and the future city development through technology and innovation.

A Smart City is one that ensures its energy, environmental, economic and social sustainability by incorporating innovative technologies, processes and services, to improve the citizens' quality of life and promote business and labour activity

However, the scope of the smart city is not described in any of the definitions above. Neither are demographic aspects such as the size, population density or number of inhabitants nor other characteristics or physical parameters that determine the scope where these definitions are framed have been taken into account. It can be concluded that the smart city definition, both the one adapted by GICI as well as the other mentioned ones, may be applied to environments where people live, coexist and perform economic activity. That is why we can refer to different environments such as cities, communities and rural areas.

For all of them, this document provides a model as well as a range of technology solutions, which allow advancing towards the described model. The most appropriate technologies in each case, the implementation and development level, are different but able to cope with all the needs in the different environments.

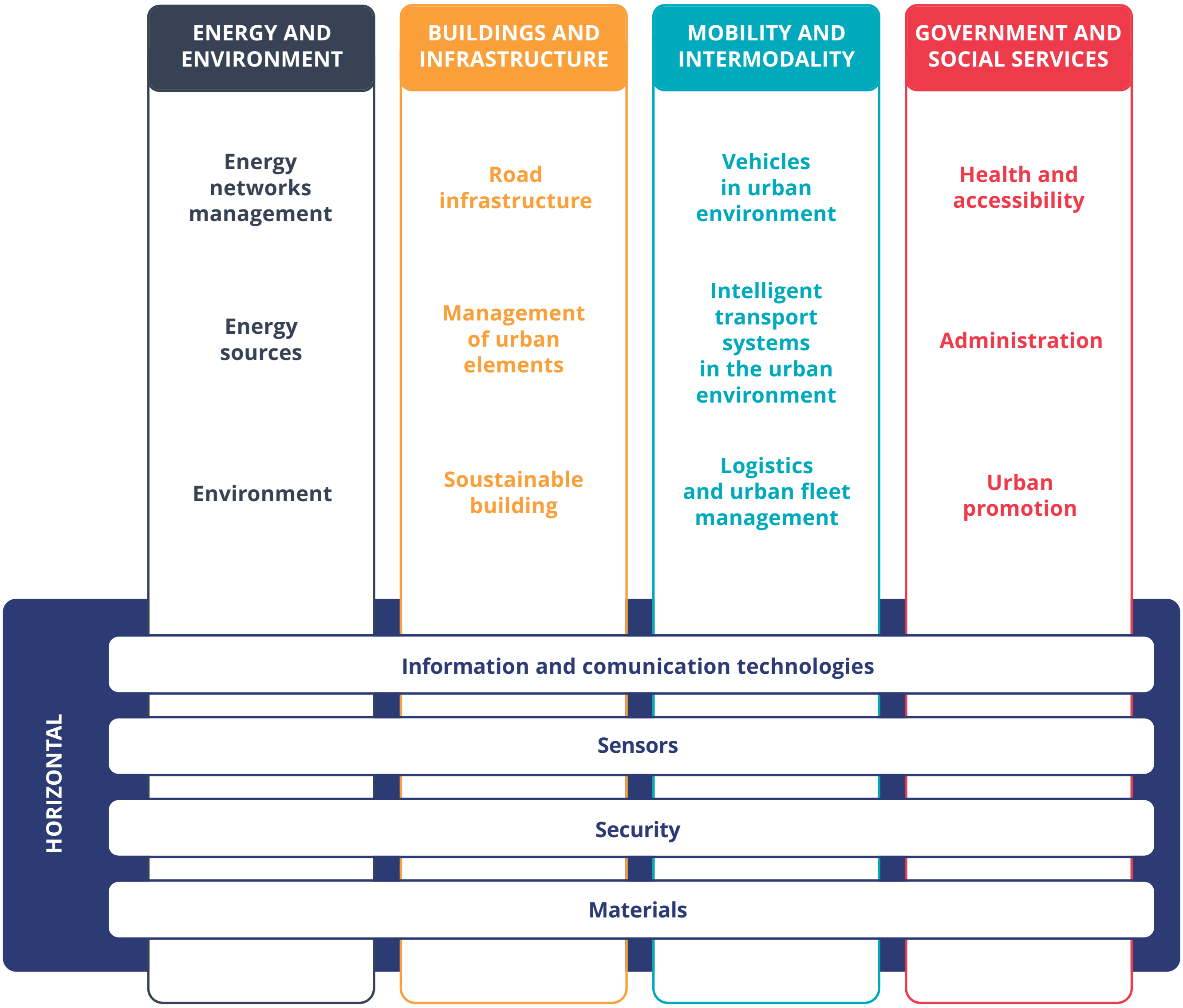
[3.2] Smart City model

Based on the smart city definition established by GICI, a model that is able to encompass all the technological aspects related to the cities in a homogeneous and balanced way has been developed. For this approach a model containing **4 major areas or blocks** identified is proposed:

1. Energy and Environment
2. Buildings and Infrastructure
3. Mobility and Intermodality
4. Government and Social Services

An additional **horizontal area** that integrates the Information and Communication Technologies (ICTs), Sensors, Security and Materials is added to these blocks.

Each of these big areas at the same time contain **multiple lines/applications** where the **technological elements** are grouped. These technological elements are described later in this document. The figure below summarizes the model content:



[3.3] Indicators

The intelligence concept in the city is an abstract one that must be specified in order to measure its progress. In this sense, it is necessary to have objective indicators that allow the measurement of intelligence, establishment of comparisons and cities classification, quantifying objectives, establishing actions and notice non-searched effects or deviations.

However, the quantification of parameters, very different in origin and treatment variables, is a complex and costly challenge. This would be to design a coherent set of indicators that allow monitoring and evaluation of progress and policy review; rethink the future in a rational and participatory way; set the initial values of which can induce a prospective rational analysis of scenarios and that enable bearing the definition of the transition processes and translate it into roadmaps. Cities also accumulate, as a result of historical development and geographical context, singularities that induce to a certain type of development. In this context, as the one pointed to smart cities, and in a scenario or increasing urbanization, the basis on which cities are planned, redefined and managed affect to three different areas: social, environmental and economic. Therefore, cities seek balanced demands and offers, where citizens live and work, chasing a limited environmental impact.

Accordingly, the selection of practical indicators, elaborated or currently available, that can concentrate on the city as the objective and to actions that can define its intelligence dimension; should seek assessment of the degree of compliance of the strategic objectives set and that contain variables referred to the quality of life, equality, emissions reduction and increasing levels of sustainability.

The following reference indicators developed by different international agencies or private organizations must be considered:

- **ISO** (International Organization for Standardization), with the technical committee TC 268 *"Sustainable development in communities"*, develops requisites, guides and techniques and tools to help communities improve resilience, sustainability and test achievements in those fields.
- **OCDE** *(Organization for Cooperation and Economic Development)*, has established 58 main economic indicators widely used; besides indexes added such as the *Better Life Index*, the *Happy Planet Index*, etc.
- **UN** (United Nations, *World Bank Development Indicators)*, which seeks indicators related to the human development such as the Sustainable Development Goals (SDGs) that try to shape inclusive, secure and resilient cities.
- **EUROSTAT** *(Sustainable Development Indicators)*, which develops different indicators in the field of socio-economic sustainability and addresses the monitoring of objectives of the Sustainable Development Strategy *(COM(2010) 2020 A strategy for smart, sustainable and inclusive grow)*, indicating 10 thematic areas and 12 indicators, supplemented by more than a hundred of secondary nature and that are the basis for the Agenda for Change or the new Urban Agenda.
- **ARCADIS** (*Sustainable Cities Index* 2015), which develops a synthetic index (SCI) through three demands: social *(People)*, environmental *(Planet)* and economic *(Profit)*. The SCI is defined by 20 indicators focused on the city as a target.
- **SCIS** (EU *Smart Cities Information System)*,[2] continuation of the CONCERTO initiative of the European Commission, which brings together collective and individual interests in encouraging knowledge in transfer and cooperation, through the SCIS website, to create Smart cities and energy sustainable Europe.

  SCIS focuses on the energy dimension of the information and communication technologies, and transport, including buildings, blocks of buildings and districts. SCIS is a portal to find the best practices and demonstration projects related to Smart cities.
- **Project European Smart Cities.** Project funded under the Framework Program, which developed a model including 74 indicators to measure the level of intelligence of a city. Currently 77 cities have been evaluated according to this model.
- **Project CITYKEYS** (*Smart City performance measurement system*, SCC-02-2014 call of H2020), where a system for the actuations evaluation is developed and validation of the implementation of different solutions for Smart cities is compared. CITYKEYS gathers information on the use, the benefits and challenges of key performance indicators. The project develops recommendations for the implementation of actuations evaluation and promotes synergies between different actors and replicability of solutions.

2. http://smartcities-infosystem.eu

As well as the indicators developed by the following national bodies:

- **CEOE** (Confederación Española de Organizaciones Empresariales). The Spanish employers organization, aware of the importance and perpendicularity of the Smart cities, has set up a Smart Cities Committee in its R&D commission. This committee has developed the document "Acciones prioritarias para el desarrollo de las Smart Cities en España" *(Priority actions for the Smart Cities development in Spain)*, which includes specific sections about standardization and indicators definitions.
- **AENOR** (Asociación Española de Normalización y Certificación). Currently, under the coordination of AMETIC, the PNE178202 standard about "Indicadores de Gestión en base a Cuadros de Mando de Gestión de Ciudad" *(Management Indicators based on the city management dashboard)* is being developed within AENOR in the working group GT2 "Indicators" within the subcommittee 2 "Indicators and Semantics" of the AEN CTN 178 "Smart Cities" committee.
- **Observatorio de la Sostenibilidad en España (Observatory of the Sustainability in Spain)** (2014 Report) identifies sustainability indicators in three areas: socio-economic (12 indicators), environmental (8 indicators), and productive sectors (10 indicators), and six synthetic or of society progress with high added value indexes.
- Besides the general references previously mentioned and based on sustainability variables, there exist broader discussion forums that are perhaps where the efforts of identifying the most convenient indicators must be joined. Thus, the AMETIC Smart City Commission definition and standardization working group and Inercia Alliance is elaborating a document where the main standard indicators that allow measuring the evolution of our cities are identified and described; shared work between "Alianza Inercia", "Comité Técnico de Normalización sobre Ciudades Inteligentes (AEN/CTN 178)" (Standards Technical Committee about Smart Cities) of AENOR and "Red Española de Ciudades Inteligentes (RECI)" (Smart Cities Spanish Network). In this paper 20 indicators have been identified according to the methodology outlined by the Basis Public Services e-Europe 2020.

In all cases, a multidisciplinary and complex effort is required, which provides measurable and reliable data based on disaggregating data from well-known sources or commissioning of specific data acquisition systems or to take advantage of suitable proxy's.

In the future, it will be necessary a convergence of these indicators that will be obtained with practise and advance in the development of solutions for cities. Although GICI does not develop indicators, it does keep in touch with entities which develop them in double sense, assuring the inclusion of terms that, as a consequence of the report, can be added to benefit the accuracy and length and using the indicators in projects promoted by the group.

[3.4] Connection with Social Challenges

Technology should follow and serve society in order to make citizens' life easier and to allow progress in the development of the intelligent urban environment based on a common vision that takes into account social, environmental and economic parameters of the cities.

In line with the European Commission provisions, the projects undertaken in this regard must be directed to:

- ✓ Promoting market demand for intelligent solutions in cities by increasing the consumers' awareness about the technologies and processes used in the implementation of smart city solutions.
- ✓ Acting as leverage through investment acquisition and planning tools for the local administrations and businesses.
- ✓ Favouring greater citizens' participation and acceptance.
- ✓ Ensuring the framework conditions for the joint public, cross-border procurement related to smart city implementations.
- ✓ Encouraging public procurement agencies working in cities and communities to become more "launch customers" for intelligent and innovative solutions that are not yet commercially available on a large scale and that may pose a higher risk than purchasing widely commercially available products.

One of the Horizon 2020 Program (H2020) priorities for research and innovation in the European Union is dedicated to **society challenges**. GICI's work is aligned with the policy priorities and the challenges of the Europe 2020 strategy reflected in this program, aiming to encourage research and innovation that allows achieving the EU policy targets.

Funding at European level will focus on the following specific objectives (challenges):

- Health, demographic change and well-being.
- Food security, sustainable agriculture and forestry, marine and maritime, and inland water research and the bioeconomy.
- Secure, clean and efficient energy.
- Smart, ecological and integrated transport
- Climate action, environment, resource efficiency and raw materials.
- Europe in a changing world - inclusive, innovative and reflective societies.
- Secure societies - protecting freedom and security of Europe and its citizens.

Thus, among the general objectives of the Spanish Science, Technology and Innovation Strategy, the orientation for the R&D activities to meet the global challenges of the Spanish society is included, which implies the coordinated implementation of R&D actions regarding the following challenges:

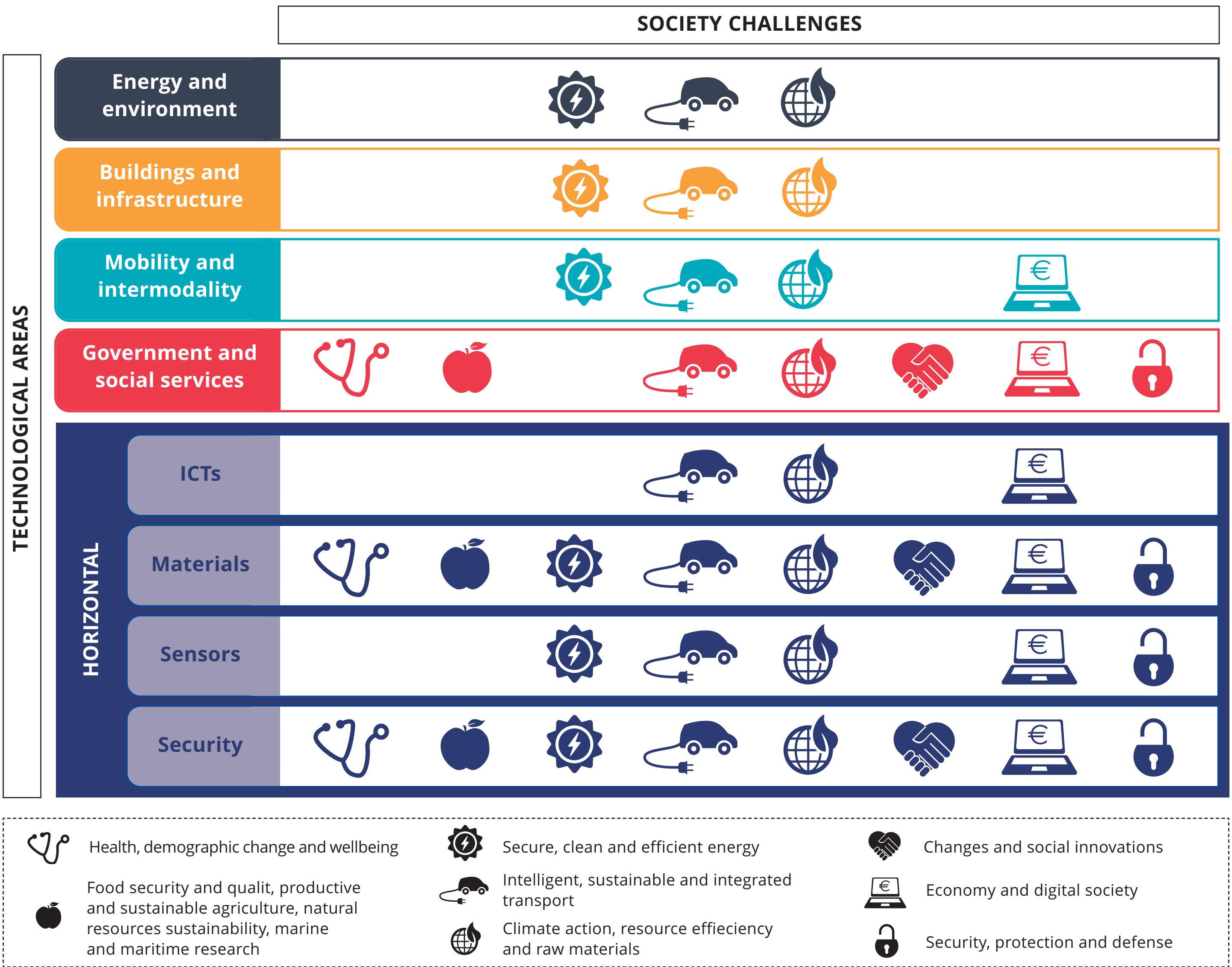
- Health, demographic change and wellbeing.
- Food security and quality, productive sustainable agriculture, resources sustainability.
- Energy, security and secure, sustainable and efficient energy models.
- Intelligent, sustainable and integrated transport.
- Climate action, resource efficiency and raw materials.
- Social changes and innovations.
- Digital economy and society.
- Citizen's freedom, security and rights protection.

To address posed social challenges it is essential to bring together a critical mass of resources and knowledge of different fields, technologies, scientific disciplines and research infrastructures. In addition, as extracted from the European guidelines, the activities must cover the full cycle from research to the market, with emphasis on activities related to innovation such as pilot exercises, demonstration activities, test beds, support for public recruitment, design, end-user innovation, technology transfer, and market innovations uptake, as well as standardization.

Moreover, it is important to have a citizenship aware of the initiatives and activities undertaken aimed at building a smart city, so they can support it with their participation and contribute to guide the development of the city in relation to their needs and interests. In this sense, institutions must become a link between the agents capable of promoting the products and services towards a smart city and the affected citizens in these areas.

As the citizenship support does not imply achieving the objective, it is necessary to establish a close relationship between society and the significant technology advances in the path towards a smart city.

As a conclusion, it is worth highlighting that inhabitants of current society are present behind the smart cities, which expect further progress and evolution towards a more sustainable world at all levels. This document is created with the vocation to guide society on the challenges of its development towards different models of smart city, as a living environment for its inhabitants.



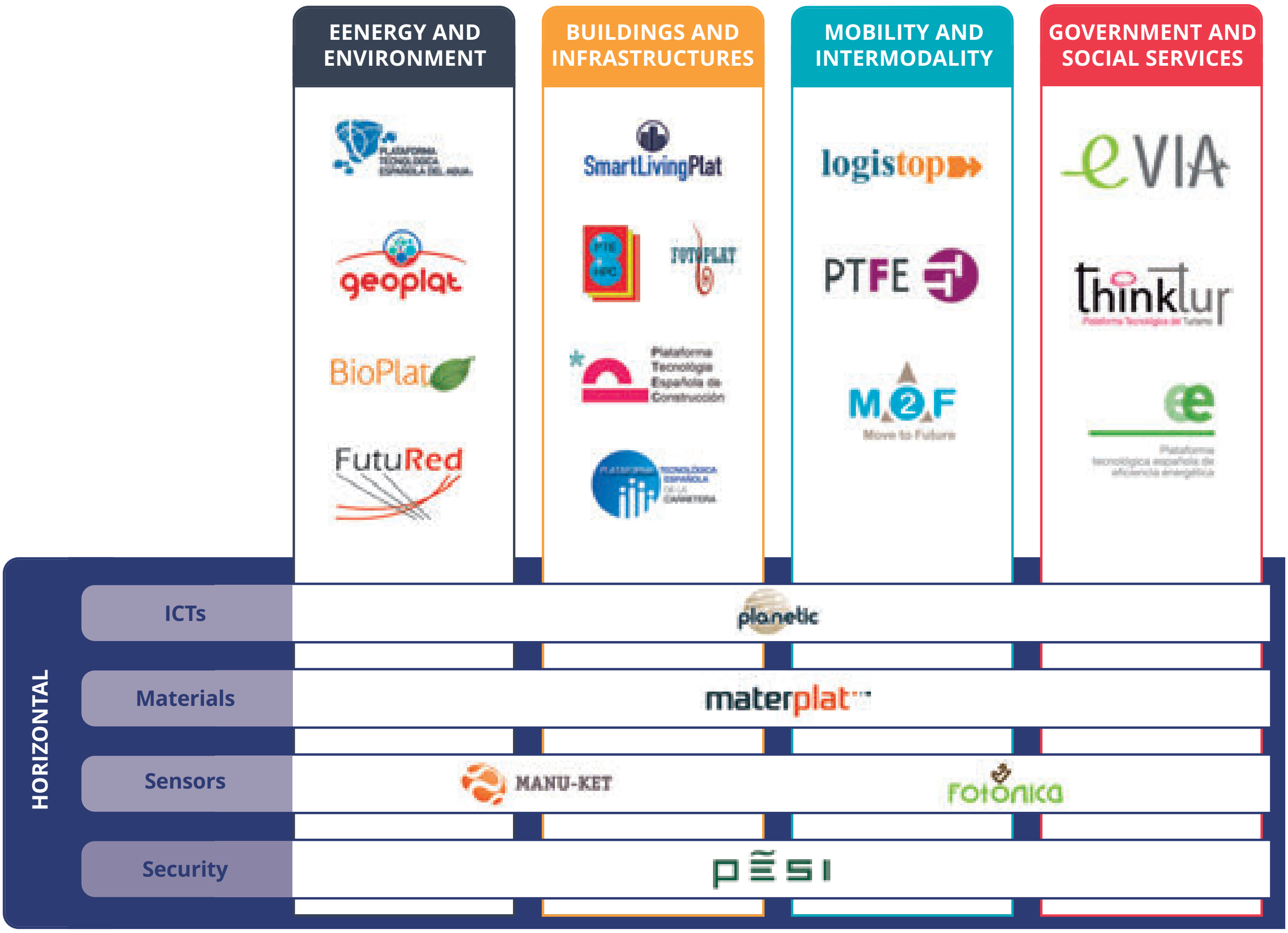
4

TECHNOLOGICAL PLATFORMS VISION

Valencia, cauce del río Turia.

The diagram below shows how the Technology Platforms participating in GICI are linked with the proposed Smart city model. Although many of them contribute to different parts of the model, each of them is located in the part of the model where there are more technological elements representation, drawing a matrix that clearly indicates the large coverage given by the platforms in the proposed model.

In this section a brief vision of a Smart City from each of the Technology Platforms point of view is offered as well as the role that each technology plays in the future model.



Besides the platform categorization in the model, the platforms share interests in different topics, according to the methodology for the elaboration of this document, which will be showed in the following chapter, in the figure it can be seen the topic interaction among the platforms. For further identification, look at Annex 8.1.

[4.1] BIOPLAT

Spanish Biomass Technology Platform

Some of the main objectives of Smart cities are to increase their energy efficiency and use of renewable energy sources, as well as reduce CO_2 emissions in these urban environments. Bioenergy is postulated as a very suitable solution to make an important contribution to all these objectives, as it involves a number of benefits for cities that are not limited to sustainable energy production (electricity and heating for all types of construction elements) and biofuels for transportation, but also induces significant positive effects in the environmental and socio-economic domains, associated with the transformation of biomass waste into highly efficient energy resources along with the creation and maintenance of labour associated with these activities.

Therefore, Smart Cities must consider using the electricity generated from renewable and indigenous resources such as biomass. Furthermore, the heat and Domestic Hot Water (DHW) production by using biomass and replacing traditional fuels involves a great future bet for cities, since it is an efficient and competitive model that can range from a limited number of households up to complete metropolitan areas and even industries. Furthermore, the Smart City model must consider the energy valorisation of municipal waste generated in cities and the energy production from this biomass source (via biogas generation and direct energy valorisation).

[4.2] eVIA

Spanish Technological Platform for eHelath, eWellness and Social Cohesion

Smart Cities are usually associated to concepts such as *Green Transport, Smart Grids, Low Carbon Emissions, Smart Buildings,* but often the **most important element of a city** and without which the city would be pointless is left out: **its citizens**.

eVia, as Technology Platform for Health and Active and Independent life, defends the concept **"Smart & Human Cities"**, based on the premise that any innovative element, technology or service implanted in a Smart City must have as its ultimate goal the **benefit to its citizens**, and this in turn implies containing the **accessible city** paradigm.

Therefore, there are certain **technological elements and specific services** to be taken into account such as solutions to support **urban mobility for all** (4ALL), elements **of security and confidence for patients and medical professionals**, optimization of **medical sensor networks**, **interoperability** with user mobile terminals, **health self-management systems** to boost healthy habits, prevention and treatment, **ICT applications for social and labour integration** for all groups and ICT tools for the city characterization as an **accessible tourist destination**.

[4.3] FOTONICA21

Photonic technologies work with the generation, detection, transportation, guidance, handling, amplification and use of light. These technologies are transversal and can be found in very different sectors. From the photonic technological standpoint, the Smart City is an environment where **fibre communications** and its control devices can be applied to helping to reduce the energy consumption which will increase the safety in communications. The **use of energy**, improving the efficiency of solar light concentration devices, the photoelectric conversion processes or lighting installations. It will improve the **citizens' health**, using less invasive image capture and processing techniques, strategies for **CBRN sensing**, detection and monitoring in complex environments, with applications in public safety; contaminant detection and monitoring of environmental parameters, **signalling and visualization dynamic**, flexible, interactive or large display elements using images reproduction technologies (2D and 3D).

