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TOWARDS SMART ZERO CO_2 CITIES ACROSS EUROPE

VITORIA-GASTEIZ + TARTU + SØNDERBORG

Deliverable 2.4: City needs and baseline definition process and methods

WP2, Task 2.6

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Abbreviations and Acronyms

Abbreviation/Acronym	Description
BREEAM	Building Research Establishment Environmental Assessment Method
CHP	Combined Heat and Power
DMP	Data Management Plan
EC	Europena Commission
EIP-SCC	European Innovation Partnership on Smart Cities and Communities
ENERPHIT	Energy retrofits certification with Passive House Components
ERDF	European Regional Development Funds
EU	European Union
EV	Electric Vehicle
FP6	6th Framework Programme
FP7	7th Framework Programme
GDP	Gross domestic product
GHG	Greenhouse Gas
GIS	Geographic Information System
IAP2	International Association for Public Participation
ICLEI	International Council for Local Environmental Initiatives
ICT	Information and Communication Technologies

ISEAL	International Social and Environmental Accreditation and Labelling
ITU	International Telecommunication Union
KPI	Key Performance Indicator
LEED	Leadership in Energy & Environmental Design
LH	Light House
NZEB	Near Zero Energy Building
OECD	Organisation for Economic Co-operation and Development
PV	Photovoltaic
RES	Renewable Energy Source
SCC	Smart Cities and Communities
SEAP	Sustainable Energy Action Plan
SET	Strategic Energy Technology
SmartEnCity	Towards Smart Zero CO2 Cities across Europe
SUMP	Sustainable Urban Mobility Plan
SUV	Sport Utility Vehicle
SWOT	Strengths, Weaknesses, Opportunities and Threats
SZCO2	Smart Zero CO2
TOE	Tonne of oil equivalent
UN	United Nations
WP	Work Package

Table 1: Abbreviations and Acronyms

0 Publishable Summary

The overall objective of WP2 “SmartEnCity Regeneration Strategy” is the development and consolidation of and integrated and systemic urban regeneration model towards Smart and Zero Carbon City concepts.

This deliverable defines the methods and process that will be applied in the diagnosis and baseline definition of the three SmartEnCity LH cities, as well as in the definition of the intervention projects of the two follower cities. In a wider sense, this deliverable can be useful for any European city willing to devise a smart urban regeneration project.

The deliverable has been divided in four parts dedicated to the approach, objectives, components and tools of the diagnosis process:

Chapter 4 provides general guidelines about integrated approach, governance framework, indicators selection and data management.

Chapter 5 provides a description of the general objectives of the SmartEnCity project in the framework of EU energy and climate policies and the roadmap to low-carbon urban living.

Chapter 6 looks through all the aspects that should be included in the integrated diagnosis and baseline definition: local conditions, energy-related and enabling technologies, needs assessment and prioritisation, and area of intervention demarcation.

Finally, Chapter 7 (outputs for other WP) includes a template for deliverables 3.1, 4.1 and 5.1, and the list of common and optional indicators to be used in the three LH cities.

The sources used to elaborate this deliverable have been mainly two: a survey conducted to LH cities through questionnaires in order to identify relevant gaps and barriers, and a state of the art revision to identify best practices to overcome them.

1 Introduction

1.1 Purpose and target group

This deliverable defines the methods and process that will be applied in the diagnosis and baseline definition of the three SmartEnCity LH cities, as well as in the definition of the intervention projects of the two follower cities. It contains a set of guidelines and recommendations to support an integrative and holistic approach, mostly focused on identifying critical factors of success in the specific context of each city.

The outputs for other WPs include the template to be used in Deliverables 3.1, 4.1 and 5.1, Diagnosis and Baseline of Vitoria-Gasteiz, Tartu and Sonderborg respectively, and the list of common and optional indicators for city characterization, selected by the three LH cities from the list proposed in D7.1.

1.2 Contributions of partners

Table 2 depicts the main contributions from partners in the development of this deliverable.

Participant short name	Contributions
TEC	General structure and coordination, Chapters 1, 2, 3 & 5; Sections 6.2.4, 6.3 & 7.1
CAR	Sections 5.3.3, 6.2.3, 6.4 & 7.2
ACC	Coordination of Section 6.2; Contributions to Sections 5.2 & 5.3; Annexes A1 & A2
TREA	Chapter 4; Section 6.2.1
UTAR	Sections 6.1.1 & 6.2.5
MON/LKS	Sections 6.1.2 & 6.2.2; preliminary review of Chapter 5
CEA	Section 6.1.3
PLAN	Section 6.1.4; Contributions to Section 5.2.1
ET	Contributions to Section 6.2.4
CEE	Preliminary review of Chapter 5
CAR, TEC, VIS, CEA, TAR, TREA, IBS, SONF, ZERO, PLAN	Contributions to Section 7.2 (selection of indicators)
VIS, IBS, SONF, PLAN, ZERO, LEC, DAPP	Review of consolidated draft

Table 2: Contribution of partners

1.3 Relation to other activities in the project

Table 3 depicts the main relationship of this deliverable to other activities (or deliverables) developed within the SmartEnCity project and that should be considered along with this document for further understanding of its contents.

Deliverable Number	Contributions
D7.1	This deliverable provides a first proposal of city characterization indicators that has been filtered by LH cities to define the definitive list of common and optional indicators included in Section 7.2.
D2.1, D2.2, D2.3	These deliverables have been developed in parallel with D2.4, and refer to specific topics that will be included in the complete SmartEnCity regeneration strategy. There are references to these deliverables in specific sections of D2.4.
D2.5, D2.6, D2.7	D2.4 provides recommendations to define the governance framework that encompasses integrated management, citizen engagement, and regeneration strategy of SmartEnCity LH projects, to be defined in these deliverables.
D3.1, D4.1, D5.1	D2.4 provides the overall description of the methods and process, as well as the template (Section 7.1) to apply in diagnosis and baseline definition of each LH city.

Table 3: Relation to other activities in the project

2 Objectives and expected impact

2.1 Objective

The overall objective of WP2 “SmartEnCity Regeneration Strategy” is the development and consolidation of an integrated and systemic urban regeneration model towards Smart and Zero Carbon City concepts.

Task 2.6 on Integrated Planning (Development of Integrated Urban Plans) is devoted to define the complete SmartEnCity regeneration strategy that will be applied in the three LH cities interventions, as well as in the development of the integrated plans of the follower cities. This first deliverable of the task is focused in the earlier stages of any urban regeneration project: diagnosis and partnership definition. As part of Subtask 2.6.3 (Identification of City needs and baseline definition process), the objective of the deliverable is the development of easy and fast methods for the identification of the strategic city needs in order to make a diagnosis of the city in terms of energy demand and consumption, energy efficiency, energy supply, CO2 emission, city structure, regulation and normative, standards, stakeholders, citizens and financial schemes. The deliverable also tries to identify gaps in existing diagnosis methodologies in order to focus properly the activities and avoid duplication.

2.2 Expected impact

This deliverable is intended to be applied in the diagnosis and baseline definition of the three LH cities, and defines a roadmap for defining the intervention projects of the two follower cities. In a wider sense, this deliverable can be useful for any European city willing to devise a smart urban regeneration project.

3 Overall Approach

Task 2.6 on integrated planning requires the coordination of several inputs from other WP2 tasks. This diagnosis focused deliverable also requires a specific coordination with Task 7.1 on evaluation plan, in charge of designing the whole system of indicators of the project.

The deliverable has been divided in four parts dedicated to the objectives, approach, components and tools of the diagnosis process:

Chapter 4 provides a description of the general objectives of the SmartEnCity LH cities interventions. It has been drafted by Tartu Regional Energy Agency (TREA) with inputs from TEC and Project ZERO (ZERO).

Chapter 5 provides general guidelines about integrated approach. It has been mainly drafted by TECNALIA Research & Innovation (TEC), with contributions from Acciona (ACC) and CARTIF Foundation (CAR). Coordinators of deliverables 2.1 (PLAN), 2.3, 2.5 (MON/LKS) and 2.6 (CEE) have reviewed this chapter in order to ensure these guidelines are consistent with their sectoral approaches on policies and regulations, business, financing and public procurement, integrated management and citizen engagement.

Chapter 6 looks through all the aspects that should be included in the integrated diagnosis and baseline definition. Several partners according to their respective expertize have contributed to this chapter (see Table 2 for detailed credits) under the coordination of TEC and ACC.

Finally, Chapter 7 (outputs for other WP) include a template for deliverables 3.1, 4.1 and 5.1, which is mainly a schematic summary of the aspects included in chapter 6, and the consensual list of common and optional indicators that has been coordinated by CAR with the participation of the partners involved in the three LH city diagnoses.

The sources used to elaborate this deliverable have been mainly two: a survey conducted to LH cities through questionnaires in order to identify gaps and barriers, and a state of the art revision to identify best practices to overcome them.

4 Towards Smart Zero CO_2 Cities

4.1 EU energy and climate policy framework

The European Union moves towards low-carbon economy. According to Roadmap 2050 Europe will reduce its GHG emission up to 95%. This will redefine every aspect of modern lifestyle – the way we eat, the way we move around, the way we travel, the way we work, the houses we build and the cities we live in. Nowhere will these changes be as fundamental as in the urban settlements. Like in every aspect of the modern social development – European cities are on the forefront of the shift to the low-carbon economy. The story of the decarbonisation of Europe's economy will be told in our cities.

The future cities of Europe are executing very different technological, economical, administrative and social principles compared with today practice. The targets and the scenarios for these changes have been described in Energy Strategy 2050 (Energy Roadmap 2050 COM/2011/0885). The strategy is saying that although it is possible to achieve ‘a secure, competitive and decarbonised energy system’ for 2050 a major changes are required in how we produce, consume and manage our energy resources. The changes even have to go further focusing to the economic and investment models, market regulations, administrative practices, individual behaviour and public acceptance. It is expected that emission will be reduced by 40% below 1990 levels by 2030 (as part of 2030 framework), below 60% by 2040 and below 80% by 2050. According to the *Roadmap to Low-Carbon Economy* (EC, 2011a) the power sector has the biggest potential for cutting emissions:

It can almost totally eliminate CO2 emissions by 2050. Electricity could partially replace fossil fuels in transport and heating. Electricity will come from renewable sources like wind, solar, water and biomass or other low-emission sources like nuclear power plants or fossil fuel power stations equipped with carbon capture & storage technology. This will also require strong investments in smart grids. Emissions from houses and office buildings can be almost completely cut – by around 90% in 2050. Energy performance will improve drastically through: passive housing technology in new buildings, refurbishing old buildings to improve energy efficiency, substituting electricity and renewables for fossil fuels in heating, cooling & cooking. Investments can be recovered over time through reduced energy bills (EC, 2011a).

Emissions from transport sector could be reduced by 60% by 2050 with the help of increasing fuel efficiency in classical petrol and diesel engines but also introduction of biofuels and hybrid and electric cars:

Energy intensive industries could cut emissions by more than 80% by 2050. The technologies used will get cleaner and more energy-efficient. Up to 2030 and just beyond, CO2 emissions would fall gradually through further decreases in energy intensity. After 2035, carbon capture & storage technology would be applied to emissions from industries unable to make cuts in any other way (e.g. steel, cement). This would allow much deeper cuts by 2050. Non-CO2 emissions from industry that are part of the EU emissions trading system are already forecast to fall to very low levels. As global food demand grows, the share of agriculture in the EU's total emissions will rise to about a third by 2050, but reductions are possible. Agriculture will need to cut emissions from fertilisers, manure and livestock and can contribute to the storage of CO2 in soils and forests. Changes towards a more healthy diet with more vegetables and less meat can also reduce emissions (EC, 2011a).

European Energy and Climate Change Policy is setting realistic and achievable goals for 2020 as a first step of energy transition. Adopted in 2008 by European Commission and Parliament it was the first binding international energy policy and is considered to be (side by side with the Kyoto protocol in 1997) a stepping stone to the new era of international policy development. The policy is proudly following over 30 years of developing the United Nations climate policy and is integrating the principles of Kyoto protocol into one compulsory package. Based on economical calculations the strategy suggests that it is possible (and feasible) to reduce the energy consumption by 20% and emissions by 20%, increase the usage of renewable energy sources up to 20% and biofuels up to 10%. These targets are developed as a part of 2020 Climate and Energy Package including also Emission Trading System (ETS), national targets for emission, usage of renewable energy sources and energy efficiency. Despite the goals being ambitious the countries are getting close to achieve these goals and EC is together with the EU members setting up new set of goals for 2030.

2030 Climate and Energy Framework set three key targets for the year 2030: reducing emissions at least 40%, increasing the share of renewable energy consumption to 27% and improving energy efficiency by 27%. The framework was adopted by EU leaders in October 2014. It builds on the 2020 climate and energy package. It is also in line with the longer term perspective set out in the Roadmap for moving to a competitive low carbon economy in 2050, the Energy Roadmap 2050 (EC, 2011a) and the Transport White Paper (EC, 2011b).

Energy production will be based on low-carbon technologies and the consumption is based on efficient technologies. Implementation of the Strategic Energy Technology (SET) Plan in 2007 by European Commission is proposing the development of the modern low-carbon energy technologies like solar power, smart grids and carbon capture and storage. These technologies will then be introduced into the market with the integration of other supporting programs like Horizon 2020.

The European Commission adopted a Roadmap to a Single European Transport Area of 40 concrete initiatives for the next decade to build a competitive transport system that will increase mobility, remove major barriers in key areas and fuel growth and employment. At the same time, the proposals will dramatically reduce Europe's dependence on imported oil and cut carbon emissions in transport by 60% by 2050. By 2050, key goals will include: no more conventionally-fuelled cars in cities; 40% use of sustainable low carbon fuels in aviation; at least 40% cut in shipping emissions; a 50% shift of medium distance intercity passenger and freight journeys from road to rail and waterborne transport. All of which will contribute to a 60% cut in transport emissions by the middle of the century (EC, 2011b).

The European Commission adopted an ambitious Circular Economy Package, which includes revised legislative proposals on waste to stimulate Europe's transition towards a circular economy which will boost global competitiveness, foster sustainable economic growth and generate new jobs. The Circular Economy Package consists of an EU Action Plan for the Circular Economy that establishes a concrete and ambitious programme of action, with measures covering the whole cycle: from production and consumption to waste management and the market for secondary raw materials. The annex to the action plan sets out the timeline when the actions will be completed. The proposed actions will contribute to "closing the loop" of product lifecycles through greater recycling and re-use, and bring benefits for both the environment and the economy (EC, 2014).

4.2 Energy consumption in urban areas

Urbanization is playing an increasing role in global energy consumption. According to the United Nations report "World Urbanization Prospects: The 2014 Revision, Highlights" the global urban population exceeded the global rural population in 2007. After that the world population has remained predominantly urban. In 2014, 54% of the world`s population is residing in urban areas and by 2050, 66% of the world`s population is predict to be urban (UN-DESA, 2014). The population growth means that urban areas are constantly dealing with the increasing energy demand. Urban areas account for 60-80% of global energy consumption and around the same share of CO2 emissions. In 2106, around 75% of Europeans live in cities.

The amount and density of end users in urban areas have supported the constant increase of energy consumption in cities for 200 years. It has supported the innovation and development of new energy technologies like natural gas networks, cogeneration, lighting bulb, district heating, combustion engine etc. Cities have been the promoters of electricity as a clean source of energy and for today have optimized most of their services to be based on electrical power. The highest economic incentive for these innovations has historically been in the industrial city. Because of the economic promises has industrial city been a role model for urban energy development for more than a century. Today the industrial economic models together with energy consumption models are in most of European cities clearly outdated and once again cities need to rethink their energy systems. It is difficult because of scale of the innovation needed but at the same time it is possible due the innovative nature of our cities.

The main problem of the urban energy management is embedded into the dialectic relationship between the settlement and the wider area that is needed for city to function - where it draws its resources. This additional territory – many times of the urban area that it is supporting – is needed for the city to exist and function. Energy resources like all the other resources are produced mostly outside of the urban area and transported to the city in forms of liquid fuels (oil, gasoline but also hydrogen), solid fuels (coal, timber, wood chips and pellets) and electricity. Urban energy balance has always been negative one - it consumes more energy than it is producing. Energy trade is a standard part of economical transaction of any city.

The way how today European cities use energy is much different from what it was in the early phase of industrialization. This model is still represented in the cities that are in today`s emerging economies, heavy industries running on coal, creating urban air pollution, environmental damage and emissions. In modern well developed deindustrialized cities energy is consumed primarily through the maintenance and operation of built-up infrastructure, rather than on industry. Most of the energy is used in buildings for creating indoor environment. Transport follows as the second and industry is the third greatest consumer of energy. In middle-income countries transportation is the highest consumer, industry and buildings create an equal mixture. In developing countries, where incomes are low, industries consume more than 50% of total energy (UN-Habitat, 2008).

Consuming patterns for the southern Europe cities are different, due to the geographical location; the need cooling is higher than heating. Consuming patterns for the southern Europe cities are different, due to the geographical location; the need for cooling is higher than heating. Countries like Italy, Malta, Bulgaria, and Cyprus use 10-15% of total electricity consumption on air conditioning (Lapillonne et al., 2015).

Cities use district heating systems all year around. When temperatures are decreasing in autumn, then the hot water from district heat system is need to heat up the radiators, heat the living environment and for domestic services like personal hygiene etc. During the cold winter, additional heat may be required to cover the peak points. In northern Europe usually gas powered heat stations are used for that reason and in some cases personal electrical heaters are needed in buildings with low thermal insulation. During the short daytime period, lighting systems consume much of electricity, because the need for safe and convenient environment. As the outside temperature increases in springtime the need for heating reduces but there will still be demand for hot water. If the population density is high enough then the demand for hot water stays relatively stable all year around so that the heat stations work constantly. To gain higher efficiency combined heat and power stations (CHP) are used. Areas where hot water usage is low in warm season an individual water heaters are used. It may not be cost effective to run the district heating plant for lowered consumption.

Buildings need more than heating. In different climatic regions and as the seasons change, also cooling is needed. In Euroheat & Power 2015 survey, total installed district heating capacity in EU was 277015 MWth, compared with the district cooling capacity, cooling accounted only for 0.5% (Euroheat & Power, 2015). This doesn't mean that cooling systems aren`t needed. Problem is that most of the today`s cooling systems are installed locally, based on one building, which is not effective in energy usage. Heating and cooling sector accounts for 50% of the EU`s annual energy consumption. “Thus European Commission has launched a strategy to optimize buildings heat and cooling sector. Strategy aim is to make the sector smarter, more efficient and sustainable, thus energy imports and dependency will fall, costs will be cut and emissions will be reduced” (EC, 2016a). District cooling pilot projects are created to reduce individual cooling systems.

As the cities grow and develop, more fuel, heat and electricity are needed. Main difference between the cities energy management is the consumption capacity. Due to the growth in demand, more/bigger power-stations have to be built near cities to produce more electricity and provide more heat. As the production capacity rises, the distribution infrastructure has to be upgraded. Without the upgrade, serious failure or blackout may occur and it can affect bigger area then the city itself. “A sustainable urban energy system will need low-carbon technologies on the supply side. Today renewable energy technologies are becoming more accessible, more and more PV-panels are installed in cities. Therefore energy production is started to shift from power plants to household. To tackle intermittency, several renewable energy sources should be combined to overcome source-specific shortages, such as solar at night, or wind during calm” (UN-Habitat, 2012).

Electricity consumption is not declining in cities. The reduction caused by the increasing efficiency is almost everywhere compensated by the growth of urban services, mostly using electricity. This increase puts additional pressure to the power production that in most cases also produces heat as a byproduct. Heat can then be sold to the district heating network to support the business of power plants. Lowering demand for the heat weakens these business models and decreases feasibility of production of electricity in combined heat and power (CHP) plants. To overcome this problem the structure of the power production can be changed reducing the need for centralized power and increasing the local production of electricity by PV panels with the help of smart grid technologies. This way the high efficiency of CHP plants and their business models can be partially maintained. Unfortunately this is not the full solution because of the seasonal nature of PV production. To maintain the balance between the dynamics of energy consumption and production will be increasing challenge of urban energy management as the portfolio of the production and consumption technologies is growing.

The concept of smart-grid infrastructure is still under development. The core of the smart grid consists of implementing modern information and communication technologies, enabling real-time bidirectional communication among all participating entities. In a smart grid every device in the system is expected to provide feedback about its own energy consumption or production. In the cities most of the city buildings are passive consumers of energy, but in the smart city concept, the role of the building must change from passive to active participant in the power system. This kind of shift needs already built up developed DG networks.

Energy storage systems are used mainly on two purposes: the integration of renewable sources and the delivery of demand-response schemes. They can participate in demand-response schemes by locally managing the demand curve, smoothing peaks and valleys. Today batteries are most common energy storage systems on the market, widely used in electrical cars and off-grid solutions. Hydrogen has also started to enter the market, but it is less common, due to the high price.

The transport sector can be taken as the biggest consumer of energy in Smart City concept. Without industries, transport sector is of the main air polluters and therefore creating important health costs. Cities need extensive amount of transport, because the quality of transport systems in a city directly affects the access to services and by this the quality of life. In smart city concept the future transport systems, both public and private, should be cleaner and more efficient. Cities with more residents have already taken the public transportation on electricity, but in private sector fossil-fuel technologies are still widely used. Electric cars and person-to-person sharing platforms are seen as the future trends, but electric cars have to become more affordable and governments have to make new regulations in “sharing economy”.

Infrastructure projects depend mostly of the city financial capacity. In smaller cities, with lower population density, local authorities have to find new ways how to finance already built district heating systems. It is getting more difficult to justify the creation of the new district heating system especially if it’s not supported by the dense urban environment with many large scale consumers and steady demand. This is increasing problem in Smart Zero CO2 (SZCO2) cities where the higher energy performance of public buildings and living environment is reducing the need for the heat energy. It is challenging for the cities to find suitable business model to overcome these problems. One of the possibilities would be the development of the new services like the central cooling network.

Cities that have found suitable business model for the development projects have to make complex planning and projecting to avoid increase of environmental impact, disturbance in city, closing off the streets, fitting into the limited urban space (or invest extra to move the energy to long distances), supporting all the stakeholders and maintaining its position in the global competition. Decisions have to increase the quality of life, living environment and reduction of environmental pressure.

4.3 Roadmap to low-carbon urban living

The main challenge of converting to low-carbon economy is the process of energy transition - to convert the energy production and the consumption to something very different from what we do have today. The main focus on this process is on efficiency through better technologies and energy management including user behaviour. Energy management will improve using modern ICT tools like smart metering. Energy production has to shift to be based on renewable energy sources like solar, wind and biomass but can also use natural gas and nuclear (especially if new and safer technologies are used). Also the structure of the energy production has to be transformed to offer better access to the grid for small scale production. Implementation of smart grid for this is inevitable. These changes have to find its economic potential and support. The roles of new business models and user driven local economies have to increase and find ways to compete with classical energy economy. For this the financial structure of energy sector has to change mainly to internalize the hidden/external cost of fossil fuel economy. This has to be supported by the changes in taxing and administrative practices as well as the changes in corporate cultures and user behaviours.

Open energy markets inside the EU and long term strategic relationships with the energy providers outside of the borders of EU will support the development of low-carbon economy in the region. Energy markets have been classically closed and protected all over the Europe by national regulations and by the long term contracts with service providers with a large financial capacity for investments. This type of market tends to be centralised and hostile towards small-scale local energy production. Opening and rethinking energy markets are creating new possibilities for local energy production and allow more diversity. At the same time the quality of energy services and the sustainability of investments have to be maintained.

Transforming the energy systems is requiring large scale investments that will help to replace the infrastructure and capital goods throughout the economy (including consumer goods, people's homes urban infrastructure, transit networks etc.) These are very substantial upfront investments, often with returns over a long period. Early research and innovation efforts are necessary. A unified policy framework that would synchronise all instruments from research and innovation policies to deployment policies would support such efforts (EC, 2011a).

Weather this framework alone will create enough impetus for change is still debatable. Private and corporate institutions will be the main sources of investments but the support of public investments is needed in those cases where a new technology requires low-risk/low-return investments. The importance of public support is essential for the new types of technologies to find their niche on the market. Non-institutionalized public investments can support the market using new investment models like crowdfunding and peer-to-peer funding schemes. For that a wider acceptance of the infrastructure investments is needed.

The transition will affect employment and jobs, requiring education and training and a more vigorous social dialogue. In order to efficiently manage change, involvement of social partners at all levels will be necessary in line with just transition and decent work principles. Mechanisms that help workers confronted with job transitions to develop their employability are needed (EC, 2011a).

New administrative procedures negotiating between the private and public interest are required that would help to develop new infrastructures without public resistance and with the support of the local communities. Communities have to be more engaged and included into the decision-making process to ensure the transparency and the protection of the vulnerable social groups. Energy transition has to lead to higher life quality not to the energy poverty.

These challenges can be fully faced only if the strategy and its sub-strategies (for 2020, 2030 etc.) will be fully implemented. This requires a more active role of the administration to facilitate, evaluate and implementation. Public institutions, especially local institutions have to take the active role in enabling the change. Communities have to incubate the new practices and support the upscaling process before the markets can take over. This requires more active role from the institutions. National and regional institutions together with the municipalities have to become leaders of socio-technical development to inspire the financial sector and public to take drastic steps towards the change.

4.3.1 Reducing consumption

Overproduction is the basic principle behind the industrial market economy. Supply of the energy services on the market is constantly higher compared with the demand and this allows the market actors to freely negotiate the transactions on the market. The rapid increase in life quality of the western civilisation during the last century has been supported by the economic development that has utilized this overproduction and created an economical model oriented to exponential growth. This has provided a safe framework for the exponential growth of the global population but has created also a consumer culture that is burning through the natural resources with unsustainable speed. For creating more sustainable future it is needed to reduce the consumption and its devastating effects to the planet.

First step on reducing the consumption is to understand why and what we are consuming. Taxonomy of the consumption is useful because it allows the distinction between the forced consumption and the voluntary consumption. Forced consumption is related with all the necessities modern high-standard lifestyle. It covers the goods and services that are required for creating comfortable life environment with adequate amount of nutrients, security and social well-being. But it also has to satisfy our needs for political activities, education, cultural activities and other ‘higher’ needs. Voluntary consumption is related with the goods and services that we necessarily don't have to consume but are tempted to. Typical example of the voluntary consumption is the success of large SUV and powerful off-road cars in American and European cities. It is possible to reduce the voluntary consumption, for example by implementing new taxes that are targeting private cars with certain oil consumption. It is much harder to reduce the forced consumption because this is related with how the public institutions are set up. To do that redesigning the wider administrative framework is usually needed.

