Developing a Strategy for the Implementation of ICT in Energy Efficient Neighbourhoods

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ABSTRACT

A support and coordination project called IREEN was set up to explore potentials of Internet Communication Technologies (ICT) to increase energy efficiency for neighbourhoods and large scale urban and rural areas. The outcome is a detailed strategy for the innovation process and an European ICT roadmap for innovation and take-up. Activities include analysis of state of the art and best practises as well as the description of relevant visions and scenarios. A group of selected experts from a broad range of fields different fields validates the outcomes of the project. Representatives from cities are involved at early stage to ensure the practicality of outcomes. Both the strategy and roadmap will result in an ICT reference guide which should help urban planners in the development of energy efficient districts and neighbourhoods. The outcomes of IREEN are expected to provide input to the next EU research initiative Horizon 2020.

Keywords

ICT for energy efficiency, neighbourhoods, strategy, roadmap

1. INTRODUCTION

One of the main challenges in developing a strategy for ICT implementation arises from the fact that the development and implementation of ICT is scattered over different fields and disciplines. In the case of energy efficient neighbourhoods the focus lies clearly on energy as the central factor. However, not so many changes related to the integration of ICT in everyday practices are motivated by energy considerations [9]. Therefore different fields have to be considered in a holistic view. IREEN covers the scope of various fields, namely ICT, construction, neighbourhoods and energy with topics of smart buildings, ecodistricts, smart cities, energy storage and trading, distributed energy generation, smart lighting, smart grids and smart meters. The activities are targeted towards the construction research community and industry, the suppliers of ICT technology, local authorities including large facility managers and owners, energy producers and providers developing new services, as well as end users profiting of local benefits and utilization of new ICT services.

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The consortium comprises of various European actors in the field of ICT, construction, energy efficiency and environmental management as well as representatives from neighbourhoods. This allows a comprehensive view on the subject together with stakeholders on the approach developed in IREEN. As IREEN follows a holistic approach, it covers technology areas in design, planning and realisation, decision support, energy management and integration technologies at a high interdisciplinary level. As a result, the common language must stay general, allowing experts from different fields to discuss about the topics. This is also the reason why the approach used in IREEN cannot go into too much detail within the different disciplines. The technology areas cover applications in neighbourhoods, transport systems, building and public spaces, energy production and storage, and energy distribution. Finally, end-user involvement plays a crucial role as the quality of a neighbourhood energy system is not only defined by the energy supply perspective, and the energy use is highly dependent on end-user behaviour. Also energy savings through behavioural change are recognised to be as high as those achieved using technological solutions [6].

The overall objective is to deliver an ICT strategy of innovation comprising of actions to be taken to ensure successful implementation. It covers an analysis of drivers and barriers, impacts and stakeholders at various time horizons and a definition of priorities. The ICT strategy is followed by an ICT roadmap of innovation for energy efficient neighbourhoods as a step wise approach to meet the ICT strategy of innovation. Practical measures and quantification of their impacts are not in the scope of IREEN. Consequently they will follow as one of next major actions after the strategy and roadmap are available. As we recognize the importance of understanding how this should happen, we deal with those matters in the section impact (see Page 5).

The objectives are supported by building a community of interest through regular expert hearings. The advisory expert group feeds back to the outcomes for the purpose of revision and validation [4]. The participation of experts from relevant fields is open and we will be happy to welcome new experts to the workshops. An events calendar, newsletter registration and further information for participation can be found on the official IREEN website [5].

The following chapter explains the method used in IREEN. It is followed by preliminary results as the project is in mid phase of completion. These consist of a description of the

developed taxonomy matrix, an analysis of researched state of the art projects and an introduction to the development of future scenarios. The paper concludes with how the results of IREEN can be exploited and what impacts can be expected.