Fotonica

Spanish Technology Platform of Photonics

[4.4] FOTOPLAT

Self-consumption, energy efficiency and advances in the world of telecommunications and computing will allow the full development of so-called Smart Cities, built for and with citizens.

The integration of photovoltaic elements extensively in the cities allows the development of an efficient model of distributed power generation that can be also integrated into the architecture and furniture of the city helping to improve the quality, efficiency, flexibility and safety of electricity supply. This is possible due to generation diversification, which allows producing in the same place where demand is claimed (e.g., activating large generation areas such as roofs and facades), and thus reducing the need for network infrastructures and its load. Almost all the smart systems of a city can be supplied thanks to photovoltaic self-consumption systems, with or without storage (buildings, traffic lights, transport information systems, environmental meters...) with a null environmental impact and with the advantage of making them energetically self-sufficient, thus improving services provided to citizens.

FOTOPLAT

Spanish Photovoltaic Technology Platform

[4.5] FutuRed

Spanish Technological Platform of Electrical Grids

Electrical networks are the medium for conveying electrical flows and coordinating all the actors in an optimal way. Also, they are the guarantors of the quality of the electricity supply.

Moreover they guarantee the technological neutrality of the different sources of distributed generation that are being implemented. This neutrality allows a competitive market, and the supra-city dimension ensures the access to efficient markets of both supply and demand.

The need to reduce electric consumption and to exploit renewable and indigenous resources are specified in energy efficiency and renewable generation integration programs. Likewise, the need of coordinating this generation increase in the cities, with a demand requiring ever more quality, involves a technological upgrade of the network itself. The higher fluctuation of distributed and renewable generation makes generating greater flexibility in the demand necessary .

[4.6] GEOPLAT

Spanish Geothermal Technology Platform

Geothermal energy will play an important role in energy supply and demand for Smart Cities. It is a continuous renewable energy production technology (24 hours a day, 365 days a year), both in air conditioning and electricity generation. Furthermore, it is characterized by a fully manageable generation model capable of compensating fluctuations and stabilizing the electrical grid of cities. Therefore, geothermal energy can contribute in the design on the future electric smart grids.

Furthermore, within the concept of Smart Cities, power grids must be combined with thermal networks. In this sense, geothermal energy can also supply cooling and highly energy-efficient heating to a set of users, distributed in a wide area, such as a neighbourhood, district or even city size, as well as other applications with thermal energy demand (spas, industries, greenhouses, etc.).

[4.7] Logistop

Urban logistics must be an extremely flexible activity, adapted to current and profound changes taking place in the urban demography and economy, to the new purchasing and distribution behaviours, as well as to the new demands of consumers and businesses.

It is the last link of most of the targeted supply chains to final consumers. Therefore, a holistic approach is needed to understand what can be done at the beginning of the supply chain to optimize urban logistics. Different business models, new processes and available technologies must be investigated and implemented; and the urban transport systems should be increasingly integrated. R&D will have to identify how new technologies can influence in the urban goods delivery and how to make the most of them.

Finally, it should not be forgotten that freight transport depends on human activities. Consequently, the evolution of the city and the citizens' lifestyles will have a significant impact in urban freight transport patterns.

logistop

Spanish Technology Platform in Logistics, Intermodality and Mobility

[4.8] M2F - Move to Future

Transport and mobility are key areas of Smart Cities, and hence an interest as an area of activity for the Move to Future (M2F) Technological Platform. The mobility of people in urban environments and the freight transport in Smart Cities involve the development of new, more efficient and connected vehicles, as well as their interaction with infrastructures and the development of Intelligent Transport Systems (ITS) to ease mobility in general. The Smart City is one of the scenarios and application environments for the development and deployment of vehicles with varying degrees of automation and of autonomous vehicles.

M2F Move to Future

Spanish Automotive Technology Platform

[4.9] MANU-KET

Spanish Technological Platform for Advanced Manufacturing

Manu-KET is the Advanced Manufacturing Technology Platform. The city will be composed of new products, manufactured more efficiently, using resources sustainably and generating less waste.

Smart Cities require new forms of manufacturing devices to support the new services that will appear in future cities.

[4.10] MATERPLAT

Spanish Technological Platform on Advanced Materials and Nanomaterials

The Spanish Technology Platform for Advanced Materials and Nanomaterials —MATERPLAT— believes that in the Smart Cities it will play an important role to be sustainable, efficient (or super-efficient) and to ensure a high quality of life for its citizens, the 'smart materials' and materials with 'super-properties' as a complement to other technologies providing a benefit derived from its direct use in the infrastructures and services improvement. Foreseeably the biggest impact of these new materials in Smart Cities will be reached in fields related to health, security, citizens' comfort and in the resources optimization.

[4.11] PESI

The security concept, very broad in its different affections *(safety, security)* and areas (resilience, protection, emergency, reliability, industrial, road, physical, cyber-security), has been contemplated by PESI in relation with the technology challenges of the Smart City through four basic pillars:

- A comprehensive security model and governance of essential services to its citizens and their resilience.
- The operation reliability of urban infrastructure and its equipment.
- The safety and protection of persons and goods and city asset.
- The cyber-security of the control systems (supply networks and essential services, infrastructures and city systems).

Spanish Technology Platform on Industrial Safety

[4.12] Planetic

From the specific area of Planetic, mainly two aspects are highlighted: the obligation to consider the **citizen as the city-centre**; and the willingness to use **technologies to serve cities' needs**. These two aspects suggest the need to offer technologies and services that are based on them for improving life in cities, for its citizens, administrations and businesses. Technology and ICTs in particular, make sense when they prove to be useful to achieve a better quality of life, greater development and competitive opportunities, and better management of resources. Otherwise, they will only be technology without achieving any of the above-mentioned objectives.

Another important aspect observed from Planetic is the **multidisciplinary** character that the technology solutions for the cities require, as ranging from sensors or computers infrastructures or the management of large amounts of data, to the development of applications and services to manage interaction with people. This confirms the commitment of Planetic with the integration of Key Enabling Technologies (KETs) such as sensors, photonics or ICTs, to provide a complementary and joint offer to complex and multidisciplinary environments like Smart Cities.

Finally, besides the technological aspect, in this context, the economic and social aspect that the Smart City concept involves should not be forgotten, as future Smart Cities won't be built only with technology, but with a definition of a social and economic model that with the help of technology, make cities more enjoyable, sustainable and healthy places to live and work.

Spanish Technology Platform for the Adoption and Promotion of the Electronic, Communication and Information Technologies

[4.13] PTC

Spanish Road Technology Platform

Traditionally, road functionality was focused on providing physical support to vehicles passing by them. Nowadays, this concept is fully overtaken and under the road infrastructure term many other elements, especially relevant in urban terms, are grouped. Some of the most outstanding ones are:

- Multi-functionality of pavements, incorporating anti-pollution capabilities, ambient noise reduction or facilitating vehicle energy charge.
- Interaction with vehicles, drivers and pedestrians: the arrival of autonomous vehicles will require integration with infrastructure (Intelligent Transport Systems - ITS).
- The world is heading towards a growing concentration of population in cities, so the environmental and economic sustainability come to the frontline.
- Quality information in real time for a more dynamic traffic management.

[4.14] PTEA

Spanish Water Technological Platform

The water sector understands "Smart City" as an ecosystem in which it is necessary to maintain a balance and quality conditions, sustainability and integration, promoting the development of life, ensuring citizens' satisfaction.

An adequate water supply and sanitation service is established as a basic need that every city must meet. The "smart" concept appears when innovative forms of water exploitation and reuse are offered, involving the citizen in the whole system, knowing his/her demand and allowing him/her to interact in the process, thus achieving foresight and anticipation capability. Water, as a resource, is an essential element for the maintenance of green areas that act as cities lungs, promoting sustainability also at an environmental level.

[4.15] PTEC

The construction sector, represented by PTEC, is key in the cities transition to the Smart City model. Both buildings and infrastructures are permanent receivers of innovative technology and provide great added value to energy and environmental sustainability, besides being an articulating link to the socio-economic activity.

Improving buildings and neighbourhoods through new restoration and conservation techniques, accessibility to buildings and infrastructures and everything related to urban planning are the most relevant aspects that contribute, specifically from the construction sector, to create the future city, having also numerous correlations with other sectors, such as the energy one, and particularly with renewable energy integration and energy management of buildings.

Plataforma Tecnológia Española de Construcción

Spanish Construction Technology Platform

[4.16] PTE-EE

The PTE-EE platform considers that energy efficiency is one of the determinant factors that must be comprehensively taken into account in the design of Smart Cities. Energy efficiency is considered in all the processes related with the city, comprising the urban planning; street lighting; the energy valorisation of city by-products; the energy building or energy refurbishment of existing buildings; the efficient transport, both public and private; the electric/thermal energy generation/distribution infrastructure deployment and the energy flows management through monitoring and control actions that allow communication between buildings and the electric/thermal energy distribution networks.

To achieve these objectives, Best Available Technologies (BAT) must be developed and deployed, such as district micro-generation facilities, based on an energy mix using the cleanest available sources and technologies, or on the use of Smartgrids that allow developing decentralized generation architectures as well as the integration of storage technologies enabling new features and services to marketers and consumers. These actions should be framed in a dialogue through a governance that allows the integration of all the stakeholders in the city, achieving more efficient and more liveable cities.

Plataforma tecnológica española de eficiencia energética

Spanish Energy Efficiency Platform

[4.17] PTE-HPC

Spanish Hydrogen and Fuel Cell Technology Platform

The Smart City, in its search for energy efficiency, supports the use of clean energies, which use renewable resources and reduce GHG emissions, always guaranteeing the satisfaction of the citizen's needs.

The use of hydrogen as an energy carrier is an ideal complement to the renewable energies-based distributed generation, besides allowing a more efficient use of electricity, storing during surplus periods and producing in lean periods. Additionally, improvements in the transportation field can be added, being the electric vehicle with fuel cell (FCEV) a reality, offering autonomy similar to today's cars, with total absence of emissions.

The existence of different alternatives, for both electric propulsion and generation, offers consumers a higher number of options when deciding the energy system that best suits their needs, geographic area or purchasing power.

[4.18] PTFE

Spanish Railways Technological Platform

The mobility and transport needs in urban and metropolitan areas should not have negative effects on the citizen's quality of life. The train, metro and tram guided systems can meet all these needs maintaining the competitiveness and without prejudice to the environment.

"A Smart City is one in which the transport of passengers and goods by rail is a backbone of the city, that thanks to the incorporation of innovative technologies, processes and services, is integrated with the various city dimensions improved peoples quality of life and promoting labour and business activity, ensuring its energy, environmental, economic and social sustainability".

[4.19] Thinktur

In the field of tourism, this concept is translated into "smart tourist destination" that covers a defined territory (municipality, region, special areas with prominent tourist activities), that take place on a cutting-edge technological infrastructure, ensuring an environmental, social, cultural and economic sustainable development, accessible to all, facilitating the interaction and integration of visitors with the environment and experience quality.[3]

Its main differential attributes are reflected in the focus of the tourist/visitor, also generating benefits for citizens; the interaction with the destination goes beyond the stay itself, comprising before and after visiting the destination itself, involving all the journey process; and additionally look for generating an experience of remembrance in the visitor memory.

Spanish Tourism Technology Platform

3. Source: own-prepared based on the definition of Segittur and the "Intelligent Tourist Destinations" Standards Subcommittee of AENOR.

[4.20] SmartLivingPlat

Buildings are basic pieces in the configuration on cities, consuming nearly half of the world's energy.

It is essential to talk in these cases about home and building automatization, both for the use and maintenance of buildings and homes and to public infrastructures (lighting networks, power grids, water and gas supply systems, sewerage, irrigation of parks and gardens, traffic management, city signalling, parking control, etc.).

In buildings and households these applications try to efficiently manage heating, air conditioning, lighting, elevators, water management and in general any system capable of being controlled. They also include security control systems, such as access control, intrusion systems, fire detection, video-surveillance, etc.

Home Automation and Smart Cities Technological Platform

5

TECHNOLOGICAL ELEMENTS

Zaragoza, Water Tower.

For the development of this Vision Document the following methodology has been followed:

Smart City definition and model

The Smart City definition and model are presented in section 3 of the document. As it is indicated therein, that is the starting point in order to develop all the content. In the Smart City definition and the model development an open approach that considers the city as a whole is taken into account.

Technological elements

A technological element is a function or application technology (short, medium or long term) in the Smart City under the model defined in this document.

In the proposed structure two technological elements levels are defined. The "micro" technological element is the smallest unit in the city model as far as technology or function is concerned. In this Vision Document 142 "micro" technological elements have been identified. The "macro" technological element is the one that combines various interrelated "micro" technological elements, and can be functional, technological, or both.

To achieve this document structure, each of the GICI integrating Technology Platforms has provided the "micro" technological elements solving the challenges that appear in their respective sectors related to smart cities. These elements have been oriented to the eight Societal Challenges defined in the National Research Programme Oriented to Societal Challenges.[4] The technological elements have been defined based on the following parameters or categories:

1. Name of the element
2. Function or Technology
3. Related Societal Challenges
4. Relevance for the Smart City (High - Medium - Low)
5. Application (Long - Medium - Short Term)
6. Detailed description

The 'technology' category covers the "micro" elements consisting on the development, validation and implementation of instruments and/or procedures, as well as techniques that allow a practical use of the city resources. The 'function' category includes the "micro" elements corresponding to services, tools, ICT applications, management systems and solutions, which enable a more efficient and sustainable city.

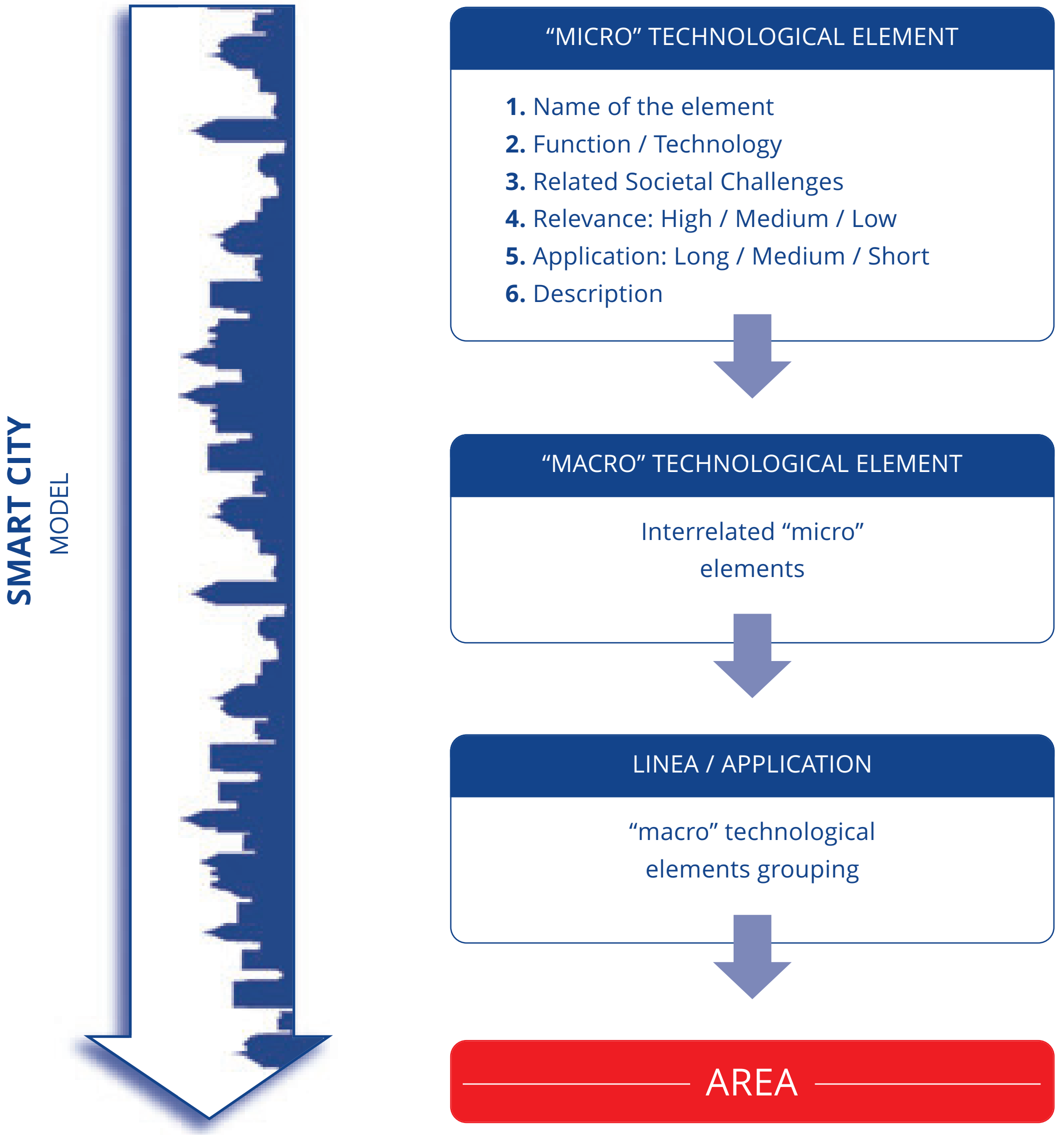
Once the full list of "micro" elements is available, they are grouped into related sets of "micro" indicators called "macro" technological elements. The methodology for grouping these elements is based on two premises. The first one is to generate some "macro" elements that have place within the Smart City model described, preventing that the same "macro" element could be positioned in different parts of the model. The second one is to avoid the duplicity of a "micro" element in several "macro" elements to work towards a structure as simple as possible. After this grouping process, the total number of "macro" elements agreed in this Vision Document is 49.

4. *Plan Estatal de Investigación Científica, Técnica y de Innovación (2013-2016). Ministerio de Economía y Competitividad.*

Lines / Applications

From the “macro” elements definition, several lines/applications have been defined. To do this, a maximum limit of 10 “macro” elements in each of them is established. These lines/applications have a higher hierarchical level and in turn constitute the high-level components within the areas that define the Smart City model.

This working methodology has generated a balanced and homogeneous model, with a simple structure to define the Smart City, which is a large and complex framework for the large amount of factors and elements that is composed of. The overall result of the followed synthesis methodology can be observed in the table consolidated in Annex 1.




CUPULA DEL MILENIO

6

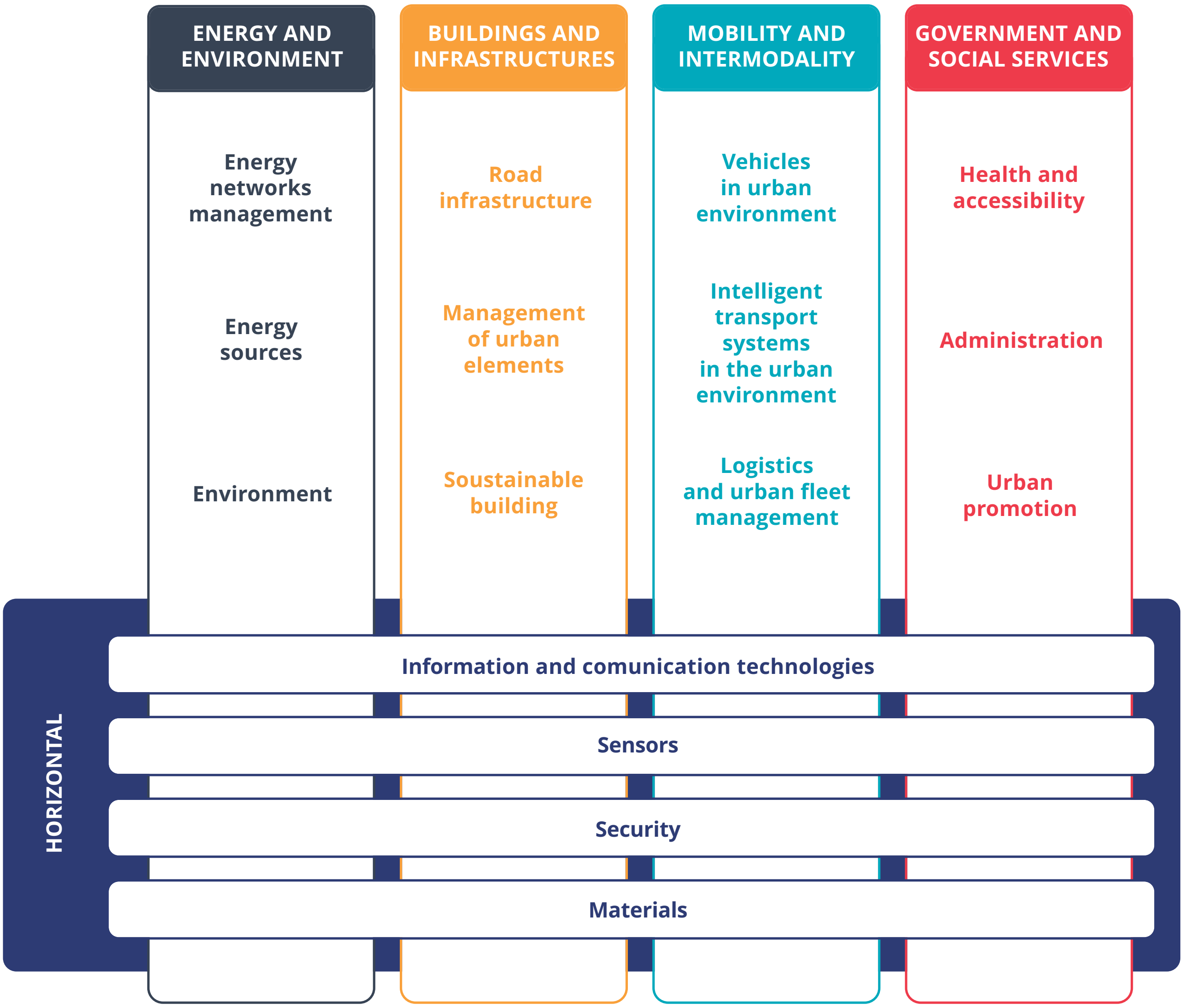
TECHNOLOGY AREAS

Valladolid. Millenium Dome.

In order to further analyse the contribution of each technology area to the Smart City model taking into account the identified technological elements, a number of lines/applications have been defined in each of these areas. The previously mentioned technological elements are grouped into these lines/applications.

The Smart City model integrates in total:

- 142 micro elements (m. E.)
- 49 macro elements (M. E.)
- 16 lines/applications
- 5 technology areas



Energy and environment technology area

This technology area addresses energy management measures that include the integration of renewable energy sources both for electric and thermal generation, as well as strategies to strengthen the energy efficiency and energy savings, all within a balance between environment and the sustainable consumption of natural resources.

Energy networks management line

Adaptation of transportation and distribution networks, in coordination with connected clients. Increased monitoring and control of the energy consumption and production. Use of the electricity generated from renewable sources and urban air-conditioning networks creation.

M. E. No. 2

m. E. No. 10

Energy sources line

Penetration of manageable distributed generation from renewable sources in urban and suburb environments. Management of electricity demand and coupling to energy generation and storage, while increasing the electric system efficiency.

M. E. No. 4

m. E. No. 18

Environment line

Implementation of tools and strategies to manage resources in a sustainable way, reducing CO_2 and other contaminants, as well as to contribute to the efficiency in the water management and quality control..

M. E. No. 3

m. E. No. 10

M. E. No. 9

m. E. No. 38

Buildings and infrastructures technology area

This technology area analyses the transport systems offering improvements in mobility and its monitoring, while reducing energy consumption.

Road infrastructure line

Development of efficient and sustainable urban and intercity transport systems allowing a better and safer mobility to an increasingly demographically developed population.

M. E. No. 2

m. E. No. 5

Management of urban elements line

Sensing and monitoring of infrastructures for a proper city management. New vehicle lighting systems design and more efficient management of cities lighting. Strengthening and improvement of the connections between the various transport systems.

M. E. No. 3

m. E. No. 7

Sustainable building line

Reduction of energy consumption and integration in buildings of energy coming from renewable sources (domestic and tertiary sector).

M. E. No. 3

m. E. No. 10

M. E. No. 8

m. E. No. 22

Mobility and intermodality technology area

This technology area considers people and goods transport efficient management systems, so that mobility needs in the urban environment are covered, reducing emissions and noise.

Vehicles in the urban environment line

Development of public/private type vehicles, for people/goods, and associated elements and infrastructure for their deployment. Use of biofuels and electric vehicles powered by electricity coming from renewable sources for urban transport to configure a sustainable and low-emissions transport network.

M. E. No. 3

m. E. No. 9

Intelligent transport systems in the urban environment line

Information and Communication Technologies for the traffic management, which facilitate intermodality and promote the use of public transport, while improving safety and efficiency of the different means of transport.

