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PROJECT FINAL REPORT

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Project acronym: ICT 4 E2B FORUM

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4.1 Final publishable summary report

Executive Summary

Information and communication technologies (ICTs) offer versatile potentials in the building and construction sector to achieve energy savings and CO^2 reduction targets in Europe. In some areas, like building automation and control, direct impacts of ICT on energy usage can be readily seen. ICT has also significant indirect impacts in other areas. In order to exploit the potentials of ICT there is a need to identify the most promising technologies. Future research efforts should be prioritized accordingly.

ICT 4 E2B Forum project, The European stakeholders' forum, crossing value and innovation chains to explore needs, challenges and opportunities in further research and integration of ICT systems for Energy Efficiency in Buildings, continued the work of the REEB project by:

- bringing together relevant stakeholders to identify and review the needs in terms of research and systems integration;
- widening the vision beyond the technical point of view to address also societal, economic, market, end-user and several other perspectives;
- updating the REEB research roadmap;
- promoting the use and further development of ICT for improved energy efficiency of buildings.

The roadmap for ICT supported energy efficiency of buildings can be summarized in simple terms as follows:

- **Short term:** ICT enables the connectivity and interoperability of individual buildings and networks and is used to ensure that existing and new buildings meet the current and emerging requirements for energy efficiency defined in relation to the surrounding infrastructure and climate.
- **Medium term:** Design, production, retrofitting, operation, use and demolition are empowered and enabled by re-configuration, optimisation, and access to real-time information, decision support and interoperability with easy to use interfaces.
- **Long term:** ICT enables and supports new business models and processes driven by energy efficiency. Buildings have evolved from energy consumers to "prosumers" (producer + consumer).

ICT will contribute to the energy efficiency of buildings mainly via design tools, automation and control systems and decision support for various stakeholders. ICT 4 E2B research Roadmap defines objectives and timeframe for future research topics and activities The implementation action plan suggests roles and actions for the main stakeholders from the public sector and building clients, ICT and Energy sector, knowledge providers, end-users and, standardisation bodies.

Previous work conducted in REEB and EeB provided a solid ground for the research roadmap presented in this document. New technologies were not identified; however the developments in interoperability and standardisation might lead to the consolidation of existing technologies. An increasing focuses and overall change to user-centric and district level solutions can be seen.

Project Context and Objectives

Context

European citizens have become increasingly sensitive to environmental issues. Supported by legislation and incentives (often at the local level), citizens and businesses alike have taken the initiative to better insulate homes and buildings, to better monitor and control their energy performance, and to avail of and install renewable energy sources such as solar panels and wind turbines. It is clear that if "green buildings" are to become commonplace, this can only be facilitated by ICT[2].

Within this framework the REEB project has summarised the vision for ICT supported energy efficiency in buildings in relation to five main Priority Areas for research and systems integration, namely **Tools for EE Design & Production Management"**, **"Intelligent Control", "Energy Management and Trading", "User Awareness & Decision Support", "Integration Technologies"**.

In this context major challenges arise indeed due to the enormous diversity of players and stakeholders involved in the built environment. In fact a whole building approach to the design and operation of buildings, where these components are integrated in a way that they reduce energy consumption through cooperation, is rarely used. As a result of this imbalance, market forces do not provide any strong incentives towards Life-Cycle-Costing for buildings, and breakthroughs are only likely if regulations are also set in place.

Addressing these gaps and challenges requires an unusual multidisciplinary and cross-sectorial collaboration across the value and innovation chains, engaging stakeholders such as industry, public organisation, standardisation bodies, banks, investors and developers. There is therefore a crucial need to initiate, structure and sustain a Forum throughout Europe and beyond towards enhanced collective innovation of European organisations relying on some community based forms of collaboration, and providing means in which a common strategic vision the advancement of ICTs for Energy Efficient Buildings are achieved.

Objectives

ICT 4 E2B Forum aimed at bringing together all relevant stakeholders involved in ICT systems and solutions for Energy Efficiency in Buildings, at identifying and reviewing the needs in terms of research and systems integration as well as at accelerating implementation and take-up.

ICT 4 E2B Forum intended to promote, through community building activities, a better understanding, a closer dialogue and a more active cooperation between researchers, end-users/practitioners, building owners, technology-suppliers, and software developers as regards the use of ICT to support informed decision-making (both human and automated) in the current delivery and use of sustainable and energy-efficient buildings and districts.

The ICT4E2B Forum continued the work of the preceding REEB project, "The European strategic research Roadmap to ICT enabled Energy-Efficiency in Buildings and constructions, and will update its research roadmap on ICT enabled energy efficient buildings via:

- enhanced involvement of and validation by stakeholders through a collaborative platform,

[2] ICT for a Low Carbon Economy Smart Buildings, Findings by the High-Level Advisory Group and the REEB Consortium on the Building and Construction sector, JULY 2009, EC Information Society and Media

- mapping and harmonisation with other related strategies *(SRAs and IAPs of related ETPs and JTIs, EeB PPP Multiannual Roadmap etc.)*.

The ICT4E2B Forum project aims at the following objectives:

- **Bring together relevant stakeholders to identify and review the needs in terms of research and systems integration**
    - Invite expert groups to provide advice in the key areas of focus;
    - Set up a wider community in the ICT4E2B domain;
    - Provide a virtual cooperation environment to facilitate communication between stakeholders;
    - Organise expert hearings, validation workshop, sessions inside international conference and national/regional events;
    - Promote networking and collaboration between the stakeholders in these events;
    - Build consensus of RTD priorities in the ICT4E2B domain;
- **Update the REEB research roadmap**
    - Identify key knowledge areas and related application fields
    - Analyse state of the art in industry and research, and other related RTD strategies;
    - Identify current industry requirements;
    - Define vision exemplified by a representative set of application scenarios;
    - Identify and rank gaps between the state of the art, recent and ongoing research, and industrial needs;
    - Develop and validate the updated research roadmap;
- **Promote the use and further development of ICT for improved energy efficiency of buildings**
    - Provide knowledge content about the state of the art, best practices, RTD results etc...
    - Propose a future extended collaborative value chain in ICT for energy efficient buildings;
    - Provide guidelines for the implementation of R&D results and best practices
    - Contribute to dissemination of standards and regulation
    - Disseminate project results and recommendations to the ICT and Construction Communities, national/regional research and industry policy makers, and widely to European industry, research community, policy makers and media

Main Scientific and Technical Results

Stakeholders Involvement

During ICT4E2B Forum project development several stakeholders have been engaged in order to create discussion around future challenges, where construction companies, ICT experts and energy stakeholders have been invited, together with local authorities in their role of planners and promoters leveraging on the political side and the local implementation of directives.

These actions belonged to the core of Project activities. Events were organized or participated in different locations around Europe to ensure that the roadmap takes into account the needs from all stakeholders in the European-wide community. Furthermore specific interviews with high-level stakeholders have been performed and a Forum have been set-up in order to have a global overview of the different perspectives and a final alignment with high-level strategic objectives in the field of ICT for Energy Efficient Buildings.

ICT4E2B Forum events included workshops, presentations, speeches on conferences, booths on fairs and less formal meetings where people were encouraged joining the discussion, fostering the discussion on ICT for Energy Efficient Buildings theme.

Clearly such activities were organized following the roadmapping workflow defined by the ICt4E2B Forum Methodology (see **Figure** 1), and allowed to:

- Build the first draft roadmap by
  - Identifying the Future Application Scenarios by interactive workshops held in Helsinki, Nice and London with invited experts
  - Identifying Thematic Areas Prioritization by interactive workshops held in Genoa (together with Genova Smart City Association) and Brussels (within Energy Efficient Building PPP Info Day)
- Improve and validate the ICT4E2B Forum Roadmap by presentations followed by open discussions held in different events and workshops, namely:
  - Hannover - CEBIT Trade Fair
  - Warsaw - Clean Energy and Sustainable Buildings Conference
  - Nice – Innovative City Convention
  - Brussels – European Electricity Grid Initiative and GridPlus Workshop
  - Amsterdam – Smart City Event
  - Brussels – European Union Sustainable Energy Week
  - Reykjavik – European Conference on Product and Process Modelling

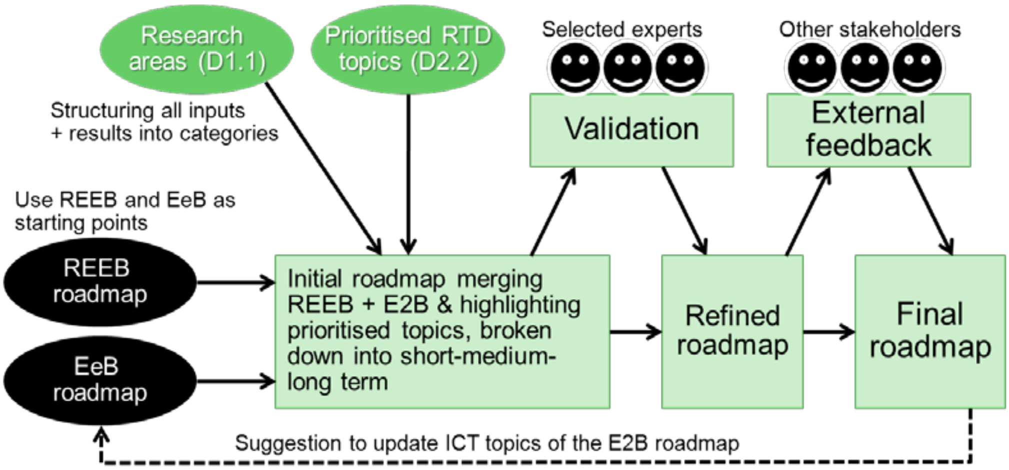

Figure 1: ICT4E2B Forum Roadmapping methodology

During these workshops it has been relevant how the different visions on the topic brought very different approaches on how the priority areas already defined in REEB and further refined during ICT4E2B Forum project can evolve. Within this framework, these visions were integrated in the roadmapping process, allowing a clear synthesis of the different perspectives.

Workshops and Events

Workshop in Helsinki

The first workshop took part in Helsinki on 4th May 2011. 9 Stakeholders attended this event. During the workshop there have been two group discussions: the first dedicated to "Design for Energy Efficiency" and the second dedicated to "Performance assessment".

Discussions were divided into particular aspects including:

- Scenario,
- Key idea/Keywords,
- Technologies,
- Impacts,
- Stakeholders.

Each group was referring to this sections by placing sticky notes with the signals and ideas. An example of brainstorming during workshop in Helsinki is shown on the Figure below.

Figure 2: Poster with sticky notes from the group discussion[3]

During first group session, the thematic area to be analysed was Tools for Energy Efficient Design and Production Management. After the discussion, the group agreed that two main technologies should be present in the future ICT tools: first is related with the definition of a specific 3D model for Energy Efficiency, that is something that has not been developed. The second technology is also related with interfaces and data exchange: the model server should be a model where people can cooperate simultaneously on the realization of a design model. Therefore there is the need to real-time access to data and efficient sharing of information.

During the second group discussion, focused was put on Performance estimation. From the results of the first brainstorming it was possible to cluster all of the ideas in three steps that are fundamental for an efficient implementation of performance estimation in the context of energy efficient design:

- Preliminary research
- Preliminary collection of information that are required for design
- Early step of design process

In these areas one of the main focus of the discussion was on the fact that it is important that Energy Efficiency should be studied as a real “science based” engineering discipline, this meaning that it is essential that the scientific method should be applied also in this context. This means that there is the need to stop proceeding by trial and error.

Workshop in Sophia Antipolis

On the workshop in Sophia Antipolis, discussion was focused on “Energy management and trading” thematic area. 10 Stakeholders attended this event. First discussion session started with a brainstorming, where the experts identified key elements, related to the thematic area under analysis, following the paradigm ICTs (Impacts, Challenges, Technologies, Stakeholders), the same as on the workshops in Helsinki. Figure below shows poster with sticky notes created during the workshop in Sophia Antipolis.

[3] Results of the Workshop on Application Scenario from group dedicated to Tools for EE design.

Figure 3. Poster with sticky notes from the group discussion[4]

In each of the key elements, experts described different stories for the description of a scenario. Finally there was an agreement on a common summary that takes into consideration different aspects arisen during the discussion.

A parallel discussion was focused on “User awareness and decision support” thematic area. Similar to first discussion a poster with sticky notes was created.

Figure 4: Poster with sticky notes from the group discussion[5]

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[4] Results of the Workshop on Application Scenario from group dedicated to Energy management and trading.
[5] Results of the Workshop on Application Scenario from group dedicated to User awareness and decision support.

Participants of the workshop have focused on the awareness of end users and answer to this issue is a need of development of smart, simple and usable interfaces for visualisation and management of energy consumption. The information provided by these interfaces should be accessible and understandable by end users. In addition, end user shall access these data, own data coming from of their private energy consumption, with quick actions done easily wherever they are by using mobile and smart phone or other wireless devices.

Workshop in London

On the workshop in London on 25th May, four discussion panels were held. 16 Stakeholders attended this event. First group was discussing in two sessions: Intelligent and integrated control and Integration Technologies. Second group was discussing on User awareness, decision support and Integration Technologies.

Group 1, at the first session, participated in a brainstorming exercise to identify the breakthrough innovation in 10 years in the area of Intelligent and Integrated Control. Figure 5 below shows poster with sticky notes, describing the results of each group members' brainstorm and the subsequent group discussion and agreed scenario.

Figure 5: Poster with sticky notes from the group discussion[6].

The focus of all the ideas that have been identified during the brainstorming and the following discussion among the experts could be briefly summarized with the concept that there is the need of really making use of all of the systems and technologies that are already available. One of the issues highlighted is that even if the number of installed systems for managing energy is high, they are not made operatives. This is due to lacking of different issues related with the four categories of Impact, Challenges, Technologies and Stakeholders.

[6] Results of the Workshop on Application Scenario from group dedicated to Intelligent and integrated control and Integration technologies.

During second group session, the scenario topic analysed was dedicated to Integration Technologies. Participants were asked to design one breakthrough object/tool/product that will be key to ICT4E2B in the next 10 years.

In this session, teams created the physical “box” that sells their idea - whether that idea will ultimately become a tangible product or not. By imagining the package for their idea, the group made decisions about important features and other aspects of their vision that are more difficult to articulate. In all cases, the box is a focusing device: it wraps up a lot of otherwise intangible information into a nice physical object, prompting decisions along the way. When group present or “sell” their boxes to each other, a number of things come to life, including the natural translation of features into benefits.

