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Sofia LORENZ FONFRIA, Ayuntamiento de Murcia
Elke DEN OUDEN & Rianne VALKENBURG, TU/e LightHouse
AMBITION, VISION & ROADMAP
SMART BUILDINGS MURCIA
D6.4 Final city report

Leader: TU/e LightHouse
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Abstract
This report (D6.4) is the final deliverable of the R4E project and contains all relevant project results for smart buildings in the city of Murcia.

The R4E project received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 649397.

Disclaimer: This report presents the views of the authors, and do not necessarily reflect the official European Commission’s view on the subject.

Versions of this report:
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WP7. Project management

Project coordination
- quality management
- project coordination
- financial & administrative activities

WP1. Ambition setting
- Ambition workshops: 3-day workshop in each city to define specific ambitions per focus area
- Ambition sharing & selecting drivers for change: 2-day meeting in Palermo to share the results of the ambition workshops and future telling and to select the drivers for change for WP2

WP2. Vision development
- Scenario workshops: 3-day workshop in each city to develop specific desired future scenarios per focus area
- Scenario sharing & selecting topics for roadmaps: 2-day meeting in Istanbul to share the desired future scenario’s of all cities with all partners and to select the topics for the roadmaps (covering sustainable technologies, behaviour and organisation)
- Scenario preparation: defining generic elements for future scenarios in preparation for the workshops with cities to develop specific desired future scenarios
- Creation of timelines: making timelines for each topic to indicate when relevant options become available on the path towards the desired future
- Expert meeting: cross learn expert meetings to share and align timelines for the focus areas and prepare roadmap workshops with cities

WP3, 4 & 5. Roadmapping
- Roadmapping training session: 2-day training session for expert partners on methodology and aim of working
- Desk study: analysis of the available information on the selected topics for the roadmaps and to identify relevant experts
- Roadmap workshops: 2-day workshops in each city to develop specific timelines for the realisation of the desired future scenario’s
- Roadmap interviews: collecting expert insights with 20 experts for each focus area

WP6. Project portfolio
- Current projects: each city identifies projects it has running that will contribute to the realisation of the roadmap, as well as the topics for cross-city learning
- New projects: each city identifies the desired new projects to ensure the timely realisation of its roadmap ambition
- Joint portfolio meeting: 2-day meeting to share the roadmaps of the different cities, as well as the current and new projects, and to identify cross-learning objectives

WP8. Communication & dissemination
- Strategy & visuals: developing a communication & dissemination strategy, logo’s and graphic charter
- Event & training: electronic project newsletters, other newsletters and information services, project and partner websites, press releases and other media releases, social media
- Regular communication activities: event橱窗
- Regular communication activities: event橱窗
- Final event: conference in Murcia

Version 4 September 2015
In the Roadmaps for Energy (R4E) project, the partners work together to develop a new energy strategy: their Energy Roadmap. The difference between the regular energy strategies and action plans and these new Energy Roadmaps is the much earlier and more developed involvement of local stakeholders. These include not only those who benefit from the new strategy, such as the citizens themselves, but also relevant research and industry partners. They offer a much clearer view of the future potential of the city in terms of measures and technologies, as well as of the challenges presented by today’s situations in the cities. The result is a shared vision, containing the desired, city-specific scenarios and the dedicated roadmaps embedded in each city’s specific context. These roadmaps take into account the diversity in the geographies, ecologies, climates, societies and cultures of the eight partner cities in the project: Eindhoven, Forli, Istanbul, Newcastle, Murcia, Palermo, Sant Cugat and Tallinn.

The R4E project focuses on the vision creation and roadmapping capabilities of the individual municipalities. This includes initiating joint activities to drive the development and implementation of innovative energy solutions in cities. In this way the R4E partners learn the process and the roadmap structure. At the same time they gain the skills they need to work independently on their future roadmaps.

The ultimate result is a process that allows the partners to work together in developing the Energy Roadmap to achieve their ‘Smart Cities’ ambition. Since energy and Smart Cities are territory to territory and city to city, the dedicated roadmaps embedded in each city’s specific context. These roadmaps take into account the diversity in the geographies, ecologies, climates, societies and cultures of the eight partner cities in the project: Eindhoven, Forli, Istanbul, Newcastle, Murcia, Palermo, Sant Cugat and Tallinn.

The R4E project follows a 4-step approach:

1. The FIRST step sets the ambitions for the project. The ambitions of the participating cities on sustainable energy and Smart Cities in general are set, as well as the partner cities’ choice of two (out of three) focus areas within Smart Energy Savings: Smart Buildings, Smart Mobility or Smart Urban Spaces.
2. The SECOND step is to develop desired city scenarios for the selected focus areas.
3. In the THIRD step, the roadmap is created. This involves identifying existing and future technologies and other developments that will enable the desired future scenarios. The opportunities and developments are plotted on a timeline to show the route and milestones towards the favoured scenarios. The roadmaps contain common parts for all the partner cities, as well as specific parts for the individual cities.
4. In the FOURTH and final step, a project portfolio is generated with new projects and initiatives to reach the ambitions, visions and roadmaps of the cities. This portfolio provides a detailed overview of individual and joint projects, and includes cross-city learning and financial plans.

The approach is characterised by four main elements:
- Backwards planning - the project starts with the development of a shared vision as a starting point for the creation of a well developed path to achieve it.
- Inclusive workshops in the cities – a cooperative process to engage key stakeholders (companies, citizens, public and private organisations and knowledge institutes) within the region in co-creating a clear and well designed implementation plan with a stronger commitment to the joint effort in the realisation phase.
- Expert knowledge is sourced in a practical and usable form during the vision development and roadmapping.
- A visual language is used to easily connect people and share main insights.

**Overview of the eight partner cities of the R4E project:**

- **Eindhoven**, Gemeente Eindhoven, the Netherlands
  - Population: 220,000
  - Area: 90 km²
  - **Smart Buildings**
  - **Smart Mobility**
  - **Smart Urban Spaces**
- **Newcastle City Council**, Newcastle City Council, United Kingdom
  - Population: 282,000
  - Area: 114 km²
  - **Smart Buildings**
  - **Smart Mobility**
  - **Smart Urban Spaces**
- **Comune di Forlì**, Italy
  - Population: 120,000
  - Area: 228 km²
  - **Smart Buildings**
  - **Smart Mobility**
  - **Smart Urban Spaces**
- **Comune di Palermo**, Italy
  - Population: 885,000
  - Area: 160 km²
  - **Smart Buildings**
  - **Smart Mobility**
  - **Smart Urban Spaces**
- **Ayuntamiento de Murcia**, Spain
  - Population: 440,000
  - Area: 885 km²
  - **Smart Buildings**
  - **Smart Mobility**
  - **Smart Urban Spaces**
- **Ayuntamiento de Sant Cugat**, Spain
  - Population: 86,000
  - Area: 50 km²
  - **Smart Buildings**
  - **Smart Mobility**
  - **Smart Urban Spaces**
- **Tallinna Keskonnakogu**, Estonia
  - Population: 430,000
  - Area: 160 km²
  - **Smart Buildings**
  - **Smart Mobility**
  - **Smart Urban Spaces**

**The three focus areas of R4E:**

- **Smart Buildings**
- **Smart Mobility**
- **Smart Urban Spaces**

**Four step approach of R4E:**

1. **Ambition setting**
2. **Vision development**
3. **Roadmapping**
4. **Project portfolio**
Ambition Setting

The aim of Step 1 is to set the ambitions for the project. An ambition expresses what a city wants to achieve in the future. For this purpose the ambitions of the participating cities on sustainable energy in general are defined and refined in a process of co-creation, using existing policy documents as a basis for workshops with the individual cities. Each city selects two focus areas for which specific city ambitions are defined.

Today’s reality

During the kick-off meeting the cities present the current status of their energy policy in general and their selected focus areas in particular. This chapter starts with a summary of this information.

Ambition Workshops

The strategic ambitions for energy-related themes in general and for the selected focus areas in particular are assessed in a series of workshops in each of the partner cities. The Ambition Workshops consists of 3-day visits to the individual cities, during which several workshops with policy-makers and stakeholders are held to gain a deep understanding of the ambitions and specific contexts of the cities. Through the networks in the cities the local stakeholders (companies, citizens, public and private organisations and knowledge institutes) are invited to participate in the workshops. Together, the participants interactively contribute to the strategic ambitions. See also the pictures of the workshops on the previous page. The results of the Ambition Workshops are reported in similar formats for each of the cities to enable cross learning between the cities.

Joint Ambition Workshop

In a joint meeting in Palermo, the cities shared their ambitions and held in-depth discussions to understand the common and specific aspects of their ambitions. The main aim of the Joint Ambition Workshop is to enable cross-city learning. In this way the cities gain a deeper understanding of the Ambition Setting process, and can improve their own ambition with inspiration from others.

The Joint Ambition Workshop is a 1-day workshop that finalises the activities of Step 1 and prepares for Step 2.

<table>
<thead>
<tr>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interview with policy makers</td>
<td>Workshop with stakeholders focus area 1</td>
<td>Project team working session to establish scope</td>
</tr>
<tr>
<td>Workshop with strategy department</td>
<td>Workshop with stakeholders focus area 2</td>
<td>Preparing main content of concept report</td>
</tr>
</tbody>
</table>

Programme of the Ambition Workshops in the cities

Morning

Finalising Step 1

- Presentation of the cities ambitions
  - Each city presents their ambition for the focus areas
- Learning from each other’s ambitions
  - In-depth discussion on common and specific ambitions

Afternoon

Preparing for Step 2

- Presentation of the Drivers for Change
  - Sharing of results of Future Telling research
- Understanding the Drivers for Change
  - Exploring the relevance for the focus areas and selection of drivers for scenario workshops
Introduction to Murcia

Murcia is the major city in south-eastern Spain, and the capital and most populous city of the autonomous community of the region (with the same name, Murcia). It is Spain’s seventh largest city, with a population of 439,712 inhabitants (about one-third of the total population of the region). Murcia has a mild climate with hot summers, mild winters and relatively low rainfall. In global terms, the region’s climate can be described as ‘an eternal spring’.

Murcia is a municipality of 890 km$^2$, at 43 metres above sea level, covering the city and 52 parishes in the surrounding 40 km. The region has 2,800 hours of sunshine each year, and the average rainfall in the Segura basin is one of the lowest in Spain (only 301 l/m$^2$).

The average temperature is 17.8 ºC. Yearly average relative humidity is 59%. Irrigation uses the 85% of the 240 Hm$^3$ consumed in the basin, whilst domestic, industrial and other uses represent only the 15% of the water consumption, 50% of it will soon be supplied with desalinated water.

Due to its location, Murcia has high levels of solar radiation during the whole year. Specifically, it has a yearly average of 5 kWh/m$^2$/day, one of the highest in Spain. The Municipality of Murcia owns 27 roof-mounted PV installations on a number of buildings to generate electricity, producing 362 KwP. The income from the sale of this energy is used to improve the energy efficiency of the installations in these buildings.

On the other hand there is little rain, which is why Murcia has developed very advanced irrigation system to make efficient use of the available water. Traditionally, Murcia has been known for its agriculture, and at present it exports fruits and vegetables to the whole of Europe. The shortage of water and its importance for crops has forced farmers to invest in high-tech systems to get the most out of the available water.
The Municipality of Murcia has a complex land planning system. 83% of the population live within a 5 km radius, and within a radius of 7 km the figure is 89%. The city centre attracts most commuters each day, and this is also the area with the most severe congestion problems.