M. E. No. 4

m. E. No. 12

Logistics and urban fleet management line

Implementation of new logistics platforms that allow savings in costs, time and emissions. Adaptation of management and maintenance systems of electrical and alternative fuels vehicles fleets.

M. E. No. 3

m. E. No. 6

M. E. No. 10

m. E. No. 27

Government and social services technology area

This technology area poses actions aimed at ensuring an easy access to the services offered by the administration and improving the citizen's quality of life.

Health and accessibility line

Development of patient diagnosis, treatment and monitoring supporting technologies performing less-invasive procedures.

M. E. No. 3

m. E. No. 10

Administration line

Development of technologies to provide the city with services that help citizens efficient use of the city and its resources.

M. E. No. 3

m. E. No. 9

Urban promotion line

Incorporation of Information and Communication Technologies (ICTs) to the public administration, so that citizens can be part of their cities decision making processes. Tools and ICT applications to characterize the city as a tourist destination.

M. E. No. 2

m. E. No. 5

M. E. No. 8

m. E. No. 24

Horizontal technology area

This technology area addresses transversal start-ups from the rest of areas, which cover base technologies that can meet needs in any of the four vertical areas described in the model.

Information and communication technologies line

Infrastructures design and deployment to host and manage information systems. Generation of a reliable and efficient software while a friendly and efficient interface is designed to facilitate access and acceptability of the corresponding technology. Provision of Internet connectivity to the elements so they can interact with the virtual environment.

M. E. No. 6 | m. E. No. 14

Sensors line

Sensors or electronic devices technology to provide a functionality in the city context.

M. E. No. 2 | m. E. No. 5

Security line

Ensuring the correct performance of an integral security essential services model, as well as the innovation incorporation in its development and a greater citizen collaboration. Advanced management of infrastructures' assets. Creating healthier and safer working environments.

M. E. No. 5 | m. E. No. 13

Materials line

Development of functional materials, suitable for extraordinary needs, adaptable and customary application technologies.

M. E. No. 1 | m. E. No. 3

M. E. No. 14 | **m. E. No. 35**

In the description of the "macro" elements, the following information is included:

- **"Micro" elements:** these elements form the macro element. The description can be consulted in Annex 1.
- **Technology or function:** indicates if the element is a technology for city application or a functionality that includes several technologies.
- **Social challenges:** they highlight the social challenges that give answers to the "macro" technological elements.
- **Relevance:** how relevant is the element in the cities application.
- **Application deadline:** if an immediate, medium term (5-10 years) or long term (more than 10 years) development of the element is expected.

Finally, it is indicated that the line between different technological areas is not sealed and the technological elements included in a technological area can have components included in a different one. The meaning of the elements, areas and generally the organisation can become technological developments and cities needs function in the next editions of vision document.

[6.1] Energy and environment technology area

The number of inhabitants living in cities is increasing, estimating that in 2050 66% of the world population will live in cities. Cities are major consumers of resources (energy, water, raw materials, etc.), and this high consumption takes place in a concentrated manner with high quality and continuity requirements. Therefore, resources management and optimization, and its consumption rationalization, are a must to ensure the sustainability of the urban environment.

On the other hand, cities are large waste producers, potentially contaminant, which need to be processed, recycled and energetically valorised. Both concepts are part of the economic and environmental policies of the European Commission that aim to reduce foreign energy dependence and to combat climate change.

Therefore, efficiency, energy saving and environmental factors are becoming a priority in the Smart Cities operation, due to, on the one hand, the rising energy price forcing to optimize its consumption and, on the other hand, the need to solve the challenges of climate change and CO_2 emissions reduction.

Smart Cities tend towards models that include smart networks for energy management or smart grids, integrating the renewable energy sources into the existing power networks, and including measures to help boost savings and energy efficiency in cities buildings and infrastructures.

In addition, these models to which Smart Cities tend, encompass the concepts of energy efficiency and sustainability, pursuing a balance between the environment and the sustainable consumption of natural resources, through adequate environment management and protection guidelines.

In the energy and environment technology area, the following lines or applications can be found:

6.1.1 Energy networks management

Changes in the way energy is produced and consumed are a challenge and an opportunity for the cities energy networks development that must be transformed into Smart Grids.

The traditional power networks, characterized by their low flexibility, distribute the electricity from large production centres located outside the cities to final consumers. The self-sufficiency and emission reduction objectives involve the increase of electricity generation in the cities, this generation coming from a set of small loads and generators acting as a single system (distributed generation) and with an important renewable component. In short, a much more fluctuating generation with less central control. To take advantage of this change in the way of generating energy, a more flexible demand is required able to effectively react to the market signals, and the introduction of new elements capable of storing the energy is needed. Optimization is finally given with management mechanisms that allow a local-character coordination of generation-demand-storage.

In the management of the energy networks, the Information and Communication Technologies are a key element, since it allows monitoring and control. Distributed sensors and actuators are responsive to the needs of increasingly complex information systems, and allow large amount of data treatment. Furthermore, increased monitoring and control of electrical distribution networks improves service quality in cities through systems to monitor, regulate, predict, distribute and manage both consumption and energy production in an intelligent way.

Meanwhile, the thermal networks (of greater presence in northern Europe countries) allow distribution of heat and cold on an area (building, neighbourhood, etc.) allowing the optimization of resources thanks to the efficiency in the centralized production. To make this possible, the deployment of new distribution structures is needed; which will allow integrating renewable thermal energy sources in buildings and creating urban air conditioning networks.

Electricity networks

Technology area	Energy and environment [6.1]: Energy networks management
Grouped items identification and coding	F.1, F.2, F.3, F.8, F.9, PL.1, PL.7
Technology / Function	Function/Technology
Social challenges	Energy Environment and Efficiency
Relevance for the city	HIGH
Application (term)	SHORT/MEDIUM

Further automation is required for the distribution grid to tackle the changes stated in the chapter introduction. Automation can be focused on the following actions, some of which are currently being done while other actions should be performed in the future:

- **Optimized network architectures** to support new control schemes. Current structures (radial operation), which were developed for a non-automated operation, will evolve into new architectures adapted for an automated operation (meshed grid).
- **Low voltage monitoring systems.** Smart metering installation as well as transformation substations (MV/LV) sensoring allows the monitoring of the whole low voltage network (while previously part of the network was almost hidden). Not only will smart metering structure provide information on clients' consumption, but also information about supply quality and continuity, connectivity, etc.
- **Automatic reconfiguration of the network.** A more complex network takes into account technical and economic aspects and has users that are able to make decisions about consumption and offer services to the network (demand management, distributed generation, etc.). Therefore, the automation of the network's operation is required, which will start with the automatic reconfiguration of the network in case of one of its elements failing.
- **Use of power electronics for network management.** Power electronics are increasingly present in the network at the connection points of many renewable energy sources and some consumers (electric vehicles, welding, household appliances, etc.). The installation of power electronics will be managed at the connection points but also at the intermediary network points in order to compensate renewable energy variability, power control and reduce potential supply quality problems that may arise.
- **Information technologies** that enable management of the great amount of information smart grids will produce in order to improve operation efficiency while ensuring safety and privacy. Main characteristics of these technologies include the ability to be integrated with real-time systems (sensors, Scada, AMI infrastructure), the distribution of the processing capacity to the network nodes where information is collected (edge computing) and the ability to manage great amounts of information (big data)..

Users' coordination (their integration in the electrical grids operation) is a key aspect of smart grids, which will be addressed in chapter *6.1.2 Energy resources.*

Thermal networks

Technology area	ENERGY AND ENVIRONMENT [6.1]: **Energy networks management**
Grouped items identification and coding	BI.1, GE.1, CO.2
Technology / Function	Function/Technology
Social challenges	Energy Environment and Efficiency
Relevance for the city	MEDIUM
Application (term)	SHORT/MEDIUM

Integration of thermal energy from renewable sources in cities aims at decreasing energy consumption by 20%, improving energy efficiency and boosting the deployment of renewable energy able to be integrated in buildings(domestic and tertiary sector), which would enable them to go beyond the goals established by the European Union policies on climate change and energy.

District heating and cooling networks –DHC– generate and provide heating and cooling from a central plant to several users and buildings: not only neighbourhoods and residential housing but also public buildings, sports centres, shopping centres and a wide range of buildings and industries. Centralization reduces power needs due to the simultaneity in energy consumption and the inertia of the systems; the improved efficiency of the energy generation, distribution and consumption of equipment; and the possibility to accommodate solutions such as waste heat recovery and renewable energy sources integration.

Cities see their future in biomass based heating and cooling systems instead of systems based on conventional fuels. The reason behind it is that biomass based systems can reduce CO_2 emissions and obtain savings for the consumers while contributing to the achievement of the 2020 sustainability objectives and fostering the use of indigenous raw materials. Therefore, it is a more efficient model with the same environmental and economic advantages, able to provide energy directly to the consumer without previous handling and storage of fuels. Furthermore, this kind of DHC systems can cover a limited number of houses to entire metropolitan areas.

Alternatively, heating and cooling usage of geothermal energy has several advantages such as no noise impact (it does not require chimneys or external units), dramatic reduction in CO_2 emissions and savings for end consumers when compared to conventional fuels. Geothermal energy is efficient and manageable (available 24 hours a day, 365 days a year), which would allow cities to reduce their energy dependence and high pollution levels.

6.1.2 Energy resources

Cities are great consumers of energy. For this reason, making use of electricity coming from renewable sources would contribute in a significant manner to reduce emissions and energy dependence. Furthermore, the economic and social activity of the region would be encouraged due to the use of indigenous and endless resources.

Future energy networks at cities will be sized in order to deal with distributed generation installed in urban and suburban areas. Most of this distributed energy will come from small-scale cogeneration as well as from renewable energy sources, which should be manageable.

Besides, the use of the electricity resources in an efficient way could involve the flattening of the daily consumption curve and thus optimize the utilization of the networks increasing the overall efficiency of the electricity system. At the same time, electricity demand must be managed and coupled to both energy generation and storage.

Meanwhile, energy storage will move renewable energy generation towards times of high energy consumption, which will reduce long distance energy flows, thus reducing losses and the need for building new infrastructures.

By combining all of these elements supply assurance will be increased, demand growth will be moderated and generation costs within smart cities will be reduced

Demand integration

Technology area	Energy and environment [6.1]: Energy resources
Grouped items identification and coding	F.5, TH.3, CO.6, EE.4
Technology / Function	Function/Technology
Social challenges	Health Food Energy Transport Environment and Efficiency Social Changes and Innovations Economy and Digital Society
Relevance for the city	HIGH
Application (term)	SHORT/MEDIUM

Energy efficiency and consumption management can be distinguished within demand. On the one hand, energy efficiency looks towards energy consumption reduction, usually by using more efficient equipment or by reducing useless consumptions (i.e. reduction of heating or lighting when it is not required due to the absence of users). On the other hand, consumption management refers to the displacement of consumption in order to consume energy at lower costs due to its higher availability without reducing the amount of energy consumed.

Within demand integration two basic aspects exist: the contractual and the technological one. It is necessary to add new contractual modalities within infrastructures managers and clients in order to offer incentives to the displacement of consumption from peak to valley or to times at which there is a higher availability of energy close to consumption. The technological aspect implies the introduction of energy managers and the automation and standardization of the different loads, making their centralized and automated management possible according to technical and economic signals.

ITCs are an underlying technology that enables putting the communication and smart management of the energy consuming equipment under way.

Renewable energy and distributed generation integration

Technology area	**Energy and environment [6.1]:** **Energy resources**
Grouped items identification and coding	C.6, F.10, FV.1, GE.3, F.6
Technology / Function	Function/Technology
Social challenges	Energy Transport Environment and Efficiency
Relevance for the city	HIGH
Application (term)	SHORT/MEDIUM

One of the objectives of smart cities is to generate a great amount of the energy they consume, which is derived from energy policies on reduction of foreign dependence and reduction of greenhouse gases.

Renewable energies with a fully manageable generation model will play an important role in stabilizing the cities electricity network. These technologies are cleaner than conventional generation processes related to fossil fuels. Furthermore, they involve advantages related to bringing closer generation and consumption such as reduction of energy losses in the network and better use of the existent distribution infrastructures.

Decentralized energy generation and distribution systems, besides having high electrical efficiency and excellent supply quality, can offer several advantages when compared to centralized generation. Some of these advantages include minimization of transport and distribution losses, relief of distribution networks, supply assurance due to a higher amount of connected power stations, etc. Furthermore, from a geographical perspective, exploitation of distributed generation systems can be adapted to renewable resources and energy needs of every point in the city, which would minimize the foreign energy dependence.

Distributed generation requires to be integrated within network operation in order to realise its full potential within the cities, which will guarantee a higher amount of distributed generation and a better supply quality. This involves the need to define contractual relationships and management interfaces between the network operator and the generation units.

Storage management

Technology area	ENERGY AND ENVIRONMENT [6.1]: **Energy resources**
Grouped items identification and coding	F.4, FV.4, CO.3, HPC.1, F.7
Technology / Function	Function
Social challenges	Energy Transport Environment and Efficiency
Relevance for the city	MEDIUM/HIGH
Application (term)	MEDIUM

Energy generation and consumption do not match because of the intermittent nature of renewable energy, the inelasticity of demand and the generation of electricity for purposes other than the electric one (i.e. thermal). Therefore, electric power exchanges are required throughout the distribution and transport network, which sometimes causes imbalances that energy storage could solve.

Therefore, energy storage enables minimizing the effects of fluctuation when manageable energy such as renewable energy enters the network and thus stabilizes the supply and demand curve. In particular, in buildings energy storage allows the optimization of the use of renewable energy based generation systems and provides a key element for comprehensive energy management by decoupling energy consumption from production.

There are currently many different technologies and forms of energy storage according to the installations' capacity. High capacity energy storage will be managed by network operators in order to stabilize the operation of the network, while storage typologies having lower capacities like electric vehicles' batteries will be distributed in the places of consumption. By lowering costs as a consequence of energy storage and after the expected increase in electric vehicles penetration rate, cities will have at their disposal a great amount of distributed energy storage units connected to the network for long periods of time, which will enable management to be at the service of the network.

Once again, to achieve the real potential of the energy storage technologies integration of its operation with the network operation throughout the use of technology is required so the optimal solution regarding the management of the three types of resources can be found: demand, generation and storage.

Energy recovery

Technology area	ENERGY AND ENVIRONMENT [6.1]: Energy resources
Grouped items identification and coding	FE.3, C.7, BI.4, GICI.1
Technology / Function	Function/Technology
Social challenges	Energy Transport Environment and Efficiency
Relevance for the city	HIGH
Application (term)	SHORT/MEDIUM/LONG

Waste generation is inherent to the functioning of the cities. Those waste streams can be handled and turned into useful energy, which would increase the overall energy efficiency of the city.

Energy recovery from waste produced at cities (solid urban waste and waterwaste) has a double impact on the city: waste management and energy generation. Biogas with high methane concentration obtained from these urban waste streams can be applied to cogeneration processes or be injected directly in the distribution gas network.

Electricity generated from the organic fraction of urban solid wastes (FORSU) is a manageable renewable energy that contributes to maintain the stability of the electricity distribution network by providing supply assurance any time of the day whatever the weather conditions are (wind, sun, etc.). This characteristic is of great importance for the achievement of a high share of renewable energy at cities without jeopardizing supply assurance.

There are two different ways to use biogas as fuel. The first one is by using biogas in situ throughout cogeneration processes, which enables exporting electricity to the network, thus satisfying both electrical and thermal energy demands at production centres. This way, transport losses are reduced, the construction of new conventional power plants for supplying those electrical and thermal demands is avoided and the overall efficiency is increased.

On the other hand, it is possible to recover energy from the braking of trains, subways, trams, etc. Instead of being lost as heat waste, this energy can be re-injected into the electricity distribution network throughout the suitable converters, re-used by the rail vehicles themselves or re-used by other elements of the infrastructure or the urban environment for purposes such as electric vehicle charging. There are success stories in which this energy has been recovered obtaining very good results and should be transferred to the whole set of railway modalities. Together with the management of smart electricity networks, including railway and city networks, the recovery of this kind of energy has a great development potential.

Additionally, there are ways of energy recovery at rails, at special points from vehicle crossing or at public spaces coming from human movement.

6.1.3 Environment

Energy efficiency and energy saving are a priority for the functioning of a smart city due to the rising price of energy, which is forcing the optimization of its consumption, the challenge posed by climate change and the need to reduce CO_2 emissions.

Environment protection must be one of the main objectives of the future cities as well as a result from the implementation of adequate tools and measures in the sustainable management of resources and pollutants reduction.

The entire city interferes in the water cycle in many ways. Urban areas collect and make use of diverse sources, from river and aquifer water to desalinated marine water or recycled water. Efficiency in water management and control of the water quality are a key issue both for natural or semi-natural water bodies (rivers, reservoirs, etc.) and urban water supply networks.

Environmental indicators and sensors

Technology area	ENERGY AND ENVIRONMENT [6.1]: **Environment**
Grouped items identification and coding	FO.4, C.9, TH.5
Technology / Function	Function/Technology
Social challenges	Health Transport Environment and efficiency
Relevance for the city	HIGH
Application (term)	SHORT

It is an unquestionable fact that the environment must be protected in current cities, and therefore a quick measurement of the possible pollution presence in cities is required in order to keep environment quality under control.

For this reason, pollution levels and air quality must be checked exhaustively by using environmental indicators and sensors when necessary. Air quality monitoring systems in urban environments measure air pollution, detect contaminants and calculate CBRN parameters (chemical, biological, radiological and nuclear), so it is possible to respond to adverse conditions for human health and environment quality.

In this context, biosensors and bio-indicators will play an important role. In the environmental field, these biological methods of analysis can be integrated in pollutants control programs by implementing them in environment security systems.

Meanwhile, by performing the proper labelling of products it is possible to know their energy environmental footprint in terms of CO_2 absorption and their production traceability.

Sustainable waste management

Technology area	ENERGY AND ENVIRONMENT [6.1]: Environment
Grouped items identification and coding	C.8, TH.6
Technology / Function	Function/Technology
Social challenges	Energy Transport Environment and Efficiency Social Changes and Innovations
Relevance for the city	HIGH
Application (term)	SHORT

Waste generation, management and processing are some of the biggest environmental problems for the urban environment. Thus, the smart management of the waste produced by citizens is a challenge for the future sustainable and clean cities.

Energy recovery from organic waste represents a solution for two different problems: to reduce the volume of waste generated at the cities and to produce energy from biomass. In addition to the energy issue, which has been addressed in chapter 6.1.2, implementation of systems towards the following is expected:

- Improvement in waste control and monitoring by using ICTs.
- Control and monitoring of pollution.
    - Development of solid waste separation and treatment technologies able to recover a higher amount of components: Waste coming from roads and buildings construction.
    - Presence of pollutants in waste.

Water recycling and treatment technologies

Technology area	**Energy and environment [6.1]: Environment**
Grouped items identification and coding	A.1, A.2, A.7, A.8, FO.3
Technology / Function	Technology
Social challenges	Health Food Energy Transport Environment and Efficiency Social Changes and Innovations Economy and Digital Society Security
Relevance for the city	HIGH
Application (term)	SHORT

Being an essential resource, water has many uses in the cities: drinking water, water for cleaning, irrigation water. Water requires different treatments in function of the final use and recycling process.

The water cycle is usually transposed at smaller scale and closer to the final user. In this way, a more intense rainwater harvesting is intended in order to treat store it tanks associated to buildings or neighbourhoods. Distributed treatment systems will allow a better use of water at a local level by recycling water with lower levels of dirtiness to be used in gardens, etc. In addition, local storage of water will improve quality of service since it will reduce the lack of supply.

If local water storage takes place underground, the "urban heat island" effect will be reduced because this effect is caused by the lack of humidity that occurs due to the low permeability of asphalt.

More energy efficient techniques for water depuration will be developed than UV irradiation techniques currently used, which have high consumption levels. The use of vegetation or membranes is one of the possible development pathways existing today.

[6.2] Buildings and infrastructures technological area

There is a big concentration in cities of infrastructures that allow the housing of a high population density along with its activity. Infras-tructures and urban elements cover the buildings, urban furniture, com-munication frameworks (stations, stre-ets, pavement, sidewalk, etc.), outdoor space (parks), services networks and special equipment (water treatment plants, etc.).

Inside these infrastructures, for ins-tance the buildings, 40% of the energy is used for climate control, which shows the importance of working on this area to achieve the objectives associated to smart city.

In this chapter, not only are issues relative to urban infrastructure going to be addressed, but also the existent points connections to other energy and mobility areas.

6.2.1 Road infrastructures

By 2050, 66% of the world population, up to 85% in the most developed areas like Europe will live in urban and suburban areas[5] as a consequence of the demographic movement. As it is stated in the Green Paper "Towards a new culture for urban mobility", one of the greatest challenges is the achievement of a better and safer mobility that ensures citizens' quality of life by developing efficient and sustainable urban and interurban transport systems.

5. COM (2007) 551 final, GREEN PAPER *Towards a new culture for urban mobility.*

Alternative fuels infrastructures

Technology area	Buildings and infrastructures [6.2]: **Road infrastructures**
Grouped items identification and coding	M2F. 6, HPC.4
Technology / Function	Function/Technology
Social challenges	Energy Transport
Relevance for the city	MEDIUM/HIGH
Application (term)	MEDIUN/LONG

A wide infrastructure is required for alternative fuels (gas, biofuels, hydrogen) and electrical vehicle charging stations. In the future, energy storage in electrical vehicles will allow the optimization of the city energy resources. To this end, technology and information technologies must be integrated in equipment for the network infrastructure and an active management of the demand coming from electrical vehicle charging stations must be promoted.

If there are alternative propulsion technologies, final consumers will have the possibility to choose the motorization modalities that better fit their needs.

More sustainable pavements

Technology area	BUILDINGS AND INFRASTRUCTURES [6.2]: **Road infrastructures**
Grouped items identification and coding	A.3, A.4, C.4
Technology / Function	Function/Technology
Social challenges	Health Energy Transport Environment and Efficiency Social Changes and Innovations Security
Relevance for the city	MEDIUM
Application (term)	SHORT/MEDIUM

New technologies, processes and mixtures of flooring and pavements made by recycling existing flooring, as well as the development of pavements with longer life cycle, lower maintenance needs and low noise emissions are included within this technological element. Besides, reuse of waste generated during construction and roads preservation will be fostered

Furthermore, this element aims at achieving a railway infrastructure with higher sustainability rates by introducing components and materials with higher recyclability rates in the system. Therefore, the use of recycled materials providing improvements in terms of service quality such as noise and vibration abatement, higher comfort, etc. while complying with existing technical requisites must be encouraged.

6.2.2 Urban elements management

Besides having the most efficient infrastructures possible in material and deployment of the supply network field of the alternative fuels for mobility, increased efficiency in infrastructure management is sought out, and having a sonorization to know the state of the rail structure gives useful information to improve the movement inside the city and plan changes in the usage or in the infrastructure that respond to the users need.

The improvement in energy efficiency of urban furniture (for instance street lights, reducing the consumption managing it smartly) are found in this section.

Railway and road infrastructure management

Technology area	**Buildings and infrastructures [6.2]:** **Urban elements management**
Grouped items identification and coding	C.1, C.2, C.3, CO.9, FO.8
Technology / Function	Technology
Social challenges	Energy Transport Environment and Efficiency Economy and Digital Society Security
Relevance for the city	HIGH
Application (term)	SHORT/MEDIUM

The development of new methods and tools for the sensoring and monitoring of the infrastructure enables the generation of information on a real time basis about road condition, traffic intensity, real speeds and travel times, incidents, adverse meteorological conditions, deterioration mechanisms, structural response, etc. as well as the management of road safety, preventive maintenance, physical securing of the perimeter and fast collection of information after the occurrence of natural disasters (floods, earthquakes).

The main axis in smart cities' creation and innovation are the infrastructures involved in their development. These infrastructures are associated with the services offered by the cities through professionals and enterprises in an evolutionary way as citizens' demand shifts to new services.

The introduction of sensors in the infrastructure allows it to generate information on a real time basis about different variables for patterns detection that helps manage the city.

To that end, the deployment of smart management for the railway infrastructure is required, which has to take into account the integration of innovative technologies for the development of an optimization and exploitation framework for infrastructure, information, maintenance, energy and engineering being connected to other modes of transport and the remaining systems of the city.

Smart lighting

Technology area	**BUILDINGS AND INFRASTRUCTURES [6.2]: Urban elements management**
Grouped items identification and coding	FO.9
Technology / Function	Technology
Social challenges	Energy Transport Environment and Efficiency
Relevance for the city	MEDIUM
Application (term)	MEDIUM

Smart management of lighting in cities is one of the energy and climate challenges that cities of the future have to face. Energy savings and CO_2 emissions reduction are the objectives to be accomplished when designing and implemented an urban lighting system. Photonic technology can help finding new light sources both for public and private lighting, taking into account hybrid systems that combine natural and artificial lighting. Furthermore, they can also be applied to urban and road signalling as well as to luminous advertising. Finally, new light sources will be useful in the design of new lighting systems in public and private vehicles.