Group 2 at morning session participated in a brainstorming exercise to identify the breakthrough innovation in 10 years in the area of User awareness and decision support. The group settled on a particular scenario that was personal, fun and community-based with energy efficiency awareness “in the background”. Similar as in previous exercises a poster with sticky notes was created.

Figure 6: Poster with sticky notes from the group discussion[7]

As the focus in the discussion on challenges and technologies was on personal, fun, community-based technologies that enable visualisation, engagement and empowerment, there was agreement that in order to achieve impacts, the technologies and supporting context needed to be personally relevant to the individual. There was agreement that technology is only one of the available tools that could be used to achieve energy saving and that in order to achieve maximum impact, ICTs would need to be combined with non-ICT tools in a suite of energy efficiency measures available to users.

During second group session the scenario topic analysed was dedicated to Integration Technologies. The session focussed on an exercise based on the “Design the Box” game (same as Group 1), where participants

[7] Results of the Workshop on Application Scenario from group dedicated to User awareness and decision support.

were asked to design one breakthrough object/tool/product that will be key to ICT4E2B in the next 10 years. By chance, many of the participants in Group 2 were the same as the participants from Group 1’s morning session. This allowed for some continuity of theme, although some participants who were not part of Group 1’s morning discussion found it challenging to ‘catch up’ with the rest of the group.

Workshop in Genoa

Workshop in Genoa on 4th July provided to Italian stakeholders represented different stakeholder groups (municipality, social housing, business, research) a better understanding of the context of the ICT4E2B Forum project and allowed them to share their needs and vision for the roadmap prioritization. 33 Stakeholders attended this event.

During the workshop there have been five group discussions, one for each of the five thematic area addressed by ICT4E2B Forum, following participants commitment and interest. During the brainstorming session, the participants addressed their company/city/organisation vision on energy efficiency in the built environment, as well as the gaps between the current situation and desired future development.

An example of brainstorming during workshop in Genoa is shown on the Figure below.

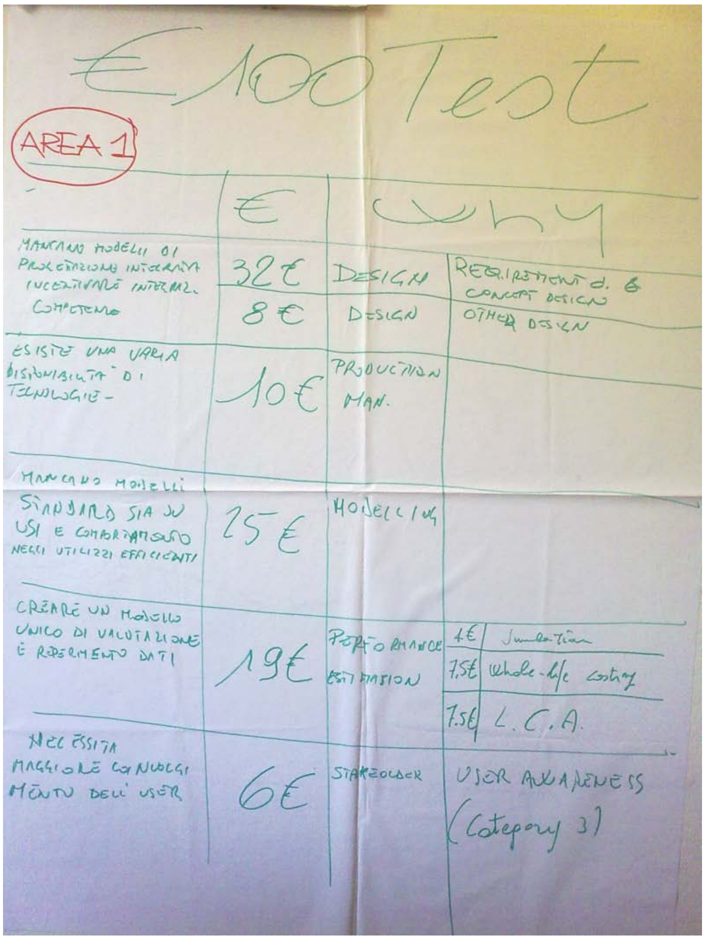

Figure 7: Result of a brainstorming group discussion

In a closer common dialogue with the stakeholders, the technical and non-technical gaps for prioritisation were identified, as well as the R&D topics that must be considered for future research and innovation priorities.

Workshop in Brussels

The last workshop on ICT Application Scenarios for energy efficiency in buildings were organized on 12th July 2011 in Brussels. 74 Stakeholders attended this event. This workshop provided European stakeholders a better understanding of the context of the ICT4E2B Forum project and allowed them to share their needs and vision for the roadmap prioritization. In a closer dialogue with the stakeholders, the technical and non-technical gaps for the prioritization roadmap were identified, as well as the R&D topics that must be considered for future research and innovation priorities.

The speakers represented different stakeholder groups (municipality, social housing, business, research). Each of them addressed their company/city/organisation vision on energy efficiency in the built environment, as well as the gaps between the current situation and desired future development. Best practices were shared, including the identified success factors in these pilot projects. Each of the speakers focused on one of the 5 thematic areas as set out in the ICT4E2B project. These are:

- Tools for integrated design and production,
- Intelligent and integrated control,
- User awareness and decision support,
- Energy management and trading,
- Integration technologies.

The speakers clearly divided the challenges and existing gaps in ICT solutions for the built environment into those of people and those of capacities.

Awareness and involvement of the citizens and end users was said to be key at all time (this is in line with the outcome of previous ICT4E2B Forum workshops). Involvement of communities in ICT solutions is a matter of demonstration impact and explaining how lives will be affected. It is not a matter of conviction. The human factor, which also implies stakeholder awareness, was seen as the most important differentiating element in successful pilot projects, with ICT being the facilitator. Transparency is an important component of both stakeholder and citizen awareness. More transparency is also key to address the issue of people being hesitant for privacy issues and it adds to address the challenge of funding.

Many EE solutions can be feasible, but banks must understand how their money is invested, which requires a different way to evaluate and monitor projects (real time). To obtain more funding, we need figures on the table. Accurate predicting costs and prove of results are needed. ICT solutions such as building simulation are mentioned as a tool to provide better insight in (cost) benefits over the longer term.

While a business model usually covers a shorter period of time than that of a building, we need a new business model and new stakeholders. This requires flexibility in tools, however, at the same time solutions need the right level of detail.

Finally, regulation by government, such as tax reliefs for applying ICT in buildings, was discussed as being crucial to give E2B a strong push forward. However, despite the need for a long term strategic planning and the need for regulation, there are energy savings to be gained right away. Providing people with tools to measure their energy use at work or at home could be an easy first step to be made, in line with the need for citizen awareness and involvement.

Priorities to address identified Challenges, Gaps and potential Solutions and are presented in the table 6 below.

Table 1. Identified areas among challenges, gaps and potential solutions.

People

- **Communication**
  - More awareness
  - Explain how lives will be affected
  - Avoid lack of information
  - Neutral information
  - Forum
- **Involvement**
  - Knowledge managment
  - Transparency
  - Education
  - Social and cultural values
  - Privacy issues
- **Mindset**
  - Political / Social will
  - Acting step by step

Capacities

- **Long term strategic planning**
  - Common, holistic view
  - Political / Social will
  - List of smart actions
  - Simplify bureaucracy
  - Integrated approach
- **Commitment stakeholders**
  - More control of business performance
  - Paid membership association
  - Awareness/knowledge management
- **Funding**
  - Different evaluation of projects
  - Accurate predicting costs
  - Clear retrofit schemes
- **Transparency**
  - Open up data
  - Facilitate transparency between local events
- **Regulation**
  - Intervention of public powers through regulations and subsidies
  - Tax relief for applying ICT in buildings
- **Technology solution**
  - Flexibility in tools
  - Building simulation tools
  - Real time information/control
  - Data security
  - Focus on storage systems
  - Open protocols
- **Monitoring**
  - Infrastructure to collect data
  - Identify measuring parameters
  - Transparency in figures

CEBIT Fair in Hannover

After the release of first draft roadmap great efforts have been dedicated in the organization and coordination of a stand at CEBIT trade fair presenting European Commission activities in the context of ICT for Energy Efficient Buildings.

Figure 8: European Commission Stand at CEBIT

ICT4E2B Forum project coordinated the presentation of demonstration set-ups by 3 different collaborative projects, namely: eSeSH, PEEBLE and SmartCode (see pictures below) but also had the opportunity to present its results and to discuss them face to face with hundreds of stakeholders met during the event.

Figure 9: Pictures of the 3 different demonstration set-ups (left: PEEBLE, center: SmartCode, right: eSeSH)

In particular during the event ICT4E2B Forum presented a poster showing its interim result (see figure below when the poster was presented to Commissioner Neelie Kroes) and distributed a specific questionnaire that allowed to collect specific feedbacks from more than 100 stakeholders, but had also the opportunity to discuss project results with hundreds of people asking information in our stand.

Clearly great attention has been dedicated to Integration technologies, were different inputs have been provided.

Figure 10: ICT4E2B Forum Interim roadmap presented to Neelie Kroes

Clean Energy and Sustainable Buildings Conference in Warsaw

In order to tackle East Europe stakeholders to update first draft roadmp, a good opportunity has been identified with Clean Energy and Sustainable Buildings Conference (CEP) in Warsaw. Within this conference two different discussion spaced have organized:

1. A booth within the exhibition centre, which allowed interacting with different interested stakeholders, gathering more then 40 filled questionnaire.
2. A dedicated conference speech, where main findings of the roadmap has been presented and different feedbacks has been collected by the attendees.

Figure 12: Booth at CEP Conference

Figure 11: Speech at CEP Conference

Specific feedbacks have provided on Energy Management and Intelligent Control priorities

Innovative City Convention in Nice

In order to enlarge the community of stakeholders taking into account the “Smart City” perspective, a specific session within Innovative City Convention in Nice has been organized in collaboration with IREEN project.

Within this session different discussion groups have been organized and, starting from the different visions elaborated by ICT4E2B Forum, new scenarios have been created for Sustainable Neighbourhoods. Such an activity allowed at the same time to upgrade ICT4E2B Forum roadmap and to pave the basis for future IREEN roadmap.

Figure 13: Poster with sticky notes from the group discussion

After a general introduction of the roadmap the attendees have been split into 4 different groups, to enhance a closer discussion. Main outputs of the 4 groups can be grouped has following:

- Relevance of Enhanced and Integrated modelling tools for EE buildings
- Need of short term investments on Advanced Maintenace System able to overcome fault-based energy leakages
- Consider Training strategies to improve user-awareness and increase building sector workers skills

European Electricity Grid Initiative and GridPlus Workshops in Brussels

The relation with European Electricity Grid Initiave (EEGI) and GridPlus project has been created into 2 different workshops. One first workshop held in February where ICT4E2B Forum roadmap and EEGI roadmap has been respectively presented and discussed and a second workshop in June where possible alignments among the 2 roadmapping activities have been identified:

- EEGI and GridPlus stressed the importance of Augmented Reality to avoid most manipulation of the installed devices for monitoring, performance or diagnosis (that means more safety for the users and the devices). Furthermore the integration of presence control system with Building Energy Management would allow an easier demand side management.
- From ICT4E2B Forum the most importance feedbacks are related to the development of agreed data models to allow BEMS to easily connect to grid, furthermore more emphasis should be posed on Co-generation system connected to Heat Network, in order to make Distribution Grid even more efficient.

Smart City Event in Amsterdam

Similarly to Innovative City Convention in Nice, Smart City Event in Amsterdam allowed to involve a wider interest community, comprising stakeholder belonging to different technical and business sectors.

Furthermore while the convention in Nice was attracting mainly people from Mediterranean countries, the event in Amsterdam allowed reaching central and northern Europe stakeholders.

In this case a speech within a “Sustainable City” session has been performed, where the draft roadmap has been presented at at the end of the speech a time frame of 10 minutes has been dedicated to discussion and feedbacks. Main findings of the discussion were related to:

- Increasing focus on user-centric solutions and integration of technologies, as most buildings are not built for users
- Consider Integrated project delivery as a main requirements for future ICT systems
- Many stakeholders stressed the involvement of entertainment to involve users
- Standardization is market drive

European Union Sustainable Energy Week in Brussels

In this case we organized a dedicated event in Brussels within EUSWE together with 2 other European Projects (EnRiMa and IREEN), trying to involve different stakeholders interested to Sustainability.

After a general introduction of the projects, the audience has been split into 3 discussion groups, each one focused on a specific project.

In particular ICT4E2B Forum focused on the companies’ perspective in ICT for energy efficiency. This group was subdivided into 2 smaller groups. Thus, they were able to work and develop ideas.

Figure 14: Group Activities within ICt4E2B Forum Session

The first subgroup decided to focus on the **easiness** of such a project. The aim is to make understandable what is happening or the use of the interphase, and make it usable with other devices, for example smartphones. The group also made a difference between the different kinds of buildings. The solutions cannot be the same for commercial buildings and for residential buildings, because of the different use. This group also concluded that the focus should not only be put on the building but also on the environment of the building, to integrate a “smart” building in a “smart” environment.

The second subgroup focused more on **ICT for energy**. Nevertheless, they advocated that ICT in buildings should not only be used for the regulation of energy but as a holistic conception included other services such as the security control or a helping device for the elderly. Indeed, it makes sense to integrate everything with ICT for energy as a control system; it would be benefic as a more integrated system in the building. The issue is on how to integrate and control all the devices in a single system.

European Conference on Product and Process Modelling in Reykjavik

Last chance to discuss and update the roadmap before its finalization was at European Conference on Product and Process Modelling (ECPPM) in Reykjavik. Such event allowed to share our results with a scientific audience coming not only from Europe but also from other relevant countries (e.g. USA, India, China, Japan, Australia).

In this case a speech within the session "RTD innovation, vision and strategies" has been given, with a dedicated session of questions and answers that allowed to retrieve useful feedbacks for the roadmap, in particular:

- Importance to define innovative ways to link energy-enhanced modelling with contracting and tendering procedures
- Standardization of Performance indicators
- Stress the alignment of European technological roadmapping with local sustainability action plan

Interviews

Two high-level stakeholders representing different sectors, Construction and Automation, expressed their interest to elaborate on specific industry needs from a practical point of view. Not only do they explain where they see priorities for impact in the long-term, they also clarify how a roadmap on ICT for Energy Efficiency in Buildings at European level will help their sector to improve both the decision-making process and the execution of measures during the usage phase of buildings.

Interview with a Construction Sector Stakeholder

"'European regulation, just as regulation at national level, should carefully consider accountability for the functionality of what is being built. This happens in other industries, why not in buildings and the built environment?"

