ICT 4 E2B Forum-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

Deliverable D2.1: Application scenarios

Document Details

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SEVENTH FRAMEWORK PROGRAMME

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1 Introduction

1.1 Purpose of the document

The objective of this document is to present future extrapolations on expected innovations to appear in the horizon in the next 10 years and beyond as a form of scenarios. This work is based on the State-of-the Art (T1.3), findings of the previous REEB project [1] and industrial requirements derived from conducted workshops. The analysis of the feedback and refinement of the scenarios will yield a vision of the future ICT4E2B, as seen by the industry and the technology experts, to form the basis for subsequent formulation of a Gap Analysis (D2.2) and the development of an updated Research Roadmap (T2.3).

1.2 Document structure

The document is structured in the following sections:

Section 1: Introduction, presents the purpose and general background of the deliverable D2.1 Application scenarios.

Section 2: Extrapolations and scenarios address the futuristic ideas derived from workshops with selected experts and propose the visions for particular thematic areas to define RTD baseline for forthcoming deliverables.

Section 3: Conclusion focuses on consolidated ICT4E2B vision and compliance with DoW by delivering the main findings followed by acronyms and terms, references and appendices (separate document).

1.3 Contributions of partners and experts

VTT has had the main responsibility to prepare this document (Sections 1, 3 and 4). Preparation of extrapolations and scenarios has been divided between partners in line with the classification developed in deliverable D1.1as follows:

1. Tools for EE Design and Production Management by VTT Technical Research Centre of Finland, Finland (hereafter VTT)

2. Intelligent & Integrated Control by Schneider Electric Buildings AB, Sweden (hereafter Schneider)

3. User awareness and decision support by D'Appolonia S.p.A, Italy (hereafter D'Appolonia)

4. Energy Management & Trading by SAP AG, Germany (hereafter SAP)

5. Integration technologies by Atos Origin, Spain (hereafter ATOS)

Workshop methodology was prepared by D'Appolonia S.p.A and conducted together with VTT. Selected experts were involved in 3 workshops in order to develop the vision for future application scenarios.

1.4 Baseline

The main inputs at the start of the work were:

- Existing roadmap on ICT contributions to improve energy efficiency of buildings by REEB project was used as baseline for ICT4E2B forum project. The European strategic Research Roadmap to ICT enabled Energy Efficiency in Building and construction REEB. As a result REEB provided a reference to improvement of energy efficiency and climate change, as well as a stimulation of the development of a large leading-edge market for ICT enabled energy-efficiency technologies in buildings that will foster the competitiveness of European industry and create new business opportunities.[1]
- EeBRoadmap "Energy-efficient buildings PPP – Multiannual roadmap and longer term strategy". EeB Roadmap provided research priorities for new methods and technologies to reduce the energy footprint and CO_2 emissions related to new and renovated buildings. It addresses also the non-technological aspects that are salient to obtain the full effects of research initiatives. [2]
- Previous deliverables from ICT 4 E2B Forum
  - D1.1 Classified Research Areas
  - D1.2 Initial analysis of the state-of-the-art
  - D1.3 Initial Analysis of research projects (partly)

Used thematic areas in this document follow the REEB categories, which were verified during the implementation of tasks 1.1 and 1.2.

1.5 Methodology

Selected experts were involved in 3 workshops held in Helsinki, Nice and London to develop the vision for future application scenarios. Planned 4th workshop in Wien was postponed to be held in relation to T2.2 and T2.3. The workshops' key objective was for the invited experts to develop the vision for future application scenarios of new ICTs for energy efficient buildings. The three workshops were organised in three different countries and had the same basic structure designed to enable consolidation of results from different workshops with different participants. More detailed description of the used methodology can be found in Appendix A – Meetings with Experts.

Partners (VTT, Schneider, D'Appolonia, SAP and ATOS) used baseline information and the expert output from workshops to formulate futuristic stories about how ICT can be enhancing energy efficiency in buildings, the scenarios. Key enabling technologies were collected out from these scenarios to define the vision.

2 Extrapolations and scenarios

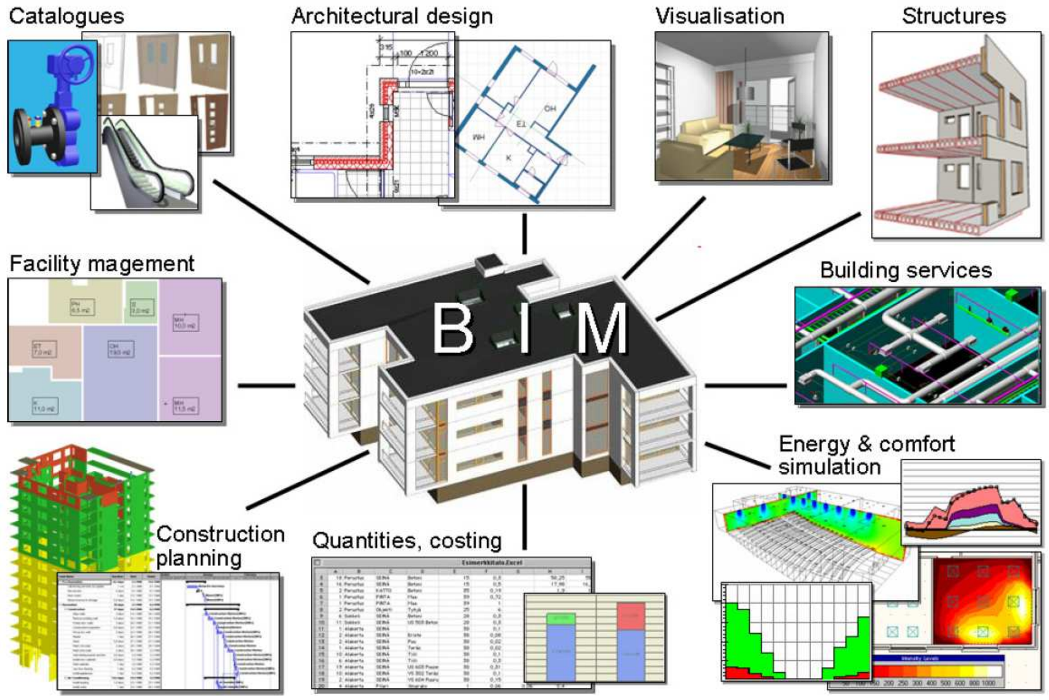
2.1 Tools for EE design & production management

This thematic area concentrates on the development of design support tools, design integration, production management, simulation and modelling tools and methods. Area is divided into four subtopics Design, Production management, Modelling and Performance estimation. In the following we provide exemplary scenarios for the different subtopics highlighted above.

2.1.1 Design

Scenario title	**Integrated BIM based design**
Keywords	BIM, collaborative engineering, design, estimation, modelling
Classification	1.1 Design, 5.3 Interoperability & standards
Beneficiaries	Architects, designers
Impacts	Building performance as required and planned Integration of design disciplines
Key ICTs	Expected progress (2020) beyond State-of-the-Art (2010)
BIM, CAD, collaborative working environments, modelling, simulation, social media, visualisation, workflow management	Model based interoperable tools for collaborative engineering, design, analysis, and simulation. Parametric libraries of re-usable design knowledge. Context specific views of design models for decision support. Tools for validation of design models with respect to coherency, energy efficiency and compliance to requirements and building codes. Integration of BIM-CAD, analysis and simulation. Advanced energy efficiency assessment and optimisation as a common practice in building design.
Scenario description	Anton is an architect working for small multidisciplinary design consultancy GREENARC specialised on sustainable buildings. The business model of the company is to assume total responsibility of energy efficient design under performance based contracts. GREENARC uses advanced model based tools for design and for verifying compliance to the contract. They assign engineering design to specialised consultancies with who they have established trusted relationships and common ICT based working methods. Based on the international reputation of GREENARC, a new client hires them to design a new office complex. Because sustainability is a key element of the client's brand, the new building is required to achieve class A rating of energy efficiency. Together with the client, Anton develops a formal specification (model) of the requirements, including the target energy performance indicators of the future building. The tool for this purpose makes use of statistical profiles of existing buildings, building users etc. It helps to translate high level indicators into specific technical requirements. This is highly appreciated by the client because he does not need to interfere in technical details. Anton and his colleagues are also happy

	because the client allows great freedom to them to select optimised design solutions under the overall total performance. By searching a publicly available database of best practices Anton finds information about several existing energy efficient buildings that serve as useful references for this case. By analysing the past usage of the client's current facilities, and the tasks and demographics of the personnel, Anton identifies potential for increased remote work. The client agrees to encourage new ways of working and reduces his requirements regarding workplaces. Anton finds from the district social media offers from a nearby school, a hotel and a cultural centre to provide meetings facilities whereby the number of especially large meeting rooms can be reduced. The required office spaces can be reduced by 30% altogether. Anton also finds an offer from a nearby shopping mall to provide excess heating energy at reasonable conditions. These and other considerations are added as options into the requirement model. Anton applies a BIM-CAD system to develop a draft design using one of the reference buildings as a baseline. The system has built-in smart advisors that actively suggest reference design solutions relevant to on-going design activities and the targeted energy profile of the building. Often occurring design items are available as parametric objects that can adopt themselves into the current context with minimum human interference. During the evolution of the draft design, the smart advisors make simple analysis of the design model, compare it to the requirements and best practices, and provide real-time guidance. Once the draft design has reached sufficient maturity, Anton makes it available to the other design experts for further development and detailed design. All designers use interoperable BIM based tools with the capability to derive context dependent views for discussions and decision making. The team uses a collaboration environment that supports sharing of models and views, discussions, annotations, workflows and version management. The design model is periodically analysed using simulations that take into account expected usage patterns, local climatic conditions, price fluctuations of the grid, local generation, energy trading etc. The analysed performance is visualised in appropriate ways, and in relation to selected reference buildings, for the client and other stakeholders for decision making. The design model is analysed with a model validation tool to identify inconsistencies and to assess compliance to the requirements. Possible deficiencies are iteratively fixed between the designers. After the client's approval Anton forwards the final model and other information relating to building permit to the building authorities. The authorities use another model validation application to assess compliance to building codes. The BIM model is approved by all parties as the contractually and legally valid carrier of design information. It is also used as the basis for verifying fulfilment of the performance based design contract together with monitored performance of the building in the first years of use.



Examples of BIM-based engineering applications [REEB & other sources]

2.1.2 Production management

Scenario title	**Intelligent BIM-based project planning tool**
Keywords	Project management, performance requirements, logistics, supply network management, intelligent e-catalogue, on-site and off-site production management
Classification	1.2 Production management, 5.1 Process integration, 5.3 Interoperability & standards
Beneficiaries	Project manager, contractors, manufacturers and suppliers
Impacts	Information obtained from BIM is integrated with construction and project management, streamlining the processes. The impacts of the construction operations on energy and emissions results from optimising logistics and supply chain management.
Key ICTs	Expected progress (2020) beyond State-of-the-Art (2010)
BIM-based project management tools, performance simulation, e-procurement, intelligent e-catalogues, ICT standards.	Production is managed through BIM-based tools enhanced 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.

Scenario description	Mr Marc works as a project manager in a construction company called SILVADOS. At the moment, he is the project manager in a construction of 10 000 sqm multi-story official building located in Switzerland. Before the construction starts, he creates the detailed assembly and delivery plan through the project planning interface of the integrated BIM-based project management system. Both construction and manufacture schedules are integrated with libraries of production methods and resources (materials, components, machinery and suppliers). All the information about the building and its equipment (qualities and performances, cost, estimated cost) is updated and accessible through the project planning interface. The project management tool is enhanced by an energy simulation module, which allows, for each construction stage, the planning of the building operations and materials purchasing according with the contractual energy performance requirements. The simulation outputs onsite-offsite production strategies based on the balance of purchasing materials with low embedded energy and logistics optimisation. The construction of the building has started and the project interface has reminded Mr Marc to order needed material for the indoor surfaces. Through the project interface he can compare the EE of different materials and products using e-catalogues, and energy needed for logistics from different product suppliers. He will access to the relevant contractual information stored in the SILVADOS's Enterprise Resource Planning (ERP) system for more detailed pricing information. After finding the optimal supplier, Mr Marc activates the purchasing process.