- Integration of efficient public and private lighting at cities:
    - New light sources
    - Control and regulation systems
    - Use of hybrid systems for lighting (natural + artificial lighting)
- Improvements in lighting systems located at road and vertical signalling (traffic, advertisement, etc.) in order to maximize energy savings and achieve a reduction in lighting pollution and CO_2 emissions.

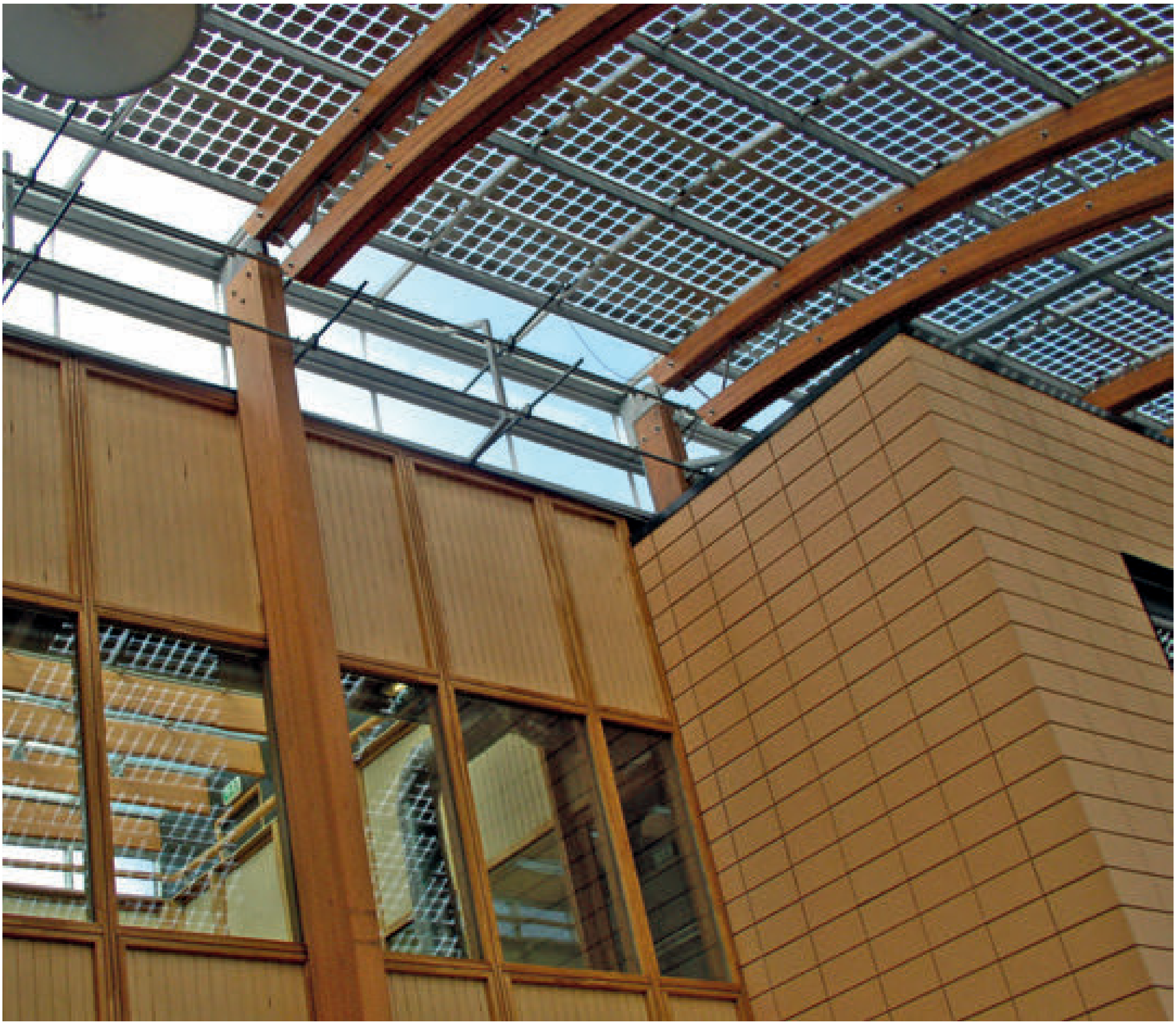
Connectivity improvement

Technology area	BUILDINGS AND INFRASTRUCTURES [6.2]: **Urban elements management**
Grouped items identification and coding	C.10
Technology / Function	Function
Social challenges	Transport Social Changes and Innovations
Relevance for the city	MEDIUM
Application (term)	SHORT/MEDIUM

Roads are an integral —and necessary— component for the optimal performance of the transport system in cities. Actions within this sector must point towards those alternatives in which the road, connected with other modes of transport, is the most adequate and sustainable solution to meet social demands on mobility.

6.2.3 Sustainable building

Currently buildings account for 40% of total energy consumption at the European Union. Energy consumption reduction and use of energy coming from renewable sources are of great importance in the building sector in order to reduce energy dependence. Besides, renewable energy integration in cities aims at reducing energy consumption by 20%, improve energy efficiency and boost the deployment of renewable energy suitable for building integration (domestic and tertiary sector), thus going beyond the projected levels established in the climate change and energy politics of the EU.



Renewable energy integration at buildings

Technology area	**BUILDINGS AND INFRASTRUCTURES [6.2]: Sustainable building**
Grouped items identification and coding	BI.2, GE.2, CO.1
Technology / Function	Function
Social challenges	Energy Environment and Efficiency
Relevance for the city	HIGH
Application (term)	SHORT/MEDIUM

Due to the buildings' current condition, a deep refurbishment must be performed so energy consumption is substantially reduced. In this way, it would be possible to achieve an energy self-sufficient building model or even a positive energy one, which would allow significant savings and reduction of the energy dependence on external sources.

A new distribution structure must be deployed to boost sustainable refurbishment, energy efficiency and integration of thermal renewable energy in buildings by developing the tools that facilitate the improvement of existing buildings, the understanding of their behaviour and their energy efficient management. This will also enable the achievement of the committed energy objectives while the required characteristics on stability and quality of service are maintained.

New construction technologies

Technology area	**BUILDINGS AND INFRASTRUCTURES [6.2]: Sustainable building**
Grouped items identification and coding	FV.2, CO.8, A.5, FO.9
Technology / Function	Function/Technology
Social challenges	Health Food Energy Environment and Efficiency Security
Relevance for the city	HIGH
Application (term)	SHORT/MEDIUM

The massive introduction of new technologies and techniques that enable the optimization of time and cost in the construction and maintenance of the built environment must take place along the whole sector value chain. Nature-based solutions whether integrating elements from nature or simulating natural processes, promote resilient (adaptable to climate change and thus mitigating its impact) and sustainable (recyclability and reusability) urban ecosystems that, in addition to improving human wealth, provide new business opportunities. Besides, they contribute to reducing energy consumption and improving urban environmental quality (i.e. by mitigating the island-effect at cities).

Information and communication technologies must contribute to the adaptability (social – ageing society -, user-centred, etc.) and resiliency (management of critical events at urban and building level) of the built environment, in addition to contributing to the preservation of resources (water, energy) at the different life cycle phases of the built environment.

Finally, new management bodies both at Project management level and at building and cities operation level must contribute to the achievement of a greater efficiency at the execution and exploitation of the built environment, therefore reducing execution times, interferences in the operation or costs for the public sector (public-private partnerships combinations). Not only does industrialized construction contribute to the optimization of execution processes, but it also achieves optimal final quality.

Zero Energy Buildings

Technology area	**Buildings and infrastructures [6.2]: Sustainable building**
Grouped items identification and coding	FV.3, CO.4, FE.4
Technology / Function	Function/Technology
Social challenges	Energy Transport Environment and Efficiency
Relevance for the city	HIGH
Application (term)	SHORT/MEDIUM

Directive 31/2010/EU Directive on the Energy Performance of Buildings establishes the following concept: Nearly Zero Energy Building (nZEB) means that a building which has a very high energy performance, in which nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including from renewable sources produced on-site or nearby. Instead of being just consumers of energy produced in a centralized way, buildings will participate in the production and management of energy, thus becoming an essential element of smart grids.

Due to the buildings' current condition, a deep refurbishment must be performed so energy consumption is substantially reduced. In this way, it would be possible to achieve an energy self-sufficient building model or even a positive energy one, which would allow significant savings and reduction of the energy dependence on external sources.

Meanwhile, energy management is a crucial aspect for energy use optimization and comfort level in smart cities. Finding solutions at neighbourhood and city level is key for achieving a reduction in energy needs, improving own resources utilization and citizens' comfort level both at their houses and public buildings.

[6.3] Mobility and intermodality technological area

Efficient management of freight and passenger transport is one of the lines of action in smart cities, whose objectives are to satisfy the increasing need for mobility for their citizens in the urban environment and to contribute to the reduction of pollutants and noise. Those objectives will be achieved by an intermodal system connected to the smart infrastructure of the city.

The following lines or applications can be defined within the mobility and intermodality area:

6.3.1 Vehicles in the urban environment

Vehicles are an essential element for freight and passenger transport and mobility in the urban environment. The need arises for new types of vehicles for both private and public freight and passenger transport, as well as other elements and infrastructures required for their deployment, in order to accomplish the objectives of pollutant emissions, carbon footprint and noise levels reduction in the urban environment, which will contribute to the development of a more sustainable vehicle pool.

Less pollutant vehicles

Technology area	**Mobility and intermodality [6.3]:** **Vehicles in the urban environment**
Grouped items identification and coding	M2F.1, M2F.2, M2F.3, HPC.2, LO.2, BI.3
Technology / Function	Technology
Social challenges	Health • Energy • Transport • Environment and Efficiency
Relevance for the city	MEDIUM/HIGH
Application (term)	SHORT/MEDIUM/LONG

This technological element includes all kind of vehicles, although implementation periods vary for each propulsion technology addressed. Light electrical vehicles for urban use (bicycles, motorcycles, tricycles, four-wheeled vehicle and microcars) will be available in the short to medium term while implementation of fuel cell vehicles for urban use and indoor logistics would take place in the medium to long term. Regarding vehicles for urban services (services and goods distribution fleets and urban buses) powered by alternative fuels (natural gas and biomethane, LPG), their implementation is expected to take place in the short to medium term, and the implementation period for electrical vehicles designed for the same applications will depend on the propulsion technology used (hybrids vehicles, battery and fuel cell electric vehicles).

Alternative fuels and electric vehicles are effective measures to decrease the pronounced environmental pollution current cities are experiencing. Furthermore, biofuels and electric propulsion coming from renewable energy sources contribute to reduce greenhouse gas emissions and help to achieve the 2020 European objectives for sustainability.

Furthermore, biofuel usage in urban transport in the short term, production of electricity from renewable sources and distributed hydrogen production for transport purposes in the long term will foster the exploitation of indigenous resources for mobility in smart cities.

Safe and connected vehicles

Technology area	**Mobility and intermodality [6.3]:** **Vehicles in the urban environment**
Grouped items identification and coding	M2F.4
Technology / Function	Technology
Social challenges	Health Energy Transport Environment and Efficiency Economy and Digital Society Security
Relevance for the city	HIGH
Aplicación (plazo	MEDIUM

A higher deployment level of advanced driving assistance systems (ADAS) and cooperative systems (C2X) in vehicles is required in order to increase safety levels of both the occupants of vehicles and the vulnerable road users, thus avoiding accidents or reducing their consequences and improving mobility in urban environments. New driving assistance systems enable vehicles to achieve a higher level of .

autonomous driving. Urban environments having infrastructure equipped with detection and information transmission to vehicles systems and because of the lower running speeds, will be capable of introducing autonomous functions such as assistance in event of traffic congestion, parking assistance system, etc

New materials and technologies for vehicles

Technology area	MOBILITY AND INTERMODALITY [6.3]: **Vehicles in the urban environment**
Grouped items identification and coding	M2F.5, FO.10
Technology / Function	Technology
Social challenges	Energy Transport Environment and efficiency
Relevance for the city	LOW
Application (term)	MEDIUM

New materials and technologies must be developed for vehicles in general and vehicles for urban use in particular. These developments will include specific safety systems specially designed for vehicles and their environment, as well as vehicles and new and more efficient light sources on the inside and outside public and private vehicles.

6.3.2 Intelligent transport systems - ITS in the urban environment

Intelligent Transport Systems (ITS) include every application coming from information and communication technologies (ICTs) in the field of transport with the aim of improving safety, mobility and efficiency of the different transport modes. Examples in the urban environment are the management of traffic by using traffic lights, information systems at transport hubs through networked applications to ease intermodality and foster the use of public transport, signalling at the urban road network, etc.

Integrated systems for the management of sustainable mobility

Technology area	**Mobility and intermodality [6.3]: Intelligent transport systems - ITS in the urban environment**
Grouped items identification and coding	M2F. 8, C.11, EV.1, LO.8
Technology / Function	Function/Technology
Social challenges	Transport Social Changes and Innovations Economy and Digital Society
Relevance for the city	MEDIUM/HIGH
Application (term)	SHORT/MEDIUM/LONG

Integrated systems for the management of sustainable mobility and urban environment infrastructures (integral traffic management, itinerary planning, information on parking availability, reserved parking, charging points and alternative fuels infrastructures, etc.) based on communication networks allows the real time management of traffic data coming from control centres, remote control devices, sensors installed in the infrastructure and nomadic devices embedded in private vehicles, taxis and fleets.

ITS for urban transport

Technology area	**Mobility and intermodality [6.3]: Intelligent transport systems - ITS in the urban environment**
Grouped items identification and coding	M2F.9, TH.7
Technology / Function	Function/Technology
Social challenges	Energy Transport Environment and Efficiency
Relevance for the city	MEDIUM/HIGH
Application (term)	SHORT/MEDIUM

There are, covered within this element, information systems for users, fleet management systems, integration systems for the management of traffic and public transport, electronic points of sale, customized recommendations systems. These systems share information both for private users and professionals (logistic operators, public transport, etc.) about parking availability, alternative fuels infrastructure and charging points reserve.

ITS for rail transport

Technology area	Mobility and intermodality [6.3]: Intelligent transport systems - ITS in the urban environment
Grouped items identification and coding	FE.1, FE.2, FE.3
Technology / Function	Technology
Social challenges	Energy Transport Environment and Efficiency Economy and Digital Society
Relevance for the city	MEDIUM/HIGH
Application (term)	SHORT/MEDIUM/LONG

Development of ITS for rail transport will provide people and economic activities with rail products and services able to satisfy their needs in an environment of growing connectivity, in which intermodal door-to-door transport of passengers and freight is becoming more relevant.

Likewise, this technological element addresses the development of smart systems for energy management in rail systems as well as energy recovery systems to benefit from surplus energy coming from other transport modes, which includes the use of simulators to optimize the consumption of energy and resources..

Traffic management systems

Technology area	MOBILITY AND INTERMODALITY [6.3]: Intelligent transport systems - ITS in the urban environment
Grouped items identification and coding	LO.1, FO.7, C.12
Technology / Function	Function/Technology
Social challenges	Transport Environment and Efficiency Social Changes and Innovations Economy and Digital Society
Relevance for the city	MEDIUM
Application (term)	MEDIUM

Nowadays cities have to face air quality problems that directly affect the wealth and quality of life of their citizens. Pollutant emissions in cities can be reduced by systems that facilitate the regulation of traffic developing applications able to calculate alternative routes or reduce travel times.

Current widespread use of social networking can be exploited for the benefit of urban mobility by developing systems and applications that foster car sharing in combination with electric vehicle usage.

Based on the traffic data obtained on a real time basis at traffic control centres from photonic technologies, sensors installed in the infrastructure or in nomadic devices embedded in private vehicles, taxis or fleets, it is possible to develop integrated systems for travel planning, sustainable mobility management in urban environments and solutions for supporting urban mobility. These developments will achieve a reduction in travel time, calculations of accessible routes on maps and applications for updating in real time temporary architectural barriers, among others.

To this end, the deployment of communication networks (fixed, mobiles, M2M, vehicle-vehicle and vehicle-infrastructure, new information systems on the vehicle (ITS)) is necessary for coordinating traffic management systems. On top of that, the administration can promote the sharing of private cars or the combination with the usage of electric vehicles by identifying through social networks when people with the same routes coincide in time.

6.3.3 Logistics and urban fleet management

Urban logistics must be an extremely reliable activity that adapts to changes in urban demography and economy, acquiring new purchase and distribution behaviours and new consumers and enterprises demands. Therefore, the fleets and their management must be adapted to the new situations. To this end, the implementation of new measures that contribute to provide a more efficient service is necessary. As examples of these measures, the development of new logistic platforms in the city that enables savings in costs, time and emissions is proposed. Other important aspects include the development of management systems and the maintenance of electric vehicle and alternative fuels powered vehicle fleets, as well as logistic business models based on new technological developments such as modular and smart containers.

New logistic platforms in the city

Technology area	**MOBILITY AND INTERMODALITY [6.3]:** **Logistics and urban fleet management**
Grouped items identification and coding	LO.3, LO.4, LO.6
Technology / Function	Function/Technology
Social challenges	Transport Economy and Digital Society Security
Relevance for the city	MEDIUM
Application (term)	SHORT/MEDIUM/LONG

Urban consolidation centres and collaborative platforms to share freight in the last mile enable savings in costs and in number of delivery travels, thus reducing CO2 emissions and traffic. These platforms allow last mile operators to share logistic information in order to share delivery vehicles and therefore enhance logistic efficiency, reduce traffic and increase vehicles load factor. In particular, the aim of these installations is to share information of urban delivery planning from several logistic operators and their delivery routes so new delivery routes that maximize vehicles capacity can be planned. Information exchange platforms can also carry out common services such as packages tracking and management of incidents on the route. Usually these platforms are associated with collaborative strategies between logistic operators that may work on specific urban areas with access problems or where a regulatory body (usually a local corporation) interferes.

Fleets management and maintenance systems

Technology area	**Mobility and intermodality [6.3]: Logistics and urban fleet management**
Grouped items identification and coding	M2F.7
Technology / Function	Technology
Social challenges	Transport
Relevance for the city	MEDIUM/HIGH
Application (term)	MEDIUM/LONG

The development of management and maintenance systems for electric vehicle and alternative fuels powered vehicle fleets and business models related to urban electric vehicles (vehicle-sharing, parking reserve, charging scheme and payment, etc.) are considered an opportunity and will also benefit their deployment. At this point, it would be interesting to carry out an analysis on the implementation of a comprehensive system of transport infrastructure charging.

New logistic models

Technology area	**Mobility and intermodality [6.3]:** **Logistics and urban fleet management**
Grouped items identification and coding	LO.7, LO.5
Technology / Function	Function/Technology
Social challenges	Transport Environment and Efficiency Economy and Digital Society
Relevance for the city	MEDIUM/HIGH
Application (term)	SHORT/MEDIUM/LONG

Logistic business models based on new technological development such as the use of ibeacons and modular and smart containers (internet of things), allow to take full advantage of the space inside vehicles and ease their handling, making it possible to communicate to the environment the vehicle's state, position and destination. This enables synergies between automated freight delivery points used by any logistic services provider and the recipient of the services while ensuring the security, reliability and tracking of the delivery, as well as new collaborative strategies in the delivery and efficient management of the reverse logistics, making use of the delivery collection points network for returning the products.

There is a potential improvement in modularising logistic units and containers. On the one hand, interfaces between long distance logistics and urban logistics are inefficient, which is partially due to the lack of modularization in the size of vehicles' bodies and containers. Currently, urban delivery makes use of big trucks that hinder traffic flows. This can be solved with a higher size module (container or truck swap body) for long distances that could be divided into multiple numbers of urban delivery containers. The modules would be transferred through automated handling to smaller vehicles of standard and multiple sizes for an improved usage. This way, urban containers would allow a better use of space at vehicles and would reduce congestion problems as they are designed for last mile distribution. This example could be transferred to other kinds of intermodal interfaces. This line of work intends to develop the concept of physical Internet for logistics, in the same way all data is collected on standard packages on the digital Internet.

[6.4] Government and social services technological area

Smart cities must ensure the access to the services provided from the administration to the citizens in a simple way.

Within the smart city model proposed in this Vision Document, one vertical area integrating the lines and actuations of the government and social services has been outlined, which is key to improving citizens' quality of life and the accessibility to the services provided by the city government. This area is divided into three lines:

- Health and accessibility
- Administration
- Urban promotion

6.4.1 Health and accessibility

The health and accessibility line comprises all the technological elements related to technologies for diagnostic support, treatment and follow up of patients by using new techniques that improve diagnosis and allow the performance of less invasive interventions for treatment of pathologies, as well as those elements that enable universal accessibility to the services offered to every citizen affected by a functional or cognitive limitation.

Advanced technologies for patient diagnosis, monitoring and intervention

Technology area	**Government and social services [6.4]: Health and accessibility**
Grouped items identification and coding	FO.5, FO.6, FO.13
Technology / Function	Technology
Social challenges	Health Economy and Digital Society
Relevance for the city	MEDIUM
Application (term)	MEDIUM

New technologies should be found in the whole patient treatment cycle.

- Techniques and devices for the early measuring of parameters related to the emergence of pathologies.
- Diagnosis support, monitoring and intervention in patients by using technologies for capturing and processing images that make use of different devices (spectrum bands, capturing or processing strategies).
- Photonic technologies for intervening or performing treatments/therapies.

Sensors and health information systems

Technology area	**Government and social services [6.4]: Health and accessibility**
Grouped items identification and coding	MK.2, EV.2, EV.3, EV.4, TH.8
Technology / Function	Function/Technology
Social challenges	Health Social Changes and Innovations Security
Relevance for the city	MEDIUM
Application (term)	MEDIUM

The new paradigm in health care in urban environments brings the implementation of ICTs-intensive devices, electronic sensors of smaller size and higher performance, and more interactive systems for improving health management. An optimization of the medical sensors network interoperable with mobile user terminals is required for the continuous and ubiquitous monitoring of patients through medical decision support applications (alarms, shared diagnosis, DSS (Decision Support Systems), etc.).

Systems and applications can be developed for health self-management and to foster healthy habits, prevention and treatment of light chronic diseases. Besides, systems for location of at-risk groups can be implemented.

Safety and confidence elements are of great relevance for patient and healthcare provider authentication, privacy and access to medical data and electronic clinical record, in particular: ECR and data bases of patients hosted in the cloud. In order to achieve this, current regulation concerning these issues must be updated (i.e. storage of clinical data outside the hospital centre computer system).

Solutions and tools for accessibility

Technology area	GOVERNMENT AND SOCIAL SERVICES [6.4]: **Health and accessibility**
Grouped items identification and coding	CO.7, FE.5
Technology / Function	Function
Social challenges	Transport Social Changes and Innovations
Relevance for the city	MEDIUM
Application (term)	SHORT/MEDIUM

Social networks (Twitter, Facebook, LinkedIn, etc.) have changed the way society and business worlds communicate, relate and access knowledge and information; and constitute a key factor for inclusion in society on equal terms. However, neither large platforms nor the “cloud” are accessible since they are not oriented towards the general public, which creates social exclusion at certain sectors of the population: disabled people, elderly people, etc.

ICTs, being most of them related to the “Internet of Things”, involve improvements in wealth, safety and control when implemented ain cities, houses, vehicles (by 2016 there will be 210 million connected cars, becoming the car’s screen the fourth most used after TV, computer and Smartphone), etc. For this reason, accessibility to this new way of using ICTs must be maintained or even increased in order to secure solutions in which the user can interact with diverse systems by using its own mobile systems (smart traffic lights, interactive signalling making use of augmented reality, etc.); and enable interfaces to be adapted to the needs or priorities of users or environment (apps that enable users to trace and guide accessible routes on maps, check the status and availability of different transport modes, rent accessible rooms, make sightseeing possible for every person, etc.).

6.4.2 Administration

The administration line includes all those technological elements related to technologies capable of providing the city with services for helping citizens to use the city and its resources in an efficient way. Therefore, within this line we can find urban planning, interoperability and intermodality and infrastructures management to the city make accessible and sustainable and make everyday life easier for every population sector.

Urban planning and new services at the city

Technology area	**Government and social services [6.4]: Administration**
Grouped items identification and coding	EE.2, CO.5, EE.1
Technology / Function	Function
Social challenges	Healt Food Energy Transport Environment and Efficiency Social Changes and Innovations Economy and Digital Society
Relevance for the city	MEDIUM/HIGH
Application (term)	SHORT/MEDIUM/LONG

Urban planning is a key aspect for improving quality of life in cities. Therefore, it is crucial to develop multimodal nodes that ensure fast and easy interoperability between freight and people transport modes and avoid all kind of barriers. Besides, infrastructures that keep society in touch with social infrastructures like hospitals, schools, libraries, etc. must also be improved.