Urbanisation is geared towards efficiency by its nature. Urban living is offering more equal access to social services with lower cost for more people. Nevertheless this potential can be missed as an outcome of bad urban planning. For example the car centric suburban development can undermine the process towards efficiency and lock its residents into the vicious cycle of forced consumption. Communities can reduce the forced consumption by better design of their services. At the same time it is possible to reduce the voluntary consumption through financial incentives and behaviour change. The process towards reducing consumption and environmental impact is possible but requires political will, well designed policies and wider social acceptance to do so.

4.3.2 Consumption in global village

One of the fastest growing areas of modern energy consumption is the indirect energy consumption that is related producing and transporting our goods and services. Almost everything we consume today is based on global production using global value chains that are optimised to generate profit not to save energy. The same goes for agricultural production - the food we eat and the raw materials for the apparel industry. Also the services are moving to the same direction. From one hand this process is creating more opportunities for the developing world but at the same time it increases the energy intensity of the goods and services because of the need for extra transportation. This also makes more difficult to implement adequate policies for reducing the consumption and its impact. It is becoming increasingly difficult to convince people to buy fewer goods when the prices of these products are decreasing. If this is happening together with the decreasing quality of these products and increasing planned obsolescence then this process is supporting throw-away-economy - the economic model where it is cheaper to buy for example new clothing for every season instead of using the old one that will then end up in dumpster after less than 6 months of usage. More and more industries are taking over this type of toxic business model that is doubling its negative impact: first through the resource usage and dodgy production practices and second through the utilisation after the short life span.

Because of the both ends of the products life cycle are in geographically (and politically) remote areas it is very hard to develop an adequate political response. The fact that it is actually cheaper to produce food or consumer goods in some few thousand kilometers away from the end consumer and ship these to the end location (sometimes by airplane) shows the weakness of existing economic models. To overcome this weakness more emphasis on local production is needed. Cities have to reinvent their economies including all its aspects: production, consumption, trade and commerce. Even if it won't be feasible to create everything on sight it is still more efficient to have local production that embeds local values and creates social security. By creating rich life environment cities can help their citizens to live meaningful life and have less desire for brainless consumption of material goods.

4.3.3 Energy supply and consumption

Low-carbon economy favors low-carbon or carbon-neutral energy production and combines that with efficient consumption technologies. Energy production policies are focusing on two main challenges - using renewable energy technologies and cogeneration. Energy distribution is facing its own challenges in coming years by incorporating the decentralized energy production models into the energy networks. With the implementation of zero-energy buildings standards the critical level of the consumption density will also be one of the key problems of the future. The biggest challenges for the end consumers are related with increasing costs of the energy services that will also include the price of refurbishing the infrastructure like the buildings, roads, power plants etc.

Economy of Europe has high energy and carbon intensity. Europe is consuming 1102.4 MTOE of energy as in 2012. 130 TOE of energy is used for producing 1M€2010 worth of goods and services. This number has decreased from 149 TOE in 2005 and 174 TOE in 1995. 2,296 tons of CO_2 is emitted in using one TOE of energy and this is only slightly less than 2,392 tons of CO_2 in 2005. Apparently Europe is not the worst region in terms of polluting the environment. China is emitting 2,956 tons, Middle East is emitting 2,588 tons, USA is emitting 2,424 tons of CO_2 per TOE. Europe is responsible for emitting 3780 Mtons of CO_2 which is 11.5% of global emission. It is 12% less emission compared with 2005.

The technologies that will be used for producing the low-carbon energy during the next decades are already on the market. As of 2012 there are 5.7 MTOE of solar electricity produced in Europe together with 17,7 MTOE of wind energy. 14% of the final energy consumption is coming from renewable resources and this has been steadily increased from 9% in 2005. The target for the renewable energy sources in consumption is 20% for 2020 and 27% for 2030. Forerunners like Sweden are already consuming more green energy compared with fossil fuels. 16% of energy consumed for distant heating and cooling in Europe is coming from renewable sources.

There is 71 GW worth of solar panels installed in European countries as in 2012 and this is remarkably more than 2,3 GW in 2005. The biggest solar power capacity is in Germany and Italy. Germany has one of the biggest total PV installations in the world (behind China and USA). Total surface of solar collectors is equal to 44.5 km2 – more than twice as much as in 2005.

Natural gas can act as a transition fuel used for shifting from carbon heavy fossil fuels like oil and coal to renewable sources like biofuels, sun and wind. Current consumption of 393 MTOE is only 11% less than 2005 with the strong user base in countries like Germany, Netherlands and France. Nuclear energy has a high potential as a future source of energy but not before safer and less polluting nuclear technologies can reach the market and this is not likely to happen anytime soon. Current supply of nuclear heat is 227.7 MTOE is only 11% less than 2005 with strong user base in France, Germany and Sweden.

Decentralized energy production is inevitable for low-carbon economy but it sets its own challenges for stability and quality of energy networks. Stability of the networks and quality of energy supply can be maintained with holding a proper balance of supply and this becomes harder with unlimited set of small-scale suppliers. Smart grid technology for power grids is one of the answers for this problem but it cannot be the full solution. The best answer for this problem would be the rapidly regulated large scale energy storage but the technology for this is not yet market ready. Part of the answer will also be better power demand management and regulation. Distant heating networks are facing specific challenges that are related with the increasing efficiency of the buildings. While economically benefitting for the building owner, efficient energy usage will raise additional questions about the feasibility of the heating/cooling networks. Paradoxically it won't be feasible to develop district heating network for the city consisting only passive houses. To overcome this challenge heating network has to be developed focusing on large scale consumers and higher energy intensity. In every city this structure is different and specific solution should be developed. It is possible that the feasible solution for this problem would be wider implementation of public energy providers as the heating/cooling networks are losing their appeal for the private investors.

4.3.4 Energy transition

“Sustainable development is a never-ending process of progressive social change. It involves multiple transitions or system innovations. Each transition is made up of processes of coevolution involving changes in needs, wants, institutions, culture and practices” (Kemp et al., 2007). According to European Roadmap 2050 energy transition is going beyond the technologies. Transition management can be based on the coevolution between the technology and other areas of society and it has to include new forms of government and social theory. Energy transition can be managed through the specific sociotechnical changes that will support the process. Strategic Niche Management (SNM) theory (Kemp, Schot, Hoogma, 1998) addresses social processes of the transition. It suggests creating and supporting the safe areas (aka sociotechnical niches) for sustainable practices to emerge and grow until these will become dominant. There are three key processes for successful niche growth and emergence: managing expectations, building social networks, and learning. Only in cooperation with the stakeholders of these safe niches can energy transition scale up and be replicated in other areas.

Managing expectations is foremost related with communication but it goes beyond that addressing the perception of the energy transition. Different stakeholders will have different expectations in the transition process especially if the process is influencing the basic consumer choices of the people. These expectations should be addressed and stakeholders should be engaged to support or at least not to resist the transition. In cases of conflicts of interest of different stakeholders the decisions have to always support the transition but also be transparent and include wider audience. Transition process should be clear and understandable, introduced and well explained. It is important to engage the stakeholders from the beginning and show their roles and responsibilities in the process. Managing expectations should be the goal of the communication strategy and engagement plan and should be developed there more in detail.

The goal of learning is to change the existing sociotechnical practices. It is useless to invest into technology while creating a Smart City if there is no change of behavior. Formal and non-formal learning/teaching (including learning together with the students) plays greater role the deeper the learning curve gets. The developers of the Smart City are emphasizing the importance of the learning and the responsibility and the mission to provide the learning/teaching to the community. This may not be enough. The widest spectrum of pedagogical tools will be used to encourage the learning including leading experts but also peer-to-peer type of sharing of experiences. Best teachers are learning from their students.

SNM theory suggests “three ways by which niches can influence the regime: by enabling replication of projects within the niche, bringing about aggregative changes through many small initiatives; by enabling constituent projects to grow in scale and attract more participants; and by facilitating translation of niche ideas into mainstream settings” (Seyfang and Haxeltine, 2012).

For supporting energy transition a new type of public policy is required.

4.4 Energy management in Smart City

As more people flux to cities and create more pressure on urban systems the more specific response is required. Important development is helping cities to deal with this challenge – arise of data. Cities have become increasingly instrumented by the help of ICT tools. More sensors that enable to capture different types of environmental information are being integrated on city systems. Moving towards to a smart city concept the data created by the sensors can be used for better energy management in Smart City. The data has to be collected and analyzed to create innovative computer based planning and operation models. Outdated energy management models and principles have to be replaced to move forward to a low-carbon economy. Calvillo et al. (2016) have proposed five main energy-related activities: generation, storage, infrastructure, facilities and transport.

They all are related, but they affect energy system in different ways: generation provides energy, while storage helps in securing its availability; infrastructure involves the distribution of energy and user interfaces; facilities (buildings) and transport are the main final consumers. All of these activities are supported by intelligence (control management), communication, and hardware (physical elements and devices).

Sustainable development is the fundamental principle of the energy paradigm. This is seen as a combination an economic, environmental and social agenda. The main difference from classical energy management models is the shift from economic growth (in almost any cost) to controlled growth that won't jeopardize the quality of an environment and social structure. Economies in the sustainable development can only grow if this is supported by the increased efficiency in the production and consumption and if it is offering equal access to the increasing life quality. This is equally true to cities. A sustainable city is a wealthy city with good environment and good access to its services.

Different aspects of sustainability have already been integrated into existing energy management models but are targeted one after another in the process of typical evolution of energy policies (Frei, 2008). This evolution is firstly focusing on bringing energy services into the market and securing the energy supply. Next step would focus on the feasibility and economical models. Only after a strong market for energy services has been established a set of new goals can be adapted focusing on environmental and finally social agenda. The strategy to combine these into the complex of connected objectives is only possible in integrated energy planning system that is supported by the new ways of controlling and driving the urban infrastructure.

Smart City can become a suitable environment for adapting sustainable energy management. It can provide an extensive overview of the resources that are used and the impact that has been created by the economic development. Smart city also provides adequate support for decision making process offering strategic framework (that is based on long term perspective) and social acceptance needed to make critical changes. From the other hand it would be difficult to implement Smart City model without sustainable energy planning. Implementation of Smart City model and sustainable energy planning can happen in complementary why by one supporting the other. Table shows how sustainable energy management and SZCO2 city model can support each other facing the demands of creating low-carbon economy.

First EU level implementation of sustainable energy planning methodology is in Sustainable Energy Action Plan (SEAP) supported by European Commission and Covenant of Mayors. This is the most advanced and widely accepted methodology for implementing sustainable energy planning with the elements of integrated energy planning. SEAP methodology is used as a basis for developing energy management model for SZCO2 cities in SmartEnCity project. Existing action plans will be analyzed and improved if needed to include the new challenges of the SZCO2 city concept.

4.4.1 Smart Zero CO2 cities

“Smart cities represent a conceptual urban development model on the basis of the utilization of human, collective, and technological capital for the development of urban agglomerations”

(Angelidou, 2014). In practice smart cities are building their effort on three pillars: efficient use of energy, transport and utilisation of modern ICT tools. Integration of the ICT tools opens up new possibilities for increased efficiency in consumption through better services that are offering precise response for the needs of the users. Fully integrated ICT tools will start to create additional value through the new qualities they will introduce to the system. Typical example of this is smart grid technology that through its flexibility is capable to integrate large variety of electricity producers that were not be able to be integrated before. One of the main qualities that fully integrated ICT tools are offering is the connectivity. This opens up new possibilities for better management on every level from end users to national administration.

The technological and economical changes will be based on the new administrative and social paradigm. The focus of the government sector will shift towards reducing the environmental impact of public services and governing enabling policy framework that is needed for implementing the low-carbon economy. The role of the governance will be redefined by this and will facilitate the structural changes these institutions have to go through. This will go hand-by-hand with the changes of people's value systems and behavior.

The technological infrastructure of low-carbon economy will be optimized for the lower energy usage and for benefiting from the ecological lifestyle choices. These choices will be supported by economical models that reflect the real cost of the goods and services and do not give the competitive edge to the industries that are subsidizing their products with the help of hidden and indirect cost models. End users and producers/providers will be acting based on the shared responsibility principles reducing the anonymity of the impacts of consumption. The design of the products, services and systems will follow the principle of eco-design and implements the transparent cost models combined with the clear labeling communicating the impact of the usage of these product and services. Improved safety and clear user information will be part of the consumption experience empowering the consumers to be more aware about the impact of their behavior.

The Smart City model goes beyond its technological parameters and includes also economic, financial and social aspects of modern urban development. Smart Zero CO2 City will take that approach even further exploring the ways how cities can create radically new relationship between the city and its impact. Smart Zero CO2 City can be described as a city that has zero carbon emissions on an annual basis. All the energy that is consumed directly or indirectly will be replaced by the local energy production and all the emission that is created by the activities of the city will be neutralized by offering carbon free energy resources to the market.

As stated in the research proposal, a Smart Zero Carbon City (SZCC) is “a resource efficient urban environment where carbon footprint is eliminated; energy demand is kept to a minimum through the use of demand control technologies that save energy and promote raised awareness; energy supply is entirely renewable and clean; and energy resources are intelligently managed by aware and efficient citizens, as well as both public and private stakeholders”.

To achieve this ambitious goal most of the energy production has to be based on renewable energy sources. If this is not an option, local low-carbon energy production has to be implemented to compensate the carbon load from conventional power plants. This and other measures have to be analyzed and suggested in Sustainable Energy Action Plan. Local energy production plant can be municipal entity but it also can utilize the resource of private production units (typically PV-panels). To include small scale production units, implementation of smart grid is inevitable that every household can be a potential energy producer. Local energy production has to be encouraged and supported by local administration. This can be done through incentives, support for organising energy co-operations, simplifying the administrative procedures and other measures.

According to EU Transport White Paper (2011), transport system has to shift out the ‘conventionally fueled’ vehicles and utilise low-carbon energy sources like biogas, hydrogen and electricity. The energy transition has to be the focus of the local mobility planning (implementing Sustainable Urban Transport Plans - SUTP) together with the supporting measures like reducing the private car usage and increasing the amount of active transport modes (walking and cycling). Smart cities will adopt mobility management regulations that will favor active transport modes and give them clear priority on the streets. Demand management and land-use planning will reduce forced consumption by reducing the need for transportation.

New and renovated buildings will be made according to Near Zero Energy Building (NZEB) standard and going beyond that creating Zero Energy Buildings and Zero CO2 Buildings that will have annual net zero site energy use and net zero site emission. NZEB standard will be implemented for 2020 as a part of the EU energy framework and will be mandatory from that point onwards. Energy efficiency principles will be implemented on district and city level. Cities that are designed to reduce the need for mobility and utilize its natural resources like sun, wind, water etc. can offer the services with lower energy cost and smaller environmental impact.

Waste management in smart cities has to focus on reducing the waste flows and reducing the impact of waste. The priority of waste management has to be on reuse. Recycling is accepted only if the reuse of items and materials is not possible. Producing energy from the waste would be the option if the reuse and recycling is not possible. Landfilling of materials will not be allowed. Smart Zero CO2 City will introduce the concept of circular economy that will create closed circulation of materials based on EU framework of Circular Economy. To avoid the carbon leakage cities have to develop procedures that will calculate the impact of imported and exported goods and services. Eco-design principles will be implemented to the production and life-cycle analysis will be implemented to product and services.

To ensure the full implementation of Smart Zero CO2 concept a set of new administrative regulations will be put into place. These regulations will help to facilitate energy transition in the community ensuring that the municipality is always moving to the right direction. For better implementation of these new regulations a new administrative model can be introduced that will support the development of low-carbon economy and develop adequate policy response for that. Table 10 illustrates the different policies Smart Zero CO2 cities will implement.

Demand	Smart City	Smart Zero CO2 City
Reduce consumption	Monitor consumption and	Train and teach;
	inform users	Support and scale up sustainable practices;
	Develop new applications	Develop new culture.
Increase efficiency	Implement new tools and introduce new technologies	Implement better management practices:
		decarbonisation as a political goal;
		sustainable planning for Energy and Mobility (SEAP, SUTP etc);
	Paperless government	make sustainable practices to become a norm for public institutions;
	Electronic voting	reshape administrative framework;
		implement sociotechnical alignment policy;
	Smart Lab, Living Lab, Makerspace	encourage local production in main industries.
Increase the usage of RES	Implement Smart Grid	Prefer and support RES in energy systems.
Involve additional investments	Implement electronic tender processes	Create new financial models;
		Reduce time and bureaucracy for administrative practices in infrastructure development;
		Involve new type of investments;
		Develop local economy.
Reduce the impact of transport	Intelligent Transport System	Demand management, land-use planning;
	Smart car and smart street	Carpooling, shared ownership models.

Table 4. Policy demand and response of Smart Zero CO2 City

Risks of Smart Zero CO2 cities

Risks of implementing of Smart Zero CO2 city model have to be assessed, analyzed and managed. It is needed that the risk management will be part of the foresight and administrative routine of SZCO2 cities. The risk management has to cover the technological, economic, social and environmental risks. Risks have to be assessed on the level of administration, executives, experts, service providers and end users.

SZCO2 city has a driving technological agenda. Typical risks related with the implementation of ‘smart’ technology are: low technological development, high vulnerability (technology is creating specific security problems), access to personal information and overwhelming computerisation (transforming everything to smart devices). Readiness of the technology can be overestimated - it may not be ready for implementing or requires additional piece of technology that is not implemented. All the technological solutions have to be analyzed from the viewpoint of large-scale implementation and its impact. People's privacy must be protected and personal data has to be used in the way that it won't create additional risk for misuse. Adding additional layer of ‘smart’ control to our living environment will increase the risks of these controls to fail in the way that is not acceptable in a living environment. It also increases the risk of unauthorised usage and vulnerability for attacks. These risks grow exponentially in modern integrated systems where the people, machines and living environment are mutually interconnected through data systems. Today failure in data systems can cause traffic accidents, power cuts, shut down of transit networks or public services and can harm the life of the citizens. These risks can be addressed and lowered by better design and more adequate technical solutions but they will not entirely disappear. Because of that a fundamental question about the balance of using smart technology in living environment should be asked. How much integration of ‘smart’ technologies in our everyday life will make our living smart before it makes us inevitably very stupid?

Economical risks are related with generating investments and implementation of new business models: feasibility of new or existing technology and its supporting systems, existing market barriers (already made investments and long term contracts in previous technology, artificially higher prices for newcomers), ever changing regulations and instability, external economic forces like the global financial market. Also it’s worth noticing that all the ‘smart’ devices or their core components are always imported and this is related with the specific risks of international trade markets. Feasibility of the ‘smart’ technology has two important aspects: aspect of the cost and aspect of the predicted income. Finding a good balance between costs and predictions helps to enable the investments. This process can be supported further by enabling regulations and well communicated long term strategy.

Typical environmental risks include the risks of increased importance of digital technology: the risk for carbon leakage (resource usage and emissions in distant countries that is related with creating elements of SZCO2 city; also the transportation), digital waste, alienation of the digital lifestyle from the environmental awareness. Carbon leakage is a feature of global production model where the goods and services are created far from their end users. Environmental impact of the creation of these activities will remain to the country of origin although it is actually part of the environmental impact of the consumption of the target country and should also be calculated as this. Corporate responsible should address the effect to the environment that the consumption in more developed countries has for the environments of specifically less developed countries like East-Asia and Africa. Digital waste is the flipside of the carbon leakage phenomenon and has as devastating effect. Our used electronic devices will be shipped to the less developed countries for ‘recycling’ and will end up polluting environment with highly toxic elements that are used in these devices like lead, heavy metals, plastic (that is usually burned in open environment). These chemicals will end up in the environment together with the chemicals that are used for ‘mining’ some of the more valuable elements from the circuit boards - different types of acids. There are several international initiatives that are fighting with digital waste but the risk remains and is increasing as the consumption cycle of electronic devices and consumer goods is growing all over the world. Corporate responsibility and national regulations should be used for uncontrolled handling of digital waste. Also - we should buy fewer things.

Typical social risks include the risks of increased importance of digital technology in society: loss of jobs when replaced by technology, new unmatched expectations for the skills and capacity, energy poverty, privatisation and restriction of public services. Digitalisation of our lives is reshaping our job market and makes many jobs obsolete. It is also creating new workplaces but the skillset required in booming digital service sector is radically different from what people possess after losing their job because of digitalisation. This mismatch is having big economic impact and is also creating unequal opportunities that is even more amplified by the divide between the 'digital natives' (who have been growing up using digital devices and computers) and the older generations. The other risk is the wellbeing the people who don't have the economic means to invest their interest into modern digital technologies. Access to SZCO2 services should not be restricted for those who do not have the money to buy the digital 'gadgets'. The same risk should be avoided in the renovation of the properties by giving access to economically vulnerable groups for avoiding energy poverty. The city has to be equally accessible for all the social groups even if it is a Smart Zero CO2 City. This principle has to be included also into the design of the public-private cooperation models and the privatization of 'smart' public services should be avoided.

Sociotechnical risks are related with the ambivalent relationship between society and technology: low public acceptance (people are not ready for implementations), unrealistic expectations (hope that new technology will solve all the old problems) and insufficient accessibility. For creating wider acceptance for SZCO2 technologies have to be nurtured in safe environments like demo areas and living labs. At the same time it is required to develop new type of skillset that is related with how the 'smart' living environment is developed. The slow uptake of 'smart' home automation systems should provide the lesson for how not to design living environments. The most crucial risk in designing 'smart' living environment is related with development of user interfaces.

In the heart of 'smart' technology is a computer but it would be a mistake to design a Smart City user interface as a typical computer interface. This would be the most efficient way to create a confusion and resistance against the 'smart' living environment. Computer interfaces are a powerful way to interact with large amount of data but they do have a steep learning curve. Also computers are designed to crash and fail the ways of how the living environment should never fail. 'Smart' living environment has to include user interfaces that are direct, linear, familiar, intuitive, fail-safe and accessible for everybody including digitally challenged and disabled people. This is foremost not an engineering task but rather a designing task and that's why user interfaces should be designed not by engineers but rather designers, artists and experts of human interactions. Nevertheless extensive learning strategy has provided together with the implementation of technology to reduce the risk of alienating end users.

SmartEnCity concept: smart integrated urban regeneration

SmartEnCity work plan is organized to develop and demonstrate a highly adaptable and replicable systemic approach towards urban transformation into sustainable, smart and resource-efficient urban environments in Europe. This approach will be laid out and implemented initially in the three Lighthouse demonstrators, to be further refined and replicated with the development of Integrated Urban Plans (IUPs) in both Lighthouse and Follower Cities.

The ultimate goal of these combined actions is to move European cities towards the Smart Zero Carbon emissions vision. This goal should be achieved through the combined deployment of a number of Europe-wide replicable strategies aimed at:

- Reducing energy demand through the use of innovative technologies in building retrofitting, sustainable and clean transport systems and intelligent control ICT; as well as raising awareness in all involved stakeholders.
- Maximizing renewable energy supply, through the use of locally available sources

This general concept is linked to the EIP SCC vision through planning and implementation in the three lighthouse cities of the following set of measures:

1) Low energy districts:
   a) Energy retrofitting of buildings: Developing a context-adaptable systemic approach towards significant reductions in the energy consumption of the building stock, addressing the key technology issues as well as identified financial and social barriers, and making use of the energy reduction potential of ICT.
   b) District heating and cooling networks: Cost effective implementation scenarios, significant increases in renewable share, efficiency improvements linked to intelligent control technologies, and residual energy recovery and use are addressed in SmartEnCity
   c) RES integration and management: Identification and use of not realized potential in RES, as well as intelligent management of electric urban infrastructure
2) Sustainable Mobility: A number of measures dealing with clean energy source promotion in both public and private fleets, as well as intelligent management for improved efficiency, optimized operation, and better integration of clean transport modes in the developing urban scenarios. Additional issues such as improvements in environmental quality (air quality, noise...) will also be addressed.
3) Information and Communication Technologies (ICTs) considered as cross-cutting, enabling technologies that will be used for monitoring and evaluation of the success of measures, as well as a means for management, control and integration of valuable information provided and made accessible to different stakeholders and a tool for social interaction.

Renovation of buildings sets energy performance targets that will go beyond existing national requirements and will even go beyond Near Zero Energy Building standard set by EU and national governments. This will set the new standard for the energy efficient renovation in partner regions. Renovation will be done according to the national and municipal building regulations and standards for safety and indoor climate. During the renovation the building envelope will be insulated and added new doors and windows. Ventilation systems will be rebuilt using recuperative heat exchangers that will reduce the heat loss. Heating systems will be renovated and new more efficient heat exchangers will be installed. Roof and facade of the buildings will be renovated. Renovation will be supported by European Union to support more vulnerable social groups and reduce the energy poverty.

Renovation will be carried out together with development of district heating networks with the integration of RES and reducing the environmental impact of the domestic energy consumption. New district cooling technology will be piloted to reduce the electricity demand during the hot season for cooling. Local renewable electricity production with PV panels will be also integrated into the 'smart' living environment. This will help to further reduce the energy dependence and emissions. The produced electricity will consumed in the area, stored into the batteries or sold into the grid. All the charging points for electric vehicles will be powered by RES electricity using only low-carbon energy sources. Combination of PV produced electricity and EV charging is one of the most interesting and promising combinations for future urban energy systems especially if combined with smart grid and local energy storage.

The local energy production will act as a pilot for distributed energy production and encourage citizens to start earning money from privately owned power plants. This will create new business opportunities in the community and opens up market for new types of investments. Different ownership models will be explored and implemented in the process challenging the existing market regulations that still are supporting large scale actors. Different technical solutions will be explored to fit the PV plants with existing urban structure. Only very few existing buildings in European cities are designed to be the ideal ground for PV plants. Finding an optimal angle and the best visibility on existing buildings will be a practical challenge to explore.

The focus of the urban mobility is the shift from private car usage to car sharing, public transport and active transport modes like walking and cycling. All these modes are supported in the project with the different combination in the pilot areas. Creating better charging network will support the uptake of EV technologies in rental services and for electric taxis. EV charging will use only RES electricity and develop additional market for locally produced solar electricity. Biogas busses will use biogas that is produced from the urban waste and by this will reduce the usage of fossil fuels. Additionally electric bicycles and ordinary bicycles are supported to create convenient rental solutions for the inhabitants of the area so they don't have to worry about the storage and maintenance.

Renovation is combined with the implementation of ICT tools for monitoring and managing consumption in renovated buildings. ICT tools will be integrated into the heating and cooling systems, electricity grid, ventilation, water network and street lighting network. These tools will allow monitoring consumption of the heat, water and electricity in real time and will regulate the indoor climate according to the user needs and comfort. Based on these tools users can track their consumption and optimise the usage for the best comfort and performance. ICT tools will be combined with Urban Management System that will integrate different 'smart' technologies.