2. METHOD

To reach the objectives of IREEN a clear methodology has been set up that allows defining the steps towards the development and implementation of different ICT technologies within an emerging interdisciplinary field. The development of a roadmap, due to difficulty and complexity, relies on single technologies and application areas, which will define consequently interfaces and interlinks between them. The approach used in IREEN has been initially developed within the REEB initiative [1] and is currently being used also in the ICT4E2B forum [4] and REViSITE project [7]. The approach has then been adapted to be suitable to reach the objectives of IREEN and consider technological singularities within its scope. The aim of this paper is to explain how the method is applied to the specific case of ICT for energy efficient neighbourhoods.

In general the approach consists in creating a community of interest that will represent the field of application and provide the relevant expertise, analyse the state of the art and develop scenarios forming a vision of the future. In the next step a roadmap that will show the way for the implementation is created. A strategy that explains different aspects of the development and implementation (e.g. barriers and drivers) accompanies the roadmap (see Figure 1).

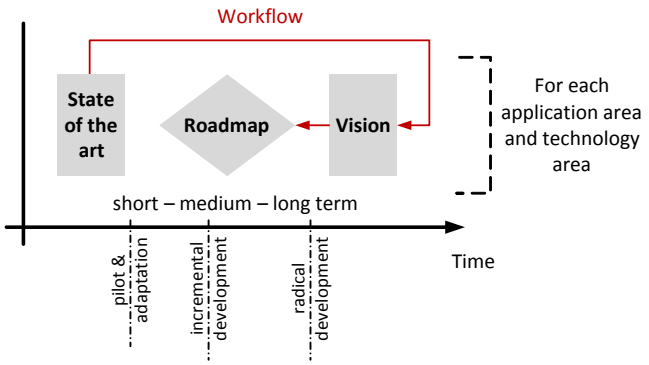

Figure 1: Method for Developing the Roadmap

As a vital part of the outcomes a process of building a wide community of interest on European scale (in IREEN called Advisory Expert Group, AEG) has been started. It builds on existing active communities such as the community on energy efficiency in buildings within the ICT4E2B forum [4], the EUROCITIES network [2] or the community for lowering the carbon footprint of ICT in cities within the Green Digital Charter initiative [3]. However it remains still open to other interested stakeholders. The community interacts through expert hearings, interviews and workshops as well as through a collaborative community space that provides information on the topic of ICT for energy efficient neighbourhoods. The purpose of these interactions is to provide validation and input to developed scenarios, strategy and roadmap. The role of the advisory expert group, representing stakeholders from different fields, is to validate further the results on a regular basis. The reason for this heterogeneity is that on the one side the future implementation of the strategy will be scattered over several fields of expertise and on the other side in the development of the connection of ICT, urban planning and energy efficiency management just to name the main fields requires an interdisciplinary approach involving experts that usually not always have the experience of working together. Apart from experts from the technology sector also local stakeholders and representatives from cities are involved to ensure practicality and relevance of the outcomes. These stakeholders should represent the different local cases. It was therefore the intention to involve practitioners from different parts of Europe, e.g. UK, Finland, Italy.

After building a community of interest the focus is put on creating cartography of case studies. The cartography is necessary to identify key exemplary projects, pilots and studies of ICT systems and applications for energy efficient neighbourhoods. The goal is to find current good and best practises as well as ICT tools and standards. The analysis of state of the art supports also the refinement of the scope of interest. The scope of interest will be further shaped during the work progress by the experiences gained in identified pilot projects that have been performed so far or are being implemented at the moment. The identified projects and technologies are used as a starting point for defining the strategy and roadmap. In some cases the starting position represents a developed technology that lacks any large scale implementation in practice. In other it means considering an already existing standard or even a mature technology that penetrated the market already. Also different aspects of use and external dependencies are being examined. The assessment of the various aspects is complemented by an analysis of relationships between consumers, distributors and energy providers. It enables to derive business models and find upcoming opportunities for companies. In the end the assessment highlights those topics where the research is concentrated at the time being. It also predefines the taxonomy for the next step – the development of future scenarios.