Adequate planning must involve reductions in congestion levels, traffic jams and travel times in the urban area due to the improvement in multimodality and the appropriate management of infrastructure, which will also involve an increase of the urban infrastructures capacity.

Sustainability management

Technology area	Government and social services [6.4]: **Administration**
Grouped items identification and coding	PL.5, GICI.2
Technology / Function	Function
Social challenges	Energy Transport Environment and Efficiency Security
Relevance for the city	HIGH
Application (term)	MEDIUM

This technological element relates to the technologies ability to support the development of processes compatible with the urban environment that enables the management of the cities life cycle. On the one hand, it includes self-sustainability systems for the cities, which monitor, evaluate and make decisions about basic parameters of the cities drawing from indicators defined by regulatory bodies. On the other hand, it includes the development of infrastructures (construction, maintenance and deconstruction) in such a way that no damage occurs to the built environment; noise, dust and vibrations levels are reduced and traffic congestion arising from interventions on existing infrastructure is minimized.

Social integration

Technology area	GOVERNMENT AND SOCIAL SERVICES [6.4]: Administration
Grouped items identification and coding	EV.5, PL.2, EE.5, GICI.3
Technology / Function	Function
Social challenges	Health Food Energy Transport Environment and Efficiency Social Changes and Innovations Economy and Digital Society Security
Relevance for the city	MEDIUM
Application (term)	MEDIUM/LONG

ICT applications for social and labour integration (social networks, specific communities to interact and share knowledge from patient to patient, patient to doctor, patient to caregiver (formal or informal), doctor to doctor). Programs for elderly people integration in labour mentoring, active ageing.

6.4.3 Urban promotion

Within this area, urban promotion technology will ease internal operation and interaction of public administration with third parties such as citizens, visitors-tourists, enterprises and social agents. Public administration interacts with them in many different action fields incorporating the end user in the decision-making process, as well as in the city characterization as a tourist destination supported by a number of technologies that cover all the travel process stages (before - during - after).

Citizen - Services connection

Technology area	GOVERNMENT AND SOCIAL SERVICES [6.4]: **Urban promotion**
Grouped items identification and coding	TH.1, TH.2, TH.4
Technology / Function	Function
Social challenges	Health Food Transport Environment and Efficiency Social Changes and Innovations Economy and Digital Society Security
Relevance for the city	HIGH
Application (term)	MEDIUM

The citizen-services connection refers to the incorporation of information technologies in the public administration, either for the internal administration management processes, as well as to manage the administration relationship with citizens, visitors-tourists, companies and social agents. Therefore, the public administration digitalization aims to reduce paperwork and speed up processes, thus promoting a more agile, effective and cheaper service.

In the Smart Cities context, eGovernment refers mainly to a more local, regional or municipal administrations, which are closest to citizens and enterprises. Technologies encompassed in this public administration concept range from communications networks necessary for the communication between systems and systems-users; the computational infrastructures to host the required software applications (sometimes in private clouds, sometimes in hybrid clouds, combination of public and private depending on data sensitivity); data storage, analysis and management systems (BigData techniques for large volumes of information and sometimes including multimedia), sometimes with considerable security and privacy restrictions, and where an optimal security management is needed; new ways of information displaying tailored to the user (monuments information, public transport information, information about paperwork procedures); and development of administrative management software using the latest trends in software design and quality, to ensure high performance and errors absence in the applications suitable to the expected service level.

In any Smart City model, the citizen is at the centre of the cities digitalization, meaning that the objective of transforming cities through technologies, must be the improvement in citizens' quality of life and opportunities improvement for citizens and companies. In addition, the citizen is no longer an inert being in this new digital-society context, but needs and wants to participate actively in their city decision-making, thus being an active player in its definition, construction and maintenance.

To make this citizen-public administration interaction possible and efficient, the citizen needs digital, regulatory, legal and administrative mechanisms in order to give their opinion, decide, influence and evaluate the services offered by the Smart City. In this technological element not only are technologies necessary, but also the establishment of series of channels, procedures and regulations that enable this interaction implementation and its regulation. It is therefore a multidisciplinary element. Some examples of these interactions include: open opinion processes about urban changes in the neighbourhood, warnings about malfunctioning or damaged urban elements, online voting, new actions or services proposals, organization of neighbourhood interest groups, participation in cultural events, etc.

Smart tourism management systems

Technology area	Government and social services [6.4]: **Urban promotion**
Grouped items identification and coding	TH.4, EV.6
Technology / Function	Function
Social challenges	Health Food Transport Environment and Efficiency Social Changes and Innovations Economy and Digital Society Security
Relevance for the city	MEDIUM
Application (term)	MEDIUM/LONG

Tourist destinations, besides its own municipal activity, should promote their different tourist resources and facilitate the business activity of tourism companies to make the city well known outwards, with the aim of increasing the number of visitors as well as the revenues coming from this activity.

For this reason, the cities with an important tourism activity need to incorporate a management system that allows them to inform, to commercialize, and to process all those resources, products and available tourist services. This management system covers both the internal city operation as the front-end, available through various mobile devices and communication channels, for an effective, fast and innovative management with the different agents they interact with (citizens, tourists-visitors, companies, public management entities and social agents).

To this end the following should be developed: ICT tools and applications for the city characterization as a tourist destination based on parameters, accessibility and sustainability standard criteria, as well as for the provision and updating of this information and the development of applications for its use, both at individual devices level (accommodation, travel agency, public transport, restaurants, museums or tourist activities among others) as well as integrated destination level.

[6.5] Horizontal technological area

In the development of the proposed model, three cross-application lines in relation to the other areas were detected, as they encompass base-technologies that could meet needs in any of the model vertical areas. Therefore, the horizontal area of the model groups the following lines: ICTs, security and sensors and materials.

On the other hand, given the existing relations between themselves, they appear within a single chapter in this Vision Document, thus offering a holistic vision of the enabling technologies they represent. For consistency with other sections of the document, the division into lines of application has been respected, although in some technological elements the interrelation and dependence is so pronounced that has been difficult to discern to what line of application they mainly affect. Hence, the distinction in either of these lines is merely organizational.

6.5.1 Information and Communication Technologies (ICTs)

The Smart City concept in relation to ICTs has been consolidated into seven technological elements:

- **Computing infrastructure:** The progressive digitalization of cities requires an increasing computing and storage capacity provided by data centres hosted both in any public Internet node and in private physical locations. These infrastructures must be designed, deployed and operated in any information system that needs hosting and data management and applications.

- **Data management and analysis systems (Big Data):** The sensing of cities is causing massive simultaneous generation of real-time data that needs to be housed, managed and analysed to exploit its value. To this end, data storage, management and analysis systems are essential for the health, energy, manufacturing or tourism sectors as well as for major beneficiaries of this technology.

- **Design and development of software applications:** Software has become an essential element for any function or device to be used to make a city become smart. Any digital system involves software generation and the more reliable and efficient this software is (less errors and higher quality), the better the results that citizens and users will perceive will be. For this reason, there are numerous technologies and methods for the design, development and verification of software produced within the Smart City context.

- **Communication networks:** The digitalization basis is the inter-communication between different devices, between humans and devices, and between humans through digital devices. Thus, Smart Cities are not excluded from this assumption, and communication network technologies are necessary for any communication established in any digitized process.

- **Display and image processing systems:** In order to facilitate communication between users/citizens and the digital systems, a friendly, efficient and intelligent interface is vital to achieve a wide acceptation of the technology including all type of users (under accessibility criteria). How is displayed distinguishes between being useful or not. Besides, images are currently being imposed to text information in many contexts and therefore technologies that treat those images are emerging, for example in medicine (medical image processing); for traffic monitoring and control; virtual office windows, in buildings access; at leisure (video games); in tourism (guides).

- **Internet of things:** The basic concept is to provide things with Internet connectivity. In this context, when we talk about 'things' it is referred to any element susceptible of being connected. The essence of the *Internet of Things (IoT*) is to add value to different elements providing them with and smart design that allows them to interact with our virtual environment.

In a technological context, the Smart City and Internet of Things concepts are two very close terms. Both concepts have their fundamentals in M2M (machine to machine) communications and with their applications and uses, bring forward what is called to be the Internet of the future.[6]

6. Source: *Smart Cities: un primer paso hacia la internet de las cosas,* Fundación Telefónica.

Computing infrastructure

Technology area	Horizontal [6.5]: Information and Communication Technologies (ICTs)
Grouped items identification and coding	PL.11
Technology / Function	Technology
Social challenges	Economy and Digital Society
Relevance for the city	MEDIUM
Application (term)	SHORT

The Computing Infrastructure lets the different digital systems of the society be lodged, managed and monitored. It consists of a series of physical and logical resources that allows the storage of the generated data, hosting of the developed applications, management of this amount of data and provides a range of monitoring services on the infrastructure to appropriately maintain and monitor it. Infrastructures must be reliable, secure and appropriate to the needs in each case, to ensure an assumable cost and energy efficiency. Technologies such as cloud computing, high-performance computing, applications platforms or virtualization systems are commonly used nowadays. These technological elements include the sizing, design, implementation and operation of the needed infrastructure to provide all the computational services (physical or virtual) that a Smart City requires.

Data management and analysis systems (Big Data)

Technology area	**Horizontal [6.5]:** **Information and Communication Technologies (ICTs)**
Grouped items identification and coding	PL.14
Technology / Function	Technology
Social challenges	Economy and Digital Society
Relevance for the city	HIGH
Application (term)	MEDIUM

The enormous amount of data that is being generated in the Smart Cities context, due to the mass sensing that is already taking place and which is expected to continue growing, supposes a challenge in terms of its management on the one hand and its exploitation on the other one. That is why, for some time, those technical and legal actions that have to do with the massive management of generated data very quickly in a short time are grouped under the Big Data concept. They are required systems that are capable of: optimally storing large amounts of data; intelligently analysing the data to infer non-explicit knowledge; managing data in order to be shared and updated without consistency losing; and of exploiting data by offering services. In the case of cities, opening up the citizen-generated and consumed data has a special relevance to obtain a mutual and common benefit. The legal aspect relates to privacy and security of data, and in addition to the needed technology, it requires a specific legal framework.

Design and development of software applications

Technology area	Horizontal [6.5]: **Information and Communication Technologies (ICTs)**
Grouped items identification and coding	PL.13, PL.15, PL.16, PL.17
Technology / Function	Technology
Social challenges	Economy and Digital Society
Relevance for the city	MEDIUM
Application (term)	SHORT

Software applications and services are used to provide the necessary logic to data and devices and to offer functionality to the user. Therefore, this element includes all technologies that enable the design and development of the software functionality. Software engineering establishes the techniques and tools for the software programs design promoting reusability and better software quality. For software programming techniques of artificial intelligence, multi-agent systems, semantic, expert systems, interoperability, middleware, security and privacy, workflow management, optimization, web services, etc. are used.

Communication networks

Technology area	**HORIZONTAL [6.5]: Information and Communication Technologies (ICTs)**
Grouped items identification and coding	FO.1, PL.10, FO.14
Technology / Function	Technology
Social challenges	Health Food Marine and Maritime Research Energy Transport Environment and Efficiency Social Changes and Innovations Economy and Digital Society Security
Relevance for the city	HIGH
Application (term)	MEDIUM

Due to the digitalization of society, communication networks are essential for the information transmission between network users. They can be fixed or mobile and facilitate communication between machines, people or people and machines, between devices and infrastructures, etc. Around communication, there are grouped networks a number or means, technologies and protocols that make up the network itself, and which allow the network to provide its functionality. The increasingly extensive use of the communications network causes a greater bandwidth and speed demand in order to meet users' demands. The use of optic technology facilitates compliance with these requirements thus promoting the network accessibility in suitable performance conditions.

Display and image processing systems

Technology area	HORIZONTAL [6.5]: **Information and Communication Technologies (ICTs)**
Grouped items identification and coding	PL.12, FO.2
Technology / Function	Technology
Social challenges	Health Transport Environment and Efficiency
Relevance for the city	MEDIUM
Application (term)	MEDIUM

The digitalization process surrounding the cities requires the establishment of human-machine interface mechanisms to make the communication between them possible. Therefore, advanced information display systems are needed to facilitate user interaction. All technologies related to man-machine interface and with image processing, treatment and visualization are encompassed in this technological element. The interface with humans in some cases may require, for example, natural language processing to understand human language, image recognition or movement detection. As for the display, the immediacy of communication makes real-time or augmented reality graphics necessary to provide the user with additional information about what is being displayed (information about monuments, transport information, information about arrangements or negotiations). Display and image processing systems use artificial vision techniques so that the computer can understand an image; or technologies for images capturing and processing using different devices (spectral bands, recruitment or processing strategies) or 3D technologies for different applications

Internet of things

Technology area	Horizontal [6.5]: **Information and Communication Technologies (ICTs)**
Grouped items identification and coding	PL.4, SL.1, SL.2
Technology / Function	Function/Technology
Social challenges	Energy Transport Environment and Efficiency Security
Relevance for the city	HIGH
Application (term)	SHORT

Closely related to communication networks and devices, 'Internet of Things' appears as a fundamental technology of the cities of the futures. From devices, to physical world objects that usually do not have this connectivity, as is the case of urban elements, buildings, cars, appliances, meters, etc., and in general everything that needs to be managed or controlled. From this perspective, technology will allow citizens to control their lives and influence the city in different fields such as health, education, culture and energy.

On the other hand, the future trend expands the concept with the so-called paradigm of Social Internet of Things (SIoT), which defines how people access and integrate with things, bringing social networking concepts to the 'Internet of Things' field, joining this concept with Internet of Everything (IoE), which aims to join people, data, processes and things to make relevant high-value connections. This concept intends to shape and treat people and objects as heirs of the same class. This abstraction implies that people and things have a common interface and that interaction takes place on an equal basis presenting itself as a world of opportunities for smart cities.

6.5.2 Sensors

This line comprises every technological element related to sensors' technology or electronic devices that offer a specific or general functionality in the context of smart grids. These are the defined Macro elements:

- **Detection, measuring and monitoring systems based on sensors:** There are plenty of parameters that are worth measuring in order to obtain monitoring systems in the smart city e.g. for health and safety applications, equipment functioning and infrastructures condition. These parameters include:
  - Cities self-sustainability monitoring, evaluating and decisions making systems about the basic parameters of the city. Advanced decision support systems (MIS/DSS).
  - Geodesics: geologic structures, soil, groundwater and surface water. Systems for the measurement of water quality parameters that allow a continuous control of their quality. Air quality monitoring systems in urban environments (contaminant, harmful or dangerous substances detection, CBRN parameters measuring).
  - Sound and lightning comfort (measuring of noise, lightning quality and light pollution).
  - Urban and interurban transport: traffic detection and monitoring system (ITS). Technologies for detecting unusual elements in the infrastructure or technologies for monitoring the infrastructure itself or the vehicles driving around. Measuring of free parking places. Vehicles localization. Traceability: active and passive RFIDs (intelligent tags). Road safety. Communications infrastructure (road and railway networks).
  - Control of (dangerous) industrial activities. Production control.
  - Techniques and devices for early detection of parameters related to the emergence of pathologies. Health monitoring (distance diagnosis – ambient assisted living, point of care diagnostic systems, falls, gait analysis, ECG, etc.).
  - Food safety, ensuring its conditions all along the supply chain.
  - Energy efficiency (generation, distribution, consumption): smart grid, smart metering. Essential services and supplies smart grids (utilities: energy, electricity, gas, water, waste): distribution network and control and operation centres. Environmental management of buildings and households, including safety.
  - Borders and environmental surveillance. Asset security (people, assets and processes). Safety and personal health. Structural health HMS.
- **Electronic sensors without batteries:** All trends expect an exponential growth in the number of sensors and electronic devices at cities. The deployment of the Internet of things will bring many benefits both for cities and citizens. Nevertheless, some disadvantages will also appear. One of the main drawbacks is the management of the batteries used by these sensors. Batteries being used at the electronic sensors network represent a problem due to their maintenance cost, both in terms of personnel and material, which implies their replacement when they become depleted. Furthermore, environmental consequences related to the use and disposal of this kind of elements must be taken into account. The development of electronic devices technologies that do not require batteries is one of the main technological challenges to overcome.
- **Smart devices:** This type of devices are already common in the health sector (medical tablets, surgical equipment, patients monitoring equipment), and in the goods manufacturing and services, vehicles, etc. They encompass what is known as embedded systems, which are electronic devices with an internal programmed functionality that provides them with intelligence and operational autonomy. They can be used in order to replace human tasks that are usually repetitive or extended in time and therefore potentially automated.

Detection, measuring and monitoring systems based on sensors

Technology area	**Horizontal [6.5]:** **Sensors**
Grouped items identification and coding	PL.6, FO.11, FO.12
Technology / Function	Technology
Social challenges	Health Food Marine and Maritime Research Energy Transport Environment and Efficiency Social Changes and Innovations Economy and Digital Society Security
Relevance for the city	HIGH
Application (term)	SHORT

A sensor is a device capable of detecting physical or chemical magnitudes and transforming them into signals that can be interpreted by another device, for example, a computer that can process and analyse signals and act accordingly. Sensing of cities has become an incipient reality that must be managed in an adequate way in order to obtain profit from the use of sensors while ensuring the proper use of the data obtained from the sensors. Some examples of sensors usage at cities include their application in the detection of substances in the air, in traffic control on streets or for cars' speed. There are several technologies for sensor manufacturing: optical, magnetic, electrical, etc. and diverse applications within the cities' area. Sensors are not usually found isolated in the environment but are grouped in sensors' networks; furthermore, they can be integrated in a wide variety of devices such as mobile phones, household appliances, meters, vehicles, etc. Sensors manufacturing must consider efficiency, cost and benefit parameters in order to offer advantageous solutions that are also realistic in terms of cost.

Electronic devices without batteries

Technology area	**HORIZONTAL [6.5]:** **Sensors**
Grouped items identification and coding	SL.1
Technology / Function	Technology
Social challenges	Salud Food Marine and Maritime Research Energy Transport Environment and Efficiency Social Changes and Innovations Economy and Digital Society Security
Relevance for the city	MEDIUM
Application (term)	SHORT/MEDIUM

Batteries used in the electronic sensors networks involve disadvantages because of the defined service life and the replacement and disposal costs. In order to solve these problems and expand the lifespan of batteries or even supress them, two strategies must be faced: new techniques for reducing the consumption of the electronic circuits, both at circuit design level and by using semiconductor components with lower energy requirements; and new techniques for the sensor to produce the energy needed to work. This technology, which is called energy harvesting, consist of the collection of waste energy from the environment (light, vibration, RF, thermal gradient) in order to convert it into electric energy to feed small sensors and intends to achieve an ubiquitous wireless and maintenance free sensoring.

Smart devices

Technology area	HORIZONTAL [6.5]: **Sensors**
Grouped items identification and coding	MK.1, PL.9
Technology / Function	Tecnología
Social challenges	Energía Transport Environment and Efficiency Economy and Digital Society Security
Relevance for the city	MEDIUM
Application (term)	MEDIUM

The new smart city paradigm and the massive use of sensors for detecting and measuring the urban environment involves the deployment of devices intensive in ICT, electronic devices smaller and with improved features and higher interactivity systems. New needs for communicating and providing the urban equipment with more intelligence and more interconnectivity (M2M) by using electronic sensors implies the design, development and testing of new generation equipment in pilot or demonstration projects in order to assess their technical and economic viability in the context of urban network infrastructures. Advanced manufacturing technologies can contribute to the massive implementation of this kind of electronic devices and ICTs in the urban environment, thus facilitating the effective integration of the different network infrastructures (transport, environment, water, energy, security, citizen information, social services), which requires the development of preindustrial pilot lines or test benches that ensure the technological capacity —in regards to the massive manufacturing—, the training aspects and the economic viability. Some examples of devices may include hubs, RTU (remote terminal units), PLC (Programmable logic controllers) or IED (intelligent electronic devices).

The public administration must develop an adequate regulation and legislation for enabling the deployment of planning and regulatory actuations compatible with the energy urban markets.

Besides, the administration must assure that the needs in the framework of energy efficiency from different society areas are covered, fostering the availability of professionals and scientists in this area.

6.5.3 Security

The concept of security within the city may be a wide topic affecting several levels and elements of the city. Besides, different dimensions of security are addressed in the urban area: from physical security (safety) guaranteeing the reliability of the industrial installations within their infrastructures and services, to citizens and enterprises protection and recovery after emergency situations, or considering digital security (cyber-security) that protects communication and computational systems required for the control and function of the city's services, among other several challenges for its application.

This is the reason why the concept of security, being a broad concept in all its different conditions (safety, security) and areas (resilience, protection, emergencies, reliability, industrial, road, physical, cyber-security), has been considered in this document in relation to the technological challenges of the smart city through four basic pillars:

- An integral security and government model of the essential services for the citizens and their resilience.
- Reliability of the urban infrastructures operation and of their equipment.
- Security and protection of people and freights and city's assets.
- Cyber-security of the control systems (supply and essential services networks, infrastructures and city's systems).

Integral security and resilience

Technology area	Horizontal [6.5]: Security
Grouped items identification and coding	PESI.1, PESI.4, PESI.8
Technology / Function	Function/Technology
Social challenges	Health Food Marine and Maritime Research Energy Transport Environment and Efficiency Social Changes and Innovations Economy and Digital Society Security
Relevance for the city	HIGH
Application (term)	MEDIUM

Essential services of the city, besides government and public administration, consist mainly of the services for supplying energy (electricity, gas, fuel) and water, sanitation and waste, transport services (travellers and freight —food, medicine, supplies—), financial system, telecommunications, traffic, education and health. To assure their correct operation, an integral security model is involved from three different perspectives: operation and reliability in supply/service (safety), physical or asset security of the assets and systems that take part in the services (security) and security of the logical systems (cyber-security) that manage their operation.

Besides this integral vision, the city governance model must take into account strategies and tools that enable it to act in an effective manner in the event of crisis and emergency situations produced by different kinds of risks: industrial (associated to the economic activity of the surrounding enterprises and industry), natural hazards (climate and natural extreme events, and their foreseeable evolution —climate change—) or provoked (wars and terrorist attacks), and the cascading effects that may be produced by the previously listed risks. In short, new technological and organizational systems capable of improving the city's reliance must be developed. Some of them include: systems for simulating risk situations and their consequences for the assets and services of the city, management of crisis and the coordination of agents (operators) and means for action, and a new concept of control centres and coordination of city's infrastructures, networks and services.

Security and reliability of urban infrastructures and equipment

Technology area	HORIZONTAL [6.5]: **Security**
Grouped items identification and coding	PESI.5, PESI.7, PESI.10, PESI.11, PESI.12
Technology / Function	Function/Technology
Social challenges	Health Food Marine and Maritime Research Energy Transport Environment and Efficiency Social Changes and Innovations Economy and Digital Society Security
Relevance for the city	HIGH
Application (term)	SHORT

Urban infrastructures consist of a set of physical assets (communication routes, water supply networks, sanitation, gas, electricity, etc.) with important equipment and the systems that control them. These assets can be public or private and their operators (mostly private, concessions) are responsible for the essential service they offer. For this reason, new advanced management and operation systems are required for assuring their reliability, availability, maintenance and security (RAMS), considering the installations' structural security and the management of the assets ageing as well. These systems will have an important technological component (sensor system, monitoring, simulation, artificial intelligence, inspection, new materials, etc.).

On the other hand, the physical conditions of the urban area from the geologic, hydrologic and climatic point of view are an important component of the structure and operation of the cities. The so-called ambient intelligence systems and monitoring systems of this physical environment, which include sensor networks and follow-up and warning systems, are of great importance for the stability of the city's infrastructures and services operation. Systems for the prediction and simulation of the environment evolution and extreme situations or other catastrophic scenarios will help define changes in the existing infrastructures, actuation plans and coordination in case of emergency.

Associated to the industrial nature of infrastructures, current security and occupational health strategies must evolve in order to address the creation of healthier and safer work environments and face workers new psychosocial risks or aging (active, because of longer working life).

The city and its adjacent industrial environment are the destination or unavoidable crossing point for an important volume of materials and products. Freight transport involves important risks because of the flow of usually large sized vehicles, especially when transporting dangerous goods. Therefore, both technological solutions on containers and transport elements and management systems of urban routes are key for the city's and citizens' safety.

Another key social aspect related to citizens' (road) mobility is road safety with high accident rates due to economic activity (two thirds of total accident rates), both caused by the activity itself (mission) and caused when getting to/from the working place (in-itinere). New organization strategies, mobility plans and technological solutions in the field of occupational road safety are accurate in the city of the future.