The design of ICT tools will ensure the safe usage of the building and public services and won't increase the vulnerability of these systems. The failure of 'smart' layer on these services won't stop the services to function and will roll the systems back to their original manual control. The user interfaces of these 'smart' systems will be designed to be simple and will not reduce the accessibility of these services for any social group. The data about the personal consumption will be treated with the care and people's privacy will be protected.

Renovation of buildings and implementation of ICT tools will be carried out together with the process of dissemination and learning in which the used technologies will be introduced to the inhabitants and the public. In this process the 'smart' technologies will be demonstrated and the concept of a Smart City will be explained. The learning process will include several demonstration objects that will be open for public including one apartment in renovated building that people can visit and explore, rent EV cars and bicycles and compare their utility costs and environmental impact with the average consumer of renovated buildings.

Special care will be taken to integrate action in these areas into a systemic frame, paying special attention to specific cross cutting aspects which address the “enabling themes”:

Inclusive governance models: enabling all relevant stakeholders’ participation, and specially enabling citizenship to get involved in the planning and decision making processes in a participative role.

Replicability aspects: through the adaptability and feasibility of business models and management procedures that make for attractive scenarios to be replicated in a wider (European) context. The demonstration activities of SmartEnCity are located in three European Cities: Vitoria-Gasteiz (Spain), Tartu (Estonia) and Sonderborg (Denmark), Three medium to small sized cities in Europe, sharing a solid background and capable to offer lessons from outstanding accomplishment in specific areas linked to the scope of the SmartEnCity project.

SmartEnCity is a demonstration project and the impact of it won't last if it would not create a change in decision making process of people and institutions. Citizens will be systematically included into the process from the beginning and will share also its outcomes. Stakeholders will be included into the core working groups of the project: designers, architects, engineers, builders, community leaders, representatives of vulnerable social groups etc. Local residents will be included to the decision making process to define the outcome of the regeneration of the demo area. Administration will implement the Smart Zero CO2 City approach to their working routine using that as a basis for the urban development in the future.

Project will start with creating a framework for social innovation and engagement. During this the public and the residents of demo area will be informed about the project activities. Smart Zero CO2 model will be introduced and the known applications will be shared with the audience. Existing knowledge and experiences from tens of dozens of Smart City initiatives from EU and other countries (‘lessons learned’) will be analysed and shared with the stakeholders. Possible risks and critical factors will be assessed, analyzed and solutions will be proposed. Expectations for the project will be carefully created amongst the actors of change. In this stage the project partners will be preparing for the following activities by creating local cooperation between the actors, experts, stakeholders and public.

After establishing the working relationship with the public and stakeholder groups the technical solution will be proposed and discussed. At this stage the public acceptance for the technological innovations will be tested and analysed. Different social groups will have different attitudes towards the new technology and the space has to be created for these attitudes to be spoken out. The consultations with experts will reveal the information about the prevailing culture in building and renovation market - what is considered to be possible, feasible or what is seen as impossible and expensive. More importantly the gaps in knowledge and skills will be revealed during this process. These gaps will be fulfilled with the help of trainings and sharing the knowledge. Also the learning program for the end users will start.

After the extensive consultations the process will start with the preparations for the retrofitting the buildings. Different technical solutions will be analyzed and created as a portfolio of suggested designs that later will be used by the architects and engineers in designing the renovation projects. Together with suggested solutions also obvious mistakes in existing designing practice will be identified and described as potentially harmful. All these materials will be available for future developments for local and the international community.

Renovations of the buildings together with the development of ICT systems, district heating networks, ‘smart’ streetlights, EV charging stations and other infrastructure will be monitored and evaluated. Mistakes in the process will be pointed out and fixed. More fundamental mistakes will be described and used as a lesson for the next developments. The process of preparation and the renovation will be extensively monitored and described for replication. Renovated buildings will be monitored for two years after the project has ended and the findings will be periodically introduced to the public. Beyond demonstration implementation, extensive monitoring and evaluation of each implemented measure will be carried out in the three lighthouse cities. Energy and CO2 savings, as well as other environmental and economic impacts and benefits will be quantified and assessed.

Lastly, in order to maximize replication potential, the SmartEnCity involves two Follower Cities (Asenovgrad in Bulgaria and Lecce in Italy), which, as project partners, will benefit from the development and implementation work in Lighthouse Cities, as well as provide inputs to ensure adaptability and flexibility of SmartEnCity output for maximum impact. Ultimately, these cities, along with Lighthouse Cities will develop, within the frame of the project, an Integrated Urban Plan, which will pave the way for further implementations in the future.

5 General design of the diagnosis process

The objective of SmartEnCity, namely Smart Zero CO2 Cities, should be framed within the paradigm of sustainable urban development. That frame includes a set of environmental, social and economic goals, but also a set of governance arrangements and procedures. Although Smart Cities and Communities (SCC) approach may be perceived as more focused on energy challenges, this topic has multiple implications that concern a cluster of domains.

The Charter of European Sustainable Cities and Towns Towards Sustainability, better known as the Aalborg Charter (1994), is an initiative approved by the participants at the first European Conference on Sustainable Cities & Towns in Aalborg, Denmark. Inspired by the Rio Earth Summit's Local Agenda 21 plan, it was developed to contribute in the field of urban environment sustainability to the EU Environmental Action Programme, 'Towards Sustainability'.

The Aalborg Charter defines a series of local strategies towards sustainability that combine governance and environmental issues:

1. Sustainability as a Creative, Local, Balance-Seeking Process
2. Resolving Problems by Negotiating Outwards
3. Urban Economy Towards Sustainability
4. Social Equity for Urban Sustainability
5. Sustainable Land-Use Patterns
6. Sustainable Urban Mobility Patterns
7. Responsibility for the Global Climate
8. Prevention of Ecosystem Toxification
9. Local Self-Governance as a Pre-Condition
10. Citizens as Key Actors and the Involvement of the Community
11. Instruments and Tools for Urban Management Towards Sustainability

The Basque Declaration ("New Pathways for European Cities and Towns to create productive, sustainable and resilient cities for a liveable and inclusive Europe") approved in the framework of the 8th European Conference on Sustainable Cities and Towns (2016) updates the environmental challenges after 30 years:

1. Decarbonise our energy systems and reduce total energy consumption
2. Create sustainable urban mobility patterns and accessibility for all
3. Protect and enhance biodiversity and ecosystem services
4. Reduce the use of greenfield land and natural space
5. Protect water resources, water and air quality
6. Adapt to climate change, and reduce the risk of disasters
7. Improve public space to create convivial, safe, and vibrant environments
8. Provide sufficient and adequate housing for all
9. Guarantee the social inclusion and integration of all parts of the society
10. Strengthen our local economies and local employment opportunities

The Leipzig Charter on Sustainable European Cities, adopted in 2007, recommends making greater use of integrated urban development policy approaches, with implementation-oriented planning tools that should:

- describe the strengths and the weaknesses of cities and neighbourhoods based upon an analysis of the current situation,
- define consistent development objectives for the urban area and develop a vision for the city,
- coordinate the different neighbourhood, sectoral and technical plans and policies, and ensure that the planned investments will help to promote a well-balanced development of the urban area,
- coordinate and spatially focus the use of funds by public and private sector players, and
- be coordinated at local and city-regional level and involve citizens and other partners who can contribute substantially to shaping the future economic, social, cultural and environmental quality of each area.

In fact, integrated approaches have been considered a prerequisite for urban sustainability in Europe as they involve "spatial, temporal and factual coordination and integration of diverse policy areas and planning resources to achieve defined goals using specified (financial) instruments" (BMVBR/BBR, 2007). Moreover, all governmental and non-governmental players relevant to urban development should get involved in a comprehensive way from the earliest stages of any project, including local residents and private agents and stakeholders.

Diagnosis supports all the subsequent process, thus an integrated approach should be applied from the start. In this sense, an integrated diagnosis faces all the challenges faced by integrated planning.

5.1 Challenges of integrated planning

Integrated planning implies the participation of all stakeholders, and the examination of all dimensions of a problem, in order to determine the most appropriate options and to arrange a suitable course of action. The implementation of integrated planning has, however, a quite paradoxical aspect: it is more necessary precisely where it is more difficult to implement, that is, in complex, multi-dimensional problems that involve several agents and stakeholders.

Urban planning is a field where integrated planning is particularly suitable due to the complexity of the urban context, both in terms of interrelated topics and multiple stakeholders.

Integrated planning is usually used to integrate a variety of means to achieve some kind of end (as coordinating different municipal departments to design or implement a specific action plan), but it might offer the best of its potential in the task of integrating a variety of different, interrelated means and ends in a more vaguely defined planning framework.

5.1.1 Integrating energy and urban planning

Energy planning is a relevant example of single-end, multiple-means integrated planning, while urban planning would be a field where all the potentials (and difficulties) of integrated planning arise.

Energy consumption in urban areas is responsible for a large share of CO_2 emission, specially related to the building and transport sectors. Energy Efficiency Directive

(2012/27/EU) considers and encourages the adoption of integrated urban planning to take advantage of all the energy savings potential present in urban areas.

The potential of this integrated approach was explored by CONCERTO, an EU initiative within the European Research Framework Programme (FP6 and FP7), focused on exploring the potential for cost-effective energy savings in buildings, and aimed to demonstrate that the energy optimisation of districts and communities as a whole is more cost-effective than optimising each building individually. The CONCERTO approach was based in bringing together all relevant stakeholders and integrating different technologies, and it was tested in a wide variety of contexts.

The global evaluation of the initiative (CONCERTO Premium, 2014) identified three main factors of success that relate to the integrated approach:

- Integrated technological approach, which includes the design of deployment strategies to adapt a variety of existing technological solutions to different local conditions.
- Integrated planning, that includes the participation of a variety of stakeholders, including experts from different departments of public administration, political representatives and professional practitioners, specialists and citizens.
- Active involvement of residents and end-users, which should be fostered through the provision of appropriate information about energy consumption, as well as energy and economic saving potentials.

In terms of integrated planning, "the CONCERTO initiative proves that if given the right planning and if all necessary stakeholders are included from the beginning until the end of the project, cities and communities can be transformed into sustainable energy pioneers." (CONCERTO Premium, 2014)

Three research projects selected in the FP7-ENERGY-SMARTCITIES-2012 Call ("strategic sustainable planning and screening of city plans" topic) have examined more deeply the role of integrated approach in urban energy planning:

- STEP-UP, Strategies Towards Energy Performance and Urban Planning
- PLEEC, Planning for Energy Efficient Cities
- InSMART, Integrative Smart City Planning

As depicted in Table 5, these three projects focused on different relevant aspects of integrated energy planning at urban level: which themes and expertizes should be integrated, how improvement potentials can be exploited, and which are the specific characteristics of each energy consuming sector. The comparison displays the existence of different ways to reach an integrated approach, as well as their potential complementarity.

Project	STEP-UP	PLEEC	InSMART
Shared objective	To improve the integration of energy and urban planning		
Themes to be integrated	• Energy & Technology • Economics • Organisation & stakeholders		
Improvement potentials		• Technology driven • Structure driven	

		• Behaviour driven	
Energy consuming sectors			• Building stock • Transport • Other energy system
Integrative tools	**City Energy Plans** • Innovative Projects • Learning Network of Cities	**Energy Efficiency Action Plan** • PLEEC tool	**Strategic Sustainable Energy Plan** • GIS energy maps • Integrated Planning Tool

Table 5. Innovative approaches to integrate energy and urban planning

5.1.2 Integrated urban planning

The Leipzig Charter (2007) recommended making "greater use of integrated urban development policy approaches", drawing up integrated urban development programmes for the city as a whole, while paying special attention to the regeneration of deprived neighbourhoods. Thus, the challenge of integrated urban planning in Europe is better captured by the concept of integrated urban regeneration, since the great majority of urban planning deals with the transformation and retrofitting of the existing city, rather than the creation of new urban areas.

Furthermore, urban regeneration is a key component to a more sustainable city, since it fosters the use of already urbanized land and it promotes compact and dense urban models, reducing the need for transportation. In recent years, there have been numerous initiatives based on improving energy efficiency, habitability and accessibility in urban areas, which have been mostly incomplete in that they did not address other fundamental issues affecting these areas, such as socio-economic vulnerability, social cohesion, etc. The difficulty of overcoming sectorial approaches that have traditionally been applied to solving the problems of the consolidated city, coupled with the difficulties of managing and financing operations, are the biggest challenges in this field. For that reason, for some time now the need to address regeneration processes from an integrated approach has been recognized.

In Europe the integrated urban regeneration approach has been building since the Declaration of Amsterdam (1975), which advocated integrated historic centers´ preservation, being renewed in 1990 with the launch of the URBAN program, which enacted a holistic approach to intervention in disadvantaged neighborhoods. However, it was not until 2010 (Toledo Declaration) that the importance of integrated urban regeneration was officially recognized in order to achieve a smarter, more sustainable and socially inclusive urban development in Europe.

The URBACT project "RE-Block. REviving high-rise Blocks for cohesive and green neighborhoods" (http://urbact.eu/re-block) is an interesting precedent of an attempt to achieve integrated urban regeneration. Its main goal was to "foster efficient regeneration of these neighborhoods, making them more attractive and improving their environmental quality, whilst creating an integrated tailor-made approach to combat poverty". As a result of the project, several policy recommendations were developed (RE-Block, 2015a):

- Although improving housing quality is usually the main component of urban regeneration, this should go far beyond building retrofitting.

- A holistic and cross-sectoral approach should be established that includes integrated and flexible funding, city and metropolitan-level strategic planning, incentives for public-private partnerships and coordinated public policies focused on giving a coherent response to community needs and demands.
- Governance mechanisms should foster residents' participation in urban regeneration projects, through coordination, participatory and integrative tools. This should include horizontal partnerships between local authorities and civic society, and vertical partnerships between local stakeholders and city-wide, regional and national authorities.

5.1.3 Integrating smart technologies in the urban context

The Smart City concept includes a variety of approaches which range from Future Studies trying to foresee the city of the future (UK Government Office for Science, 2014), to a generic trademark comprising a plethora of commercial products focused on making this future real. Although there is neither explicit definition nor recognized theory on Smart City (Albino, Berardi & Dangelico, 2015; Harrison & Donnelly, 2011), there are similarities among the variety of projects and some classification efforts have been undertaken. Despite the difficulty to keep track of the many Smart City projects launched in recent years, there is a series of topics and fields shared by many of these projects, as well as certain regional differences (Neirotti, De Marco, Cagliano, Mangano & Scorrano, 2014). The diversity of Smart City projects can be analyzed in terms of topics, methods, agents, design and implementation processes, or business models (Giffinger & Gudrun, 2010; Angelidou, 2014). The European Commission has proposed a vision of Smart City focused on the intersection of three major topics: energy, transport and communication, with an approach that highlights the potential environmental and sustainability dimensions of Smart City, not present in the previous definitions (Kramers, Höjer, Lövehagen & Wangel, 2014).

In any case, every Smart City Project is a combination of more or less mature technologies applied to different fields. In recent years there has been a great deal of foresight studies from technology companies, trying to figure out new fields and possibilities for their technological developments, beginning to design specific products and services for the city. At the same time, the first implemented projects have shown the limitations of the traditional approach: the proper functioning of the city depends more on the correct interaction of the different existing tools than on the addition of new superb tools (Molina, Arana & Jiménez, 2015). In this sense, specific challenges may be identified for integrating smart technologies in the urban context: "It is not one single technology, but rather a set of socio-technical systems that need to interact in an intelligent way, in order to deliver a broad set of benefits to an individual network of beneficiaries" (SmartImpact, 2015:14-15).

Smart City should be conceptualized as a tool at the service of a vision, a city project at the service of a transformation strategy. This means not to replicate but to generate genuine projects adapted to local conditions: each city, town or region should find its own Smart project, supported by their own strengths and opportunities, taking into account the multidimensional nature and interrelated problems of urban phenomenon (Molina, Arana & Jiménez, 2015).

5.2 Integrated Diagnosis

5.2.1 Integrated process

The diagnosis phase, including baseline calculation and city needs identification and prioritization, may be the first step of any process of intervention, but it cannot be independently designed, since it will condition the following steps. The partners involved and the methods used in the earliest stages of any process leave their distinctive marks, which determine the whole process to a greater or lesser extent.

Baseline definition and city needs identification are parallel processes that should be interlinked in such a way that they both provide feedback to each other. City needs assessment may be focused on (subjective) perception, while baseline definition implies a focus on (objective) measurement. What to measure should be guided by perceived needs, but the opposite is also true: perceived needs should be validated through measurement.

As city needs assessment is at least partly subjective, those agents able to contribute to this phase of the project can make their perspective prevail over others'. Therefore, a critical decision to make early on should be the definition of an initial partnership, which should bring together different municipal departments and public bodies, local stakeholders, as well as knowledge and technology partners to take part in the whole process. Different levels of participation, specific coordination procedures, etc. should be defined and periodically revised within the framework governing the whole project.

There are some critical aspects that should be defined, in terms of which activities should be implemented, and which agents should be in charge of them. Process, governance and tools are mutually interdependent and should be defined from a common approach.

The goal of sustainable urban development and the tools designed for achieving it (Local Agenda 21, Integrated Urban Planning) have defined a complex methodological ecosystem that combines a series of diagnosis and governance tools and procedures intended to ensure a balance among the environmental, social and economic dimensions of urban development.

In Table 4 we can see a comparative chart of a variety of urban integrated planning methodologies and their proposals in terms of process, governance mechanisms and diagnosis methods:

- Process: activity sequence, relationship among phases.
- Governance: participating agents, and their respective roles, decision-making mechanisms, interdisciplinary cooperation, community involvement and citizen engagement.
- Methods: knowledge domains, and their relationship, planning techniques and other specific tools.

Integrated planning methodologies combine these aspects in specific ways depending on their goals and scope, as well as their urban, cultural, institutional and political context. (See a detailed description in Annex A2.)

The use of any of these methodologies will depend on the context and the scope of the intervention, but we should always take into account the relationship among the different components (activities, partners, tools and procedures) of the process.

The SmartEnCity Integrated Strategy (D2.7) will define a whole methodology for implementing Smart Zero CO2 Cities. *Figure 1. Preliminary scheme of SmartEnCity Integrated Strategy* displays a preliminary version of this strategy, with a sequence of activities, a distinction between partners depending on their role in the project, and a variety of interaction flows among the different components.

	Elements of the methodology	Local Agenda 21 (ICLEI, 1996)	Ecocity (2004)	ESCI (IDB, 2011)	Ecodistricts Protocol (2016)
Process	Activity sequence	✓	✓	✓	✓
	Relationship among phases	✓	✓	✓	✓
Governance	Participating agents	✓	✓	✓	✓
	Roles	✓	✓		
	Decision-making mechanisms	✓	✓		
	Interdisciplinary cooperation	✓	✓		✓
	Community involvement	✓	✓		
Methods	Knowledge domains	✓	✓	✓	
	Domains relationship	✓	✓		
	Planning techniques	✓	✓	✓	
	Tools	✓	✓	✓	✓

Table 6. Comparative of Integrated Planning Methodologies

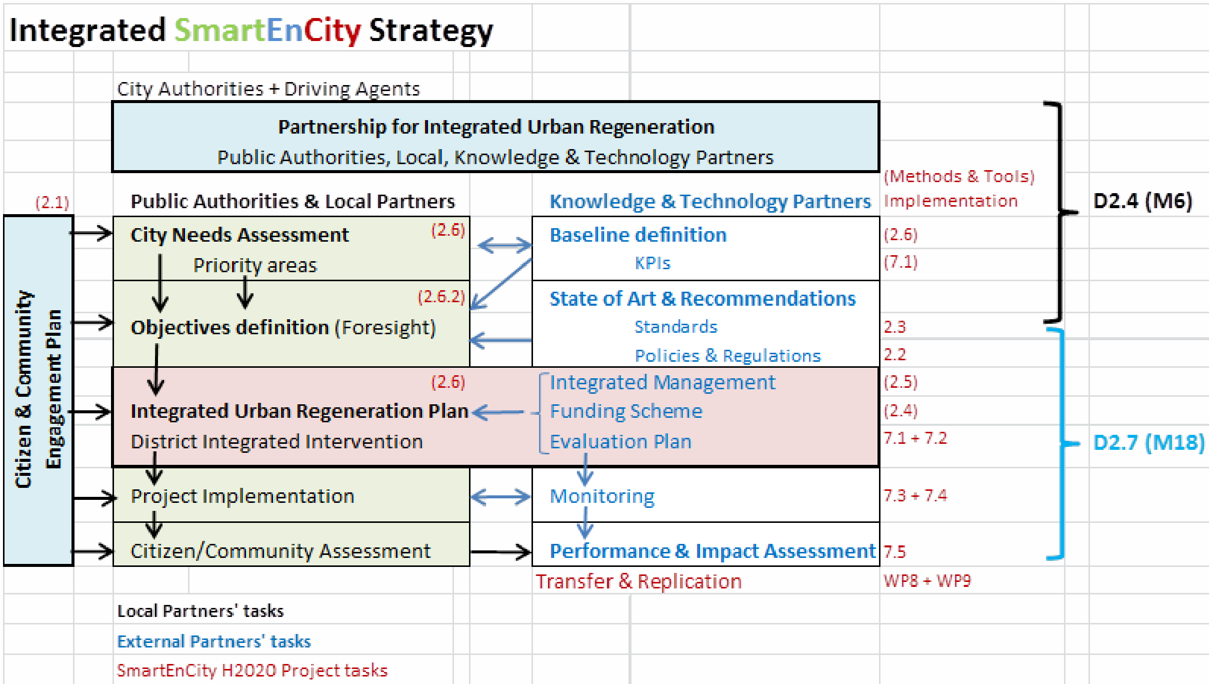


Figure 1. Preliminary scheme of SmartEnCity Integrated Strategy

5.2.2 Governance framework

The implementation of Local Agenda 21 required a deep rethinking of government organization and procedures (ICLEI, 1996), and so does integrated urban planning. The holistic approach of sustainability and integrated planning requires "a paradigm shift in the way local government manages policy fields, multi-level governance and functional areas." (AEIDL, 2013:31)

Urban planning and urban regeneration deal with a complex reality that requires the integration of multiple points of view. Both horizontal, which brings together different policies and sectoral departments, and vertical coordination, which brings together different levels of government, are critical for the sake of integrated planning. In this sense, the governance framework and its capacity to tie different areas and levels of government, has been identified as a critical factor for the success of integrated interventions (AEIDL, 2013:4). Moreover, dealing with such complex, multidimensional problems always requires the inclusion of monitoring, feedback and learning procedures to facilitate early identification of deviations along the process.

Multi-level governance

Multi-level governance is a key aspect of any project that implies a wide range of policy instruments, as urban planning or urban regeneration projects require: "tax regimes and financial instruments for stimulating local investment, planning regulations, development programmes that offer subsidies for particular activities, specific policies promoting integrated approach or mechanisms for public participation" (RE-Block, 2015b). Since these instruments are usually managed by different departments and levels of public administration, an integrated approach requires a framework for the coordination of all these public partners (Tasan-Kok & Vranken, 2011).

URBACT II RegGov network defined ten recommendations for good multi-level governance (RegGov, 2012):

1. Strengthening regional governance from the bottom up: No local projects without integrated city-wide strategies.
2. Integrated urban development: Area-based and cross-sector approaches.
3. Activating and enabling inhabitants: Short-term successes and long-term visions.
4. City networking: Give institutions a face and foster mutual trust.
5. Coalition-building: Cooperation as a principle of work.
6. Physical and infrastructure investments: Linked to socially integrative activities.
7. Monitoring at all involved levels: Early warning system and seismograph of results.
8. Special funding programmes: A chance for social innovation input in mainstream policy.
9. Bundling where necessary: Stronger integration at programme level.
10. Urban agenda: The strong role of cities in the next EU funding period.

Multi-level governance, vertical and horizontal coordination, strategic partnership, citizen engagement and participation, as well as other integrative tools are more developed in some European countries than in others: "In many of the EU-15 countries the governance culture has assimilated the principles of integrated approach as a necessary method to deal with the complexity of urban problems. The new Member States are developing the culture and governance of the integrated approach also in relation to the possibilities of benefitting at best of EU funding" (AEIDL, 2013:32). Thus, the institutional context can act as a barrier for integrated planning and multi-level governance, so specific strategies should be defined in order to get the best possible governance framework.

Policies integration

An urban regeneration project is never isolated from a wider context. Their efforts should be coordinated with other urban and sectoral policies. Barriers and gaps in policies and regulations for the integration of SmartEnCities projects have been identified in D2.1 by some of the 'Lighthouse cities' stakeholders. There is a wide span of barriers for example market conditions, legislation from EU to local level, institutional failures and different interests of the actors involved in the city transformation processes. Some of the major barriers concerning policies integration are summarized below:

Market

Market conditions in many cases do not favor the best solution from an environmental point of view. Often the perception of cost-effectiveness works against the SmartEnCities solutions. Several reasons can affect the cost-effectiveness perception of measures to be implemented: technology maturity (subsidies to support technology maturing periods have shown lack of success), market uptake (some new products may be economically competitive only if sold with significant scale). Cost effectiveness studies performed at current energy prices however does not consider full benefits of measures (for example, more precise accounting of environmental externalities such as impact on air quality and health would favor electric vehicles).

Legislation

The legislation does not always work for the most cost-effective SmartEnCity transformation. One example is the EU-legislation and building codes which have a unilateral focus on the energy consumption of the single building. This enforces investments in buildings to fulfil the standard; regardless that surplus energy might be available and could be used. If it is legally possible a solution to this could be to add flexibility to the building standards by making it possible to avoid fulfilling the zero-energy standard in specific areas if certain conditions are present (e.g. minimum volume of available surplus heat for the next 20 years).

Policy and Social engagement

Social engagement of citizens and local stakeholders is vital to the successful transformation to SmartEnCities. Lack of information at the level of both decision makers and practitioners may hinder the implementation of energy-efficiency measures. Information asymmetry as in the landlord/tenant problem also affects spread and adoption of energy efficiency measures.

Citizens may consider certain measures as a decrease in their quality of life (e.g. shifting from individual to collective transport).

A large number of measures may require the coordination of different actors from different sectors/functions, resulting in a divergence of interests.

"Not my business": Integrated solutions are required covering urban planning, buildings licensing, energy infrastructures, transport, water and waste management, but these domains are often classified under different departments, all having their own targets and budgetary constraints.

Politicians tend to think and act on the short term, whilst transformation towards a sustainable city may take decades. Additionally, actions against climate change do not result in direct benefits for the implementer.