On completion of the state of the art analysis a development of emerging use cases and future scenarios is carried out. These scenarios are to cover the entire value chain of energy supply, distribution, storage and end use. A scenario is a picture of widely implemented technology in the future. Several scenarios form a vision of the technologies being implemented and applied in a system where ICT is used for assessing and managing energy efficiency on a neighbourhood scale. In the next step the scenarios suggest a path of development from pilot towards large-scale implementations. This includes visions for improved and new business cases to overcome hurdles on entry to the market such as limitations through finance, required standards and fragmented research systems and markets. Moreover they take into account circumstances and characteristics such as technology, costs, security issues and regulations.

In the next step the identified visionary scenarios are refined and prioritised according to their maturity and their expected impact. The priorities are needed for defining the single steps of the roadmap. They are developed by weighting and balancing the expected impact and the action needed to be taken to reach this impact. By doing this the identified

roadmap will comprise of a structured set of priorities in terms of research, large-scale use trials, knowledge capitalisation, standardisation, transfer to market, ICT based service interaction along with potential future instruments and vehicles (new business models, private public partnerships, long-term living labs etc.). This will support experimentation deployment and transfer to market of innovation while achieving a major impact in energy efficiency in the built environment supported by ICT. At the same time also the different aspects of the development and implementation such as policy context, barriers and drivers, actors that will influence the implementation, or are being influenced are identified as a Strategy for European scale innovation and take-up created. This must be done under the consideration of the changes in international markets. The ICT roadmap as well as the strategy defines the way to the vision while considering integration in the existing market system that will be subject to changes in any case. In the end it should be clear how the technologies enter the market in the best way.

Next to the developed roadmap and strategy, the formed community of interest is one of the main outcomes. The experts should interact also after the work in IREEN has been done and at the same time disseminate the results in their respective community. There will be also an ICT reference guide created that will support urban planners in considering ICT solutions in their future work.

3. PRELIMINARY RESULTS

As the project is in the mid phase of completion, the roadmap is not available yet. However, preliminary results can be presented. The creation of the IREEN taxonomy forms the basis for the roadmap and work leading to the roadmap. In contrast to the approaches in REEB [1] or ICT4E2B [4], IREEN uses an approach based on a taxonomy matrix (see Figure 2). It has been reworked based on inputs received from the advisory expert board at the first Advisory Expert Group (AEG) workshop. This taxonomy matrix is the first tool developed by IREEN and helps to organise the case studies and scenarios. It helps to manage the broad scope of the project and to identify topics that need further coverage.

In the structure of the matrix technology areas consist of energy consumers (such as neighbourhoods, energy used in transport and buildings), energy production and storage, and energy distribution. To ensure that the interests of people are covered an extra category people involvement is added (see Figure 2). It covers how their energy efficiency can be improved by utilizing ICT solutions. The neighbourhood category covers processes on the neighbourhood level such as planning, operation and maintenance as well as security, safety and risk management. Transport systems cover topics related to decreasing the need for transport, minimizing energy consumption and increasing energy efficiency. Buildings cover all kinds of buildings in a neighbourhood such as housing, commercial and service buildings as well as public spaces with an emphasis on how the topics relate to actions on a neighbourhood level. Energy production includes all common forms of energy such as heating cooling, gas and fuels, electricity from centralized to decentralized production, evaluated with respect to their primary energy usage. Energy distribution consists of increasing energy efficiency by minimizing transport losses or improving the operation of distribution networks.

3.1 Analysis of Projects

As described before, one of the first results of IREEN is an analysis of current case studies to identify key exemplary projects and pilots on ICT for energy efficient neighbourhoods. It currently involves 58 selected projects that were identified and analysed by IREEN members and provides an overview of best practices and associated ICT tools.

The state of the art can be classified in three types of projects with the largest share in large scale innovation pilots with 48 % followed by R&D Projects with 43 %. Projects providing action plans have the smallest share with 8 %.

Figure 3 shows the share of all outcomes showing e.g. if a tool or methodology was developed or both. The number of projects is larger than the total number of analysed projects as a project could cover a tool and a standard at the same time. Mostly methodologies and tools were found, rarely frameworks and standards.