Security and protection of people, goods and assets

Technology area	Horizontal [6.5]: Security
Grouped items identification and coding	PESI.2, PESI.3, PESI.6
Technology / Function	Function/Technology
Social challenges	Health Food Marine and Maritime Research Energy Transport Environment and Efficiency Social Changes and Innovations Economy and Digital Society Security
Relevance for the city	HIGH
Application (term)	MEDIUM

Citizen security in the smart city of the future will require new models and technologies supporting it. On the one hand, public (state or local) and private security services must find innovative ways to develop and offer their services to society together with an advanced model for collaborating and coordinating among those public and private agents.

On the other hand, citizens must find mechanisms enabling a greater collaboration in the design of the security of their city and provide means for effective collaboration during risks, incidents and emergency situations (with diverse agents: police, social assistance workers, health services, fire fighters, rescue teams, etc.). Furthermore, the city's government shall be opened to this participation by developing a legal framework for initiatives and encouraging the use of adequate technological means and organizational schemes for this collaboration.

In addition to the management of assets shaping the urban infrastructures, targeted security and protection plans will be specified together with contingency plans that take into account the interdependencies between essential assets and services and the critical ones in order to ensure their correct operation and fast recovery in case an incident occurs (related to security or operation). These plans will be based on new surveillance and crisis management technological systems for the infrastructures operators (mainly private ones) that must interoperate with the management and coordination systems of the security and civil protection and emergencies systems.

Cyber-security

Technology area	Horizontal [6.5]: **Security**
Grouped items identification and coding	PESI.9
Technology / Function	Function/Technology
Social challenges	Health Food Marine and Maritime Research Energy Transport Environment and Efficiency Social Changes and Innovations Economy and Digital Society Security
Relevance for the city	HIGH
Application (term)	SHORT

Industrial control and automation systems of the supply systems and networks (energy, water), infrastructures and means of transport as well as certain essential services of the city (lightning, traffic) are especially vulnerable to cyber-attacks since they rely on telecommunication public networks (data and action commands transmission). Information and .

telecommunication systems of essential services (health, government, public safety and emergencies) are also exposed to these risks. For this reason, their logical protection must be ensured to the maximum throughout specific cyber-security strategies and tools for these systems.

6.5.4 Materials

Materials are a strongly transversal element in the classification introduced in this document. This is due to the fact that many technologies, processes or services offered to smart city citizens require advanced or special materials that directly provide fundamental properties or functionalities (for example for people's safety or health), or indirectly serve as support elements (for example for transport, information storage, energy, water, etc.).

Advanced materials

Technology area	Horizontal [6.5]: Materials
Grouped items identification and coding	MT.1, MT.2, MT.3
Technology / Function	Function/Technology
Social challenges	Health Food Marine and Maritime Research Energy Transport Environment and Efficiency Social Changes and Innovations Economy and Digital Society Security
Relevance for the city	MEDIUM
Application (term)	SHORT

Among the most adequate materials for the transformation concept involved in the evolution of communities towards smart cities, this document highlights those advanced materials that play a relevant role on their own without being a constituent part of other elements, thus providing added value when improving any kind of urban infrastructure in terms of efficiency, durability or performance, or providing benefits in the field of sustainability or comfort for the citizens.

Outstanding characteristics of advanced materials include, besides their intrinsic functionality and sustainable character, greater robustness and simple maintenance with anti-fatigue systems and physical elements, self-diagnosis, self-repairable or anti-vandalism, new possibilities of low cost purchasing and maintenance, and where appropriate easy and cost-effective replacement of pieces. In short, materials adapted from the design step to the citizens needs that enable improved interaction with the user and therefore become friendlier.

One of the main advantages of new advanced materials will be adaptability, as they are designed for operating mostly in a passive way —without energy consumption—, being capable of providing controlled responses under specific stimuli, bearing extraordinary conditions or adjusting their functionality to actual needs. Some of these new materials will also be accompanied by technologies for adapted arrangement/installation and on-site manufacturing in order to create custom applications (for example: additive manufacturing at the destination point, flexible and modular installation systems, etc.).

7

BARRIERS AND OPPORTUNITIES

Málaga, Malagueta beach and Bullring.

Barriers for the development of smart cities are associated to technological aspects, regulatory aspects and mainly to the lack of financing mechanisms that foster the deployment beyond planning and piloting. In particular, the following **barriers** are highlighted:

Financial aspects are related to the need of making the benefits obtained by citizens and enterprises operating in the smart city tangible and, based on these tangible benefits, developing business plans for supporting the deployment of new solutions, products and services. The economic crisis Europe and in particular Spain are facing hampers the access to bank credit. Under this framework specific funding plans starting at the European and Spanish administration are of great importance.

Some solutions in the smart cities require the use of a great amount of information (consumption behaviour, travelling behaviour, etc.) including private data from citizens. Therefore, the challenge is to create value and develop solutions from this data while guaranteeing this information's privacy

Frameworks at the different regulatory levels (local, autonomic, national, European) must be created enabling different solutions to compete and an agile promotion of the required changes for new ways of doing things, technologies to be deployed and their associated functionalities.

Many solutions currently possible in terms of technical needs involve a change in citizens' behaviour in order to be implemented.

Lack of standardization is an important barrier in any field for the massive deployment of solutions. The existence of a standardization able to ensure interoperability is a basic principle that fosters price reduction due to increased competition and sustainability of solutions towards the future.

Solutions usually require the collaboration between different sectors or areas within municipalities that are not always coordinated or do not have the same priorities.

Public administration dynamics hamper the adoption of novel solutions that in many cases are unique and involve an extra initial cost compared with conventional solutions. In this regard, incentives such as innovative public procurement help facilitate the first purchase of novel solutions, which makes overcoming this barrier possible

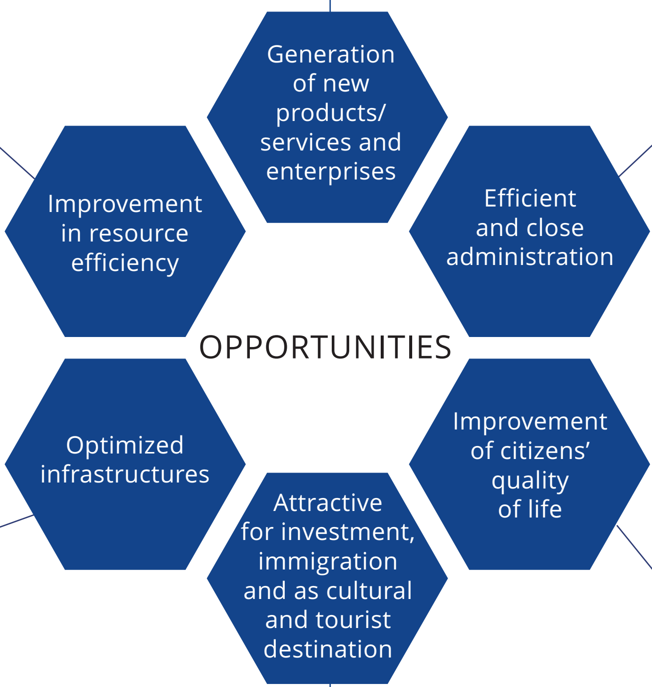
The extrapolation of successful solutions from one city to another is one of the working principles in cities. These solutions can be easily extrapolated but sometimes it is necessary to adapt them to the particularities of each city (both physical and social).

In any case, they also represent important **opportunities** that are incentives for progressing in this area:

Enterprises capable of implementing and spreading novel solutions that involve progress in cities sustainability will achieve in general terms an increase in turnover, or the emergence of new products/services lines, or even new enterprises.

Smart cities imply the sustainable use of the environment and of natural resources, both in terms of energy and water consumption, as well as in recycling and recovering energy from waste, etc.

The improvement of the administration regarding its operation and its relationship with the citizens will end up in a better assessment coming from the citizens and a reduction in management costs regarding the relationships with the administration and also with enterprises.



More rational use of infrastructures by deleting congestions and extending their service life.

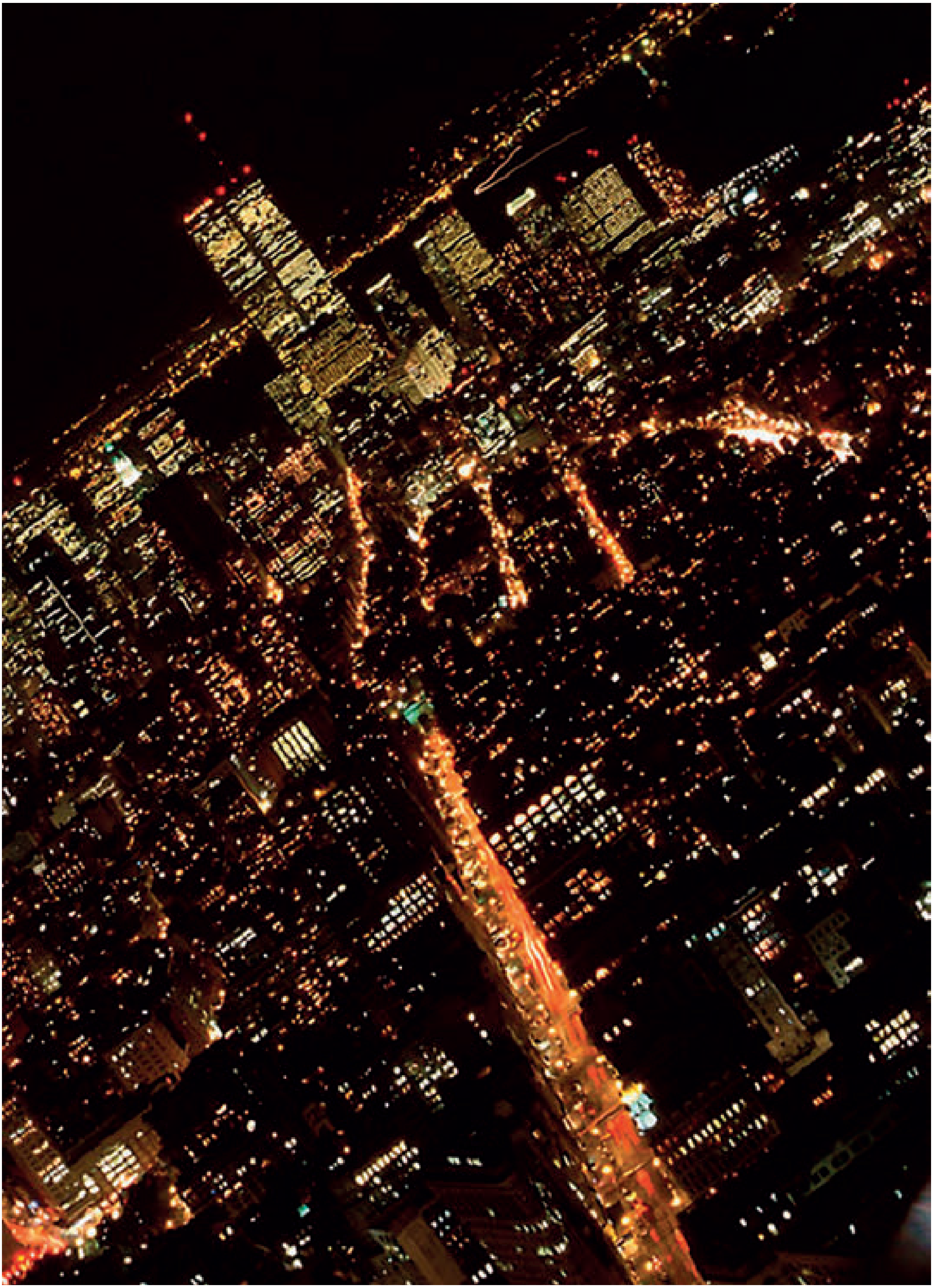
Without forgetting that a city is defined to a large extent by its population density, the smart city enables their citizens to improve their quality of life by implementing solutions that make their life more comfortable, healthier, longer and more independent, encouraging an improved integration between people and environment.

Due to the benefits stated before, cities scoring higher in the smart cities ranking will have a greater demand as destination for living or being visited.

8

ANNEXES

Seville, Alamillo Bridge.



[8.1] Annex 1. Matrixes of technological elements

The following tables show the technical support on which the document is based and its methodology is explained in the sections 5 and 6 of the document.

In the table of technological Elements "MICRO" (total 142) the characteristics of the technological elements that Platforms have identified as relevant for urban atmosphere relative to their application fields are covered. These "MICRO" elements are consolidated in the elements "MACRO" (total 49), which are grouped in entities of higher level called lines (total 16), which are simultaneously grouped in technological areas (total 5).

The contents of the table are described and table elements "MACRO" and "MICRO" are included in the following lines.

Each technological "MICRO" element includes:

- An **identificator**, whose codification consists of a platform acronym and a number (e.g. M2F.1 for the first element of the Technological Platform of Automotive - Move 2 Future).
- The **platform name** that has identified the element.
- **Title of the element.**
- The **area**, the **line** and the "MACRO" **element** to which is linked.
- **Classification in technology or function**, depending on if the "MICRO" element is linked to the technology or if, on the contrary, it is referred to a functionality in the smart city field.
- The **relevance grade** for a **Smart City** (High/ Medium/ Low).
- The **temporary horizon for application** (short/ medium/ long term) depending on the immediate future, 5-10 years or from 10 years for the implementation.
- **Challenges of the Society** to which it is linked.
- Detailed **description**.

In total, 142 "MICRO" elements have been identified.

“MICRO” technological elements

Identi-ficator	Platform	Technological element	Area	Line/ Application	MACRO element	Technology/ function	Relevance grade for a Smart City	Aplicación (CML plazo)
F.1	FUTURED	Automation of the electrical grid	Energy and Environment	Energy networks management	Electricity networks	Function	high	short
F.2	FUTURED	Intelligent meter boxes	Energy and Environment	Energy networks management	Electricity networks	Technology	high	medium
F.3	FUTURED	Power electronics	Energy and Environment	Energy networks management	Electricity networks	Technology	high	short / medium
F.4	FUTURED	Energy storage management	Energy and Environment	Energy resources	Storage management	Function	medium	long
F.5	FUTURED	Demand management	Energy and Environment	Energy resources	Demand integration	Function	high	medium
F.6	FUTURED	Generation management	Energy and Environment	Energy resources	Renewable energy and dis-tributed genera-tion integration	Function	high	medium
F.7	FUTURED	Energy storage through electric vehicle	Energy and Environment	Energy resources	Storage management	Technology	medium	long
F.8	FUTURED	ICTs for smart grids	Energy and Environment	Energy networks management	Electricity networks	Technology	high	short
F.9	FUTURED	New components for electric grids	Energy and Environment	Energy networks management	Electricity networks	Technology	medium	medium
F.10	FUTURED	Renewable energy integration	Energy and Environment	Energy resources	Renewable energy and dis-tributed genera-tion integration	Function	high	medium
M2F.1	M2F	Light electric vehicles	Mobility and Intermodality	Vehicles in the urban environment	Less pollutant vehicles	Technology	high	medium
M2F.2	M2F	Less polluting vehicles for urban services	Mobility and Intermodality	Vehicles in the urban environment	Less pollutant vehicles	Technology	medium	short
M2F.3	M2F	Electric vehicles for urban services	Mobility and Intermodality	Vehicles in the urban environment	Less pollutant vehicles	Technology	high	medium / long

Social challenges								Description	Identificator
		x						The increase in automation of city grids allows the improvement of the service's quality.	F.1
		x						With the activation of functionalities such as remote reading and remote power control, deployment of smart-metering stands as an essential demand management tool.	F.2
		x						Power Electronics shows up more and more in both consuming and generating equipment that is connected to the grid. The grid will slowly incorporate power electronics in its own facilities. Coordination of all these electronics will allow the optimization of distribution resources.	F.3
		x						Energy storage will play a crucial role in intelligent cities because the stationary energy systems minimize the fluctuation effects of the introduction of non-manageable energies such as renewable ones and stabilize the offer/demand curve.	F.4
		x		x				As services of a distribution grid in smart cities management of electric demand and energetic efficiency will contribute to increasing supply security, moderating demand growth, decreasing generation costs and the necessity of constructing new electric infrastructures.	F.5
		x						Future distribution grids will have to be measured to support the introduction of distributed generation found in urban and suburban setting. That generation will be renewable in great measure and must be as manageable as small-scaled cogeneration.	F.6
		x	x					Management as storage of the electric vehicle will allow the optimization of the cities' energy resources. Current electric vehicles are considered demand and are included in demand management.	F.7
		x				x		The need to monitor and control the grid is more precise way needs the deployment of a communication grid parallel to the electric grid and the creation of grid management systems close to the client (medium and low tension). Increased control will improve the service's quality.	F.8
		x						The creation of new conductive materials whose characteristics allow the distribution of high-density energy with low losses, reduced volume and weight, low cost and manageable must be prioritized.	F.9
		x		x				The deployment of a new supply structure that allows the integration of new generation from renewable sources that will reach the promised energy goals and maintain the necessary service stability and quality is necessary.	F.10
			x					To reach the emission reduction in urban settings the development and deployment of light electric vehicles for urban use, including 2 wheeled vehicles (bicycles, motorcycles), tricycles, quadricycles and microcars (up to 700 kg) is necessary.	M2F.1
			x					With that same objective, deployment of less contaminant vehicles for urban services (merchandise delivery, service and urban buses fleets) with "cleaner" fuels (natural gas, bio methane, biofuels, GLP) is necessary.	M2F.2
			x					And additional step in the reduction of emissions in urban settings is the development of electric vehicles (hybrids and electric with battery and fuels batteries) for urban services (merchandise delivery, service and urban buses fleets).	M2F.3

Identi-ficator	Platform	Technological element	Area	Line/ Application	MACRO element	Technology/ function	Relevance grade for a Smart City	Application (SML term)
M2F.4	M2F	Safe and connected vehicles	Mobility and intermodality	Vehicles in the urban environment	Safe and connected vehicles	Technology	high	medium
M2F.5	M2F	New materials and technologies for vehicles	Mobility and intermodality	Vehicles in the urban environment	New Materials and Technologies for Vehicles	Technology	medium	medium
M2F.6	M2F	Infrastructures for alternative fuels and recharge stations for electric vehicles	Buildings and infrastructures	Road infrastructures	Alternative fuels infrastructures	Function	medium	short / medium / long
M2F.7	M2F	Management and maintenance systems for fleets	Mobility and intermodality	Logistics and urban fleet management	Fleets Management and Maintenance Systems	Technology	medium	short / medium / long
M2F.8	M2F	Intelligent systems and services for urban area vehicles	Mobility and intermodality	Intelligent transport systems - ITS in the urban environment	Integrated systems for the management of sustainable mobility	Technology	high	short / medium
M2F.9	M2F	ITS for public transport	Mobility and intermodality	Intelligent transport systems - ITS in the urban environment	ITS for urban transport	Function	high	short / medium
FE.1	PTFE	Intelligent railway management systems	Mobility and intermodality	Intelligent transport systems - ITS in the urban environment	ITS for rail transport	Technology	high	short / medium
FE.2	PTFE	Construction of simulators that help optimise the use of energy in the main electric railways in Europe	Mobility and intermodality	Intelligent transport systems - ITS in the urban environment	ITS for rail transport	Function	medium	long
FE.3	PTFE	Use of railway energy surplus	Energy and environment	Energy resources	Energy Recovery	Function	high	short
			Mobility and intermodality	Intelligent transport systems - ITS in the urban environment	ITS for rail transport			
FE.4	PTFE	Energy efficient buildings	Buildings and infrastructures	Sustainable building	Zero energy buildings	Function	medium	short / medium
FE.5	PTFE	Guidance systems that greatly improve accesibility, mobility and direction of disabled and impaired people	Government and social services	Health and accessibility	Solutions and tools for accessibility	Technology	high	short / medium

Social challenges								Description	Identificator
			x					Deployment of driving assistance technology (ADAS) and cooperative systems (C2X) in vehicles will allow an increase in security levels for their occupants and the vulnerable users surrounding them by avoiding accidents and diminishing their consequences and improving mobility.	M2F.4
			x					Development and application of new technologies and materials in vehicles, especially in urban use ones, as well as the specific security systems for vehicles and their environment.	M2F.5
			x					Creating or increasing alternative fuel (gas, biofuels, hydrogen) and electric vehicles recharge infrastructures is necessary to facilitate the deployment and an ample use of cleaner vehicles in urban areas.	M2F.6
			x					Development of management and maintenance systems for electric vehicle and alternative fuel vehicle fleets. These systems should include vehicle sharing systems, parking reservations, pricing and payment.	M2F.7
			x					Development and deployment of comprehensive traffic management systems, available in formation systems, parking reservation systems and recharge stop systems and alternative fuel infrastructure systems. Information management and HMI.	M2F.8
			x					User information systems, traffic and public transport management integration, intermodality, security, simplification or integration of public transport payment processes.	M2F.9
			x			x		Intelligent management of energy optimizes and makes its use in railway systems sustainable. Distinguishing the main parameters that come together in energy consumption allows the optimization of available resources.	FE.1
			x			x		Knowing the main parameters that influence the different elements of the railway system in energy demand during operations and operative procedures, and identifying the technology and solutions that are capable of contributing to the optimization of the demanded energy.	FE.2
		x	x	x				Development of suitable systems that allow the use of energy surplus in the railway systems allows the use of non-contaminant vehicles which would improve life quality.	FE.3
		x	x	x				Construction of buildings that exploit renewable energy sources and reach energy consumption 0 allows savings and reduction of exterior dependence.	FE.4
x			x					Development of 3 already technically validated technologies in real operation conditions in Madrid Metro: 1) Magnetic technology (magnetic band in the pavement + a user's device capable of following walks effectively. 2) Guided by radiofrequencies (RFID) (sound markers that communicate with the users laptop). 3) Guided by Bluetooth markers connected to the users phone number.	FE.5

Identi-ficator	Platform	Technological element	Area	Line/ Application	MACRO element	Technology/ function	Relevance grade for a Smart City	Application (SML term)
BI.1	BIOPLAT	Biomass district HVAC	Energy and Environment	Energy networks management	Thermal networks	Function	high	short
BI.2	BIOPLAT	Biomass building HVAC (service sector and domestic sector)	Buildings and infrastructures	Sustainable building	Renewable Energy Integra-tion at Buildings	Function	high	short / medium
BI.3	BIOPLAT	Biofuels for transport	Mobility and intermodality	Vehicles in the urban environment	Less pollutant vehicles	Function	high	short
BI.4	BIOPLAT	Waste energy value	Energy and Environment	Energy resources	Energy recovery	Function	high	short
GE.1	GEOPLAT	Geothermal district heating and cooling	Energy and Environment	Energy networks management	Thermal networks	Function	high	short
GE.2	GEOPLAT	Geothermal building HVAC (service sector and domestic sector)	Buildings and infrastructures	Sustainable building	Renewable Energy integration at buildings	Function	high	short
GE.3	BIOPLAT + GEOPLAT	Use of renewable electric energy in cities	Energy and Environment	Energy resources	Renewable energy and distributed generation integration	Function	high	short
FO.1	FOTÓNICA21	Communication grids / fibre optics	Horizontal	ICTs	Communication networks	Technology	high	short
FO.2	FOTÓNICA21	Augmented reality systems	Horizontal	ICTs	Display and image processing systems	Technology	medium	medium
FO.3	FOTÓNICA21	Water purifying and measurement systems	Energy and Environment	Environment	Water recycling and treatment technologies	Technology	high	short

Social challenges								Description	Identificator
		x		x				HVAC through the use of biomass substituting traditional fuels is a good bet for the future of cities as it allows the reduction of CO_2 emissions and helps save other fuels, as well as helping meet the sustainability objectives for 2020 and encourage the use of autochthonous raw material. On the other hand, district HVAC or district heating and cooling is a more efficient model that provides the user energy directly avoiding the need to manipulate and store fuels with the same economic and ambient advantages. They can also encompass a small number of homes to entire metropolitan areas. Urban HVAC grids are widespread in North and Center of Europe and are considered as a key efficient management of cities.	BI.1
		x		x				HVAC through the use of biomass substituting traditional fuels is a good bet for the future of cities as it allows the reduction of CO_2 emissions and helps save other fuels, as well as helping meet the sustainability objectives for 2020 and encourage the use of autochthonous raw material.	BI.2
		x	x	x				The use of biofuels for urban transport allows the creation of a more sustainable mobile park, which reduces the emissions of greenhouse gases to the atmosphere produced by rolling traffic in cities and helps the sustainability objectives of 2020, as well as encouraging the use of autochthonous resources. Biofuels are an effective to diminish the high environmental contamination that cities suffer nowadays.	BI.3
		x		x				Waste energy valuation is a measurement that contributes solutions to two problems: allowing the reduction of the volume of waste in cities and creating energy through a biomass source. This solution is being put into practice in center-European countries, where a double impact is produced: management of waste and generation of clean thermal energy for neighborhoods close to power stations. Producing Biogas suitable for introduction in the national gas grid is also possible.	BI.4
		x		x				HVAC through geothermal doesn't generate any visual impact (no chimneys nor external units) nor sound impact, it allows a drastic reduction of CO2 emissions and helps consumers save compared to other conventional fuels, among other benefits. It is and efficient and manageable HVAC model (available 24 hours a day 365 days a year) that will allow cities to diminish their energy dependence and their high pollution levels. District HVAC or district heating and cooling is a model with the same advantages, considered a key element for the efficient management of energy in cities because it contributes energy to building and homes from a sole focal point of generation.	GE.1
		x		x				HVAC through geothermal doesn't generate any visual impact (no chimneys nor external units) nor sound impact, it allows a drastic reduction of CO_2 emissions and helps consumers save compared to other conventional fuels, among other benefits. It is and efficient and manageable HVAC model (available 24 hours a day 365 days a year) that will allow cities to diminish their energy dependence and their high pollution levels.	GE.2
		x		x				Cities are the greatest drain of energy. A use of energy generated from renewable resources would contribute to the reduction of emissions and energy dependence, as well as using inexhaustible and autochthonous resources which would benefit the socioeconomic activity in the region. There are renewables technologies with a completely manageable generation model which will play and important role in the stabilization of grids in cities.	GE.3
x		x		x		x	x	Integrated photonics, optical interconnections, ultrafast communication networks and an increase of bandwidth to ease accessibility to health, security and other services (tele assistance, etc.). Decrease in data center consumption.	FO.1
						x		Availability of new ways of user-adapted information display(monument, transport, red tape information).	FO.2
x	x			x				Photonic systems for quality parameter measurement in water would allow a continuous control of its quality. Water purifying techniques also use UV irradiation by employing conventional lamps with a large drain of energy that could be substituted by more effective sources.	FO.3