Some of these barriers may be overcome by an intense communication campaign to show the benefits to join the projects: Involving the citizens by participatory processes where it makes sense and the making of a political consensus agreement, or opening up for local economical ownership by shares – for example, in RES-projects where large returns can be expected.

City	Coordination of SmartEnCity intervention project with other city plans
Vitoria-Gasteiz	Sustainable Energy Action Plan Sustainable Urban Mobility Plan
Tartu	LH project is based on all the existing data and experiences of City of Tartu and TREA namely the participation in Covenant of Mayors initiative and others. City of Tartu is investing into the sustainability and this has been a constant strategy for last seven or more years. In this sense, LH project is coordinated with all plans that are applicable to relevant tasks (mainly, Sustainable Energy Action Plan).
Sonderborg	A previously developed baseline and heat plan including scenario developments will be used as a data basis to the extent this is reasonable. LH project is linked together with Sønderborgs zero-emission target in 2029 in project Zero.

Table 7. Policies integration: coordination of SmatEnCity interventions with other city plans

Project partnership

Partnership was a key element of sustainable development planning in the ICLEI methodology for Local Agenda 21 (ICLEI, 1996). This approach implied the integration of a variety of points of view along the whole process, starting from diagnosis phase, as well as the design of an *ad hoc* governance model for the planning process. This was a response to the challenge of integrating the three wide pillars of the sustainable development approach: environmental, social and economic development, with all the associated conflicts. More bounded goals do not require such broad arrangements, but these general models can be used as a reference for designing proper partnership and governance models in integrated urban planning and regeneration projects.

The main strength of a partnership should be its ability to coordinate the efforts of partners with different technical, administrative, social or political capacities. In this sense, the selection of the appropriate partners is as important as the definition of their respective roles in the process. Urban planning and urban regeneration projects require a combination of local and technical expertise, as well as the cooperation of all the levels and departments of public administration. A complex project involves a wide variety of capacities and probably a great number of partners; and this usually requires defining specific management procedures to coordinate all the contributions.

The diagnosis phase is focused in recollecting, processing and analyzing data that will become the basis for decision making, so the role of the partners involved in this stage of the process can be defined from their relation to these data-related tasks. In any case, partners responsible for management, coordination and decision-making should be defined from the first day, as these tasks reach the whole process. Similarly, some of the partners involved in the diagnosis phase will also participate in subsequent stages of the project, so the diagnosis partnership cannot be defined without the perspective of the whole project.

Citizen engagement

Although citizen engagement and public participation is recognized as a critical component of any integrated urban regeneration project, there are a variety of factors that must be taken into account to devise a participatory process.

There are different contexts for a participatory process, which are dependent on socio-economic conditions and governance culture and experience. From an evaluation of more than 50 projects implemented in the framework of 2007-2013 Programme of the European Regional Development Funds (ERDF), it can be stated that:

"In northern Europe, in particular, it appears that 'institutionally integrated processes' dominate, with a top-down approach to bottom-up practices. Here long-term planning frameworks are characterised by complexity, vertical articulation, and a higher level of effectiveness in public administration, but also some rigidity of rationale and obstructive bureaucracy, as outlined for instance in the case of neighbourhood managers. The issues may stem in some part from the repetition of long-term practices, and incapacity to renew methodology in a framework that remains the same.

In contrast, southern European and new Member States that lack a national framework are more dependent on a local context; here participation arises out of extemporaneous opportunities, intuitive actions and self-organised social innovation, possibly filling gaps left by institutional governance or profiting from particular contextual conditions. This attitude has the positive effect of enhancing dynamic initiatives and innovative models. It is characterised by adaptive capacity and civic engagement, and designs interesting exceptions to the mainstream models, but often lacks continuity." (AEIDL, 2013:51-52)

Different levels of public participation or citizen engagement can also be identified.

A classical work from Sherry R. Arnstein (1969) described the effects on citizen empowerment of different approaches of citizen engagement in development projects. She defined a ladder of citizen participation which included a series of steps that were non-participatory (manipulation, therapy), different degrees of tokenism (informing, consultation, placation) and different degrees of citizen empowerment (partnership, delegated power, citizen control).

From a more pragmatic approach, Ecocity project (Gaffron et al., 2005) defined a "community involvement pyramid" with five levels of public participation:

- No knowledge: community has no knowledge of planning aims and processes
- Information: community is informed about planning aims and processes
- Consultation: citizens and stakeholders are consulted about their wishes, concerns, etc.
- Participation: citizens and stakeholders participate in defining aims and in producing masterplans

- Decision-making: citizens and stakeholders contribute to the decisions shaping the actual development

In a similar approach, IAP2 Spectrum of Public Participation differentiates five levels of public participation, which imply different goals and promises to the public (IAP2, 2014). Table 8 displays a comparative chart of the three typologies.

Anyway, more participation doesn't imply automatically better results; conversely it can hinder the process in case participation promises cannot be fulfilled. The engagement approach should take into account the governance culture, the administrative structures, or the policies and regulations that define (and usually narrow) the decision-making framework to determinate the kind and scope of citizen participation. In this sense, the citizen engagement strategy should be defined in the earlier stage of the process, along with the governance framework and the communication strategy of the whole project, in order to avoid the risk of any misunderstanding.

Arnstein (1969)		Ecocity (2005)	IAP2 (2014)
Non-participation	Manipulation	No knowledge	
	Therapy		
Degrees of tokenism	Informing	Information	Inform
	Consultation	Consultation	Consult
	Placation	Participation	Involve
Degrees of citizen power	Partnership	Decision-making	Collaborate
	Delegated power		Empower
	Citizen control		

Table 8. Levels of public participation

5.3 Measurement

5.3.1 Knowledge domains

The comprehensive and holistic nature of sustainable city concept has compelled to establish a wide and quite unbounded framework. However, there are several attempts to standardize the domains that should be included in an integrated approach to sustainable cities.

Departing from the local strategies towards sustainability defined in the Aalborg Charter (1994), the Aalborg Commitments (2004) stablished a set of domains to better categorize the efforts on sustainable urban development:

1. Governance
2. Urban management
3. Natural common goods
4. Responsible consumption
5. Planning and design
6. Better mobility
7. Local action for health

8. Sustainable local economy
9. Social equity and justice
10. Local to global

After the recommendations of Leipzig Charter (2007) on applying an integrated approach to urban planning, LC-FACIL URBACT II network defined a Reference Framework for Sustainable Cities that establishes 30 objectives distributed in 5 dimensions (see Table 9).

However, district-level approaches may be much more bounded. Table 10 displays the number of indicators used by different district-level urban development certification tools (see 7.1 for a more detailed description). In that comparative chart we can see a core of traditional categories (environmental, social and economic) shared by all the certification systems, while there is a variety of complementary, more specific domains only included in some of the systems. Mobility and governance would be the most extended of these complementary domains, while energy becomes a specific domain only in one of the systems (although the more popular one).

Dimension	Objective
Spatial	1. Develop sustainable urban planning and land use 2. Ensure spatial equity 3. Encourage territorial resilience 4. Preserve and enhance architectural, cultural and urban heritage 5. Promote high quality and functionality of public spaces and living environment 6. Develop alternative and sustainable mobility
Governance	7. Ensure an integrated territorial strategy 8. Foster sustainable administration and financial city management 9. Implement a process for assessment and on-going improvement 10. Increase citizen participation 11. Strengthen governance in partnership 12. Facilitate capacity building and networking
Social	13. Ensure social inclusion 14. Ensure social and intergenerational equity 15. Build up a supply of housing for everyone 16. Protect and promote health and well-being 17. Improve inclusive education and training 18. Promote culture and leisure opportunities
Economical	19. Stimulate green growth and the circular economy 20. Promote innovation and smart cities 21. Ensure connectivity 22. Develop employment and a resilient local economy 23. Encourage sustainable production and consumption 24. Foster cooperation and innovative partnerships
Environmental	25. Mitigate climate change 26. Protect, restore and enhance biodiversity and ecosystems 27. Reduce pollution 28. Adapt to climate change 29. Manage natural materials resources sustainably and prevent waste 30. Protect, preserve and manage water resources

Table 9. Dimensions and objectives for a European vision of tomorrow's cities (RFSC, 2016)

Knowledge domain	BREEAM	LEED	HQE2R	DGNB	DPL
Environmental	20	26	21	11	7
Social	7	3	15	12	12
Economic	3	6	3	4	6
Mobility	7	14	5	-	-

Energy	.	6	-	-	-
Governance	3	-	-	8	-
Management	-	-	-	10	-
Housing & Urban Design	-	-	9	-	-
Basis data	-	-	-	-	4
Total	40	55	53	45	29

Source: BREEAM Communities 2012 / LEED 2009 for Neighbourhood Development / DGNB New Urban Districts / HQE2R project for Urban Planning and Development / DPL, Sustainability Profile of Location.

Table 10. Indicators by knowledge domain, in different district-level certification systems

SmartEnCity proposal

Several city application areas have been defined in order to cover the main characteristics of cities. In the case of the indicators proposed in the framework of SmartEnCity project have been structured according to the scheme below. (See detailed list in Chapter 7.)

Domain	Subdomain
City characterization	Key features of the city Land use characterization Socio-economic features of the city Environmental features of the city
Energy supply network	City energy profile Potential local energy resources in the city Environmental impacts in the city due to energy consumption
Transport and mobility	Mobility City profile City statistics for mobility Environmental impact of the mobility
Urban infrastructures	Available infrastructures in the city for managing transport, waste, water and environment Existing transport utilities Existing environment monitoring infrastructure Existing city monitoring infrastructure Communication infrastructure in the city
City plans & regulation and governance	City plans and strategies Public procurement procedures & regulations and normative Governance
Citizens	Existing actions for citizen engagement Channels for citizen engagement Current scenarios of citizen engagement

Table 11. City characterization indicators: domains and subdomains

5.3.2 Data management

Data is a central component of any diagnosis. It should be defined the way in which data is collected and processed in diagnosis phase, how it will be used in the subsequent stages of the project, and how it will be communicated.

Barriers and gaps identified by LH cities include lack of data, or restrictions related to privacy issues, and insufficient spatial disaggregation (Table 12). The complexity of any urban regeneration project implies the use of a wide variety of data from several sources, so a Data Management Plan (DMP) that anticipates these problems is always highly recommendable. This DMP should cover the handling of data during and after the intervention project, what data will be collected, processed or generated, what methodology will be applied, which data will be shared or communicated (to other partners, to the public) and how, and how data will be curated and preserved (EC, 2016b).

LH City	Barrier and gaps identified in pre-diagnosis phase
Vitoria-Gasteiz	• It is not very common to get data at building scale because of its confidentiality. The data gathered at this scale could not be gathered without public bodies' commitment and support. These data (at building scale) serves for the internal analysis and decision making but most of it would not be possible to be included in the diagnosis deliverable due to its confidentiality. Some data was impossible to gather, like: number of dwellings in which residents are also owners, population who lives alone or has reduced mobility, population without employment, etc. Other data, especially those related to building characteristics, were not available and had to be obtained through a specific field work campaign. • Data sources depending on private companies (for example: energy consumption per building) were not possible to access due to privacy issues. • In any diagnosis using GIS, there is a common difficulty in the integration of data, due to the different levels and formats of information.
Tartu	• The best overview and data exists on town level. There is no data available on district level and there is also significant lack of the existing culture to analyze the separate districts from the energy management point of view. • The knowledge about the buildings is relatively good but it is not based on real data but estimations and modeling based on the research about other soviet-type architecture.
Sonderborg	• Collecting data about electricity use is resource demanding as it is part of the personal data protection act in Denmark and therefore not accessible to the public. Instead it has to be aggregated data generated from grid companies selling electricity in the area (usually several different companies), which can be a slow process. • Getting accurate data on energy consumption in industries (incl. farming) is a barrier. Not accessible in accurate form as data are anonymized. • Certain data on transport is calculated on a national level and have to be transformed to data on local level.
Common problems	• **Lack of data** • **Confidentiality / privacy issues** • **Spatial disaggregation of data** • **Comparative analysis of different levels**

Table 12. Barriers and gaps in data handling identified by LH cities

Communication

There are several ways and places where the data should be used:

- Internal technical work: the information is used to put in common technical criteria among all the municipal departments with responsibility in a certain area. For instance, data from mobility surveys should be used to coordinate the works of the Urban Planning Department, the Traffic Department, the Local Police, etc. How: Internal periodical meetings, Intranet tools, email.
- Sectoral working groups, with the participation of technicians and political representatives. It is fundamental to reach agreements between those two sectors: politicians give their political view and the technical staff provides technical aspects to help political agents to take decisions. How: Periodical meetings.
- Transversal meetings, with agents of other public administrations with responsibility in the areas of work. There are some aspects of the city's sustainability that are not fully under local control, and other (regional, national) agents could have things to say. How: Periodical meetings.
- Public participation, communication & awareness (citizens, associations, companies, etc.). In parallel to the previous works, data are also used to empower citizens and give them some chances to decide about aspects of the policies to be developed. Afterwards, when specific actions are applied, citizens must be informed about all the changes and how they will affect their daily lives. How: Website & social media, specific on-street campaigns, advertising and articles in traditional press & media, specific participation processes, direct postal an digital mailings.

5.3.3 Indicators

An indicator is a parameter, or a value derived from parameters, which describes the state of an issue. The purpose of defining Key Performance Indicators (KPI) is to establish the criteria to evaluate how an action or intervention is influencing in the achievement of goals. (There is a multitude of indicator systems focused on the characterization and measurement of urban attributes; a more detailed reference can be found in *D7.1 KPIs definition for pre-intervention data collection.*)

Criteria for selecting indicators

As stated in *D7.1 KPIs definition for pre-intervention data collection*, there is a set of criteria for selecting indicators to ensure a suitable screening:

- Relevance
- Completeness
- Availability
- Measurability
- Reliability
- Familiarity
- Non-redundancy
- Independence

The types of indicators and KPIs to be defined must be aligned with their potential uses and the evaluation framework established in the project. Concerning SmartEnCity evaluation framework plan, this must fulfil the following objectives:

- Characterize the cities in order to know the current city profile which allows defining the interventions to be implemented in LH cities and the subsequent evaluation of the project effects in the city.
- Define the baseline scenario of the district in order to evaluate the performance gained.
- Assess the project impacts in the city, showing the progress achieved after the implementation of the interventions.

SmartEnCity Indicators & KPIs

Two figures have been defined for making city diagnosis and evaluating the performance of interventions:

- Indicators: They are defined for their use in the diagnosis of cities in order to characterize and identify the main features of a city, their strengths and weaknesses and evaluate the current sustainable or smart index. The diagnosis done through these indicators will allow to define the needs of the city (e.g. most suitable interventions), setting city objectives (e.g. to create a Smart Zero Carbon City) and/or the type of strategy to be adopted in the future (e.g. Urban Integrated Plan). On the other hand, indicators can be used for comparing current situation of several cities.

- Key Performance Indicators (KPIs) are suitable for obtaining the needed information to evaluate the effects of the interventions defined in the demo-area in terms of performance.

When an evaluation plan includes also the effects of the interventions in the city, a high level indicator category must be defined in order to analyse the impact of the integrated actions. As a consequence, indicators are split in two categories according to the moment in which they are used:

- City index, for city diagnosis for analyzing the features of the city before the beginning of a project/intervention.
- City impact index, a subset of the former, for analyzing the impact of the intervention in specific features of the city.

In the project SmartEnCity, an evaluation plan based on indicators and KPIs has been defined for the identification of strategic city needs and assessing the performance of the interventions. This plan is directly applied in the Lighthouse cities into two stages:

- Stage 1: During the planning phase
    - Characterization of the cities in order to know the current city profile in areas such as energy, transport, infrastructure, governance and citizens before the intervention.
    - Definition of baseline of the demo-area in technical, environmental, social and economic performance before the intervention.
- Stage 2: After the intervention starts
    - Evaluation of the performance gained after the interventions in the demo-area in technical, environmental, social and economic performance.

- Analysis of the impact of SmartEnCity in the cities in order to calculate the benefit of the intervention in the city and show changes in the city profile in the areas agreed in the city diagnosis.

Figure 2 depicts the stages of a project on which indicators and KPIs take part.

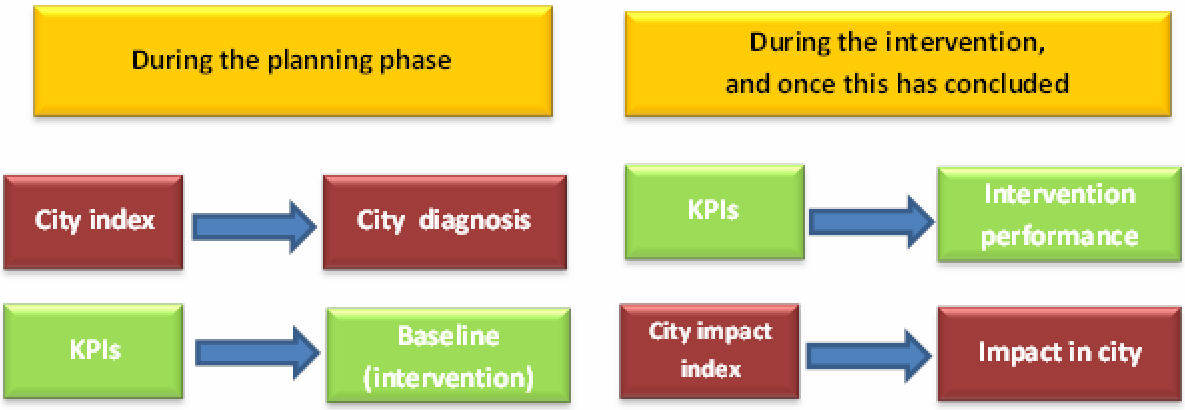


Figure 2. Indicators and KPIs usage in SmartEnCity different stages

6 City diagnosis and characterization

This chapter tries to summarize all the aspects that could affect the design and implementation of a smart urban regeneration project and, thereby, should be analyzed in the diagnosis phase. It pretends to be a comprehensive review, but anyway it is mediated by the nature of SmartEnCity LH projects.

City characterization is conceptualized as a set of improvement potentials framed in a set of local conditions, which act as barrier or drivers to potentials:

- The local conditions affecting project objectives have been classified in three groups: socio-economy, business environment, financing and funding capabilities, and urban environment. (Policies and regulations can be included in this category, but they have been analyzed separately in D2.1.)
- The components of the intervention are related to improvement potentials and include energy-related technologies (energy supply and consumption, building stock and retrofitting, mobility) and enabling technologies (ICT and social engagement).

The definition and prioritization of city needs should be built from a proper analysis of the former, identifying those components (barriers to remove, drivers to boost) that are likely to have a biggest impact in the achievement of the pursued objectives.

Finally, although intervention baseline should be outlined during diagnosis phase, it can't be detailed before the intervention project has been fully devised.

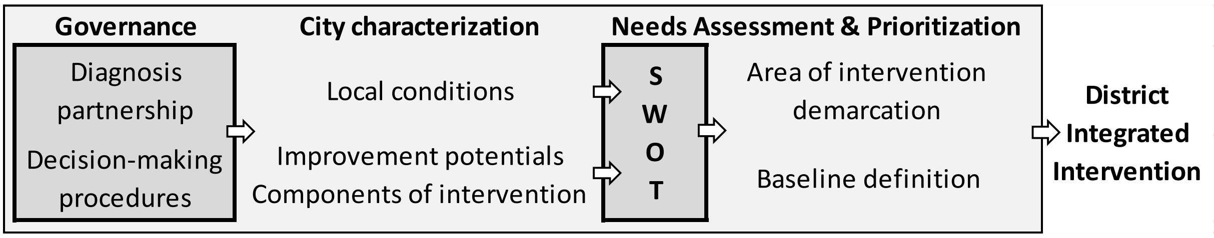


Figure 3. SmartEnCity diagnosis process

6.1 Local conditions

6.1.1 Socio-economic characterization of the city

The aim of this section is to characterize the cities in the light of socio-economic characteristics in order to better target the interventions to be implemented in LH cities. This means analysing local conditions and the current profile of the city that may affect the project objectives. The focus of this chapter is on economic performance, prosperity, equity, innovation (defined in D7.1) and on characterization of population.

The description of the city and the indicators can be divided into two: characteristics that help to understand the overall socio-economic context of the city, but during the project will probably not change; although these indicators are not conditioned to change they are essential to be acknowledged for the intervention methods (e.g. population, ethnic composition, age structure, ICT use, income, etc.), and 2) characteristics that will probably change during the project as a result of the intervention (e.g. number of initiatives for smart city growth).

Socio-economic characterization of a city is related to the interaction of social and economic factors. Social factors are the factors that influence our daily life: age, economic status, religion, ethnicity, family, education, political views, etc. Economic factors are, for example, related to costs and prices of goods. These viewed together provide us with the context and allow to see the connections and effects influencing the cities' readiness to cope with the challenges the SmartEnCity projects aims to address.

City index for city diagnosis

This section elaborates on the city level indexes. As a basis the structure of more detailed divisions (current economic performance, city prosperity, innovation, equity) from D7.1 and overview of the population are used. Most of the indicators come from D7.1 proposal; some other indicators have been added (highlighted) as they can be useful in specific contexts.

The most difficult part of giving an overview of the socio-economic conditions is the scarcity of data of some useful indicators (especially in the case of smaller cities). Thus the indicators must resort on data collected or collectable by the city itself or by national institutions, or make estimates about the city based on values on country level. The primary geographical level used in the analysis is the city (these can be extended to urban regions, if necessary). Possible datasets available to use for city diagnosis include city level datasets, national registers, estimates based on census data, designing questionnaires or surveys for data collection, datasets of organisations (OECD, ITU, etc.), and enquiring associated stakeholders.

Indicators for population overview

The aim of population overview indicators is to describe the population composition and get the aim of city dynamics.

Taking into account the ethnicity aspect from the side of social composition may be important in social engagement activities – in what language should the citizens be addressed. The level of education and age may indicate who are the probable interest groups, what could be the best approaches for citizen engagement, providing information and choosing communication channels. Depending on the city the social composition varies, thus there is a need for adaptive communication for different social groups taking into account the ethnicity, age, gender, education and other factors in the design of communication strategies.

In cities where the *de iure* and *de facto* populations are different it is important to take into account this aspect in deciding what datasets to use. For example, Tartu is a university town, meaning that during the school period its population composition is rather different from the summer period. This affects the housing rental market making them one of the important interest groups in the process. Students can be more sensitive to prices and more mobile, but at the same time they are more receptive and diffusers of the ideas.

Otherwise, these are the basic characteristics that the city should have access using city level or national level databases. Meaning no additional data collection is necessary.

Indicator	Formula	Unit	Description	Possible dataset
Population				
Population count	-	Inh	Total number of persons inhabiting a city	City data

Population density	Total city population / Land area city	Inh/km^2	Population per unit area in the city	City data
Annual population change	[Total population / Total population] × 100	%	Change in the number of inhabitants in the last year	City data
Median population age	-	Years	Median age is the age that divides a population into two numerically equal groups	City data
% of population > 75	-	%	Number of persons older than 75 years	City data
Ethnic diversity	*[Ethnic group × 100] / Total population*	*%*	*Share of different ethnic groups*	*City data/Estimate based on census data*
*Inhabitants with higher education per 100 000 population**	*Inhabitants with higher education / 100 000*		*Number of higher education degrees per 100 000 population*	*ISO 37120:2014; City data/Estimate based on census data*

* Also described in city prosperity (Indicator: Proportion of working age population with higher education)

Indicators for current economic performance of the city

The aim of indicators of economic performance is to describe how well the city is doing in economic sense. The indicators are macro level describing the overall structure of economic activities in the city (e.g. economic freedom, energy intensity of economy, etc.) and micro level describing the households or individuals (e.g. median disposable income).

This chapter is connected with chapter 6.1.2. Business environment, financial capabilities.

Indicator	Formula	Unit	Description	Possible dataset
Current economic performance of the city				
GDP *per capita*	Gross Domestic Product at market prices / Total city population	M€/Inh	The monetary value of all the finished goods and services produced within a city's borders in a specific time period considering the number of inhabitants	City data/National registers
Energy intensity of economy*	GDP value of the city / total energy consumption	MWh/GDP	This indicator will serve to understand the energy consumed in relation with the economic situation of the city	City data/National registers/Enquiry
Median disposable income	-	€	Median disposable annual household income	City data/National registers
Economic freedom	-	-	*Measure of the degree of economic freedom*	*The Heritage Foundation & The Wall Street Journal (on a country level)*

* Alternative on a country level: Gross inland consumption of energy divided by GDP

Indicators for city prosperity

City prosperity indicators help to define the development potential, resources for economic development and the soil for innovation. City prosperity could also be measured on a governance level (overall activity and actions towards smart city initiatives), so it does not deliver only the minimum, but is exemplar for other cities, too.

Indicator	Formula	Unit	Description	Possible dataset
City prosperity				
New business registered per 100,000 population	New business / 100 000		Number of new businesses per 100 000 population	City data
Working age population	*[Working age population × 100] / Total population*	*%*	*Proportion of working age population (18-65 years) of whole population*	*City data*
Proportion of working age population with higher education	[Population at working age with higher education / Population at working age] × 100	%	Proportion of working age population (18-65 years) qualified at level 5 or 6 ISCED (Short-cycle tertiary education or bachelor's or equivalent level)	City level data/Estimates based on census data
City unemployment rate	[Number of citizens unemployed / Total labour force] × 100	%	Unemployed citizens in relation to employed and unemployed who are legally eligible to work	City data/National registers
Youth unemployment rate	[Number of youth citizens unemployed / Total labour force] × 100	%	Percentage of youth labour force unemployed	City data/National registers
Number of strategies/plans/programmes/initiatives to promote sustainability: energy, mobility, waste management	-	*Number of strategies/plans/programmes/initiatives*	*Is there any specific strategy/plan/programme/initiative for promoting sustainable living in the city?*	*City data*
Expenditures by the municipality for a transition towards a smart city	-	*€*	*Annual expenditures by the municipality for a transition towards a smart city*	*City data*

Indicators for innovation

Public opinion on innovation and technology (e.g. Eurobarometer 2015 analysis[1]) would allow estimating the attitudes towards innovations brought about in society by science and technology. But since no universal regularly measured indicator or dataset could be found, indirect quantitative indicators can be used. Innovation can be measured on a city level and on an individual level. City level is connected with economic structure and performance

[1] Eurobarometer Qualitative Study – Public Opinion on Future Innovations, Science and Technology

describing the overall economic system and support to innovations. Individual level is more connected with habits and susceptibility to new technology among the citizens (f. e. ICT use). Both of them are indicators for how prone people can be to adopt new innovative solutions. If no data on individual level is available on city level, country level can provide a good estimate.