Ger Maas from Royal BAM Group, the Netherlands, is involved in European projects on the subject of E2B and Smart Cities. According to him, an energy efficiency roadmap becomes even more valuable at district level. "One of the biggest challenges for the construction sector is the management of the transition from centralised to decentralised energy generation", he says. "How can we properly measure and manage the energy flow in the opposite direction? How can we ensure guarantees that households will actually deliver the energy they generate, and will this be sufficient to provide the bigger players such as the industries and shopping malls with the amount of energy they need? In general, we need to better understand how reliable the decentralised energy system is and how we can carefully monitor this."

Will decentralised energy really take off? Important regulation and accounting are required, in which ICT can play a crucial role. Contractual practices are one of the main topics addressed in the ICT4E2B Forum roadmap, especially in the thematic area of EE Design and Production Management. Where [stimulation through] contracts in the construction industry are concerned, Maas stresses the importance of new business models with performance-based contracts instead of materials- and activity-based contracts. "Performance-based contracts have already been studied quite extensively", he says. "We know how to handle them. There are already many public-private partner contracts in Europe involving 30 year finance, maintenance and management guarantees in operation. However, owners and customers are still hesitant to discuss this explicitly. Where I do see a gap, is in the proper use of these performance-based contracts on a broad scale, especially within the existing legal frameworks. European regulation, just as regulation at national level, should carefully consider accountability for the functionality of what is being built. This happens in other industries, such as the food sector, why not in buildings and the built environment?"

Maas expects that performance agreements will not only ease the integration of tools and communication between stakeholders; they will improve the quality of the discussions and the contracts and finally the performance of the houses, buildings and the whole built environment.

"We should adapt learnings from ICT and energy efficiency to parallel developments in water efficiency and the ageing society"

The added value of ICT in this change of direction, according to Maas, is the ability to monitor the quality of the buildings during their usage phase. This output allows partners to learn together for a sustainable future, based on real data and real measures. This does not only include monitoring through sensors. Even more important will be the analysis of specific – mature – data-reflecting the agreements in the contracts in place.

Considering the long-term vision of this roadmap, Maas stresses the need to look beyond the area of energy efficiency at the adaptation of ICT learnings to parallel developments in water efficiency, and even the ageing society. "These challenges require similar answers and our sector will have to deal with solutions in each of the areas", he says. "Monitoring, for example, will be a major issue in retirement homes. How do people move inside the buildings and what does this teach us for improvement in design and construction? The sensors and devices may look different, but the analogies behind the technologies are similar. Data and analysis obtained for energy efficiency could be equally used for other societal challenges. The relevance of these technologies stretches far beyond energy efficiency."

Interview with an Automation Sector Stakeholder

"There is a huge need for communication standardisation. We know what to do, but we don't know how to do it"

A roadmap on ICT for Energy Efficiency is not simply about technology and innovation, according to Olivier Cottet from the division Strategy & Innovation at Schneider Electric. "For us, this roadmap can function as a way to answer specific needs expressed before". He emphasises the need to extend previous research on the subject of energy efficiency in buildings to get to the next level of detail, and to better understand *how* to do things.

Cottet: "When we speak of communication between sensors and controllers, inside and outside the building, there is a huge need for communication standardisation and protocols for the exchange of data between machines, using web services. We need such research. When we speak of energy management, for example, the rules exist, we know what to do and we know this for years. But we don't know how to do it and if we are able to do it. We have already done good work, but the road is longer."

Another example: we know ways to reduce energy consumption of a building through reducing the losses and reusing fatal energy losses. In a data centre, for example, this could be done by using a heat pump to capture the waste heat. But how to build, set and control a heat pump able to reuse the captured waste heat? Cottet: "Again, we know what to do, we don't know how. And research programmes aim to find answers from this point."

"We need standardisation on lexicon, not on protocols"

One of the main outcomes in the ICT4E2B roadmap in different thematic areas, is the urgent need for standardised protocols. However, taking into account the evolving situation of energy markets and thus the need for flexibility, there is a limit to the functionality of strict standards in the long run. Cottet acknowledges the importance of standardisation on semantics, not on protocols. “All standardisations are discussed on the level of physical layer of the technology and not on the language. While in communications, for example, not the way we communicate - by paper or by email- is the problem. In energy efficiency the challenge ahead lies in the lexicon we use, many words are multi interpretable. There is a huge need to create a common language, in terms of words and values, such as temperatures, but also in European regulation. Each country has different standards and rules to measure the energy performance. Also, current rules and standards about air quality, for example, have been written in a time in which it was not yet possible to measure the quality of the air. A lot of imposed regulation is now useless, in that way standardisation in Europe is a must. But one should never standardise technology solutions - the technical layers - or you will stop innovation.”

Despite various objectives in different sectors, Cottet trusts that stakeholders in the whole building value chain can make this standardisation happen, as long as standards will not contradict with the interest or open protocol strategies in one of the sectors.

Synergy with EeB PPP Multi-annual Roadmap

The Energy-efficient Buildings (EeB) PPP, launched under the European Economic Recovery Plan [9], will devote approximately € 1 billion in the period 2010-2013 to address the challenges that the European construction sector and its extended value chain are facing in their ambitious goal of researching new methods and technologies to reduce the energy footprint and CO_2 emissions related to new and renovated buildings. This represents the initial and highly strategic step of a longer term set by the industry to create more efficient districts and cities while improving the quality of life of European citizens.

Within this framework the Energy Efficient Building Association (E2BA) [10], in its role of industrial interlocutor of the European Commission in the EeB PPP, and in particular the Ad-hoc Industrial Advisory Group (AIAG) has developed a multi-annual roadmap with the objective of identifying the main research priorities for industrial stakeholders and to define a long term strategy in the framework of energy efficient building technological area.

The methodology for EeB Roadmap development used by the AIAG has been based on the broad consultation of E2BA members and the enlarged network of stakeholders. In fact through the E2BA members and their multiplying effect, a large community of local authorities, capital providers, developers (designers, engineers, contractors), supply chain (materials and equipment suppliers), investors and owners as well as end users have been reached, providing a broad overview of the research needs for the future of the sector. Indeed, over 200 contributions highlighting research challenges and opportunities have been gathered from more than 100 E2BA member organisations, organised in five working groups. It is very important to underline that this stakeholder-based approach has been taken as reference and baseline for the ICT4E2B Forum approach, where this large-based approach has been further extended with the “Forum” concept that should continuously involve stakeholders in roadmap development. Furthermore it is worth to notice that 4 of the 6 partners of this project are members of E2BA, which allows the project to exploit the already mentioned multiplying effect of the association.

During EeB Roadmap preparation, an in-depth analysis of strategic research agendas, implementation plans and relevant R&D position papers from running European Technology Platforms (ETPs) and Joint Technology Initiatives (JTIs) was performed in parallel. This was duly confronted with other relevant European initiatives, such as the roadmaps of the industrial initiatives or the SETIS information system within the SET Plan. This allowed the building up of a taxonomy, which globally maps the European R&D priorities landscape, relevant to energy-efficient buildings. In case of ICT4E2B Forum the main input for the taxonomy has been the one delivered by REEB that has been further investigate and refined during the project, nevertheless it is worth to notice that the main thematic areas of ICT4E2B and REEB can be easily resembled in EeB PPP taxonomy.

The two parallel exercises performed by E2BA demonstrated a powerful synergy and have been very important in the identification of research priorities. More than 1700 inputs from relevant European initiatives of potential interest for energy-efficient buildings have been identified. The inputs collected from the E2BA members have been compared with research priorities identified from the analysis of the strategic research agendas, implementation plans and relevant R&D position papers, as a crosscheck that relevant research challenges for the sector were not missed. An in-depth analysis and clustering exercise has been performed on the research gaps and challenges gathered during this initial phase. Five major areas have been identified, each grouping several research challenges (see figure below).

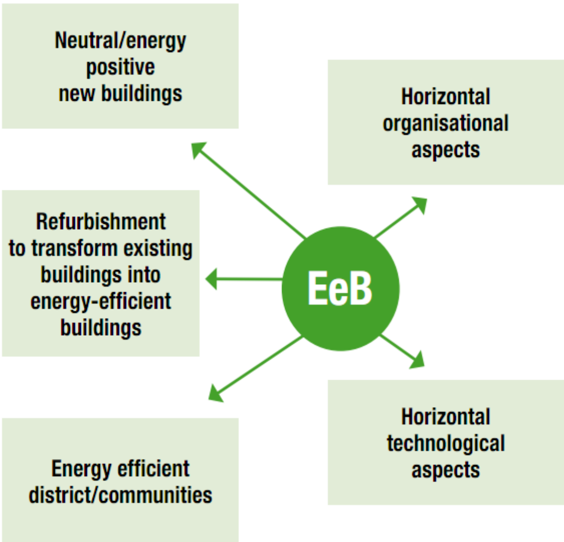

Figure 15: EeB PPP Multi-annual Roadmap

All the five areas can be influenced by development of ad-hoc ICT,which could effectively contribute to the advancement of the energy-efficient built environment. At the same time with the development process of the new Framework Programme (FP), E2BA have already started two relevant road-mapping exercises that can take relevant contribution from the outcomes of ICT4E2B Forum:

1. Update of the PPP Multi-annual Roadmap, whose first version was released in 2010. E2BA is going to accurately reconsider the different prioritised challenges under the 5 main areas. The document will present E2BA Vision, priorities and targets for future research in the field of energy efficiency for buildings and district. Indeed the overarching goal of E2BA is to support both Climate and Energy policies set at European level. This requires making building owners ready to invest into a built environment having lower energy demand and lower GHG emission footprints over their whole life cycle, thanks to “idiot proof” user interfaces that prevent building users from misbehaviors leading to energy overconsumption. This update work will be influenced by the activities performed by running project and by the new priorities underlined by stakeholders. ICT4E2B Forum will be able to contribute by the

detailed analysis of running activities performed in D1.3, while prioritisation performed in D2.2 will allow giving the perspective of ICT4E2B stakeholders.

2. Development of New Long Term Strategic Roadmap, to really adapt the E2BA long term strategy at the general socio-economic evolution and to the specific need of the upcoming Framework Programme, it seems necessary the development of new long term strategic roadmap with a clear perspective of what the field of energy-efficient buildings can achieve at different timescale. Indeed several meetings have been organized in order to gather information from the different stakeholders involved in the value chain of construction for energy efficiency. ICT4E2B Forum contributed in identifying research priorities and future development for the EeB Multiannual roadmap in almost all of the steps of the value chain from Design to End of Life. Indeed one of the main idea is to consider a practice oriented integration of ICTs to support construction sector processes. This priority is widely supported by the E2BA/ECTP community and this will require a strong involvement in fostering the development of integration technologies. Within this activity ICT4E2B Forum roadmap (D2.3 and D2.4) will be able to give a clear understanding of what are the vision, gaps and priorities and all ICT4E2B relevant challenges.

It is apparent that a strong link and a synergetic strategy is required among the initiatives that leaded to the preparation of both of the Roadmaps (ICT4E2B Forum and EeB PPP Multiannual).

Vision

The following vision is slightly modified from the previous REEB project [1]:

ICT will contribute to the energy efficiency of buildings mainly via design tools, automation and control systems and decision support for various stakeholders.

- **Short term:**ICT enables the connectivity and interoperability of individual buildings and networks and is used to ensure that existing and new buildings meet the current and emerging requirements for energy efficiency defined in relation to the surrounding infrastructure and climate.
- **Medium term:** Design, production, retrofitting, operation, use and demolition are empowered and enabled by re-configuration, optimisation, and access to real-time information, decision support and interoperability with easy to use interfaces.
- **Long term:**ICT enables and supports new business models and processes driven by energy efficiency. Buildings have evolved from energy consumers to "prosumers" (producer + consumer).

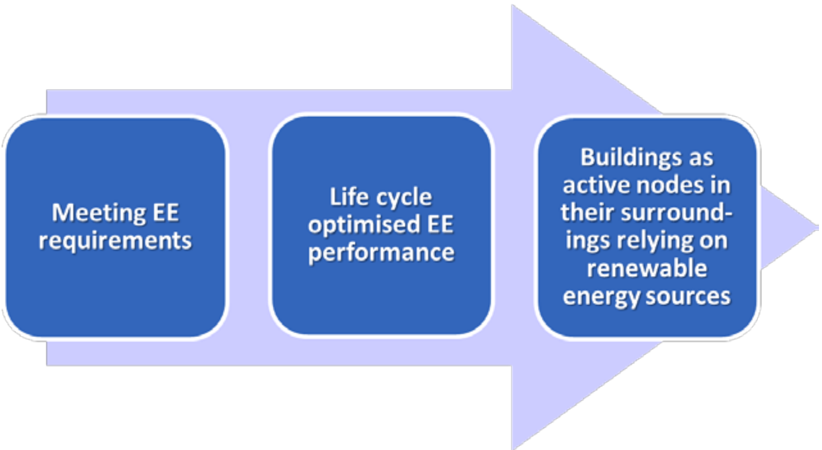

Figure 16: Updated vision for ICT enabled energy efficiency in short, medium and long term

An industrial transformations within the construction sector is envisaged through the role of ICT for energy efficiency in buildings as follows:

- Life cycle approach: Integrated design teams, using interoperable model-based tools and communication/collaboration platforms optimise the whole life performance of buildings.
- Smart buildings: Most buildings will be "smart" and control themselves maintaining the required and optimal performance and responding proactively to external conditions and user behaviour anticipating them, rather than reactively. Holistic operation of subsystems is supported by integrated system architectures, communication platforms, standard protocols for interoperability, sensors, and wireless control technologies.
- Construction as a knowledge based industry: Industrialised solutions are available for configuring flexible new buildings as well as retrofitting existing buildings. Customised solutions are developed by configuring re-usable knowledge from catalogues within organisations and industry-wide.
- Business models and regulations are driven by user perceived value. Financing models provide incentives to stakeholder towards whole life performance of buildings. ICT tools support performance measurement, validation and holistic decision making.

Strategic Research Agenda

Tools for EE design and production management

Vision

BIM-CAD, Collaborative design environments, user interfaces

The architects and engineers are provided with libraries of intelligent (parametric) objects that can adopt (design / configure) themselves in a specific context with essentially less human interference than today. Transformation of design process from computer assisted manual work into a knowledge based “industrialised” process.

Best-practices will be embedded in BIM models as reference design solutions where built-in “smart advisors” will analyse or simulate the evolving BIM during the design process presenting various EE indicators as optimal solutions associated to the current design activity, instrumenting EE performance estimation as coherent feature of preliminary design phase.