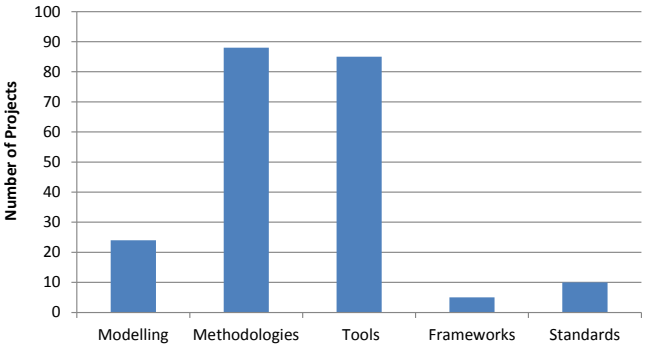

Figure 3: ICT Results

The distribution of projects by area of application can be seen in Figure 4. Projects can be represented in more than one category. Only a small share of projects dealt with the topic of neighbourhoods. One of the reasons for this is that the neighbourhood topic is a complex one. Transport is underrepresented, too. Buildings cover a large fraction of projects with a maximum in residential buildings.

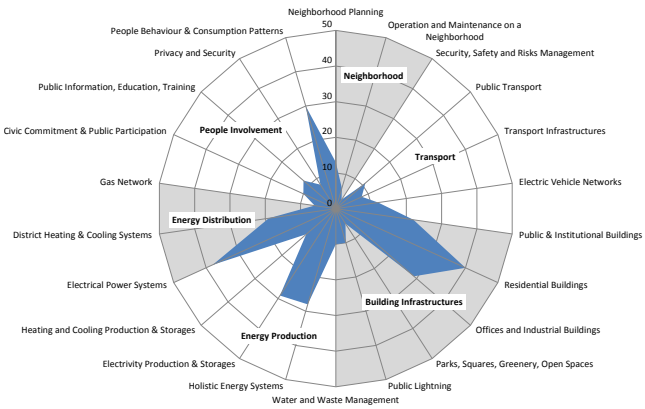

Figure 4: Application Areas Covered

Technology Areas	Application Areas: Neighbourhood: Neighborhood Planning	Neighbourhood: Operation and Maintenance on a Neighborhood	Neighbourhood: Security, Safety and Risks Management	Transport: Public transport	Transport: Transport Infrastructures	Transport: Electric vehicle networks	Building, Infrastructures & Public Spaces: Public & institutional buildings	Building, Infrastructures & Public Spaces: Residential buildings	Building, Infrastructures & Public Spaces: Offices and industrial buildings	Building, Infrastructures & Public Spaces: Parks, squares, greenery and open spaces	Building, Infrastructures & Public Spaces: Public Lightning	Building, Infrastructures & Public Spaces: Water and Waste Management	Energy Production & Storage: Holistic energy systems	Energy Production & Storage: Electrivity production & storages	Energy Production & Storage: Heating and cooling production & storages	Energy Distribution: Electrical power systems	Energy Distribution: District heating & cooling systems	Energy Distribution: Gas network	People Involvement: Civic commitment & public participation	People Involvement: Public information, education and training	People Involvement: Privacy and security	People Involvement: People behaviour & consumption patterns
Design, Planning & Realisation																						
Design																						
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EE Services: business concepts and financing																						
Integration Technologies																						
Process Integration																						
System Integration & Open Data																						
Interoperability & Standards																						
Knowledge Sharing																						
Virtualisation of the Built Environment																						
Communication																						

Figure 2: Taxonomy Matrix: Application Fields and ICT Groups

The distribution of projects by type of technology can be seen in Figure 5. Again, projects can be in more than one category. It shows that the topic of energy management is the most covered one whereas design, planning and realisation are not so common.

