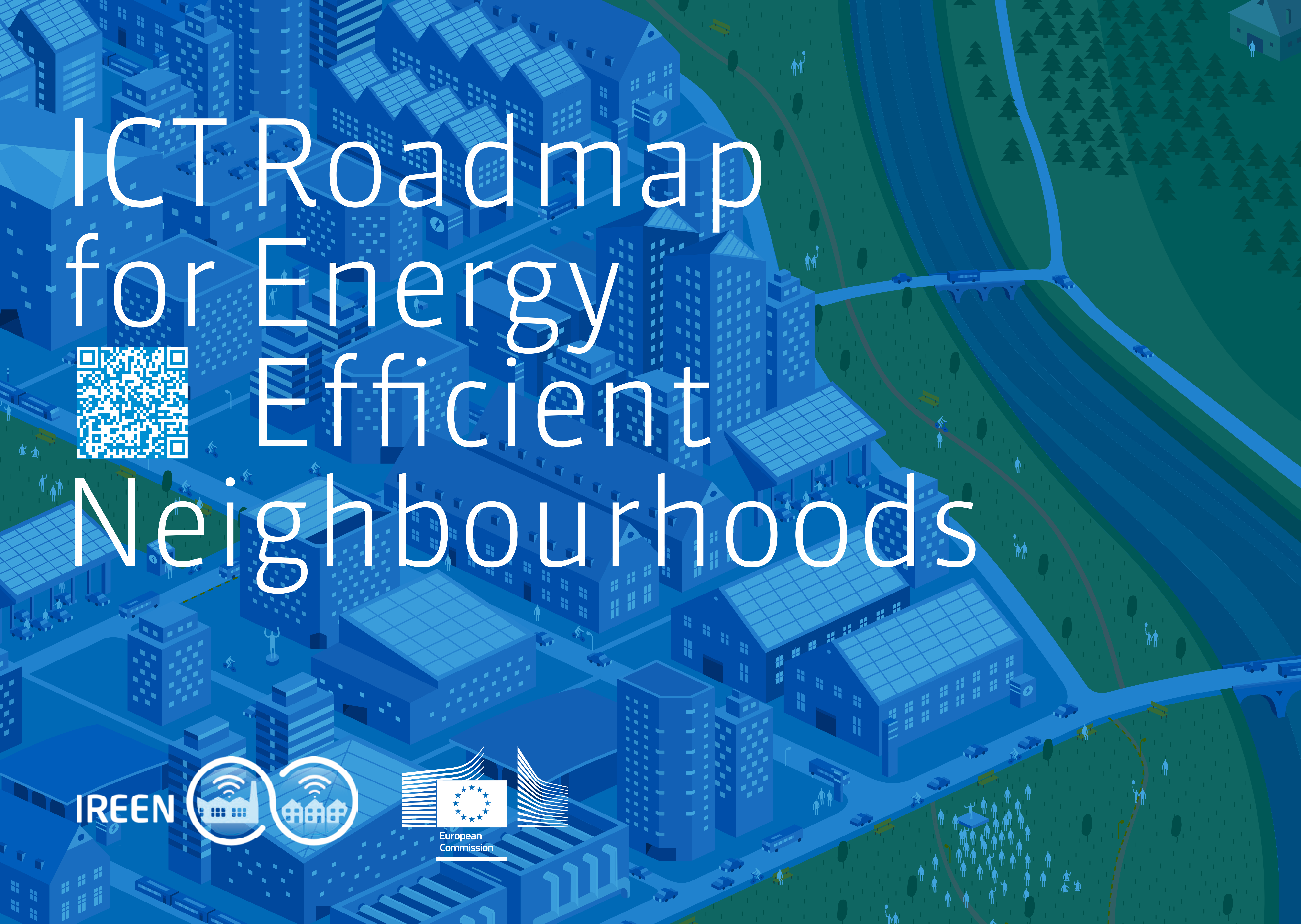

ICT Roadmap for Energy Efficient Neighbourhoods

IREEN

European Commission

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Definitions

Neighbourhood:
includes all the systems and processes on a neighbourhood level, such as the development of city and neighbourhood plans, design of an area and its associated services, as well as operation and maintenance of a neighbourhood. A neighbourhood is a specific geographic area within a larger city or town. It is a localised community with a set of social networks. It can be defined in many ways, for example by postal zip codes, groups of blocks, census-defined blocks, tracts, or neighbourhoods as defined by the cities or residents themselves [1]. In IREEN the focus is on districts at a general level and the results aim to be applicable to all neighbourhood areas, regardless of the specific definition. The term 'district' is considered to be similar to a neighbourhood.

Energy efficient neighbourhood:
one which operates at a high level of energy efficiency, including energy supply, distribution and demand.

Energy positive neighbourhood:
one in which the annual energy demand is lower than energy supply from local renewable energy sources. The aim is to provide a functional, healthy, user friendly environment with as low energy demand and little environmental impact as possible [2].

Acronyms

API	Application Programming Interface
BEMS	Building Energy Management System
BRIC	Brazil, Russia, India and China
CHP	Combined Heat and Power
DER	Distributed Energy Resources
EE	Energy Efficiency
EMS	Energy Management System
ESCO	Energy Service Company
EU	European Union
FP7	Seventh Framework Programme
GIS	Geographical Information System
ICT	Information and Communication Technology
IREEN	ICT Roadmap for Energy Efficient Neighbourhood
LCA	Life Cycle Assessment
NEMS	Neighbourhood Energy Management System
PV	Photovoltaic
ROI	Return On Investment
RTD	Research and Technology Development
UEE	Urban Energy Enterprise

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Executive summary

The vision of IREEN is one where neighbourhoods use smart, efficient, systems to distribute and manage energy in order to maximise the environmental and social benefits for all users.

As cities struggle with climate change and energy demands as well as changes in population, demographics, congestion and pressure on key resources; sustainability is the ultimate goal. To succeed in the future, communities will need systems that maximise the opportunities offered by ICT and that can support energy-efficient neighbourhoods. The IREEN roadmap demonstrates the ways in which technology can support energy efficiency decisions at a neighbourhood level and contribute to the sustainability agenda. It is a research and strategy document which aims to inform policy and programmes in the context of Europe's 2030 Framework for Emissions as we go forward to Horizon 2020.

IREEN Community

The project has worked with over 200 experts from across a wide range of disciplines including municipalities, technologists, ESCOs, energy suppliers, NGOs, academics as an iterative process to form a stakeholder network and an Advisory Expert Group (AEG). Their role was to act as a sounding board and provide in-depth content and feedback. We used a range of formats, including bilateral meetings, workshops, questionnaires, virtual hearings and presentations followed by question and answer sessions. The process allowed us to gather views on a wide range of technology and energy-related topics structured on the IREEN scoping matrix.

IREEN Methodology

IREEN broadens previous roadmaps developed by FP7 projects and includes a commonly agreed definition for an ICT-enabled energy efficient neighbourhood. The development of a classificatory methodology and a taxonomy matrix ran in parallel to allow relevant conclusions to be drawn as to what works in which context.

Case Studies

The IREEN case studies are derived from examples provided by experts, a number of which have featured in papers published by the project. They illustrate activities already underway and show how organisations are successfully taking steps toward using technology for energy efficiency. They demonstrate the role of technology in achieving better performance across a range of domains.

Future Scenarios

The feedback received from stakeholder engagement activities has helped shape the scenarios to provide insights into the potential future use of technology for energy efficient neighbourhoods. They are not predictions. They are stories of possible futures, imagining how technology could be applied over the next 10 to 15 years, in order to challenge assumptions and stimulate thinking about the present.

Recommendations

The roadmap makes a series of recommendations. The intention is to suggest and guide stakeholders towards the key areas of development. These include the simulation, modelling, analysis, monitoring and visualisation of entire districts; data analytics and the integration of "big data"; energy brokering; neighbourhood management systems; models for performance metrics; assessment models, including economic analysis; tools for management and integration and sharing of power from renewable energy sources and interconnection to smart grids; advanced control systems to balancing loads; methods to estimate and validate the impacts of ICT on energy efficiency.

Full details of all the IREEN recommendations may be found in D3.3.2 Roadmap for European-Scale Innovation and Take Up (www.ireenproject.eu)

Introduction

For the majority of inhabitants in Europe, energy supply has not been a problem in their lifetime. This is likely to change in the next 10 to 20 years. Tackling complex challenges such as resource shortages and climate change at the scale and pace needed requires the creation of new approaches.

The purpose of IREEN is to map a future that shows the role of technology in supporting energy efficiency. IREEN goes beyond individual buildings and systems by considering whole neighbourhoods and districts. By looking at the role of ICT for energy efficiency from a holistic point of view, its scope covers both urban and rural districts and incorporates findings from the wider international context. This includes the entire energy chain from sustainable energy production and distribution, through to analysing future energy demand.

The enabling role of ICT
Many core enabling technologies are being deployed today to manage sustainability. In the case of energy efficiency, these range from advanced building controls, energy management systems, smart meters, to grid automation and optimisation. Tomorrow's energy positive buildings, neighbourhoods and districts (those that generate more energy than they consume) will be empowered by electronic embedded components and ICT systems and infrastructures. These will not only meter the energy consumed and/or generated, but have the potential to provide real-time information to city planners and managers in order to optimise energy consumption.

A major contribution to future frameworks for research and innovation
IREEN is an FP7 funded coordination action supported by the European Commission to develop a strategic research agenda. The aim is to inform policy and programmes such as Horizon 2020 [3] and Europe's 2030 Framework for Emissions [4], including recommendations on how ICT can be used to create energy efficient districts.

The purpose of this document is to provide a summary of how ICT can be used to improve the energy efficiency of neighbourhoods and to demonstrate how ICT can contribute to the future development and planning of a range of smart neighbourhood systems.

IREEN stresses that the technology infrastructure must be flexible and capable of being adapted to the needs of both residents and local authorities in a variety of cities. The work has included collecting independent, demand-side visions from the building and neighbourhood communities, whilst identifying the key aspects within these visions that leave room for sustainable urban development.

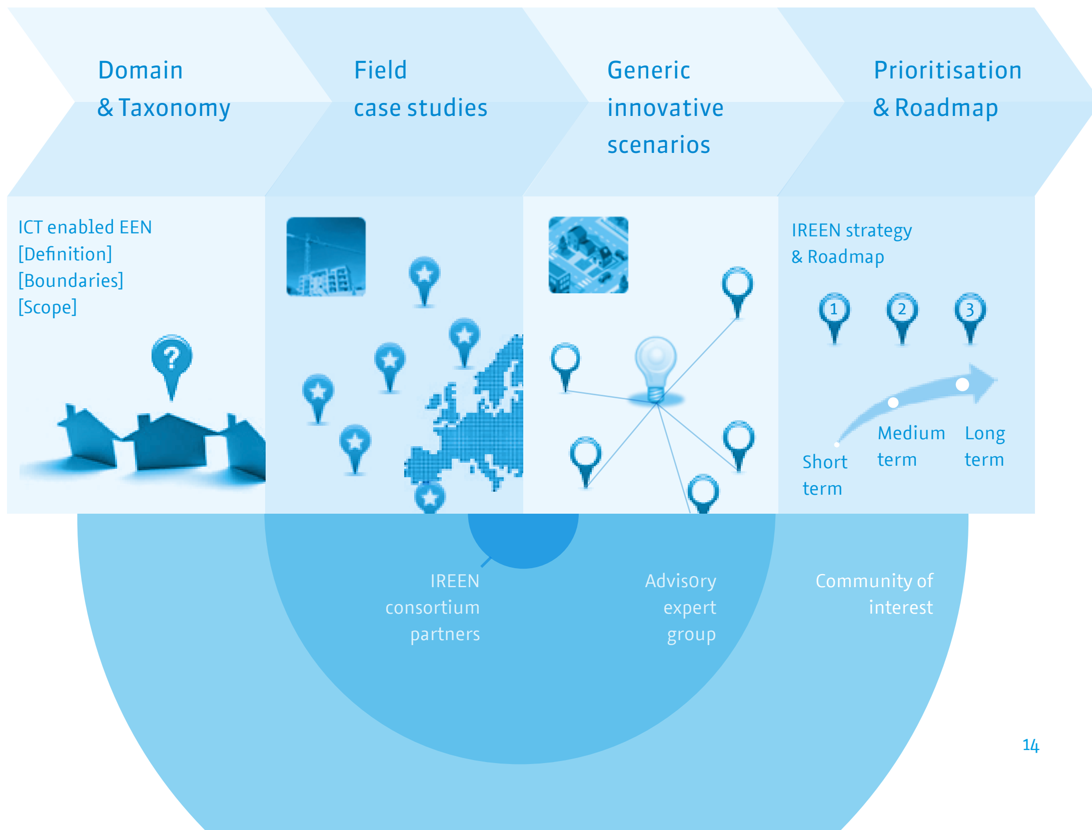
A smart, sustainable energy system requires the co-operation of many different stakeholder groups and the integration of a variety of energy sources.