Intelligent product catalogues with auto-design BIM software are available to choose producer independent materials from embedded EE-product catalogues. Intelligent (parametric) objects in libraries can adopt (design / configure) themselves in a specific context with essentially less human interference than today. There exists protection of the intellectual property rights (IPR)of design knowledge that is shared digitally with other organisations.

Semi-automatic generation of production plans by combining BIM with libraries of productions methods and resources (materials, components, machinery and suppliers) is available. Self-learning design system with embedded case-based learning is used. Integration of building and district level models include energy exchange between buildings, local generation, storage and grids.

Model analysis and validation, 3D-Visualisation

The decision making of owner/user is supported by exploiting virtual environments where simulation, visualisation, interaction and mixed reality with text, diagrams, 3D and comparison with EE indicators derived from BIM, will be used to evaluate entire life cycle cost of building supporting the interest of stakeholders.

Systems and service integration at all levels throughout the building life cycle enable collaboration of distributed teams. Versatile model analysis tools will be available for analyses and validation of BIMs, alerting users to take corrective actions e.g. with respect to coherency, EE and compliance to requirements and building codes.

Most commonly used building simulation tools will be fully interoperable with commercial design tools and BIM. Also full scale building simulation will take less amount of time where several alternative solutions can be studied rather quickly and easily. Test cases by comparing software tools in standardised reference cases will be used to develop validation/ certification process of tools.

Standardise performance indicators at European level will be available where they can be assessed based on standardised BIM and building energy management systems(BEMS) data which is available from various enterprise systems.

EE Verification, performance based contractual practices:

Project management interface will provide integrated context-oriented information for on-site and off-site construction management; implementation of ICT on remote construction projects will be commonly used for managing workflows and process flows.

Production will be managed through enhanced BIM-based tools with features to include output of optimised operations to improve energy efficiency. These include the logistics optimisation to reduce emissions and the purchasing of sustainable materials.

Quantifying tools for measuring EE and production management will be available with product database specifying the energy value of materials and logistics. There is real time collaboration between stakeholders for design, production management and building operation phase.

There are tools to specify the performance of the building and to verify it with respect to requirements. Monitoring is based on the real (future) building and analysis or simulation using BIM. Such tools will support performance-based contracts. The vision is to accept computer based analysis as contractually valid verification of EE.

Key research topics

Following presents some of the identified research topics in four categories:

Design

- Development of libraries of best practices and reference design solutions
- Certification of tools
- Development of contractual and legal validity of BIM, and digital information in general, as the carrier of design information without the need for “documents” like text and drawings (~”BIM-PDF”)
- Development of tools supporting design and service configuration management

Production management

- Development of tools to support collaborative working environments, modelling, simulation, social media, visualisation, workflow management
- Development of BIM-based project management tools, performance simulation, e-procurement, intelligent e-catalogues, ICT standards
- Development of tools to optimise production EE as part of life cycle (e.g. on/off-site production, local procurement, waste management)
- Enhancement of service provider/facilitatorimplementation of user requirements, service solutions based on integrated information models

Modelling

- Modelling interactions (energy trading transactions) between buildings and smart electricity and heating/cooling grids
- Development of tools to model analysis and validation for EE. Two kinds of validation is required
  (1) Ontology e.g. check that different stakeholders/tools have the same definition of the needed information about e.g. windows
  (2) Instantiated data e.g. check if a specific building, based on its model, complies with requirements e.g. EE
- Development of tools to support modelling of user behaviour with respect to energy consumption for design phase
- Enhancement of current BIM models (IFC) with standardised EE attributes
- Development of information models for mobile technologies

Performance estimation

- Definition ofEE performance indicators and related assessment methods and tools
- Standardisation of performance indicators at European level in a way that they can be assessed based on standardised BIM and BEMS data which is available from various enterprise systems
- Development oftools to show overall performance of the building throughout life cycle and financial instrument to support stakeholders in evaluating the total cost and benefits
- Establishing estimated performance as contractually valid requirement and defining related verification methods
- Development of test cases for simulation software tools to support validation and certification
- Establishing virtual testing environment for Performance Estimation
- Development of performance verification tools /performance -driven process

Drivers, barriers and impacts

General expectation today is short term, i.e. fulfilling the requirements at lowest possible cost. A trend for stakeholder group is needed towards a longer term strategy for life cycle optimised buildings.Industry might gain more control, but energy efficiency factor needs to become the part of core strategy of business changing business models. In the current scenario companies need to provide added value to clients (e.g.EE services), thus not only changing the business models but by having other business in parallel differentiated by brand.

Regulation for energy efficiency centres will enhance on the regulation, directives, building codes, building permissions etc. The importance of integration of renewable energy sources increases and advanced stakeholders will support integration of building life cycle in operation phase as a longer-termstrategy.

New applications will be driven by increasing EE awareness and new EE business models and services, and will mostly be enabled by integration of various functions/tools and improved communications between stakeholders.

As a barriers in the current scenario, for buildings to be energy efficient requires more efforts from the architects and designer where supporting tools for designing embeddedwith EEfeatures and simulations consumes excessive amount of time and resources. There is a need to enhance such tools in a way that more results for designing and

evaluation purposes in less time and with resources can be realized. Following are the identified barriers:

- Lack of interoperability
- Stakeholder specific sub-optimisation and inability to integrate model based information between stakeholders supported by the current regulations (e.g. tendering procedures)
- Unresolved IPR of semantically rich information
- Un-availability of EE data about materials and products
- No systematic feedback from operation to design
- Lack of rewarding contract models that support holistic optimisation; Incompatibility of business incentives for design vs. whole life cycle performance. No systematic feedback from operation to design
- Commonly used design simulation tools are not 100% interoperable with design tools leading to duplication of work and also requireexcessive time for full scale building simulation
- Prevailing business modelsare focusing on delivery costs instead of value to client
- Inability to measure, verify and prove EE of buildings
- Inability to integrate model based information between stakeholders

Gained impacts are:

- Compliance at lowest cost
- EE services (performance based contracts providing incentives for both sides, participation of stakeholder group in life cycle optimisation of buildings)
- Life cycle optimised buildings
- Branding

Intelligent Control

Vision

Full energy-efficiency benefit is harvested through collaborating subsystems and optimal predictive control balancing the trade-off between comfort and energy consumption, local production and storage. Buildings are collaborating on district and city level and building controls are automatically interacting with the smart grid in able to exploit maximum amount of renewable energy sources on-site and level the use to avoid peaks. The systems have self-diagnostics and provide a high degree of monitoring while protecting privacy of individuals. Building controls are derived and tuned based on dynamic building models that through simulation show the nominal energy consumption.

Key Research Topics

To increase energy efficiency through intelligent control requiresresearch in several areas. Following presents some of the identified research topics in four categories:

Automation and control

- Enhancement of energy prediction models and tools
- Development of energy optimal coordination algorithms between applications such as HVAC, lighting, security, etc.
- Development of application of predictive controls considering weather forecast, demand response events and peak power constraints
- Generating optimal building controls from a Building Information Model (BIM)
- Development of real-time algorithms for energy-efficiency diagnosis
- Developing building controls responsive to smart-grid interactivity
- Enhancing optimal controls on district and city level
- Enhancing equipment manufacturers to provide dynamic models of their products enabling simulation
- Development of algorithms that learns tenant behaviour and derives optimal control decision based on this information.

Monitoring

- Decreasing production and deployment cost of basic communicating meters
- Increasing data collection while protecting the privacy of individuals
- Embedding more intelligence in sensors to perform local analysis
- Developing self-diagnosing equipment detecting suboptimal energy performance

Quality of service

- Development of better interoperability and reliability of the technologies and systems
- Enforcement of detection of problems
- Embedding self-diagnosis in sensors
- Using virtual reality for diagnosis and repair
- Including sensors and diagnostics in building materials

Wireless sensor networks

- Development of communication standards ensuring multi-vendor interoperability. In particular for wireless communication supporting battery-less low-power devices.
- Definition of standardised roles and services for sensors
- Development of automatically adapting network topology

- Establishment of cost-effective deployment procedures

Drivers, barriers and impacts

The main driver for intelligent control is increased EE but also to produce economic savings through acting on dynamic energy prices and curtailment events. Another is the need to balance the energy flow between consumption, local production and storage within the building.

Potential barriers include:

- Lack of interoperability between different building systems, i.e. security and HVAC.
- The return on investment of a particular functionality can be hard to estimate accurately
- Lack of tools for easy deployment of advanced functionality
- Lack of global systematic approach for energy efficiency
- Security concerns
- Privacy concerns

The main impacts are

- Increased and sustained EE through active control and fault detection
- Buildings as active components able to interact with the smart grid

User awareness and decision support

Vision

ICT supports understanding, capturing and formalising customer/client needs into requirements, conveying them to all stakeholders and validating compliances. The impact of ICT on EE is well understood thanks to the diffusion of model-based evidence. Standardised methods and indicators are available for decision-support to assess and benchmark the energy performance of districts, buildings, systems and components. Performance audits, labelling and continuous commissioning are supported by recorded data of real time performance.

Main roles of ICT in awareness and decision support are to:

- Provide information to users of buildings, owners, facilities managers, local authorities and urban planners about energy consumption
- Enable occupants to control devices in buildings in order to decrease consumption
- Make occupants aware on how their activities will influence energy use from short and long term perspectives
- Motivate and support behaviour changes by highlighting other factors that affect energy usage (like demographics, family composition)

Information is the key issue in supporting decisions and creating awareness. It is easily available, comprehensible and useful for further operations through various interfaces and taking advantage of gaming and mixed reality. It is possible to gather information about many environmental factors (temperature, humidity, CO_2 concentration, solar radiations, etc.) and predict possible energy use.

As users in the SmartGrid era will be able to not only consume but also produce energy (hence called prosumers), and interact with the smart buildings, the dynamics and complexity of the system increases. Being able to use information and communication technologies may provide an insight on the prosumer current and future activities that is not possible in the conventional grid. As the future energy monitoring and management system will be in close cooperation with the enterprise systems, enterprise services will integrate information coming from highly distributed smart metering points in near real-time, process it, and take appropriate decisions.

The decision making process can consider prosumer-specific behavioral information either measured, assumed or explicitly provided by the prosumer. This will give rise to a new generation of applications that depend on ”realworld” services which constantly hold actualized data as they are generated. Furthermore the integration of potential future behavior of the prosumer may enable better correlation and analytics. This crowdsourcing of information via bidirectional mobile communication with the prosumer, which relates to his infrastructure, planned activities and current context may provide us with not only better understanding but also future knowledge that could be considered in future energy management and decision support systems.

Key research Topics

Performance Management

- Implementation of multi-criteria performance monitoring analysis and optimisation by using the information collected during the monitoring, and take corrective/optimisation measures to improve the energy efficiency while maintaining operation goals.
- Forecasting of energy demand by taking into account not only the current building operation conditions but also its expected evolution, which depends on external entities such as the weather forecast and the scheduled building usage profile.
- Dynamic integration of smart building users, their needs while in parallel striving towards quality of service and energy efficiency.
- Development of a multi-dimensional visualisation system of parameters of building operations and data sharing from technical systems;
- Definition of performance metrics and policy marker at European level.
- Use of product Integrated Virtual Energy Laboratory (IVEL) as quantifying tool for measuring energy performance, consumption and costs throughout building’s life cycle;
- Development of Decision Support System (DSS) as well as benchmarking tools that exploits comprehensive and transferable indicators easily understood by urban planners to find the best integrated building concept, and user to find the best way to control their buildings. With the momentum of green design, new technologies and applications are continuously being developed to assist in sustainable living. A large percentage of energy is consumed in buildings, majorly impacting our individual carbon footprint. By monitoring buildings’ energy consumption in real time with a web or mobile application users can pinpoint vampire devices, times of high or low consumption, and wasteful patterns of energy use.

Visualisation of energy use

- Development of new human-machine interfaces (HMI) and smart energy meters incorporated into BMS is important to provide real-time information on energy consumption in building.

- Web & mobile device accessible “energy account” could provide users a usable device to have real-time control on energy consumption and an intuitive way to understand how to modify their daily behaviour that affects energy consumption.
- Improvement of integrated energy visualisation tool in order to provide users a detailed vision of their individual carbon footprint considering the overall of daily activities they performed is needed. However, the development of common rules as a base for readable reports on energy consumption to end-users is needed.
- Consider the end-user needs (cultural context, comfort, user’s behaviour, etc.), exploiting intelligent system for data management. This could be done with the help of new cross-domain stakeholders such as sociologists.
- Identifying of the level of individual knowledge that each user (such as occupant, inhabitant, and building’s owner) must have about the buildings in which he lives or works in. This kind of knowledge should be referred to the followings subjects:
    - Geographical information: the place where the building is built, in order to be able to identify the features of the building itself, like orientation to the sun, wind exposure and so on, but also information the external environment
    - The inner comforts: for instance the electric equipment, which are installed in the building, that increase the daily level of well-being for users living or working in the building and are directly or indirectly used by end user.

Behavioural change

Creation of paperless on-line solutions to easily display up-to-date drawings and other construction related materials on site:

- Showing evidence and demonstrate the comparison of investment and operational costswith the achieved energy savings and energy efficiency improvement.
- Development of intelligent and usable e-learning system that allows changing residents’ behaviour as a result of ICT in order to increase its added value. These systems will help citizens to improve their behaviour by learning new ways of conducting daily activities.Theuser-friendly websitesbecome the “gym” where users, easily from their house, could learn the merits and methods of energy conservation in order to reduce energy consumption and save money.
- Development of tools for comparison at neighbourhood level or with similar unities, e.g. family composition and user density within the building.
- Development of on-line tools to verify the adequacy and compliance with the Energy Performance of Buildings Directive (EPBD).
- Development of ICT solutions should enable “social sharing” since “social pressure” is one of the best means of getting people involved in changing their behaviour.
- Intuitive mobile applications for smart phones will help users to quickly understand their usage habits by clearly identifying total consumption as well as individual device consumption. This kind of applications and devices installed in buildings can help in obtaining valuable information. Users will be able to turn on electrical appliance in the most appropriate moment to reduce energy or when the net will be less charged using their smart phones being away from home or using television for example.

Drivers, barriers and impacts

The main drivers to increase users to get aware of energy consumption and efficiency from short and long term perspectives are represented by the:

- Identification of individual knowledge
- Lack of standardised data formats and models that can enable rapid integration in applications
- Enable user-specific information assessment and advanced energy management
- Reduction of technological equipment cost and energy consumption.
- Identification of European standards and common metrics

In addition, it is important to train occupants to understand that they are a key component in the building and of any EE strategy.