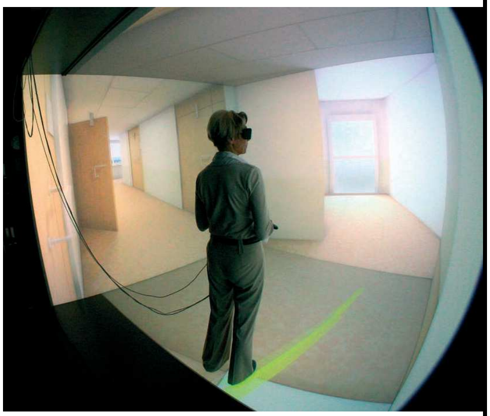
2.1.3 Modelling

Scenario title	**BIM servers for collaborative BIM based design**
Keywords	Model servers, interfaces, real time collaboration, cloud technology
Classification	1.1 Design, 1.3 Modelling, 5.3 Interoperability & standards
Beneficiaries	Architects, designers, contractors
Impacts	Improved collaboration, efficiency and real time access to information.
Key ICTs	Expected progress (2020) beyond State-of-the-Art (2010)
Model servers, interfaces, cloud technology, energy modelling software	Project stakeholders have an access on the relevant project related information through a customised interfaces empowered by additional energy modelling software. Information can be distributed to different servers and owned by various stakeholders (e.g. authorities, building owners, designers). Cloud technology provides opportunity for project stakeholders to collaborate real time with the model from any location.
Scenario description	Anton, the architect, works every now and then from home. He has there a broadband Internet connection, but instead working with his own laptop he access with it (PC Over IP) to the high performance workstation in the company's premises, where the model server is locating. Other designers working with the same project access similarly remotely to the model via a secure internet connection according to the agreed cloud strategy between the project's stakeholders. Anton doesn't need to carry his company laptop with him, but he can work with his

	private laptop as well. He accesses to the model in the company's server from his laptop through a customised interface. That includes an energy modelling software, but instead using his laptop he uses the computing power of the workstation in company's premises to run the energy modelling software.

2.1.4 Performance estimation

Scenario title	**Integrating requirements and design for energy rated design**
Keywords	BIM, interoperability, simulation, end-user requirements
Classification	1.1 Design, 1.3 Modelling, 1.4 Performance estimation, 2.3 Performance management
Beneficiaries	Architect, Designer, Owner
Impacts	Use of BIM and integration of ICT from the conceptual design phase to set parameters for energy efficiency. Also the cost and time are essential factors for decision making process to foresee the added value of ICT integration to achieve energy efficient design.
Key ICTs	Expected progress (2020) beyond State-of-the-Art (2010)
BIM, Interoperability, Simulation, Virtual environment	Interoperability between building industry BIM software's; transferring the relevant parameters from requirements model to design model(s). Performance indicators effecting on energy efficiency on neighbourhood and building levels (e.g. location of site, water use, on-site energy production, indoor climate, comfort) are defined using related assessment methods and tools. European level certification of the tools and libraries of best practices and reference design solutions. The decision making of Owner/user is supported by exploiting virtual environments. Defined requirements from conceptual design are represented as corresponding design options with the help of various energy simulation tools. Building regulations are embedded in BIM-based assessment software.
Scenario description	Ms Virtanen from Developer Ltd. contacts the local green Architect, Mr Heino to propose energy efficient residence design for the company's recently purchased 10,000 sqm land in western Europe. Developer has already a potential buyer for the future residential building: non-profit organisation providing assisted living for disabled students in the nearby polytechnic. The goal is to involve the potential end-users and owner to the definition of performance requirements, as well. Mr Heino contacts Energy consultant team to propose him permutation and combination of site/location based data to propose preliminary design criteria. The team uses location based simulation software to test, for example, annual weather format supplemented by estimated solar radiation per hour for suggesting suitable automated HVAC (low-thermostat set-back), moisture control, and vertical (window) openings in design to decide shape/size of rooms. The interior designer uses Auto-Design BIM software to choose producer independent materials (to add thermal mass), LED and CFL lighting fixtures, smart window glass, electrical equipment's to allow adequate distribution of heat by using Building automation control system reducing electricity consumption. At

	the same time software also generates a price list of the selected equipment. Data analysis and integration of obtained interoperable software tools proposes the first design concept in a simulated environment to analyse energy consumption with respect to energy consumption in neighbourhood in compliance with green building codes. This preliminary concept and the landscape design with smart water management integrated with water harvesting are introduced to the owner for verification in virtual reality.	 Source: hospitool.vtt.fi

2.1.5 Vision

<u>BIM-CAD, 3D-Virtual environment, EE LCC evaluation:</u>

The architects and engineers are provided with interoperable BIM tools to design buildings and to estimate and evaluate the EE performance of a building from the very early design phase throughout the design process. Simulation and visualisations will be used to attain an EE building design to support the performance requirements. Advanced EE assessment and optimisation will be as a common practice in building design.

<u>Collaborative design environments, user interfaces:</u>

Integration of ICT will actualise by introduction of interoperable collaborative environments and synchronisation of internal workflows of companies with the inter-enterprise design process. Project stakeholders will have context specific views of design models for decision support. Designers working with the same project access remotely to the models via a secure internet connection according to the agreed cloud strategy between the project's stakeholders and use parametric libraries of re-usable design knowledge. Project management interface provide integrated context-oriented information for on-site and off-site construction management; implementation of ICT on remote construction projects managing workflows and process flows.

<u>EE material and product databases:</u>

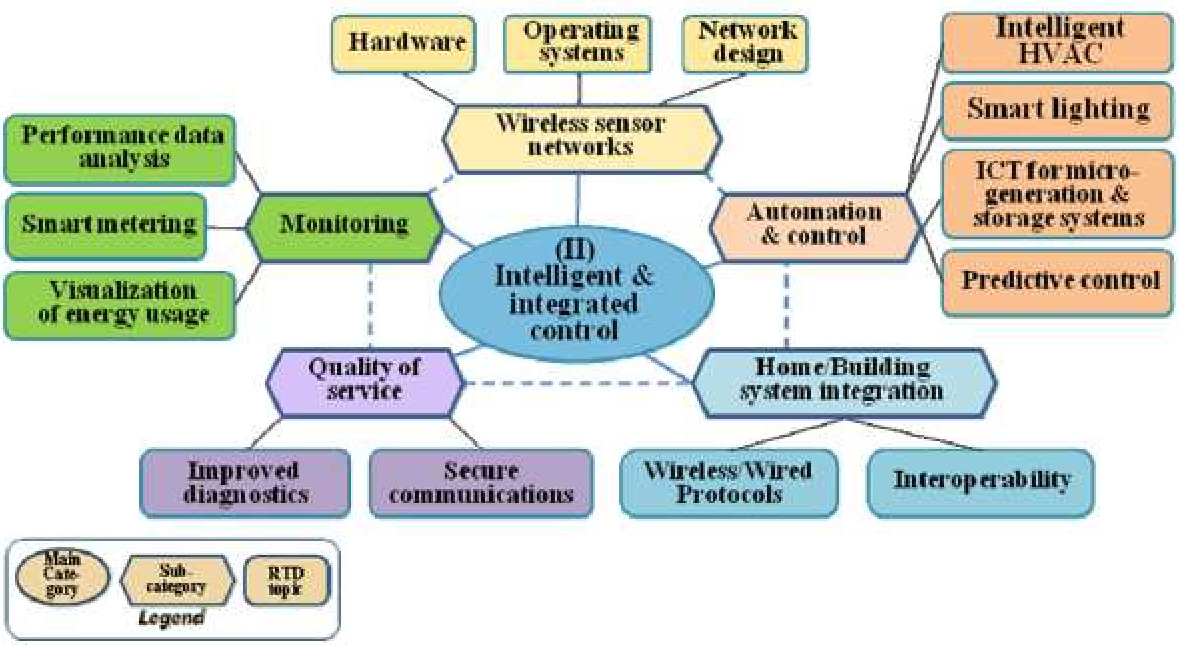
Country specific regional database of energy efficient materials based on EU's construction energy conscious regulations. During conceptual design, a designer obtains producer-independent information about different material and system solutions. Quantifying tools for measuring EE and production management will be available with product database specifying the energy value of materials and logistics.

<u>Model analysis and validation:</u>

Versatile model analysis tools will be available to validate the BIMs and alert users to take corrective actions e.g. with respect to coherency, EE and compliance to requirements and building codes.

2.2 Intelligent control

This section focuses on the areas of automation & control, monitoring, quality of service and wireless sensor networks. These topics include meshed, self-adaptable and easy to install sensor networks (i.e. hardware and software, operating systems and protocols), development of automation and control technologies, improved diagnostics, performance data analysis, smart metering and actuation, intelligent and predictive control systems etc.



Source: REEB

In the following we provide an overview of key scenarios identified for the different areas highlighted above.

2.2.1 Automation & control

Scenario title	**An energy optimised office building**
Keywords	Model predictive control, integrated control, Smart
Classification	2.1 Automation & control, 4.2 Smart grids, 5.2 System integration, 4.1 Building and district energy management
Beneficiaries	Facility managers, building owner, tenants, utility companies
Impacts	▪ Energy savings due to integrated control of the building and holistic predictive optimisation including e.g. future weather conditions. ▪ The building is an active component towards the electrical utility, capable of managing load shedding requests and adapt to real-time pricing

Key ICTs	Expected progress (2020) beyond State-of-the-Art (2010)
Optimisation algorithms, computer models, data interfaces, open standards	Interoperable products from different manufacturers are crucial to harvest all the available energy savings. It is important that integration of products is very easy and feasible with a limited skill set. A possible path to get there is through standardised communication and functionality profiles of products.
Scenario description	Mr. Jones is the facility manager of a complex building of about 10 000 m2, with offices, meeting rooms, a company restaurant and 500 daily users. Mr. Jones is a happy man: about one year ago, he convinced his boss that there was a huge potential for energy (and money) savings if a Building Management System (BMS) was installed in the building. And today, the actual figures confirm what he and the supplier of the system presented at that time. Although the cost was not negligible, the return on investment is now confirmed to be less than 3 years. The BMS is now connected to the heating, ventilation and air-conditioning systems, to many active components in the building (lights, shutters, fans, etc.) and to a lot of various sensors (presence, temperature, humidity, light, etc.). Integration of the system to the existing installation was easy because of the high compatibility with other commercial solutions. Currently it is winter, and the sun is shining: unoccupied south-facing meeting rooms shutters are left open, in order to maximise solar gains and avoid using the heating system as much as possible. However, when people enter the meeting room and manually override the automatic control, requesting the shutters to be closed (because they need to use a beamer for their meeting), the system adjusts the light to the needed level, starts up heating and adjusts the ventilation rate. When the meeting is over and people leave the room, the presence sensors send the information and the system falls back to the standard setup. The BMS not only focuses on the room level control, like the meeting room, but also on the total behaviour of the building. Continuously the system accesses the weather forecast and data from the utility such as real-time pricing and demand-response events. Based on this information in combination with predicted building usage the system plans the optimised load profile for the next day as well as a few other options for the facility manager to choose from. Mr Jones has knowledge of the activities in the building and can choose a suitable profile. The photovoltaic panels (installed on the building's roof) are also monitored by the central system. The use of the electricity generated by these PV cells is privileged by the BMS (for lighting, other electrical office appliances, etc.) when it is available. It has been sized to cover a good part of net electricity requirements for the whole building. Mr. Jones is definitely a happy man. 