Methodology & community

Methodology

The IREEN roadmap used a structured approach to manage the broad study area of the project.

Step 1
Taxonomy
The IREEN taxonomy complements previous roadmap projects, namely REEB (Roadmap for Energy Efficient Buildings) [5] and ICT4E2B Forum [6]. The focus area of ICT enabled energy efficient neighbourhoods is vast. It includes the entire energy chain from energy consumption in buildings and transportation, through to energy production and distribution in a neighbourhood. Similarly, the ICT deployed ranges from design and energy management to decision support and integration technologies.



The IREEN user scenarios should be considered as a functional basis for future large-scale deployments of robust, scaleable technologies in a smart neighbourhood context.

Step 2
Setting the scene: Innovative scenarios
IREEN has developed a number of innovative scenarios. These describe situations expected to be common in the short to mid-term (i.e. by 2015 and up to 2020-2025). Each is based on an anticipated common usage of mature technologies.

The value chains for energy production, storage, delivery and consumption in smart cities and neighbourhoods are complex. The ICT support solutions proposed by IREEN take this into account.

IREEN proposes integrated solutions which allow stakeholders to share and exploit data and information generated by linking a range of intelligent devices and systems. These include sensors, meters, IT-based equipment and components, distributed energy resources and software.

The IREEN user scenarios should be considered as a functional basis for future large-scale deployments of robust, scaleable technologies in a smart neighbourhood context. Implicit in these proposals is the need to remove obstacles to the implementation of new business models. These include the failure to agree common ICT standards, fragmented and uncoordinated research and inefficient public research and inefficient public procurement.

More than 20 innovative scenarios have been described in IREEN. These are based on expected innovations in the field of ICT for energy efficiency neighbourhoods – both urban and rural – which are likely to appear in the next 10 years. A selection of these scenarios is presented in this document.

Community

Step 3
Vision, roadmap and recommendations
The roadmap is an evidence based vision which identifies how ICT can contribute to improving energy efficiency and energy positiveness in both urban and rural neighbourhoods.

It offers an essential foundation for developing an ICT roadmap for European scale innovation. This includes identifying future RTD and priorities in terms of impact, short, middle and long-term research priorities and technology development. It fundamentally defines what the priorities are and how they might be achieved. The roadmap is outlined in this document.

The IREEN taxonomy, scenarios, vision and roadmap have been developed as an iterative process in cooperation with experts from relevant fields, territories, energy and buildings in Europe and other countries. This has resulted in a comprehensive, agreed and common shared vision. The community includes:

- The IREEN consortium partners
- An Advisory Expert Group
- A Community of Interest

Experts provided active contributions and feedback through:

- Thematic workshops
- Interviews – *See the selection of testimonials in this guide (page 22)*
- Online collaboration

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Testimonials

It is essential that the key decision makers in cities - and their rural equivalents - should endorse the proposals which underpin the IREEN Roadmap.

The IREEN partners conducted interviews with over 30 senior city and region representatives from across Europe. The expert hearings had two objectives. The first was to document current ICT use, systems and infrastructure. The second was to analyse their targets for future procurement and the benefits that they hoped to gain. Input has improved both the roadmap and scenarios.

The following selection of interviews demonstrates different visions, best practices and ICT needs addressed by various cities. The full interviews, and additional ones, are published in the IREEN in the EC Wiki portal [7].

Amsterdam

"The people and the process behind technology play a crucial role."

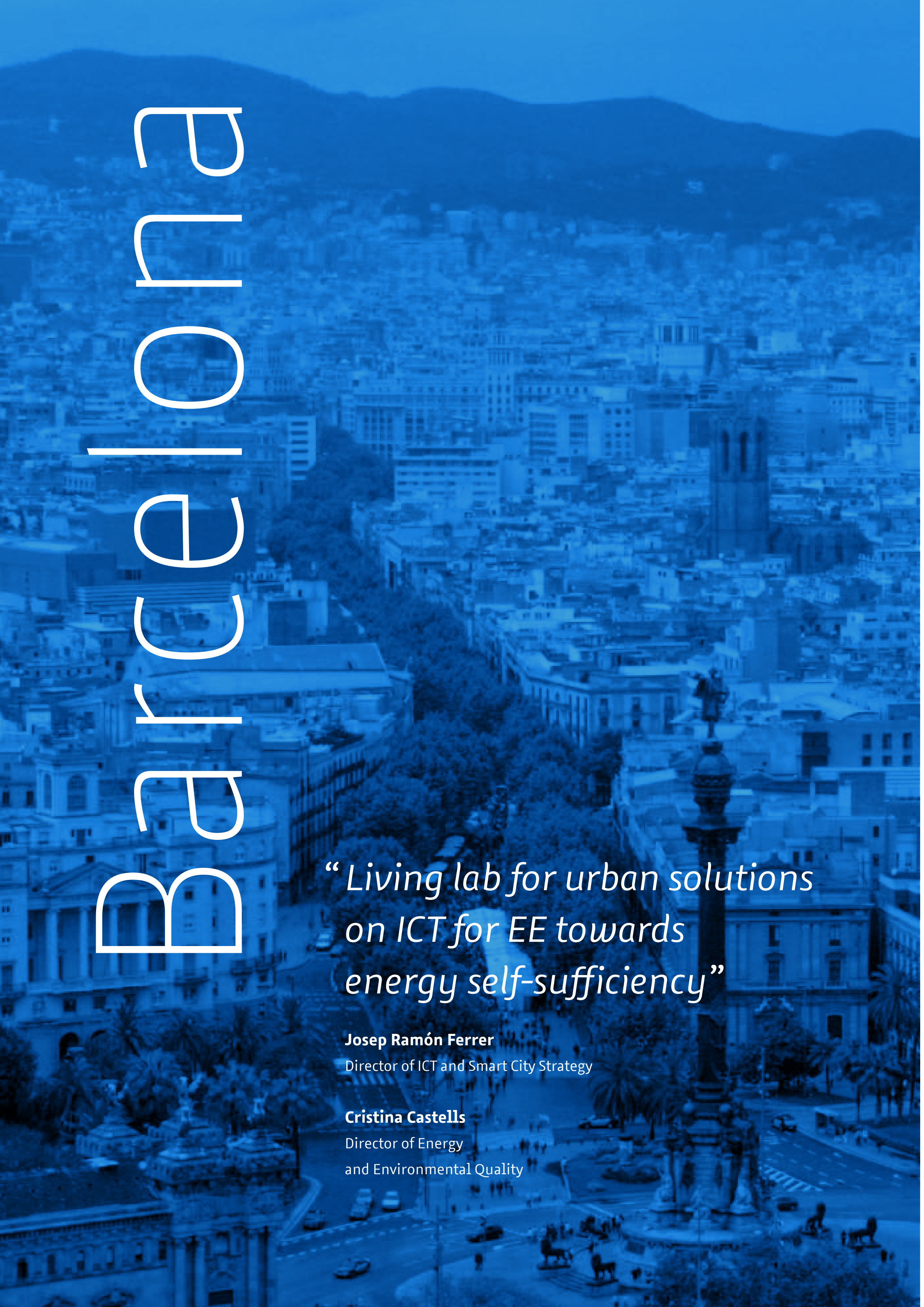
Caroline Combé
Manager and project leader of the EU Smart Cities and Communities Initiative project TRANSFORMation Agenda for Low Carbon Cities

"Together with our international partners in the project TRANSFORM [8], we will create a roadmap on integrated planning that is tested in smart urban labs, and replicable to other European cities. In Amsterdam, we selected the project Energiek Zuidoost, which is also the focus area for our Amsterdam Smart City platform. Zuidoost has many offices and data centres and relatively high energy consumption. At the same time it is estimated that the age of its residents will increase in the near future. The area as such is on the municipal agenda for reformation with the objective to find new business models with sustainability as a differentiator. One of the ways to achieving this is through a better understanding of energy supply and demand of local stakeholders. For example, is it physically feasible to transport the heat from a data centre to be re-used in the nearby hospital?

We have learned that in successful ICT-related projects, the people and the process behind technology play a crucial role. For example, in Amsterdam we have created an atlas for integrated planning in projects in the field of energy efficiency. We collected a wide range of data from heat and electricity use, buildings and their age, vacancy rates etc., obtained from public and private parties. Outsiders were quite sceptical at the beginning. They questioned the level of detailed information that all parties involved could bring to the table. It was mainly because of dialogue and perseverance of the project manager that data in usable format from different sectors was obtained. It is also essential to bring different stakeholders together from the very first beginning to understand where impact can be made.

ICT can play a role in working with more detailed data for flexible use. For example, by providing better insights in weather conditions or fluctuations in the smart grid. As such, ICT can ease the energy distribution with inclusion of renewables by minor adjustments and without the need for an entire new infrastructure. Through ICT we can also obtain quantitative and insightful data on energy use, avoiding privacy issues, one of the main barriers for effective energy efficiency measures.

With regard to financial models we need a better understanding of the added value of short-term ICT investments in relation to long-term societal and economic developments. How can we calculate energy efficiency with the inclusion of, for example, the fluctuating energy prices and change in people awareness over time? We expect that those insights will certainly help the decision-making process in city transformation."



Barcelona

“Living lab for urban solutions on ICT for EE towards energy self-sufficiency”

Josep Ramón Ferrer
Director of ICT and Smart City Strategy

Cristina Castells
Director of Energy
and Environmental Quality

“

Our political vision related to smart cities could be summarised in improving citizens ‘quality of life, their social wellbeing and promoting economic growth in the city. The objective is to be a self-sufficient, independent city in terms of energy. Capable of providing all the energy - as much local and renewable energy as possible and also promoting a reduction on the energy demand - and, at the same time, being able to produce economic growth. This is a process in time: begin with EE buildings, then neighbourhoods, then the smart city.

We also have the vision of a highly connected city in and with a global world. There is a need for improving the main infrastructures in terms of mobility, transports and logistics, and to promote better digital infrastructure. We are proposing an open and innovative model offering companies and projects to experiment in Barcelona, always with the vision of promoting citizens quality of life. The city as a test-bed, a living lab for urban solutions and a city with a “human size” and at “human speed”. Citizens will include EE and ICT in their daily habits if they find them useful both individually and at a neighbourhood scale. We also encourage partnerships with other cities to promote a shared approach on what we think will be the future of ICT and EE that will transform city landscape in the next fifteen years: IoT and Smart Cities.

”

Some of our ICT for EE projects that could be seen or managed at a neighbourhood scale:

- **Buildings’ energy efficiency**
  Improvement of building infrastructure in public buildings to save energy and combat climate change. Smart monitoring. Easy tools to check EE in buildings
- **Smart lighting**
  Using lampposts as a multi-service and innovative urban tool: including mobile phone antennas, Wi-Fi network, touristic info, etc. inside the lamppost
- **Watering tele-management**
  Improve watering management with smart sensors and using remote control systems

Cardiff

"The need for a resilient ICT infrastructure is crucial to support future development and attract firms to the city."