Indicator	Formula	Unit	Description	Possible dataset
Innovation				
Creative industries	[Number of citizens working in creative industries / Total labour force] x 100	%	Share of people working in creative industries.	City data/National registers
Research intensity	Expenditure on R&D in a city / GDP of the city	€	R&D expenditure as percentage of city's GDP	City data/National registers/Questionnaire/Enquiry
*Number of internet connections per 100 000 population**	*Number of internet connections / 100 000*	*Connections/100 000 hab.*	*Total number of internet connections in the city in relation to the population of the city*	*Enquiry/ITU*
*Number of cell phone connections per 100 000 population**	*Number of cell phone connections / 100 000*	*Connections/100 000 hab.*	*Total number of cell phone connections in the city in relation to the population of the city*	*ITU*
*Smartphone penetration**	*Number of smartphones / Total mobile phones*	*%*	*Number of smartphones in relation to total mobile phones*	*ITU*

* Alternative on a country level.

Indicators for equity

Equity is a measure of fairness and justice. The most prevalent equity measure is the Gini Coefficient that represents the income distribution of a nation's residents. The differences in income can induce social inequality in different levels (education, living conditions, ICT use, etc.). Equity in housing field can be measured by affordability of housing. This measure can be segmented into affordability by rental market and by purchase market. Equity in housing field can also be measured by the percentage of the stock reserved for social housing.

Households with smaller income are very sensitive to monthly communal expenditures. One of these is the proportion of cost of energy (mobility, heating, electricity) of household income. This impact can be measured by energy poverty (summed over the types or separately), but information of expenditures on a household level probably acquires a request for additional data from the energy providers or a special survey among the citizens (if not already carried out).

Socio-economic position also conditions attitudes and awareness. Participation in elections (national or local) can be used as an estimate for measuring public interest and activity of citizens. In regions where environmental awareness is higher the project goals should be more easily achieved. Environmental awareness could be assessed with survey or questionnaire among the citizens, but needs unified methodology and extra data collecting.

The same is with satisfaction with living environment. All these could be indicative of attitudes prevalent among the citizens.

Indicator	Formula	Unit	Description	Possible dataset
Equity				
*Gini Index**	-	-	*Measure of inequality*	*OECD, World Bank*
Affordability of housing	Average price of house or annual rent / Minimum or average annual salary	Ratio	Measure of the affordability of non-social housing	City data/National registers/Data mining from real estate portals
Percentage of the stock reserved for social housing	[Social housing/public protection destiny / Total building stock] × 100	%	Measure of the governmental action to improve housing accessibility	City data
Energy poverty level	Average of the energy bill of household / average salary in the country	Ratio	The energy poverty can be understood as a lack of access to “modern” energy services and to goods comfort conditions	Survey/Questionnaire
Fuel poverty/Energy poverty	Number of households unable to afford the most basic levels of energy / total number of residential buildings	Ratio	Percentage of households unable to afford the most basic levels of energy	Survey/Questionnaire
Voter turnout in last municipal election	*[Number of persons that voted in the last municipal election / Total city population eligible to vote] x 100*	*%*	*Voter participation level. Measure of public/citizen activity*	*City data*

* On a country level.

6.1.2 Business environment, financial capabilities

Approach: Context & Ambitions

As a first approach, the European Innovation Partnership on Smart Cities and Communities Strategic Implementation Plan defines the context for business models, procurement and financing mechanism as follows:

“In most cases, new investments will be needed to generate the broad uptake of smart city solutions. However, due to the economic crisis and increased demand for public services (demographic change, care, transfer of tasks from central government levels etc.), the public sector – locally and centrally – has limited budgets. This means that new market-oriented and sustainable strategies of public private cooperation must be developed and cities must seek greater levels of external investment. The investment community seeks certainty, and scale. However, most cities, at an individual level, presently deliver neither of these. Continuing 'business as usual' will not create enough value and scale for city administrations, cities, businesses and solution providers. The goals developed in the vertical priority areas cannot be achieved in traditional ways, for several reasons. Firstly, there is a need for smart solutions that are developed in collaboration between citizens, local and global industries, municipal utilities and the local public agencies – this often defies conventional procurement and tendering procedures. Secondly, although solutions must be local, such typically small-scale individual solutions are unnecessarily expensive and preclude the development of a business case for innovative smart city solutions at pan-European scale. Finally, the matching and combining of complex city needs with industrial needs for longer term process and product innovation can be improved significantly." (EIP-SCC, 2013:19)

This way Smart City projects need to be economically feasible without public subsidies in the near future, and meanwhile, these subsides should be clearly defined in order to draw a sustainable roadmap for urban retrofitting, if Europe is willing to transform its cities into more sustainable and competitive. This assumption will only be achieved if all stakeholders involved in the processes of city transformation are able to identify the added value of the investments. Public and private collaboration and a stronger integration of the value chain is a strategic issue to leverage public and private investments.

Local conditions definition will be first component in order to identify the current local context affecting projects objectives. Second component will be which the improvement potential is, and hence which are the project challenges

In order to approach to existing challenges for Smart City projects, European Innovation Partnership on Smart Cities and Communities Strategic Implementation Plan defines the following ambitions for the business models, procurement and funding:

"Smart cities will integrate local solutions within a European or global market, by aggregating local demand and developing common solutions.

Business models for smart cities and communities should consist of a more modular approach to local ecosystem solutions, which can be used in cities throughout Europe, and thus define a European market for smart city solutions, technologies and products. Local ecosystems are collaborations between industry, governmental bodies and citizens to meet specific local goals.

Financing of smart city solutions will be possible, if investments in smart assets are used for lowering the operational expenditure. Investments from different stakeholders can be combined, making cost per implementation more affordable, by creating a European market for broadly usable solutions (aggregated demand), and ensuring a long-term perspective for investments. Citizens should be also involved in innovative "crowd funding" mechanisms, in order enhance their sense of awareness by getting tangible outcome from smart cities initiatives, engagement and stimulation of technological providers along industrial value chains (e.g. from production of new materials to new ICT systems solutions, or systems to store energy) hold the potential to drive innovation much quicker into smart cities. This requires new forms of public procurement of innovation and engagement with industries.

Procurement procedures need to be changed and new procedures need to be developed. For smart city solutions, cities need to participate in local governance entities, with joint ventures and joint investments." (EIP-SCC, 2013:19-20)

According to this ambition context each project could develop specific challenges on the issues previously described related to business environment and financial capabilities.

Local conditions for business models and financing mechanisms

Local conditions definition will include the following issues, closely related to business models and financial capabilities:

- Policies and regulation
- Market barriers
- Procurement system
- Investment, funding and financing mechanism.

For this purpose following questions and items to be worked out are proposed in order to approach a local conditions definition:

A. **Policies and Regulations**: Based on the regulation framework affecting working areas as Building retrofitting; energy supply and use; smart mobility; investments in ICT, or others. The analysis to be made must focus on:
    1. How these regulations affect the business models?
    2. Which is the general regulation framework for public procurement?
    3. Which is the general regulation framework for PPPs and other kind of public private collaborations?

B. **Market**: Specifically barriers in the market define consumer context for current business models which could demand new solutions, models or financing mechanism for investment. This will merge how to improve the relation between the products, service, and the market or final consumer for the working areas on the new business models pathway. Improvement on this issue could be oriented on how can the market barriers be solved or improved and more specifically, how can a better matching between business models and market be achieved developing necessary changes on the market analysis, on the products or services, on the deliverable channels or services processes, on the cost and revenue stream?

C. **Public procurement** conditions for projects in order to promote a closer public - private working context:
    1. Identification of the different services (consultancy, project definition, construction works, exploitation, O&M etc.) necessary for the actions to be developed in the different working areas.
    2. Procurement system, types of procurement processes etc in regard to working areas and services/products.
    3. Which are the main entities or organizations that will launch services to procurement for the different services previously described?

D. **Investment, funding and financing mechanism** in order to cover finance and investment gaps, reduce risks and uncertainty:
    1. Identification of the different financing sources for the different works and services or the whole project necessary for the financing of the actions to be developed in the different working areas.
    2. At a minimum, % over general budget and stakeholder financial potential contribution (name & type: public, private, others)
    3. If existing, which is the financial gap on each working area?
    4. How can the financial gap be closed?
    5. How can the cost–revenue stream be improved?
    6. Which other funds are available for Smart City projects development?
    7. Which other financing and innovative mechanism can be developed for Smart City projects development?

Improvement potential on business models and financing mechanisms

Together with existing challenges definition according to the general context described, second component would be to identify which the potential for improving local conditions for business models and financing mechanisms is.

According to the general common ambitions framework presented, it is proposed that challenges and improvement potential definition will be worked out on the city needs definition on business environment and financial capabilities area according to these questions:

i. How stakeholder engagement and coordination can be improved in order to promote better local stakeholder collaboration.
ii. How solutions, technologies, products and services can reach the market in a better way.
iii. How markets can be better focused and identified by business models.
iv. How business models can achieve solving what new/current market needs.
v. How new financing models can achieve improving the relation on cost/revenue, improve and reduce risks and uncertainty and limiting and reducing payback periods.
vi. Which challenges must face public procurement mechanisms in order to: promote stakeholder collaboration and improve how solutions technologies, products and services reach in a better way the marketplace?

Finally relevant KPIs for measuring city innovation potential (selected from D7.1 proposal) could be useful to measure several issues closely linked with innovation, new business models and city financial capacity:

- GDP per capita
- Energy intensity of economy
- New business registered per 100,000 population
- Proportion of working age population with higher education
- City unemployment rate
- Youth unemployment rate
- Creative industries
- Research intensity

6.1.3 Urban environment and quality of life

Energy consumption and its efficiency is closely linked to most of the urban environment aspects of a city, as the city's configuration, location, land uses, activities and resources consumption influence the local energy balance. There are some clear aspects affecting energy consumption (climate, urban density, accessibility, mobility), whereas other can have a more indirect influence (air quality, water consumption, waste production, etc.) Depending on the city, some variables could be more important than others.

Following there is a procedure that can be used to characterise a city and how those characteristics influence the energy balance.

Relevant environmental variables

- Climate (rainfall, temperatures, etc.) Climate is one of the key factors that affect the need of heating/cooling in the residential and public sectors, but also in other sectors, such as food distribution.
- Land uses (urban density, brownfields recovery). Urban fabric is related to almost all the questions related to sustainability in a city. The energy consumption of the mobility sector is greatly influenced by the type of urban fabric. The creation of a public transport system is more expensive and difficult in disperse cities. On the other hand, cities without enough green spaces are affected by heat island phenomena.
- Accessibility to basic services. This variable is interconnected with the urban fabric. Less accessibility means more need of private car, and a worse quality of life for people without a car (young people, elder people).
- Air quality: pollution, noise. Noise, CO2, NOx… all kind of pollutants (mostly related to personal mobility) could be reduced if some actions are applied to densify cities and create diverse neighbourhoods.
- Water consumption. Water is actually one of the scarcest resources in some cities, mainly in drier geographic locations. Even in cities with plenty of water, purification and transport of water can be a significant part of the energy consumption.
- Waste production, waste recycling. The generation of a circular economy is fundamental to create sustainable cities, and waste reduction and recycling are key factors in that trend.

Definition of methodologies, measurement units and standards

The city should define how, when and what is going to measure: define a clear methodology for each variable to be measured. For instance, if accessibility to basic services will use a 300 m distance or 500 m distance buffer; what standards and applications will be used to measure and define the noise; how will be population density calculated (what is urban and what not?); etc.

Definition and measurement of indicators to monitor the evolution of the urban environment will be explained in detail in WP7, while calculation methods are defined in the catalogue of *European Common Indicators* (Ambiente Italia, 2003).

6.1.4 Policies and regulations

Local, regional and national policies and regulations define a normative framework that conditions any intervention. This aspect has been analysed in D2.1. Barriers identified for a SmartEnCity transition in the major EU-directives regulating the four main topics of the project (building retrofitting, energy supply, mobility and ICT) are summarized in Table 13. This EU-legislation, which is implemented in the national legislations in different ways, affects to all cities within member states of the European Union.

EU Directives	Gaps / barriers
The Energy Performance of Buildings Directive (2010/31/EC)	Lacks a long term binding target for existing buildings that could further incentivize renovation of the building mass. Has a unitary focus on the energy consumption of the single building. (Future legislation should

	have a more holistic approach focusing on the whole value chain covering efficient technologies, district heating, smart metering and billing.)
The Renewable Energy Directive (2009/28/EC)	Lack of mandatory energy efficiency requirements for new power plants and heating distribution systems. Current restrictions regarding the development and improvement of European networks of interconnections should be overcome to foster market integration. Lack of common standards for smart grid solutions including energy buffering and storage. Legislation should allow more active and informed consumer participation than today and allow new actors such as aggregators.
The Clean Vehicles Directive (2009/33/EC)	Lack of a clear definition of Clean Vehicles. Bias for diesel vehicles is potentially bad for the local air quality in cities.
The Alternative Fuels Infrastructure Directive (2014/94/EU)	Lack of harmonized and clear standards for the production of alternative fuels makes the environmental benefits unclear.
The General Data Protection Regulation (GDPR)	Challenging to harvest and use data in a way that is secure and respects the individual's right to privacy. Data Protection Directive versus monitoring energy behaviour inside houses

Table 13. Some gaps in EU legislation which affect SmartEnCity projects

6.2 Components of the intervention

6.2.1 Energy supply and consuming patterns

In today's situation cities use mainly fossil fuels to meet their energy needs, although several steps have been taken, there is still big gap between the non-renewable and renewable energy sector. Comprehensive analysis must be carried out to understand different consuming patterns in infrastructure, transportation and industry. It is known that buildings are responsible for 40% energy consumption in the EU and fossil fuel usage is highest in the transportation sector therefore consumption model management may be very effective way to reduce the energy need in different fields.

Four steps have to be made to evaluate city energy supply:

- Firstly, energy production and consumption need to be thoroughly overviewed and mapped.
- Secondly, energy related processes and their effectiveness need to be assessed.
- Thirdly, city energy balance need to be calculated
- Finally, the technology level in energy transformation need to be observed.
- In order to understand the consumption patterns of the city, thorough measurements and evaluation needed to be carried out in buildings, transportation and industry.

Questions for evaluating energy policy in city:

- Existence of an energy action plan.
- Allocated investments in sustainable energy projects.
- Development of non-profit organizations who promote sustainable energy.
- Amount of public events promoting energy efficiency and renewable energy.
- Finally, are the energy labels certificates taken into use?
- Incentive schemes at national level to help increase interest in energy efficiency.

In order to improve energy management cities have to prepare their action plans. This action plan is called the Sustainable Energy Action Plan (SEAP) and it will be the main document to achieve the ambitious targets. Tartu has set up its targets for 2020 to decrease of CO2 emissions by 108 159 tCO2/y in comparison to 2010 and consume 200 000 MWh less energy annually. The share of renewable energy will increase from 38% to 45% by 2020. Vitoria-Gasteiz plans to reduce its overall emissions by 25% which means 216 340 tCO2/y in comparison to 2006. Sonderburg has already reduced CO2 emissions by 25%, according to the Roadmap 2010-2015.

The characterization of a city should include the following aspects:

- Energy supply: share of different energy sources, distribution infrastructures.
- Consuming patterns: built-up infrastructure, transportation, industry, others.
- Existing energy policies and management tools (Table 14) at urban, regional or national level.

Demand	Smart Zero CO2 City	Energy Management
Reduce consumption	Train and teach	Empower the community
	Support and scale up sustainable practices	Set up the strategy for low-carbon economy
	Develop new culture	Empower the community
Increase efficiency	Implement better management practices	Set up local energy management systems
	Decarbonisation as a political goal	Include impact evaluation into the decision making process
	Sustainable planning for Energy and Mobility (SEAP, SUTP etc.)	Initiate sustainable planning for Energy and Mobility
	Make sustainable practices to become a norm for public institutions	Set up local energy management systems for public institutions
	Reshape administrative framework	Include impact evaluation into the decision making process
	Implement sociotechnical alignment policy	Create space for new sociotechnical practices in energy model
	Encourage local production in main	Monitor the impact of local consumption

	industries	and production
Increase the usage of RES	Prefer and support RES in energy systems	Include RES practices into the energy model
Involve additional investments	Create new financial models;	Create space for experimental services in energy model
	Reduce time and bureaucracy for administrative practices in infrastructure development;	Include impact evaluation into the decision making process
	Involve new type of investments;	Create space for experimental investment models
	Develop local economy.	Monitor the impact of local consumption and production
Reduce the impact of transport	Demand management, land-use planning;	Include impact evaluation into the decision making process
	Carpooling, shared ownership models.	Create space for experimental ownerships models
Reduce the impact of waste	Create circular economy	Include circular economy into sustainable planning
Reduce the carbon leakage and environmental impact in third countries	Reduce the need for consumption by social services and cohesion	Monitor the impact of local consumption and global production chains

Table 14. Policy demand, response and management approach in SmartEnCity.

6.2.2 Building stock and retrofitting needs

From a generic perspective, it could be applied the following analysis methodology in order to make a diagnosis of a generic City in terms of building retrofitting:

1. Classifying the building stock according to its construction period, for the purpose of identifying different categories with similar construction features.

2. For each construction period, **establishing a set of indicators to get a global diagnosis and advance an action strategy**. The following are some of the main energy indicators evaluated on standards BREEAM and Passive House (described in D2.2):

Indicator	Description	Standard range
Primary energy demand (kWh/m² year)	The primary energy demand includes all necessary energy applications for heating, cooling, domestic hot water, auxiliary electricity,	120 kWh/m² year (Enerphit)

	lighting, and other electricity uses.	
Heating demand (kWh/m² year)	The heating demand of a building is calculated in order to know how much thermal energy is needed to maintain the comfort temperature.	25 kWh/m² year (Enerphit)
Thermal transmittance (W/m²K)	Also known as "U-value", refers to how well an element conducts heat from one side to the other, which makes it the reciprocal of its thermal resistance.	Exterior wall: U ≤ 0,85 W/m²K Roof: U ≤ 0,35 W/m²K Windows: U ≤ 0,85 W/m²K (Enerphit)
Air tightness (h^{-1})	Building air tightness is the resistance to uncontrolled flow of air through gaps and cracks in the fabric. It is often expressed in terms of the leakage airflow rate through the building's envelope at a 50 Pascal pressure divided by the heated building volume.	$n_{50} \leq 1.0\ h^{-1}$ (Enerphit)
Renewable Energy (% of CO2 reduction)	Use of renewable or free energy resources applying local technologies with low or zero carbon emissions.	10-20% (BREEAM)
Internal lighting (% of Low Energy Lamps)	The aim of this indicator is to encourage the provision of energy efficient internal lighting, thus reducing the CO_2 emissions from the building.	75-100% (BREEAM)

Table 15. Main energy indicators evaluated on BREEAM and Passive House Standards

6.2.3 Urban mobility

The complexity of urban mobility planning (especially in big cities) calls for new approaches towards cleaner and more sustainable means of transport. The concept of Sustainable Urban Mobility Plans (SUMPs)[2] has emerged from a broad exchange between EU stakeholders and urban mobility planning experts, and has as its central goal improving accessibility of urban areas and providing high-quality and sustainable mobility and transport to, through and within the urban area. The starting point of every SUMP is making a city diagnosis in terms of: existing infrastructure, available technology, policies and regulations, land use and urban design, consumer preferences and behaviours, availability of financial resources.

A SUMP must be linked to a long-term strategy for the future development of the transport and mobility services and infrastructure. The outcome should be a delivery plan for short-term implementation of the strategy, specifying the implementations timing, related responsibilities, and required financial resources.

The city diagnosis should include at least the following issues:

Mobility city profile:

[2] http://ec.europa.eu/transport/themes/urban/doc/ump/com(2013)913-annex_en.pdf

- Transport means and typology: This includes both private and public transport; modal split and its evolution along past years. It is interesting to analyse the antiquity of the vehicles and the rate of alternative fuelled ones. Depending on the city size, urban design and transport infrastructure available, some transport means will be preferred to others (e.g. bikes and motorcycles against cars). Additionally, an efficient public transport network will favour its use by citizenship.
- Rate of sustainable vehicles: alternative fuelled vehicles against traditional ones.
- Existing mobility infrastructure, both for traditional and alternative fuelled vehicles: The existence of an efficient network of electric recharging points, biogas plants, filling stations, etc. will ease the adoption by citizens of alternative fuelled vehicles against traditional ones.
- Mobility regulations and ongoing mobility plans: Not only local, but also regional and national regulations and policies should be analyzed as they have a direct impact in the city. Available financial resources play a strong role here.

City statistics for Mobility: This information can be obtained through sensor monitoring in some cases (traffic congestion, environmental maps) and through surveys in others.

- Percentage of use for each transportation mean: This should give a clue on which transport means need to be reinforced when trying to achieve specific targets (e.g. 20% emissions reductions, etc.)
- Traffic congestion map: Inductive loops and webcams are very common to monitor traffic. These maps provide a useful tool to diagnose traffic congestion and identify the most critical areas and peak hours.
- Parking occupation map: parkings must allow for easy traffic flow and access to city services. There must be enough of them and they must be located in strategic locations, also to ease the access to public transport.
- Mobility energy savings map (maintenance cost analysis): When comparing the energy efficiency of alternative fuelled vehicles against that of conventional ones, it is important to address the efficiency balance from Well to Wheel (not just from Tank to Wheel), that is, accounting for all the production, distribution and fuel consumption processes.
- Environmental city maps: Pollution and noise maps. The derived analysis will help to diagnose the actual need of introducing more sustainable transport means.
- Social media and citizen mobility information platform for transportation: local authorities from every city usually set up public websites, mobility plans and promotions (e.g. bus ticket savings), transport related apps, etc. to get feedback from citizens on the quality of urban transport and the related infrastructure

A thorough analysis on the previous issues can provide a clear picture of a city characterization in terms of mobility. Quantification will come through the definition of a set of diagnosis indicators. A non-exhaustive list is provided below:

Mobility profile: number of private and public vehicles (motorcycles, cars, vans, buses, etc.)

Mobility statistics: number of public transport trips (bike, motorbike, taxi, private car, etc.); daily average length per trip (in each kind of transport mean); percentage of alternative fuelled vehicles (electric, gas, etc.); number of EV charging stations (typology in terms of power, AC, DC, etc.), number of electric recharges; kWh recharged in the EV charging stations; biogas plants, biogas transportation means (e.g. trucks); number of public parking areas and slots.

6.2.4 ICT infrastructure and services

A Smart City can be defined as one that ICT to enhance the management of a variety of urban functions. *Smart Cities Readiness Guide* (Smart City Council, 2015) defines a diagnosis methodology based on a framework that collects the relationship between city's responsibilities, what it needs to accomplish for citizens, and its enablers, the smart technologies that can make those tasks easier (Figure 4).

The Smart City Framework		City Responsiblities					
		Universal aspects	Energy	Built Environment	Transportation	Telecommunications	Other
Technology Enablers	Instrumentation and Control						
	Connectivity						
	Interoperablity						
	Security and Privacy						
	Data Management						
	Computing Resources						
	Analytics						

Figure 4. The Smart Cities Framework (adapted from: Smart City Council, 2015:24)

The ICT infrastructure and services of a city can be evaluated using this framework, measuring the level of deployment of the different technology enablers in each of the fields of urban management:

- **Instrumentation and control**: how a smart city monitors and controls conditions.
- **Connectivity**: how the smart city's devices communicate with each other and with the control center. Connectivity ensures that data gets from where it is collected to where it is analyzed and used.
- **Interoperability**: ensures that products and services from disparate providers can exchange information and work together seamlessly.
- **Security and Privacy**: technologies, policies and practices that safeguard data, privacy and physical assets.
- **Data Management**: the process of storing, protecting and processing data while guaranteeing its accuracy, accessibility, reliability and timeliness.

- **Computing Resources**: the combination of computers and computing capacities responsible for the different data processing tasks.
- **Analytics**: the process of creating value from the data that instrumentation provides.

In the framework of SmartEnCity, some vertical domains are specifically relevant:

- General aspects
- Energy
- Built environment
- Transportation
- Telecommunications

In this sense, the city characterization should include an inventory of existing and planned urban integrated infrastructures and services, as well as their scope and service level.

A complementary approach could be evaluating the readiness of an instance, like a city or building, to become smart through the evaluation of some use-cases: whether these are possible to fulfill or are they easy to implement when needed (Table 16).

Service level	Use-cases to evaluate
City	• Control street lights so they are only lit when there are any road users present. • Automatically capture and calculate city's KPI's. • Make aggregated and anonymous building/stairway level data available for public use. • Public city guide screen kiosks (touch screen, tourist info, parking info, maps etc). • Application for seeing which car charger stations are free, book in advance. • Track air quality, noise, light and electromagnetic pollution. • System for shared electric vehicles. • Provide accurate weather from many small weather stations in resident apartments and bigger ones from buildings.
Building	• Is the building connected to the fast-internet • Is it possible to control central heating and ventilation. • Optimize energy consumption based on current and forecasted weather. • Optimize energy consumption based on electricity market prices. • Track energy consumption of apartments and find outliers (someone using considerably more or less than average). • Introduce game theory elements so for example stairways can compete with each other which one uses the least energy every month with some rewards and fame. • Detect when big building trash cans get full and need to be taken away. • Front door video lock. When someone wants to visit, chooses the apartment number and calls. The video call appears on the inhabitants' phone with a button to let the visitor in.
Apartment	• Individual central control of each radiator for temperature control, user can define time based temperature profiles (e.g. less heating during day when people are at work). • Motion detectors to control actuators, detect that someone is home (e.g. turn on a dim LED strip when going to the bathroom at night). • Use smartphone and home wifi router to detect that someone is home and execute some logic (such as turning on hallway lights when coming home). • Central power outlet control to turn on/off various devices (e.g. turn off the boiler when going away for the weekend but turn it back on few hours before coming

	back). • Central relay / circuit breaker control (e.g. turn on the sauna when coming home from skiing). • Central apartment dashboard displaying various information, allows creating custom rules (turn on a light when motion is detected etc), compare to neighbor stairway, display weather, room temperature etc. Plugs into a wall and acts as a gateway speaking various protocols such as X11 (power lines), Zigbee radio, wifi, bluetooth etc. • Home media player control. • Energy usage monitoring for entire apartment but also individual power outlets (e.g. show a graph of how much money you spend on your TV per month). • Old person emergency control (emergency button or automatic motion detection brace). • Electric curtains (e.g. program to open them automatically in morning to wake up). • Electric scale (graph your weight change over time). • Heart monitor. • Sleep monitor and statistics. • Bluetooth beacons - who is home and in which rooms (e.g. arm home security automatically if nobody is home). • Electric lock (e.g. open automatically if phone is near a beacon). • Automatic vacuum cleaner (e.g. start it automatically when nobody is at home). • Smoke detectors (e.g. trigger a central alarm and alarm the neighbors, kill the stove power). • Network camera (e.g. see how your pet is doing). • Voice commands (e.g. “lock the front door”). • LED strip dimmer (e.g. in the kitchen, can be light dimly during the night when going to get a glass of water). • Colored LED light (philips HUE etc controlled by some rules). • "I need help" switch in shower. • Automatic water, gas, electricity remote readers so residents don’t have to report them manually. • Window open warning. • Security system, window opened when nobody is home, motion detectors, and password on the wall. • Water/gas/electricity comparison to oneself or neighbours (e.g. use gaming elements). • Notifications on smartphones, Android wear, Apple watch (e.g. smoke detector going off). • Weather station inside and outside (temperature, humidity, noise, light level, CO2 etc). • Online coffee maker (e.g. program it to make a fresh coffee by the time you wake up). • Time and electricity price based rules (for example heat the boiler when electricity is cheaper). • Energy usage advisor (e.g. the best time to use the washing machine). • Track your vehicle position (e.g. track how much you drive each month). • Control car pre-heater (e.g. program the car with your smartphone to be warm when going to work in the morning in winter) • Track user location in app, location based triggers (e.g. turn on light when arriving at home)

Table 16. Smart City service levels and use-cases to evaluate

6.2.5 Social and citizen engagement

Social engagement centres on how to empower citizens in the decision making. This includes actively including stakeholders and different interest groups into the process of decision making and, if social engagement is defined through social change, it should result in the change of behaviour (see D2.2 for definitions on Social Engagement) for a better functioning community and future. Thus it is vital that the process is supported by systematic and coordinated activities. The main issues that should be analysed when trying to make a diagnosis of a generic City in terms of citizen engagement should incorporate the following broad steps. These steps are supported by standards that can help to define a homogenized framework in the process of social engagement.