2.2.2 Monitoring

Scenario title	**Energy management through easy living**

<table>
<tr><td>Keywords</td><td colspan="2">Wireless sensor networks, open standards, energy management</td></tr>
<tr><td>Classification</td><td colspan="2">5.3 Interoperability and Standards, 2.4 Wireless sensor networks, 2.1 Automation & control, 2.2 Monitoring, 3.2 Visualisation of energy use</td></tr>
<tr><td>Beneficiaries</td><td colspan="2">Building owners, tenants, software and hardware companies, energy service providers</td></tr>
<tr><td>Impacts</td><td colspan="2">▪ Energy savings due to increased awareness
▪ Energy savings due to automated control
▪ Detection of faulty equipment</td></tr>
<tr><td colspan="2">Key ICTs</td><td>Expected progress (2020) beyond State-of-the-Art (2010)</td></tr>
<tr><td colspan="2">Wireless sensor networks, open communication protocol</td><td>The Smart Grid requires smart buildings; however, to facilitate this connectivity the interface should be standardised both in terms of communication but also behaviour and philosophy.</td></tr>
<tr><td>Scenario description</td><td colspan="2">The Andersson family lives in a two storey stand-alone house. Today they bought so called ‘E-Box’ and they are eager to try it out. According to the commercial the E-Box should work as the brain of the home, coordinating all appliances ensuring ‘easy-living’.

The physical installation consisted of just connecting the box to a power outlet. The box only uses wireless communication technology and has no physical interfaces, not even a button.

The E-box is now powered up and an online indication is showing on the box. “OK, now what?” asks the daughter Kajsa. “Let’s turn on the TV”, answers the mother Lena. Indeed, the E-Box welcoming screen was on the TV showing the first step of the configuration phase of the system. The box had already detected all the ‘E-ready’ devices in the building including the TV, washing machine, stove, windows, security system and much more. The long list was not surprising since most electronic devices are ‘E-ready’ nowadays.

The basic configuration was quick and effortless but the ‘E-Box’ offers limitless possibilities. Anybody is free to write his own application for the box, one can also share this application in a dedicated online repository making it available for everybody.

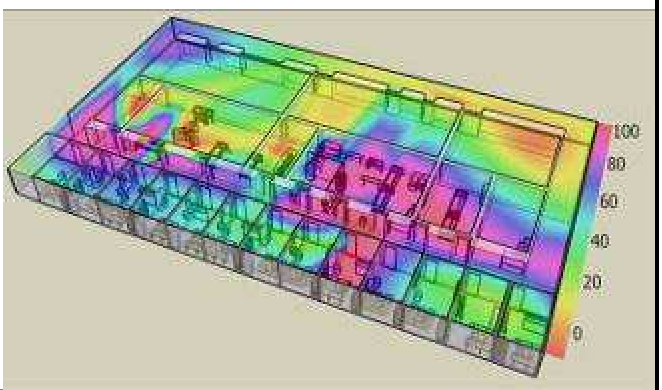
A standard functionality of the box is energy management of the building. The box informs about energy usage and suggests ways to reduce it. It also provides enhanced connectivity to the smart grid if the family chooses to.

The next morning when Lena is the last person to leave the house she locks the door and her handheld device shows that everything is OK, implying that no window is open and no electrical appliance like e.g. an iron is drawing power. Without any action from Lena the E-Box sets the indoor temperature to a more economical level until the time the family is expected to return, all in the spirit of easy-living.</td></tr>
</table>

2.2.3 Quality of service

Scenario title	**What is the problem?**
Keywords	Quality of service, data analytics, building information model
Classification	2.3 Quality of service, 5.4 Knowledge sharing, 2.2 Monitoring
Beneficiaries	Facility managers, building owner, tenants, building service providers
Impacts	▪ Energy savings due to diagnosed faulty behaviour ▪ Detection of faulty equipment ▪ Increased comfort
Key ICTs	**Expected progress (2020) beyond State-of-the-Art (2010)**
Diagnostic algorithms, building model, simulation, statistics	Hand held displays would require that the device knows its location and orientation. Within a building there is currently no adopted technology for this.
Scenario description	Lars is a service technician working for an energy management company. He has just been called to a site with a reported problem. Apparently the energy consumption for a certain part of the ventilation system is showing an unexplained increase in energy consumption. The building management system is equipped with diagnostic capabilities and has rooted down the problem to three possible causes prioritised after probability; the first one is a jammed air filter. The diagnostic algorithms do not only survey energy consumption but also control accuracy, measurements and quality of measurements. Further, it checks for forced actuators and strange behaviours such as simultaneous heating and cooling, which should never occur. Lars has been communicated the causes and starts out with inspecting the filter, which turns out to be clean and with no indication of overly obstructing the airflow. He then moves on to the second possible problem, a defect air duct pressure sensor, but he has no idea were in the building this particular sensor is placed. He pushes the 'show me' option on his handheld device and it presents him with a semi-transparent three dimensional visualisation of the building with the sensor highlighted. The origins of this model are the architect drawings from before the time of construction. Since then the data has been kept up to date with all modifications of the building.  Lars follows the directions he is given and when he is close enough, he utilises augmented reality to help him find the sensor. His display also shows him the current sensor measurements. Lars realises the sensor is faulty and replaces it, since the sensor was suspected he had brought a spare just in case. A few minutes after informing the building management system that the sensor has been replaced, he is told that everything is back to the normal lower energy consumption. Lars leaves the building with a smile on his face - yet another easy service mission.

2.2.4 Wireless sensor networks

Scenario title	**Where is the energy going?**
Keywords	Monitoring, wireless sensor networks
Classification	2.2 Monitoring, 2.4 Wireless sensor networks, 3.2 Visualisation of energy use, 3.3 Behavioural change, 5.3 Interoperability and Standards
Beneficiaries	Facility managers, building owner, tenants
Impacts	▪ Energy savings due to increased awareness ▪ Detection of faulty equipment
Key ICTs	Expected progress (2020) beyond State-of-the-Art (2010)
Wireless sensor networks, open communication protocol	To utilise the benefits of WSN they need to be standardised, low cost and easy to install and commission.
Scenario description	Mr Fisher is the CEO of a small IT company located in a multi-tenant building. The facilities are mostly office spaces covering one of the floors of the building. In line with the company's energy-aware profile, Mr Fisher would like to have more information about how energy is spent than just the monthly energy bill. With this consideration in mind Mr Fisher approaches an engineering company to plan specific actions for improvement of energy monitoring within the facilities. From their perspective this should be done through the application of wireless sensor networks (WSN). The benefits of their suggestion are low cost installation and easy configuration to support energy data collection and aggregation. There are also accompanying services providing energy reports and dashboards. Further, WSN will not require additional wiring, will not harm the interior and design of the facility, but will provide the flexibility of easy re-installation in case of change in e.g. space planning. The building management system is also using wireless communication for temperature measurement used for zone control. In agreement with the building facility manager, Mr Fisher is given access to these measurements along with the thermal energy data associated with his floor. The data is easily incorporated because both systems use the same standardised wireless communication protocol. One year after the installation Mr Fisher is more than happy with the result. He can now see how the energy bill is distributed down to the granularity of individual power outlets. 

2.2.5 Vision

Integration & interoperability:
Interoperable products from different manufacturers are crucial to harvest all the available energy savings. In particular for residential applications it is important that integration of products is very easy and feasible with a limited skill set. A possible path to get there is through standardised communication and functionality profiles of products.

Online data resources:
Buildings would benefit from online data resources in standardised format, serving for example weather data.

Smart Grid infrastructure:
The Smart Grid requires smart buildings; however, to facilitate this connectivity the interface should be standardised both in terms of communication but also behaviour and philosophy.

Human machine interfaces:
Some of the identified scenarios include augmented reality through a hand held display. This would require that the device knows its location and orientation. Within a building there is currently no adopted technology for this.

Wireless Sensor Network:
To utilise the benefits of WSN they need to be standardised, low cost and easy to install and commission.

2.3 User awareness & decision support

Three subclasses have been identified for the Thematic area of "User awareness and decision support tools":

- Performance management: definition of metrics for performances evaluation, identification and standardisation of key performance indicators (KPI), methodologies for analysing KPIs
- Visualisation of energy Use: development of simple, easy understandable and comparable mechanisms for the visualisation of energy performance data
- Behavioural change: identification of levers that enable changes in end-users behaviours.

ICT4E2B Forum Workshops on application scenarios have highlighted the fact that most of the participating experts have an interest in this thematic area "User awareness and decision support tools". Indeed, many of the experts participating to the workshops have expressed the idea that even if most of the technologies are already available, there is great part of work that could be performed on the User awareness side. Indeed in the three subcategories identified within the thematic area it is possible to identify many actions that have yet to be implemented and many stakeholders that have yet to be involved. Following pages aims at identifying possible future application scenarios in the three sub classes.

In the following we provide an overview of key scenarios identified for the different areas highlighted above.

2.3.1 Performance management

Scenario title	**Commissioning of energy efficiency**
Keywords	Standards, monitoring, human behaviour
Classification	1.4 Performance estimation, 2.1 Automation & Control, 2.2 Monitoring, 2.3 Quality of services, 2.4 Wireless sensor networks
Beneficiaries	Building owners, users, operation and management
Impacts	▪ Enlightened user decisions ▪ Immediate adjustment of building services according to changes in user behaviour leading to energy savings and optimised indoor environment
Key ICTs	Expected progress (2020) beyond State-of-the-Art (2010)
Building Performance Information Model, Building Automation System (BAS), advanced metering and sensor systems	Intelligent monitoring to existing buildings Consistency of building information in building information models New software tools to analyse information from different sources Requirement of Building Performance Information Model (BPIM) as part of building permit process Storing building permits as models not 2D information
Scenario description	Karl works as a maintenance man in an office complex consisting of five multi-storey buildings. Most of the day he moves around the complex by keeping the structures and systems working as they should be. The utilisation rates of spaces changes constantly and it is important to optimise the energy use so that for example in empty spaces the ventilation is not working in full speed. On the other hand the same system needs to be adjusted for a space full of users all day.

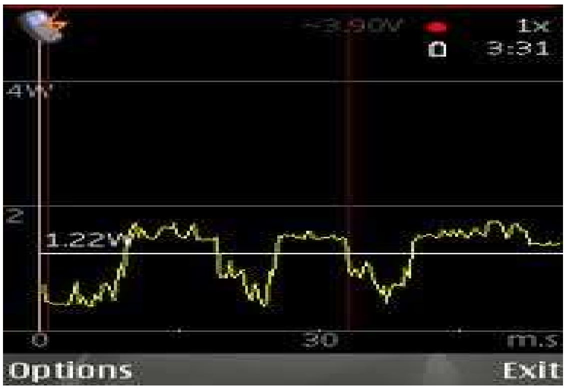
	There exists and intelligent monitoring system in the building. BASwill automatically adjust according to user preferences; however, Karl can also manually operate it when needed. He gets notification to his mobile device, for example, if electricity consumption in particular space exceeds the requirements defined in BPIM.