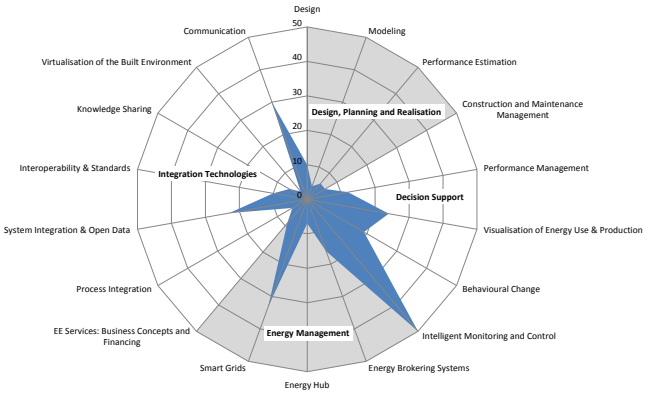

Figure 5: Technology Areas Covered

Figure 6 shows the geographic distribution of the analysed projects. It can be seen that most researched projects are located in the EU with most being in Spain and France, few in the US and Asia, one in Africa and none of them in Australia.

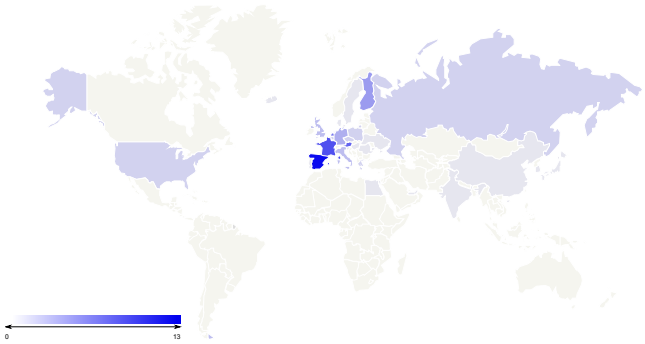

Figure 6: Geographical Distribution of Projects (based on Mundigl [8])

3.2 Creation of Case Scenarios

After the state of the art analysis is completed the development of emerging use cases and future scenarios is carried out. The scenarios picture a state as if pilots were implemented

in larger deployments with a time horizon of ten years. At the time of writing 15 scenarios exist with more being in development. The goal is to have at least one scenario per application area from the matrix (see Figure 2) to cover the broad range of topics. Scenarios are reviewed with an iterative process, involving AEG members, the community of interest and consortium partners.

Each scenario relies on the previous state of the art research and is written as a visionary story that describes a time where today's state of the art has successfully been implemented on a large scale. Scenarios start by providing some background to the vision as an introduction. They progress to describe additional factors that help with the acceptance of the technology. The vision ends by providing a further outlook and a conclusion to the vision to describe the impact. Each scenario contains:

- Visionary description
- Expected impacts
- Stakeholders and beneficiaries
- Expected progress beyond state of the art
- Application within the taxonomy matrix

An excerpt from a scenario is provided as example (see Figure 7). It envisions a building controlled on a neighbourhood level to provide energy for heating and domestic hot water (DHW). It begins by providing some background of this management tool and continues to narrate its effects on the consumer from his point of view. This example comes to the conclusion that the scenario would impact on a reduction of energy consumption and CO_2 emissions achieved through a better utilization of resources (optimization achieved collecting information at utility company level). In addition it increases awareness of people for energy/ICT related topics. People living in the districts as well as energy service companies are identified as stakeholders and beneficiaries. The expected progress beyond state of the art is the extension of the basic monitoring system, to go beyond the accounting utilization (e.g. bills) and develop a platform to use information of heating and cooling loads to optimize the operation of power plants.

Scenario Title	Heating and DHW in buildings controlled on a neighbourhood level (from the consumer point of view)
Description	The municipality of Smartburg implemented together with the local utility and several building owners a local management system for the distribution and use of thermal energy in buildings. This measure was implemented during the installation of smart meters for electricity in the buildings of a neighbourhood to reduce the investment cost. Hannah has recently moved to the neighbourhood. During her first view on the flat she saw a display next to the bathroom door showing the current temperature, DHW consumption and weather forecast for the next days. She liked this idea very much and because the flat was not far away from her work as well, she decided to rent it.