ISEAL's Codes of Good Practice and Credibility Principles help to design the overall process of social engagement and the strategies while UN REDD+ Social and Environmental standards focus more on human-rights side (and also environmental aspects), Aarhus Convention focuses on public participation and environmental information, and European Regional/Spatial Planning Charter (Torremolinos Charter) defines the overall principles in the process of regional/spatial planning taking into account the human aspect.

Defining the purpose, sustainability, scope, forms and resources of social engagement

The engagement process should take into account all interest groups, and contribute in creating equality and sustainability of the activities.

ISEAL Assurance Code builds on a set of principles for effective assurance and describes how these principles are applied in practice. It helps the organisations to develop assurance systems that ensure audit consistency and rigour at the same time as promoting accessibility and efficiency. It helps to ensure accurate results from assessments of compliance and to encourage the use of assurance to support learning. Its principles can be widened to the development of social engagement plans and activities.

ISEAL Impacts Code requires standards systems to develop and implement a monitoring and evaluation plan that includes all the steps required to assess their contributions to social and environmental impact. These steps include identifying the impact they are seeking to achieve, defining strategies, choosing indicators and collecting data, conducting regular analysis and reporting of data as well as additional impact evaluations, and setting up feedback loops to improve their standard's content and systems over time. Its principles can be widened to the development of social engagement plans and activities.

ISEAL's Credibility Principles: Sustainability principle aims at defining the sustainability and its objectives in order to make decisions that are the best interest of society and the environment. Relevance principle addresses the most significant sustainability impacts of product, process, business or service and only including requirements that contribute to their objectives, reflecting best scientific understanding and relevant international norms; adapting where necessary to local conditions.

UN REDD+ Social and Environmental Standards aim at democratic governance, ensuring the full and effective participation of relevant stakeholders in design, planning and implementation.

European Regional/Spatial Planning Charter defines that implementation of regional/spatial planning objectives should be co-ordinated between various sectors, co-ordinated and co-operated between various levels of decision-making.

Relevant questions to ask to estimate the compliance with standards provided:

- Have the objectives been defined?
- Have the desirable outcomes been defined?
- Are the form and methods for engaging the interest groups defined?[3]
- Has there been any best practice or role model created?
- Are there any social/economical/cultural/political/legal barriers that hinder the implementation of the process in the city?
- How the public and possible interest groups disposed are concerned the issue?
- What is the expected benefit (and for whom) by participation?
- What is the role of the municipality?
- Who are the people responsible for carrying out the activities?
- Do these people have the knowledge and capacity to work on the process?

Creating a roadmap for better coordination of activities of social engagement

This includes defining the activities, sufficient time-frames for actions, developing the engagement and communication plan.

ISEAL Standard-Setting Code focuses on the standards development process, as well as on the structure and content of the standard. It captures the good practices that should be followed in standards development for any sector or product to ensure the standard is credible, effective and achieves its objectives. Its principles can be widened to the development of social engagement plans and activities.

Aarhus Convention aims at public participation that includes setting up the appropriate procedures for effective public participation and setting up sufficient time-frames.

Relevant questions to ask to estimate the compliance with standards provided:

- Has the engagement plan been developed?
- Has the communication plan been developed?
- Are the time-frames for activities sufficient and in accordance with national regulations?
- Are the activities for approaching the public and different interest groups relevant?[4]

Defining the interest groups and stakeholders

Understanding possible stakeholders (giving a socio-economic overview of possible interest groups) and understanding local context is of significant importance in defining stakeholders and interest groups.

Aarhus Convention aims at public participation that includes defining the public concerned.

ISEAL's Credibility Principles: Engagement principle aims at engaging balanced and representative group of stakeholders.

[3] For example, IAP2 public participation spectrum
[4] For example, Engaging Queenslanders: A guide to community engagement methods and techniques

ISEAL's Codes of Good Practice also deal with the stakeholders' identification and engagement.

Relevant questions to ask to estimate the compliance with standards provided:

- Is the list of possible stakeholders and the public complete?
- Who is the public concerned and involved?
- Do the stakeholders have the motivation and resources to participate in the process?
- Are the methods to engage stakeholders suitable for them (for example, using adaptive communication strategies)?
- Are the stakeholders equally represented in the process?

Producing comprehensive information materials, disseminating them and providing the public with the information

This includes defining communication mediums and activities related to the dissemination, etc. that are relevant targeting the audience.

Aarhus Convention aims at guaranteeing the right to access information, that means the access to environmental information and collecting and disseminating environmental information.

ISEAL's Credibility Principles: Transparency and Truthfulness principles aim at providing accurate information, including about the process itself.

Relevant questions to ask to estimate the compliance with standards provided:

- Is the information provided true and neutral?
- Are the communication channels manifold and suitable?
- Are the communication channels accessible to interest groups?

Assessing the quality and effectiveness of the engagement process, continuous monitoring and evaluation (participation activity of interest groups, understanding of the provided material by stakeholders, feedback from the stakeholders) **and reflecting on the results**

UN REDD+ Social and Environmental Standards aim at democratic governance, respecting and protecting stakeholders' rights and promote sustainable livelihoods.

ISEAL Impacts Code requires standards systems to develop and implement a monitoring and evaluation plan that includes all the steps required to assess their contributions to social and environmental impact. These steps include identifying the impact they are seeking to achieve, defining strategies, choosing indicators and collecting data, conducting regular analysis and reporting of data as well as additional impact evaluations, and setting up feedback loops to improve their standard's content and systems over time. Its principles can be widened to the development of social engagement plans and activities.

ISEAL's Credibility Principles: Improvement principle seeks to understand the impacts and measuring and demonstrating progress towards intended outcomes.

Relevant questions to ask to estimate the compliance with standards provided:

- Has the monitoring and evaluation plan been developed?

- Has the process been transparent, non-discriminatory and democratic?
- Has the process and results been evaluated?
- What is the feedback from the stakeholders?
- Is the process in accordance with national and international regulations?

Queensland Government in Australia has developed a document "Engaging Queenslanders: A guide to community engagement methods and techniques" and Community Places has developed a guide "Community Planning Toolkit – Community Engagement" that provide a list of techniques and methods how to approach possible stakeholders and community. The former also provides a list of questions that can be asked in addition to provided here for more detailed understanding of the community. Also, Kotter International has provided a framework to lead change in an organization that can be implemented in the building up of the social engagement process in the SmartEnCity project.

6.3 Needs assessment and prioritisation

A needs assessment is a systematic process for determining and addressing needs, defined as gaps between current and desired conditions. In these terms, city characterization or baseline defines current conditions, while defining the "desired" conditions implies a specific decision-making process.

Leipzig Charter recommends analysing the current situation of a city or neighbourhood in terms of strengths and weaknesses, so they can become the basis to develop a vision for the city where specific objectives should be consistently framed. Anyway, the local conditions should be confronted with the external conditions affecting to the city (regional, national, European and global challenges), so a SWOT Analysis (Strengths, Weaknesses, Opportunities, and Threats) is highly recommended to ensure an intervention is well aligned with internal and external forces, and can take advantage of both. To achieve the integration of all the components, local conditions identified in the diagnosis, objectives defined in the decision-making process, and tools and means defined in the intervention project should fit in a common framework of analysis. Local conditions may be strengths or weaknesses, while smart technologies may be considered opportunities or threats depending on how they can be matched to local conditions.

We can find some differences in the data used in the definition of the three SmartEnCity LH cities intervention projects (see Table 17). While Vitoria-Gasteiz and Tartu mainly focused in the diagnosis of the current conditions, identifying potential barriers, Sonderborg efforts were focused on defining the challenges and objectives in terms of energy savings. Both approaches can be useful, but it would be better to combine them: analyzing both current and desired conditions.

Anyway, city characterization and needs assessment are parallel processes that should be interlinked in such a way that they both feedback each other. City needs assessment may be focused on (subjective) perception, while characterization implies a focus on (objective) measurement. What to measure should be guided by perceived needs, but the opposite is also true: perceived needs should be validated through measurement. This implies that a combination of quantitative and qualitative sources should be used, and that decision making and citizen engagement processes are critical factors that determine the understanding and perception of city needs.

Which data have been used for supporting the definition of the area of intervention and the components of LH project? [questionnaire sent to LH cities]			
Evaluated variables	Vitoria-Gasteiz	Tartu	Sonderborg
Socio-economy	Residents: age groups, nationality, socio-economic problems. Owners: income levels, grants received for rehabilitation and its objective. City-level economic activities	Financing schemes Data & experience from previous renovation schemes	-
Building stock	Accessibility (elevators & building entrance), state of conservation, building skin insulation, renovation of windows, type of heating systems, number of dwellings per building, etc.	Prevalent architecture: type of building construction Urban structure: geographical location & connections with other districts	-
Energy supply & consumption	Energy typology of buildings	-	Local energy use: kWh/m2 (heat/cold & electricity), RE %: renewable energy share of total energy consumption. Local energy production: Local energy production & fuel consumption, Emissions of CO_2, NOX, SO_2 and particles
Sustainable Mobility	City-level mobility & infrastructures	-	Fuel consumption in road transportation Fuel consumption in other transport modes Emissions of CO_2, NOX, SO_2 & particles
ICT infrastructure	-	-	-
Other	Environmental issues	-	-

Table 17. Data used for supporting the definition of SmartEnCity LH cities intervention projects

6.4 Area of intervention demarcation

Urban planning has a spatial dimension that can never be ignored. The different issues covered by SmartEnCity project have different spatial implications that should be taken into account:

- Building issues can easily be assigned to some specific areas of a city.
- Mobility issues are mainly related to complex functional flows that involve the whole city.
- Urban infrastructures (energy supply, ICT) are basically ubiquitous and their improvement may imply city-wide or district-level interventions depending on the barriers to overcome or the gaps to be filled.

Integrated planning should ensure the consistency and best interaction of the different components of the intervention, whether city-wide or district-centered. In this sense, the intervention project should firstly identify city-level bottlenecks and district-level priority areas where the intervention is likely to have the greatest impact. Most of these issues are usually identified in urban and sectoral planning, so the integrated intervention should be devised from the basis of existing plans and policies at urban level, and focused on designing a strategy to deal with those problems through integrated smart solutions.

Leipzig Charter demands special attention to deprived neighbourhoods, but doesn't include an explicit definition. It mostly emphasizes the negative effects that the spiral of deprivation may have for the whole city, as well as the advantages of dealing with it in an early stage with an integrated approach. A classic text from OECD (1998) defines deprived or distressed urban areas as "portions of cities or their suburbs, usually at the scale of residential neighbourhoods, in which social, economic and environmental problems are concentrated. ... The cumulative effect, however, is to limit access to opportunities, resources and services that are considered normal or standard in other parts of the city" (OECD, 1998:15). LUDA, improving the quality of life of Large Urban Distressed Areas (research project financed by FP5, 2004-2006) identified some common characteristics of deprived areas:

- They are marked by social exclusion and economic marginalisation;
- They often occur as a result of socio-economic changes and the decline of older industries;
- They have experienced a spiral of decline;
- Residents experience a lower quality of life in comparison to averages in cities and urban regions;
- They often contain underused land." (LUDA, 2006)

There are many methods and experiences of deprived areas detection, most of them using different variations of multidimensional analysis through GIS. A GIS project is the best way to join and combine different types (social, economic, residential, etc.) and scales of information.

- The first step to design a GIS project is the clear definition of our analysis objective understanding its components and implications. This may be based in an existing methodology or may be constructed and designed ad hoc.

- The second step is to collect process and organize all possible information (alphanumeric and cartographical information) in a GIS project. This will need some adaptation processes in order to integrate and structure all the information.
- The third step consists on the definition of indicators to measure, taking into account the objectives of the analysis and the information available.
- The fourth step consists of the calculation and implementation of indicators.
- In a next step the indicators can be combined through statistics (multivariate analysis), weighting and aggregation techniques or others.
- Finally, the results are prioritized and represented in thematic maps showing the differences among city areas.

In order to gather all the necessary data for the analysis, research can include: field work, archival work, office work, interviews with key informants, etc., depending of the kind of intervention and the data directly available (Molina, 2014).

6.5 Intervention baseline

The stages for evaluating the intervention performance of a project consist of:

- Technical definition of the district integrated intervention through a diagnosis phase of the existing systems, the design of alternatives, the definition of concept designs and the implementation plan.
- Development of an evaluation plan for assessing the performance of interventions. This plan consists of setting appropriate KPIs and deployment of customized procedures for their evaluation.
- Definition of monitoring program to be deployed in the demonstrators. Tailored and rigorous monitoring programs will be defined to meet the evaluation objectives.
- Design of a data collection approach which allows collecting and storing the data compiled from the monitoring systems.
- Execution of the intervention and installation of monitoring equipment according to the general schedule of the project and the monitoring program previously defined.
- Evaluation of the intervention performance through a comparison of baseline and final performance.

In the case of SmartEnCity, we pretend mainly to assess the energy performance and savings, environmental impact, the cost effectiveness and the social acceptance of the three types of interventions defined in the project: district renovation, sustainable mobility actions and citizen engagement actions. A common and methodological framework for the evaluation of the interventions as a whole will be defined for assuring that the energy conservation measures are working in an appropriate manner and the energy savings are achieved. Thus, a procedure for the assessment will be defined by means of the adoption of standards KPIs and procedures and an exhaustive and rigorous monitoring program will be tailored in order to meet with the evaluation objectives. The application of this methodological procedure will allow evaluating the performance of the whole project. The generation of a baseline will take part of this procedure and serves to identify the starting point of the project in order to evaluate the improvements achieved once the project has concluded.

However, due to the complexity and heterogeneity of the foreseen interventions in the three cities and that each demonstrator differs from others in the access to the data, this common methodological procedure will be adapted to each intervention. Following, it is described each of the phases which cover the evaluation of intervention performance

Phase 1. Technical definition of the district integrated intervention

This stage provides a clear definition of the complete renovation, technical solutions, specifications, request of the necessary licenses and permits and the deployment plans for implementing the demo action in all of its pillars (building retrofitting, integrated infrastructures and sustainable mobility. This diagnosis will guide the evaluation plan in order to make compatible with the demo-area and inhabitant characteristics.

Phase 2. Evaluation plan for assessing the performance of intervention

This stage includes the definition of scope of the plan, the selection of proper KPIs and the establishment of suitable procedures able to evaluate the interventions performance.

Scope

The definition of scope covers the objectives pursued with the evaluation plan. In the case of SmartEnCity, some objectives are expected by the European Commission (e.g. t CO2 reduced in each LH), whereas others objectives are interesting for partners implicated in the deployment of interventions (e.g. costs reduction). Therefore, this framework for evaluation plan will be agreed among partners.

Approach

It is essential that KPIs proposed are aligned with the possibilities of each intervention. Thus, the selection of proper KPIs and the procedures for evaluating the intervention performance requires the involvement of partners working directly in the interventions, in the data collection and data monitoring. On the other hand, the guides already published by the European Commission about KPIs for Smart Cities will be used in order to follow the requirements from this institution (e.g. guides published by SCIS and CITYkeys projects). In the case of SmartEnCity, additional sources will also be used (e.g. CIVITAS for mobility and ISO 14040 for Life Cycle Analysis).

As a result, an agreed and common set of KPIs will be defined according to the possibilities of each intervention. In addition, specific procedures for evaluating such indicators in each city will be defined in line with the progress of interventions.

KPIs

KPIs will be used for evaluating the objectives expected to be reached as well as other objectives that are desirable. Due to SmartEnCity project aims to assess the performance of the project from a holistic point and, specifically, the energy, social and economic performance of the three interventions defined in the project: district renovation, urban mobility and citizen engagement actions, the KPIs have been structured as shown in

Figure 5.

These KPIs have been grouped by type of interventions and they encompass 4 categories: technical, environmental, social and economic. Such structure is aligned with the scheme proposed by SCIS in the Key Performance Indicators Guide.

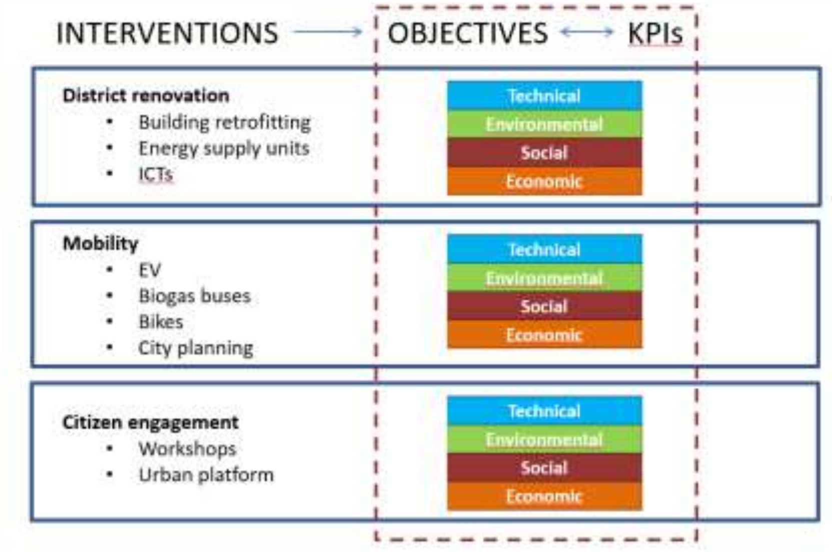


Figure 5. KPI Categories

Phase 3. Data collection approach and monitoring program

It will deploy an evaluation strategy for gathering, monitoring and storing data from each type of intervention (building retrofitting, district heating, smart grid, smart mobility and citizen engagement activities). Some of these data will be monitored and stored automatically in ICT infrastructure, whereas for those data which cannot be collected directly in Urban Platforms, it will define a specific procedure.

Phase 4. Execution of the intervention and installation of monitoring equipment

For the case of district renovation, the implementation of the monitoring systems has to be developed in parallel to the construction works, whereas for the mobility action, it will define a specific strategy for the implementation of monitoring equipment in the vehicles. Then, once the monitoring equipment is available, it is needed a commissioning phase to ensure that the implementation plan has been properly deployed in the three demo sites and that all the data acquisition systems work as expected, to assure that monitoring is performed in an appropriate manner.

Phase 5. Intervention performance evaluation

The evaluation of project performance must be done according to the evaluation plan established. The assessment will be done taking into account that it is needed to define a baseline that describes the characteristics of the interventions before the implementation of energy efficiency measures in buildings and the sustainable mobility actions. With a proper baseline definition, the change and improvement on the system due to the energy efficiency measures can be easily identified and calculated.

A set of KPI will be obtained as an outcome of this baseline definition, in order to be further compared with the KPI obtained from the monitoring process of the demonstration project once finished. In principle, the baseline has to gather the same number and kind of parameters that will be measured in the monitoring process. When it cannot be possible, a sample of parameters will be selected.

Concerning the period considered for collecting data, it will depend on the type of intervention. For the case of district renovation, it is important to meter to meter all energy consumption data of the building before the retrofitting works start during at least one year. In case, any monitoring system can be installed, baseline will be evaluated through simulation tools and with the support of energy bills. Once the works have been concluded, it is recommend monitoring the energy generation, supply and consumption for at least two years in order to guarantee a consistent evaluation. For the case of sustainable mobility actions, all these details will be defined in the protocol for mobility.

7 Outputs for other WPs

7.1 Template for Deliverables 3.1, 4.1 and 5.1

General structure:

(A) Definition of the process as a whole
(B) City Characterization
(C) City needs definition and prioritization
(D) Intervention Baseline

Implications for LH cities:

- Most of (A) and (C) has already been defined for the H2020 proposal, and should mainly be revised and refined.
- (B) should be defined taking into account city-level indicators included in Section 7.2.
- (D) has been delayed to be coordinated with monitoring program (M18).

Follower cities should develop the whole process: A+B+C+D, with their own timeline.

(A) Defining the process as a whole

- Process:
    - Activity sequence
    - Relationship between phases
- Governance:
    - Participating agents in each phase
    - Roles
    - Decision-making mechanisms
    - Interdisciplinary cooperation
    - Community involvement / citizen engagement
- Methods:
    - Knowledge domains
    - Relationship between disciplines
    - Planning techniques
    - Tools (data sources & processing methods, others)

References: Chapter 5; Annex A2

(B) City characterization

- **Local conditions**
  - Socio-economy (Section 6.1.1)
  - Business & funding (Section 6.1.2; D2.3)
  - Environment (Section 6.1.3)
  - Policies and regulations (local, regional, national level)

  Table 19. City characterization: common and optional indicators
  Table 20. Governance, city plans & regulation: common and optional indicators

- **Energy supply and consuming patterns** (Section 6.2.1)
  - Energy sources and distribution infrastructures
  - Consuming sectors
  - Energy policies and management (Table 14)
  - Policies and regulations (D2.1)
  - Standards (D2.2)
  - Business model and funding (D2.3)

  Table 21. Energy supply network: common and optional indicators

- **Building stock and retrofitting needs** (Section 6.2.2)
  - Building stock characterization (**¡Error! No se encuentra el origen de la referencia.**)
  - Policies and regulations (D2.1)
  - Standards (D2.2)
  - Business model and funding (D2.3)

  Table 21. Energy supply network: common and optional indicators

- **Urban mobility** (Section 6.2.3)
  - Mobility city profile
  - City statistics for mobility
  - Policies and regulations (D2.1)
  - Standards (D2.2)
  - Business model and funding (D2.3)

  Table 22. Urban mobility and transportation: common and optional indicators

- **ICT infrastructures and services** (Section 6.2.4)
  - Monitoring & Communication Infrastructures
  - Smart City Services (Table 16)
  - Policies and regulations (D2.1)
  - Standards (D2.2)
  - Business model and funding (D2.3)

  Table 23. Urban infrastructure: common and optional indicators

- **Citizen engagement** (Section 6.2.5)
  - Purpose, scope, forms and resources
  - Coordination of activities
  - Interest groups and stakeholders
  - Communication strategy
  - Monitoring and evaluation
  - Standards (D2.2)

  Table 24. Citizen engagement: common and optional indicators

(C) City needs definition and prioritization

- City-level SWOT analysis (inputs from city characterization)
- Specific spatial analysis:
    - Identification of priority areas and bottlenecks
    - Demarcation of areas of intervention
- Pre-definition of the district integrated intervention:
    - General strategy (matching district and city-level needs)
    - Selection of components

(D) Intervention baseline

- Technical definition of the district integrated intervention
- Evaluation plan: definition of KPIs
- Data collection approach and monitoring program
- Installation of monitoring equipment
- Performance evaluation

7.2 List of common and optional indicators

Target	Common	Optional	Total
City characterization	9	18	27
Governance, city plans & regulation	9	6	15
Energy supply network	19	13	32
Urban mobility and transportation	14	32	46
Urban infrastructure	0	19	19
Citizen engagement	6	7	13
TOTAL	**57**	**95**	**152**

Table 18. Number of common and optional indicators by target

7.2.1 City characterization

City characterization		
Field	Common Indicators	Optional indicators
Key features of the city	Size Population Population density Annual population change Median population age	% of population > 75
Land use characterization	Land consumption (Total built surface/Total city surface)	Building stock
Socio-economy: economic performance	Median disposable income	GDP per capita Energy intensity of economy (GDP value of the city /total energy consumption)
Socio-economy: city prosperity	Proportion of working age population with higher education City unemployment rate	New business registered per population Youth unemployment rate
Socio-economy: equity	-	Percentage of the stock reserved for social housing Energy poverty level (Average of the energy bill of households / average salary in the country)
Environmental features	-	Waste generated per capita Nitrogen dioxide emissions per capita Fine particulate matter emissions per capita Air quality index Days PM10 > 50 µg/m3 Noise pollution Green space per population

Table 19. City characterization: common and optional indicators

7.2.2 Governance, city plans & regulation

Governance, city plans & regulation		
Field	Common Indicators	Optional Indicators
City plans and strategies	Existence of plans/programs to promote energy efficient buildings Existence of plans/programs to promote sustainable mobility Existence of local sustainability action plans Signature of Covenant of Mayors Existence of Smart Cities strategies Existence of public incentives to promote energy efficient districts Existence of public incentives to promote sustainable mobility	-
Public procurement procedures & regulations	Existence of regulations for development of energy efficient districts Existence of regulations for development of sustainable mobility	Existence of local/national Energy Performance Certificate (EPC) Share of Green Public Procurement
Governance	-	Involvement of the administration on smart city projects Multilevel government Paperless government (incl. e-signature)