2.3.2 Visualisation of energy use

Scenario title	**EETrainer: Energy Efficiency methods to train your tenants**
Keywords	Interview of stakeholders, training session on user awareness, improve user motivation, improve customer behaviour and eco-responsibility, reduce energy consumption and save money
Classification	Visualisation of energy user, User Energy Awareness
Beneficiaries	End user, buildings' owners, energy efficiency consultant company
Impacts	▪ Involvement of tenants in group discussion activities, act to understand the issue on global warming and assess the importance of use efficient countermeasure ▪ Improvement of user awareness and reduction of consumption with the introduction of accessible and "user-friendly" tool ▪ Tenants, as end users, know what they can do to decrease their environmental impact (CO2 footprint) with their individual contribution
Key ICTs	Expected progress (2020) beyond State-of-the-Art (2010)
Intelligent interfaces for energy display, integrated energy visualisation tool, e-learning website	Definition of standard metrics and units as well as the definition of efficient information delivery process. Improvement of integrated energy visualisation tool in order to provide to users a detailed vision of their individual carbon footprint considering the overall of daily activities they performed. Development and diffusion of simple and accessible e-learning website between all kinds of users (with different knowledge about the use of computer). These "user-friendly" website shall became 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.
Scenario description	Christopher is the owner of a national chain of full-service buildings established near Milan (Italy). Communications and awareness is a difficult task for Christopher's company in order to achieve the goal of zero-energy building for building owned by public authorities fixed for after 31 December 2018. Because tenants have a significant impact on the ability to manage energy, it is a significant challenge for the company to control energy consumption behaviours. To create an impact, Christopher must convince a diverse group of tenants of the merits and methods of energy conservation. To have an impact on its tenants' behaviour, Christopher with the help of an energy efficiency consultant company provided a wide range of awareness tools to the tenants, including: ▪ an intelligent and accessible energy consumption display in order to show to the tenants the real-time energy consumption ▪ mock-ups of complete floors, developed by an energy visualisation tool, to facilitate visualisation of energy consumption and thus increasing awareness

	of tenants ▪ meetings with senior tenant staff ▪ the use of banners in corridors and in the halls of its buildings ▪ the publication of a e-learning website that aims at the distribution of multimedia contents related to the methods of energy conservation, notices, and schedules of energy retrofits.  *Banners in the corridors to demonstrate consumptions reduction (source: D'Appolonia)*

Scenario title	**Control and awareness of consumption**
Keywords	Energy consumption, energy monitoring, energy awareness
Classification	Visualisation of energy use
Beneficiaries	Users, energy suppliers
Impacts	▪ Monitor the energy consumption. ▪ Reduce the consumption at home. ▪ Reduce the expenses in energy. ▪ Be aware of the best time to consume energy at home in relation with the energy cost and the demand
Key ICTs	Expected progress (2020) beyond State-of-the-Art (2010)
Sensors, applications, devices	With the momentum of green design, new technologies and applications are continuously being developed to assist in sustainable living. A large percentage of energy consumption is in the home, majorly impacting your individual carbon footprint. By monitoring home 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. Intuitive applications will help users to quickly understand their usage habits by clearly identifying total consumption as well as individual device consumption. With this kind of applications and devices installed at homes, the obtaining of this kind of valorous information can be done, 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.
Scenario description	John and Susan, like most newlyweds, have bought recently a new home to live together. With their recent wedding, many friends and family have given them all kinds of devices such as a new washer, dryer, blender, microwave etc. When they received their first electricity bill reporting the energy consumption, they realise

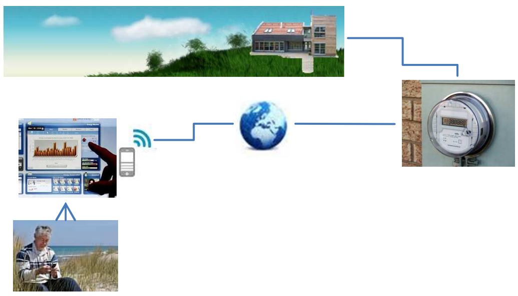
	that with all these devices the consumption has soared with the consequent increase in the cost. So they decide to contact a specialist company that has a computer program to always know household consumption and reports the price of energy at all times.  After the installation of the corresponding sensors and devices to monitor the energy consumption and the installation of the program on their TV and PC, everything was ready at their home. Through this program, which is available through television or mobile, they know at all times the consumption in the house, which allows them to be aware of it and informed about the best time to, for example, start the washer depending on the price of electricity at all times.

Scenario title	**Energy awareness support of university district users**
Keywords	Embedded systems, energy consumption, sensor system
Classification	User awareness / visualisation of energy use
Beneficiaries	Two main stakeholders are distinguished within this scenario. The first ones are those which carry out different activities inside the district, crossing the streets, using the buildings and walking through a green area. The second group of stakeholders are those who are responsible for the buildings and can manage the aspects related to the energy performance of these buildings. Managers of public and private buildings and facilities and owners or tenants of a dwelling are included within this group. In some cases, the building manager is also the final user.
Impacts	▪ Increasing habitants, users and building managers awareness. Transfer of good practices to the stakeholders in terms of being aware of their carbon footprint and reducing their energy consumption. ▪ Make people aware of the spending power is in their day to day. ▪ Relate the number of people who are in a public building to the spending power is made. ▪ Know the exact power spikes that occur during the day on public buildings to try to make more sustainable use of it.
Key ICTs	Expected progress (2020) beyond State-of-the-Art (2010)
Embedded systems, sensors, RFID	Basic functionality of sensors and actuators, i.e. measurement and control, can be extended to form smart objects. These smart objects provide additional services, e.g. unique identification, localisation or event-driven actions. When smart objects are meshed together, smart spaces come into existence. The networked smart objects are not only aware of their own location but they also have context-aware information available, meaning that smart objects in a class- or conference room are aware of the fact where they are and what that means. Spatial, temporal and context information are taken into account to provide such functionality. The multitude of smart objects and smart spaces form the

	districts Internet of Things (IoT).
Scenario description	Marc is voluntarily participating in an activity organised by the University inside the Sustainability Plan aimed at improving the awareness of the habitants and users of the district of their Carbon Footprint. Marc, before participating in the awareness action, wasn't aware of his carbon footprint, so he didn't know the amount of energy associated with all the daily activities carried out inside the district. After participating in the experimentation, he will be aware of this amount of energy. In order to participate in the awareness action, Marc has been provided with a mobile device that he can use anywhere and anytime inside the district. This mobile device will allow the user to get and store information related to the Carbon Footprint associated with the activities he is carrying out, as well as the consumption of energy of the building he is using or the technologies implemented in the building to reduce its consumption of energy. The acquisition and transfer of information will be achieved through the installation of different embedded systems inside the public and private district buildings, the personal or public means of transport, etc. such as RFID tags. By receiving this information, the student is aware of the average energy associated with his activity carried out inside the building per unit of time. On the other hand, he knows which technologies can be implemented to reduce this consumption. In this case, the student realises that the building manager, who is also participating in the University action, has followed some of the recommendations to improve the energy efficiency of the building. To do so, he has implemented in the building a system to monitor and control the energy consumption and use. The student goes to the university to attend a course. An embedded system detects his entrance to the building. The building has its different areas monitored with embedded systems. Thus, the student knows its Carbon Footprint associated with the activities he has carried out in the various areas where he has stayed. In each place, he has information related to the technologies implemented to reduce the energy consumption. For example, he realises that some sensors have been installed on the windows of each classroom to control the use of heating and air conditioning installations. During this experiment, Marc learns how his daily activities contribute to CO2 emissions, and learns that there are alternative ways to do the same activities... so at the end he is able to optimise his activities to obtain good scores. At the end this implies that inefficient buildings will be less used, so the owners/managers of these buildings will be socially forced to make energy improvements to their built environment stock.

2.3.3 Behavioural change

Scenario title	**EE Habits: the wisdom to live your daily life**
Keywords	Increase the understanding of the benefits of energy efficiency, make the link between actions and behaviour by individuals, motivate users to modify behaviour that affects energy consumption, reduce energy consumption and save money
Classification	Behavioural change by real-time pricing, Decision support
Beneficiaries	End-users / investors, building owners, software suppliers, energy providers

Impacts	▪ Increasing involvement of building users and owner on the use of BMS ▪ World wide web accessibility to control your building ▪ Daily energy consumption plan act to follow the scheduled activities planned by users
Key ICTs	**Expected progress (2020) beyond State-of-the-Art (2010)**
Decision support tools, real-time information, reports on mobile devices	Development of a decision support tool that helps planners to find the best integrated building concept, and user to find the best way to control their buildings Development of new BMS that can give real-time information on energy consumption in building and that could controlled by mobile devices Development of useful and common rules to provide a readable report on energy consumption to end users Development of web accessible “energy account” in order to provide to users a usable device to have real-time control on energy consumption and a intuitive way to understand how to modify their daily behaviour that affects energy consumption
Scenario description	Daniel woke up early this morning because he is invited to attend to a technological workshop concerning the last generation of mobile phone. He is a young guy who lives alone in his house where electric equipment is all controlled by a BMS. While he was travelling by train to reach the venue of the workshop, he connected to his “energy account” profile with his smart phone, a web application provided by local energy provider and linked to his own BMS, retrieving information about the energy consumption of the last week presented as a readable report. The report presents three columns: - Bonus, with references to good energy saving actions performed - Malus, with references to bad energy actions performed - Action to do, where for both bonus and malus columns are proposed suggestions to improve his behaviour in order to decrease energy consumption. During the assessment of the report Daniel received a sms. It was an “alarm” message sent by his own BMS that registered that the PC was not turned off and there was an alteration of his consumption plan planned for the current day. Daniel managed the critical situation easily and quickly by switching off the PC by a command send from his smart phone to his BMS.  *Interaction between final user and BMS (source: D’Appolonia SpA)*

2.3.4 Vision

The “Roadmap for a transformation of energy use in buildings” [5] developed by World Business Council for Sustainable Development in 2009, has identified as one of the 2050 Objectives that in future, building occupants “will fully comprehend and value energy efficiency” and they will be at the basis of a “new energy culture”. According our review of the state of the art (Deliverable 1.2), we have identified that information is the key issue in supporting decisions and creating awareness. Therefore information should be easily available, comprehensible and useful for further operations.

<u>Sensors, applications, devices and software tools to analyse information from different sources</u>

These are needed to collect information from existing buildings and used as a part of intelligent monitoring. Consistency of building information in building information models requires definition of standard metrics and units, as well as the definition of efficient information delivery process.

<u>Decision support tools</u>

There is a need to develop a decision support tool that helps 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 consumption is in the home, majorly impacting our individual carbon footprint. By monitoring home 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.

<u>Intelligent interfaces for energy display</u>

Developing new BMS is important to provide real-time information on energy consumption in building. This information could be controlled by mobile devices. Web 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. Intuitive applications 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 at homes 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.

<u>Integrated energy visualisation tool</u>

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.

<u>E-learning</u>

Development and diffusion of simple and accessible e-learning website between all kinds of users (with different knowledge about the use of computer) will help citizens to improve their behaviour by learning new ways of conducting daily activities. These “user-friendly” website shall became 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

2.4 Energy management & trading

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 electricity grid is such an infrastructure connecting however entities with limited interactions among them -- up to now.

Today's grid features a typical centralised approach where few powerful central stations broadcast energy to the different consumers. However as renewable energy resources pave their way, we expect that future users will not be simply consumers of energy but also producers; hence the term “prosumers” has been coined to reflect the ability to interchangeably slip to these roles.

Prosumers will be able to not only better manage their energy based on real-time information they acquire, but also buy and sell the energy they produce online. Some go even further and see new business opportunities for buildings as well as large groups of users that are able to sell their energy signature flexibility online hence acting as balancing partners in a smart grid.

In the following we provide an overview of key scenarios identified for the different areas highlighted above.

2.4.1 Building energy management

Buildings of the future are expected to be equipped with intelligent sensors and other devices that will enable them to monitor and in real-time adjust their behaviour in order to match their energy goals. This holds true for the building internals e.g. optimisation of its operations as well as externally if the building is seen as part of a larger smart grid infrastructure (e.g. in the scope of a smart city).