Any technology that hopes to affect energy use, especially by individuals, must take into account the "**motivation of the users**", i.e.

- What does each individual really care about?
- What motivates him or her?
- What lifestyle do they have / would they like to have?
- What are the person's desires?
- Is it to have fun?
- To be comfortable?
- To make a difference?
- To become more integrated into the community?

Therefore, the best technology would tap into a person's motivations, lifestyle and habits would enable him/her to better understand and be able to make aspirational, fun, 'desirable' lifestyle choices that would have the effect of reducing energy. Technologies are progressing with increasing velocity and the knowledge of people, who must make decisions and act upon to meet energy reduction targets, is easily lagging behind.

Furthermore "**social pressure**" is one of the best means of getting people involved in changing behaviour, and that technology that enables EE in the next 10 years or sooner would need to enable social sharing.

As a key barrier people are usually not willing to adopt new things especially if it requires a change in their behaviour. They have had gained habits through the years and it is not easy to convince them to change. Otherwise, people are reacting when they are dissatisfied with a situation. So it is not about a lack of willingness, but about a lack of triggers: this clearly indicates that one of the needs for large spreading of ICT for energy efficiency is thus identify the right direction to make people reacting. Therefore presented solutions have to be user friendly as much as possible as well as relevant and effective.

Designers, architects and civil engineers can use different software tools supporting their decisions, however mostly they are not operating with the same format standard. The **identification of European standards and common metrics is** fundamental to have regulation that allow to obtain a reference metric that can be used across different European Countries. There is a general trend to make uniform data standards, but also special engine software tools available (like FME - Feature Manipulation Engine) that are able to transform a format into another. Moreover, from the standardisation point of view it would be useful to have a complete list with energy features for each material product for instance in the field of construction.

From the impact point of view the users and owners of buildings will be the main beneficiaries as they will be empowered to make informed decisions about the building and its use. Although technology is only one of the available tools that could be used to achieve energy saving and that in order to achieve maximum impact, ICTs would need to be combined with non-ICT tools in a suite of energy efficiency measures available to users.

Energy management and trading

Vision

It has been shown that value is created when interactions among people, businesses and generally entities exist. For these interactions to happen, networks are formed that operate with their own rules over an infrastructure. The smart grid enabled city is an emerging complex system of systems where different stakeholders will have to strive towards achieving their goals while interacting with eachother. At parts of the city such as the districts, the energy signature and efforts towards its better energy efficiency will heavily depend on the utilization of availability and optimal usage of the local resources. The latter may be very dynamic and depend on several complex conditions such as weather, prosumer behavioural patterns, business interactions etc.

Energy Management and Trading are seen as key issues in the emerging future energy infrastructure. An energy market is one possible direction towards easingthe interactions among all smartgrid stakeholders withinthe scope of a smart city. It is not clear how thesemarkets will operate and what the minimum requirements are in order to have them functional and beneficial fortheir participants. Buildings could play a key role in energy markets as they are no longer passive energy consumers but active prosumers and by adjusting their energy flexibility can take part also in energy markets. Buildings are no longer seen as standalone entities but as an integral part of a larger ecosystem both internally (within the subsystems of the building) and externally (with other smart city entities e.g. buildings, transportation system, public lighting, etc.).

In this context future smart buildings are expected to play a pivotal role. Within the buildings themselves, intelligent devices are monitoring and actuating autonomously its behaviour in order to achieve the desired functionality. Users are now able to interact with the building and configure it to fulfil their needs, event temporarily; this is possible only because a new generation of energy services enable this kind of interaction. Several optimisations take place at local and building wide level considering the internal as well as external conditions.

Buildings are no longer striving towards energy optimisation only at building-wide level but also consider district or even smart citywide constraints. As such they may collaborate with nearby buildings in order to achieve energy efficiency. Additionally they collaborate within a smart city infrastructure e.g. the transportation system and use their resources (internal operations, electric vehicles on their parking place, etc.) to assist the optimal electricity network operation e.g. acting as an energy-balancing partner. With the emerging opportunities that the smart grid offers, buildings can now buy and/or sell electricity on available marketplaces, intelligently plan their energy behaviour and even provide new revenue sources to their owners by adjusting flexibly their behaviour to demand-response conditions from the electricity grid.

The buildings of the future will be part of a live ecosystem that will heavily interact and collaborate with users and external entities to optimally manage their energy footprint locally and as part of the ecosystem.

Key research topics

From the research perspective there are several issues that need to be investigated. Some of these include:

- Migration towards open and fully open and service-based infrastructures
- Energy storage and flexible management of it
- Adoption of collaboration tools for open cross-industry information exchange
- Enhancement of energy prediction models and tools
- Standardisation
- Development of energy optimisation and control models and tools
- Development of real-time analytics
- Development of models and methods for assessment and comparison of energy footprint during the whole lifecycle of processes
- Development of tools for data security, privacy and trust management
- Development of Internet based energy services for smart buildings
- Integration with online energy marketplaces
- Easy integration of alternative energy resources and Demand-Response management
- Development of tools for the assessment of approaches during their whole lifecycle including cost, environment impact, maintenance etc.

Drivers, barriers and impacts

There are several stakeholders that will directly or indirectly impose drivers. The key drivers may come from the quest towards energy management and efficiency and be driven by key stakeholders such as DSO, facility management, etc. The enabling ICT technologies may be provided by the market players who will drive them. Economic and Policy/Regulation reasons imposed at European wide level may also push towards this direction.

Potential barriers include:

- Lack of awareness on innovation for energy management as part of an ecosystem
- Lack of demonstrating clearly the benefits in real-world lighthouse projects
- Lack of open standardised approaches for energy data monitoring and assessment
- Lack of policies and incentives at national and European wide level
- Inadequate workforce skills and training
- Lack of ICT tools for enabling interaction of all stakeholders
- Lack of business adaption and availability of value added services
- Security concerns
- Privacy concerns
- Failure to anticipate the lifecycle management i.e. from cradle to gravefor the maintenance of large scale systems
- Focus on standalone solutions and goals and failure to consider collaboration at all layers.

Significant economic, social and innovation impact may be achieved.We see three distinct directions relevant to Energy management and trading:

- Building Energy Management: Here significant impact could be achieved, tackling energy efficiency and with the first results already available in the short-term.
- District Energy Management: Significant impact could be achieved in the mid and long term that could lead to optimal energy management at district and smart city level.
- Smart Grid and the Building Environment: Integration with the Smart Grid and optimal consideration of the Building environment and advances in other sectors e.g. construction could both lead to high impact and act as an enabler for energy efficiency.

Integration technologies

Vision

The dynamic nature of design projects requires parallel processes, smooth workflow and tight control. There are applications to give support to all these needs and allowing different profiles of experts work together in a project with no difficulty related to coordination of processes and the shared control of the entire project. These kinds of applications offer smart workflows that are synchronised automatically depending on the status of the project without any help.

Embedded diagnostics methods, which are capable of running on local controller devices, allow early detection of anomalous energy consumption and/or malfunction of individual components (dampers, valves, coils, etc.) in sub-systems such as air handling, heating, cooling, or lighting. Load management algorithms consider future energy consumption and based on that adjust the consumption curve by shifting or curtailing some of the loads. In case of system optimisation, the control strategy uses the information about the operation states, loads, weather conditions, tariffs, and equipment characteristics.

Data models and real-time communication protocols are standardised in order to allow all the stakeholders to develop their devices without problems at the moment to plug them and make them to work together. Devices from different producers arein use at the moment when plugging them, because all the devices inside and outside the buildings share the same protocols. Other domains protocols and standards are integrated as needs and applications of buildings will increase.

The information from different stakeholders is shared between them using inter-organisational knowledge platforms, where the information is organised by term and which offers an easy way to be consulted.

Key research topics

Nowadays, in thedesign and construction process of abuilding, very differentapproachesareneeded, which leads to engagein the process different kindof professionalswithin their respectiveroleintheproject. Taking it into account and also the increasing complexity of the buildings in order to improve their efficiency, leads to a very high demand of ICT tools to achieve the objectives:

- A collaboration tool between all the stakeholders involved in the project in order to interact between them in the building life cycle.
- Better implementation of building lifecycle by changing the point of view regarding the importance of its energy costs.

- New embedded devices for monitoring and control the energy consumption in the buildings and in a lower level, taking into account each flat/office that compounds the building.
- Better tools to share and generate the knowledge between all the stakeholders involved (e.g. cloud technology).
- Combination of human networks, social capital, intellectual capital, and technology assets, facilitated by a culture of change.

The technological development that is requested to satisfy these demands has been structured in the following RTD topics:

- <u>Process integration</u>: focused in the development of reliable and useful tools in relation with collaboration and business work flows. In fact, it is one of the most interesting and key areas of research in order to end up with a tool capable of make efficient the interaction between all the roles involved in the projects.
- <u>System integration</u>: related with integration platforms and services supported, SOA, Middleware, Development methods and tools as Integrated design environments (IDE), embedded devices for control and monitoring of consumption, data modelling methods, Plug&Play. Identifying and understanding the borders of systems or between stakeholders is essential.
- <u>Interoperability and standards</u>: related with research areas involving data models and real time (in-side and out-side building) communication protocols. Rapid development of coherent standards for interoperability is needed. These standards should contemplate future systems and the broader range of applications that are being envisaged now. Moreover, improved interoperability must therefore be a core element of all future initiatives.
- <u>Knowledge sharing</u>: management of the access to knowledge using a platform with repositories, forums etc. with a user profile to split the users depending on their role and area of expertise. Also including data mining and semantic search.
- <u>Network management functions</u>: these are used in every control solution to design, configure, commission and install devices. Often network management functions appear invisible or operate automatically in the background during system/device configuration.

Drivers, barriers and impacts

One driver to be taken into account that enhance the technological changes in relation with ICT for energy efficiency buildings is the social awareness about the problem of the Climatic Change and its relation with the building's energy consumption. On the other site, it's necessary to consider the presence of internet in most of homes and offices that gives more technological options to develop embedded software and devices to balance the consumption and the generation of energy in buildings as well as the real-time monitoring and control.New protocols like IPv6 will ease the communication and integration between different devices inside and outside the buildings as well as the implementation of the Smart Grid concept.

The main barrier at this point is the lack of knowledge about the importance of the adoption of a building life cycle in relation with energy cost. As we know, a lot of stakeholders take part in the building life cycle and usually most of them are not big companies. Therefore most of them are focused in their role on it and it's difficult to find any stakeholder that can lead the adoption of it overall the whole process.

The difficulty that represents to adapt the existing building to the new approaches of energy efficiency in buildings is another barrier at this point. It's clear that the installation needs to be automated and more complex and no always it is possible without a big investment.

Expected benefits and business opportunities to key can be summarised in the following ones:

- Better knowledge about building life cycle energy performance and the importance of its adoption regarding reduction in building project execution times and costs and higher quality of the buildings
- Implementation of the smart-grid concept. Higher integration of buildings in the energy networks will allows exploiting the building's energy generation and storage capabilities and their associated equipment, as future electric cars.
- New business opportunities for ICT, energy and building sectors.
- Higher sustainability with lower resource's consumption (i.e. travel, energy, etc.) via changes to the way we work.
- Achieve a standardisation regarding communications and protocols to ease the interoperability and the communication among different devices.
- Share of knowledge among all the stakeholders involved in energy efficiency.

Implementation Action Plan

Based on the SRA the necessary actions by different stakeholders were identified.

Integrated Design

Technical Scope

The life time performance of a building is largely determined in the design phase. This is especially the case when new buildings are designed. Design for retrofitting of existing buildings is also crucial as buildings and/or their subsystems and components are renewed several times throughout their life time. Complex building systems need to be optimised based on multiple and often conflicting criteria. The degree to which the designed energy efficiency potential will be actually materialised, depends on the downstream life cycle stages (construction, commissioning, operation, user behaviour etc.). Therefore integration between different information sources, stakeholders and stages is of fundamental importance for design.

Classification

1.1 Design; 1.2 Production management; 1.3 Modelling; 1.4 Performance estimation; 5.1 Process integration; 5.2 System integration; 5.4 Interoperability & standards.

Target Outcomes

The main RTD targets for integrated building design are interoperability of various ICT applications and the ability to share information at high semantic level between stakeholders over all life cycle stages:

- Enhancement of existing design, analysis and simulation applications as well as catalogues with energy related attributes and interoperable interfaces based on standards.
- ICT platforms to facilitate sharing of and negotiations about the evolving design information within and between organisations. The challenges include e.g. providing open access to relevant stakeholders, presenting information in context driven ways, supporting both the agreed inter-organisational

transactions and internal workflows of each organisation, and protecting the IPR of semantically rich information.
- Holistic optimisation of the interactions between different subsystems considering technical, commercial, sustainability and regulatory factors.
- Methods for collaborative development of early stage design concepts and decision support with context driven visualisations.
- Tools for modelling existing buildings &facilities for retrofitting design e.g. by scanning.
- Collaborative configuration design and customisation based on reference solutions, adaptation rules and catalogues of parametric objects.
- Methods and services for very long time data archival and recovery over generations of standards, tools and storage media.
- Simulation based systems for refining requirements for highly interdependent complex systems and for validating the contributions of different subsystems to the overall energy performance in areas like complex office or public buildings and major infrastructures.
- Definition of standardised energy performance indicators which can be calculated from available design and operation data. Methods for ICT-based validation of the actual performance compared to the designed performance. Certification procedures for performance assessment software and methods.
- New design processes and collaboration forms.

Expected Impacts

Integrated design has direct impacts on the design process itself as well as on the subsequent life cycle stages which depend on design information. The energy performance of the target system depends ultimately on the combined impact of design, materialisation and operation.

- Engagement and empowerment of relevant stakeholders in the design and decision making process.
- Enhanced use of proven reference design solutions with less reinvention.
- Awareness and improved understanding of stakeholders about the impacts of various design options and generally about the impacts of ICTs on energy efficiency.
- Improved quality of design with respect to compliance to requirements, consistency, number of errors, and predictable and optimised life cycle performance.
- Better information support to the downstream life cycle stages (materialisation, operation).

Suggested roles of stakeholder in implementation

Public sector, building clients: Promote integrated design in the procurement of buildings. Require comprehensive standards-based information delivery. Promote and adopt standardised performance indicators / metrics. Develop and implement contractual conditions that incentivize the design team towards holistic life cycle performance. Promote the rights of citizens to receive information about designed buildings andt o participate in consultations about them.