Table 20. Governance, city plans & regulation: common and optional indicators

7.2.3 Energy supply network

Energy supply network		
Field	Common Indicators	Optional Indicators
City energy profile	Primary Energy Consumption in the city per year Final Energy produced in the city per year Residential buildings energy consumption per year Primary Energy Consumption in the city per capita Final Energy produced in the city per capita Total building energy consumption in the city per capita Residential buildings energy consumption per capita Portion of households connected to the district heating and cooling	Public lighting energy use per year Total buildings energy consumption per year Public building energy consumption per year Public lighting energy use per capita Public buildings energy consumption per capita
Energy uses in building typologies	Total residential natural gas energy use per capita Total residential oil energy use per capita Residential electrical energy use per capita	Total residential biomass energy use per capita Percentage of the energy consumption by end use in residential buildings: space conditioning Percentage of the energy consumption by end use in residential buildings: domestic hot water Percentage of energy consumption by end use in residential buildings: lighting and appliances Percentage of the energy consumption by end use in public buildings: thermal and cooling uses Percentage of the energy consumption by end use in public buildings: electrical uses
Potential local renewable energy resources	Energy use from District Heating Percentage of total energy derived from renewable sources Energy use from Biomass Energy use from PV Energy use from Solar Thermal Energy use from Hydraulic Energy use from Mini-Eolica Energy use from Geothermal	Budgets devoted to renewable energies and Energy Efficiency
Environmental impacts of energy consumption	-	Global Warming Potential (GWP) per capita

Table 21. Energy supply network: common and optional indicators

7.2.4 Urban mobility & transportation

Urban mobility & transportation		
Field	Common Indicators	Optional Indicators
Mobility City Profile	Total number of private cars per capita Total number of public buses per capita Total number of public bicycles per capita Number of two-wheel motorized vehicles per capita	Total number of vehicles in the city per capita Total number of commercial cars per capita Total number of taxis per capita Total number of trucks per capita Number of bicycles per capita
City Statistics for Mobility	Percentage of electric private cars Percentage of electric taxis Percentage of electric motorcycles Number of public EV charging stations Total number of recharges per year Total kWh recharged in the EV charging stations Cost of a monthly ticket for public transport in relation to the national minimum wage or average wage	Kilometers of high capacity public transport system per population Kilometers of light passenger public transport system per population Kilometers of bicycle paths and lanes per population Total annual number of trips Total annual number of trips by private car Total annual number of public transport trips Total annual number of trips by bike Total annual number of trips by motorbike Total annual number of trips by taxi Total annual number of trips on foot Annual number of public transport trips per capita Daily average time by trip Daily average length by trip Daily average length by private car trip Daily average length by public transport trip Daily average length by bike trip Daily average length by motorbike trip Daily average length by taxi trip Daily average length by foot trip Percentage of electric commercial cars Percentage of electric public buses Parking facilities per capita Number of public parking areas Number of available parking slots Pedestrian area per capita Transportation fatalities per capita
Environmental impact of mobility	Transport energy use per capita Transport greenhouse gas emissions per capita Percentage of renewable energy use in public transport	-

Table 22. Urban mobility and transportation: common and optional indicators

7.2.5 Urban infrastructure

Urban infrastructure		
Field	Common Indicators	Optional Indicators
Transport utilities	-	Number of parking information panels
Environment monitoring infrastructure	-	Number of air quality stations Number of noise stations Number of weather stations Number of loan point for public bicycles Number of smart-meters installed
City monitoring infrastructure	-	ICT citizen oriented platforms Data privacy
Communication infrastructure	-	Percentage of the population covered by a mobile-cellular network Percentage of the population covered by at least a 3G mobile network 3G Mobile network cells 4G Mobile network cells Number of cell phone connections per 100.000 population Number of internet connections per 100.000 population Number of landline phone connections per 100.000 population Smartphone penetration Free Wi-Fi zones Cable Network Cable Network Types

Table 23. Urban infrastructure: common and optional indicators

7.2.6 Citizen engagement

Citizen engagement		
Field	Common Indicators	Optional Indicators
Existing actions related to citizen engagement	Recycling rate Voter turnout in last municipal election Number of local associations per capita	
Channels for citizen engagement	Number of awareness raising campaigns	Number of information contact points for citizens Number of municipal websites for citizens Number of websites consultation per capita Number of interactive social media initiatives Number of discussion forums Number of thematic events Number of newspaper columns
Current scenarios of citizen engagement	Citizens participation in smart city projects Professional stakeholder involvement	

Table 24. Citizen engagement: common and optional indicators

Annex A1. District-level development certification tools

BREEAM Communities 2012

Building on the high level aims and objectives of the various standards in the BREEAM family, BREEAM Communities is an independent, third party assessment and certification standard based on the established BREEAM methodology. It is a framework for considering the issues and opportunities that affect sustainability at the earliest stage of the design process for a development. The scheme addresses key environmental, social and economic sustainability objectives that have an impact on large-scale development projects.

BRE recognises that the selection of an appropriate site for development is a critical factor in determining how sustainable a new community will be. In the UK, the process of selecting sites for development is largely determined by developers, landowners and the planning system. Many decisions taken during the design and planning stage of a large development will have a fundamental impact on its sustainability. This scheme covers the assessment and certification of the designs and plans for a development at the neighbourhood scale or larger. A post-construction certification is not included in this assessment due to the long timescales for large developments. BREEAM may develop further stages of performance evaluations for communities at the in-use and regeneration stages.

There are three steps involved in the assessment of sustainability at the master planning level:

1. Following site selection there is a process whereby the developer must show the suitability and need for specific types of developments on the site as part of a planning application. Strategic plans for the wider area, usually contained within the local authority's planning documents, should indicate the housing, employment or services that are required. The new development will need to respond to these local requirements in order to receive planning permission. In this scheme the process described above is assessed under 'Step 1 - Establishing the principle of development'. During this step BREEAM assesses the degree to which the design team under-stand the opportunities to improve sustainability that necessitate a site-wide response, such as community-scale energy generation, transport and amenity requirements. All issues must be covered to ensure a holistic strategy for the site.
2. The next step in the master planning process determines the layout of the development. This will include detailed plans for how people will move around and through the site and where buildings and amenities will be located. This is called ‘Step 2: Determining the layout of the development’ in BREEAM Communities.
3. ‘Step 3: Designing the details’ involves more detailed design of the development including: the design and specification of landscaping, sustainable drainage solutions, transport facilities and the detailed design of the built environment. The latter includes the use of whole building assessment methods such as the building related BREEAM schemes.

The issues within this certification tool are grouped into five impact categories which are considered through appropriate criteria in Steps 1 to 3 described above. It is difficult to categorise sustainability issues definitively, as they often affect all three dimensions of sustainability (social, environmental and economic). By assigning categories, BREEAM seeks to provide some clarity about the intention of each issue. For the purposes of scoring and rating, there are three additional categories that have been combined into one category in the manual. Social and economic wellbeing encompasses the three categories of social wellbeing, local economy and environmental conditions. A sixth category promotes the adoption and dissemination of innovative solutions. The categories are listed below with a brief description of the aims of their issues:

- **Governance (GO)** Addresses community involvement in decisions affecting the design, construction, operation and long-term stewardship of the development
- **Social and economic wellbeing (SE)** Addresses societal and economic factors affecting health and wellbeing such as inclusive design, cohesion, adequate housing and access to employment
- **Resources and energy (RE)** Addresses the sustainable use of natural resources and the reduction of carbon emissions
- **Land use and ecology (LE)** Addresses sustainable land use and ecological enhancement
- **Transport and movement (TM)** Addresses the design and provision of transport and movement infrastructure to encourage the use of sustainable modes of transport
- **Innovation (Inn)** Recognises and promotes the adoption of innovative solutions within the overall rating where these are likely to result in environmental social or economic benefit in a way which is not recognised elsewhere in the scheme.

Source: BRE, 2013.

LEED 2009 for Neighbourhood Development

The LEED for Neighborhood Development Rating System responds to land use and environmental considerations in the United States. It is designed to certify exemplary development projects that perform well in terms of smart growth, urbanism, and green building. Projects may constitute whole neighborhoods, portions of neighborhoods, or multiple neighborhoods. There is no minimum or maximum size for a LEED-ND project.

Although projects may contain only a single use, typically a mix of uses will provide the most amenities to residents and workers and enable people to drive less and safely walk or bike more.

Existing neighborhoods can also use the rating system, and its application in this context could be especially beneficial in urban areas and historic districts. LEED-ND has additional relevance for existing neighborhoods, as a tool to set performance levels for a group of owners wanting to retrofit their homes, offices, or shops, and finally for shaping new green infrastructure, such as sidewalks, alleys, and public spaces.
In conclusion, LEED for Neighborhood Development emphasizes the creation of compact, walkable, vibrant, mixed-use neighborhoods with good connections to nearby communities. In addition to neighbourhood morphology, pedestrian scale, and mix of uses, the rating system also emphasizes the location of the neighborhood and the performance of the

infrastructure and buildings within it. The sustainable benefits of a neighborhood increase when it offers proximity to transit and when residents and workers can safely travel by foot or bicycle to jobs, amenities, and services. This can create a neighborhood with a high quality of life and healthy inhabitants. Likewise, green buildings can reduce energy and water use, and green infrastructure, such as landscaping and best practices to reduce storm water runoff, can protect natural resources. Together, well-located and well-designed green neighborhood developments will play an integral role in reducing greenhouse gas emissions and improving quality of life.

The LEED 2009 for Neighborhood Development Rating System is a set of performance standards for certifying the planning and development of neighborhoods. The intent is to promote healthful, durable, affordable, and environmentally sound practices in building design and construction.

To earn LEED certification, the applicant project must satisfy all the prerequisites and qualify for a minimum number of points to attain the project ratings listed below. Having satisfied the basic prerequisites of the program, applicant projects are then rated according to their degree of compliance within the rating system.
LEED for Neighborhood Development certifications are awarded according to the following scale:
Certified 40–49 points
Silver 50–59 points
Gold 60–79 points

Platinum 80 points and above

The certification process is carried out in 3 stages:

1. Conditional Approval of a LEED-ND Plan. This stage is optional and if the conditional approval of the plan is achieved, a letter will be issued starting that if the project is built as proposed, it will be eligible to achieve LEED for Neighbourhood Development certification. The purpose of this letter is to help the developer build a case for entitlement among land-use planning authorities, as well as attract financing and occupant commitments.
2. Pre-Certified LEED-ND Plan. This stage is available after 100%of the project's total new and/or renovated building floor area has been fully entitled by public authorities with jurisdiction over the project. Any changes to the conditionally approved plan that could affect prerequisite or credit achievement must be communicated as part of this submission. If precertification of the plan is achieved, a certificate will be issued starting that the plan is a Pre-Certified LEED for Neighbourhood Development Plan and it will be listed as such on the USGBC website.
3. LEED-ND Certified Neighbourhood Development. This final step takes place when the project can submit documentation for all prerequisites and attempted credits, and when certificates of occupancy for buildings and acceptance of infrastructure have been issued by public authorities with jurisdiction over the project. Any changes to the Pre-Certified LEED-ND Plan that could affect prerequisite or credit achievement must be communicated as part of this submission.

Requisites are divided in several categories:

1. **Smart Location and Linkage:** Regarding to the selection of the location and natural and/or ecological linkage to the site as well as mobility aspects such as common displacement distances.
2. **Neighbourhood pattern and design:** Regarding morphology of the urban fabric, walkability of the streets, connections and mixed uses.
3. **Green infrastructure and building:** Regarding building and infrastructure efficiency in diverse aspects like energy, water, pollution, reuse, resource preservation, heat island reduction, solar orientation and Res.
4. **Innovations and design process:** Regarding innovation and exemplary performance and presence of LEED accredited professional.
5. **Regional Priority Credit:** Regarding regional priority.

Source: USGBC, 2014.

DGNB New Urban Districts

Certification is developed by DGNB. The scheme's objectives are the following: resource and energy-efficient construction and operation, high quality of life and amenity of public space, improved life cycle assessment and low life cycle costs, connectivity between district and surrounding areas and mix of uses.

The system's requirements are the following: minimum size 2 ha gross development area, the district includes a range of buildings and publicly accessible areas, mixed use (residential use 10 - 90 %), the owners of the area have no objections against the certification and specific minimum requirements within the criteria.

Is differenced of the building certificate in three basic aspects:

- The assessment evaluates publicly accessible areas (streets and roads, squares, green and open spaces)
- Takes basic building consumption into account (e.g. heat, electricity and water demand)
- Takes context and setting into account (e.g. adjoining open spaces, educational institutions, supply centres, public transport access)

Figure 6. DGNB certification phases

The accessibility indicators used are the following: education/ support/ leisure, special user group facilities, local retail (baker, butcher, chemist, etc…), medical care, services, cultural facilities, restaurants and sport facilities.

Figure 7. Evaluation criteria for New Urban Districts

Source: DGNB, 2013.

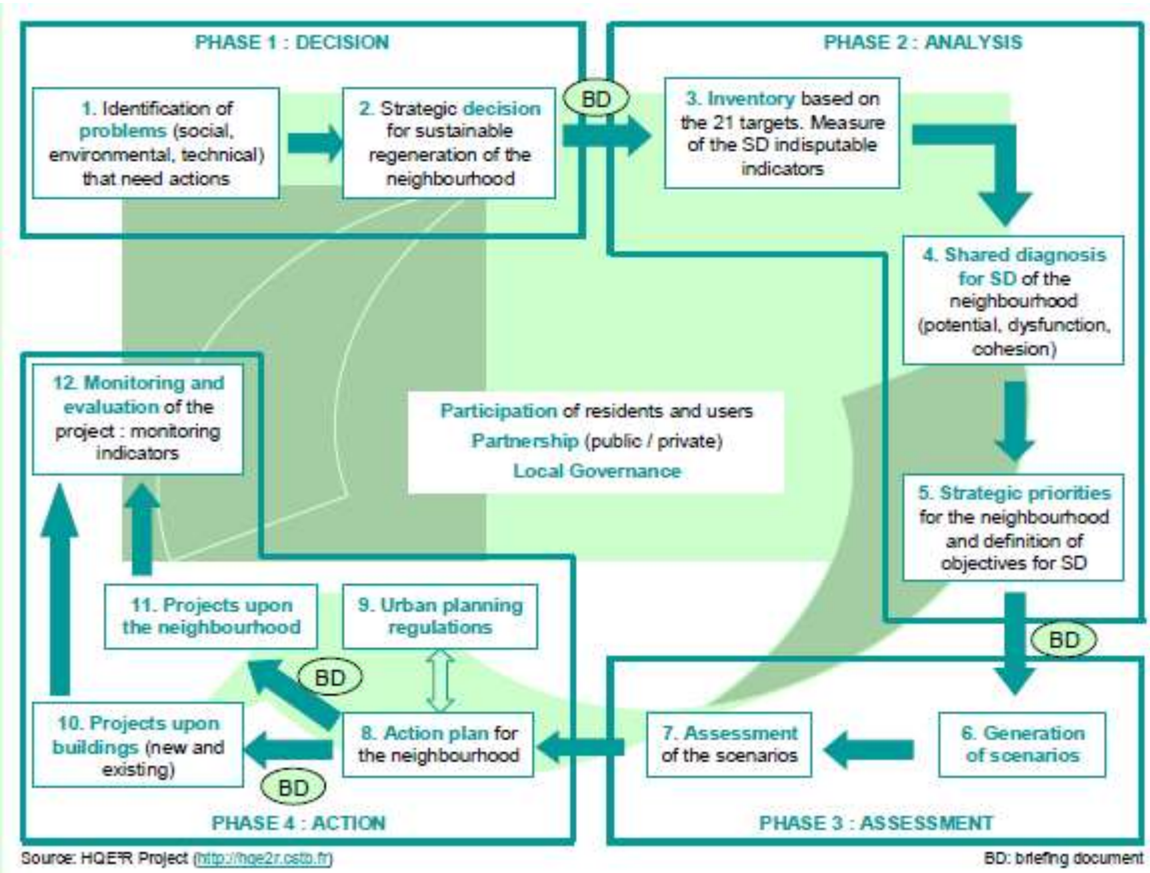
HQE2R project for Urban Planning and Development

HQE2R is a project proposed in 1999 to the European Commission and that started in 2001 and lasted until 2004. The acronym is a contribution to the promotion of the HQE process in the market of the rehabilitation, that requires to take into account the neighbourhood and its regeneration as well as economic aspects.

The key aspects on this project are the following:

- To develop a new methodology together with the necessary tools to promote sustainable development and the quality of life at the crucial and challenging level of urban neighbourhoods.
- To provide decision aid tools for municipalities and their local partners, focussing on the goals of the inhabitants and users of neighbourhoods.
- With its integrated approach, to provide a framework which can be generally applied in European cities.

There are 14 demonstration neighbourhoods spread in 8 eight European countries. The methodology of the regeneration process in divided in 4 phases as shown in the following figure:



It establishes 6 sustainable development principles (amongst the 28 principles mentioned in the Rio Declaration of 1992):

1. **Economic efficiency**: to respect the rules of economic efficiency, but on condition to include all external costs, whether social or environmental
2. **Social equity** : Right to employment and housing but also the fight against poverty and social exclusion

3. **Environmental caution** : Precautionary principle and Liability principle
4. **Long term principle** : impacts and reversibility assessment
5. **Principle of globality** : the global in relation to the local; principle of subsidiarity
6. **Principle of governance** : participation by residents and users of the building and of the city

There are also established 21 objectives and targets for the different cities organized as follows:

TO PRESERVE AND ENHANCE HERITAGE AND CONSERVE RESOURCES

1 - To reduce energy consumption and improve energy management
2 - To improve water resource management and quality
3 - To avoid land consumption and improve land management
4 - To reduce the consumption of materials and improve their management
5 - To preserve and enhance the built and natural heritage

TO IMPROVE THE QUALITY OF THE LOCAL ENVIRONMENT

6 - To preserve and enhance the landscape and visual comfort
7 - To improve housing quality
8 - To improve cleanliness, hygiene and health
9 - To improve safety and risk management
10 - To improve air quality
11 - To reduce noise pollution
12 - To minimise waste

TO ENSURE DIVERSITY

13 - To ensure the diversity of the population
14 - To ensure the diversity of functions
15 - To ensure the diversity of housing supply

TO IMPROVE INTEGRATION

16 - To increase the levels of education and job qualification
17 - To improve access for all residents to all the services and facilities of the city by means of easy and non expensive transportation mode
18 - To improve the integration of the neighbourhood in the city by creating living and meeting places for all the inhabitants of the city
19 - To avoid unwanted mobility and to improve the environmentally sound mobility infrastructure

TO REINFORCE SOCIAL LIFE

20 - To reinforce local governance
21 - To improve social networks and social capital

The HQE2R project offers guides to integrate sustainable development in specifications, particularly related to neighbourhood development planning and regeneration:

- The elaboration of an **Action Plan**
- **New buildings**
- **Rehabilitation**
- The realisation of non-built elements within the development planning project:
    - **Public spaces**
    - **Green spaces**
    - **Water spaces**
    - **Street furniture and lightning**

Source: Charlot-Valdieu, 2003.

DPL, Sustainability Profile of Location

This methodology created by IVAM[5] assesses in a clear and transparent way the spatial plan for a district on sustainability, based on the information from the urban plan. It so helps urban designers to creatively improve the sustainable performance of a district

The initiative aims to develop and test a challenging tool for assessing sustainability at district-level. The target groups for the application of the tool are municipalities, project developers, citizens, business community's etc. The name of the tool is DPL. The tool assesses in a clear and transparent way the spatial plan for a district on sustainability, based on the information from the urban plan. It so helps urban designers to creatively improve the sustainable performance of a district.

The tool can be used in selected phases of an urban planning process. In the phase of definition the tool supports to formulate quantifiable objectives for sustainability as part of a total set of requirements. In the phase of design it helps to compare the different plan alternatives and improves the urban plan. In the phase of evaluation the tool can be used to monitor a location and compare the sustainability performance of various districts in a town.

Until now, the initiative performed three steps:

1. Define and unravel the concept of sustainability for urban planning.
2. Develop a prototype instrument to asses a district on sustainability.
3. Test the prototype in case studies. (Not explained in the present document)

The outcomes of these steps are presented in the next paragraphs.

1. DEFINE AND UNRAVEL THE CONCEPT OF SUSTAINABILITY FOR URBAN PLANNING

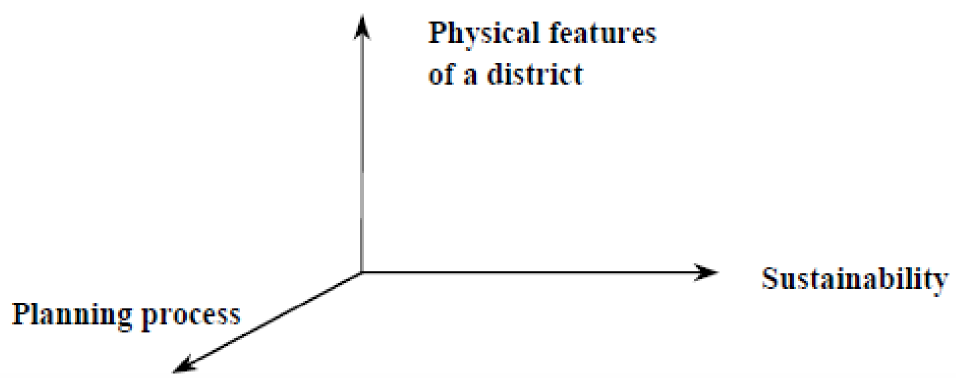


Figure 8. The three axes of DPL instrument

Sustainability on the X-axe is interpreted as an integral concept, which is systematically divided into various levels of criteria, which are presented in the form of a pyramid. The top is presented by the overall concept of sustainability (see Figure 2). On the second level you

[5] Research and consultancy agency in the field of sustainability in Amsterdam

find three elements which are closely connected to the three P's: environment (Planet), liveability (People) and economy (Profit).

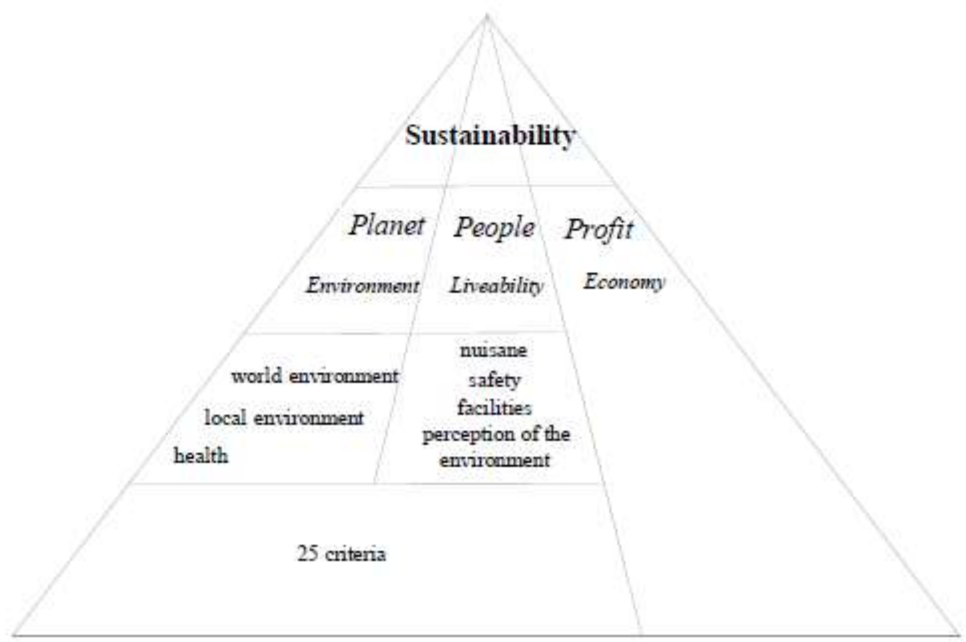


Figure 9. Pyramid for sustainability

On the second level the two elements, Environment and Liveability are unravelled in 7 themes (see Figure 2), followed by 25 criteria in the fourth level. These 25 criteria are selected for the prototype tool from a total of 200 criteria that were found in literature and currently existing tools. This selection is meant to be a first set towards a more complete and consistent set of criteria for sustainability. Each criterion is connected to an indicator. The DPL scores for each criterion are determined by translating information from the urban plan with a formula and data into a score for an indicator. The scores for these indicators are the outcome of the DPL tool.

2. DEVELOP A PROTOTYPE INSTRUMENT TO ASSES A DISTRICT ON SUSTAINABILITY;

On the basis of this pyramid for sustainability a first DPL prototype tool was developed that assists planners to determine the sustainability performance of a district. It consists of three parts:

1. The DPL questionnaire;
2. The DPL matrix;
3. The DPL profile.

1. The DPL Questionnaire

The sustainability performance of a district is determined in the prototype on the basis of the physical characteristics of a neighbourhood. The necessary information of an existing neighbourhood or information from an urban plan is filled in the questionnaire. Examples of physical characteristics are the number and floor area of houses, offices, roads, the modal split and nuisance from noise, odour etc. This information is automatically transformed to the DPL matrix.

2. The DPL Matrix

The DPL matrix automatically transforms the information from the questionnaire into

indicator scores by using the formula and the data. The DPL consists of two axes (see Figure 1). The Y-axe presents the various functions of a neighbourhood, such as houses, parks, offices, infrastructure, factories etc. The X-axe presents the 25 indicators for sustainability.

Each box of the matrix consists of data and formula. For example for the indicator energy use of houses, data for energy consumption is connected to the m2 living space, which is filled in the questionnaire.

3. The DPL profile

With help of the matrix the DPL profile is calculated and related to the amount of ground surface of the district in question (see Figure 4). In this figure the DPL profile is limited to 8 indicators.

Compared to other tools for assessing urban sustainability, DPL represents a relative simple and flexible approach. The idea is to use a limited number of indicators based on already collected data, which are often accessible in the municipal registers. From these data, environmental, social and economic profiles for the district are calculated. If data are not available, the model allows alternative methods for a 'best estimate' on the indicator. It also allows new indicators to be included, if they are of special interest of the municipality. All the indicators used by DPL model are divided into 4 categories:

1. Basis data
2. Environmental indicators
3. Social indicators
4. Economic indicators

DPL-tool provides sustainability benchmarks within certain types of urban districts (high-rise, mixed areas, low-dense etc.), and thereby making the sustainability comparison and benchmarking more relevant for the actual area being assessed. Its only problem is that is very focused on the Nederland's and to apply it in another country, an adaptation must be done.

Source: Kortman et al., 2007.

Comparative chart

A comparative chart has been done in order to clarify differences in indicators between the different certification tools. A division has been done according to common topics in all of the certification tools analyzed.