Identificator	Platform	Technological element	Area	Line/ Application	MACRO element	Technology/ function	Relevance grade for a Smart City	Application (SML term)
FO.4	FOTÓNICA21	Air quality measurement systems	Energy and Environment	Environment	Environmental indicators and sensors	Technology	high	short
FO.5	FOTÓNICA21	Biomedical image	Government and social services	Health and accessibility	Advanced technologies for patient diagnosis, monitoring and intervention	Technology	medium	medium
FO.6	FOTÓNICA21	Phototherapy, minimal invasive techniques	Government and social services	Health and accessibility	Advanced technologies for patient diagnosis, monitoring and intervention	Technology	medium	medium
FO.7	FOTÓNICA21	Traffic monitoring systems	Mobility and intermodality	Intelligent transport systems - ITS in the urban environment	Traffic management systems	Technology	high	short / medium
FO.8	FOTÓNICA21	Railway detection and monitoring systems (urban and long-distance)	Buildings and infrastructures	Urban elements management	Railway and road infrastructure management	Technology	medium	medium / long
FO.9	FOTÓNICA21	Lighting and light-signalling	Buildings and infrastructures	Urban elements management	Smart lighting	Technology	high	short
			Buildings and infrastructures	Sustainable building	New construction technologies			
FO.10	FOTÓNICA21	New sources of vehicle lighting (private and public)	Mobility and intermodality	Vehicles in the urban environment	New Materials and Technologies for Vehicles	Technology	medium	medium
FO.11	FOTÓNICA21	Observation, detection and monitoring photonic technologies for environments with different characteristics	Horizontal	Sensors	Detection, measuring and monitoring systems based on sensors	Technology	high	medium
FO.12	FOTÓNICA21	Chemical and biochemical parameter analysis and measurement photonic technologies	Horizontal	Sensors	Detection, measuring and monitoring systems based on sensors	Technology	high	short / medium
FO.13	FOTÓNICA21	Patient diagnostic and monitoring assistance photonic technologies	Government and social services	Health and accessibility	Advanced technologies for patient diagnosis, monitoring and intervention	Technology	high	short / medium
FO.14	FOTÓNICA21	Communication encyption and security photonic systems	Horizontal	ICTs	Communication Networks	Technology	medium	medium / long

Social challenges								Description	Identificator
x				x				Air quality monitoring systems in urban environments (atmospheric contamination measurement, contaminant substance detection, NRBQ parameter measurement).	FO.4
x						x		Image caption and processing technologies employing different devices (spectral bands, processing and caption strategies) as diagnostic, monitoring and intervention help.	FO.5
x						x		Photonic technology for therapy/treatment intervention and realization .	FO.6
			x	x				Photonics systems for monitoring and detection of traffic.	FO.7
			x				x	Technologies for detection of strange elements in infrastructure or technologies to monitor infrastructure or the vehicles that move around it.	FO.8
		x	x	x				Public and private lighting (new light sources, regulation and control systems, etc.). Use of hybrid lighting systems (natural and artificial light). Lit up traffic signs and vertical signs (traffic, advertising etc.).	FO.9
		x	x	x				Incorporation of more effective sources inside and outside public and private vehicles.	FO.10
						x	x	Border surveillance, environmental surveillance, etc. Systems that allow the detection of damaging substances (gasses, explosives, etc.).	FO.11
x	x						x	Border surveillance, environmental surveillance, etc. Systems that allow the detection of damaging substances (gasses, explosives, etc.).	FO.12
x								Early measurement techniques and devices for parameters related to pathology appearances.	FO.13
						x	x	Optic encryption technologies. Photonic security communication systems.	FO.14

Identi-ficator	Platform	Technological element	Area	Line/ Application	MACRO element	Technology/ function	Relevance grade for a Smart City	Application (SML term)
C.1	PTC	Infrastructures optimization	Buildings and infrastructures	Urban elements management	Railway and road infrastructure management	Function	high	medium
C.2	PTC	Security management	Buildings and infrastructures	Urban elements management	Railway and road infrastructure management	Technology	high	short
C.3	PTC	Sensor infrastructure	Buildings and infrastructures	Urban elements management	Railway and road infrastructure management	Technology	medium	medium
C.4	PTC	Safer, more efficient and sustainable road surfaces	Buildings and infrastructures	Road infrastructures	More sustainable pavements	Technology	medium	medium
C.6	PTC	Energy integration sources	Energy and Environment	Energy resources	Renewable Energy and Distributed Generation Integration	Technology	medium	medium
GICI.1	FUTURED	Energy recuperation	Energy and Environment	Energy resources	Energy recovery	Technology	high	medium
C.7	PTC	Energy recuperation	Energy and Environment	Energy resources	Energy recovery	Technology	medium	long
C.8	PTC	Material reuse	Energy and Environment	Environment	Sustainable waste management	Technology	medium	short
C.9	PTC	Product econaming	Energy and Environment	Environment	Environmental indicators and sensors	Function	medium	short
C.10	PTC	Conectivity improvement	Buildings and infrastructures	Urban elements management	Connectivity improvement	Function	medium	short
C.11	PTC	Promotion of cooperation between different forms of transport	Mobility and intermodality	Intelligent transport systems - ITS in the urban environment	Integrated systems for the management of sustainable mobility	Technology	medium	medium
C.12	PTC	Pricing systems establishment	Mobility and intermodality	Intelligent transport systems - ITS in the urban environment	Traffic management systems	Function	medium	medium
PL.1	PLANETIC	Energy monitoring	Energy and Environment	Energy networks management	Electricity networks	Function	high	medium
PL.2	PLANETIC	Behavior models	Government and social services	Administration	Social integration	Function	medium	short
PL.4	PLANETIC	Internet of things	Horizontal	ICTs	Internet of things	Function	medium	long

Social challenges								Description	Identificator
			x					Improvement of road-state monitoring technologies in real-time, taking into account traffic intensity, incidences, adverse weather conditions, real speed and itinerary times.	C.1
			x	x				Monitored roads that capture and transmit information about its condition and contribute information for preventive maintenance and physical perimeter assurance.	C.2
			x			x	x	Infrastructure sensoring to generate real-time variable information and detect patterns for the management of road safety.	C.3
			x	x				New technologies, processes and mixes in pavement and road surface recycling.	C.4
		x	x					Renewables energy use and optimization of control and traffic systems' energy consumption, infrastructure signals...	C.6
		x		x				Valuation of city waste (solid urban waste and sewage) allows to extract energy from it. One form of this energy is methane, which when properly refined and purified is able to be injected in the gas distribution grid.	GICI.1
		x	x					Recuperation of rolling traffic energy. Exploitation techniques for the energy created by the passing of vehicles to feed management and traffic control systems and recuperation of solar energy and thermal energy from the pavement.	C.7
			x	x				Reuse of waste generated during construction and maintenance of roads..	C.8
			x	x				Econaming of products (according to use of recycled products, CO_2 emissions during production, durability and noise it produces).	C.9
			x		x			Promotion and improvement of the connection between different means of transport (road, railway, airway) to provide a good service to citizens joining people with social infrastructures (hospitals, schools, libraries, etc.).	C.10
			x		x			Development of integrated systems for itinerary planning and sustainable movement management in urban environments, based on the reception of traffic data in real-time coming from traffic control centers, sensors installed in infrastructure and nomad devices installed on private vehicles, taxis and fleets.	C.11
			x		x			Analysis of the establishment of a global pricing for the use of railway infrastructures.	C.12
		x						Systems to monitor, regulate, predict, distribute and manage both the consumption and the production of energy in and intelligent way.	PL.1
					x	x	x	To shape the behavior of the residents of a city and systems so the physical elements adapt to a better quality of life for people in their homes, neighborhood and city.	PL.2
		x	x	x			x	This element addresses technologies that allow people and things to be shaped and treated as inheritor entities of the same class. It is an abstraction that implies that people and things have a common interface and that the interaction occurs at an equal's level presenting a world of opportunities for Smart Cities.	PL.4

Identi-ficator	Platform	Technological element	Area	Line/ Application	MACRO element	Technology/ function	Relevance grade for a Smart City	Application (SML term)
PL.5	PLANETIC	Sustainability management	Government and social services	Administration	Sustainability Management	Function	high	short
PL.6	PLANETIC	Sensor technologies and systems	Horizontal	Sensors	Detection, measuring and monitoring systems based on sensors	Technology	high	short
PL.7	PLANETIC	Wireless self-management devices for electric and gas consumption	Energy and Environment	Energy networks management	Electricity networks	Technology	high	Largo
PL.9	PLANETIC	Remote control devices for electric, water, gas, traffic, lighting grids, ...	Horizontal	Sensors	Smart devices	Technology	high	Largo
PL.10	PLANETIC	Communication grids	Horizontal	Information and Communication Technologies (ICTs)	Communication networks	Technology	high	medium
PL.11	PLANETIC	Cloud computing	Horizontal	ICTs	Computing infrastructure	Technology	medium	short
PL.12	PLANETIC	Intelligent interfaces	Horizontal	ICTs	Display and image processing systems	Technology	medium	long
PL.13	PLANETIC	Artificial intelligence	Horizontal	ICTs	Design and development of software applications	Technology	high	long
PL.14	PLANETIC	Data management systems (Big Data)	Horizontal	ICTs	Data Management and Analysis Systems (Big Data)	Technology	high	medium
PL.15	PLANETIC	Web services supply	Horizontal	ICTs	Design and development of software applications	Technology	high	medium
PL.16	PLANETIC	SW engineering	Horizontal	ICTs	Design and development of software applications	Technology	medium	medium
PL.17	PLANETIC	Process optimization	Horizontal	ICTs	Design and development of software applications	Technology	medium	short
EE.1	EFICIENCIA ENERGÉTICA	Legalization and regulations	Government and social services	Administration	Urban Planning and New Services at the City	Function	medium	medium

Social challenges								Description	Identificator
				x				Auto sustainability systems for cities monitoring, evaluating and making decisions about basic city parameters.	PL.5
x	x	x	x	x	x	x	x	Wireless sensor grids; physical and environmental monitoring parameters, home automation and inmotics, Smartphones, energy efficiency (generation, distribution, consumption): smart grid, smart metering; Medicine (tele diagnostic/ambient assisted living, Point of Care diagnostic systems...): Health (Falls, walk analysis, EDG, etc.); urban: luminous contamination, waste management, noise measurement, open parking spot measurement, transport; vehicle location, traceability, Passive and active RFIDS (Intelligent Tags).	PL.6
		x		x				Gateways, final nodes, routers.	PL.7
		x	x	x				Hubs: RTU (Remote terminal units); PLC (Programmable logic hub); IED (Intelligent electric devices).	PL.9
x	x	x	x	x	x	x	x	Fixed, Mobiles; M2M; vehicle-vehicle and vehicle infrastructure, New information systems in vehicles (ITS).	PL.10
						x		IaaS, PaaS, SaaS	PL.11
						x		Man-machine interaction; advanced information systems for users; natural language processing; real-time graphics; artificial vision, augmented reality; capture, movement analysis and reconstruction.	PL.12
						x		Context modelling; learning systems (neuronal grids, genetic algorithms, etc.); semantics grids; decision-making grids (expert systems, multi-agent systems, etc.); action and intelligent feedback diagnostic systems.	PL.13
						x		Analysis and supply of great amounts of data, including multimedia. It includes the purchase of smart city data that comes from sensors and other sources; process and analysis of both; reuse, because using data for application in smart cities is as important as gathering it; and interoperability between different data sources.	PL.14
						x		Simulation and display; training simulators; public transport optimization, data distribution and management; incident analysis and diagnostics; identity, privacy and security.	PL.15
						x		App development; software modeling, CPS (Cyber-Physical Systems); Interoperability; Middleware.	PL.16
						x		Forecasting (forecast of demand); Scheduling; Routing.	PL.17
x	x	x	x	x	x	x		Legalization and regulations consists in deploying a planning and regulating acts compatible with urban energy markets.	EE.1

Identi-ficator	Platform	Technological element	Area	Line/ Application	MACRO element	Technology/ function	Relevance grade for a Smart City	Application (SML term)
EE.2	EFICIENCIA ENERGÉTICA	New services and business model	Government and social services	Administration	Urban planning and New Services at the City	Function	high	medium
EE.4	EFICIENCIA ENERGÉTICA	Efficiency in use and management of energy	Energy and Environment	Energy resources	Demand integration	Function	high	short / medium
EE.5	EFICIENCIA ENERGÉTICA	Social awareness	Government and social services	Administration	Social integration	Function	high	long
TH.1	THINKTUR	Electronic-Point-of-Sale systems (EPOS systems)	Government and social services	Urban promotion	Citizen-services connection	Function	medium	medium
TH.2	THINKTUR	Personalised Recommendation System	Government and social services	Urban promotion	Citizen-services connection	Function	medium	medium
TH.3	THINKTUR	Energy Management Systems (EMS)	Energy and Environment	Energy resources	Demand integration	Technology	high	medium
TH.4	THINKTUR	DMS Destination Management System / Advanced	Government and social services	Urban promotion	Citizen-services connection	Function	high	short
			Government and social services	Urban promotion	Smart tourism management systems			
TH.5	THINKTUR	Bioindicators and biosensors	Energy and Environment	Environment	Environmental indicators and sensors	Function	medium	medium
TH.6	THINKTUR	Waste management systems	Energy and Environment	Environment	Sustainable waste management	Function	high	short
TH.7	THINKTUR	Sustainable transport	Mobility and intermodality	Intelligent transport systems - ITS in the urban environment	ITS for urban transport	Technology	high	short
TH.8	THINKTUR	Location-based services	Government and social services	Health and accessibility	Sensors and health information Systems	Function	medium	medium
LO.1	LOGISTOP	Traffic management systems	Mobility and intermodality	Intelligent transport systems - ITS in the urban environment	Traffic management systems	Technology and function	medium	short / medium
LO.2	LOGISTOP	Electric/hybrid vehicle for merchandise transport	Mobility and intermodality	Vehicles in the urban environment	Less pollutant vehicles	Technology	medium	medium / long
LO.3	LOGISTOP	Urban merging centers	Mobility and intermodality	Logistics and urban fleet management	New logistic platforms in the city	Function	medium	short

Social challenges								Description	Identificator
x	x	x	x	x	x	x		New Services and business models for cities associated to energy efficiency, identifying training needs, institutional support, regulation, as well as new market creation methods.	EE.2
x	x	x	x	x	x	x		Efficiency in the use and management of energy in cities drives the optimization of energy use and management with the objective of obtaining additional improvements in savings and responsible consumption. TIC applied to energy efficiency, monitoring, active management of demanded energy can be included in the element.	EE.4
x	x	x	x	x	x	x		Social consciousness makes proposals in different areas of society; consumers, professionals, scientists, etc. Collecting cities' needs to promote the demanded energy and professional and scientist's availability.	EE.5
	x		x		x	x		Electric sale point systems allow an increase in citizen-service-establishment interaction and an improvement in a visitors experience in the city.	TH.1
			x		x	x		Recommendation systems will make access for citizens to service information that better adjusts to their profile based on other users information easier.	TH.2
		x		x				Solutions that make the reduction of energy use easier. They can be activated through different devices and operate in the group of establishment of the city (hospitals, hotels, schools, public building, etc.).	TH.3
x			x	x	x		x	Systems created to increase the efficiency and effectiveness in daily management of tasks, products, resources, services that encompass the cities.	TH.4
			x	x				Development of bio indicators and biosensors for the detection of contaminants in final products for a better quality of life and safety.	TH.5
		x	x	x	x			Systems oriented toward the development and implementation of: Improvement of control and follow-up of waste through TICs. Control and follow-up of pollution. Use of polluting substances present in waste.	TH.6
		x	x	x				Development and application of technologies and intelligent transport systems (ITS) to vehicles and management of fleets, infrastructures and demand (mobility).	TH.7
					x		x	Location of risk group systems.	TH.8
			x			x		Availability and use in real-time of information such as traffic, infrastructure availability etc. for logistic operators and other stakeholders that allows a more efficient traffic management, a better infrastructure management and a decrease of urban transports carbon footprint. This would include the use of ITS, C-ITS, parking-space availability sensors technologies etc.	LO.1
		x	x	x				Use of hybrid/electric vehicles for merchandise urban distribution on a larger scale in cities will help decrease its carbon footprint and noise-level.	LO.2
			x					These facilities allows savings in costs and number of trips required for merchandise delivery, helping diminish $C0_2$ emissions and decreasing city traffic.	LO.3

Identi-ficator	Platform	Technological element	Area	Line/ Application	MACRO element	Technology/ function	Relevance grade for a Smart City	Application (SML term)
LO.4	LOGISTOP	Last-mile collaborative platforms	Mobility and intermodality	Logistics and urban fleet management	New logistic platforms in the city	Technology and function	high	medium / long
LO.5	LOGISTOP	Modular containers	Mobility and intermodality	Logistics and urban fleet management	New logistic models	Technology	high	medium
LO.6	LOGISTOP	Automated drop points	Mobility and intermodality	Logistics and urban fleet management	New logistic platforms in the city	Technology	high	medium
LO.7	LOGISTOP	Reverse logistic efficient management	Mobility and intermodality	Logistics and urban fleet management	New logistic models	Function	medium	short / medium
LO.8	LOGISTOP	Use of socials networks to promote sustainable passenger transport	Mobility and intermodality	Intelligent transport systems - ITS in the urban environment	Integrated systems for the management of sustainable mobility	Technology and function	medium	short / medium
CO.1	PTEC	Establishment of renewable energies in construction	Buildings and infrastructures	Sustainable building	Renewable energy integra-tion at buildings	Function	high	short / medium
CO.2	PTEC	District heating and cooling	Energy and Environment	Energy networks management	Thermal networks	Technology	high	short / medium
CO.3	PTEC	Energy storage	Energy and Environment	Energy resources	Storage management	Technology	medium	medium
CO.4	PTEC	District and building restoration and preservation	Buildings and infrastructures	Sustainable building	Zero energy buildings	Technology	high	short / medium
CO.5	PTEC	Urban planning	Government and social services	Administration	Urban planning and New Services at the City	Function	high	long
CO.6	PTEC	Building and district energy management	Energy and Environment	Energy resources	Demand integration	Technology	high	short/ medium

Social challenges								Description	Identificator
			x			x		Platforms that make sharing logistical information between last mile operators possible to be able to share delivery vehicles and improving logistical efficiency, reducing traffic and increasing vehicle load factor. Above all the objective would be to share delivery planning information of various OLs and their routes so that delivery routes that use maximum capacity of vehicles are planned. These information sharing platforms can also have other common services associated such as package traceability and route incident management. Normally these platforms are associated to collaborative strategies between OLs that could work in certain urban spaces with access problems, and where a regulating entity (normally local corporation) also intervenes.	LO.4
			x			x		Modulating of logistical units and containers is an area with lots of potential improvement. On the one hand, displays between long distance logistics and urban logistics are inefficient, and part of the problem is a lack of modulating of size in vehicles and containers. Nowadays urban delivery is done with large trucks, blocking traffic. One solution could be a larger module (container or mobile box on a trick) for long distance, which contained a multiple number of urban delivery containers that would go in smaller vehicles for a better use, and the transfer would be made through automated handling. Urban containers, already prepared for last-mile distribution, would allow a better use of vehicles' space and would produce less traffic problems. The example could be applied to other intermodal displays. This work area is a road towards the concept of physical internet for logistics, through which they try to standardize logistical units in modules, just like data packaging in digital internet.	LO.5
			x			x	x	The idea is a design and use of merchandise delivery points in the form of automatic offices or similar, that can be used by any logistical service supplier and any client, guaranteeing safety and reliability of delivery and traceability for the addressee. The location of these delivery points is something to be considered.	LO.6
			x	x				Exploiting the same pick-up point grid to support product returns of different retailers, to reduce this type of traffic.	LO.7
			x			x		Exploit the potential of social networks to identify coincidences of people who make the same trip and promote shared use of private vehicles or combined with electric vehicles.	LO.8
		x		x				Moving towards a zero GHG emission building model whose energy balance tends to be zero or positive is necessary.	CO.1
		x		x				Energy distribution and generation systems must be promoted to supply building on a neighborhood scale and even city scale due to the improvement they have on global energy efficiency.	CO.2
		x		x				Energy storage is a priority when enhancing the use of generation systems based on renewable energy and energy management.	CO.3
		x		x				A complete renovation that allows a substantial reduction in energy consumption is necessary due to the current state of buildings. It must be made so that achieving an energy autonomous building model or even a positive energy model is possible. Maintaining the building park, especially the historic and heritage.	CO.4
			x	x				Urban planning is an essential aspect to improve quality of life in cities.	CO.5
		x		x				Energy management is a key aspect in optimization of energy use and comfort. District and city scale is essential.	CO.6

Identificator	Platform	Technological element	Area	Line/ Application	MACRO element	Technology/ function	Relevance grade for a Smart City	Application (SML term)
CO.7	PTEC	Building and infrastructure accesibility	Government and social services	Health and accessibility	Solutions and tools for accessibility	Function	high	short / medium
CO.8	PTEC	Construction processes	Buildings and infrastructures	Sustainable building	New construction technologies	Function	high	short / medium
CO.9	PTEC	Infrastructure sensoring	Buildings and infrastructures	Urban elements management	Railway and road infrastructure management	Technology	high	short / medium
A.1	PTEA	New water technologies	Energy and Environment	Environment	Water recycling and treatment technologies	Technology	high	medium
A.2	PTEA	Water storage	Energy and Environment	Environment	Water recycling and treatment technologies	Technology	high	short
A.3	PTEA	Urban elements	Buildings and infrastructures	Road infrastructures	More sustainable pavements	Function	high	short
A.4	PTEA	Road surfaces	Buildings and infrastructures	Road infrastructures	More sustainable pavements	Function	high	short
A.5	PTEA	Covers and plant walls	Buildings and infrastructures	Sustainable building	New construction technologies	Function	medium	medium
A.7	PTEA	Recycled water stations	Energy and Environment	Environment	Water recycling and treatment technologies	Function	medium	medium
A.8	PTEA	Water-treatment stations	Energy and Environment	Environment	Water recycling and treatment technologies	Technology	high	long
MK.1	MANU-KET	Incorporation of electronic sensors and communication elements in capital goods for grid infrastructure	Horizontal	Sensors	Smart devices	Function	high	short / medium / long