Murcia has selected two focus areas for the R4E project:

- **SMART BUILDINGS**
- **SMART MOBILITY**
Mobility and transport

To make a good diagnosis of Urban Mobility in Murcia, it is necessary to analyse the social and demographic situation in detail. Regarding mobility, the chart of "MOBILITY KEY DATA OF MURCIA" shows the essential mobility data of Murcia Municipality, based on our SUMP (Sept. 2009). This shows that the use of public transport remains relatively low compared to other large cities (10.33%).

In terms of comparativeness with the rest of Spain, the following chart shows that Murcia has similar levels to Barcelona regarding motorised travel:

Public transport

The use of Public transport represents the 10% of all journeys in Murcia, meaning the 17% of all motorised journeys. Regarding the City Bus System, the City has a good set of accessibility to travellers and several bus stops. It offers a good system of bus information and an adequate cover: 300 meters within the Murcia City Centre. The tram has very positively benefited public transport in Murcia. Over the last two years has improved the rate of use of public transport. Murcia’s tram has served in those 2 years to 704747 passengers.

Electric mobility

Murcia City has a considerable fleet of electric vehicles. Nevertheless, our public electric network of chargers must be expanded. This would foster the demand of electric vehicles and would gradually grow the number of registered electric vehicles. Great efforts are being made by our Municipality in order to spread out the needs of changing mobility habits. We do incorporate electric vehicles to our usual means of transport, always in detriment of fossil fuels. Murcia City Council is currently looking for strong financing schemes in order to support the development of a proper e-mobility infrastructure, to better facilitate the introduction of electric mobility in Murcia.

Traffic and circulation

Traffic in Murcia indicates that there is a high use of private vehicles for commuting, which accounts for 51% of all trips and 81% of all motorised trips, (Sept, 2009). Roundabouts are our main Traffic hotspots in the City, where there is the higher volume of traffic. In addition, also make it a place where unfortunately there is the higher level of conflicts, casuistic and accidents. The average speed is quite high in Murcia (22km/h) and there are no significant variations between peak and valley period. Furthermore we cannot address significant traffic congestion in Murcia, though it is a big city. From further analysis, it has been concluded that the global system used for traffic management in Murcia should give more priority to public transport rather than private one. Nevertheless, Murcia offers a massive use of private vehicles, which mainly causes heavy traffic in the roundabouts of the City (here below Murcia road’s distribution).

Existing studies and surveys show a great interest by citizens to change their usual means of transport, as for a more efficient one. Citizens in Murcia give great importance - as mainly everywhere else - to saving opportunities, towards mobility alternatives.

Walking

The City of Murcia has over 252,000m2 of pedestrian zones - just in the city centre and 100,000m2 in the surroundings districts. Murcia City Council has built and marked an urban route, so-called "Walk 10,000steps", which covers a distance of 10,000 steps and connects 8 urban districts within the centre of Murcia. (See pedestrian areas in orange colour).

Our Council continues to highlight streets and pathways to further expand the pedestrian zones and enlarge the traffic-restricted areas in order to encourage people to walk on daily basis. So far, we do have in Murcia over 338,000 daily trips made by foot. This accounts for 37% of total daily trips, being equivalent to 0.87 trips per person per day.
Demographical aspects
Number of inhabitants in 2014: 439,712
Population density: 497 inhab./km². Due to the extension of Murcia Municipality, percentage of people living outside the city is bigger (61.33%) than percentage living in the urban centre (38.67%). The highest density of population (in red) occurs in the urban centre.

Social aspects
Percentage and evolution of people from foreign origin:
- Inhabitants (2014): percentage
  - Spanish origin: 388,510 (88.36%)
  - African origin: 18,121 (4.12%)
  - American origin: 17,420 (3.96%)
  - European origin: 13,387 (3.04%)
  - Asian origin: 2,258 (0.51%)
  - Others: 16 (0.00%)

In Murcia the population increased to 50,000 people from 2003 to 2011. A soft decrease of population has been registered in the last years.

Economical aspects
Income per head in comparison to the national average income in 2014: Murcia €18,529, Spain €22,780.
Due to financial and economic global crisis which extremely affected Spain and its regions, the number of unemployed in Murcia increased in 32,600 people since 2007 to 2013. In 2014 a downward evolution can be seen, and number of unemployed was reduced in 2,600 people.

According to sector, unemployment in Murcia (2014) mainly affects Services.

Evolution of the population in Murcia 2003-2014

Murcia foreign population 2003-2014

Registered unemployment, Murcia 2005-2014:

http://www.murciaencifras.com/datos-basicos
Environmental aspects

In 2008 Murcia was the first Spanish city to join the Covenant of Mayors initiative, in order to take action to reduce 20% of CO2 emissions in 2020. Within this context, Murcia also launched in 2008 the ‘Local Climate Change Strategy’. Recently, in 2015, Murcia joined the European initiative to fight the climate change, Mayors Adapt.

The total area of the city is 890km2. The extension of with green space making up 67.72km2, or 55%.

Total surface of public parks and gardens in the municipality: 4.2 km2

Water consumption per head 143 lit/day. Cost of water in Murcia is the higher in Spain 2.5 €/m3

SMART Real Time Water Management Center – smart meter infrastructure

Drinking Water Network is 2,187 km long. 164 km are main pipes of up to 1,000 mm diameter.

Biogas production in the Waste Water Treatment Processes (WWTP), which ensures a large part of its energy consumption of the by this renewable energy source.

Climate conditions: average temperature 18.4 °C, rain=fall 215 mm in 2013 .

Evolution of air quality (in number of days):

<table>
<thead>
<tr>
<th></th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>172</td>
<td>123</td>
<td>84</td>
<td>111</td>
<td>92</td>
</tr>
<tr>
<td>Admissible</td>
<td>186</td>
<td>229</td>
<td>280</td>
<td>246</td>
<td>273</td>
</tr>
<tr>
<td>Bad</td>
<td>4</td>
<td>13</td>
<td>6</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Very bad</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Recent projects

1. MOBISEC - Mobility Initiatives for Sustainable European Communities
   Grant DG MOVE (Transport and mobility) of the EU
   Current Coordinator of the project.
   Main topics: promotion of the use of the bicycle as usual transport; Guarantee the safety of users of public roads and especially cyclists and pedestrians; strategies to promote the intermodality of bicycle with other transport and Citizen participation.

2. MUTRANS (Murcia-Transport).
   Grant DG MOVE (Transport and mobility) of the EU
   Current Coordinator of the project.
   Mutrans is the integrated urban mobility platform of the City of Murcia. The web and App include all the information needed to move around Murcia tram, bus and bicycle, and can set routes combined. Also available in English to encourage a sustainable tourism.

3. R4E Roadmaps for Energy
   H2020-EE-2014-3-MarketUptake
   Current
   Topics Enhancing the capacity of public authorities to plan and implement sustainable energy policies and measures

4. SMARTSPACES – SAVING Energy in Europe’s Public Buildings Using ICT
   CIP ICT Policy Support Programme.
   Current
   The project started on 1 January 2012 and will last for three years. It will set up 11 pilot sites in 11 cities in 8 countries and be operated by 26 partners with an overall budget of almost 7 million Euros.

5. SMARTPA – Smarter Public Administrations in the EU
   Life Long Learning Programme
   Current
   This project aims to improve the use of ICT, particularly cloud computing and required competences, in European public administrations

6. SURE. Sustainable Urban Energy in the ENPI Region.
   Program CSUDAD of the EuropeAid Office of the European Commission.
   The aim of the project is exchanging experiences in energy planning, promotion of the Covenant of Mayors and technical advice for achieving the targets of the Covenant (20-20-20), meaning: decrease of CO2 emissions 20%, increase of energy efficiency 20% and renewable share 20% for the year 2020.

7. « ENPCOM project- European network for the promotion of the Covenant of Mayors »
   “Europe for Citizens” DG Culture
   ENPCOM is a network of local governments, citizens, industry organizations and associations aimed at strengthening the involvement of European citizens in the fight against climate.

8. Creation of Local Energy Agencies in Bordeaux, Latina, Murcia, Riga and Porto
   Intelligent Energy for Europe Programme
   PEPESEC supports the development of sustainable energy communities by increasing the role of local community planning in developing a more efficient supply, distribution and use of renewal energy sources (RES) and conventional energy, demand-side management and associated mobility.

9. Partnership Energy Planning as a tool for realising European Sustainable Energy Communities (PEPESEC)
   Intelligent Energy for Europe Programme
   PEPESEC brings producers and consumers, implemented energy-efficient green public procurement (GPP) procedures in local administrations, and organised training sessions for municipalities’ procurement staff. At the same time, five pilot cities set up integrated energy efficiency action plans, which included the involvement of stakeholders and awareness-raising campaigns for citizens.

10. ProSto project
    Intelligent Energy for Europe Programme
    The overall objective of ProStO is to support European local authorities in planning, developing, introducing and managing efficient solar thermal ordinances (STOs).

11. Pro-EE: improve energy efficiency through sustainable public procurement
    Intelligent Energy for Europe Programme
    Pro-EE brought together producers and consumers, implemented energy-efficient green public procurement (GPP) procedures in local administrations, and organised training sessions for municipalities’ procurement staff. At the same time, five pilot cities set up integrated energy efficiency action plans, which included the involvement of stakeholders and awareness-raising campaigns for citizens.

12. NICE Project (Networking Intelligent Cities for Energy Efficiency)
    FP7 funded project
    The NICE project aimed to support the fulfilment of the Green Digital Charter commitments.

13. Networks:
   • Signature in 2008 of the Covenant of Mayors
   • Member of Mayors Adapt, launched in the context of the EU Adaptation Strategy and is implemented within the Covenant of Mayors
   • Vice president of the CIVITAS network in Spain and Portugal
   • Member of Eurocities
   • Member of ENERGAIN, Spanish network of Energy Agencies
   • Signature in 2009 of the Green Digital Charter. European Innovation Partnership on Smart Cities and Communities (EIP-SCC)
   • Members of EnerAgen, the Spanish Association of Energy Agencies
   • Members of RECI, the Spanish network of Smart cities
   • Vice-Chair of the Technical Committee of Standardization AENOR CTN 178 on Energy in
Smart Cities

- Presidents of the Spanish Network of Cities for the Bicycle (RCxB)
- Municipal Observatory of bicycle. It is a consultative body of the City of Murcia composed of representatives of all political groups of the municipal corporation, municipal technicians, representatives of associations of bicycle users, citizens’ associations in defence of sustainable mobility and companies that regularly work with the City Council in advocacy and promotion of cycling.

15 December 2015
Jaime RUIZ HUESCAR & María Cruz FERREIRA COSTA, Ayuntamiento de Murcia
Today’s reality: Smart buildings

The city of Murcia has seen a strong construction sector during the period 2000 – 2007. From that time, the property bubble meant that the city has not had many examples of private smart building projects. With respect to Municipal Buildings, the Murcia City Council has built some remarkable buildings like the ‘Edificio Municipal multiusos de Abenarabi’, which is a good example of monitored and integrated systems. It uses the latest advances in communications, and can be considered as a reference in energy efficiency at regional level.