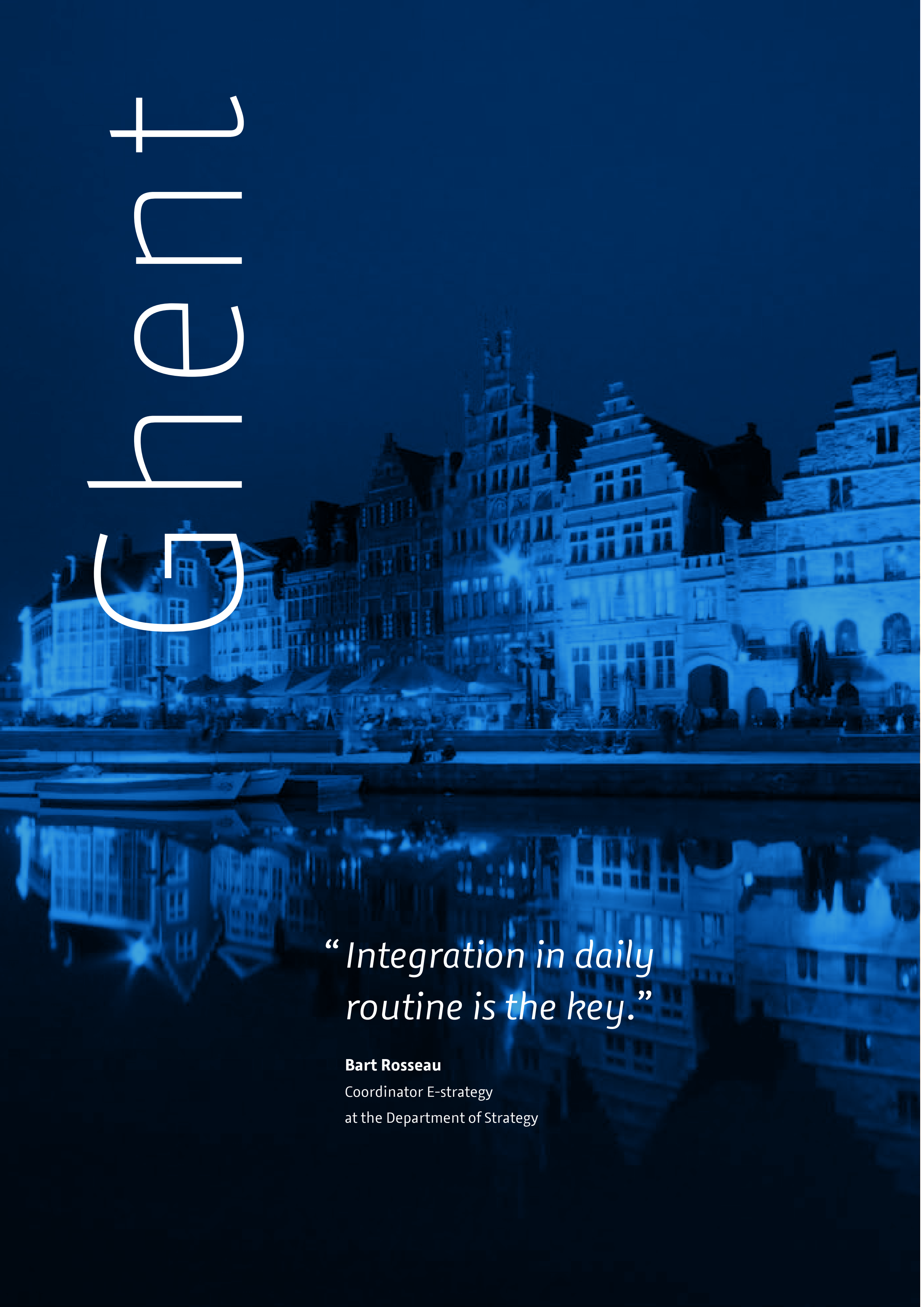
Gareth Newell
Head of International Policy
Public policy and urban development

Steve Durbin
Head of Internal Services
Project Executive of Cardiff's
Super Connected cities programme

"The strategy of Cardiff City Council (Wales) recognises that ICT is a key enabler of more efficient services, with a proactive approach to the roll-out of 4G and Wi-Fi across the city. A fundamental rationale behind this strategy is that the delivery of a smart (knowledge informed) city is the pre-requisite for the achievement of a 21st century sustainable city. This city will increasingly rely on ICT solutions using real-time data to deliver sustainable growth while increasing their level of citizen participation and overall social capital. Cardiff is expanding in size. The need for a high capacity and resilient ICT infrastructure system is crucial to support future development and attract firms that need this capability. Cardiff is already addressing this with the Super-Connected Cities Action Plan and the provision of ultra-fast broadband, Wi-Fi and 4G across the local authority. The main project funding has been agreed, wireless deployment to schools is starting now, and one service provider has already deployed 4G across the city.

The integration of existing knowledge is needed to handle the overwhelming and conflicting transactions associated with the management of sustainability. There is also a crucial need to develop and manage content and added-value information. A key ambition of the city of Cardiff is to develop the 'Smart Living' concept, and where the city can demonstrably improve things to citizens. For managing the costs of deploying current technology at large scale, it would be good to invent the 'killer project' for which you get a momentum from all stakeholders.

What we need in our city to take energy efficiency measures to the next level is a holistic view on integration / interoperability of systems beyond energy and water; the leverage on the infrastructures - developing services on top of it; and the development of District Heating Networks / CHP and smart meters & intelligent control, along with more relationships with citizens & businesses."



Ghent

“Integration in daily routine is the key.”

Bart Rosseau
Coordinator E-strategy
at the Department of Strategy

“

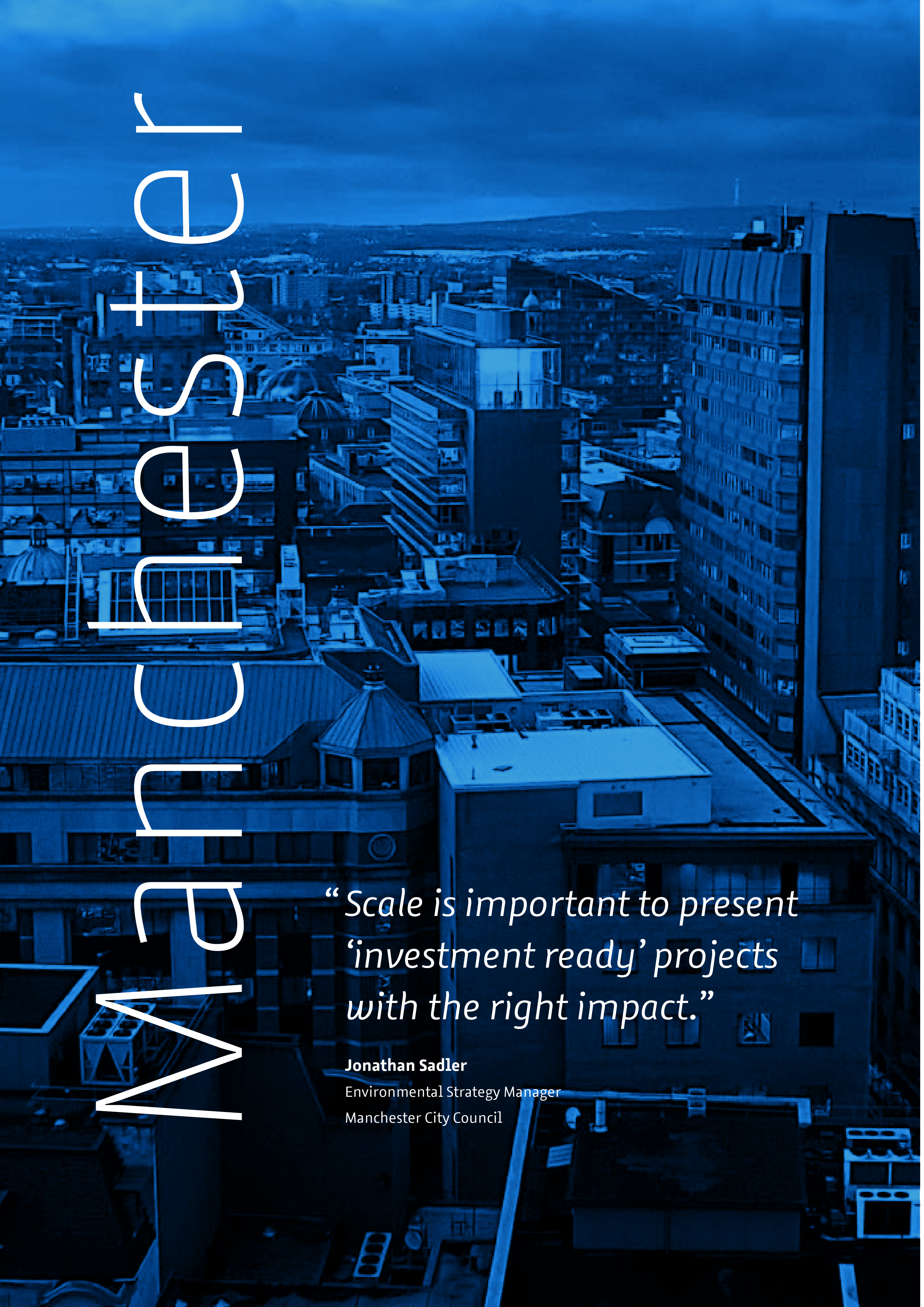
It would be very useful to have an open data warehouse in which all energy data is collected. Technically this is feasible today, but for such a central platform we need requirements for speaking the same lexicon and a key framework for data formation and clarity on legal boundaries. Each stakeholder, including the citizen, can share information and people will only have access to the platform when they also deliver data. Ghent already has an interactive website providing all core statistical figures of the city, aiming at effective use of open data across different policy departments. We can also use information from our 3D models of the city, such as the shade of buildings for the calculations on effectiveness of solar panels. Energy efficiency is not the key driver for open data and 3D models, but can be a trade-off.

We found that city officials often lack knowledge of ICT systems and fear too much dependence on the suppliers. Our own city ICT department has evolved from service desk to policy support provision for ICT in the city. Such change requires different people skills, which I think is an important element for cities in considering the use of ICTs.

It’s clear that ICT must be embedded in daily life and the services citizens use. Integration in daily routine is the key. What are the real incentives for residents and end-users? We have learned that energy alone is never enough reason to convince people. In this respect, we aim to intensify our relationships with energy companies as our city partners. They are the stakeholders who can make a real difference in this area. They could embrace the energy transition as an opportunity to position themselves as partners of neighbourhood energy initiatives. Belgium has a diffuse political landscape with a complicated decision-making process. This means that most energy efficiency activities take place at neighbourhood level, not at city or regional level.

”

Manchester



"Scale is important to present 'investment ready' projects with the right impact."

Jonathan Sadler
Environmental Strategy Manager
Manchester City Council

The overarching vision and action plan Manchester: A Certain Future [9] is overseen by a partnership of key stakeholders, including the private sector, public sector, universities and the third sector, as well as the public sector. The plan aims to coordinate action toward a low carbon future (41% reduction of carbon emissions) by 2020, from 2005. The UK is the first country in the world to have a legally binding, long-term framework to cut carbon emissions and adapt to climate change.

"

Capital funding is not necessarily a major problem in the UK, the Government has established a £3bn Green Investment Bank to support low carbon programmes. There are other sources of funding too that could be considered, such as high street banks, pension funds and overseas investment.

The challenge is largely having 'investment ready' feasible projects, with a strong enough business case to attract investment. Project development funds and resources are therefore more critical at this juncture. There is still a lack of expertise or readiness to grasp energy efficiency projects, as the kind of projects that are required could be perceived complex or technical in nature, and certainly new and unfamiliar territory. To embrace an energy efficiency project today is like 'going on a journey' that is complex and requires commitment, vision and leadership.

The overall priority around energy efficient neighbourhoods is to help implementation. Real demonstrators, numbers or other quantifiers (e.g. how much carbon is saved by X intervention) are needed to help stakeholders as well as city leadership to achieve change. Scale is important to enable significant change to be delivered with the right impact and to attract investors and delivery partners. Investors are typically interested in schemes that are in tens of millions rather than millions – which is why working together in the city-region with neighbouring authorities is important to build scale.

For our heat networks, a joint venture is underway between the Green Investment Bank and Greater Manchester Combined Authority to identify and prepare three projects that are ready for investment. These include Manchester's Town Hall Extension and up to 6 nearby buildings. The mapping and identification of these heat network projects is initially done at a high level to create a pipeline of projects that can then be developed and taken forward for investment.