Figure 7: Excerpt of an Exemplary Scenario

The taxonomy matrix helps as a tool to visualize, compare, prioritize and classify the scenario, such as behavioural change in technology areas and residential buildings in application areas within this example scenario. This helps to identify which scenarios are missing still and which topics need further coverage.

Finally, the detailed scenarios are analysed for key technologies and with feedback of the AEG used to create the IREEN roadmap.

4. EXPLOITATION OF RESULTS

The main impact of the IREEN project is ensured by enabling the exploitation of results, by establishing a collaboration framework between the ICT sector, the building sector and the energy sector and disseminate the outcomes (e.g. state of the art in Section 3). A large number of activities have been used, including new formats such as LinkedIn group, the IREEN forum, stakeholder and AEG workshops. Exploitation of results is considered as a priority within the project and is done at three levels:

1. IREEN core partners.
2. AEG members and other relevant external experts invited by the IREEN consortium.
3. Potential new technology programmes where project partners, AEG members and other relevant external experts together with the relevant stakeholders are able to develop new strategic projects.

The IREEN consortium and the AEG members make sure that the results are continuously disseminated and updated based on feedback by the IREEN community. It is furthermore expected that the roadmap in particular will evolve and be developed further. This results in:

- Engagement with potentially interested stakeholders in order to generate a broad awareness of the activities and to obtain feedback on the work in progress to ensure that a comprehensive validation from stakeholders covering all market sectors is addressed at all stages of the project.
- Disseminate information about the international state of the art in terms of large scale pilots and supply side ICT standards, ICT based innovation projects, methodologies & tools, and building upon this, develop an effective knowledge exchange about good practices.
- Promoting emerging technologies and ICT solutions which are being developed by European innovation projects and companies to early bird innovative cities in Europe, as well as to industrial stakeholders.
- Stimulating dialogue with key actors, allowing them to actively participate in the elaboration of the vision, priorities and innovation roadmap.

5. IMPACT

The global impact of IREEN includes improved participation, more effective involvement, networking and cross fertilisation of industrial organisations, academia / RTD institutes, companies (including SMEs) and local and regional authorities in terms of defining future RTD and priorities for ICT

based energy efficiency in the built environment. IREEN will encourage and facilitate the participation of industrial organisations in future European ICT research activities through their involvement in the broad IREEN community. One specific impact is to create new markets for ICT-based customized solutions:

- IREEN identifies best practices, results from recent and ongoing European and national RTD projects, and potentially new novel ICT solutions and disseminates these to relevant stakeholders.
- IREEN contributes to open markets for ICT solutions also through engagement of key ICT players from different fields and promotion of ICT standards.

Secondly, it reduces energy consumption and CO_2 emissions through ICT:

- IREEN identifies ICT and automation applications, and integration opportunities both at building and neighbourhood levels.
- With the support of the AEG the greatest impact potential and recommended actions to exploit these opportunities are gathered.
- IREEN harmonizes methodologies for assessing energy efficiency impacts of ICT in quantifiable terms and recommends usable metrics or further work on such methodologies as may be needed. Quantification of measures and implementation of ICT technologies are destined to be conducted afterwards.

In addition, IREEN establishes a collaboration framework between the ICT sector, the buildings and construction sector, and the energy sector.

The overall goal of developing an ICT energy efficient neighbourhoods roadmap is brought into the real world through the provision of recommendations and information on future developments in order to support strategic decisions. IREEN provides inputs to the industry for the identification as well as development of products and services identified within the roadmap as gaps. In addition, IREEN is of importance for public authorities that can use the IREEN roadmap to consider ICT implementation in energy efficient neighbourhoods within their local low carbon action plans. Finally, IREEN helps focusing the research topics by providing input for the next EU research initiative Horizon 2020. This will have also an indirect influence on the industry dealing with innovation and public authorities implementing first demonstrators.

6. ACKNOWLEDGMENTS

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