Scenario title	**Commercial Building Energy Self-optimisation**
Keywords	Building Performance Information Management (BPIM), Energy Management, Performance Specification
Classification	Performance Analysis and Evaluation
Beneficiaries	Energy provider, building facility management
Impacts	Automatic adjustment of the building’s energy usage to its users Energy acquisition from the smart grid market Lower energy costs via future planning consideration
Scenario description	Nicolette is an administrative assistant in a multinational company. The HQs of the company are in a modern futuristic building that can control all of its functions in an autonomic way. Sensors in corridors enable the usage of lights when people walk proactively. Similarly sensors in the meeting rooms enable monitoring of current temperature and adjustment of it when needed. Additionally air-flow and quality is adjusted depending on the number of people sensed as well as the CO_2 levels in the room. Nicolette maintains an accurate meeting calendar for all meeting rooms in the building. Hence it is known a priori when meetings will take place and approximately the number of people attending. 20 minutes prior to the meeting the heating is turned on (and not at a predefined hour in the morning as in the

	old building), while the air quality monitoring enables the windows to automatic open when needed (and not at fixed intervals) enabling better energy efficiency and management. This in conjunction with lights, hot water etc. enable the building to automatically manage its resources better, matching them to better fit its users' needs and without doing energy actions if not needed (e.g. heat the meeting room if no one is in). Additionally since meetings are known in advance, it assists the BEMS to buy electricity at online marketplaces hence providing even lower operating costs for its owner.

2.4.2 District energy management

In the smart grid era the focus is not on the individual prosumer or the individual building but on the larger ecosystem of them. Hence energy efficient districts/neighbourhoods may enable cooperation among their actors in order to attempt to better utilise local energy resources that are available. As a typical example the NOBEL project sets up a local neighbourhood market in an effort to match local electricity demand and supply. Districts are seen in the broader energy scope including buildings, electric cars, public infrastructure (e.g. public lighting system) as well as other energy presumption and storage resources available.

Scenario title	**District energy management supported with electric cars**
Keywords	Electric mobility, energy management, forecasting, grid, charging points,
Classification	District energy management
Beneficiaries	Electric car drivers, grid operators, demand side managers with demand response, households
Impacts	Curtail critical situations in the grid and better utilise energy storage options.
Key ICTs	Expected progress (2020) beyond State-of-the-Art (2010)
Load management systems Dynamic pricing and tariff systems	Development of load management systems for the grid with demand response and options of customer engaged load curtailment. Development of dynamic pricing and tariff systems that can communicate with end user applications.
Scenario description	Ella drives an electric car to commute to her office as well as for small distances within the city she lives in. She knows her driving habits well. During the time in the office she maintains her driving profile via a mobile application provided by the DRSM. Ella has a private garage in her home with a private charging station and a public charging station at the parking space next to her office. Her car takes 5 hours to charge fully. For her energy needs within the home she has a contract with an energy retailer that also provides her with an additional contract for charging her car at available public charging stations distributed within the city. For load curtailment Ella has an additional contract with the DSO (Distribution Service Operator) and DRSM (Demand Response Side Manager). Dominic works at the DSO & DR and is responsible to assure that the levels of energy are in balance throughout the day. As these amounts may vary, he has different options to curtail or increase the available energy. With the enabled district energy management he is provided with a system that can generate forecasts of available and needed energy in the grid. The information is further represented in a geographic information system that gives him an overview of the current and predicted energy situation within the district.

	Dominic sees that additional amounts of energy will be required in the grid at noon of the day he has been provided with a forecast. He sees that the required amount can fully or partially be supplied by the electric cars, which will be connected to the grid at that point of time. After assessing other opportunities he decides to set a demand response (DR) signal to the electric cars that he has a contract with. Throughout the day he closely monitors the grid situation. At noon the energy demand in the grid sharply increases, yet due to the demand response signal this additional demand is curtailed and no critical instances within the grid arise. Ella has activated the demand response capability with the DR provider via her mobile phone, hence she is granted with a financial compensation for helping out Dominic to easily manage his infrastructure.

2.4.3 Smart grids and the built environment

In the larger scope of the smart grid the buildings may play a key role for balancing energy. Being able to adjust their internal energy consumption to match external needs they can assist the network. Additionally it is expected that buildings will be part of larger facility management efforts for energy efficiency, hence energy not used on a specific building may be transmitted to a nearby one. The key is the sharing of energy related information, so that optimisation can be achieved.

Scenario title	**Energy Trading for Industrial Facilities**
Keywords	Energy trading, marketplace, broker, forecast, load
Classification	Energy Trading, Energy Management
Beneficiaries	Industrial energy managers, broker, energy market, forecast provider
Impacts	Trading via energy markets, optimal energy procurement
Key ICTs	Expected progress (2020) beyond State-of-the-Art (2010)
Trading desk, energy portfolio management system, energy market access, market information system	This scenario assumes mature technologies in the following areas: ▪ Interoperability standards covering information needs of all disciplines throughout the energy market systems ▪ Advanced metering systems in place ▪ Adjustable industrial processes ▪ Online Marketplaces
Scenario description	Ingo is the energy manager of an energy intensive industrial facility. As such he is responsible to procure energy in a manner that is economically efficient and sustainable. For this, the company of Ingo has decided to procure its energy via the energy market with the support of an energy broker. The broker is “Tom”, he acts as the link between the energy market and Ingo’s company. As an energy broker he provides market information when and who to optimally procure energy. This is enclosed in an energy strategy that Tom and Ingo have defined together. Ingo’s company produces goods that are very energy intensive to manufacture, as energy costs claim 15+ % of the total production costs. Ingo can overlook the past load profiles in his energy portfolio management system. Further the system provides forecasts that are derived from historic loads and the production planning system. With this together Ingo has an overview of the energy he has needed in the past and what he may require in the future. This information is combined with

	transactions that he has executed on the energy market with his trader. As such Ingo always has an overview of the energy he has procured or may additionally have to procure in the future Tom watches the energy market as a broker very closely. In daily updates he receives a report from the energy portfolio management system of Ingo. When Tom sees a situation in the market that makes it cost optimal to procure energy, Ingo is informed to take the decision and react. The further grid related information exchange or financial transactions are not part of this scenario. If for any case too much energy should have been procured, this energy can be sold via Tom on the after day market. Vice versa, this may also apply. Additionally Ingo's factory features processes that can be flexibly scheduled and adjusted in very short time. This gives Ingo the possibility to bid in the real-time market balancing services. For instance when much low priced electricity is temporarily available, energy-hungry processes are scheduled, while when the price is very high these can be flexibly rescheduled. Furthermore since the factory has many heat related processes, Ingo is able to sell the by-products of his factory e.g. for water heating etc. This enables a better holistic energy footprint management for the whole factory.

2.4.4 Vision

Information and Communication technologies are in the heart of the emerging smart grid and energy efficiency efforts with respect to buildings. Energy management and trading empowered with ICT will flourish. New, highly distributed business processes will need to be established to accommodate these market evolutions. The traditional static customer process will increasingly be superseded by a very dynamic, decentralised and market-oriented process where a growing number of providers and consumers interact. Such an infrastructure is expected to be pervasive, ubiquitous and service-oriented. A new generation of affordable ICT infrastructure has to be developed to support these changes, complex business processes and enable the efficient functioning of the deregulated energy market for the benefit of European citizens and businesses. The architecture of such distributed system landscapes has to be designed, standards must be created and widely supported, and comprehensive and reliable IT applications will need to be implemented.

ICT will make it possible for future distributed energy systems to be self-managing, self-sustaining and robust, and will enable dynamic reorganisation and coordination of services markets. Therefore the Internet-based infrastructure will be tightly coupled with the energy domain, and used to support the development of new mechanisms for trade based on supply and demand in the electricity market. Different models and scenarios for a highly distributed information-based energy infrastructure will emerge. Transaction platforms will provide services such as electronic marketplaces, facilitating the commercial activity associated with the buying and selling electricity and its derivatives, not only for utility companies but also for decentralised consumers and producers.

We are moving towards the 'Internet of things', where almost all devices will be interconnected and able to interact. The same will hold true for energy metering devices. New information-dependant intelligent energy management systems will be needed for an infrastructure capable of supporting the deregulated energy market. They will be able to provide almost real-time data that in turn will have a significant impact on existing and future energy-management models. Decision and policy makers will be able to base their actions on real-world, real-time data. Households and companies will be able to react to market fluctuations by increasing or decreasing consumption or production, thus directly contributing to increased energy efficiency.

Several scenarios such the ones mentioned here are envisioned. The trend is clear as we move towards collaborative infrastructures and information exchange among all actors, which may give rise to innovative new energy efficiency applications especially in the building domain.

2.5 Integration technologies

In this section named *Integration technologies* is focused on the following RTD topics:

- Process integration
- System integration
- Interoperability & standards
- Knowledge sharing
- Virtualisation of built environment

These subcategories include technologies to satisfy needs in fields as collaboration tools, service oriented services, middleware, communication protocols, knowledge management among others.

2.5.1 Process integration

Scenario title	**Open design collaboration**
Keywords	Process integration, domain of the processes, workflow
Classification	Process integration
Beneficiaries	Architects, designers, engineers
Impacts	▪ Synchronisation of different documents and confidence on that. ▪ Different profiles of experts can work together in an optimal way. ▪ Process integration controlled since the beginning.
Key ICTs	Expected progress (2020) beyond State-of-the-Art (2010)
New software applications	In this field, a lot of improvements exist to be done. It's easy to understand that in present and more in future different kinds of experts will have to work together in the constructions of new buildings. So the expected progress in this field is the creation of new applications that will ensure the correct communication and work between them. Smart workflows will be taken into account in these applications in order to make the job in a most coordinated way.
Scenario description	Let's think about an architectural study in which works different types of experts. We can think about architects, engineers, designers etc. All of them right now are starting a really huge project that is about the construction of a big building that will have flats, offices and shops. It seems to be clear that the different profiles of the team will need a powerful tool to be able to work together without difficult and with efficiency. In the future, there exists a tool to do so that will include smart workflows. The dynamic nature of design projects requires parallel processes, smooth workflow and tight control. With this kind of applications professionals will achieve all these with the confidence that documents are synchronised and that the right type of document is at hand to clearly illustrate their inputs. With this kind of applications they will control all the workflows including intelligent workflows that the tool will give to them automatically. For sure, at the end of the design they will need less time to do so; the process will be integrated and controlled since the beginning.

	 Source: http://www.cambridgenetwork.co.uk/

2.5.2 System integration

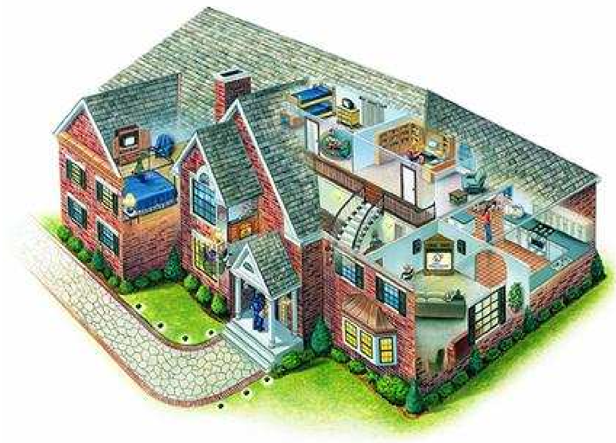
Scenario title	**Energy efficiency and cost optimisation of a technological building**
Keywords	Sub-metering and building networks, supervisory control strategies
Classification	Energy consumption control / building sensors
Beneficiaries	Building managers, users of the building
Impacts	▪ Building-level optimisation through the balancing of local generation and consumption achieved by coordinated control of consumption, generation, and storage devices. ▪ Optimal operation of individual devices.
Key ICTs	Expected progress (2020) beyond State-of-the-Art (2010)
Middleware, sensors, PLC, Zigbee, building network	Embedded diagnostics methods, capable of running on local controller devices will be developed to allow for 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 will consider future energy consumption and based on that will try to adjust the consumption curve by shifting or curtailing some of the loads. In case of system optimisation, the control strategy will use the information about the operation states, loads, weather conditions, tariffs, and equipment characteristics.
Scenario description	Let's think about a technological building that we can describe as an interdisciplinary research and training centre where physicists, chemists and biologists investigate scientific issues at the nanoscale. It is located in a recently reconstructed historical building with about 4000 m2 divided on 3 floors. Given the specific regime of Labs, one of the important targets for it, in addition to energy efficiency and cost optimisation, is the reliability and quality of energy supply.