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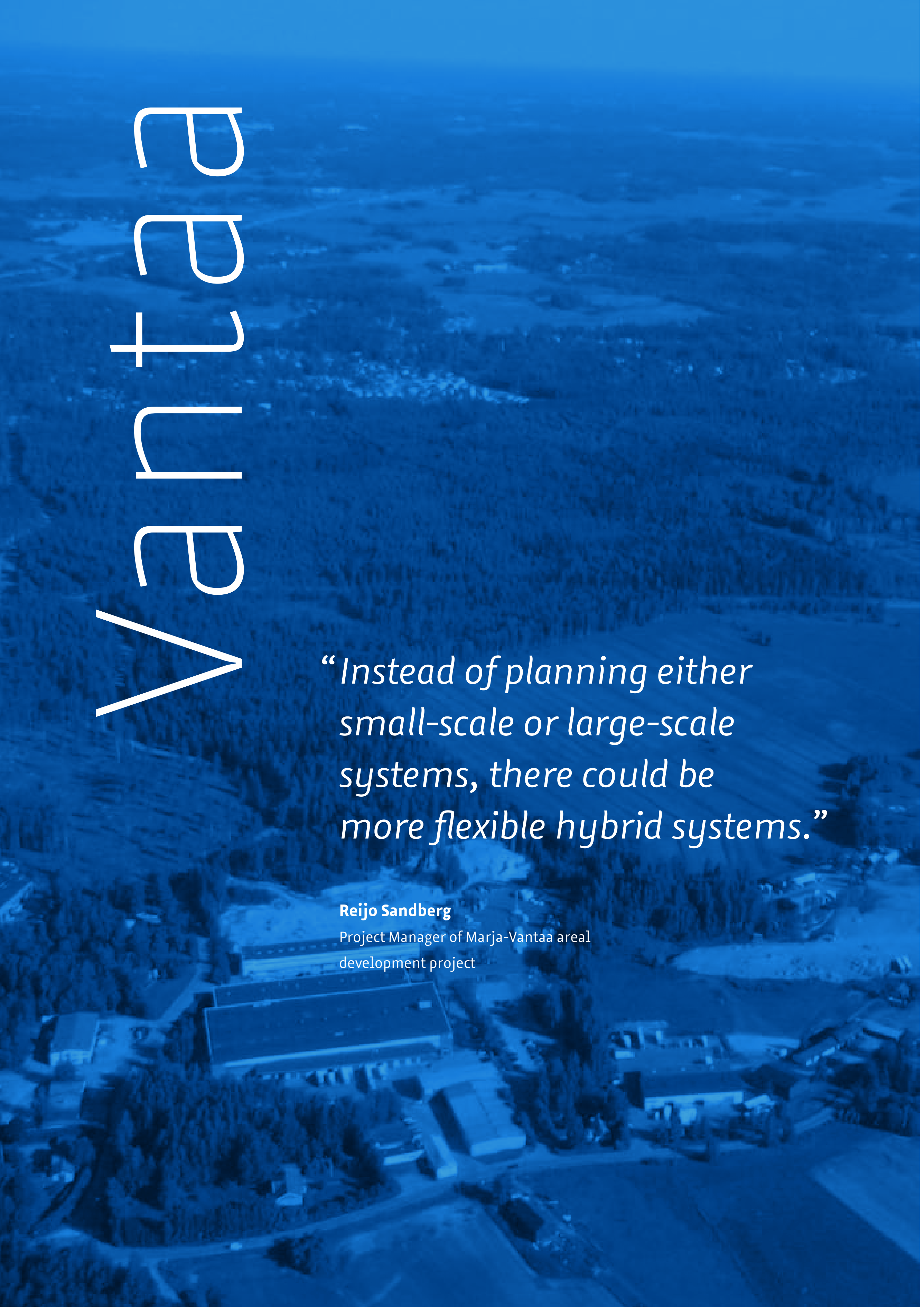


Vantaa

"Instead of planning either small-scale or large-scale systems, there could be more flexible hybrid systems."

Reijo Sandberg
Project Manager of Marja-Vantaa areal development project

"

A major issue is planning the Helsinki metropolitan area, where Vantaa is situated, as a whole. Important projects include the new district of Kivistö, new ring railroad line and the change of fuel mix in the power plant towards more bio fuels. Moreover, there are a number of development projects in which the city participates, such as the KEKO project [10] for using ICT for following eco-efficiency indicators in the city.

The major obstacle to EE is that there is a tendency to concentrate more on investment costs than costs over the lifetime of the project. Also, very often the one who makes the investment decision (builder, etc.) is not the one who pays the energy bills (tenants, etc.). Therefore there are no incentives to plan and build efficient buildings. Monetarily the benefits of energy efficiency are too small and spread over long periods of time to be very effective.

Possible solutions include instilling more 'big picture' type planning practices that include different points of views, and changing lifestyles towards eco-efficiency. For instance, in many instances a district-level solution for energy management would make more sense than every building having their own system. In some cases, instead of planning either small-scale or large-scale systems, there could be lighter, more flexible hybrid systems that combine features of both.

"

Visionary scenarios

IREEN represents its taxonomy through a matrix setting out 6 key 'Application Areas' and 4 'Technology Areas'. The matrix is used for categorising the whole spectrum of ICT solutions for neighbourhoods.

For each Application Area, IREEN developed several scenarios to analyse future trends. These scenarios consider the potential business cases, likely developments in technology and identify potential energy efficiency impacts. Some have been specifically tailored for urban communities while others have a rural focus. A number cover both types of communities.

The scenarios are the next step from pilots and research projects to larger deployments and proof of scalability. The following pages introduce example scenarios for each Application Area; the full list of available scenarios is provided at the end of the section.

		Application Areas					
		Neighbourhoods - Urban and Rural Communities					
		Neighbourhood planning	Transport system planning	Energy Production and Storage	Buildings infrastructures and public spaces	Energy distribution	People involvement
Technology areas	Design, planning and realisation						
	Decision support						
	Energy management						
	Integration technologies						

IREEN Taxonomy matrix with main Application and Technology areas

1

Neighbourhood planning

Integrated ICT environment for information sharing and collaborative design, planning and decision making between stakeholders involved in urban area development and renovation.

Urban Energy Enterprise

Description
The scenario describes a municipality or other urban organisation wishing to make decisions about the commercial and engineering viability of an energy project or intervention, by modelling and visualising an Urban Energy Enterprise. The approach considers the energy use, demand, storage, production and trading of in an urban environment.

The Urban Energy Enterprise is able to help plan and manage local energy generation, storage and trading by creating a dynamic system simulation. This helps cities specify, design, finance, install and operate demand side participation solutions for decentralised energy generation, storage and cooling. Operating as a "virtual power plant", this creates a trading system within an urban environment.

3D modelling techniques are used to create virtual machines and network components of the system architecture. This allows variable system configurations to be 'installed' and tested for viability within existing digital models of a city's physical infrastructure.

The Urban Energy Enterprise incorporates the multiple technical, financial, policy and regulatory datasets required to accurately portray the complexity of an advanced dynamic simulation. These datasets include hardware specification, configurations and costs, spatial planning profiles, capital and operational expenditure profiles plus revenue opportunities from delivery of services on behalf of the network/system operator.

"At Cerro del Baile neighbourhood, we want to promote a sustainable urban development from the beginning, in coordination with all the stakeholders and with a vision of energy efficiency and inexpensive maintenance. The project includes public lighting that could graduate light intensity and a cogeneration plant for the neighbourhood, in such a way that, in the long-term, neighbours could turn into prosumers.
There are two big challenges:
1. to be able to acquire the land to build this plant at a good price
2. to be able to get to an agreement with the three major ESCOs.
The IREEN roadmap could be helpful to orientate our steps in this urban project."

Raul Terrón
Councillor of Urbanism
San Sebastián de los Reyes

Impacts
The approach turns cities into energy generators. This offers an opportunity to exercise demand side management which in turn may lead to a reduction in energy consumption, waste and CO_2 emissions. It also provides revenue streams which can be used to enhance sustainable energy security and create employment.

The current development of smart grid technologies presents an opportunity to design and install sophisticated systems to monitor and control generation, distribution and storage. A virtual power plant also provides the opportunity to use advanced energy management services such as demand response capabilities and electric vehicle maintenance. This requires careful planning, specification and procurement.

A platform for comprehensive planning and operational modelling of the energy networks within a city is a valuable toolkit for parties looking to underwrite opportunities to invest in new low carbon infrastructures. Data outputs from a detailed simulation allow investors to assess risk accurately.

Stakeholders and Beneficiaries

- Investors (especially renewables)
- Network providers
- Urban authorities
- Local businesses
- Inhabitants
- UEE operator

Progress beyond State of the Art

- Full simulation of the potential of the aggregation of production, storage and demand response at an urban level
- Simulation of revenues achievable from energy trading in an urban context
- Real time management of the above

2
Transport system planning

Services to users of public transport: displays showing cost/energy information, route selection guidance.

Improving the Public Transport Experience through the Transporter System

Description

The city public transportation company has introduced a package of ICT tools called “The Transporter” aimed at improving the public transport experience the user in order to promote public transport as an everyday mobility option.

The system improves the public transport experience from different points of view:

- It shows users the energy and cost benefit of using public transport by making a price and CO2 comparison of price and CO2 emissions. This is achieved through displays installed on buses/trains that show the amount of CO2 and money saved compared to using private vehicles
- It provides added reliability and comfort to the public transportation service via a personalised route planner on portable devices. This is aimed at improving the user experience by providing information on how to reach a specific point of the city. The system is interfaced with the regional train network and bicycle routes. This service is also complemented by GPS location displays installed on buses/trains that continuously shows the current position. When the user plans his journey within the city, the Transporter shows “energy efficient suggestions” on how to save energy by using alternative means of transportation. For example, the transport connects with the weather forecast: if the next day is going to be sunny the system adds the “travel by bike” choice, interfaced with the public transportation network as needed.

Barbara is a regular user of public transport and the Transporter application helps to make public transport an attractive choice. She needs to go from her home to a specific street in the city centre to meet friends. She opens the Transporter application and selects the desired route. The system also includes a "bring me home option"; the ability to get directions to her home no matter where she is in the city helps alleviate any anxiety about the usage of public transportation. The system also takes into account the overall system status, performance along the particular bus line, the specific bus that will arrive, weather, traffic, city events, planned works and user history

The system offers Barbara two options to reach her destination:

A. Go to the closest bus stop by foot then take the bus, alight at the 5th stop and walk to your final destination
B. Cycle along the cycle path to the closest metro station, take the metro train for three stops then travel to your final destination on foot. (The app tells her that the forecast is sunny and suggests "why not take the bike?")

She chooses Option B. The system offers real time information on her location and as she enters the metro, she can purchase her ticket through Transporter. A display at the metro shows the total amount of energy being saved by all those taking the train rather than using private vehicles. This is a calculation based on the number of people travelling. As she reaches her own stop, the system her reminds to leave the train and continues to assist her during the journey to her destination. Barbara had a pleasant and efficient experience and she feels encouraged to use her bike again in combination with public transport.

Impacts

- Increase the attractiveness and ease of use of public transport, showing the price and energy efficiency benefits to the neighbourhood community
- Reduces personal transport in the city and associated energy consumption impact
- Increases awareness on energy efficiency

Stakeholders and Beneficiaries

- People living and moving within the city neighbourhoods
- Urban planners and city managers: those responsible of performing traffic management activities and planning the viable for the neighbourhood
- Local transport companies
- Urban authorities

Progress beyond State of the Art

- Development of interfaces and integration technology to combine and exploit information from different sources
- Effective algorithms machine learning techniques to optimise the travel routes using combined means of transport.
- Development of energy monitoring functionalities to provide a real-time view of the status of the energy consumption and carbon emissions of the public transport at neighbourhood level

3
Buildings, infrastructures and public spaces

Holistic monitoring and diagnostics of energy systems and interfaces for optimising operation and maintenance.

Neighbourhood Buildings and Infrastructure Maintenance

Description
Maria belongs to the staff of the local authority in charge of monitoring and supervising the energy networks operations at the level of an urban district. She is in contact with the network utility operators involved in the urban energy distribution (electricity, gas, or heat networks).

On the technical side, all the information monitoring systems of the utilities have been integrated around the urban GIS. Thanks to remote energy meters Maria can visualise in real-time all kinds of energy flows within the networks and especially at the interface of each network node (buildings, car parks, open public spaces, centralised production and storage units, street lighting systems, charging stations for electrical vehicles, etc.). Other types of sensors also contribute to surveillance of network operations. This allows Maria to monitor the energy networks, detect problems and intervene as required.