*E2BA:*Promote RTD on integrated design towards interoperable design tools, ICT infrastructures for cross-organisational collaborative engineering and contractual conditions to incentivize design teams for optimised life cycle performance of buildings. Activate the construction design sector to adopt new technologies and collaborative business models.

Construction sector companies and organisations: Establish guidelines and template agreements for integrated design covering the roles and responsibilities of stakeholders, interoperability requirements of shared design information, compliance conformance validation procedures, intellectual property rights of shared digital information etc.

ICT sector: Increase the semantic level of (the input & output information of) design tools. Develop standards based interfaces. Develop ICT platforms / infrastructures that allow companies to fully manage their internal workflows (e.g. design iterations &internal approvals) using their in-house tools while interacting in a controlled way with external project partners (information releases, conformance checking, change requests, audit trail & interference resolution). Develop generic catalogues for re-usable information (products, materials, reference design solutions, best practices). Provide ICT platforms / infrastructures as services (IaaS, Infrastructure as a Service) with appropriate service contracts suitable to temporary project teams in the construction sector. Develop 3rd party trust services for information sharing and archival.

Energy sector: Provide information about local energy provision and exchange conditions. Suggest protocols for energy management between the energy grids, local generation, storages and buildings.

Knowledge providers: Train construction professionals to collaborate and negotiate in virtual environments. Educate construction ICT experts to develop and deploy interoperable design tools and collaborative design environments. Provide information brokerage services about materials, products and services from various providers to specific target groups.

End-users: Require open access to design information about new or renovated buildings and participate in public consultations about them. Provide information to building user profiles. Participate in web based communities (social media) to share user experiences.

Standardisation bodies: Develop and enhance standards for interoperability (IFC, IFD, IDM).Develop and standardised performance metrics (EE indicators and validation methods) based on information that is available from current and emerging ICT systems.

Component Catalogues

Technical Scope

Catalogues of materials and components are needed to support the design of (new and retrofitted) buildings and their subsystems as well asfor procurement. The catalogues should provide access to versatile commercial and technical information (including e.g. energy efficiency related properties). The information contents should be at high semantic level in order to allow full exploitation of increasingly model based design tools.

Classification

1.1 Design; 5.3 Knowledge sharing; 5.4 Interoperability & standards.

Target Outcomes

- Catalogues with semantic information of materials, components and re-configurable design solutions. Parametric objects to support configuration/adaptation of generic component types for specific applications.
- User interfaces for semantic search and filtering for user and context specific data delivery.
- Standards-based interfaces / web-services for interoperability with various CAD tools and engineering applications for design, performance analysis, simulation, visualisation etc.
- ICTs for brokering information from several sources e.g. combining manufacturer specific catalogues to serve specific groups of information users (examples: architects, building services designers).
- Standardised data models of catalogue contents, in this context regarding especially energy related data e.g. embodied energy.
- Toolkits for catalogue authoring, publication and maintenance.
- New business and service models for information providers and brokers.

Expected Impacts

- Improved efficiency and quality of design through use of pre-existing knowledge.
- Improved energy efficiency through availability and re-usability of energy related data.
- Accelerating take-up of more sophisticated ICT due to increasing information availability

Suggested roles of stakeholders in implementation

- *Public sector, building clients:*Expectapplication of proven construction solutions when radically new solutions are not especially required.
- *E2BA:* Promote industrialised construction supported by methods for custom design.
- *Construction sector companies and organisations:* Develop industrialised construction and renovation methods. Publish product/solution information catalogues. Set up and operate sector-wide catalogue services.
- *ICT sector:* Develop ICT tools for catalogue authoring, maintenance, publication, brokering between different catalogue services and user profile driven information delivery. Enhance existing design tools with support for using external catalogues, parametrics and configuration management.
- *Energy sector:* Suggest information to be provided about local generation and storage facilities.
- *Knowledge providers:* Train/educate construction professionalson industrialised construction methods, mass-customisation and configuration design.
- *End-users:*Require comprehensive information about buildings, their subsystems and components.
- *Standardisation bodies:*Continued development ofICT standards for product information, regarding e.g. energy aspects (same also in 5.3), and metadata for catalogue items.

Data Models

Technical Scope

Achieving energy efficiency requires holistic management of information from many stakeholders over the product (building) life time. Common concepts and language are prerequisites for communication between both humans and ICT systems. Agreed data models (ontologies) are needed to bridge the gaps and to enable information sharing and re-use without error-prone manual interpretation, re-entry and loss of data.

Classification

1.1 Design; 5.4 Interoperability & standards.

Target Outcomes

- Existing data models for various application domains extended with EE specific concepts in the short term.
- Common cross-disciplinary concepts by alignment of sector specific ontologies to support balancing of energy provision and consumption (e.g. grinds and buildings).
- Definitions of metadata of shared information in distributed collaborative design and engineering, and catalogues of materials and products.
- Standardised representation of functional/parametric product/system objects with embedded configuration/customisation logic.
- Convergence of agreed models and ontologies for different inter-related applications areas, leading to standardized data models covering energy related aspects in a broad range of applications in the long term.

- Test cases, methods and procedures to validate the compliance of software tools and shared data with respect to agreed data models (ontologies).
- Forums bringing together developers of data models (ontologies) from inter-related application areas (e.g. buildings, process plants, grids etc.) to join forces towards harmonisation of ICT standards related to energy efficiency. The already launched activities in this area are foreseen to remain necessary in the long term.

Expected Impacts

- Standardised data models (ontologies) covering energy related information and interactions within and between related application areas (buildings, smart cities, energy systems).
- Improved ease of access to EE knowledge through a common ontology.
- Interoperability of design software through compliance to standardised data models.
- Improved energy efficiency through holistic optimisation using integrated information.

Suggested roles of stakeholders in implementation

- *Public sector, building clients:* Promote access to and re-usability of building information throughout the life cycle via model based design. Specify information delivery requirements in construction projects aiming at high semantic level. Adopt digital data as contractually valid original information.
- *E2BA:* Promote transition from paper-oriented documentation towards digital and computer-interpretable (model-based) information as a key to transform construction from a resource providing industry into a knowledge based industry.
- *Construction sector companies and organisations:* Define information requirements. Deploy model based tools and require interoperability between them.
- *ICT sector:* Develop new model based tools and enhance the semantic power of existing tools. Comply with interoperability standards. Develop tools for analysis and compliance assessment of model based data.
- *Knowledge providers:* Train/educate construction professional to understand information requirements of other related disciplines.
- *End-users:* Expect to receive customised information for different needs, regarding both logical content and presentation.
- *Standardisation bodies:* Continued development of standards for product information regarding e.g. energy aspects (same also in 5.2).

Application Tools

Technical Scope

Application tools for design include general purpose CAD tools with sector specific add-ons and a huge variety of specific tools for engineering analysis, life cycle performance estimation, simulation, visualisation etc. The main research needs are related to issues like: early stage design and decision making, enhancing the scope of existing tools to support design for EE, increased utilisation of previous good design solutions, information sharing between various ICT tools through interoperability and reducing the gap between predicted and actual energy performance of systems through holistic engineering methods e.g. simulation.

Classification

1.1 Design; 5.3 Knowledge sharing; 5.4 Interoperability & standards.

Target Outcomes

- Concept design – Profiles of end user groups regarding their requirements and energy consumption patterns. Tools for early stage conceptual design, life cycle energy performance estimation based on reference data, visualisation and decision support of design options. Methods, e.g. based on simulations, to derive detailed requirements from models of complex systems.
- Detail design – Configuration design based on templates, reference solutions, parametric adaptation rules and intelligent component catalogues. Modelling existing buildings/facilities for retrofitting design e.g. using scanning. Context aware visualisation of the evolving detail design solutions for cross-disciplinary decision making.
- Engineering analysis and simulation applications – Domain specific application tools enhanced with energy related aspects and interoperable interfaces based on standards. New tools for integrated assessment and visualisation of costs, environmental impacts, comfort etc. Holistic simulators of complex systems such as buildings interacting with energy systems and infrastructures. Procedures and test cases for certifying software tools.
- Supply network management, production planning and management – Decision support for selection of materials, components, suppliers and production strategies (e.g. offsite vs. onsite production considering logistics and local resources). Simulation supported real-time production management. Context related multimedia content provided to workers on portable devices. Inter-enterprise ICTs supporting coordination towards contractual goals, including energy efficiency.
- Visualisation and decision support – Besides informing stakeholders about real-time progress towards EE objectives and highlighting trade-offs between environmental and economic concerns, ICTs should also proactively suggest options for decision making.

Expected Impacts

- Awareness and ability of stakeholders to make grounded decisions about design and production options.
- Reusability of proven solutions through model based design technology, interoperability, configuration design and intelligent catalogues.
- Improved quality of design through holistic consideration of the interactions between various subsystems.
- Certified software tools reducing he gap between predicted and actual system performance.

Suggested roles of Stakeholders in implementation

- *Construction sector companies and organisations:* Shift from in-house tools increasingly to commercially supported tools. Provide test cases for comparing different tools within an application area.
- *ICT sector:* Develop methods for validation of software tools. Integrate isolated tools and improve their interoperability. Develop toolkits and business models for co-development of ICT-applications with domain experts.
- *Knowledge providers:* Educate construction sector ICT experts to specify and develop ICT applications.
- *End-users:* Specify requirements for the contents and visualisation of design information.
- *Standardisation bodies:* Provide methods and procedures for software validation.

Visualisation of Energy Use

Technical Scope

Definition of new interactive Graphical User Interfaces exploiting the new types of mobile devices such as smart phones and tablets. Availability of broadband internet connection wherever the user is located.

Classification

1.1 Design; 2.2 Monitoring; 3.2 Visualization of energy use; 5.1 Process integration.

Target outcomes

- Innovative and easy to use attractive interfaces and mobile applications to visualize real-time data related to energy consumption and to predict real time costs. This has the purpose to increase the knowledge about real end-user needs, and to identify the level of individual knowledge that each user must have about the buildings in which he lives or works in.
- New IT solutions and embedded sensors will come from other field of use as pervasive technologies that will be user centric.

Expected Impacts

Energy consumption visualization allows end users to oversee and control their own consumption, allows detecting potential misuses of buildings due to a lack of awareness of the users, potential disorders and/or pathologies of the monitored building. Moreover, conditional maintenance approaches can bring added value in guaranteed performance contracts.

Suggested roles of stakeholders in implementation

- *Public sector, building clients:*Increase the adoption and diffusion at local, national and international level of the rules for allowing a better visualization of end-user private energy data.
  - *ICT sector:* Information is the key issue in supporting decisions and creating awareness. ICT operator will have a twofold role:
    - develop intuitive and easy to use user interfaces for visualization of energy consumption
    - collaborate with energy and public sector to the dissemination and communication of the potentialities of the new visualization tools to general public
- *Energy sector:* To provide incentives to their customers to facilitate the installation of energy visualization displays in the buildings.
- *Knowledge providers:* Organization of training sessions and development of e-learning websites to disseminate the advantages related to new visualization energy tools to final users.
- *End-users:*To be stimulated by the new visualization tool to reduce the energy consumption and change their behaviour towards better energy efficiency.
- *Standardisation bodies:*Spreading awareness providing specific guidelines particularly those that affects data security protocols to guarantee the protection of user private energy data during the visualization procedure

Performance Management

Technical Scope

Development of models and methods to allow relevant stakeholders to assess the energy efficiency in buildings in order to improve their EE performance, such as Artificial Intelligence methods and Genetic Neural Network. Definition of new reliable and easy to use data management system for managing energy performance data.

Classification

1.1 Design; 1.4 Performance Estimation; 2.2 Monitoring; 3.3 Behavioural change; 5.1 Process integration

Target Outcomes

- Multi-dimensional visualisation system of parameters of building operations and data sharing from technical systems.
- Virtual 3D energy simulation environment as quantifying tool for measuring energy performance, consumption and costs throughout building's life cycle.
- Sensing techniques, possibly coupled with dynamic building simulation models.
- Innovative web/mobile applications to monitor buildings' energy indicator.

Expected Impacts

- Promote behavioural changes in building residents, building operators and owners by highlighting other factors that affect energy usage (like demographics, family composition).
- Users can pinpoint vampire devices, times of high or low consumption, and wasteful patterns of energy use by monitoring buildings' energy consumption in real time with a web/mobile application

Suggested roles of stakeholders in implementation

- *Public sector, building clients:* Enable the adoption and diffusion of performance management system at neighbourhood, city-wide, regional, national and international level.
- *E2BA:* Promote the uses a European observatory on energy performance involving a European wide database.
- *Construction sector companies and organisations:* Guarantee of measured energy performances to meet pre-set contractual values used as benchmark. Energy performance management achieves an high level of comfort and health (thermal comfort, acoustics, indoor air quality and accessibility in particular).
- *ICT sector:* To develop effective methods to assess the impact of ICT solutions on the energy efficiency in buildings. Creation of a European database on energy performance measurements.
- *Energy sector:* Support public sector actors in the definition of actions useful to perform a widespread adoption of ICT performance management system among end-user.
- *Knowledge providers:* To promote the use of performance management tools among designers, engineers, architects, urban planners. To provide training actions for building residents on the utility of performance management tools to evaluate the EE of the buildings in which they are living.
- *End-users:* Shall be educated in the subject of energy and cost saving opportunities given by the adoption of performance management tools, for example to pinpoint vampire devices, times of high or low consumption, and wasteful patterns of energy use.
- *Standardisation bodies:* To introduce harmonised European standards that allow to obtain a reference metric to be used across different European Countries. To make a complete list with energy features for each material and product, for instance in the field of construction.

Behavioural Change

Technical scope

Introduction of new multimedia devices act to provide in an attractive way suggestion/recommendation to end-user concerning the impact of their daily behaviour in the scenario of energy saving

Classification

1.4 Performance Estimation; 2.2 Monitoring; 3.1 Performance Management; 3.2 Visualization of energy use; 5.1 Process integration

Target outcomes

- Evidence and comparison of investment and operational costs with the achieved energy savings and energy efficiency improvement.
- Intelligent and multimedia system that facilitate the changing of residents behaviour as a result of ICT in order to increase its added value. These systems will help citizens to improve their behaviour by learning new ways of conducting daily activities.
- The user-friendly websites become the “gym” where users, easily from their house, could learn the merits and methods of energy conservation in order to reduce energy consumption and save money.
- Tools for comparison at neighbourhood level or with similar unities, e.g. family composition and user density within the building, by exploiting census for protecting privacy.