To accomplish with their necessities they plan to install a middleware that not only offers control and visualisation of the energy consumption but also energy optimisation by developing supervisory control strategies, through the development of an intelligent gateway with embedded logic supporting inter-building energy exchange and developing novel virtual sub-metering technologies and event-based middleware applications that will support advanced monitoring and diagnostics concepts.

Existing infrastructure: Preliminary metering infrastructure for individual floors is already available. The building is also equipped with a monitoring and control system for some high-value pieces of equipment and devices with special requirements for energy supply. Next year, the building will be equipped with new photovoltaic generators, which will increase the flexibility of the electricity supply.

This scenario is particularly suitable for validation of the sub-metering and building networks supervisory control strategies. It will be used to validate prototypes of non-intrusive load monitoring and optimisation of local generation-consumption matching by the energy management system. In addition to that, the diagnostic concepts developed as part of the middleware technology, can be tested on this site too.

Metrics: The reliability and the quality of energy supply is one of the most important targets for this type of building. That is why, besides energy efficiency and cost optimisation targets, we need to take into account also targets related to avoided outages and quality of power supply.



Source: http://www.cavemanhometheaters.com/

2.5.3 Interoperability & standards

Scenario title	**Integration of electrical appliances at home**
Keywords	Standards, integration, interoperability, control
Classification	Integration with standards
Beneficiaries	Electrical appliances vendors, end-users, engineers
Impacts	Shared standards between existing ones and new ones

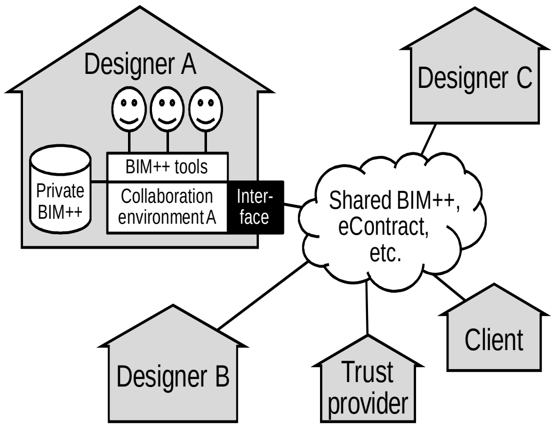
Key ICTs	Expected progress (2020) beyond State-of-the-Art (2010)
Integration, interoperability, control	Data models and real-time communication protocols will be standardised in order to allow all the stakeholders to develop their devices without problems at the moment to plug them. Producers will not have to think about if their devices will be effective at the moment to plug them because all the devices inside and outside the buildings will share the same protocols.

Scenario description	John and Rachel have decided to live together in a new flat allocated in a building of new construction in the city surroundings in a zone of recent construction. Their new flat has all the advancements regarding energy management including a monitoring and basic control operation that allows feeding this data model with real time data. John loves innovation in any field, he is engineer. So they decide to buy the most advanced electrical appliances that are existing in the market. They pretend to connect them to the BIM of the flat and through the mobile phone, taking into account the cheapest electricity rate during the day, turn on their electrical appliances. When they try to connect the electrical appliances to the BIM to do so, a huge interconnectivity problem appears because the protocols used by the BIM and the appliances were completely incompatible. So, in future it is really necessary that the energy management tools that we have at home use the same protocols and standards that are used in the electrical appliances in order to achieve a correct interconnection between them and take profit of the features that can offer.

Source: http://www.lgblog.com.my

Scenario title	**Collaborative BIM-based integrated design**
Keywords	BIM, collaboration, design, contract management, workflow management, legal aspects
Classification	5.1 Process integration, 1.1 Design, 1.3 Modelling

<table>
<tr><td>Beneficiaries</td><td colspan="2">Designers</td></tr>
<tr><td>Impacts</td><td colspan="2">BIM as contractually and legally valid information. Enhanced autonomy of design companies to manage internal work processes in inter-enterprise projects. More holistic and optimal design solutions (e.g. energy efficiency). Less errors. Faster process. Availability of information to those who need it, in a form that they need it and when they need it.</td></tr>
<tr><td colspan="2">Key ICTs</td><td>Expected progress (2020) beyond State-of-the-Art (2010)</td></tr>
<tr><td colspan="2">Audit trail, BIM, CAD, collaboration environments, contract model, document management, PDM, data security, workflow support, and ICT standards in all these areas.</td><td>Integration of the functions listed on the left into company specific internal collaboration environments which are interoperable with similar systems of other companies and synchronise internal workflows of companies with the inter-enterprise design process.</td></tr>
<tr><td>Scenario description</td><td colspan="2">Instead of using a common – and usually different – collaboration environment in different projects, which was still the case as late as in 2010, each firm in the building project uses their own internal collaborative environment in all of its projects. Users no longer need to learn several systems. The new systems fully support the internal workflow of each firm e.g. approvals of design versions before releasing them to other companies.



Source: http://www.tekla.com/ae/about-us/news/pages/teklaaffirmstruebimcollaborationwithnewsoftwareversionteklastructures17.aspx

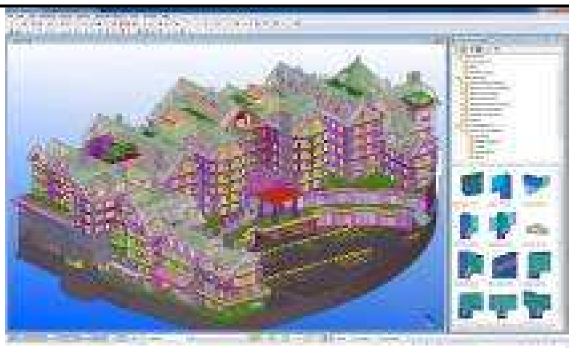
The different enterprise specific working environments are inter-operable and make released information automatically and transparently available to other project participants with appropriate contents and format based on their roles.

The digitally represented design contract provides semi-automatic coordination of the inter-enterprise design process. The audit trail of each transaction is recorded in a secure and legally valid way.

The shared information has flexible semantics levels (from “dummy” documents to BIM, or hybrid combinations such as augmented reality). All these qualify as contractually valid information without the need of “paper” documents. IPR of shared information is protected to enable others to use but not to change / copy it.

Versatile model analysis tools are used to validate the BIMs and alert users to take corrective actions e.g. with respect to deficiencies, energy efficiency, geometric clashes, compliance to requirements / standards / contract, inconsistencies etc.

The design environment supports conference-style negotiations with shared views of any information. Once completed, the design information is archived in a way that maintains its accessibility over the full life time of the building e.g. 100 years.</td></tr>
</table>

	 Source:www.tekla.com

2.5.4 Knowledge sharing

Scenario title	**Looking for information about ICT4E2B**
Keywords	Information, data mining, access to knowledge
Classification	Knowledge sharing
Beneficiaries	Building managers, constructors, designers
Impacts	▪ Access to knowledge in an easily and centralised way. ▪ Ease of sharing information.
Key ICTs	Expected progress (2020) beyond State-of-the-Art (2010)
Knowledge platforms	All the knowledge of all stakeholders involved in construction and energy efficient buildings issues will be shared between them using inter-organisational knowledge platforms that will contain all the information organised by term and will offer an easy way to be consulted.
Scenario description	During the design phase of a new office building, the designer just ran into some problems regarding the management of the energy efficiency in building that had to be quickly dealt within order to solve such problems. He then recalled that the attended a conference recently in which he heard about the creation of a kind of repository with all kind of information related to energy efficient buildings where many experts kept there all their know-how to share it with their colleagues around the world. Access to it was free and the information search was done in a semantics way that offers the obtaining of lots of related information without much effort. All the knowledge of all stakeholders involved in construction and energy efficient buildings issues will be shared between them using inter-organisational knowledge platforms that will contain all the information organised by term and will offer an easy way to be consulted. This will facilitate a good way to taking advantage of the experience in previous buildings and share it in a properly way.

	 *Source: http://www.deborahswallow.com/*

2.5.5 Vision

Process integration:

The dynamic nature of design projects requires parallel processes, smooth workflow and tight control. New applications to give support to all these needs and will allow to different profiles of experts work together in a project with no difficulty related to coordination of processes and the shared control of all the project. This kind of applications will offer smart workflows that will be synchronised depending on the status of the project without any help. They will do it automatically.

System integration:

Embedded diagnostics methods, capable of running on local controller devices will be developed to allow for 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 will consider future energy consumption and based on that will try to adjust the consumption curve by shifting or curtailing some of the loads. In case of system optimisation, the control strategy will use the information about the operation states, loads, weather conditions, tariffs, and equipment characteristics.

Interoperability & standards:

Data models and real-time communication protocols will be 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. Producers will not have to think about if their devices will be effective at the moment to plug them because all the devices inside and outside the buildings will share the same protocols. Other domains protocols and standards will be integrated as needs and applications of buildings will increase.

Knowledge sharing

All the knowledge of all stakeholders involved in construction and energy efficient buildings issues will be shared between them using inter-organisational knowledge platforms that will contain all the information organised by term and will offer an easy way to be consulted.

3 Conclusions

3.1 Recapitulated visions

Following summarises the generated elements of visions in each thematic area. Consolidated vision will be represented in the forthcoming deliverable D2.3 Draft research roadmap.

<u>Tools for energy efficient design and production management:</u>

- Model based interoperable tools for collaborative engineering, design, analysis, and simulation.
- Parametric libraries of re-usable design knowledge.
- Context specific views of design models for decision support.
- Tools for validation of design models with respect to coherency, energy efficiency and compliance to requirements and building codes.
- Integration of BIM-CAD, analysis and simulation.
- Advanced energy efficiency assessment and optimisation as a common practice in building design.
- BIM-based tools used in production management and enhanced with features to include output of optimised operations to improve energy efficiency
- Customised interfaces for project stakeholders empowered by additional energy modelling software
- Real time collaboration of project stakeholders from any location using cloud technology
- Interoperability between building industry BIM software's; transferring the relevant parameters from requirements model to design model(s).
- Performance indicators effecting on energy efficiency on neighbourhood and building levels defined using related assessment methods and tools.
- European level certification of the tools and libraries of best practices and reference design solutions.
- Defined requirements from conceptual design are represented as corresponding design options with the help of various energy simulation tools. Building regulations are embedded in BIM-based assessment software.