An alert light at a school on the electrical network dashboard indicates to Maria an anomaly at this node. It is a sunny day and normally the electricity production of the PV panels installed on the building roof exceed the building consumption, with surplus of energy transferred to the grid. By comparing the current situation with the historical data recorded during days with similar weather conditions the system has detected an anomaly. A self-testing procedure applied to the remote building energy meter allows Maria to check that the meter is fully functional. Maria contacts Peter, the Facility Manager of the school to inform him of the problem. Peter is able to investigate the problem through the BEMS maintenance tool of the school, checking the functioning of all building equipment and devices.
Some days later the warning occurs again. This time the problem is at a green park. It is nightfall and the lighting system of the park should have been switched on automatically having detected a decrease of luminosity. The maintenance system checks if a rule is transgressed (e.g. when the ambient luminosity is lower than a minimum value, the lights should be on). Thanks to this remote testing procedure, Maria notices that the luminosity sensor is malfunctioning. A request form is automatically generated and sent to the maintenance technical staff.

In another example, a section of the gas network indicates a failure (i.e. a leak) in the network. Maria urgently calls the gas network utility and the city security services to organise and coordinate the action.
The gas network information system is integrated to the urban GIS and Maria can also visualise the current pollution level in the city, the climatic conditions (wind, etc.), and the urban traffic and run simulation tools, to take relevant decisions and optimise the management of this crisis.

Impacts

- Assistance to local authorities, facility managers, and utilities, monitoring of energy networks
- An overall improvement of the efficiency of the whole neighbourhood energy network
- First steps to predictive maintenance at urban level to check operation of neighbourhood devices from an energy view point

Stakeholders and Beneficiaries

- Local authorities
- Facility managers
- Energy suppliers, utilities
- ESCOs

Progress beyond State of the Art

- Future energy management systems at neighbourhood level will include functionality to analyse operating conditions, forecast future performance, detect failures, identify causes, and suggest maintenance operations. The supporting methodologies will make use of approaches like comparative analysis of historical data, case-based reasoning and rule-based analysis, etc.
- Integration of heterogeneous information and management systems around urban digital models
- Development of new solutions to guarantee the reliability and accuracy of sensors deployed in smart cities
- High level of existing sensing/ measurement capabilities
- Centralised implementation of self-tests and failure detection algorithms to check equipment remotely

3

Energy production & storage

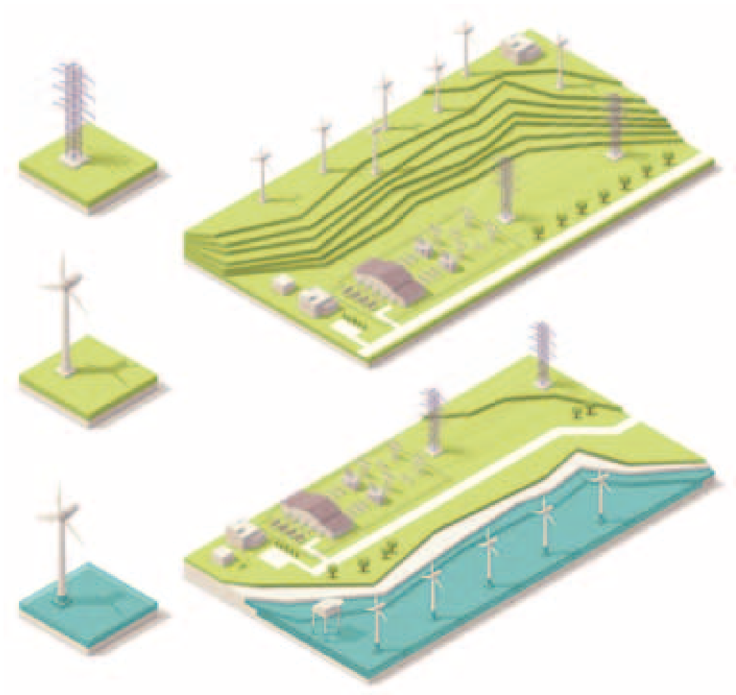
Integrated planning of energy systems with open access to up-to-date information about existing and planned buildings, infrastructures, energy systems and sources, and tools for holistic performance assessment.

Integrated Planning Tools for Energy Systems

Description

Frank is working on planning the energy systems in new districts in the Happyville City. He uses a planning tool that is linked to other planning tools and data sources (traffic, detailed city planning, water and waste infrastructure, etc.). The tool shows available energy systems and possible energy sources, and assesses their environmental, social and economic performance. He can use the tool to find the optimal energy solution based on the value criteria set by the local decision makers. Changes in the city plan which influence energy demand, size of distribution losses or available roof space for solar panels are automatically sent to Frank and his planning team; they can then take these changes into account in choosing the optimal energy system.

Energy planning was challenging for Frank. Districts are often in a state of change: buildings are being renovated or demolished and new buildings being added. His planning tool takes all of these changes into account. Frank's team is currently planning the extension of the district heat network to a new residential area. Yesterday he received information about a major renovation activity in one of the large buildings. This will reduce energy consumption significantly and will



impact on the district heating and cooling network. Frank uses the tool with the new information and reaches a conclusion. The new district should have a local network heated by ground source heat pumps and solar collectors. Some of the buildings should increase their thermal mass and use advanced hot water saving appliances to decrease the maximum peak demand and therefore reduce costs of the system. The tool gives the necessary information to show the decision makers the implications of this new option.

Impacts

- Reduced primary energy consumption by holistically and optimally planned energy systems
- Reduced energy costs
- Reduced emissions
- Reduced transmitting losses of heat/energy
- Time saved in the planning stage of energy systems
- More open planning process, environmental, social and economic impacts visible for different energy systems

Stakeholders and Beneficiaries

- Energy companies
- City planners
- Inhabitants
- Energy Service Companies

Progress beyond State of the Art

- Data handling methods and tools needed
- Development of integration of existing tools, e.g. GIS integration to existing tools
- Development of business models required.

"One barrier for energy efficiency in the city is the evaluation criteria for the planned projects in the city. These criteria follow the ordinary logic of the lowest cost instead of the most energy efficiency. It is hard to convince people that energy efficiency projects will generate revenues in the future, and pay back investment costs in terms of energy savings. In this context, an integrated planning is essential to facilitate communication between stakeholders on energy efficiency performance."

Gloria Piaggio
City of Genova
Head of EU projects in Genova City Council

4
Energy distribution

Energy brokering and saving (ESCO) services to producers and consumers helping them to reduce overheads for energy management, balance loads, save energy/costs, and generate income.

Energy Brokering System

Description

Kate works as an energy broker in the energy service company Greensystems. The company has contracts with local energy producers and consumers to purchase and sell energy on their behalf. Her first task at work is to check the energy planning tool forecasted energy production for the day. This is based on information from the regional network of local weather stations from photovoltaic panels, solar thermal collectors, wind mills and available capacity from the biogas plant of the Sunny Valley City. She sees the predicted solar energy production will be good in the next few days due to a sunny weather.

Kate receives a notification that the energy system is automatically adjusted to rely on solar energy, thus saving city's biogas sources for usage during night and winter time. This means that both the electricity and thermal energy storage start uploading the excess solar energy production through automated control. Plus she makes a special offer to electricity grid operators and to thermal users in the city to buy the energy.

In addition to brokering, Kate provides energy saving services as an ESCO for the optimisation of energy on behalf of her customers. All buildings and local producers have their own energy management systems and some of them have authorised Kate to access some information and send control signals. She uses an ICT system for this. This system also interacts with the external energy suppliers to provide pricing information. Relying on the economic information from dynamic pricing systems, she sends signals to her customers' energy management systems about profitable actions. For instance, electricity cars are set to upload the batteries between 11:00 and 14:00.

During the day Kate also supervises the peak power demands. These are linked to the electricity price. On a few occasions she signals to the large energy consumers, such as shopping and office centres, to shift loads to minimise the overall peak power demand, keeping the cost level of electricity steady. Based on the ESCO contract, Kate's company utilises the roof surfaces of the shopping centre for electricity production with photovoltaic panels. In addition to sales of energy, an agreed part of the customers' cost saving goes to Greensystems.

Impacts

- Savings and balanced energy production and consumption at district level
- Reduced efforts of stakeholders for energy management, for example for optimising energy consumption, peak saving and managing renewable energy usage
- New business opportunities for energy service companies via ICT verifying savings due to the broker's actions
- Creating a market for a new ICT service which integrates energy management and brokering systems with pricing forecasts and user profiles

Stakeholders and Beneficiaries

- Energy service companies
- Energy providers
- Consumers

Progress beyond State of the Art

- Energy brokering system for buying and selling energy
- Standards for communication protocol between various energy management & brokering systems and the grid concerning e.g. pricing, forecasts, user profiles, offers to sell, buy, etc.

4 Energy distribution

Service for optimised delivery of biomass (e.g. firewood) in rural areas: locating suppliers, coordinating group ordering, optimising transport to clients in the area and providing storage nearby.

GotWood? – Application to Optimise Delivery of Biomass Fuel in Rural Areas

Description

Matti lives in a remote area. The nearest shop and bus stop are seven kilometres away from his house. Living in such a sparsely populated area, people rely on efficient and reliable supplies of goods and energy. Matti is a busy man and he also likes the idea of having his wood conveniently transported directly into his storage room whilst reducing his environmental impact.

Matti's neighbour showed him "GotWood?", a dedicated tool for mobile devices to locate the closest and most efficient wood suppliers in the region. The tool has a simple, user-friendly interface. It can also operate through the mobile phone networks. His neighbour uses it regularly to order wood with the lowest carbon footprint. He also suggested that they should pool their deliveries in order to save more money.

When wood gets low in Matti's store, he uses the "GotWood?" app on his smart phone to look for the latest offers on wood. The application assists Matti in taking an environmentally friendly option by evaluating the carbon footprint of the supply. This is arrived at by calculating the distance of transport from the supplier, the origin of the wood, life cycle assessments and humidity. If Matti does not need the wood straight away the application can offer to pool the transport for further reductions. At the press of a button Matti will receive price offers on his selection of suppliers and the winning supplier will transport the wood directly to his house.

This e-market solution for biomass fuel (e.g. wood), leads to optimised logistics as well as assistance in making informed decisions. The service is attractive for an ageing population and people with disabilities. The tool can be extended to other forms of energy such as plant oil or services such as food delivery or cesspool cleaning to maximise the platform's impact on energy efficiency.

Another important service of "GotWood?" is the optimisation of storage services of wood. Firewood for the winter requires more room than it is available in Matti's house; however he cannot spend long days moving the full load under cover during the rainy autumn. Therefore he needs to order firewood twice a year from wood suppliers. Matti could get the firewood cheaper if it is not dry but then he would need to store it for 2 years. Matti's neighbour has under-utilised farm buildings that could be used as storage. Matti could then transport smaller amounts a few times with a trailer or he could bring it to Matti with his tractor. This could cost less than paying for multiple transports or building larger storage.

There are more people like Matti that need firewood storage space in the neighbourhood. Matti's neighbour could be interested, especially as his farming activities are quiet in the winter.

The "GotWood?" platform offers the functionality of matching demand/offer of firewood storage services in order to optimise the sharing of storage available in the neighbourhood. Through the tool Matti will easily find firewood storage closest to his location, payment to the neighbour offering the space will be facilitated by the platform.

Impacts

- Decrease of energy consumption related to transport of biomass fuels
- Increase energy awareness of the community

Stakeholders and Beneficiaries

- Inhabitants of rural communities
- Suppliers of wood
- Associations of wood suppliers

Progress beyond State of the art

- Develop a centralised database of suppliers of biomass resources
- Semantic representation of wood suppliers' data from many sources
- Study on human machine interaction with focus on rural areas, for instance the study of simplified interaction with internet systems and real world

"The harmonisation of various standards between tools and instruments is quite an obstacle to overcome. We should not discuss real-time monitoring when preconditions such as standardisation of mobile devices and good internet connection are not in place or are too costly. In this regard, the telecommunication companies are very important stakeholders in the neighbourhoods. They play a significant role from planning policies to implementation activities, such as providing free Wifi spots. The better we interact with them and the better we align strategies, the better services we can provide to our citizens."

Inete Ielite
City of Riga
Riga SEAP Management Board Member

5 People involvement

Social networks for sharing information about good energy efficiency practices among people living in the same area. Provide incentives e.g. bonuses/discounts offered by commercially sponsored campaigns.

A Social Network to Connect Neighbours

Description

Placing value on existing neighbourhood communities, building a "sense of place" and educating them to good energy efficient practices are essential to improving neighbourhood sustainability.