Apart from these examples, the Murcia City Council has been involved in the European ‘Smart Spaces’ project to reduce energy consumption in municipal buildings using ICT and by raising awareness. Murcia City Council achieved a reduction of the energy bill by 16% in five of its more representative buildings. The use of metering equipment in such buildings, combined with recruitment and dissemination activities, helped to make this possible.

Thanks to this project, the municipal staff can monitor the energy consumption of their building in real-time with just a few clicks. This ‘Free Access’ to energy consumption data has been very helpful in raising staff awareness about energy saving. The online platform, allows them to view the specific energy consumption of each department and to check how the behaviour of people in the offices affect energy use.

There is a lot of work to be done yet in the field of monitoring and improving energy efficiency in Murcia’s municipal buildings. There are a total of 500 buildings with different characteristics and uses, so the big challenge is how to install a precise and affordable monitoring system meets all the requirements and provide useful data to take decisions and act accordingly.
Ambition: Smart, interconnected green buildings maximise user comfort in Murcia 2050

1. Interconnected buildings optimise comfort and use of resources

In 2050, the buildings in Murcia are interconnected by a tele-management system that enables sharing of energy and resources. This makes a big contribution to users’ comfort and convenience, both inside and outside the buildings.

Strategic ambitions
- In 2050 buildings in Murcia inter-communicate, think and act in order to provide comfort and user-centered services with energetic autonomy.
- In 2050 in Murcia tele-management will allow buildings to inter-operate in order to optimise resources.

2. Buildings proactively adjusting to changing user needs

In 2050, people in Murcia value buildings that proactively adjust to their changing needs. Through profiles based on the expected use (presence and activity) and external factors (weather, season etc.), buildings actively choose the optimal energy settings to maximise comfort for users.

Strategic ambitions
- In 2050 the buildings in Murcia adjust themselves to the needs of their users and to external factors. The buildings being flexible and granted in terms of comfort by the use of centralised intelligent systems. The use is also optimised.
- In 2050 buildings in Murcia inter-communicate, think and act in order to provide comfort and user-centered services with energetic autonomy.

3. ‘Clean & green’ buildings and city

In 2050, Murcia is among Europe’s top ‘clean & green’ cities. This is achieved by green urban planning that values CO2-neutral, energy-producing buildings. These use renewable energy sources and have a low impact on nature, both during their construction and in daily use.

Strategic ambitions
- In 2050 all buildings in Murcia are zero-net balanced throughout the city. The buildings generate clean produced energy to fit their use. The capacity to store the energy is also realised. A greener Murcia is energy self-sufficient.
- In 2050 in Murcia the buildings will run on renewable energies, will be built with reusable materials and will not generate waste that may have a negative impact on nature.
- In 2050 Murcia is amongst the top 10 green, eco-friendly cities in Europe. Urban planning creates enough green to minimize local CO2-emission and local heat stress. The citizens are aware of their energy consumption and reduce their use.
Creating the visual of the desired future scenarios
**Vision development**

The aim of Step 2 is to develop visions for the cities on the selected focus areas. A vision is based on a long-term perspective on the world — in this case we are focusing on 2050. Two main activities take place in this step: Future Telling research and the development of the desired future scenarios in the cities.

**Future Telling**

The first part of the vision development activity is to identify Drivers for Change that influence the future of Smart Cities in general, as well as of Smart Buildings, Smart Mobility and Smart Urban Spaces in particular. The Future Telling research method develops context-related possible future scenarios in a creative and imaginative way and leads to Drivers for Change for liveable Smart Cities in 2050.

The method is briefly described on the following pages and more elaborate in the Future Telling 2050 D2.1 Report — Drivers for Change.

Developing desired future scenario’s

Of the 18 Drivers for Change for Smart and Sustainable Cities, the cities chose four Drivers for Change for each focus area that relate best to their specific contexts and ambitions. Together with the ambitions of step 1, these are used to develop the desired future scenarios for the focus areas.

**Scenario Workshops**

The desired future scenarios for the selected focus areas of the cities are created in a series of workshops held in each of the partner cities. These Scenario Workshops consist of a 3-day programme in each city, and include sessions with policy-makers and stakeholders to develop a rich, contextual scenario for the city. Local stakeholders (companies, citizens, public and private organisations and knowledge institutes) are invited to take part in the workshops through the networks in the cities. The results of the Scenario Workshops are reported in the same format for each city to facilitate cross-learning between the cities.

Two sessions are held for each focus area. In the morning session the outline for the vision and the desired future scenario is developed. The main stakeholders work with the set ambition for the focus area and the selected Drivers for Change to understand their impact on the city in 2050. Together, the participants define the main elements of the vision. Then, in the afternoon session, a broad spectrum of stakeholders are invited to enrich the desired future scenario by making specific additions. Based on the outlined vision, they carry out a further in-depth exploration of the main elements of the vision. In all the sessions, the participants interactively build a visualisation of the desired future scenario. See also the pictures of the workshops on the previous page.

The result of the vision development step is a visualisation of the desired future scenario in an A0-format poster. The poster shows the visual together with a brief explanatory text. A common visual language is used to make sharing easier and to facilitate discussion among the cities on common and specific aspects of the visions.

**Joint Vision Workshop**

In a joint meeting in Istanbul the cities presented their desired future scenarios to each other, and held in-depth discussions to understand the common and specific needs in their visions.

This Joint Vision Workshop served two purposes:

- To enable cross-city learning. The cities gain a deeper understanding of the vision development process, enabling them to improve their own vision with inspiration from others.
- To describe the needs as input for the roadmapping step.

The Joint Vision Workshop finalised the activities of Step 2 and prepared for Step 3.
Future Telling research

The future is unpredictable and elusive. Recent changes in technology, ecology, economics and society have already led to significant changes.

The expectation is that the complexity that people and organizations will experience will increase further in the years ahead. A number of current Drivers for Change will lead to radical changes in the future. For example, new developments in information technology will create opportunities that we cannot imagine today. These will undoubtedly change our lives significantly, including the way we shop, travel, move, communicate and work.

Another example is the increasing level of social connectivity, which will drastically affect the relationships between organizations and their strategies. Even today, disruptive developments in many areas are challenging us to redesign our world.

This constant process of change has also become more complex: developments are so rapid that the future is unpredictable, based on our knowledge and models of the past and present. Predictions based on analyses appear pointless. The new complexity is characterised by simultaneous developments with far-reaching effects. We need a new way to visualise the future, with all the opportunities and challenges that it will bring – an approach that is creative, imaginative and research-oriented. Even though we can’t predict the future, we can create a range of possible context-related future scenarios. These desired scenarios will direct our decision-making, from short-term actions to long-term consequences.

In the R4E project, the Future Telling research method is used to develop possible, context-related future scenarios in a creative, imaginative way. This implies a structured method to map the expertise and ideas of the thought leaders. The process focuses on Smart Cities, in particular using analysis to gain insight into the Drivers for Change for cities in 2050.

Thought leaders

Finding suitable Drivers for Change requires both broad and specialist views. The research involves 25 interviews with thought leaders holding different views on smart and sustainable energy in cities. A broad spectrum of experts with a visionary scope was chosen from knowledge institutes, companies, consultancies and profit or non profit organisations. Their expertise was both general on (smart) cities, and specific on mobility, buildings and urban spaces.

To overcome possible cultural bias, the experts were drawn from all over Europe, and even included thought leaders from the USA. These thought leaders are introduced on the following pages. For the interviews, the requested expertise of the thought leaders was not specifically their future vision, but their knowledge of important influences in their own fields. The Future Telling method inspired them to use their knowledge to visualise future trends and to describe possible future scenarios in rich stories. In fact, the richness of those stories makes them fertile input for the R4E project.

Future Telling card set

The Future Telling method uses a set of 52 cards showing general future trends derived from an extensive research project by The Hague University of Applied Sciences. The cards are shown on the previous page. They are used to trigger ideas by the research participants, and to inspire them to tell rich stories about how they think these trends will influence the future.

Structured interviews

The Future Telling card set is used in the interview. The interviewees are asked to identify relevant future trends and to tell stories about how they imagine these trends could develop.

The card set with a broad collection of general trends helps in the interviews with specialists by making them consider all the relevant directions (social, technological, economic, ecological, political and demographic), and at the same time to consider more distant future scenarios. The trends that are presented on the cards trigger their thinking, and inspire them to give rich descriptions of how they see the future developing in relation to energy in cities in 2050.

The interviews contain three main questions:

1. Sort the 52 trends on the cards into three categories:
   - Not relevant in the context of smart and sustainable energy in cities
   - Already relevant now
   - Relevant in the future

2. Take the selected cards in the category ‘relevant in the future’ and pick the 10 cards that in your opinion will have the greatest impact on quality of life (or lack of it) in cities in the context of smart and sustainable energy. (The interviewees can also add missing trends which they regard as important.)

3. Tell stories about how you imagine these 10 trends will develop and what the future in cities will look like.

Drivers for Change

A limited yet representative number of Drivers for Change are distilled from the large volume of expert material. In this phase, the data from the interviews is analysed by means of clustering, selecting and comparing the quotes by the thought leaders. The clustering is based on both commonalities and contradictions in the statements by the experts on the specific topics.

A Driver for Change needs to address the topic of a cluster, as well as to point in the directions that the future might take. So for each cluster, a short title and a description are given to capture the richness of that cluster. The quotes by the thought leaders serve as an inspiration to paint richer stories of the possible new future scenarios.

The analysis led to 18 Drivers for Change for the future of sustainable and liveable cities in 2050. We identified Drivers for Change at the general and smart city levels, as well as more specific Drivers for Change for the future of buildings, mobility and urban spaces.

Selection of Drivers for Change

For the focus area Smart Buildings, the city of Murcia selected four Drivers for Change:

- Better buildings
- Technology with a human focus
- Democratised energy systems based on open data
- Applying new technologies

The following pages give brief descriptions of the chosen Drivers for Change stating the essence of the changes. These are supported by a few quotes from the experts.
Better buildings

In 2050, new buildings combine historical qualities and new technologies, creating maximum comfort and functionality for their users. Historical expertise in building for specific local climates is used to design solutions for new buildings, and for thoughtful upgrading of those already existing. The latest technologies and materials are applied to make buildings self-sufficient or even energy positive, contributing to abundant of renewable energies in cities. Policies aim at improving the quality of neighbourhoods and strengthening the sense of community, and not only at reducing energy consumption.

This Driver for Change represents the following cluster of quotes of the thought leaders:

- Blending the quality of our architectural past with the opportunities of new technologies
  
  FT15.02. By 2050 we will be in a scenario where the building itself stores the energy that it needs. ... Today, even in this building, there is a lot of energy stored in every battery in every machine, but they are not connected to one another. There is a lot of cars parked underneath this building, and whether there will be cars in the future or cars will be slightly different, but there will be battery powered mobility. So all of that collective energy can plug into the building, to pair with the building. And buildings can then plug in into other buildings and share all this energy that is there.

- ... because the climate change is a reality, it will effect more the lower class people. Which is a big number of people in Europe these days. Last year, we had a big crisis and people did not use any gas and energy for cooking anymore. They were reducing the amount of energy because they were not able to pay the bills. We need to be very careful about these things. Energy savings in this way is easy ... I believe we should make policy that is not aiming for reducing energy, but aim for increasing the quality of fabrics and buildings. But if you are not able to explain why this is necessary, then it will not work, because no one will invest money voluntarily to do that.