<u>Intelligent control</u>

- Integration of interoperable products from different manufacturers is very easy and feasible with a limited skill set through standardised communication and functionality profiles of products
- Buildings benefit from online data resources in standardised format serving for example weather data
- Standardised interface between smart buildings and smart grid in terms of communication but also behaviour and philosophy
- Human machine interfaces employ augmented reality through a hand held display
- Standardised, low cost, easy to install and operate WSN networks

<u>User awareness and decision support</u>

- Building Performance Information Model
- Intelligent interfaces for energy display
- Integrated energy visualisation tool
- E-learning website
- Decision support tools

- Real-time information
- Reports on mobile devices

Energy management and trading

- New generation of affordable ICT infrastructure for dynamic and decentralised energy production
- Standards for deregulated energy market
- Comprehensive and reliable IT applications
- ICT for self-managing, self-sustaining and robust distributed energy systems
- Internet-based infrastructure for dynamic reorganisation and coordination of services markets
- Transaction platforms for providing services such as electronic marketplaces, and facilitating the commercial activity associated with the buying and selling electricity and its derivatives, not only for utility companies but also for decentralised consumers and producers
- Interconnected energy metering devices
- Intelligent energy management systems for an infrastructure capable of supporting the deregulated energy market
- Systems providing real-time data
- Decision support tools based on real-world and real-time data
- Collaborative infrastructures and information exchange among all actors

Integration technologies

- Process integration to enable parallel processes, smooth workflow and tight control by using new applications supporting all these needs and allowing different profiles of experts work together
- Early detection of anomalous energy consumption and/or malfunction of individual components in building services using embedded diagnostics methods
- Adjustment the consumption curve by shifting or curtailing some of the loads using load management algorithms
- Standardised data models and real-time communication protocols to allow all the stakeholders to develop their devices
- The needed knowledge from all stakeholders involved in projects will be shared between them using inter-organisational knowledge platforms

3.2 Compliance with the DoW

Two minor changes were made compared to the DoW:

1. Selected experts were involved in three workshops (meetings) instead of four in order to develop the vision for future application scenarios. The 4thhas been held in relation to T2.2.

2. Instead of using Delphi survey, we have organised a set of workshops aiming at identifying key elements of application scenarios exploiting "face to face" interaction with experts. This approach allowed us to gather information in different steps from different experts allowing us to obtain a recursive process thanks to the reviews that experts were asked to perform during the workshops. A detailed description of Workshops objectives and the methodology at their bases is given in Appendix A – Meetings with Experts.


Pictures from ICT4E2B Forum
Workshops in Sophia Antipolis and London

4 Acronyms and terms

BAS	Building Automation System
BIM	Building Information Model
BMS	Building Management System
BPIM	Building Performance Information Management
CAD	Computer Aided Design
CFL	Compact florescent light
Cloud technology	The use of additional computing power over Internet
CO2	carbon dioxide
Dashboard	Instrument panel, operating table, switch desk
DR	Demand Response Side Manager
DSO	Distribution Service Operator
EE	Energy Efficiency
GIS	Geographical Information System
HVAC	Heating, Ventilation, and Air Conditioning systems
ICT4E2B	Information and Communication Technologies for Energy Efficient Buildings
LCA	Life Cycle Assessment
LCC	Life Cycle Cost
LCM	Life Cycle Management
LED	Light emitting diode
MEP	Mechanical Electrical and Plumbing works
PC	Personal Computer
REEB	European Strategic Research Roadmap to ICT enabled Energy-Efficiency in Buildings & Construction
RTD	Research and Technology Development
TV	television
WSN	Wireless Sensor Networks

5 References

[1] Hannus, Matti; Kazi, Abdul Samad; and Zarli, Alain, Eds. *ICT Supported Energy Efficiency in Construction - Strategic Research Roadmap and Implementation Recommendations*, 2010 REEB Project Consortium

[2] EeB - The Ad-hoc Industrial Advisory Group, *Energy-Efficient Buildings. Multi-Annual Roadmap And Longer Term Strategy*, 2010 (http://www.ectp.org/groupes2/params/ectp/download_files/36D1191v1_EeB_Roadmap.pdf)

[3] ICT4E2B Forum, Deliverable 1.1, *Classified Research Areas*

[4] ICT4E2B Forum, Deliverable 1.2, *Initial Analysis of the state-of-the-art*

[5] World Business Council for Sustainable Development, *Roadmap for a transformation of energy use in buildings,* 2009 (http://wbcsd.3xscreen.co.uk/wbcsd-eeb.html)

6 Appendix A – Meetings with Experts

6.1 Detailed methodology description

The workshops' key objective was for the invited experts to develop the vision for future application scenarios of new ICTs for energy efficient buildings. The three workshops were organised in different countries and they had the same structure designed to enable consolidation of results from different workshops with different participants.

The participants were asked to present their ideas and then invited to further analyse their own first scenario concepts during different steps of iteration. The iteration continued by email communication after the workshop.

Two (or one) weeks before the workshops, a template for scenario description and a list of topics (as below) were sent to the experts. They were invited to identify application scenarios in the following thematic areas:

Thematic Area	Scenario topics
1. Tools for integrated design and production	• Design • Production management • Modelling • Performance estimation
2. Intelligent & Integrated Control	• Automation & control • Monitoring • Quality of service • Wireless sensor network (WSN)
3. User awareness & decision support	• Performance management • Visualisation of energy use • Behavioural change
4. Energy management & trading	• Building energy management • District energy management • Smart grids and the built environment
5. Integration technologies	• Process integration • System integration • Knowledge sharing Interoperability & standards

The expected outcome from a workshop is a number of scenario descriptions using the standard template. The key elements that should be identified for each scenario are (ICTs):

- **I**mpact
- **C**hallenge
- **T**echnology
- **S**takeholders

<u>**Materials provided by workshop organizer**</u>

- sticky notes
- flipcharts
- pens for experts and for writing on flipcharts
- camera to take pictures of sticky notes

Structure of the workshop

The workshop is structured into the following three phases:

1. Introduction (plenary session)
2. 2 Group Discussions (parallel sessions) with a lunch in the middle of the two group sessions
3. Conclusion (plenary session)

1. **Introduction (plenary session)**: about 1 hour

The project coordinator (or a consortium partner) made a short introduction presenting the general objectives of the project. Furthermore he/she described the structure of the day and the methodology used for the group discussions, expected results included.

Following, the experts introduced themselves to the others in a “tour de table”. Each participant had the choice to express a preference for the group in which they wanted to take part. This choice was reviewed by moderators to obtain balanced smaller groups of people.

Then the workshop was structured in two separate parts dedicated to group discussions with a timing described as follows:

2. **First Group discussion (parallel session):** about 1 hours and 30 minutes

Each group will be provided of a flipchart divided as in Figure 1 (that is a simplified version of the flip chart that we had in Helsinki).
Moderator will collect the name of group participants.

The groups’ discussion has been divided in activities as follows:

- o **10 minutes**: **silent brainstorming** on ideas related with the thematic areas of the group. Moderator could give advice that the sticky notes will be then clustered according to the poster. Each expert could prepare a set of sticky notes as many as he wants.
- o **30 minutes**: Clustering of sticky notes on the poster and free **discussion** on the clustering activities
- o **10 minutes**: each expert should **write** on a piece of paper a story based on what he thinks is the better description of a scenario collecting ideas from the sticky notes attached on the poster.
- o **15 minutes**: final discussion among all the experts of the group to identify what is the most **representative story** among those prepared by the experts. The choice of the **Top scenario** could be made with a voting after a brief presentation of each expert story.

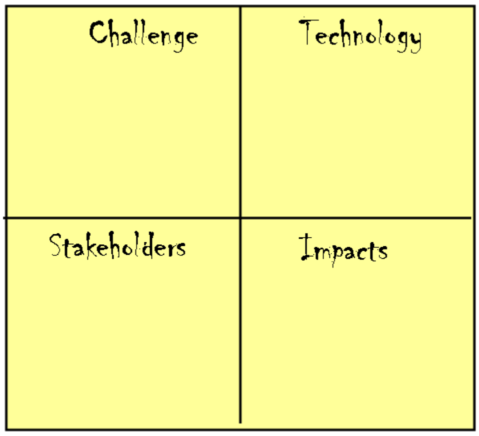


Figure 1: A0 Poster for each group

Final 20 minutes the four groups come back together and each group has 5 minutes to present its own Top scenarios to the others.

Second Group discussion (parallel session): about 1 hour and 30 minutes
The groups of experts have been called to define the physical “box” that sells their revolutionary idea for ICT in energy efficiency, whether that idea will ultimately become a tangible product or not.

By imagining the package for their idea, the teams make decisions about important features and other aspects of their vision that are more difficult to articulate. This exercise named "Design the box" has been inspired by Gamestorming[1], a book with a collection of brainstorming methods defined to gather information from participants in an organized way.

The game "Design the box" is popular among software developers when setting out to capture the customer's view of a new application, but its use doesn't stop there. The game can help facilitate any vision-oriented discussion, and has been used to describe topics ranging from "our future methodology" to "the ideal hire". 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 teams present or "sell" their boxes to each other, a number of things come to life, including the natural translation of features into benefits.

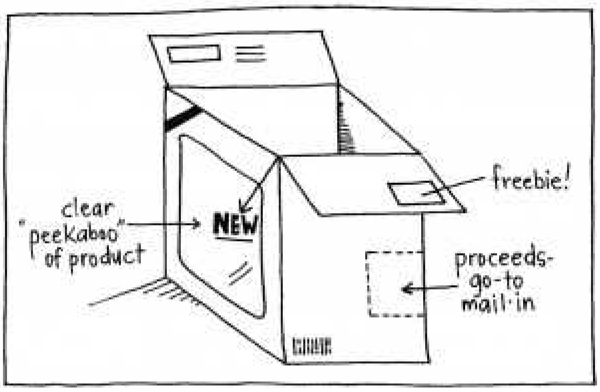
The exercise moves through three phases: an introduction, box creation and sharing by "selling".

Phase One: Fill the Box

Before a group can jump into creating a box, they need to reflect on what could be in it. To get people oriented, consider laying out some building blocks:

- Possible names of the idea
- Possible customers, end users, or buyers
- Possible features, functions, or other important defining details.

This may be familiar ground, or it may be entirely new to the group. They key in setting up the exercise is to give teams "just enough" information to feel comfortable starting.



Phase Two: Make the Box

Give the teams a set amount of time, 30 minutes or more, to create the box for their idea. Ask them to imagine coming across the box on a retail shelf, shrink-wrapped and ready for sale. In designing the box, teams may be helped by a few of these prompts:

- What's it called?
- Who's it for?
- What's its tagline or slogan?
- What are its most compelling features? Benefits?
- What imagery would make it stand out to you?

Teams may self-organize naturally; most participants will want to create their own box regardless of how they're arranged. Make sure you have ample supplies for them to do so, and make sure they know that there is no wrong way to create their box.

Phase Three: Sell the Box

Each team or individual should be offered the chance to stand up and "sell" their boxes back to the group. It may be worthwhile to keep a timer for these stand-up presentations, and consider offering a prize to the team that does the best job "selling" their box back to the group.

Look for a naturally occurring breakthrough as they present back their boxes. People put features on the box, but when they sell them, they translate those features into benefits.

[1] http://www.gogamestorm.com/?p=576

6.2 Workshop on May 4, 2011, Helsinki

Background: The first workshop of ICT4E2B Forum was held on May 4, 2011 in Helsinki and organised by consortium partners VTT Technical Research Centre of Finland and D'Appolonia. The approach of the workshop was dedicated to bring together the industry experts and working group to develop the vision for future application scenarios. The workshop participants included:

Person	Organisation	Role in the group
Experts:		
Jouko Pakanen	Aalto University	Expert in group 2
Alain Zarli	CSTB Centre Scientifique et Technique du Bâtiment	Moderator of group 2
Tapio Ristimäki	Enterprixe Software	Expert in group 1
Anu Kätkä	Lonix	Expert in group 3
JarnoMitjonen	Lonix	Expert in group 2
MauriLaasonen	Tampere University of Technology	Expert in groups 3 and 1
Jarmo Laitinen	Tampere University of Technology	Expert in group 1
Veijo Lappalainen	VTT Technical Research Centre of Finland	Expert in group 2
Kalevi Piira	VTT Technical Research Centre of Finland	Expert in group 3
Consortium partners:		
ElisabettaDelponte	D'Appolonia	Note keeper in group 1
Christian Mastrodonato	D'Appolonia	Moderator of group 3
Wolfgang Krauss	SAP	Expert in groups 3 and 2
Oskar Nilsson	Schneider Electric	Expert in group 2
Matti Hannus	VTT Technical Research Centre of Finland	Moderator of group 1
Nusrat Jung	VTT Technical Research Centre of Finland	Note keeper in group 3
Sami Kazi	VTT Technical Research Centre of Finland	Expert in group 1
Johanna Nummelin	VTT Technical Research Centre of Finland	Note keeper in group 2

Introduction: At first, short overview of the ICT4E2B Forum was presented by project co-coordinator, Mr. Christian Mastrodonato from D'Appolonia, Italy, following with the elaborated objectives and expected results by project partner Mr. Matti Hannus from VTT. Furthermore, the workshop methodology including thematic areas and scenario topics was explained (see Table 1). Based on interests and expertise of participants two thematic areas were selected and three groups formed: one group for thematic area 1 and two groups for thematic area 2. Each group had assigned moderator to stimulate the discussion and a note taker to capture the discussions. Another group for thematic area 2 processed also a scenario relating to energy management and trading.