The municipality has implemented a social network platform called EE-NEIGHBOURS where individuals register as members to a particular neighbourhood community. From this platform the citizens can share information and access a whole series of services aimed at improving the neighbourhood's energy efficiency and people's quality of life.

These services are:

- Interactive and shared information about good energy efficiency practices
- Information about activities organised in the neighbourhood in order to strengthen the social relationships among the people living in the same area and educate them on energy efficiency
- Information about other people living in the area and neighbourhood services, the closest supermarket, bicycle shops, etc.

Participation to the program can be incentivised through commercial bonuses and discounts offered by commercial activities in the neighbourhood that support the initiative.

Marc has been a member of EE-NEIGHBOURS for one year and he is about to move to a new neighbourhood. He is going to move on Friday and on Wednesday he notifies EE-NEIGHBOURS of his new address. He can now access all energy relevant information about the new neighbourhood; for example he can compare electricity costs. He is also told about a bike sharing station just one block away.

On Saturday EE-NEIGHBOURS notifies Marc that another neighbourhood member, Alicia, is using an innovative heating method to save energy and Marc has the option of contacting this person for more information. The network informs Marc that next Sunday the municipality is organising an education activity to promote the use of bikes in the neighbourhood offering a guided city bike-tour.

Impacts

- Improve people awareness on energy efficiency good practices and reduce energy consumption
- Build a "sense of place" and strengthen the social relationships within the neighbourhood communities
- Improve quality of life in the neighbourhood

Stakeholders and Beneficiaries

- Inhabitants
- Those who have a role in promoting good energy efficiency practice within the neighbourhood community, for example the city municipality and the country government

Progress beyond State of the Art

- Type and scope of the application is new and involves the integration of mature technologies

"Barriers to energy efficiency are more varied and context-dependent than a simple lack of information. A process of user involvement, developing innovation in real world context, delivers a greater impact than a standard automated control solution by exploiting local knowledge and preferences to specify context-specific measures. The research demonstrated the potential for social media engagement to extend living lab style innovation to wider participation – potentially incorporating the majority of a neighbourhood community. In terms of the IREEN aims to guide future innovation in ICT for energy efficiency, this work makes an important contribution to the discussion over greater automation versus greater user involvement, significantly in support of the latter."

Matt Batey, Richard Bull and Regis Decorme
From the scientific paper
Living labs: Successful User Engagement on Energy-efficiency through Participatory Innovation

6
Additional scenarios

Here are more examples how ICT could contribute to energy efficiency in neighbourhoods.

Neighbourhood

—

Scenario 1.2
Integrated ICT environment for holistic, monitoring, control and operation of distributed generation, storage and consumption.

Transport

—

Scenario 2.2
Service for optimising the charging schedule of electrical vehicles and guiding users to find charge points and pay for their use.

Scenario 2.3
Intelligent self-learning traffic light control giving priority to public transport and collecting data for optimised traffic control and urban (re-)planning.

Scenario 2.4
Optimised use of parking spaces via dynamic pricing and information of available places to users via smartphones or GPS car systems.

Scenario 2.5
Intelligent transport system for rural areas with electric cabs for up to 8 people collected from from multiple locations and transported to common or nearby locations via dynamically optimised routes. Ordering and payment are via smart devices.

Building, infrastructures and public spaces

—

Scenario 3.2
Energy management services at neighbourhood level for various stakeholders: information consolidation and display, alerts on anomalies, benchmarking, demand control/suggestions, optimisation, etc.

Scenario 3.3
Simple tools for end users to design their home and make decisions on technical solutions. integrated with guidance and incentives on energy efficient solutions.

Scenario 3.4
Smart control of heating and domestic hot water combining info display, simple user control, data collection for optimisation at neighbourhood level, billing, etc.

Scenario 3.5
Instrumentation, monitoring and smart control of water supply and consumption in order to save resources, not only water but also significant energy needed for purification, pumping and waste water treatment.

Scenario 3.6

Smart street lighting using LEDs and sensors to dim lights when there are no vehicles or people in the vicinity.

Scenario 3.7

Understanding energy efficiency in rural buildings using infrared cameras, data and best practice sharing.

Energy production and storage

Scenario 4.2

Tools and community services to assess the potential of exploiting pitched roofs for photovoltaic panels and solar thermal collectors, and to optimise their use in the neighbourhood. This is relevant especially in rural areas where large roof areas are available, power outages are frequent or buildings may be off-grid.

Scenario 4.3

Holistic management of energy production and consumption in rural neighbourhoods optimising the use of local microgeneration (e.g. CHP, biomass, wind, PV, solar thermal), storage (e.g. cars, ground as thermal mass) and conversion (e.g. to hydrogen).

Energy distribution

Scenario 5.3

Decision support for consultations between the owner, a local energy champion and remote experts to optimise energy solutions in rural communities.

People involvement

Scenario 6.2

Teaching people to appreciate energy efficiency by capturing energy from their physical activities (e.g. gyms, bikes, etc.) for useful and fun purposes (e.g. lighting, charging mobile devices, earning a small amount by selling to the grid, etc.).

Scenario 6.3

Raising awareness of personal energy footprint via monitoring and collecting data from domestic hot water system and electrical appliances at home; transport, work and leisure with sensors. Providing easy to read visualisations, context driven guidance and benchmarks with friends and community members.

Scenario 6.4

Computer games simulating life in a neighbourhood, giving scores for cost and energy savings. Incentivising people though competition with friends and neighbours.

Scenario 6.5

Smart holidays in rural areas: visitors are provided with a tool that shows to them targets and tips to achieve. They are offered incentives to meet the targets.

Scenario 6.6

Energy production by specialised social enterprises rural areas using a variety of sources: offshore, renewables, biomass, wind, hydrogen, etc. Efficient production, storage and distribution through ICT.

Full scenarios

A full copy of each scenario is available in document D2.2.2 at the IREEN website or with the QR code.

Roadmap

Purpose

The IREEN vision and roadmap for ICT supporting energy efficient neighbourhoods has been created with the help of a community of experts from the EU and beyond. It is based on an in depth understanding of the latest technologies and uses a number of scenarios to show how it might be applied.

ICT plays a crucial role in meeting the challenges facing municipalities as they move towards becoming smart, sustainable cities.

The roadmap shows how ICT can support and enable energy efficiency in neighbourhoods in both urban and rural areas.

The coverage is wide ranging and includes enabling technologies, applications and system integration, standardisation, ICT-based service development and deployment. It looks at energy brokering, the role of ESCOs and the engagement of end users.

The aim is to address the increasing globalisation of the market and the need to prepare European companies across the ICT, construction and energy sectors for both the challenges and opportunities provided by an international market in the field.


Urban
Rural
Energy production & storage
Design planning & realisation
Buildings infrastructures & open spaces
Transport
Integration technologies
Decision support
2:40
People involvement
Energy distribution
Energy management

Vision for ICT enabling energy efficient neighbourhoods

IREEN envisages that the energy efficiency of a neighbourhood can be maximised by considering all energy related systems as a whole.

IREEN envisages that the energy efficiency of a neighbourhood can be maximised by considering all energy related systems as a whole and using advanced ICT. This requires a holistic approach at the neighbourhood (and even city) level and includes the entire energy chain, and all forms of energy consumption and production.

The key principles for achieving energy efficient neighbourhoods are:

a. Minimisation of energy demand through high energy efficiency and optimum energy demand management
b. Reducing energy transmission losses through efficient distribution
c. Optimum energy supply and storage. This includes all energy flows (electricity, heat, cooling and fuels). Energy can be supplied from various energy sources, and their usage is optimised from environmental and economic viewpoints

Peak load demand can be managed, smoothing loading with demand side management according to other energy supplies and demands. Load management would be beneficial to balance pressures at regional and national levels.

There is no single solution suitable for all districts. The local optimum energy solution from a technical, economic and environmental point of view needs to be based on the areas own characteristics, potentials and challenges.

Innovation roadmap

The integration and collaboration of different sectors and expert areas has been identified as one of the key requirements of achieving energy efficiency at the neighbourhood level.

IREEN aims to identify how ICT can support the overall energy efficiency and energy positive performance of neighbourhoods. Technology can support this by providing automation and control, guidelines, design and planning tools, data sharing platforms and data mining methods. ICT can also provide the decision support systems and benchmarking tools for meaningful impact analysis.

The change can be difficult to manage due to the broad range of stakeholders and organisations involved. The integration and collaboration of different sectors and expert areas has been identified as one of the key requirements of achieving energy efficiency at the neighbourhood level.

The stakeholder network includes urban, district and neighbourhood planners, transport system designers, energy companies and designers, ICT experts, and local people living and working in the area. It follows that governance issues, particularly privacy, security and data protection should be given high priority.

Different departments of municipalities have traditionally operated with a high degree of autonomy. This is also often the case for energy, construction and ICT companies. Communication and co-operation between the stakeholder networks can therefore be difficult. This problem needs to be addressed from the start for the innovation roadmap to work properly.

City representatives face an economic challenge to finance energy efficiency measures and source ICT investments as well as understand the costs and benefits (ROI) of solutions. They are inevitable concerns about return on investment and pay back times. One of the representatives interviewed stated that “it is hard to convince people that energy efficiency measures will generate revenues in the future, and pay back the investment costs.” Hence the need for new business and financing models.

The roadmap

Structure of the roadmap

The roadmap has been structured into 8 sections:

The first section is focused on urban and rural neighbourhood planning, design and operation as well as decision support.

The following five sections present application areas, the focus being on the planning, design and operation, and decision support needs of each:

- transportation
- buildings, infrastructures and public spaces
- energy distribution
- energy supply
- people involvement

Two separate sections on energy management and integration technologies focus on cross-cutting issues.

Integrated city planning and management

Integrated city planning and management is critical to kickstarting the transformational change needed to become a smart city or neighbourhood. Retrofitting of existing neighbourhoods is an important issue. City representatives expressed enthusiasm for access to and use of 3D models (e.g. for analysing the shading caused from buildings and trees to solar panels), use of geographic information systems (GIS) for spatial analysis and urban planning, and simplified CO2 calculations to identify trends. One of the keys to providing a holistic view point is the integration of different experts into the planning process from the start.

It is important to provide support for decision makers with an analysis of different options and their impacts, as well as by helping them to comprehend the added value of ICT investments over the long term. **Decision support** tools play a crucial role for performance assessment, benchmarking and easy-to-understand visualisation of different options and their economic, environmental and social impacts.

People are genuinely interested in meaningful, visualised monitoring application that gives them the ability to control their real time energy use.

IREEN application areas: planning, design and operation, and decision support needs

Improvements in the **energy efficiency of transportation** were reviewed from the view point of how to decrease the transportation needs within a district by providing alternatives. A key issue is the role of the urban planning process as a means to manage and decrease transportation demand. In the planning phase other traffic solutions need to be considered that could compete with the ease and comfort of private vehicle use. Initiatives such as encouraging people to cycle, walk and adopt remote working have much to contribute.

Buildings are considered from the view point of their interconnections within neighbourhoods and not as single entities (this has been raised in other projects, such as [2]). Numerous city representatives highlighted the need to retrofit buildings in order to improve energy efficiency. There is also a need for reliable information about the impact of interventions. Monitoring is essential to compare performance with relation to energy targets. They were also interested in remote monitoring for the control of infrastructure such as street lighting (e.g. dimming). Other topics raised included the integration of renewables in buildings and the ability to balance energy loads.

The self-sufficiency and “energy positiveness” of a neighbourhood was highlighted in relation to **energy supply and distribution systems.** This could be achieved by increased local and distributed energy production combined with waste-to-energy utilisation and efficiently managed energy demand. The optimisation of energy systems and remote management at the city level were raised by experts. A key point is the need for energy flows to be made visible to citizens and stakeholders.

People involvement is essential. It is important to create opportunities for inhabitants to participate in the planning process. Increasing an awareness of energy usage and the possibility for technologies to support people on a day to day basis are part of this. People are genuinely interested in meaningful, visualised monitoring application that gives them the ability to control their real time energy use. They want to understand the financial savings of their energy efficiency actions and the amount of local or even their own energy production.

Energy management

The focus here is on the efficient management of fluctuating energy production and distributed energy production, e.g. through solar, wind and CHP plants.