- We also have the problem of social housing that were built in the last decades and all these houses are very bad. Poor constructions, poor systems. After the second World War the set-up, of cities of houses, has been forgotten. There is now no more money to change completely. The problem is that these neighbourhoods become the place where the new people will stay and that creates a lot of conflicts.

FT718. In 2050 you will get windows with electricity generating capacity in them. And smarter houses, and new infrastructure for electricity with IQ as we say. A lot will happen in new and refurbishing old buildings.
Technology with a human focus

In 2050, we’ve mastered the challenge of ever more complex, multifunctional systems and the need to make them easier to use. Those systems are user-focused: that means users can understand how the systems work, and how their own behaviour affects sustainability and energy use. Robotics and smart (home care) systems support living at home, helping people to live healthier lives and to stay in their homes longer as they get older. There’s a range of available solutions that plug-in directly to the city’s open energy platform.

This Driver for Change represents the following clusters of quotes of the thought leaders:

a. Smart systems with a human touch
b. Improving quality of life with robotic support and home care systems

FT22.12. It is important to invest constantly. So people understand immediately the advantages of new technologies for sustainability in buildings and houses. Just to save electricity or for condition, because they immediately save money. That is very easy to understand. This requires a change for the experts to develop good scenario’s. Not in the far future, or even the future, it starts right now. They have to present in a way that people easier understand.

FT15.13. Now today there is things you can do in the home and around to save energy. ... The value in Euros is not worth much. And I don’t think honestly that most home owners want to reduce their energy bill either. They just don’t want it to go up. ... We have the technology to help you do that. Some of these technologies even mean that they can help to reduce your bill. So you could save 5 Euros a month. If you could translate that 5 Euros into something that is valuable. So if you say look, if you allow us to join you, or to involve you in this response-demand program, you will see no reduction in your home comfort, the heating will be on, etc. And we will take those credits and with those credits, we will give you another system in the elderly home where your mother lives, 300 miles away. It is very simple, you can set a scenario, that if the lights do not get on between 7-8 in the morning, or she doesn’t put the kettle on between 7-8, then we will send you a text message and you can ring her up to see if she is alright. ... So instead of the 2 or 3 Euros, translate that into a service that is very cheap to deliver but of a very high value to the individual. The challenge around utilities is to engage with the customers.

FT23.01. ... This is the weak part of the story. If we do not speak about these weak elements of the society in the suburbia, then there is no way to talk about energy. Energy is invisible, people do not see it and do not understand it. They do not know where energy comes from and they do not connect the fact that you have energy and that creates problems in terms of emissions and pollution. So if you do not connect to that idea that energy has an impact on everybody, then you can never win.

FT 15.17. ... Interesting will be the lighting. If you want more lighting, and you want to turn the switch, you are actually saying ‘I want more light for reading’. Now the building can do anything to his ability to analyse and see if it does so by letting more lights in from using the blinded windows or change the transparency of the walls. It will do whatever the most efficient solution is to give you what you need. And then as a last resort, okay turn the light on. The switch of tomorrow is just a sensor and the robotic support mechanism will change walls, windows, blinds, everything to help you get what you need.
Democratised energy systems based on open data

In 2050, energy systems are open, bidirectional, multi-purpose platforms on which (renewable) energy and energy management services are open to all. Entrepreneurs have developed business models that provide value for them, for their users and for society at large. Citizens can choose freely from a range of available options. The system ensures privacy and security of users, who are always in control. Ambient energy networks provide connectivity for (wireless) access to data and energy. Increased computing power and artificial intelligence make system resilient: self-organising, self-sustaining and self-learning.

This Driver for Change represents the following clusters of quotes of the thought leaders:

a. Open infrastructures to bring together supply and demand of energy in decentralised systems
b. Privacy and security in systems and services build on open data
c. Being in control with or being controlled by intelligent systems
d. Merging brain power and computer power to make smarter decisions
e. Integrating (wireless) data and ambient energy networks

FT13.04. One of the other things in district heating now is that the one who owns the network is also the one who provides the service. It is like a monopoly. You cannot choose. We need a new type of district heating - open. Not only to increase the investment capacity, but also for everybody to be able to put heat on the network. So that you have a distinction between the network infrastructure and the heat generation capacity. Because in the city there are a lot of heat sources, e.g. industries, data centres. They produce a lot of heat and this can be used to heat buildings. So you need this openness, like for electricity.

FT19.04. The other important value is openness. The way I described it, the way we organise it has to be open. Technology is available, but what kind of openness do we want? By getting this openness you get a new form democracy. ...

FT19.06. The other important value is openness. The way I described it, the way we organise it has to be open. Technology is available, but what kind of openness do we want? By getting this openness you get a new form democracy. ...

FT3.09. In cities you will need some sort of layered structure, in which you have a grid that provides stability and interconnectivity, and on top of that you will have more freedom and less restrictions to design your own thing. It will affect the city as it will no longer be needed to have global or national grid that is built by a government. But there will be local grids that provide enough stability by sharing resources so that you have a guaranteed stable energy production in the way you want it. You need to ensure that everybody can connect to such a grid, but it will be more local grids, that do not necessary need interaction. ...

FT3.10. There may be a competition of energy networks. Also there will be an integration of data and energy networks. But it could also be a completely new energy internet that is competing with the existing systems.

FT13.35. Data is the fuel of the 21st century. ...

FT13.05. ... the fact that people do not need energy, but they need to wash, to cook, to be warm. The fact that they will be able to produce energy directly, or coming from their neighbour. And the fact that digital technology will allow to combine this supply and demand, I will guarantee that all activity will move from energy producer and energy distributor towards energy manager. ...

FT1.06. Analysing and monitoring our human systems on the social level, in public spaces or in social contexts, we will have a lot of new conditions which we do not know up till now. Next to an impact on humanity, it means that we have to redefine what is life and what is public and what are our civil rights. ...

FT10.14. ... I think in 35 years, when we really get this wisdom of the crowd, and let the crowd of humans, robots or together decide. You cannot really draw a line between humans and robots and you can’t actually soon draw a line between a human and computer. ...
Applying new technologies

In 2050, a range of new technologies are available and affordable. Some of them are already in development, others are still unknown. Cities apply those technologies in new solutions that contribute to the quality of life, and in particular to the creation of smart buildings, smart mobility and smart urban spaces.

This Driver for Change represents the following cluster of quotes of the thought leaders:

- Applying new technological solutions to increase quality of life in cities

FT17.7. There is another trend that is now not included: in 2050 humanity has moved into space. We will have much more activity in space, on the moon, on asteroids. … When we succeed to harvest energy in space and beam it to earth it will be a revolution.

FT215. We will have our first test satellite up with solar power in 2017. We might be able to have the world’s first beaming of solar energy from space.

FT5.01. In 2050 I imagine that they are looking for the new world in space, out of our world. … and maybe, if we will create a much better world than this one, there will be no-one left on this planet.

FT8.11. … Technology will make diseases extinct. … To be honest I do not know how feasible this is by 2050, surely aids, maybe not distinct, but under control. But if the key could be unlocked, for cancer for instance, I think this would have a huge impact on people’s lives. Also because we will be getting older, so the more that you can cut out these kind of things would contribute to premature deaths, but also having an impact on the quality of life …

FT10.13. … I am not saying that by 2050 we will have an infinite amount of energy, but we will have so much that we can consider things like the ‘beam-me-up-Scotty’ type of stuff or space travelling.

FT5.07. … Technology will enter all kinds of fields and disciplines, so this will happen everywhere.

FT2.12. Maybe the sweet spot is fabrication in the city, in vertical farms or whatever, 3D printing food. If I want a cup of coffee, I’ll print the cup. The table will be a 3D printer, printing up my cup. One of the divisions in Carnegie University has a project on programmable matter. At the moment they are little units, but their idea is to have them at micrometre scale, where the particles are basically magnets, they change colour, they’ve got behavioural autonomy and swarm collective intelligence. It is basically very fine dust that can take form and shapes and lock into. It may sound as fantasy now, but this sort of thing will be there in 2050 …

FT5.06. Today all buildings have an AC grid (alternating current), some today have a DC grid (direct current). By 2050 there will be DC grids. The majority of the assets in the buildings will be DC.
Creating the visual of the desired future scenarios
In 2050, the people of Murcia enjoy buildings that proactively adjust to their changing needs. Through profiles based on the expected use (presence and activities) and external factors (weather, season etc.), buildings actively choose the optimum energy settings to maximise comfort for users.

The buildings are interconnected by a telemanagement system that enables sharing of energy and resources. This makes a big contribution to users’ comfort and convenience, both inside and outside the buildings.

Murcia achieved a position among Europe’s top ‘clean & green’ cities by green urban planning that values CO₂-neutral energy-producing buildings. The buildings use renewable energy sources and have a low impact on nature, both during construction and in everyday use.

Elements of the desired future scenario are:

**Flexible use of buildings**
The buildings in Murcia facilitate highly flexible use, for different users, different activities and in different seasons. Walls, installations and furniture can be rearranged easily — for example using flexible partitioners, changeable windows or ‘floating’ desks. Standardised protocols enable roaming profiles for user settings in the virtual space. Smart management systems support effective and efficient use of the workspaces.

**Enhancing working & family life**
The buildings recognise people and can adapt to their personal preferences and habits by providing the desired atmosphere and climate settings. Homes cater for teleworking and remote healthcare through good connectivity and smart appliances. Use of the latest technologies facilitates a whole range of other activities — for example using augmented reality for easy enjoyable shopping, navigation and other everyday tasks.

**‘Green’ buildings technologies**
The latest technologies are used in the buildings for easy energy saving, generation and storage. Examples are the use of energy-absorbing materials, and light tubes to bring daylight into the heart of the building. The buildings are climate-proof, so they can absorb heavy rain showers. And they are resistant to earth-quakes through the use of innovative solutions like flexible materials and active bumpers. Wireless networks are used to charge energy-efficient appliances.

**Learning buildings**
The buildings are interconnected not only do they learn during use, but they can also share their learnings. The use of all utilities (energy, water, waste and other resources) is monitored. Patterns of use are recognised so upcoming activities can be anticipated, providing maximum comfort for users. This active data sharing allows the buildings to learn from each other, providing maximum user comfort at the lowest energy consumption.

**Master Intelligent System**
Murcia’s Master Intelligent System uses open data and standard protocols all over the city, providing new services on an open platform. People can easily access and connect to the platform, wherever they are. Energy supply and demand are matched — and legally embedded — in the central system. The focus is on the users’ needs, with priority for emergency services when necessary. Energy can be exchanged freely between users, appliances, vehicles and buildings.
Focus and milestones

The aim of Step 3 is to develop specific roadmaps for the cities in the selected focus areas. A roadmap shows all existing and future technologies and other relevant developments that enable the achievement of the desired future scenarios by 2050. Two main activities take place in this step. Firstly, the roadmapping research to define the general roadmaps. Secondly, the definition of milestones for the years 2020 and 2030, and local solutions and research projects to create city-specific roadmaps.

General roadmaps

Desk studies and expert interviews are conducted to collect input for the roadmaps. The roadmaps explore the options to achieve the cities’ desired future scenarios. The resulting General Roadmaps for Smart Buildings, Smart Mobility and Smart Urban Spaces provide input for the city-specific roadmaps.