Knowledge domain	BREEAM	LEED	HQE2R	DGNB	DPL

Knowledge domain	BREEAM	LEED	HQE2R	DGNB	DPL
ENVIRONMENTAL INDICATORS	1.Flood risk assessment 2.Noise pollution 3.Energy strategy 4.Existing buildings and infrastructure 5.Water strategy 6.Ecology strategy 7.Land use 8.Microclimate 9.Adapting to climate change 10.Green infrastructure 11.Flood risk management 12.Water pollution 13.Enhancement of ecological value 14.Landscape 15.Ligh pollution 16.Sustainable buildings 17.Low impact materials 18.Resource efficiency 19.Transport carbon emissions 20.Rainwater harvesting	1.Smart location 2.Imperiled species and ecological communities 3.Wetland and water body conservation 4.Agricultural land conservation 5.Floodplain avoidance 6.Prefered location 7.Brownfield redevelopment 8.Steep slope protection 9.Site design for habitat or wetland and water body conservation 10.Restoration of habitat or wetlands and water bodies 11.Long-term conservation management of habitat or wetlands and water bodies 12.Tree-lined and shaded streets 13.Certified green building 14.Building energy efficiency 15.Building water efficiency 16.Construction activity pollution prevention 17.Water-efficient landscaping 18.Minimized site disturbance in design and construction 19.Stormwater management 20.Heat Island reduction 21.Solar orientation 22.On-site renewable energy sources 23.Wastewater management 24.Recycled content in Infrastructure 25.Solid waste management infrastructure 26.Light pollution reduction	1.Household waste management 2.Site building waste management 3.Neighbour nuisances 4.Noise pollution due to traffic or other activity 5.Noise pollution due to construction 6.Quality of interior air 7.Quality of outside air 8.Local management of natural risks 9.Preservation and enhancement of natural heritage 10.Optimization of land consumption 11.Use of brownfields & polluted sites 12.Environmental concerns in planning 13.Drinking water consumption 14.Use of rainwater 15.Rainwater management 16.Sewage network 17.Reduce greenhouse gas emissions 18.Energy efficiency for heating and cooling 19.Energy efficiency for electricity 20.Use of renewable energy sources 21.Reduce greenhouse gas emissions	1.Life cycle assessment 2.Water and soil protection 3.Changing urban microclimate 4.Biodiversity and interlinking habitats 5.Considering possible impacts on the environment 6.Land use 7.Total primary energy demand and renewable primary energy share 8.Energy-efficient development layout 9.Resource-efficient infrastructure, earthworks management 10.Local food production 11.Water circulation system	1.Materials 2.Energy 3.Areal disposal 4.Rainwater treatment 5.Soil pollution 6.Waste collection 7.Air pollution

Knowledge domain	BREEAM	LEED	HQE2R	DGNB	DPL
SOCIAL INDICATORS	1.Demographic needs and priorities 2.Consultation and engagement 3.Housing provision 4.Delivery of services, facilities and amenities 5.Public realm 6.Local vernacular 7.Inclusive design	1.Mixed-income diverse communities 2.Community outreach and involvement 3.Neighbourhood schools	1.Strengthening the local community 2.Developing the social economy 3.Cultural links across the globe 4.Engagement in the sustainable development process 5.Effective participation in decisions & projects 6.City amenities within neighbourhoods 7.Foster academic success 8.Role of the school in neighbourhoods 9.Local amenity 10.Social and economic diversity 11.Age distribution diversity 12.Safety for people & goods 13.Neighbourhood cleanliness 14.Reducing substandard housing 15.Access to care and health	1.Social and functional mix 2.Social and commercial infrastructure 3.Objective/ subjective safety 4.Public space amenity value 5.Noise protection and sound insulation 6.Open space offer 7.Inclusive access 8.Development layout and flexible use 9.Urban integration 10.Urban design 11.Use of existing structures 12.Art in public spaces	1.Noise pollution 2.Odor pollution 3.Social security 4.Traffic security 5.Industrial health threats 6.Quality of public service 7.Access to public transport 8.Public parks and gardens 9.Water 10.Urban Quality 11.Residential quality 12.Social cohesion
ECONOMIC INDICATORS	1.Economic impact 2.Utilities 3.Labour and skills	1.Local food production 2.Existing building reuse 3.Historic resource preservation and adaptive use 4.Innovation and exemplary performance 5.LEED accredited professional 6.Regional priority	1.Economic vitality and jobs 2.Shops 3.Social and economic diversity	1.Life-cycle costs 2.Fiscal effects on the municipality 3.Value stability 4.Efficient land use	1.Local workplaces 2.Type of local companies 3.Sustainable companies 4.Mix of functions in the area 5.Flexibility in the area 6.IT infrastructure in the area

Knowledge domain	BREEAM	LEED	HQE2R	DGNB	DPL
OTHER ISSUES	Governance: 1.Consultation plan 2.Design review 3.community management of facilities Mobility: 1.Transport assessment 2.Local parking 3.Safe and appealing streets 4.Cycling network 5.Access to public transport 6.Cycling facilities 7.Public transport facilities	Mobility: 1.Locations with reduced automobile dependence 2.Bicycle network and storage 3.Housing and jobs proximity 4.Walkable streets 5.Compact development 6.Connected and open community 7.Mixed-use neighbourhood centres 8.Reduced parking footprint 9.Street network 10.Transit facilities 11.Transportation demand management 12.Acess to civic and public spaces 13.Acess to recreation facilities 14.Visitability and universal design Energy: 1.Building energy efficiency 2.Heat Island reduction 3.Soalr orientation 4.On-sire renewable energy sources 5.District heating and cooling 6.Infrastucture energy efficiency	Mobility: 1.Safe and convenient foot paths and cycle ways 2.Non-pollutant and efficient transport 3.Improvement of the public transport system 4.Improvement of road safety 5.Local management of technological risks Housing and urban design: 1.Diversity of housing 2.Building Quality 3.Housing Quality 4.Satisfaction of users and residents 4. Visual quality of natural landscape 5.Visual quality of urban landscape 6.Enhancement of architectural quality 7.Preservation and enhancement of natural heritage 8.Reuse of materials in construction 9.Reuse of materials in public spaces	Management: 1.Energy technology 2.Efficient waste management 3.Rain water management 4.Information and telecommunication management 5.Maintenance, upkeep, cleaning 6.Quality of transport systems 7.Quality of motor transport infrastructure 8.Quality of public transport infrastructure 9.Quality of bicycle infrastructure 10.Quality of pedestrian infrastructure Governance: 1.Participation 2.Concept development process 3.Integrated planning 4.Municipal involvement 5.Management 6.Construction site and construction process 7.Marketing 8.Quality assurance and monitoring	Basis Data: 1.Inhabitants 2.Number of dwellings 3.Total surface 4.Length of road

Annex A2. Integrated urban planning methodologies

There is a great variety of sustainable urban planning methodologies. Four of them have been selected and compared depending on their approach to the following aspects:

- Process
    - Activity sequence
    - Relationship between phases
- Governance
    - Participating agents in each phase
    - Roles
    - Decision-making mechanisms
    - Interdisciplinary cooperation
    - Community involvement
- Methods
    - Knowledge domains
    - Relationship between disciplines
    - Planning techniques
    - Tools employed

Local Agenda 21 Planning Guide (ICLEI, 1996) was intended to assist local governments and their local partners to implement the United Nations‘ Agenda 21 action plan for sustainable velopment and the related United Nations' Habitat Agenda, based on the experience from ICLEI's Local Agenda 21 Model Communities Programme (MCP). This planning approach was considered a fundamental first step to provide the residents of their communities with basic human needs, rights, and economic opportunities, and at the same time ensure a vital, healthy, natural environment; in other words, a planning approach to empower local communities and governments to manage their cities, towns, and/or rural settlements in a sustainable way (ICLEI, 1996:xi).

Ecocity Book II (2005) is based on the project ECOCITY – Urban Development towards Appropriate Structures for Sustainable Transport in order to give practical support to planners and decision-makers working for sustainable urban development patterns, with a priority to creating a framework for sustainable transportation patterns by designing structures convenient for pedestrians, cyclists, public transport and efficient distribution logistics while also finding sustainable solutions in the sectors of energy, material flows and socio-economy (Gaffron et al., 2008:7)

Emerging and Sustainable Cities Initiative (2011) is the IDB's technical assistance program providing direct support to the development and execution of city Action Plans. It employs a multidisciplinary approach to identify, organize and prioritize urban interventions to foster sustainable growth of emerging cities, with a transversal approach based on three pillars: environmental and climate change sustainability, urban sustainability, and fiscal sustainability and governance (IDB, 2014).

Ecodistricts Protocol (2016) is a "framework for achieving people-centered, economically vibrant, planet-loving neighborhood- and district-scale sustainability". It is a tool for fostering neighborhood and district-scale sustainability as well as a certification standard, but designed as a flexible performance framework rather than a prescriptive standard. (EcoDistricts, 2016:7)

Local Agenda 21 Planning Guide (ICLEI, 1996)		
Process	Activity sequence	Partnerships Community-Based Issue Analysis Action Planning Implementation and Monitoring Evaluation and Feedback
	Relationship between phases	Monitoring is primarily useful for internal management purposes. Evaluation and feedback are used for both internal and external purposes. An effective evaluation and feedback system provides regular information to both service providers and users about important changes in local conditions and progress towards targets; with this information, the actors can adjust their own actions and behaviors. Evaluation information is used to guide planning and resource allocation (budgeting) processes so that these processes are kept accountable to the Community Vision and its action objectives. If an Action Plan fails to correct problems or to satisfy prioritized needs, the feedback system triggers further planning or action.
Governance	Participating agents in each phase	• Service providers: those people who control and manage services; • service users: those people who use and are affected directly by services; • parties whose interests are indirectly affected by the impacts of the service or service system; and • parties with a particular knowledge related to the service or the service environment.
	Roles	Once the scope of the planning exercise is determined, the partnership structures are defined, and participants are identified, terms of reference should be developed to define roles and responsibilities in the planning process.
	Decision-making mechanisms	Residents, key institutional partners, and interest groups (stakeholders) in designing and implementing action plans. Planning is carried out collectively among these groups. It is organized so as to represent the desires, values, and ideals of the various stakeholders within the community, particularly local service users.
	Interdisciplinary cooperation	Community-based issue analysis involves 2 components: (1) process to gather and discuss the knowledge and wisdom of local residents about local conditions. (2) technical assessments to provide stakeholders with further information that may not readily be available to them. Popular knowledge and technical research are then reviewed together by the stakeholders.
	Community involvement	Involving local communities in the analysis of development and related service issues is essential to the optimal solution of problems. Municipal investments are more likely to succeed and win public support if they are responsive to the articulated needs, concerns, and preferences of service users.
Methods	Knowledge domains	Service systems: • infrastructure (e.g., public transit systems, sewerage systems); • programs (e.g., health clinics, public safety); • procedures (e.g., development approval processes); • management routines (e.g., repeated activities such as waste collection or building inspections); and • management interventions (e.g., pollution control)
	Relationship between disciplines	Balance among the three development processes: economic development, community development, and ecological development
	Planning techniques	Partnerships for sustainable development planning purposes. Community-Based Issue Analysis. Common/shared Community Vision
	Tools employed	Participatory System Analysis. Rapid Urban Environmental Assessment (RUEA). Comparative Risk Assessment (CRA). Force Field Analysis.

Ecocity Book II (2005)		
Process	Activity sequence	Project goal, pre-planning (studies and analysis),site analysis, urban planning (spatial and sectoral concepts), ECOCITY masterplan, detailed planning (urban structure and sectoral plans and reports), sectoral plans, implementation (feasible projects), implemented project
	Relationship between phases	Flexible planning strategies should allow learning from the experience of completed phases for the following phases of planning. Planning results should be submitted to continuous monitoring and feedback processes based on checklists or indicators, correcting the course whenever necessary.
Governance	Participating agents in each phase	Pre-planning: different interest groups of the Community Domain. Urban Planning: planners and Community Detailed Planning: planners Implementation: planners, implementators
	Roles	Policy makers Administrations Citizen experts Professional experts General interest groups Investors and owners Other relevant stakeholders
	Decision-making mechanisms	Planning domain is responsible for design and research, while community domain is responsible for choice and legitimation of selected options.
	Interdisciplinary cooperation	Experts considering systemic links and harmonizing solutions for their sectors and for the other sectors. Broaden horizons, innovative ideas, quality improvement, simultaneously learning and providing sources to others.
	Community involvement	Is essential part of ECOCITY planning and decision making processes. It not only provides opportunities for people to better understand policies and projects but it also increases the people's sense of ownership and thus also commitment. Anmd it must go beyond a mere provision of information or gathering of opinions though consultation.
Methods	Knowledge domains	Urban planning, transport, social issues, economic issues, energy, environmental issues, other relevant issues. Citizens, stakeholders, interest groups and intended users and inhabitants
	Relationship between disciplines	urban structure and function interacts with transport system and quality of life. Density, mix of uses…
	Planning techniques	Multidisciplinary planning team, iterative process, bottom-up design, overlaying technique, planning with scenarios. Guidelines: plan the general route in terms of urban planning, urban structure, transport, energy and material flows, socio - economic factors. Many projects achieve only good sectorial solutions. Developing a holistic concept is necessary. Integration of sectors, integration of participating agents and stakeholders, tailoring the plan to local requirements and circumstances.
	Tools employed	Local transport performance, *netzwerkzeug*, energetic and bioclimatic calculation and simulation tools.

ESCI: Emerging and Sustainable Cities Initiative (IDB, 2011)		
Process	Activity sequence	Identifying the most urgent challenges to the city's sustainability (evaluation based on: quantitative analysis of 120 indicators, technical and qualitative analysis based on specialists in sectorial topics, baseline studies on different disciplines). After preparing the Action Plan, the Bank supports the city in identifying funds and preparing priority interventions. PHASES: Preparation, analysis & diagnosis, prioritization, action plan, pre-investment, monitoring, investment.
	Relationship between phases	Analysis and evaluations provide a diagnosis of the sectors and areas that require more attention. The information obtained is filtered by instruments and prioritization criteria or filters (Bank filters, public opinion, climate change and disaster risks, economics and multi-sectorality). After this, strategies, areas of action and interventions are reflected in an Action Plan.
Governance	Participating agents in each phase	Preparation: Work teams and institutions Analysis and diagnosis: The city authorities, specialists and the Bank technical team Prioritization: specialists Action plan: Bank's technical team and the team of city counterparts Pre-investment Monitoring: citizens groups and private-sector, technical profiles
	Roles	
	Decision-making mechanisms	
	Interdisciplinary cooperation	
	Community involvement	
Methods	Knowledge domains	Environmental and climate change issues, urban issues, fisical and governance issues
	Relationship between disciplines	
	Planning techniques	Communication Platform, city's technical team coordinator interacts with local institutions,
	Tools employed	Baseline studies, evolution of urban footprint, vulnerability map, GHG inventory, indicators, traffic light exercise, interviews with sectorial experts, populations census, reports, disaster risk, vulnerability and historical analysis , filters to prioritize, action plan, financial plan, program of implementation, pre-investment studies, financial structure, mitigation risk tools, project execution timetable, monitoring system, cities network

Ecodistricts Protocol (2016)		
Process	Activity sequence	Project registration, imperatives commitment, formation, roadmap and performance.
	Relationship between phases	Before proceeding with certification, convene key stakeholders and collaboratively develop an Imperatives Commitment of your project's equity, resilience and climate protection strategies. Formation phase focuses on shaping the necessary leadership, collaboration and governance conditions within a district to align interests and investments and enable and accelerate the achievement of desired outcomes. Formation is also the starting point in equity strategy. 3 steps: assess readiness, build a project team and commit to collaboration. Every district needs a clear action plan: roadmap (set of targets, strategies and milestones). 3 steps: establish the context; assess baseline performance, set targets and identify strategies; assemble roadmap. Performance phase: feasibility confirmation and final design. 3 steps: implement roadmap, report progress and enhance governance.
Governance	Participating agents in each phase	City officials, community-based groups, real estate developers, financers, major stakeholders, project team,
	Roles	
	Decision-making mechanisms	
	Interdisciplinary cooperation	Strong alignment and coordination between stakeholders in fundamental.
	Community involvement	
Methods	Knowledge domains	
	Relationship between disciplines	
	Planning techniques	
	Tools employed	Certification. Imperatives commitment: equity, resilience and climate protection.

Annex A3. References

AEIDL (2013). *Urban development in the EU: 50 projects supported by the European Regional Development Fund during the 2007-13 period*. European Commission, Directorate General for Regional and Urban Policy http://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/50_projects/urban_dev_erdf50.pdf

Albino, V., Berardi, U., & Dangelico, R. M. (2015). "Smart Cities: Definitions, Dimensions, Performance, and Initiatives." *Journal of Urban Technology* 22(1): 1-19.

Ambiente Italia (2003). *European Common Indicators. Towards a Local Sustainability Profile*. Final Project Report Development, Refinement, Management and Evaluation of European Common Indicators Project (ECI). http://www.cityindicators.org/Deliverables/eci_final_report_12-4-2007-1024955.pdf

Angelidou, M. (2014). "Smart city policies: A spatial approach." *Cities* 41, S3-S11.

Arnstein, Sherry R. (1969) "A ladder of citizen participation". *Journal of the American Institute of planners*, 35(4), 216-224.

BMVBS/BBR (Eds.) (2007). *Integrated Urban Development – a Prerequisite for Urban Sustainability in Europe*. BBR-Online-Publikation 09/2007. http://d-nb.info/984960236/34

BRE (2013). *BREEAM Communities 2012 Technical Manual*. Building Research Establishment. http://www.breeam.com/bre_PrintOutput/BREEAM_Communities_0_1.pdf

Calvillo, C.F.; Sánchez-Miralles, A.; Villar, J. (2016) "Energy management and planning in smart cities." *Renewable and Sustainable Energy Reviews* 55: 273–287. http://www.sciencedirect.com/science/article/pii/S1364032115012125

Charlot-Valdieu, Catherine (2003). *HQE2R Methodological Framework*. CSTB France. http://www.e-core.org/content/workshops/nov03/charlot-valdieu.pdf

CONCERTO Premium (2014). *Energy solutions for smart cities and communities. Lessons learnt from the 58 pilot cities of the CONCERTO initiative*. Editor: Steinbeis-Europa-Zentrum on behalf of the European Commission, DG Energy. http://www.concertoplus.eu/concerto1_lrage.pdf

DGNB (2013). *The DGNB Certification System For Urban Districts*. 2013. Deutsche Gesellschaft für Nachhaltiges Bauen e.V. http://www.dgnb-system.de/en/schemes/about-schemes/certification_requirements_urban_city_districts.php

EC (2011a). *A Roadmap for moving to a competitive low carbon economy in 2050*. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions COM/2011/0112 final. http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52011DC0112

EC (2011b). *WHITE PAPER Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system*. European Commission COM/2011/0144 final. http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52011DC0144

EC (2014) *Towards a circular economy: A zero waste programme for Europe*. Communication from the Commission to the European Parliament, the Council, the

European Economic and Social Committee and the Committee of the Regions COM/2014/0398 final/2. http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52014DC0398R(01)

EC (2016a) Towards a smart, efficient and sustainable heating and cooling sector. European Commission - Fact Sheet. http://europa.eu/rapid/press-release_MEMO-16-311_en.htm

EC (2016b). *Guidelines on Data Management in Horizon 2020*. European Commission. Directorate General for Research & Innovation. http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/hi/oa_pilot/h2020-hi-oa-data-mgt_en.pdf

EcoDistricts (2016). *EcoDistricts Protocol* v1.1. https://ecodistricts.org/wp-content/uploads/2016/05/ed-protocol-guide-V1-1B.pdf

EIP-SCC (2013). *Strategic Implementation Plan*. European Innovation Partnership on Smart Cities and Communities. http://ec.europa.eu/eip/smartcities/files/sip_final_en.pdf

Euroheat & Power (2015) "Statistics Overview." *District Heating and Cooling Country by Country 2015 Survey*. http://www.euroheat.org/wp-content/uploads/2016/03/2015-Country-by-country-Statistics-Overview.pdf

Frei, C. W. (2008) "What if…? Utility vision 2020." *Energy Policy* 36: 3640-3645.

Gaffron, Philine; Huismans, Gé; Skala, Franz (2008). Ecocity Book II. How to make it happen. Deliverable of ECOCITY, Urban Development towards Appropriate Structures for Sustainable Transport FP5 Project (2002-2005). Vienna: Facultas Verlags- und Buchhandels AG. http://www.gea21.com/publicaciones/ecocity_ii

Giffinger, Rudolf; Gudrun, Haindlmaier (2010). "Smart cities ranking: an effective instrument for the positioning of the cities?" ACE: Architecture, City and Environment, 4 (12): 7-26.

Harrison, C. & Donnelly, I. A. (2011). "A theory of smart cities." *Proceedings of the 55th Annual Meeting of the ISSS-2011*, Hull, UK (Vol. 55, No. 1).

Huete García, M. Á.; Merinero Rodríguez, R. & Muñoz Moreno, R. M. (2016). "Urban Regeneration Policy from the Integrated Urban Development Model in the European Union: an Analytical Approach Based on the Study of Spanish Cities." *Local Government Studies* 42 (2), 267-286.

IAP2 (2007) *IAP2 Spectrum of Public Participation*. International Association for Public Participation Australasia, IAP2. https://www.iap2.org.au/resources/public-participation-spectrum

ICLEI (1996). *The Local Agenda 21 Planning Guide. An introduction to sustainabie development planning*. International Council for Local Environmental Initiatives (ICLEI), Local Agenda 21 Initiative, International Development Research Centre (IDRC), United Nations Environment Programme (UNEP). http://www.democratsagainstunagenda21.com/uploads/4/4/6/6/4466371/iclei.local-agenda-21.planning.guide.pdf

IDB (2014). *Methodological Guide. Emerging and Sustainable Cities Initiative*. Inter-American Development Bank. https://drive.google.com/file/d/0B93Bl6qR3zQ_OXgyN3lwMURqNE0/view

Jensen, J. O. (2009). "Sustainability Profile for Urban Districts in Copenhagen". Paper presented at Sustainable Cities and Regions: Enabling Vision or Empty Talk?', Örebro University, Sweden, March 11-13 2009., Örebro, Sweden.. http://vbn.aau.dk/files/18950039/Sustainable__profile.pdf

Kemp, R.; Loorbach, D.; Rotmans, J. (2007). "Transition management as a model for managing processes of co-evolution." *The International Journal of Sustainable Development and World Ecology* 14: 78-91.

Kemp, R.; Schot, J.; Hoogma, R. (1998). "Regime shifts to sustainability through processes of niche formation: the approach of strategic niche management." *Technology analysis & strategic management*, 10(2), 175-198.

Kortman, J.G.M.; van Ewijk, H.A.L.; Otto, A.A. (2007). *DPL: A tool for assessing a district on sustainability*. IVAM Environmental Research University . http://www.irbnet.de/daten/iconda/CIB4205.pdf

Kramers, A., Höjer, M., Lövehagen, N., & Wangel, J. (2014). "Smart sustainable cities– Exploring ICT solutions for reduced energy use in cities." Environmental Modelling & Software 56, 52-62.

Lapillonne, Bruno; Pollier, Karine; Samci, Nehir (2015) *Energy Efficiency Trends in Residential in the EU*. Odyssee-Mure Project. http://www.odyssee-mure.eu/publications/efficiency-by-sector/household/household-eu.pdf

LUDA (2006). *LUDA E-Compendium: Handbook E2. Understanding Large Urban Distressed Areas*. LUDA, Improving the quality of life of Large Urban Distressed Areas. http://www.luda-project.net/compendium/hbe2-200606.pdf

Molina Costa, Patricia (2014). "Methodology for demarcation of priority areas for integrated urban regeneration", *BIA Urban Regeneration Forum*. Bilbao, September 24-27.

Molina Costa, Patricia; Arana Bollar, Maider; Jiménez Romera, Carlos (2015). "Integrating Smart City projects in urban planning." *6th European Conference on Energy Efficiency and Sustainability in Architecture and Planning*, pp. 103-110.

Neirotti, P., De Marco, A., Cagliano, A. C., Mangano, G., & Scorrano, F. (2014). "Current trends in Smart City initiatives: Some stylised facts." *Cities* 38, 25-36.

RE-Block (2015a). *Policy Development Recommendations*. URBACT II RE-Block Network. http://urbact.eu/sites/default/files/policy_recommendations_report.pdf

OECD (1998). *Integrating Distressed Urban Areas*. Final report, Urban Affairs Division, OECD Paris. http://www.oecd-ilibrary.org/urban-rural-and-regional-development/integrating-distressed-urban-areas_9789264162884-en

RE-Block (2015b). *Urban Governance Guidelines*. URBACT II RE-Block Network. http://urbact.eu/sites/default/files/smarturbangovernanceguidelines.pdf

RegGov (2012). *Final Report*. RegGov. Regional Governance of Sustainable Integrated Development of Deprived Urban Areas URBACT Network. http://urbact.eu/sites/default/files/import/Projects/Reg_Gov/documents_media/Reggov_finalreport_web.pdf

Seyfang, Gill; Haxeltine, Alex (2012). “Growing grassroots innovations: exploring the role of community-based initiatives in governing sustainable energy transitions.” *Environment and Planning C: Government and Policy* 30: 381-400.

Smart City Council (2015). Smart Cities Readiness Guide. The planning manual for building tomorrow’s cities today. http://smartcitiescouncil.com/resources/smart-cities-readiness-guide

SmartImpact (2015). *SmartImpact Baseline Report*. URBACT Network: SMARTImpact Local Impacts from Smart City Planning. http://urbact.eu/file/13019/download?token=zIw_Otwn

Tasan-Kok T., Vranken J. (eds) (2011). *Handbook for Multilevel Urban Governance in Europe*. European Urban Knowledge Network, Wilco, Amersfoort.

UK Government Office for Science (2014). *Future of cities: origins, meanings and uses. London: Foreign Project*, Future of Cities Collection. https://www.gov.uk/government/collections/future-of-cities

UN-DESA (2014). *World Urbanization Trends. The 2014 Revision*. United Nations, Department of Economic and Social Affairs. https://esa.un.org/unpd/wup/Publications/Files/WUP2014-Highlights.pdf

UN-Habitat (2008) “Energy Consumption in Cities.” *State of the World’s Cities 2008/2009 – Harmonious Cities*, pp. 156-163. http://www.rrojasdatabank.info/statewc08093.4.pdf

UN-Habitat (2012) “Energy.” Urban themes. http://unhabitat.org/urban-themes/energy/

USGBC (2014). *LEED 2009 for Neighborhood Development Rating System*. US Green Building Council. http://www.usgbc.org/sites/default/files/LEED%202009%20RS_ND_07.01.14_current%20version.pdf