Neighbourhood level Energy Management Systems (NEMS) are largely automatic and provide control over energy demand together with the aggregation of energy supplies from a variety of sources. A key goal of NEMS is to maximise economic and environmental benefits for energy system users, whilst also minimising energy distribution losses. NEMS offer flexible services, based on real time data, to the overall grid. This enhances the possibility of establishing new markets and improving the overall efficiency of energy supply.

Integration technologies

Integration technologies are one of the most important areas of ICT for improving the energy efficiency of neighbourhoods. Priority development topics include interoperability of systems and tools, open communication and the improved collaboration of different sectors of expertise. The ability to use data from a range of sources underpins these activities.

There is a need for information exchange between the different areas of expertise. For example, urban plans, building designs, geographical information systems (GIS), weather and climate conditions, transport plans and energy distribution network maps all generate complex data sets which would benefit from integration.

The creation of truly energy efficient (or even net zero energy or energy positive) neighbourhoods requires effective collaboration, participation and knowledge exchange between a broad range of experts.

Innovation roadmap

IREEN aims to identify how ICT can support the overall energy efficiency of neighbourhoods. This is complex due to the broad range of stakeholders and organisations involved. The integration and collaboration of different sectors and expert areas has been identified as one of the key aspects of achieving holistic energy efficiency at a neighbourhood level. Traditionally the different sectors of municipalities have operated relatively independently, as is often the case for energy, construction and ICT companies. This can lead to sub-optimised decisions, when planning, operation and controlling are not synchronised.

Drivers

Reasons/motivation why something new is needed or useful

Barriers

Reasons why achieving something new is difficult

Impacts

Reasons why the investment to the described ICT is justified

Stakeholders

Users

State of the art

Summary of current situation

Needed new capabilities in short, medium and long term

Short summary of current situation, including: what is on-going? What is maturity level? What gaps exist?

Vision

Reasons why the investment is justified

Innovation roadmap

Neighbourhood planning

Drivers

Political pressure on districts, urban or rural, to design energy efficient neighbourhoods. Sustainable action plans. The need for retrofit in a large number of neighbourhoods. Opportunities for EE improvements via holistic approaches created by ICT.

Impacts

Optimised energy efficient neighbourhood. Ability to intelligently react to changes. Simplified metrics. Increased synergy for different stakeholders on the strategic vision and long-term actions.

Barriers

Lack of interoperability. Communication and standardisation issues across organisational boundaries. Lack of appropriate data. The challenge to predict the impact of energy efficiency interventions. Length of time of return on investment.

Stakeholders

City planners, inhabitants, energy companies, district network operators, construction sector, transport sector, innovation and digital entrepreneurs.

	State of the art	Short term	Medium term	Long term	Vision
Design, planning and realisation	Sub-system focused approach Non-digitised spatial data Non-integrated databases with limited access Non-interoperable discipline specific tools	• Open access to various databases for design and planning • ICT standards for neighbourhood level information sharing including data privacy	• District-scale design, simulation and multi-criteria optimisation tools • Neighbourhoods configuration tools relying on pre-designed parametric solutions	• ICT tools and platforms for integrated multidisciplinary collaborative design & planning	Energy efficiency at the heart of holistic planning of new and existing neighbourhoods
Decision support		• Visualisation of spatial and other relevant data (e.g. social trends), as well as their impacts and changes related to energy efficiency	• Tools to analyse and visualise neighbourhoods as holistic ecosystems and support spatial planning based on assessment of different design decisions and scenarios and their impacts	• Mature smart neighbourhood models showing interdependencies between energy systems and behaviours	

Innovation roadmap

Transport system planning

Drivers

Increasingly rich information on congestion and population density. Open data driven analysis offering new insights into overcoming the sub-optimisation of transport systems. Changing traffic patterns.

Impacts

Behavioural change in mobility. Reduced pollution and energy consumption. Decreased congestion. Improved manageable traffic flows. Increased reliability of transport. Adoption of 'sharing' concepts. Increased traveler satisfaction as a result of seamless journey experiences.

Barriers

Compartmentalised transport modalities. Conflicting objectives and agendas of stakeholders. Privacy and security concerns.

Stakeholders

Transport authorities and planners. Urban authorities and planners. Transport operators. Energy service and utility companies.

State of the art	Short term	Medium term	Long term	Vision
Basic analysis tools for the information provision of the traffic impact of urban design interventions Transport systems optimised for journeys using a single modality, with limited historical data and contextual information Immature data sets for transport patterns, usually excluding energy impact	**Design, planning and realisation of transport systems**			Manageable transport patterns based on optimised data and interactive transport infrastructure
	• Advanced information models describing interaction between working, living and consuming • Techniques and models for integration of ICT solutions in transport infrastructures • Tools for modelling, simulating and visualising energy demands & availability near transport infrastructure	• Virtualisation of work, services and retail activities, integrating the consumer processes • Information exchange between transport information systems and energy management systems • Flexible transport system planning adaptable to changing demands • Multi-modal transport hubs enabling vehicle switching and ride sharing for seamless journeys using historical transport data	• ICT for the joint planning of traffic infrastructure • Billing and routing tools based on automatic information provisioning • Systems for traffic flow prediction and real-time management	
	Decision support for transport system planning			
	• Standardised data sets for analysis relating individual transport needs and building profiles	• Multi-stakeholder planning tools for transport infrastructure placement	• Predictive analysis based multi-stakeholder planning tools for integrating transport infrastructures	

Innovation roadmap

Buildings, infrastructures and public spaces

Drivers

Regulations and urban policies. Incentives for “smart grid ready” buildings and infrastructure. Opportunities for energy efficiency driven businesses. Energy market liberalisation.

Impacts

Life-cycle optimised buildings as integral nodes of neighbourhoods. More informed decision-making. Full interoperability between applications.

Barriers

Lack of interoperability standards, limited access to operational/dynamic data, low consumer engagement. Possibly conflict requirements from stakeholders. Prevailing business models focus on delivery cost instead of value to client. Separation of organisational capital expenditure and revenue expenditure budgets.

Stakeholders

Building designers, city planners, inhabitants, facility managers, energy companies, ICT tool development companies.

State of the art	Short term	Medium term	Long term	Vision
	Design, planning and realisation			
Tools focus on energy aspects at single building level Design tools do not integrate reliable prediction of performance during operation Public lighting systems are not optimally designed to adapt to use & environmental conditions Smart metering is on-going for monitoring and billing, but not for decision-support at neighbourhood level	• Capitalised/typified knowledge on building consumption & usage profiles • Models & techniques for embedding ICT solutions in building renovation • Databases on human and material local resources, best practices, investment guidance • LED-based lighting with intelligent control	• Models and tools to predict/ simulate energy behaviour of buildings interacting with other nodes and smart grids • Semantic & interoperable LCA-based performance assessment tools • Configuration tools relying on pre-designed parametric solutions, for design or renovation of neighbourhood buildings, taking into account empirical rules and operational constraints & strategies	• Fully interoperable multi-criteria design & realisation based on ICT standards and platforms for information sharing • Tools for optimised design or renovation of buildings	Optimised energy design of buildings, infrastructure and public space, taking account of all potential interactions between neighbourhood components
	Decision support			
	• Collection and visualisation of available open data at neighbourhood level for building end-users’ awareness and benchmarking	• Interoperability standards, methods and tools to integrate and analyse monitored data, and support decision-making by final users and other stakeholders (including commissioning)	• Self-learning systems for optimised decision support	

Innovation roadmap

Energy distribution

Drivers

EE business models & markets. Faster, cost effective solutions through improved design & planning, efficient use of existing capacity, methods for holistic planning. ICT supported customer transparency, involvement, cost reductions, social aspects.

Impacts

Increased energy efficiency of transmission, operation and utilisation of existing capacities. Increased grid friendliness and services. Holistic planning and global optimum designs. Increased reliability and security of supply. Variable pressure networks.

Barriers

Added complexity of ICT controls. Cyber security and privacy issues. Interconnected networks architecture requires change in paradigms, operation, and policies outside of core competencies. Existing structures not holistic. Long innovation cycles.

Stakeholders

Distribution network operators and designers, plant operators, energy service and utility companies, local authorities, municipal energy planning offices and policy frameworks, ICT companies.

State of the art	Short term	Medium term	Long term	Vision
	Design, planning and realisation			
Isolated planning and operation of networks, optimised at local level. Long investment horizons, focus on security of supply	• Modelling & simulation tools to assure flexible and adaptive energy networks • Extend design methods with dynamic considerations and utilise detailed data	• Lifecycle data model of energy infrastructure data • Concepts for stakeholder involvement and collaboration	• Integrated simulation and optimisation of complex interactions in different energy domains • Network construction and maintenance management systems at neighbourhood or city level	Optimally planned and operated distribution networks across domains connecting stakeholders
Smart meter rollouts. Vendor specific approaches	• Harmonisation of data exchange formats of planning data			
Pilots of connected micro CHP, real time markets, vehicle to grid integration, DSM, storage management		• Integration of planning tools to share information on a neighbourhood scale		
	• Security practices for handling increased complexity and issues of interconnected energy networks			
	Decision support			
Central management of distribution networks	• Concepts for use of smart meter data (privacy, ownership, benefit sharing, unified access) • Concepts and tools for proactive maintenance of energy distribution infrastructure	• Profiling of energy distribution grid data • Models and methods to handle complex interactions between different domains assisted by context aware decision support with real-time data	• Methods for sharing data for advanced (e.g. model predictive) control techniques • Methods for systematic operation optimisation	

Innovation roadmap

Energy production and storage

Drivers

Increasing complexity due to transition towards multi-energy source production and a growing share of distributed and renewable energy production (with variable generation).

Impacts

Optimised use of energy (renewable) sources resulting in reduced environmental impact. Increased reliability and security of energy supply. Paradigm change of co-production and management from centralised to distributed systems. Holistic & optimal planning process.

Barriers

Complexity, standardisation and compliance are costly and time-consuming. Integration challenges with respect to various ICTs, organisations, stakeholder groups and processes. The optimisation criteria for decision support under political debate.

Stakeholders

Energy producers and companies, energy storage operators, district heating and cooling companies, prosumers, cities, rural/ urban and building planners.

	State of the art	Short term	Medium term	Long term	Vision
Design, planning and realisation	Tools for designing, modelling and simulating centralised and single energy production units separately Energy production of a neighbourhood not optimally planned No holistic approach to design and operation with various fluctuating energy sources	• ICT to support evolving business models, guidelines, regulations, rules promoting co-operation and coordination at different levels • Interoperable modelling and simulation tools for holistic planning of multi-energy systems as required for different levels of planning	• Interoperable databases / data sharing platforms with open access interfaces, enabling access to various data: urban plans, GIS, weather data, buildings, etc. • Interoperable optimisation tools for the planning phase, with life cycle and sustainability approaches & access to relevant information from multiple sources	• Collaborative design environments enabling stakeholders to view and comment on plans from a range of expertise areas	Optimised multi-energy source production & storage, enabling a balanced and holistic life cycle approach
Decision support		• Methods for the prediction of energy production and storage in relation to energy demand based on simulations, historic data, weather data, etc. • Visualisation of results • ICT supporting optimised usage of multi-energy source mix	• Visualisation of potential alternative energy sources and their impacts • Visualisation of predicted and current energy production & storages and demand in a neighbourhood	• Tools for assessment of energy, exergy and sustainability of multi-energy systems of a neighbourhood at the design/planning and operation phases	

Innovation roadmap

People involvement and empowerment

Drivers

Expectations of improved comfort and sustainable lifestyle. Social pressure. Diffusion of mobile technologies. Possibilities for financial return.

Barriers

Lack of awareness and motivation of people towards EE. Lack of awareness of ICT potential for EE. Resistance to change behaviour and lifestyles. Limited financial ownership of neighbourhood energy systems.

Impacts

Energy efficient behaviour via awareness on EE practices and related cost savings. Influence of inhabitants on neighbourhood design and planning. Faster communication and feedback loops with the planning group. Energy production optimisation by extensive use of renewable sources (concept of 'prosumers'). Increased value on existing neighbourhood communities.

Stakeholders

Inhabitants. Prosumers. Municipalities, public authorities and governmental institutions (as responsible of informing people on energy efficiency). Community groups and owners. Utilities.