Roadmap Workshops

The city-specific roadmaps are created in a series of workshops held in each of the partner cities. These Roadmap Workshops consist of programmes with three sessions in each city.

In the first session, the policy-makers and city representatives select the topics from the general roadmaps as focus for the city-specific roadmap. This choice is based on their specific ambitions and context. They also define intermediate milestones for 2020 and 2030 on the path to their desired future scenarios.

Then, for each of the focus areas, local stakeholders (companies, citizens, public and private organisations and knowledge institutes) are invited to take part in the roadmapping sessions. With all the available knowledge of potential developments and the given focus of the city, the local stakeholders generate project proposals for (local) solutions and research proposals, as a first step towards the project portfolio. See also the pictures of the workshops on the previous page.

The results of the Roadmap Workshops are reported in the same format for each of the cities, facilitating cross-learning between the cities.

Joint Roadmap Workshop

In a joint meeting in Newcastle, the cities presented their city-specific roadmap enriched with current projects and proposals for new projects, and held in-depth discussions to understand the common and specific learning objectives and opportunities for joint projects. The Joint Roadmap Workshop served two purposes:

• To enable cross-city learning. The cities gain a deeper understanding of the roadmapping process, and can improve their own roadmaps with inspiration from others.
• To describe the common learning ambitions as input for the Project Portfolio step.

The Joint Roadmap Workshop finalised the activities of Step 3 and prepared for Step 4, in which the project portfolio will be further developed.
How to read the general roadmap

The resulting General Roadmap contains four important elements:
- The timeline from now (2016) to the visions for 2050 as described in the desired future scenarios of the cities (see D2.2 — Report Vision Development for the full set of desired future scenarios).
- The eight common needs in the desired future scenarios as described by the cities in the Joint Vision Workshop (see also D2.2) are indicated at the end of the timeline in 2050 as the goal of the roadmap.
- The relevant topics for the focus area on which developments are required to achieve the desired future scenarios. These topics cover sustainable technologies, sustainable behaviour and sustainable organisations.
- The options that will become available in the short or longer term for each of the topics.

Each topic has a timeline showing the developments that are relevant to that topic. The image shows the elements of the General Roadmap.

Timeline from now (2016) to the vision (2050)

Elements of the Smart Buildings General Roadmap
Relevant topics Smart Buildings

The generic roadmap shows timelines for the topics requiring developments to achieve the desired future scenario in 2050. The selected topics for the Roadmap Smart Buildings are described briefly here.

**Sustainable technologies**
The first element needed to achieve the sustainable energy ambitions is the availability of sustainable technologies. A wide range of sustainable technologies is already available, and new technologies are constantly being developed. But unfortunately there is not always a consensus on the best option for the future. The Roadmap Smart Buildings includes the following technology developments:

**URBAN BUILDING PLANNING**
Urban Building Planning is about a structured approach to buildings within the overall city planning strategy. This topic refers to the need for integrated mapping of existing assets on a city-wide scale in developing holistic use and refurbishment strategies. This includes strategies for cultural heritage buildings and the introduction of progressive building standards, as well as developments towards the use of closed-cycle systems.

**ENERGY-SAVING BUILDING SOLUTIONS**
Energy-Saving Building Solutions refers to materials, systems and strategies to reduce the energy needed for the construction, operation and lifetime maintenance of the building. This includes strategies for building materials and systems, as well as flexible and adaptable energy-savings concepts. It also refers to the way buildings and their components will be constructed in the future.

**MATERIALS & CIRCULAR SYSTEMS**
Materials & Circular Systems is about material, water and waste cycles in buildings and their contribution to energy-efficiency and resource savings. The topic refers to the importance on closing material, water and waste cycles of buildings and the use of low-impact materials. This includes how buildings and their materials can be made increasingly adaptive, so they contribute to an urban metabolism based on closed resource cycles.

**SUSTAINABLE ENERGY TRANSITION**
Sustainable Energy Transition refers to the transformation of energy systems on the scale of building and grid towards integrated renewable-energy solutions. It is about the way current energy systems are becoming increasingly smart and integrated, shifting towards solar-based, building-integrated renewable-energy solutions. The topic includes future grid developments for electricity and heat, including storage solutions and integrated management.

**ENERGY SHARING**
Energy Sharing refers to strategies that make individual buildings into contributors to efficient city-wide solutions. This topic deals with the active future role of buildings in the overall energy system, including supply and demand matching and contributions to improved grid stability. More specifically, this topic is about how to optimise overall district energy performance based on future energy grids.

**ICT & BUILDING MANAGEMENT SYSTEMS**
ICT & Building Management Systems is about the increasing generation and use of data to manage and optimise energy in buildings and grids. This refers to smart meters and their evolution towards smart networks supported by building information and home management systems. It also includes the increasing availability of real-time data and the interoperability of networks, resulting in improved performance through shared learning.

**Sustainable behaviour**
One of the crucial elements of a sustainable city is the behaviour of citizens. Making a collective shift to more sustainable solutions and energy-saving alternatives requires awareness. In many cases, the available technologies are not sufficiently attractive to gain acceptance in mass markets. The Roadmap Smart Buildings includes the following behavioural developments:

**VALUES, MOTIVES & BEHAVIOURAL CHANGE**
Values, Motives & Behavioural Change includes personal and institutional ways to drive transformations by new approaches to information, experience and personal accountability. This includes instruments like incentives, pilot projects and lifestyle coaching, all of which can contribute to evidence-based decision-making and lifestyle changes.

**Sustainable organisation**
Last but not least, the element of sustainable organisation is addressed. How can we organise the collaboration between relevant parties (public, private, citizens) to achieve the desired future scenarios? Because the technology is not yet mature, new business models are needed to enable learning processes, and these can be modified and updated as necessary. The Roadmap Smart Buildings includes the following organisational developments:

**INNOVATIVE BUSINESS MODELS**
Innovative Business Models refers to new financial schemes, investment models and market mechanisms that accompany transition processes or arise as a result of those processes. This also includes new and inclusive value systems, coherent monetary systems and new ways of managing energy at personal and community levels, viewed from societal, environmental and economic perspectives.

**POLICIES & LEGISLATION**
Policies & Legislation refers to the role of municipalities and the changes in policies, with a holistic focus on improving the quality of life and societal value for the community as a whole. This includes policies and legislations on environmental and energy standards, as well as innovations, public tenders, public investments and taxation to reach the overall political goals.

**The city specific roadmap**
The general roadmap describes the developments on a timeline, indicating when experts estimate that those development will be broadly available. For the cities to create their specific roadmaps, they were asked to focus on the topics that are most relevant for them to reach their own desired future scenarios. The cities create milestones for 2020 and 2030, describing what they will look like when their own developments and city projects have evolved. In this way each city can indicate the focus and pace that it will need to achieve. Projects can then be proposed on this basis to define (local) solutions or research leading to further realisation of the roadmap.
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<td>Definition of the level of renovation potential, related to legislative, cultural heritage buildings, and available and upcoming technologies.</td>
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<td>Designing buildings for easy disassembly to enable re-use of all components and/or materials in closed-cycle systems.</td>
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<td>Refurbishment solutions</td>
<td>Modular building blocks</td>
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<td>Buildings with multi-layered systems for energy and material sustainability (up to five floors).</td>
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<td>A closed system for the collection, storage, recycling and re-use of rain and grey water wastewater.</td>
<td>Organic materials, such as clay and wood, locally produced and re-useable, are used in buildings and building structures.</td>
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<td>Data gathering to identify measurable units of control or energy, data to optimise energy consumption.</td>
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<td>District energy performance</td>
<td>Evidence-based decisions</td>
<td>Transparent information</td>
<td>Making efficiency fun</td>
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<td>Sharing energy by bringing buildings in their environment to achieve higher standards to compensate for the negative energy balances of existing buildings.</td>
<td>Sharing rights and obligations</td>
<td>New strategy for district level, e.g. by peak-shaving existing grid and providing sufficient reserve capacity.</td>
<td>The creation of independent knowledge and access to knowledge to support municipalities in evidence-based decision-making.</td>
<td>Better and transparent data for citizens on energy costs in relation to their lifestyle and behaviour.</td>
<td>‘Gamification’ solutions to counter the ‘irrelevant effect’ and to make striving for efficiency is fun, both now and over time.</td>
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<td>Pilot projects &amp; living labs</td>
<td>Social interventions</td>
<td>Evidence-based decisions</td>
<td>Market mechanisms</td>
<td>Future-proof tendering</td>
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<td>Experimentalising the use of model buildings to initiate public discussion, change the aesthetic perception and create acceptance.</td>
<td>Using a range of social intervention mechanisms (e.g. ambassadorial education, neighborhood competitions) to create a dialogue with citizens and increase awareness.</td>
<td>The creation of independent knowledge and access to knowledge to support municipalities in evidence-based decision-making.</td>
<td>Smart balancing of the energy mix through market mechanisms to shave peak demand using priority schemes; three outcomes are conceivable in case of scarcity or emergency.</td>
<td>Tenders demand technology future-proof solutions that allow changed use of buildings in the future and the integration of upcoming technologies.</td>
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<td>New financing schemes</td>
<td>Inclusive value system</td>
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<td>Financing schemes that include revenue mechanisms to allow investments in energy upgrading and renovation (the ‘truth of costs’).</td>
<td>A coherent monetary system that includes value for real environmental impact, e.g. using taxes and incentives.</td>
<td>Inclusive policies that serve to favor societal benefits over individual benefits, e.g. the right and obligation to exploit all opportunities for the sun-finning roofs for solar energy harvesting.</td>
<td>New policies that define the desired outcomes rather than the ways to reach them, e.g. procurement procedures including health and social aspects.</td>
<td>Policies addressing the quality of life and social value.</td>
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<td>Community manager</td>
<td>New investment models</td>
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<td>Inclusive value system</td>
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<td>A role is defined for match-making in districts of people and their behaviour, technical solutions and legislation to optimise resources.</td>
<td>Creating win-win situations by combining public, private and company investments in inclusive solutions, e.g. use of renewable energy.</td>
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<td>Progressive standards</td>
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<td>Clarification of goals and alignment of measurement procedures at European level, including regular updating of standards in line with increasing knowledge</td>
<td>Leave to favor societal benefits over individual benefits, e.g. the right and obligation to exploit all opportunities for sun-finning roofs for solar energy harvesting.</td>
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<td>Policies expressing a need for new economic development.</td>
<td>Inclusive policies</td>
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<td>Municipalities take the lead in implementing CO2 fees to promote sustainable development through investments in sustainable solutions.</td>
<td>Policies addressing the quality of life and social value.</td>
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<td>Raising investment funds</td>
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Meeting progressive standards
Design strategies will adjust to progressive standards, e.g. zero emission, energy positive or CO₂-neutral approaches to new and existing buildings.

Tailored production of entire buildings
New production technologies, e.g. additive manufacturing and organic materials allow off-site production of buildings.

Adaptative building systems and materials
Materials with changing properties, e.g. insulating with variable heat transmission coefficient or glass with variable transmissivity.

Integrated grid
Bidirectional, interoperable, open grid, integrating thermal, electrical, water and gas networks into one energy management system.

Abundant renewable energy
Sustainable energy is widely available and affordable as a result of large-scale solutions such as wind & solar parks and alternatives.

Swarm technologies
Intervene in user events (connected appliances) to balance the grid and adapt to fluctuating supply of renewable energy.