Expected impacts

- More accurate broadcasting of information to users of buildings, owners, facilities managers, local authorities and urban planners about energy consumption.
- Awareness of occupants on how their activities will influence energy use from short and long term perspectives.
- Motivation and support for behaviour changes by highlighting other factors that affect energy usage (like demographics, family composition).

Suggested roles of stakeholders in implementation

Public sector, building clients: To create a legislation and incentives to promote the use of behavioural changes tools among building owners and residents to decrease the energy consumption. To define regulation that allows sharing of end-user consumption data (e.g. in a neighbourhood or thematic community) while protecting privacy.

- *Construction sector companies and organisations:* ESCOs will be able to show evidence to building owners and residents of the comparison of investment, operational costs and energy savings that can be achieved through the adoption of behavioural change ICT tools.
- *ICT sector:* To develop ICT solutions, mobile access interface, multimedia tablets, which are extremely user friendly as well as relevant and effective. These solutions should also enable “social sharing”, according to specific regulation about data privacy management that currently are missing and should be released, since “social pressure” is one of the best means of getting people involved in changing behaviour.
- *Energy sector:* Providing real-time pricing information to end users.
- *Knowledge providers:* To adopt and promote the development of usable software application (accessible by pc and mobile devices as smart phones/tablets) aimed at changing residents’ behaviour. Promoting change in collective behaviors, tackling large groups.
- *End-users:* Shall be surrounded by display, control panels and multimedia system useful for a better understanding of the advantages related to the modification of everyday behaviour for decreasing energy consumption.
- *Standardisation bodies:* Spreading awareness and acceptance on the necessary changes, providing specific guidelines, particularly those that affects lifestyles and behavior.

Real-time Analytics on Energy Data

Technical scope

A significant amount of information (Big Data) is generated by the future smart buildings. Real-time analytics need to be done in order to be able to assess the business value of data collected and take the relevant business decisions. To do so high-performing cloud-based systems, new parallel algorithms, efficient Complex Event Processing (CEP) technologies etc. will need to be significantly advanced.

Classification

1.2 Production management, 2.2 Monitoring, 2.4 Wireless sensor networks, 3.1 Performance management, 3.2 Visualisation of energy use, 4.1 Building Energy Management, 4.2 District energy management, 4.3 Smart grids and the built environment, 5.1 Process integration, 5.2 System integration, 5.3 Knowledge sharing

Target outcomes

- IT architectures and tools for High performance real-time analytics of “Big Data”.
- New distributed analytics algorithms and services.
- Mobile End-User applications

Expected impacts

- Correlation of business aspects and energy consumption.
- Cost effective plans considering energy aspects.
- Improved decision-making processes through visibility of energy.
- New service providers in the knowledge economy.

Suggested roles of stakeholders in implementation

- *Public sector, building clients*: Promote open interoperable data exchange formats. Promote privacy-preserving data collection.
- *E2BA:* Consider the value by real-time analytics on huge data and acquisition of potentially new insights. This is applicable for consumers, districts and smart cities Integrate real-time analytics for better monitoring and understanding of energy usage at system level, in order to enhance decision making.
- *Construction sector companies and organisations:* Consider in decisions, analysis of data for the specific optimal case in their line of business.
- *ICT sector:* High performance cloud computing approaches. Real-time communication and computation platforms for large amounts of data.
- *Energy sector:* Provision of fine-grained data over time (eventually even minute-wise or less) and nature (at device level, building level etc.).
- *Knowledge providers:* Education on understanding analysis results and the impact in their tasks.
- *End-users:* Integration of results in their everyday life. New applications with insights on their own infrastructure.
- *Standardisation bodies:* Develop/enhance standards for interoperable and efficient information exchange and processing.

Smart Building integration in the Demand Response/Energy trading

Technical scope

Future Smart Buildings are seen as an integral part of smart cities and can have a significant impact on their Demand Response programmes. Hence they should be seen as stakeholders participating in DR concepts and energy trading at neighbourhood or city level. DR and energy trading may assist at system-level (e.g. neighbourhood or smart city) to better manage its resources and adjust dynamically to its needs. New IT tools and methods for assessing a system-wide view are needed as well as basic services and applications that will enable DR and local market electricity trading.

Classification

2.2 Monitoring, 3.1 Performance management, 4.1 Building Energy Management, 4.2 District energy management, 4.3 Smart grids and the built environment, 5.1 Process integration

Target outcomes

- New technologies and applications enabling smart buildings to act as balancing partners in the smart grid e.g. sophisticated energy management systems that can monitor and control context-aware energy processes
- New systems considering energy costs and trading their energy flexibility as a new revenue.Source [11]
- New approaches in interacting with the building's users and consider their tasks/schedule (e.g. via their calendar) for the building-wide energy planning.

Expected impacts

- Business Performance not only cost-optimised but also energy-optimised (or a mix of various Key Performance Indicators).
- Integration of new infrastructures (smart buildings) in real-time energy management at building and grid level. For instance consideration of in-building produced energy with its needs and external acquisition.
- New revenue sources for smart building managers/owners.

Suggested roles of stakeholders in implementation

- *Public sector, building clients:* Promote energy-aware buildings. Enable trading of electricity at neighbourhood or city-wide level. Integration of all energy aspects beyond electricity, including heating/cooling into an system-wide view.
- *E2BA:* Consider the buildings as active part of a larger ecosystem and not as standalone isolated entities. Buildings of the future will be able to (i) communicate their state, (ii) adjust their state based on internal and external interactions (e.g. with a market, other buildings, energy efficiency guidelines etc.
- *Construction sector companies and organisations:* Consider what the ICT capabilities of future buildings should be and enable them at all phases (design, construction etc.).
- *ICT sector:* Real-time monitoring and Real-time energy management approaches for the smart building lifecycle should be considered.
- *Energy sector:* Integrate interactions with energy flexible infrastructures (such as the smart buildings)
- *End-users:* Integration of results in their everyday life. New applications with insights on their own infrastructure.
- *Standardisation bodies:* Interact with the buildings and share information so that both can benefit from energy efficiency approaches.

Building models for control

Technical scope

During the operations phase dynamic building models can be useful in a real-time sense, e.g. to make optimal control decisions including weather forecast and variable energy pricing. Such models are preferably of low complexity to minimize computational effort for optimization and tuning for a specific building.

Research efforts are needed to find efficient model formats and to validate them using real-world data. This would support a systematic approach to energy efficiency.

Classification

1.3 Modelling; 2.1 Automation & control; 3.1 Performance management; 4.1 Building Energy Management; 4.3 Smart grids and the built environment

Target outcomes

Developed mathematical model formats suitable for building optimization.

Algorithms to tune the model parameters for a specific building and application.

Expected impacts

Ability of buildings to rapidly balance energy flow between consumption, storage and local production.

Buildings as active componentsin the smart grid.

EE through optimal control decisions.

Forecast of energy need as function of weather and energy data.

Suggested roles of stakeholders in implementation

- *Public sector, building clients:*Promote local production and storage of energy in buildings. Local production emphasizes the need of balancing energy flow, which this technology is a core component for.
- *E2BA:* Promote RTD on model generation methodology suited for building control.
- *Construction sector companies and organisations:* Development of building component models that could feed the generation of control models.
- *ICT sector:* High performance cloud computing approaches. In general, more optimal control can be achieved with access to more computing power, and thereby better EE. Additionally, off-site computations could include multi-site optimizations.
- *Energy sector:* Promote local production and storage of energy in buildings. Local production emphasizes the need of balancing energy flow, which this technology is a core component for.

Deeper consumption energy control

Technical scope

In order to use energy more efficiently, the end user needs timely and precise information about his home consumption, including detailed information about each household appliance energy consumption.

Wireless sensor networks are needed to monitor the energy consumption by sensing the devices in households. All these devices monitored through the building energy management should be essential in the visualisation of energy use by end user and allow them to make decisions regarding this information.

The results from the EU research project e-Diana [12] (Embedded Systems for Energy Efficient Buildings) showed that is possible to improve energy efficiency and optimize building energy consumption by 25%, providing real-time measurement, integration and control by raising the awareness of the user about his household appliance energy consumption.

Classification

2.2 Monitoring, 2.4 Wireless sensor networks, 3.1 Visualisation of energy use, 4.1 Building Energy Management, 5.2 System integration

Target outcomes

- Integrated BMS with wireless sensor networks.
- Monitoring and Metering System: will provide information regard power consumption of the different household appliances through two main user interfaces:
  - PC or TV
  - Mobile (through smartphones)

Expected impacts

- Using this information, end users will be aware of consumption of each device taking it into account to reduce it.
- Reductions in the bill's price by selecting the hours with lower price to switch on devices with more consumption.

Suggested roles of stakeholders in implementation

- **Public sector, building clients**: Public bodies must work to raise the awareness of the citizens and companies to the benefits of using more sophisticated systems to control the energy consumption.
- *E2BA:* A better Efficient Energy Consumption control should be added on the section " 2.1.6 Performance monitoring and management" for the EeB roadmap.
- *Construction sector companies and organisations:* Establish guides to install the wireless sensor networks in the buildings
- *ICT sector:* Development of new BMS and interfaces for end users.
- *Energy sector:* Clear establishment of energy prices per hours.
- *End-users:* Be aware of this new information and use it to take decisions regarding energy consumption.
- *Standardisation bodies:* Develop one main standard to unify all the existent standards and protocols used by different companies on the market.

Energy brokerage among end-users

Technical scope

Within the introduction of the capability to generate renewable energies in buildings, they are able to generate their own energy and in some cases they cannot consume all the energy they generate in each moment and in other situations they need more energy than they can produce. It is important to take into account these points and supply energy brokerage technologies to new buildings.

The EU research Project Encourage [13] is actually developing an intelligent gateway with embedded logic supporting inter-building energy exchange. These energy brokerage mechanisms will provide an intelligent gateway with embedded logic supporting inter-building energy exchange. This brokerage agent will communicate directly with other buildings and local producers to negotiate possible use of the electricity produced locally in their premises.

Classification

5.2 System integration, 4.2 District energy management 4.3 Smart grid and building environment, 2.2 Monitoring,

Target outcomes

- New algorithms in charge of predicting the load and generation of energy in each building.
- Internal technological platforms in buildings in charge of the brokerage of energy, which will enable effective interaction with external world, including other buildings, local producers, or electricity distributors.

Expected impacts

- Real-time energy management in relation with consumption and generation in each moment.
- Real-time Demand-Response depending on local resource availability.
- Collaboration of buildings and local energy producers with each-other.
- End-users with active participation in the future smart grid environment.
- Allowing effective interaction with external world, including

other buildings, local producers, or electricity distributors.

Suggested roles of stakeholders in implementation

- *Public sector, building clients:* Public bodies must work to raise the awareness of the citizens and companies to the benefits of using renewable energy in buildings and the technologies needed for brokerage.
- *E2BA*: Enabling Energy brokerage among end-users should be added on the section "2.1.6 Performance monitoring and management", section "The smart-cities initiative" for the EeB roadmap.

  Construction sector companies and organisations: Establish guides to install the energy brokerage mechanisms in the buildings.
- *ICT sector:* Improvement of brokerage technologies from other sectors to be adopted in buildings.
- *Energy sector:* ESCOs (Energy Service Companies) should take into account new business models related to energy brokerage.
- *Standardisation bodies:* Develop/ harmonise standards for BMS, local energy systems and grids.

Contact details

For additional information concerning the ICT4E2B Forum project please visit the project website or contact:

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- **Mostostal Warszawa SA** – Juliusz Zach - J.Zach@mostostal.waw.pl

4.2 Use and dissemination of foreground

Section A (public)

TEMPLATE A1: LIST OF SCIENTIFIC (PEER REVIEWED) PUBLICATIONS, STARTING WITH THE MOST IMPORTANT ONES										
NO.	Title	Main author	Title of the periodical or the series	Number, date or frequency	Publisher	Place of publication	Year of publication	Relevant pages	Permanent identifiers[8] (if available)	Is/Will open access[9] provided to this publication?
1	*ICt for Energy Efficienct buildings: proposed approach for a stakeholders-based strategic roadmap*	*Christian Mastrodonato*	*Proceedings of the CIB W78-W102 2011: International Conference –Sophia Antipolis, France, 26-28 October*		*CSTB - France*	*Paris*	*2011*		http://www.linkedin.com/redir/redirect?url=http%3A%2F%2F2011-cibw078-w102%2Ecstb%2Efr%2Fpapers%2FPaper-119%2Epdf&urlhash=F-fX&trk=prof-publication-title-link	yes
2	*ICT for energy efficient buildings: stakeholder-based strategic roadmap*	*Matti Hannus*	*eWork and eBusiness in Architecture, Engineering and Construction – Gudnason & Scherer (Eds)*		*Taylor & Francis Group*	*London*	*2012*	*783-790*		*No*

[8] A permanent identifier should be a persistent link to the published version full text if open access or abstract if article is pay per view) or to the final manuscript accepted for publication (link to article in repository).
[9] Open Access is defined as free of charge access for anyone via Internet. Please answer "yes" if the open access to the publication is already established and also if the embargo period for open access is not yet over but you intend to establish open access afterwards.

TEMPLATE A2: LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities[10]	Main leader	Title	Date/Period	Place	Type of audience[11]	Size of audience	Countries addressed
1	Workshop	ATOS	EEB Data Models Community	24 January 2011	Brussels	Scientific Community	13	EU wide
2	Workshop	VTT	Scenario Definition Workshop	4 May 2011	Helsinki	Scientific Community, Industry	9	Finland, Sweden, Norway
3	Workshop	DAPP	Scenario Definition Workshop	25 may 2011	Sophia Antipolis	Scientific Community, Industry	9	France, Italy, Spain
4	Workshop	DAPP	Scenario Definition Workshop	25 May 2011	London	Scientific Community, Industry	16	UK, Ireland, France
5	Pens	DAPP, MOST	ICT4E2B Forum pens	July 2011				
6	Leaflets	MOST	ICT4E2B Forum	July 2012				
7	Workshop	DAPP	Prioritization Workshop	4 July 2011	Genoa	Scientific Community, Industry, Policy Makers	33	Italy
8	Workshop/Event	DAPP	Prioritization Workshop	12 July 2011	Brussels	Scientific Community,	74	EU wide

[10] A drop down list allows choosing the dissemination activity: publications, conferences, workshops, web, press releases, flyers, articles published in the popular press, videos, media briefings, presentations, exhibitions, thesis, interviews, films, TV clips, posters, Other.

[11] A drop down list allows choosing the type of public: Scientific Community (higher education, Research), Industry, Civil Society, Policy makers, Medias, Other ('multiple choices' is possible).