	State of the art	Short term	Medium term	Long term	Vision
Design, planning and realisation	Governments / cities / authorities publishing plans on the internet and invite comments from people Generic information on EE and carbon footprint issues in isolation of real time information from the neighbourhood systems	• Web and social media for viewing and commenting on designs • Exploitation of mobile applications to improve information sharing (e.g. from smart meter) and participation in the design process	• Virtual environments where information is exploited to show to inhabitants the EE and advantages of proposed design solutions	• Collaboration platforms to create opportunities for inhabitants to influence neighbourhood planning	Active and informed inhabitants with maximium EE behaviours Sustainable buildings and neighbourhoods meeting inhabitants expectations and aspirations
Decision support		• Web and mobile applications to monitor energy data for activities in the neighbourhood and provide EE suggestions • Applications in existing social networks aimed at sharing information on EE good practices	• Web and mobile applications for visualisation of energy consumption, savings, benchmarking and predictions	• Competition and gaming mechanisms to incentivise inhabitants to use data from intelligent monitoring control installed in the neighbourhood	

Innovation roadmap

Energy management

Drivers

Regulations for smart metering systems. Opportunities for better energy management due to future internet technologies enabling easy to deploy and cost effective systems. Open data trend.

Impacts

Neighbourhoods transformed into active entities in the energy market enabling ICT-based products/services for energy efficiency and energy management at neighbourhood level. Redundant energy sources increase reliability of supply.

Barriers

Different legacy energy management systems using proprietary formats for data exchange. Lack of integration with other ICT systems (e.g. traffic systems, security systems). Regulation barriers.

Stakeholders

Households, building owners, building maintenance companies, energy management companies, municipalities , energy brokers, ESCOs.

State of the art	Short term	Medium term	Long term	Vision
Buildings' energy management solutions at a mature level. Neighbourhood networks in earlier development Topics are addressed by on-going research projects. E.g. adaptation of the electrical network to allow bidirectional energy exchange on the grid	**Intelligent monitoring and control**			Planning, monitoring, control and management systems for dynamic energy market enabling neighbourhoods
	• Interoperability of existing BEMS • Intelligent e-vehicles charging system • Data models supporting information exchange	• Methods for optimising multiple energy elements • EMS enabling active components/ nodes reacting to neighbourhood level dynamic changes • Advanced prediction strategies and methodologies • Tools to manage and optimise EE mobility	• Systems for holistic real time management of energy • Self-learning EMS • Methods for big data collection and advanced real time analysis	
	Energy components and smart grids at the neighbourhood level			
	• Methods for optimised utilisation of DER • Management systems for microgrids	• Modular energy components and control systems, and flexible configuration methods. • Cellular (modular) control architecture between different hierarchy levels	• Systems to coordinate energy flows between different neighbourhoods	
	Energy efficiency services: business concepts and financing			
	• Identifying regulation barriers and how to overcome them	• Tools to neighbourhood stakeholders for balancing supply and demand in energy trading	• ICT tools, interfaces and e-market places for neighbourhood energy trading	

Innovation roadmap

Integration technologies

Drivers

Energy efficient neighbourhoods require integration of processes and systems for design, planning, transport, energy, automation, control, etc.

Barriers

Privacy: regulations prevent use of users 'energy consumption patterns and citizens' concern on data privacy. Lack of standards.

Impacts

Holistic processes to manage and optimise energy related systems at neighbourhood level. Open access to data. Enhanced exchange of information and knowledge between stakeholders. Integrated workflows.

Stakeholders

ICT developers and system integrators. All stakeholders as users of communication tools.

"ICT solutions are essential to obtain detailed and real-time energy consumptions follow up, thus allowing to evaluate precisely the impact of energy saving measures including traditional retrofitting actions. When conducting those actions, it is important to think about preparing the buildings, infrastructures and networks to embed ICT solutions in a near future. In this context, issues of proprietary communication protocols from equipment manufacturers have to be addressed."

Yves Prufer
Deputy Director Energy & Environment
Métropole Nice Côte d'Azur
Marie Tatibouet
Energy Officer
Métropole Nice Côte d'Azur

State of the art	Short term	Medium term	Long term	Vision
Process integration Mature, widely used methods available to manage non-integrated processes of district services	Process integration • Business process modelling and cross-organisational process integration at district scale	• ICT applications for managing cross organisational processes and information flows	• Process models for EE process integration at district level including performance indicators and methods to derive them from ICT systems. Data models for information exchange at high level of semantics	Neighbourhood systems well integrated and interoperable with a trustful and reliable EE data and EE knowledge sharing
System integration and open data Dispersed data integration limitation due to proprietary semantics and formats. Accessibility and interfaces limited to few stakeholders	System integration and open data • Solutions like middleware and service oriented architectures using cloud to integrate systems for data management applications, gateways and communication channels • Open access to energy data • Energy-related data governance models to enable the integration of different systems	• Energy-focused data models to enable data exchange and interoperability between applications and data sources • Standardised APIs provide access to data with different consolidation levels to comply with privacy and security of information regulations and end user requirements		

Interoperability & standards
ICT platforms for exchanging information from a range of data sources at building scale.
No platforms at neighbourhood scale

Interoperability & standards

- Deployment of standards for data models and communication protocols to support the interoperability of EE systems at applications and district scale

- Data consolidation level defined for exchange of energy data at neighbourhood scale from legacy equipment and stakeholders

- ICT platforms to support multiple simulations and controls for EE management of systems at neighbourhood scale

Neighbourhood systems using open standards to access reliable EE data for knowledge sharing

Knowledge sharing
Limited capacity extract data on energy efficiency.
No ability to contextualise data to other areas (e.g. health, mobility)

Knowledge sharing

- Open access to energy-related data in city silos
- ICT solutions to store, analyse, and visualise energy data

- Services providing data in distributed repositories (e.g. web, cloud services, information brokering, etc.) via data mining
- Algorithms to extract knowledge, patterns and energy indicators

- Pervasive knowledge sharing infrastructures supporting flexible solutions adapting to increasing complexity. (e.g. intelligent product catalogues for design and planning)

Virtualisation of the built environment
Telepresence and teleconferencing reducing travelling and increasing flexible working.
Cloud computing as space and energy saving

Virtualisation of the built environment

- Cloud based tools enhancing communications and information exchange between users.
- Collaborative tools for neighbourhood teams

- Virtual hardware providing network based services to provide a range of services across locations
- Services and tools for car sharing and customer driven public transportation
- E-services (e.g. public services, retail, etc.)

Neighbourhood systems using open standards to access reliable EE data for knowledge sharing

Privacy and security
Privacy & security of EE neighbourhoods linked to the smart grid. (e.g. IP based security technics)

Privacy and security

- Improvement to regulations and legal frameworks for rights of ownership, access and aggregation of EE data
- Models using IP-based security technologies at neighbourhood scale

- Methods and principles to anonymise stakeholders energy data for sharing

Energy efficiency in rural areas

Rural areas offer considerable potential for renewable and distributed energy solutions including micro-CHP and off-grid systems.

Special characteristics of rural neighbourhoods

Experts contributing to IREEN have stated that the majority of ICT solutions supporting urban and rural communities are broadly similar. Both need access to innovative business and financial models to fund proposals aimed at optimising energy efficiency. In each case these must fit unique local conditions. Both have legacy stocks of buildings that require upgrading. This is particularly true of rural areas where buildings are often older and less energy efficient.

Rural areas offer considerable potential for renewable and distributed energy solutions including micro-CHP and off-grid systems. They may also offer the option of producing additional energy utilising biomass and wind power.

Rural communities also present other unique challenges.

Improving energy efficiency in rural areas is made more problematic by population dispersal, often at low densities. This coupled with a dispersed energy infrastructure and an ageing building stock can make investment in improving energy efficiency unattractive since the financial return is likely to be very low or even negative.

The problem is made worse by rural depopulation. This affects the age structure since it is mostly working aged people who leave. Second homes can also result in a fluctuating population resulting in an impact on energy demand in areas where supply, particularly electricity, may be comprised.

Mobility patterns are different in rural areas where the use of private vehicles cannot be easily substituted. This leads to a higher environmental impact per head, rural areas usually have higher fuel costs.

Typically people living in rural areas are more self-supporting and independent. They may also have a stronger sense of individualism and can be more resistant to change. In some European countries energy poverty is more acute for rural households in areas where household income levels are lower than their urban counterparts.

The development needs of rural energy efficiency

Whilst there are clearly physical differences between urban and rural areas, when it comes to implementing ICT solutions such as control systems there are many similarities.

It is more challenging to increase the energy efficiency of rural transportation by means of neighbourhood planning. The combination of physical distance between places and low population density intensifies the problem. A partial solution lies in upgrading broadband connectivity in rural areas in order to reduce the need for personal mobility.

Against this it should be noted that there are now mature renewable technologies which, applied intelligently, could make some rural areas net exporters of energy.

Benchmarking against countries external to the EU

IREEN's findings have been benchmarked against non-European countries. The BRIC countries being a good example. Improving energy efficiency and the exploitation of renewables is high on their agenda, yet there are few examples of this at the neighbourhood level. Brazil, China and India all now recognise the need to raise awareness to improve energy efficiency in the general population.

Significantly South Korea, which already has broadband speeds which are much faster than those in most EU member states, has some advanced local area systems under way. The Korea Micro Energy Grid [11] is a significant development project for optimal total energy provision in an area in South Korea.

Brazil, China and India all now recognise the need to raise awareness to improve energy efficiency in the general population as a first step.

Turning the roadmap into actions

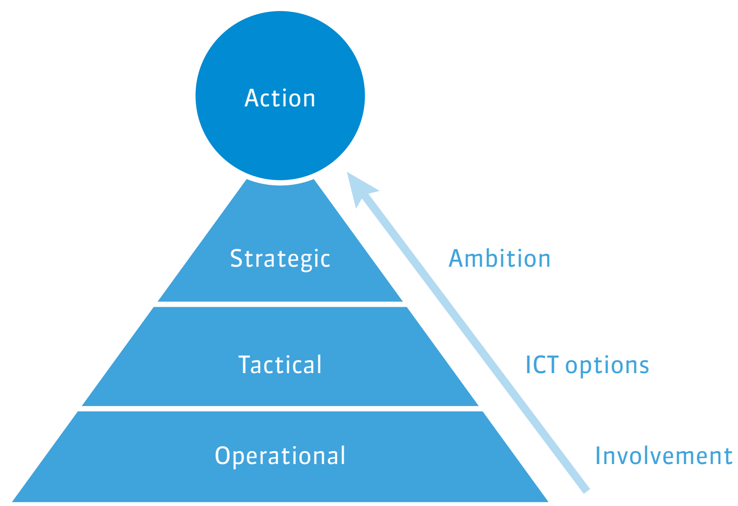
IREEN has developed a toolkit based on the roadmap. This can be used to highlight options for improving energy efficiency in any specific neighbourhood. It can be used by local organisations that want to improve the energy performance of their area. It offers guidance in:

- Linking local strategic agendas to EU developments and funding programmes
- Matching local objectives to innovative technologies
- Assessing the relevant stakeholder roles and perspectives
- Building consensus on taking action

Using the toolkit, stakeholders can find new opportunities to combine applications and technologies. They will also be able to best prepare their region for future actions by aligning their ambitions with the European agendas that are being developed in this area.

The toolkit is evidence based. It has been structured by the outcomes of interviews with key practitioners and the conclusions of expert workshops. Users of the toolkit will be presented with a range of options which they can then analyse and discover for themselves which are the most appropriate to meet their unique local needs.

The toolkit material is available online [12]. The roadmap, the vision against which it was validated and interviews with city managers are available on the EC hosted IREEN Wiki [7] (access to the European Research and Innovation Participant Portal is required [13]).



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As a signatory to the Covenant of Mayors and a founder of the Green Digital Charter [14], Manchester is proud to support the development of the IREEN roadmap. The city has ambitious targets for the reduction of carbon and the development of energy efficiency. Elements of the roadmap focusing on the need for interoperability and data standards complement our approach for a data observatory incorporating energy data. Alongside this is the need to utilise technology to its full potential with plans for district level interventions, including an energy network for Manchester city centre. My hope is that the IREEN roadmap will support cities across Europe to identify key elements for the use of ICT for energy efficiency and offer a vision going forward."

Cllr Nigel Murphy

Councillor Nigel Murphy,
Executive Member for the Environment,
Manchester City Council, UK and Vice Chair of
Eurocities Knowledge Society Forum (KSF)


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