Open energy and data system
New standards and protocols to connect systems and enable roaming of services across interoperable, open networks.

Sharing best practices
Buildings share experience on sustainable performance through learning algorithms and artificial intelligence.

Super-Europe smart grid
Wide-area electricity network connecting Europe, North Africa and Asia, unifying super-grid and smart grid capabilities.

Proactively adaptable materials
Self-regulating buildings that proactively adapt to changing conditions (e.g. weather) and usage.

Urban metabolism
Lease options for construction materials — “materials as a service” — e.g. no ownership because the material are part of a closed resource cycle.

Self-adapting buildings
Buildings made of living organic materials that adapt to changing user needs, climatic conditions and usage.

New city-wide solutions
New solutions that open up new possibilities, e.g. superconducting networks, or recovering energy from solar space power stations.

Local production of tailored building components
New technologies e.g. 3D-printing, Factory 4.0 enable meeting production of tailored components, supporting flexibility and diversity.

(Re-)use of local materials
Local and tailored production of building components, using local opportunities and (re-)use of local materials e.g. wood, clay.

Affordable storage solutions
New storage solutions that are cheaper to produce, e.g. flow batteries and graphene.

Seasonal storage
Heat/cold storage and extraction in large water volumes, e.g. aquifers, tanks and surface water.

District storage solutions
Large-scale storage solutions to share electrical and thermal energy, e.g. power-to-gas or —hydrogen.

Real-time data
Real-time data is available on actual energy use, for monitoring and improvement towards sustainable behaviour patterns.

Personal profiles
Technologies that recognise people and automatically adjust systems to personal preferences and lifestyle patterns, e.g. for secure access to buildings and increased comfort.

Lifestyle coaching
Personalised advice based on real-time data to optimise the use of resources in relation to individual lifestyles.

Personal energy budget
Credits for energy (similar to mobile phone credits), that enable higher consumption at extra costs, with discounts for sustainable behaviour.

100% renewable energy import
Cities and territory politics ensure that all imported energy is 100% renewable sourced.

Legal security for innovation
Regulations to safeguard health and safety of people while promoting innovative solutions, e.g. safe re-use of grey water in buildings.

Flexible pricing and new business models
People can contribute to grid stability and minimisation by choosing levels of flexibility with dynamic pricing enabled by swarm technologies.

Circulatory economy
A holistic, systemic approach and total value business models (including societal, environmental and economic aspects) at all suitable scales.

Energy efficiency and sustainability
- Zero-emission and self-sufficient buildings through energy saving, generation and storage solutions
- Buildings focus on people’s needs and comfort
- Low-environmental-impact solutions
- Continuous improvement strategies for buildings

Renovation to secure cultural heritage
- Deep energy renovation of historical buildings
- Non-invasive technologies
- Smart grid integration

Versatile, flexible and proactive
- Versatile buildings and spaces
- Proactive adjustment to specific users and changing needs
- Buildings are prepared for future smart grid integration
- Designed for flexibility

Future smart grid
- Intelligent master system managing building performance across the city
- Community-owned grid

Community sharing
- Smart grid integration in the district level
- Sizing through sharing
- Collective approach to infrastructure decision-making

High-quality, easily accessible systems
- Rooming profiles for energy access and community sharing
- Monitoring and learning
- Easily-accessible open platforms
- Enabling the transition to sustainable energy
- Evidence-based, future-proof decision-making

Sustainable behaviour
- Collaboration and shared responsibility of citizens
- Incentives for sustainable behaviour
- Technology leading to sustainable behaviour

Desired future scenario
The Smart Buildings theme focuses on the built environment and sustainable energy solutions for buildings, including residential, public and commercial and office buildings. The ambition of the cities is to create self-sufficient buildings that can generate their own green energy, and have very low environmental impact during construction, use and renovation. Self-sufficient districts and cities are created with a blend of sustainable solutions for buildings ranging from new to historic. The owners and users of the buildings are well aware of the shared desire to save energy, and are actively engaged in achieving it by applying energy-efficiency measures.
Urban building planning

Short term developments
- In the short term, integrated mapping of the existing building stock, including its energy performance and the potential for improvement and use support integrated urban planning processes.
- Specific energy strategies for cultural heritage buildings are developed for the refurbishing of historical buildings, incorporating available and upcoming technologies.
- Rewealthing and rejuvenation strategies focus on the quality of internal and external spaces of the existing building stock. This includes the implementation of new and flexible forms of use, as well as sharing of spaces and infrastructure.
- General city design strategies focus on re-use, re-densification and re-building of the existing buildings and public spaces, defining priority areas for intervention.
- A life-cycle approach for buildings is considered, based on design for disassembly and re-use of materials, using closed cycle systems as far as possible.

Mid term developments
- Once experience has been gained and processes and strategies have been developed, the annual building refurbishment rate will be scaled up to 3 to 5% of the existing building stock, from today’s typical rate of 1%. The minimum energy standard for refurbished buildings is the ‘passive house’ standard. However the standards will develop further, with increasing requirements for higher levels such as zero-emission, energy-positive or CO2-neutral performance over lifetime.

Long term developments
- In the long term buildings increasingly adapt nature-based strategies, and are integrated in and adapting to the surrounding natural systems. In this way they offer harmonious living environments for their occupants.
Energy-saving building solutions

Short term developments
- Refurbishment plays a major role, and solutions for the upgrading of building envelopes and installations is gaining importance, including on-site renewable energy generation. The aim is to achieve nearly zero-energy standard in new buildings, and where possible also in existing buildings.
- Modular, prefabricated building blocks allow material and energy savings through centralised productions processes, with increasing flexibility and adaptability of buildings over their life-cycles.
- Customised refurbishment solutions for cultural heritage buildings allow improvement of energy performance while also meeting cultural protection standards. Increased energy performance is achieved through higher standards for both new buildings and those surrounding them.

Mid term developments
- Buildings are becoming increasingly energy-efficient and energy-producing, with a development towards energy-positive buildings as standard. Energy-producing facades and roofs cover all users’ energy needs, including extra demand for electric mobility.
- Wood is increasingly used as a sophisticated building material, even for structural purposes in multi-storey buildings.
- Buildings are based on customised local building components, which are produced by new technologies such as 3D printing or Factory 4.0 solutions, enabling greater flexibility and diversity.

Long term developments
- Entire buildings are produced decentralised and on-site using new production technologies such as 3D printing and with local organic materials.
- Self-adapting buildings based on “living” organic materials can adapt to changing user needs, climate conditions and usage.
Materials & circular systems

Short term developments

- In the short term, water is considered as an increasingly valuable resource, and water cycles in buildings will be closed as far as possible.
- Closed water cycles at district level connect buildings, terraces and gardens to systems for water retention, storage and re-use.
- Building work increasingly uses organic materials such as clay and wood. These are locally produced and re-usable, reducing the overall carbon footprint of constructions.
- Biomass energy solutions use urban green waste for energy production, closing green waste cycles.

Mid term developments

- In the mid-term, smart life-cycle assessment allows calculation, tracking and optimising of material life cycles, energy use and even societal value of buildings over their lifetime.
- High-performance materials and eco-materials with a very low lifecycle impact are standard in buildings.
- Materials and components are locally produced through tailored production processes based on the (re-)use of locally available resources.
- Adaptive building systems and materials with changing properties are available, optimising the thermal performance of building envelopes.

Long term developments

- In the long term buildings are self-regulating, with materials and systems that proactively adapt to different climatic conditions or usage.
- Buildings contribute to an urban metabolism based on closed resource cycles, understanding materials as a service.
Sustainable energy transition

**Short term developments**
- In the short term, buildings generate enough energy to meet their own energy demand through integrated electrical and thermal energy solutions based on renewable energy.
- Electrical and thermal grids evolve, allowing storage of decentralised renewable energy produced by buildings, as well as balancing of supply and demand.
- Renewable energy technologies evolve towards more efficient and sophisticated integrated systems, e.g. advanced solar solutions such as photovoltaic-thermal collectors for building integration or small-scale co-generation power solutions based on renewable fuels such as biogas or biofuel.
- Large-scale renewable energy installations such as wind and solar parks are used widely throughout the territory.
- All available exterior building surfaces are used to harvest solar energy through integrated energy solutions such as flexible and translucent photovoltaic or thermal collector facades.

**Mid term developments**
- In the mid-term, direct current (DC) systems allow the use of PV electricity through energy-efficient in-house grids, together with increasing amount of shared sustainable electricity storage solutions on all scales for buildings and mobility.
- Energy storage systems are increasingly affordable through the use of new materials and technologies such as flow batteries and graphene-based solutions.
- Affordable seasonal heat/cold storage is shifting the season-to-season availability of harvested thermal energy through large-scale natural or artificial storage options such as aquifers and water storage tanks.

**Long term developments**
In the long term, bidirectional integrated grids together with affordable storage solutions allow truly sustainable energy systems. Grids are interoperable, creating mixed thermal, electrical, water and gas networks within a single energy-management system. The growing affordability and availability of sustainable energy solutions, based on a mix of decentralised small-scale and large-scale installations, lead to an abundance of renewable energy in the long term.
**Energy sharing**

**Short term developments**
- In the short term, energy resources at city and district level are mapped and managed efficiently, allowing supply and demand matching between producers and consumers of electricity and heat, with individual buildings as contributors to efficient city-wide solutions.
- Existing energy grids with an increasing share of decentralised renewable energy generation are stabilised at district levels by peak shaving measures and by providing sufficient storage and generation capacity.
- Sustainable energy generation and consumption are regarded as community assets, through which people share corresponding rights and obligations, collectively increasing the total amount of renewable energy of a district.
- Energy performance is evaluated at district level. New buildings with higher energy standards and renewable energy production compensate for the older building stock with a negative energy balance.

**Mid term developments**
- Energy grids are self-healing and bidirectional, with a large number of interconnected decentralised production facilities for renewable energy, and mechanisms to ensure grid stability and continuity of service in case of failure.
- District storage systems are used to balance fluctuations in electrical and thermal energy supply and demand using efficient, large-scale storage solutions such as power-to-gas and hydrogen.

**Long term developments**
- In the long term district energy performance is optimised through innovative approaches such as ‘swarm’ technologies, connecting appliances to self-learning and self-balancing networks and other city-wide solutions such as superconducting networks.
ICT & building management systems

**Short term developments**
- In the short term, ICT & Building Management Systems are evolving. This allows increasing generation and use of data for energy optimisation and management in buildings and grids, based on detailed control through smart meters.
- ICT technologies allow the creation and control of smart networks at local level to share electrical and thermal energy among neighbours.
- Right from the design phase, building information management systems allow simulation of building energy performance. This allows their life-cycle energy balances to be optimised and their contribution at district level to be determined.

**Mid term developments**
- In the mid-term, building and home management systems allow building energy performance and operation to be optimised using public (e.g. weather forecasts) and private (e.g. individual user consumption patterns) data.
- Detailed real-time data is available on energy use and building performance, as well as on user comfort and behaviour, to improve and optimise building operation. This allows the creation of users’ personal profiles, with adaptive systems that can be adjusted to match users’ personal preferences.