Social challenges								Description	Identificator
			x		x			Addressing complete solutions to improve accessibility is necessary in society.	CO.7
		x		x			x	Construction process is key for cities. Their efficiency and adaptation to their environment make up the key to quality of life in cities.	CO.8
		x	x	x		x		Sensors for infrastructures to monitor and control their condition, which would allow to adjust maintenance plans and collect information quickly after natural disasters (floods, earthquakes).	CO.9
x		x		x	x	x	x	Impacts of diverse typology: – Improvement of superficial and subterranean water quality. – Relieve effects of “heat island”. – Generate CO_2 drains. – Direct involvement in climate change (palliative measure).	A.1
x	x			x	x		x	Differences in water cost and evolution of price (Socioeconomic impact), Risks/derived costs, local storage as guarantee of supply: – Collection and storage of water in warehouse over and underneath the building. – Reuse of rainwater for cleaning, bathrooms...	A.2
x		x		x	x		x	Design and selection of pavement to reduce impacts: – Increase infiltration capacity under cities. – Reduce Heat Island Impact. Know each pavements (material behavior and choose it based on conditions: – Permeability and deceleration flow behavior is a relevant value for urban surface behavior (floods) – Thermal pavement behavior affects urban environment (Heat island) – The climate and the ground tipology are key factors in the desing and pavement selection phases	A.3
x				x				Larger creation of permeable areas in cities. Larger presence of sustainable urban drain systems. Design of basic urban elements with a larger functionality: Curbs, roundabouts.	A.4
x	x			x				Covers on roofs, walls and around fronts of buildings for larger connectivity. Urban gardens. Functions: – Recovery of “lost” natural ground. – Rainwater management once it reaches the city.	A.5
x			x	x			x	Recycling systems in the own building. Transform urban elements into water storage zones Reduce the “Heat island” effects and create CO_2 drains	A.7
x				x		x		Purifying through membranes/Treatment in itinere.	A.8
		x	x	x		x	x	New communication needs and provisioning of higher intelligence and interconnectivity (M2M) of urban equipment through electronic sensors imply the design of a new generation of equipment, development and testing in pilot or technical viability presentation project, and above all else, economic project in grid urban infrastructures context. Advanced production technologies can contribute to a massive implementation of these kind of electronic devices and ICTs in urban sphere facilitating the effective integration of different infrastructure grids (transport, environment, energy, water, security, citizen information, social services).	MK.1

Identi-ficator	Platform	Technological element	Area	Line/ Application	MACRO element	Technology/ function	Relevance grade for a Smart City	Application (SML term)
MK.2	MANU-KET	Incorporation of electronic sensors and communication elements in medical goods	Government and social services	Health and accessibility	Sensors and health information systems	Function	medium	medium / long
FV.1	FOTOPLAT	Renewable energy incoporation	Energy and Environment	Energy resources	Renewable energy and distributed generation integration	Technology	high	short / medium
FV.2	FOTOPLAT	Architectural incorporation	Buildings and infrastructures	Sustainable building	New construction technologies	Technology	high	short / medium
FV.3	FOTOPLAT	Nearly Zero-consumption Buildings	Buildings and infrastructures	Sustainable building	Zero energy buildings	Function	high	medium / long
FV.4	FOTOPLAT	Energy storage management	Energy and Environment	Energy resources	Storage management	Technology	high	medium / long
EV.1	eVIA	Urban mobility support solutions	Mobility and intermodality	Intelligent transport systems - ITS in the urban environment	Integrated systems for the management of sustainable mobility	Function	medium	short
EV.2	eVIA	Medical information security systems	Government and social services	Health and accessibility	Sensors and health information systems	Technology/ function	high	medium
EV.3	eVIA	Medical sensor grids	Government and social services	Health and accessibility	Sensors and health information systems	Technology	medium	medium
EV.4	eVIA	Self-management health applications	Government and social services	Health and accessibility	Sensors and health information systems	Function	high	medium
EV.5	eVIA	Social integration and inclusion tools	Government and social services	Administration	Social integration	Function	medium	medium
EV.6	eVIA	Tourist accesibility applications	Government and social services	Urban promotion	Smart tourism management systems	Function	medium	medium

Social challenges								Description	Identificator
x								The new model of healthcare in urban environments includes the introduction of intensive devices in ICTs and smaller electronic sensors with higher benefits, and higher interactivity systems. They are systems with higher added value.	MK.2
		x						Incorporation of energy in electric grids as distribution generation is one of the strong points of photovoltaic technology due to the nearness of the generation to the consumption points. This will allow savings in energy transport and will eliminate the need of so many grid developments.	FV.1
		x						Apart from achieving what has already been said in renewable energy incorporation, architectural incorporation is trying to substitute specific passive elements of buildings into active elements that produce electricity.	FV.2
		x						Zero-consumption building will be demanded in a short period of time, because in 2018 all Public building must comply with the definition of the European Directive, and in 2020 private buildings will have to meet certain requirements. Therefore they will need to be efficient with energy consumption and also provide generation elements that allow the building to be energetically self-sufficient.	FV.3
		x						Storage is one of the key factors for incorporation of solar photovoltaic energy in the grid, considering that it is a non-manageable energy, incorporating storage elements will allow its manageability.	FV.4
			x		x			Support solutions for urban mobility (accessible route calculations on maps, real-time seasonal architectural barrier updating applications, etc.).	EV.1
x							x	Safety and trust elements for patients and medical professional's authentication, privacy and access to personal medial information and historic electric clinic. Relevant importance case: HCE and database patients accommodated in the cloud. Update of valid legislation (storage of clinical data outside the central hospital computer systems).	EV.2
x								Optimizing of medical sensor grids, interoperability with user cellphone terminals (mainly Smartphones) low-power sensors, for continuous and ubiquitous monitoring of patients through medical decision support applications [alarms, shared diagnostic, DSS Decision Supports Systems), etc.].	EV.3
x								Self management health systems and applications to promote healthy habits, prevention and light chronic illness treatments.	EV.4
					x	x		AICT applications for social and work introduction (social networks, specific interaction and information sharing communities between patient-patient, patient-doctor, patient-caregiver (formal or informal), doctor-doctor. Incorporation programmers for elderly people (work mentoring, active aging).	EV.5
x			x		x	x		ICT tools for city characterization as a tourist destination according to standard access criteria, as well as supply and update of said information and development of applications for their use. At both an individual level (hotel, public transport, restaurant, museum, tourist activities) and an integrated level.	EV.6

Identi-ficator	Platform	Technological element	Area	Line/ Application	MACRO element	Technology/ function	Relevance grade for a Smart City	Application (SML term)
HPC.1	PTEHPC	Hydrogen energy storage. Distributed storage and generation	Energy and Environment	Energy resources	Storage management	Technology	high	long
HPC.2	PTEHPC	No-emission road transport	Mobility and intermodality	Vehicles in the urban environment	Less pollutant vehicles	Technology	high	long
HPC.4	PTEHPC	Alternative fuel infrastructure: hydrogen	Buildings and infrastructures	Road infrastructures	Alternative fuels infrastructures	Technology	medium	long
GICI.2	FUTURED	Indicators	Government and social services	Administration	Sustainability management	Function	medium	medium
GICI.3	FUTURED	Electric administration	Government and social services	Administration	Social integration	Function	medium	long
PESI.1	PESI	Essential city services security	Horizontal	Security	Integral security and resilience	Function	high	long
PESI.2	PESI	Innovation in security services	Horizontal	Security	Security and protection of people, goods and assets	Function	medium	medium
PESI.3	PESI	Citizen participation in city security	Horizontal	Security	Security and protection of people, goods and assets	Technology/ function	high	long
PESI.4	PESI	City resilience, crisis management and government	Horizontal	Security	Integral security and resilience	Technology / Function	high	long

Social challenges								Description	Identificator
		x		x				Massive energy storage systems based on hydrogen use as an energy vector would contribute towards the Renewable energies participating more intensely in the electric mix. Exploitation of renewable electric surplus in valley hour consumption. Massive energy storage systems would contribute towards the Renewable energies participating more intensely in the electric mix. In moments of energy shortage and peak consumption moments, generation plants based on battery as fuel would generate electricity very efficiently (over 70%). Massive energy storage systems would contribute towards the Renewable energies participating more intensely in the electric mix. In moments of energy shortage and peak consumption moments, generation plants based on battery as fuel would generate electricity very efficiently(over 70%). Hydrogen storage would complement generation delivered through Renewable energies. Each consumer becomes an agent in the grid, generating, consuming or storing energy according to their capacity, needs, or interests at a family level, community level or local level.	HPC.1
x			x	x				Electric vehicles with battery as fuel(FCEV) allows more than 500km autonomy with "well to wheel" efficiency superior to current thermal engine vehicles. Improvement in efficiency along with the absence of emissions in urban areas would have positive effects on health, even if the main energy came from fossil fuel.	HPC.2
		x	x					The existence of different propulsion alternatives will give consumers more maneuvering room when choosing motorization that adapts to their needs, geographic area or purchasing power. Large regions of center and north Europe have already settled on hydrogen refuel infrastructure deployment, connecting them before 2030.	HPC.4
		x	x	x			x	This technological element refers to the ability that technologies have to help the development of processes that are completely compatible with urban environment, which allow management of cities' life cycle. On the one hand this can include self-sustainability systems for cities monitoring, evaluating and making decisions about basic city parameters, starting out from indicators defined by regulatory organisms.	GICI.2
x	x	x	x	x	x	x	x	Administration's ability to offer citizens paperwork electronically.	GICI.3
x	x	x	x	x	x	x	x	Essential city services, along with government and public administration, are defined mainly by energy and water supply services, sanitation and waste, transport services (travelers and merchandise), financial system, telecommunications, traffic, education and health. Assuring their correct operation means a three perspective safety model: operation and reliability in supply/service (safety), heritage or physical safety of assets and systems that make them up (security and logical system security (cybersecurity) that manage their operation.	PESI.1
					x		x	Safety services, both public (federal, autonomous or local) and private, require incorporation of innovation in development and need to offer their services to society and the citizens in future Smart Cities; improvement in collaboration and coordination between public and private agents is a premise in this context.	PESI.2
			x		x	x	x	Citizens must find mechanisms for a larger collaboration in their cities safety design and have access to the means for an effective collaboration in risk situations, incidents and cases of emergency (with different agents: police, social assistance, health services, firefighters, rescue, etc.). City government must be open to this participation, must create legal framework for initiatives and favor technological means and organization ways adequate for this collaboration.	PESI.3
x	x	x	x	x	x	x	x	City government has strategies and tools that allow effective acting in crisis situations and emergencies produced by different types of risks: industrial (associated to industry and company economic activity), natural risks (extreme climate and nature effects and possible evolution —climate change—) or provoked (attacks) and waterfall effects because of the former. Simulation systems of the effects and consequences of such risk, and the management of the crisis and means of conduct and coordination of operators to alleviate are a help to improve cities' resilience.	PESI.4

Identi-ficator	Platform	Technological element	Area	Line/ Application	MACRO element	Technology/ function	Relevance grade for a Smart City	Application (SML term)
PESI.5	PESI	City infrastructure, grid and equipment monitoring and management	Horizontal	Security	Security and reliability of urban infrastructures and equipment	Technology / Function	high	short
PESI.6	PESI	Urban infrastructures protection and resilience	Horizontal	Security	Seguridad y Protección de Personas, Bienes y Patrimonio	Technology / Function	high	medium
PESI.7	PESI	Citiy physical security	Horizontal	Security	Security and reliability of urban infrastructures and equipment	Technology / Function	high	medium
PESI.8	PESI	Safe control centers	Horizontal	Security	Integral security and resilience	Technology / Function	high	medium
PESI.9	PESI	Cibersecurity for essential system and grid industrial control systems	Horizontal	Security	Cyber-security	Technology	high	short
PESI.10	PESI	Safe and healthy work environments	Horizontal	Security	Security and reliability of urban infrastructures and equipment	Technology / Function	baja	medium
PESI.11	PESI	Road safety (work)	Horizontal	Security	Security and reliability of urban infrastructures and equipment	Function	medium	medium
PESI.12	PESI	Transport safety (dangerous goods)	Horizontal	Security	Security and reliability of urban infrastructures and equipment	Technology / Function	medium	medium
MT.1	MATERPLAT	Intelligent materials	Horizontal	Materials	Advanced Materials	Function	medium	short

Social challenges								Description	Identificator
	x	x	x	x	x	x	x	City infrastructures are made up of a collection of physical assets (communication channels, water supply grids, sanitation, gas, electricity, etc.) and the equipment and systems that control them. These assets can be private or public property and the operators (mostly private -owners or licensees) are responsible for the services they offer. Advanced management systems are needed for the former that assure their reliability, availability, maintenance and security (RAMS, including structural safety and management of aging. These systems need and important technological component (sensor, monitoring, simulation, artificial intelligence, inspection, new materials, etc.).	PESI.5
	x	x	x	x	x	x	x	Beyond management of the assets that make up urban infrastructure their own security plans are required, with specific protection systems and measure and contingency plans keeping in mind interdependency between assets and certain essential services, assuring their correct operation and rapid recuperation in case of a security incident or operating problem. Surveillance and security systems, as well as conduct management s and infrastructure operator (mainly private sector) coordination in possible incident systems (and crisis situations).	PESI.6
		x	x	x	x	x	x	City natural conditions, from a geological, water and climate point of view are an important part of its structure and operation. These environmental intelligence systems and monitoring of different elements of the physical environment with sensor grids and tracking and alert systems are of great importance to assure stability in cities' infrastructure and services operation. Simulation systems for its evolution or for extreme situations that can be foreseen or other catastrophic events will help determine changes in existing infrastructures, action plans and coordination in cases of emergency.	PESI.7
x	x	x	x	x	x	x	x	Infrastructure and Service control centers can be conceived for different functions: operation and management, security, interdependence supervision, emergency coordination, etc. These Control centers attached to essential infrastructures and services must have special reliability conditions in operation and security (physical and logical), based on a new completely safe concept and design.	PESI.8
x	x	x	x	x	x	x	x	Industrial automation and control of systems and supply grids (energy, water...) systems and certain city essential services (lighting, traffic,) are especially vulnerable to cyberattacks to the extent that they lean on public telecommunication grids (data transmission and acting orders). Due to this, their logical protection must be assured through specific cybersecurity strategies and tools for these systems.	PESI.9
x		x	x	x	x		x	Current labor security and health strategies must evolve to take into account the creation of healthier work environments, new risks to workers such as psychosocial and aging of the workers (extension of work life).	PESI.10
x		x	x	x	x		x	Accident rates in citizen road transport has high rates in spite of their slow decrease. Economic activity is behind two thirds of the accident rate, both because of the own activity and because of trip to and from work. New organization strategies, mobility plans, technological solutions and prevention culture in road work safety are important in cities of the future.	PESI.11
x			x	x	x		x	Cities and their industrial environment are a destination for an important volume of materials and products. This merchandise transport has great risks because of the trips of the vehicles, mostly large, and especially when we talk about dangerous merchandise. Both technological solutions in containers and transports as well as urban route management are key to the safety of the city and its citizens.	PESI.12
x	x	x	x	x	x	x	x	Materials capable of generating and producing a controlled and generally reversible answer to modifications in the environment (both chemical and physical) and therefore are susceptible to being used as functional materials that act to benefit people and environment.	MT.1

Identi-ficator	Platform	Technological element	Area	Line/ Application	MACRO element	Technology/ function	Relevance grade for a Smart City	Application (SML term)
MT.2	MATERPLAT	High-performance materials	Horizontal	Materials	Advanced materials	Function	high	short
MT.3	MATERPLAT	Adaptable materials and application technologies	Horizontal	Materials	Advanced materials	Technology	medium	medium
SL.1	SLIVINGPLAT	Non-battery omnipresent electronic sensors (with energy harvesting)	Horizontal	ICTs	Internet of things	Technology	high	short / medium / long
			Horizontal	Sensors	Electronic sensors without batteries			
SL.2	SLIVINGPLAT	Electronic circuits and components (semiconductor) with super low energy consumption (for both more battery life and no battery sensors)	Horizontal	ICTs	Internet of things	Technology	medium	short / medium

Social challenges								Description	Identificator
x	x	x	x	x	x	x	x	Materials whose characteristics or properties make them adequate for use under extraordinary conditions or needs.	MT.2
x	x	x	x	x	x	x	x	Adapted situation and on-site manufacturing materials and technologies for personalized application (for example: additive manufacturing at destination, flexible and modular situation systems...)	MT.3
x	x	x	x	x	x	x	x	Batteries used in electric sensor grids present specific inconvenient that include a defined shelf life, replacement and elimination cost. Up until today they represent one of the weak links in large sensor grids. Energy harvesting consists in capturing residual energy in the environment (light, vibration, RF, thermic gradient...) to turn it into electric energy and feed small sensors trending towards ubiquitous sensoring, with no cables nor maintenance.	SL.1
x	x	x	x	x	x	x	x	Batteries used in electric sensor grids present specific inconvenients that include a defined shelf life, replacement and elimination cost. One of the keys to increase shelf life of batteries or even getting rid of them using energy harvesting techniques is the reduction of the consumption of the electric circuits they feed, both at a circuit design level as a semi conductive component with less energy requirements.	SL.2

Consolidated table

The "MICRO" elements identified in the table before are grouped in 49 technological "MACRO" elements. In total, the model is made up of 16 lines in 5 areas.

The technological "MACRO" elements meet and unify several technological "MICRO" elements. The "MACRO" elements have been grouped in higher-level entities called lines, and consequently, these have been grouped into areas. Here we can observe the result of the synthesis methodology. The following is indicated in the following table:

- **Areas** that cover the Smart City model
- **Lines** that make up each area
- **Title** of "MACRO" elements
- **"MICRO" Elements** into each "MACRO" element
- Classification of each "MACRO" element in technology or function
- **Challenges of the society** to which it is linked
- **Temporal horizon** for a Smart City (high/medium/long term) depending on an immediumte future, 5-10 years or since 10 years for the implementation.

Area	Line/ Application	MACRO technological element	Grouped items identification and coding	Technology/ function	Social challenges								Relevance grade for a Smart City	Application (SML term)
ENERGY AND ENVIRONMENT	Energy networks management	Electricity networks	F.1, F.2, F.3, F.8, F.9, PL.1, PL.7	Function/ Technology			x		x				High	Short/ Medium
		Thermal networks	BI.1, GE.1, CO.2	Function/ Technology			x		x				Medium	Short/ Medium
	Energy resources	Demand integration	F.5, TH.3, CO.6, EE.4	Function/ Technology	x	x	x	x	x	x	x		High	Short/ Medium
		Renewable energy and distributed generation integration	C.6, F.10, FV.1, GE.3, F.6	Function/ Technology			x	x	x				High	Short/ Medium
		Storage management	F.4, FV.4, CO.3, HPC.1, F.7	Function			x	x	x				Medium/ High	Medium
		Energy recovery	FE.3, C.7, BI.4, GICI.1	Function/ Technology			x	x	x				High	Short/ Medium/ Long
	Environment	Environmental indicators and Sensors	FO.4, C.9, TH.5	Function/ Technology	x			x	x				Medium	Short
		Sustainable waste management	C.8, TH.6	Function/ Technology			x	x	x	x			High	Short
		Water recycling and treatment technologies	A.1, A.2, A.7, A.8, FO.3	Technology	x	x	x	x	x	x	x	x	High	Short
BUILDINGS AND INFRASTRUCTURES	Road infrastructures	Alternative fuels infrastructures	M2F.6, HPC.4	Function/ Technology			x	x					High/ Medium	Medium/ Long
		More sustainable pavements	A.3, A.4, C.4	Function/ Technology	x		x	x	x	x		x	Medium	Short/ Medium
	Urban elements management	Railway and road infrastructure management	FO.8, C.1, C.2, C.3, CO.9	Technology			x	x	x		x	x	High	Short/ Medium
		Smart lighting	FO.9	Technology			x	x	x				Medium	Medium
		Connectivity improvement	C.10	Function				x		x			Medium	Short/ Medium
	Sustainable building	Renewable energy integration at buildings	BI.2, GE.2, CO.1	Function			x		x				High	Short/ Medium
		New construction technologies	FV.2, CO.8, A.5, FO.9	Function/ Technology	x	x	x		x			x	High	Short/ Medium
		Zero energy buildings	FV.3, CO.4, FE.4	Function/ Technology			x	x	x				High	Short/ Medium

Area	Line/ Application	MACRO technological element	Grouped items identification and coding	Technology/ function	Social challenges								Relevance grade for a Smart City	Application (SML term)
MOBILITY AND INTERMODALITY	Vehicles in the urban environment	Less pollutant vehicles	M2F.1, M2F.2, M2F.3, HPC.2, LO.2, BI.3	Technology	x		x	x	x				High/ Medium	Short/ Medium/ Long
		Safe and connected vehicles	M2F.4	Technology	x		x	x	x	x	x	x	High	Medium
		New materials and technologies for vehicles	M2F.5, FO.10 M2F.8, C.11,	Technology			x	x	x				Low	Medium
	Intelligent transport systems - ITS in the urban environment	Integrated systems for the management of sustainable mobility	EV.1, LO.8	Function/ Technology				x		x	x		Medium/ High	Short/ Medium/ Long
		ITS for urban transport	M2F.9, TH.7	Function/ Technology			x	x	x				High/ Medium	Short/ Medium
		ITS for rail transport	FE.1, FE.2, FE.3	Technology			x	x	x		x		Medium/ High	Short/ Medium/ Long
		Traffic management systems	LO.1, FO.7, C.12	Function/ Technology				x	x	x	x		Medium	Medium
	Logistics and urban fleet management	New logistic platforms in the city	LO.3, LO.4, LO.6	Function/ Technology				x			x	x	Medium/ High	Short/ Medium/ Long
		Fleets management and maintenance systems	M2F.7	Technology				x					High/ Medium	Medium/ Long
		New logistic models	LO.5, LO.7	Function/ Technology				x	x		x		High/ Medium	Short/ Medium/ Long

GOVERNMENT AND SOCIAL SERVICES	Health and accessibility	Advanced technologies for patient diagnosis, monitoring and intervention	FO.5, FO.6, FO.13	Technology	x						x		Medium	Medium
		Sensors and health information systems	MK.2, EV.2, EV.3, EV.4, TH.8	Function/ Technology	x					x		x	Medium	Medium
		Solutions and tools for accessibility	CO.7, FE.5	Function				x		x			Medium	Short/ Medium
	Administration	Urban planning and new services at the city	EE.1, EE.2, CO.5	Function	x	x	x	x	x	x	x		Medium/ High	Short/ Medium/ Long
		Sustainability management	PL.5, GICI.2	Function			x	x	x			x	High	Medium
		Social integration	EV.5, PL.2, EE.5, GICI.3	Function	x	x	x	x	x	x	x	x	Medium	Medium/ Long
	Urban promotion	Citizen - services connection	TH.1, TH.2, TH.4	Function	x	x		x	x	x	x	x	High	Medium
		Smart tourism management systems	TH.4, EV.6	Function	x	x		x	x	x	x	x	Medium	Medium/ Long

Area	Line/ Application	MACRO technological element	Grouped items identification and coding	Technology/ function	Social challenges								Relevance grade for a Smart City	Application (SML term)
HORIZONTAL	ICTs	Computing infrastructure	PL.11	Technology							x		Medium	Short
		Data management and analysis systems (big data)	PL.14	Technology							x		High	Medium
		Design and development of software applications	PL.13, PL.15, PL.16, PL.17	Technology							x		Medium	Short
		Communication networks	FO.1, PL.10, FO.14	Technology	x	x	x	x	x	x	x	x	High	Medium
		Display and image processing systems	PL.12, FO.2	Technology	x			x	x		x		Medium	Medium
		Internet of things	PL.4, SL.1, SL.2	Function/ Technology			x	x	x			x	High	Short
	Sensors	Detection, measuring and monitoring systems based on sensors	PL.6, FO.11, FO.12	Technology	x	x	x	x	x	x	x	x	High	Short
		Electronic sensors without batteries	SL.1	Technology	x	x	x	x	x	x	x	x	Medium	Short
		Smart devices	MK.1, PL.9	Function/ Technology			x	x	x		x	x	Medium	Medium
	Security	Integral security and resilience	PESI.1, PESI.4, PESI.8	Function/ Technology	x	x	x	x	x	x	x	x	High	Medium
		Security and reliability of urban infrastructures and equipment	PESI.5, PESI.7, PESI.10, PESI.11, PESI.12	Function/ Technology	x	x	x	x	x	x	x	x	High	Short
		Security and protection of people, goods and assets	PESI.2, PESI.3, PESI.6	Function/ Technology	x	x	x	x	x	x	x	x	High	Medium
		Cyber-security	PESI.9	Technology	x	x	x	x	x	x	x	x	High	Short
	Materials	Advanced materials	MT.1, MT.2, MT.3	Function/ Technology	x	x	x	x	x	x	x	x	Medium	Short

[8.2] Annex 2. Work participants

The work team GICI is composed by the following stake-holders:

- **Coordinator:** Fernando García Martínez *(Gas Natural Fenosa – FutuRed).*
- **Technical Secretariat:** Enrique Morgades Prat *(Fundación CIRCE – FutuRed).*

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[8.3] Annex 3. Glossary

AENOR - Spanish Association for Standardization and Certification

CEOE - Spanish Confederation of Business Organizations

CI - Smart Cities

GHG - Greenhouse Gases

GICI - Smart Cities Workgroup

ICT - Information and Communication Technologies

IED - Intelligent Electronic Devices

IoE - Internet of Everything

ITS - Intelligent Transport System

OCDE - Organisation for Economic Co-operation and Development

OL - Logistic Operator

UN - United Nations

PLC - Programmable Logic Controller

PTE - Spanish Technological Platform

RTU - Remote Terminal Units

SCI - Sustainable Cities Index

SIoT - Social Internet of Things

Smart Cities
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