						Industry, Policy Makers		
9	Conference	DAPP,VTT	CIB W78-W102 2011	26-28 October 2011	Sophia Antipolis	Scientific Community, Industry	50	Worldwide
10	Conference	SAP	“Enterprise applications in the era of SmartHouses and SmartGrid”, Smart Grids Panel, 37th Annual Conference of the IEEE Industrial Electronics Society (IECON 2011)	10 November 2011	Melbourne, Australia	Scientific Community, Industry		Australia and Oceania
11	Conference	SAP	Challenges and Opportunities for Energy Efficient Buildings and Cities”, Smart Lighting	31 January – 1 February 2012	Dusseldorf	Scientific Community, Industry		Germany
12	Poster	MOST	Poster with presented activities, methodology and vision of the project	February 2012				
13	Leaflets	MOST	New revision of ICT4E2B Forum leaflets	February 2012				
14	Workshop	DAPP	GridPlus	22 February	Brussels	Scientific	20	EU wide

			workshop	2012		Community, Industry		
15	Fair	DAPP	CEBIT	6-10 March 2012	Hannover	Industry, Media	160	Worldwide
16	Conference	MOST	CEP Clean Energy Partnership	17-18 April 2012	Warsaw	Scientific Community, Industry, Policy Makers	60	Poland and Central Europe
17	Workshop	VTT,MOST	E2BA Roadmap workshop	24-26 April 2012	Paris	Scientific Community, Industry	30	EU wide
18	Booklet	MOST	Comparative analysis: National research & technological development (RTD) Frameworks in the context of ICT for energy efficient buildings	June 2012				
19	Conference	DAPP	Innovative City Convention	5-6 June 2012	Nice	Scientific Community, Industry, Policy Makers, Media	21	France, Italy, Spain and EU wide
20	Workshop	SAP	EEGI Roadmap workshop	13-14 June 2012	Brussels	Scientific Community, Industry, Policy Makers	20	EU wide
21	Conference	DAPP	Smart City Event	27 June 2012	Amsterdam	Scientific Community, Industry, Policy Makers, Media	40	EU wide

22	Conference	DAPP	ECPPM	25-27 July 2012	Reykjavik	Scientific Community, Industry	35	EU wide and Worldwide
23	Conference	SAP	“European SmartGrid Research and Challenges”, Symposium on Microgrids	3-4 Sept 2012	Evora, Portugal	Scientific Community, Industry		EU and US wide
24	Workshop	SAP	EU-US joint open workshop on cyber security of ICS and Smart Grids, organized by the European Commission and US Dept. of Homeland Security	15 October 2012	Amsterdam	Scientific Community, Industry		EU and US
25	Conference	SAP	Panel on “What is the Horizon Ahead of Smart-Grids?”, IEEE IECON 2012,	26 October 2012	Montreal, Canada	Scientific Community, Industry		Worldwide
26	Book	DAPP	ICT Roadmap for Energy-Efficient Buildings Research and Actions	February 2013				
27	Event	DAPP	ICT4e2B Forum Final Event	28 February 2013	Brussels	Scientific Community, Industry, Policy Makers		

4.3 Report on societal implications

Replies to the following questions will assist the Commission to obtain statistics and indicators on societal and socio-economic issues addressed by projects. The questions are arranged in a number of key themes. As well as producing certain statistics, the replies will also help identify those projects that have shown a real engagement with wider societal issues, and thereby identify interesting approaches to these issues and best practices. The replies for individual projects will not be made public.

A General Information *(completed automatically when **Grant Agreement number** is entered.*

Grant Agreement Number:	260156
Title of Project:	
Name and Title of Coordinator:	

B Ethics

1. Did your project undergo an Ethics Review (and/or Screening)? • If Yes: have you described the progress of compliance with the relevant Ethics Review/Screening Requirements in the frame of the periodic/final project reports? Special Reminder: the progress of compliance with the Ethics Review/Screening Requirements should be described in the Period/Final Project Reports under the Section 3.2.2 *'Work Progress and Achievements'*	***No***
2. Please indicate whether your project involved any of the following issues (tick box) :	***NO***
RESEARCH ON HUMANS	
• Did the project involve children?	
• Did the project involve patients?	
• Did the project involve persons not able to give consent?	
• Did the project involve adult healthy volunteers?	
• Did the project involve Human genetic material?	
• Did the project involve Human biological samples?	
• Did the project involve Human data collection?	
RESEARCH ON HUMAN EMBRYO/FOETUS	
• Did the project involve Human Embryos?	
• Did the project involve Human Foetal Tissue / Cells?	
• Did the project involve Human Embryonic Stem Cells (hESCs)?	
• Did the project on human Embryonic Stem Cells involve cells in culture?	
• Did the project on human Embryonic Stem Cells involve the derivation of cells from Embryos?	
PRIVACY	
• Did the project involve processing of genetic information or personal data (eg. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)?	
• Did the project involve tracking the location or observation of people?	
RESEARCH ON ANIMALS	
• Did the project involve research on animals?	
• Were those animals transgenic small laboratory animals?	
• Were those animals transgenic farm animals?	

• Were those animals cloned farm animals?	
• Were those animals non-human primates?	
RESEARCH INVOLVING DEVELOPING COUNTRIES	
• Did the project involve the use of local resources (genetic, animal, plant etc)?	
• Was the project of benefit to local community (capacity building, access to healthcare, education etc)?	
DUAL USE	
• Research having direct military use	No
• Research having the potential for terrorist abuse	

C Workforce Statistics

3. Workforce statistics for the project: Please indicate in the table below the number of people who worked on the project (on a headcount basis).

Type of Position	Number of Women	Number of Men
Scientific Coordinator		2
Work package leaders	2	3
Experienced researchers (i.e. PhD holders)	2	5
PhD Students	1	
Other		

4. How many additional researchers (in companies and universities) were recruited specifically for this project?	
Of which, indicate the number of men:	

D Gender Aspects

5. Did you carry out specific Gender Equality Actions under the project?

O	Yes
X	No

6. Which of the following actions did you carry out and how effective were they?

		Not at all effective				Very effective
❑	Design and implement an equal opportunity policy	O	O	O	O	O
❑	Set targets to achieve a gender balance in the workforce	O	O	O	O	O
❑	Organise conferences and workshops on gender	O	O	O	O	O
❑	Actions to improve work-life balance	O	O	O	O	O

O Other:

7. Was there a gender dimension associated with the research content – i.e. wherever people were the focus of the research as, for example, consumers, users, patients or in trials, was the issue of gender considered and addressed?

O Yes- please specify

X No

E Synergies with Science Education

8. Did your project involve working with students and/or school pupils (e.g. open days, participation in science festivals and events, prizes/competitions or joint projects)?

O Yes- please specify

X No

9. Did the project generate any science education material (e.g. kits, websites, explanatory booklets, DVDs)?

X Yes- please specify: Booklet

O No

F Interdisciplinarity

10. Which disciplines (see list below) are involved in your project?

O Main discipline[12]: 2.3

O Associated discipline[12]:1.1 | O Associated discipline[12]:2.2

G Engaging with Civil society and policy makers

11a Did your project engage with societal actors beyond the research community? *(if 'No', go to Question 14)*

X	Yes
O	No

11b If yes, did you engage with citizens (citizens' panels / juries) or organised civil society (NGOs, patients' groups etc.)?

X No

O Yes- in determining what research should be performed

O Yes - in implementing the research

O Yes, in communicating /disseminating / using the results of the project

[12] Insert number from list below (Frascati Manual).

11c	**In doing so, did your project involve actors whose role is mainly to organise the dialogue with citizens and organised civil society (e.g. professional mediator; communication company, science museums)?**	X ○	Yes No

12. Did you engage with government / public bodies or policy makers (including international organisations)

- ○ No
- X Yes- in framing the research agenda
- ○ Yes - in implementing the research agenda
- ○ Yes, in communicating /disseminating / using the results of the project

13a Will the project generate outputs (expertise or scientific advice) which could be used by policy makers?

- ○ Yes – as a **primary** objective (please indicate areas below- multiple answers possible)
- X Yes – as a **secondary** objective (please indicate areas below - multiple answer possible)
- ○ No

13b If Yes, in which fields?

Agriculture		Energy	X	Human rights	
Audiovisual and Media		Enlargement		Information Society	X
Budget		Enterprise		Institutional affairs	
Competition		Environment	X	Internal Market	
Consumers		External Relations		Justice, freedom and security	
Culture		External Trade		Public Health	
Customs		Fisheries and Maritime Affairs		Regional Policy	
Development Economic and Monetary Affairs		Food Safety		Research and Innovation	X
Education, Training, Youth		Foreign and Security Policy		Space	
Employment and Social Affairs		Fraud		Taxation	
		Humanitarian aid		Transport	

13c If Yes, at which level?

- X Local / regional levels
- X National level
- X European level
- X International level

H Use and dissemination

14. How many Articles were published/accepted for publication in peer-reviewed journals?	**0**
To how many of these is open access[13] provided?	
How many of these are published in open access journals?	
How many of these are published in open repositories?	
To how many of these is open access not provided?	
Please check all applicable reasons for not providing open access:	
❑ publisher's licensing agreement would not permit publishing in a repository ❑ no suitable repository available ❑ no suitable open access journal available ❑ no funds available to publish in an open access journal ❑ lack of time and resources ❑ lack of information on open access ❑ other[14]: ……………	

15. How many new patent applications ('priority filings') have been made? *("Technologically unique": multiple applications for the same invention in different jurisdictions should be counted as just one application of grant).*		
16. Indicate how many of the following Intellectual Property Rights were applied for (give number in each box).	Trademark	
	Registered design	
	Other	

17. How many spin-off companies were created / are planned as a direct result of the project?	
Indicate the approximate number of additional jobs in these companies:	

18. Please indicate whether your project has a potential impact on employment, in comparison with the situation before your project:

❑ Increase in employment, or	❑ In small & medium-sized enterprises
❑ Safeguard employment, or	❑ In large companies
❑ Decrease in employment,	❑ None of the above / not relevant to the project
❑ Difficult to estimate / not possible to quantify	

19. For your project partnership please estimate the employment effect resulting directly from your participation in Full Time Equivalent (*FTE = one person working fulltime for a year*) jobs:	*Indicate figure:*

[13] Open Access is defined as free of charge access for anyone via Internet.

[14] For instance: classification for security project.

Difficult to estimate / not possible to quantify	X

I Media and Communication to the general public

20. As part of the project, were any of the beneficiaries professionals in communication or media relations?

○ Yes X No

21. As part of the project, have any beneficiaries received professional media / communication training / advice to improve communication with the general public?

X Yes ○ No

22 Which of the following have been used to communicate information about your project to the general public, or have resulted from your project?

X	Press Release	❑	Coverage in specialist press
❑	Media briefing	❑	Coverage in general (non-specialist) press
❑	TV coverage / report	❑	Coverage in national press
❑	Radio coverage / report	❑	Coverage in international press
X	Brochures /posters / flyers	X	Website for the general public / internet
❑	DVD /Film /Multimedia	X	Event targeting general public (festival, conference, exhibition, science café)

23 In which languages are the information products for the general public produced?

❑	Language of the coordinator	X	English
❑	Other language(s)		

Question F-10: Classification of Scientific Disciplines according to the Frascati Manual 2002 (Proposed Standard Practice for Surveys on Research and Experimental Development, OECD 2002):

FIELDS OF SCIENCE AND TECHNOLOGY

1. NATURAL SCIENCES

1.1 Mathematics and computer sciences [mathematics and other allied fields: computer sciences and other allied subjects (software development only; hardware development should be classified in the engineering fields)]

1.2 Physical sciences (astronomy and space sciences, physics and other allied subjects)

1.3 Chemical sciences (chemistry, other allied subjects)

1.4 Earth and related environmental sciences (geology, geophysics, mineralogy, physical geography and other geosciences, meteorology and other atmospheric sciences including climatic research, oceanography, vulcanology, palaeoecology, other allied sciences)

1.5 Biological sciences (biology, botany, bacteriology, microbiology, zoology, entomology, genetics, biochemistry, biophysics, other allied sciences, excluding clinical and veterinary sciences)

2 ENGINEERING AND TECHNOLOGY

2.1 Civil engineering (architecture engineering, building science and engineering, construction engineering, municipal and structural engineering and other allied subjects)

2.2 Electrical engineering, electronics [electrical engineering, electronics, communication engineering and systems, computer engineering (hardware only) and other allied subjects]

2.3. Other engineering sciences (such as chemical, aeronautical and space, mechanical, metallurgical and materials engineering, and their specialised subdivisions; forest products; applied sciences such as geodesy, industrial chemistry, etc.; the science and technology of food production; specialised technologies of interdisciplinary fields, e.g. systems analysis, metallurgy, mining, textile technology and other applied subjects)

3. MEDICAL SCIENCES

3.1 Basic medicine (anatomy, cytology, physiology, genetics, pharmacy, pharmacology, toxicology, immunology and immunohaematology, clinical chemistry, clinical microbiology, pathology)

3.2 Clinical medicine (anaesthesiology, paediatrics, obstetrics and gynaecology, internal medicine, surgery, dentistry, neurology, psychiatry, radiology, therapeutics, otorhinolaryngology, ophthalmology)

3.3 Health sciences (public health services, social medicine, hygiene, nursing, epidemiology)

4. AGRICULTURAL SCIENCES

4.1 Agriculture, forestry, fisheries and allied sciences (agronomy, animal husbandry, fisheries, forestry, horticulture, other allied subjects)

4.2 Veterinary medicine

5. SOCIAL SCIENCES

5.1 Psychology

5.2 Economics

5.3 Educational sciences (education and training and other allied subjects)

5.4 Other social sciences [anthropology (social and cultural) and ethnology, demography, geography (human, economic and social), town and country planning, management, law, linguistics, political sciences, sociology, organisation and methods, miscellaneous social sciences and interdisciplinary , methodological and historical S1T activities relating to subjects in this group. Physical anthropology, physical geography and psychophysiology should normally be classified with the natural sciences].

6. HUMANITIES

6.1 History (history, prehistory and history, together with auxiliary historical disciplines such as archaeology, numismatics, palaeography, genealogy, etc.)

6.2 Languages and literature (ancient and modern)

6.3 Other humanities [philosophy (including the history of science and technology) arts, history of art, art criticism, painting, sculpture, musicology, dramatic art excluding artistic "research" of any kind, religion, theology, other fields and subjects pertaining to the humanities, methodological, historical and other S1T activities relating to the subjects in this group]