**Long term developments**
- In the long term, open energy and data systems allow interoperability of networks resulting in performance improvement through mutual learning. This is based on new standards and protocols to allow connection of systems.
- Buildings are active and self-learning, communicating and sharing experience on sustainable performance through learning algorithms and artificial intelligence.
- ICT contributes to the creation of extended smart grids, e.g. a super-Europe smart grid that connects Europe, North Africa and Asia, unifying super-grid and smart grid capabilities.
### Values, motives & behavioural change

#### Short term developments
- Behavioural change depends greatly on the availability of reliable data. In the short term the transparency of data is increasing. This makes the real costs of energy visible, including externalised or hidden costs such as those relating to the environmental impact of fossil fuels. This supporting information helps to drive system transformation and behavioural change.
- Incentive strategies encourage people to change their behaviour towards more sustainable lifestyles, motivating through financial and non-financial rewards for individual or collective efforts towards overall societal sustainability.
- Experience and experimentation through pilot projects and living labs promote public discussion and awareness of new building methods and lifestyles. This helps to create acceptance for sustainable buildings, and positively influences the aesthetic perception of sustainable architecture.
- New social intervention mechanisms such as energy ambassadors, specific educational programmes and neighbourhood energy competitions promote dialogue with citizens and increase their awareness of and interest in sustainability.
- Cities can make evidence-based decisions as their access to knowledge increases and changes, with independent entities providing information and supporting municipalities.

#### Mid term developments
- In the mid-term information is increasingly transparent, ensuring that citizens have clear and transparent access to data on aspects like energy costs, individual lifestyle and behaviour, and the related environmental impact. This information allows individuals to take evidence-based decisions.
- Strategies like ‘Gamification’ solutions make energy efficiency and related lifestyle changes fun. For example, these use personal apps and competitions between citizens, allowing comparisons of personal performance and changes towards sustainability.
- Lifestyle coaching by experts helps citizens to optimising their personal use of resource relating to their individual lifestyles. This is based on personalised advice based on the available real-time data.

#### Long term developments
- In the long term personal environmental accountability drives individual behavioural change, avoiding ‘rebound’ effects. This personal accountability is based on citizens’ individual use of goods and services, and takes into account embodied energy, CO₂ emissions and other indicators of environmental and social impact.
The Smart Buildings theme focuses on the built environment and sustainable energy solutions for buildings, including:

- Zero-emission and self-sufficient buildings through energy saving, generation and storage solutions
- Buildings focus on people's needs and comfort
- Low-environmental-impact buildings
- Buildings adapt to provide a Proactively adaptable
- Renovation to secure cultural heritage
- High-efficient buildings
- Holistic rejuvenation to improve energy performance
- Advanced solar solutions
- Electrical and thermal grids as Community manager
- Sharing rights and obligations
- Inclusive policies
- Technology, e.g. photovoltaic thermal networks to share (renewable) energy
- Energy-positive buildings with neighbours.
- People benefit from the assets of all company investments in inclusive technology, e.g. power-to-gas or -hydrogen.
- Small scale co-generation or biofuel.
- Acceptance.
- Inclusive policies with neighbours.
- Making optimal use of territorial solutions for housing and mobility, in Asia, unifying super-grid and smart
- Urban metabolism
- Highly-efficient buildings
- Achieve near-zero-energy new
- Energy use, for monitoring and transparent information
- Renewable energy harvesting.
- Sustainable energy is widely
- The creation of independent solutions for large-scale solutions such as wind
- The role is defined for match-making in Municipalities embrace innovation through flexible legislations for new, cultural heritage buildings, and
- Small scale co-generation or biofuel.
- Community sharing
- Sharing best practices
- Lifestyle coaching
- Personalised advice based on real-time data to optimise the use of resources in relation to individual lifestyles.
- Personal environmental accountability
- Consumption-based accountability, including embodied energy and CO2 emissions from personal use of goods and services.

Ambition, Vision & Roadmap SMART BUILDINGS

The R4E project received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 649397.

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SMART BUILDINGS
Innovative business models

**Short term developments**
- In the short term, new financing schemes promote investments, for example in energy upgrading and renovation of the existing building stock. This includes new revenue mechanisms based on ‘truth of costs’, a long-term holistic evaluation of costs and benefits for society.
- The ‘community manager’ emerges to deal with the complexity of communities. This role is defined for match-making in districts. To optimise the use of resources, the community manager matches the energy needs of people—taking into account their behaviour—with the available technical solutions in the district and legislation.
- New investment models allow the creation of win-win situations based on combined public, private and company investments. These allow inclusive solutions, for example in the field of renewable energy installations.
- An inclusive value system makes existing monetary systems and mechanisms more coherent. Value criteria for the real environmental impact of products and services are included, for example through taxes and incentives.
- Market mechanisms contribute to balancing the energy system, allowing peak shaving and increasing overall energy efficiency.

**Mid term developments**
- In the mid-term, new mechanisms such as personal energy budgets allow personalised energy consumption. This could be based on energy credits (similar to mobile phone credits), enabling higher consumption at extra cost as well as discounts for sustainable behaviour.

**Long term developments**
- In the long term, new business models are based on flexible pricing schemes. This encourages people to contribute to overall grid stability and energy efficiency through flexibility in their use of energy in response to dynamic pricing.
- Contributing to the circular economy, business models are based on a holistic and systemic approach. This takes into account the total value of products and services, including their societal, environmental and economic value at different scales.
**Policies & legislation**

**Short term developments**
- In the short term, progressive standards are based on clear goals at European level and alignment of national measurement procedures, e.g. for nearly zero-energy buildings. These changes are the result of regular updating of standards based on increasing knowledge.
- Innovation policies of municipalities are based on flexible legislations for new, energy efficient and more sustainable building concepts and strategies. Municipalities accept the associated risks to promote innovation.
- Policies are increasingly inclusive, favouring clear societal benefits over individual benefits. For example this results from citizens’ right and obligation to exploit all opportunities to use sun-facing roofs for solar-energy generation. In this was citizens contributing to the energy self-sufficiency of city districts.
- Municipalities use mechanisms like CO2 taxes to raise investment funds and to promote sustainable development by investing in sustainable solutions.
- Municipal policies address quality of life of citizens and social values for society as a whole. Desired outcomes rather than the way to reach them are defined, for example in public procurement procedures, including health and social aspects.

**Mid term developments**
- In the mid-term, tendering promotes future-proof solutions by including specific demands like flexibility and the ability to change the use of buildings, or easy future upgrading with new technologies.
- City and territory policies ensure 100% renewable energy imports as political and societal goal.

**Long term developments**
In the long term, the legal security of innovations is assured at different levels. Regulations safeguard the health and safety of people and promote innovative solutions. These contribute to sustainability and resource saving, for example by the safe re-use of grey water in buildings.
**SMART BUILDINGS ROADMAP MURCIA**

**SUSTAINABLE ENERGY TRANSITION**
- **Integrated electrical and thermal energy solutions**
  - Buildings generate sufficient energy to cover their electrical and thermal energy demand.
- **Electrical and thermal grid**
  - Buildings as storage solutions for balancing production of renewable energy and consumption profiles of the building.
- **Advanced solar solutions**
  - Applying advanced solar thermal technology, e.g. photovoltaic/thermal collectors for electrical energy and hot water/heat pumps.
- **Small scale co-generation**
  - Combining heat and power solutions based on renewable fuel, e.g. biogas or biowaste.
- **Large-scale renewable energy production**
  - Making optimal use of terrestrial geothermal or renewable energy, e.g. wind and solar parks.
- **District energy performance**
  - New solutions are designed to achieve higher standards to compensate for the negative energy balances of existing buildings.
- **Building energy management systems**
  - Supporting the design phase of (energy-positive) buildings in order to promote and optimise the life-cycle energy balances.
- **Direct current (DC) systems and decentralised storage**
  - Shared sustainable electricity storage solutions for housing and mobility, in combination with energy-efficient in-house DC-grids.

**ICT & BUILDING MANAGEMENT SYSTEMS**
- **Spatial energy management systems**
  - Smart systems use data about building and users to optimise energy consumption.
- **Innovative energy management systems**
  - Integrating advanced management systems for new and existing buildings.
- **New investment models**
  - Creating win-win situations by combining public, private and company investments in innovative solutions.
- **Social interventions**
  - Using social intervention mechanisms (e.g. social innovations in education, knowledge management) to support municipalities in evidence-based decision-making.
- **Evidence-based decisions**
  - The creation of independent knowledge and access to knowledge to support municipalities in evidence-based decision-making.
- **Shareable information**
  - Bidding transparent and user-friendly data to optimise operation.
- **Market mechanisms**
  - Smart balancing of the energy mix through market mechanisms to show peak demand using priority schemes.

**URBAN BUILDING PLANNING**
- **Integrated mapping of assets of existing buildings**
  - Creating an integrated overview of all buildings, their energy performance and potential.
- **Energy strategy for cultural heritage buildings**
  - Definition of the level of innovation potential, related to legislations for cultural heritage buildings, and available and upcoming technologies.
- **Rethawing strategies**
  - Holistic rejuvenation to improve quality of buildings, their use and outdoor environment to update the value of existing building stock.
- **Flexible use strategies**
  - Redefine the use of buildings (how much space do people need?) and then use by sharing private and public space and assets in buildings (community sharing).
- **City design strategy**
  - Overall strategy for the city, including definition of priority areas in the city for re-use, re-designation and re-building.
- **Design for disassembly**
  - Designing buildings for easy disassembly to enable re-use of all components and/or materials in closed-circuit systems.
- **Revaluing nature**
  - Bringing nature back into buildings to enhance health and well-being of users, e.g. green façades or outlooks as 'lungs' of buildings.
- **Systematic water approach**
  - Reaching-closed water cycles at district level for recycling, reusing and re-use in buildings, terraces and gardens.
- **Energetic use of all surfaces**
  - Buildings integrated energy generation solutions, e.g. transparent, flexible and organic photovoltaic, or solar thermal collector façades.
- **High-performance and eco-materials**
  - Eco-materials with low life-cycle impact and high-performance materials (e.g. lightweight bio-foam).
**MILESTONE 2030**

100% of the energy bought by the city council is renewable and increasing numbers of buildings provide energy. Near-zero energy buildings are present in the city. An open platform is accessible for all citizens and buildings, and provides transparency on renewable energy generation and consumption through new services and apps. Citizens’ energy bills are more affordable, with less impact on household finances.

**SMART, INTERCONNECTED GREEN BUILDINGS MAXIMISE USER COMFORT IN MURCIA 2050**

In 2050, the people of Murcia enjoy buildings that proactively adjust to their changing needs. Through profiles based on the expected use (presence and activities) and external factors (weather, season, etc.), buildings actively choose the optimum energy settings to maximise comfort for users. The buildings are interconnected by a telemanagement system that enables sharing of energy and resources. This makes a big contribution to users’ comfort and convenience, both inside and outside the buildings.

**Elements of the desired future scenario are**

- **Flextible use of buildings**
  - The buildings in Murcia facilitate highly flexible use, for different users, different activities and in different seasons. Walls, installations and furniture can be rearranged easily — for example using flexible partitions, changeable windows or ‘floating’ desks. Standardised protocols enable working profiles for user settings in the virtual space. Smart management systems support efficient and effective use of the workplaces.

- **Enhancing working & family life**
  - The buildings recognise people and adapt to their personal preferences and habits by providing the desired atmospheres and climate settings. Homes offer for teleworking and remote healthcare through good connectivity and smart appliances. Use of the latest technologies facilitates a whole range of other activities — for example using augmented reality for enjoyable shopping, navigation and other everyday tasks.

- **‘Green’ buildings technologies**
  - The latest technologies are used in the buildings for easy energy saving generation and storage. Examples are the use of energy-absorbing materials, and light tubes to bring sunlight into the heart of the building. The buildings are ‘climate-proof’, so they can absorb heavy rain showers. And they are resistant to earthquakes through the use of innovative solutions like flexible materials and active bumpers. Wireless networks are used to charge energy-efficient appliances.

- **Learning buildings**
  - The buildings are interconnected: not only do they learn during use, but they can also share their learnings. The use of all utilities (energy, water, waste and other resources) is monitored. Patterns of use are recognised to support new activities can be anticipated, providing maximum comfort for users. The active data sharing allows the buildings to learn from each other, providing maximum comfort even at the lowest energy consumption.

- **Master Intelligent System**
  - Murcia’s Master Intelligent System uses open data and standard protocols all over the city, providing new services on an open platform. People can easily access and connect to the platform, whereas they are Energy supply and demand are matched — and legally embedded — in the central system. The focus is on the users’ needs, with pricing for emergency services when necessary. Energy can be exchanged freely between users, appliances, vehicles and buildings.

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The cities plotted the presented current and future projects on a matrix, indicating when the result of the project would be visible in the city (horizontally) and the expected impact on the city, in terms of energy or emission (vertically).
Project portfolio

The aim of Step 4 is to develop a portfolio of projects that the cities can work on—individually or jointly—and that help them to reach their desired future scenarios. The cities created an overview of running projects, and in a joint meeting they selected common ambitions that they all want to pursue. The new projects have to explore many new ways forward. This means that new project proposals are worked out in specific project plans, all relating to the learning opportunities between cities. The financial opportunities are also explored in this step.

Joint workshop

In a joint meeting in Newcastle the cities presented current projects and proposals for new projects based on their city-specific roadmaps. They held in-depth discussions to understand their shared and specific learning objectives and opportunities for joint projects. First, the cities presented their projects and plotted them on a poster to show when the results will be visible in the city and how they will impact energy and emissions in the city. The picture at the left on the previous page shows the result of this first part of the workshop.

Secondly, a marketplace was held in which city representatives could put forward themes for further development into project portfolios. A theme is a challenge to become a smart city with the ability to grow into a project programme. The themes build on the running and new projects presented by the cities.

In the marketplace, each city took on the role of ‘seller’ of a theme and proposed it to ‘buyers’. The buyers supported the themes, and were able to enrich them by ‘negotiation’ to include objectives which they considered important. If three cities ‘bought’ a theme, it was accepted. The marketplace resulted in 14 themes. Together it was decided to merge some of these themes. This left 10 themes for further elaboration in groups.

Thirdly, the cities worked in groups to elaborate the themes by describing their objectives, relevant projects and innovation opportunities. The resulting rich discussion combined the insights of all the experts, and built on the visions and roadmaps.

The groups then presented their proposals in a plenary session, after which all the cities described their learning objectives related to the themes.

Towards a project portfolio

The themes defined in the joint workshop will be further developed into project portfolios that contain local projects in the cities, but also joint projects, all forming part of the project portfolio. The project portfolios are not included in this report as they will not be made public.
Running Projects Smart Buildings Murcia

PV INSTALLATION OF 20KWH ON MUNICIPAL BUILDING

This is a recent project that we have been focused on during the last 4 months. We have had to deal with really annoying bureaucracy works because the electricity provider imposes a lot of red tape before they give you the license to produce electricity with PVs. We expect to use that electricity for lighting in the upper floors of the Municipal building where it is installed.

New Project Ambitions Smart Buildings Murcia

RENEWABLE ENERGY & SOLAR FURNITURE FOR EDUCATION

Schools will be provided with equipment and demonstrative material about renewable energy and sustainable behavior to teach children from a young age how important it is to make use of resources properly when it comes to interact at home or at school with lighting, air conditioning and using the rest of the household appliances. It is also aimed to take renewables at schools so that kids can interact with them and learn the basics. E.g. lockers with mobile solar chargers.

ENERGY DEMAND MANAGEMENT SYSTEM ON BUILDINGS

Once monitored a group of specific public or residential buildings, the Project will evaluate and study the demand curve of these buildings and user in order to identify peaks of consumption. The goal is to prevent from these peaks and contribute to have a more flat demand curve by changing the consumption habits and acting on main equipments.
3 THE MODULAR OFFICE SPACE

The city council would offer their whole floor of one of their office buildings and it will be refurbished to make it fully modular. The refurbishment will consist of the creation of a comprehensive network for energy and services within the ceiling system, use the spaces of the lower ceilings for systems, like water and provide cooling and heating. In that case you can put walls where you want and be flexible in use of buildings.

4 THE CONTROL OF HVAC AND LIGHTING SYSTEMS

Many current buildings are not ready for all these new technologies and not easy to convert to these new possibilities. However, it is feasible for a few of them and not too costly. Objective to reduce energy consumption of the building, especially outside office hours with an integrated control system that, according to pre-established parameters (comfort, temperature, timetables, presence, etc.) allows remote operation and automation.

5 ACCESS CONTROL AND LOCALISATION OF PEOPLE

Provide buildings with specific control access technology able to identify users in all the spaces of a building so that we can act and adjust the lighting, HVAC and IT equipment depending on the occupancy level in order to remove the energy consumption of the equipment during unnecessary time. Also the localization of people with reduced movements (in wheelchairs. In emergency situations they can locate people that need help for evacuation.
CONTRIBUTIONS

The results in this project are co-created with many stakeholders in the cities. We would like to thank all participants for their valuable contributions.

Participants of the ambition workshops:
- Mercedes Albacone
- Elena Alday
- Enrique Alvarez
- Carmen Blanco
- Carmen Caballero
- Enrique Almanza
- Jose Maria Cerera Hernandez
- Alvaro Cazor
- David de Diego Villarubia
- Jara Feliu Gomez-Salcedo
- Álvaro Garcia Montoro
- Jose Gambin Orenes
- Virginia Jerez
- Roberto Jose Liñán Ruiz
- Silvia Lopez Belmar
- Tomas Lopes Garcia
- Sofia Lorenzo
- Salvador Mateo
- Antonio Martinez
- Sebastian Martinez
- Pedro J. Molina Fernandez
- Santiago Molina Orate
- Pepe Osorio
- Luis Pan Sanchez-Blanco
- Juan Antonio Romera
- Jaime Ruiz
- Ginés Fco. Sánchez
- Pedro Tomas
- Antonio Valdelvira
- Patricia Zambudio
- Murcia Municipality, Education
- Association of Architects-COAMU
- Murcia Municipality, Urban Plan
- Murcia Municipality, Traffic&Transport
- Murcia Municipality, Industrial engineer
- Murcia Municipality, Maintenance of buildings
- Murcia Municipality, Urban Cleaning
- IDEA ENERGY LAB
- KIO Networks España
- Regenera Levante
- Murcia Municipality, Urban Cleaning
- DGT
- Murcia Municipality, Maintenance of buildings
- Advisor of engineers- COIRM
- Murcia Municipality, ICT
- Murcia Municipality, Energy&Climate Change Office
- Murcia Municipality, Industrial engineer
- Murcia Municipality, Industrial engineer
- TRAVINIA MURCIA
- Murcia Municipality, Maintenance of buildings
- Associate of engineers- COIRM
- Murcia Municipality, ICT
- Murcia Municipality, Energy&Climate Change Office
- Murcia Municipality, Education
- DGT
- Murcia Municipality, Industrial engineer
- Envisiones OO
- IDEA ENERGY LAB
- ALEM- Local Energy Agency of Murcia
- KIO Networks España
- Regenera Levante
- Murcia municipality
- Murcia municipality
- Vodafone
- Renault Murcia
- Universidad de Murcia
- Colegio Ingenieros técnicos Indus.
- Satillo energia
- INFO
- UCAM
- El Corte Ingles informatica
- Telefonica
- ALEM- Local Energy Agency of Murcia
- Select Astenosco
- IDEA ENERGY LAB
- Murcia municipality
- CETENMA
- TRANVIA MURCIA
- MURTRAFIC
- Eumurial
- Murcia municipality
- Murcia municipality
- Colegio Ingenieros Industriales
- TRANSPORTE DE MURCIA
- Universidad de Murcia
- Colegio de Ing. Telecomunicaciones
- Murcia municipality
- ElectroMurcia
- ALEM- Local Energy Agency of Murcia
- IRSA
- Murcia municipality
- Universidad de Murcia
- Murcia municipality
- Universidad de Murcia
- Conexión Velasco
- Juan Villar
- UCAM
- El Corte Inglés informática
- URBAMUSA
- IRSA

Participants of the scenario workshops:
- Elena Alday
- Carmen Almanza
- Ginés Angel Garcia
- Francisco Arias
- Carmen Blanco
- Andrés Brugaldas
- Antonio Caballero
- Sergio Caravaca
- Agustin Celaya
- Antonio Contreras
- Juan Pedro Collado
- Colegio Arquitectos
- Murcia municipality
- CONEY
- Siemens
- Murcia municipality
- Murcia municipality
- Murcia en Bici
- UMU
- Murcia municipality
- Dirección General de Industria Región de Murcia
- Colegio arquitectos Región de Murcia
- QUARTZENERGY

Participants of the roadmap workshops:
- Joaquín Albera
- Elena Alday
- Carmen Alonso
- Carlos Balle
- Agustín Celaya
- David de Diego Villarubia
- Antonio Dominguez
- Jose Manuel Edo
- José Miguel Garcia
- Ginés Angel Garcia
- Aura Gonzalez
- NATividad Higueras
- Guillermo Jimenez
- Roberto Jos Lilian
- Sonia Lujan
- Rafael Marin
- Miguel Mifano
- Santiago Molina Orate
- Javier Mar
- Jose Maria Muñoz
- Juan Miguel Muñoz
- Luis Pan
- Jose Miguel Parejos
- Alfonso Ramallo
- Juan Antonio Ruiz
- David Sanchez
- Germán Sanchez
- MulyBICI
- Consultant experto movilidad sostenible y bicicleta
- Colegio Ingenieros Españoles
- Circutor
- Alterna Tecnologias
- CONEY
- Universidad de Murcia
- Fundación desarrollo sostenible
- URBAMUSA
- UCAM
- Fundación desarrollo sostenible
- ODINS
- Regenera Levante
- TRANVIA MURCIA
- URBAMUSA
- MURTRAFIC
- Colegio Ingenieros técnicos Industriales de Murcia
- Colegio Ingenieros Industriales
- CETENMA
- Universidad de Murcia
- Circutor
- IRSA
- URBAMUSA
This report contains the results of the ambition setting, vision development and roadmapping activities for smart buildings in the city of Murcia. Workshops were conducted with policy makers, strategy departments, integral project managers, department managers and external stakeholders and strategic partners to define a shared ambition, create a desired future scenario, develop a city specific roadmap and identify initial (local) solutions and research projects to achieve the desired future in the specific context of the city. The participants will continue working on the project portfolio.

This report is the final public deliverable of the Roadmaps for Energy (R4E) project. The R4E partners work together to develop a new type of energy strategy through visions and roadmaps for the 8 partners cities, in co-creation with local stakeholders. The project supports the development of visioning and roadmapping capacities within the municipalities to spur future development and implementation of innovative energy solutions.