Table 1: Thematic areas and scenario topics (topics not covered in the workshop are marked with grey)

Thematic Areas	Scenario topics
1. Tools for integrated design and production	▪ Design ▪ Production management ▪ Modelling ▪ Performance estimation
2. Intelligent & Integrated Control	▪ Automation and control ▪ Monitoring ▪ *Quality of service* ▪ *Wireless Sensory Networks*
3. User awareness and decision support	▪ *Performance management* ▪ *Visualisation of energy use* ▪ *Behavioural change*
4. Energy management and trading	▪ Building energy management ▪ *District energy management* ▪ *Smart grids and the built environment*
5. Integration technologies	▪ *Process integration* ▪ *System integration* ▪ *Knowledge sharing Interoperability & standards*

Workshop Sessions: During the first group session, each group was provided with sticky notes and A1 sheets (see Figure 2) with specified columns containing the scenario topic, name for the scenario, key idea/key words, technology explorations, impacts and respective stakeholders. The preferred scenario topic was selected and then experts were asked to silently write their ideas on sticky notes and place them to columns Scenario Name or Key idea/words. Then participants were asked to list the related ICTs and impacts, explorations or random ideas within the ICT domain. Depending on the group, the interactive method was used in different stages of the workshop. The sticky notes were discussed by each participant leading to step-wise logical organization of them to generate the conception of relationships, technologies, impacts and stakeholders within selected scenario topic.

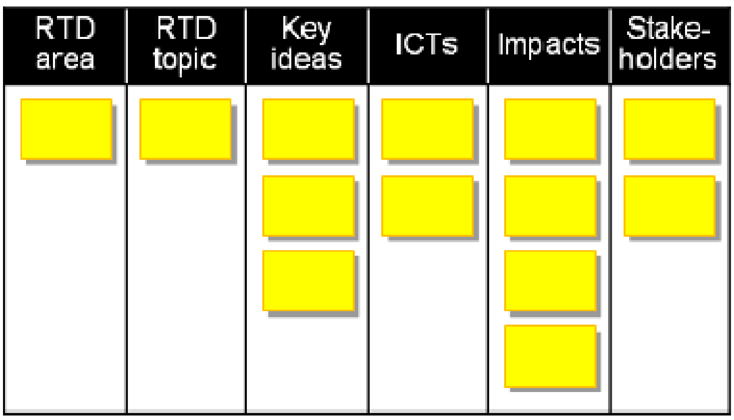


Figure 2: A1 sheet structure to stimulate generation of ideas of involved parties

Plenary session: After a short break, second group session was started by re-grouping the experts into the two groups (one group per selected thematic areas) and the above described procedure was repeated. Thorough discussion was carried out and the moderators of each group with the note-taker presented the final results at the plenary session.

6.3 Workshop on May 24, 2011, Nice

This section presents discussions related with two thematic areas: User awareness & decision support and Energy management & trading.

Figure 3: Image of the original A0 poster with sticky notes for Group Discussion

Group on “User awareness & decision support”

Moderator	Alain Zarli
Note Taker	Andrea Cavallaro
Experts	Tayyab Abbas Shamsi
	Sylvian Robert
	Pascal Torres
	Heidy Van Beurden

Description of the First Discussion Session: The First Discussion Session starts with a silent brainstorming where the experts identified key elements, related to the thematic area under analysis, following the paradigm ICTs (Impacts, Challenges, Technologies, Stakeholders). Figure 3shows the original A0 poster with sticky notes attached on it, Table 2 summarises the results related with this discussion.

Challenges: According to our analysis, the main challenges that have been identified (second column of Table 2) are related essentially to 5 main subjects:

- Identification of the Individual Knowledge
- Improvement of Energy Information Management in order to lead stakeholders to better understand the value of their daily actions in the context of reduction of energy consumption
- Reduction of Technological Cost and Energy Consumption
- Distributed Architecture
- Identification of European standards and commons unit metrics

Thus, regarding the **Identification of Individual Knowledge** the discussion has focus on the need to identify the level of individual knowledge that each user (such as occupant, inhabitant and building 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.

Regarding the **Improvement of Energy Information Management,** main outcomes of the discussion are related with the need for an efficient and smart tool for real-time energy consumption visualisation and management. This tool, exploiting an energy bank database, should help the users to obtain a real-time assessment of the efficiency of their daily energy actions. This could be achieved by using a World Wide Web accessible, smart, and usable interface, and also providing them useful suggestions to manage their habits to decrease energy consumption and billing costs.

Table 2: Flip Chart and sticky notes from First Group Session

Scenario Topic	Challenges	Features of all the mentioned challenges	Technologies	Stakeholders	Impacts
User Awareness & Decision Support	Individual knowledge (of occupants/inhabitants of buildings) on: - place, the environment where they work/live - comfort, the set of benefit provided by the buildings where they work/live "Energy bank account" Real-time information (Good action/ bad action/ current cost) Personalised information Component improvements suggestions Comparative information (me vs my neighbour)	Heterogeneity Privacy and security Smart but not complex Fun Automatic tuning Cultural specification Simple user interfaces Transparency of information	Augmented reality Serious gaming Reports on mobile phone Smart interface for energy consumption visualisation	Public and professional employee ICT players Constructors Architect Energy Expert Public Administrator Academic Energy service provider Residential house/building occupants Office building occupants End users Building owners Neighbours	Empowerment Jobs (installation, education) Reduce billing cost Real-time global energy information to cities and inhabitants Reduce carbon consumption Waste time in office: a comfortable environment to work, where all the office/building equipments are controlled by a well parameterised BMS

	Reduce Technology cost Increase user and buildings owners involvement by BMS Three budgets: - energy saving - energy equipment security - communication		Information about effect on all interfaces Modelisation Centralised intelligence	Technicians and manual mode	
	Energy storage renewable Decentralisation Delivery to grid Global communication F.I. Scalability		Energy efficiency retrofit Intelligent decision support tools on energy consumption	Aggregators (providing information)	Energy - Democracy: a way to aware people
	EU standards and common unit metrics		E-learning website	Disposal (waste management)	
			Holistic view		
			Energy renewable sources -> transport		

An idea arisen during discussion is related with the **Reduction of Technological Cost and Energy Consumption.** The reduction of technological costs, (related to buying and installing energy equipment in buildings and usually carried on by final user), will help to increase the diffusion of these equipment, the development of efficient distributed architecture like smart grid, and the global reduction of energy consumption.

Regarding the **Identification of European standards and commons unit metrics** the main issues that arose from discussions are related to the fact that it is fundamental to have regulation that allow to obtain a reference Metric that can be used across different European Countries. Moreover it has been noticed that from the standardization 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.

Finally, with reference to the above challenges, several key ideas/needs were identified as useful common features that must be held by each challenge, and these are the following:

- Heterogeneity of the system
- Privacy and security
- Smart and fun but not complex to use
- Enable Automatic tuning
- Implement cultural specification
- Transparency of information provided to end users

Technologies: The focus of this part of the discussion is on the identification of technologies that will be fundamental for future development of ICT to increase the level of user awareness between the identified stakeholders. The fourth column of Table 2 shows all the sticky-notes that have been written during the session.

No new advanced technologies were identified, but the attention focused on four technologies areas that need an important effort for their development and that should be integrated to existing system.

The first technology area is referred to the 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. The adding value of this kind of improvement shall be given by the representation format of the collect data.

Related to the previous technological area, also the improvement of intelligent decision support tools on energy consumption is required.

Another technology is mainly related with integration of existing systems: indeed there is the need to obtain tools for analysis of design and model alternatives integrated with systems for visualization, simulation and validation. This concept is strictly related with that of Holistic Analysis SW that could also integrate viewpoints from different users.

Finally, to increase definitely the awareness of the user, according to the energy efficiency system installed in buildings, e-learning web site should be developed and provided by service provider in order to guarantee a comfortable instrument to present the necessary rules for an energy efficient life in building.

Impacts: This part of the discussion, focused on the identification of the possible impacts derived from the development of the challenges, was less developed than the first two parts because of lacking time.

Stakeholders: Finally, regarding the stakeholders, the discussion did not pick out any important new stakeholders. Table 2 presents all of those that have been identified as relevant for the thematic area analysed.

Description of a Scenario: With reference to the above key elements identified for "User awareness and decision support" thematic area, each expert made up different stories based on what he thinks is the better description of a scenario collecting ideas from the sticky notes attached on the poster.According to our analysis, it was useful noticed how the potential target of stakeholders involved in these scenarios was heterogeneous, but mainly focused on the awareness of end users. Starting from this last consideration in the following is presented the classification of the four scenarios developed.

<table>
<tr><td rowspan="2">User Scenario</td><td>A generic end user that wants to change his behaviour in order to reduce energy consumption, billing cost and improve the energy efficiency of his own building has the following needs:

▪ Personal interface accessible by PC or smartphone that shall provide the following information:
o Comfort setup, related to user preferences
o Agenda, useful to balance the equipment energy load consumption in relation with the daily activities scheduled in agenda by user

▪ Automatic pilot of HVAC and light system

▪ Daily report on:
o Personal energy consumption attitude (referred to different time period)
o Suggestions to better understand which actions are necessary to improve user behaviour
o Alert system on window left opened, PC switched on, etc.</td></tr>
<tr><td>A generic user arrives at work. He takes a coffee and starts his PC on.
Afterword he logs on, automatically a pop-up appears telling: "Is the temperature fine?".
The user clicks on "No" and selects the comfort desired temperature. These answers are saved and stored on a dedicated database that contains all building's user answer of the day.
An intelligent data processing SW (e.g. based on statistical treatments) adjusts the monitoring control algorithm of the BMS using as input the information given by the user.
The user and his colleagues feel fine and work well.</td></tr>
</table>

Building Owner Scenario	A building owner that wants to improve the energy efficiency of his buildings, controlling and monitoring the real-time energy consumption, has the following needs: ▪ All equipment must communicate together with low costs (referred to both installation and communication cost) ▪ Easy connection to a centralised intelligent unit, that can use a wide knowledge database o The new configured building can reuse information pre-elaborated parameterisation data of other buildings already configured in order to learn quickly the better ways to optimise energy consumptions ▪ Simple, Intuitive and accessible communication dashboards to control all the environment of the buildings
Building Technical Management Scenario	A energy technician that intends to assess the real energy efficiency of the building in which he installed energy equipment has the following need: ▪ Simple parameter to configure Building Management System: o Default preferences, developed for the building o Auto-tuning preferences, acquired by BMS during the daily work ▪ Simple, Intuitive and accessible communication dashboards dashboard that should be able to manage alarms (by sending e-mail and/or sms to the user) ▪ Daily report system of all manual modes

Description of the Second Discussion Session: "Design the box"

Name of the Box	Baby, Help it grow!	
Kind of Product	This is a game service that allows producing goods. It is composed by a set of different system: ▪ SW ▪ BMS ▪ Energy solution	
Potential customers / Stakeholders	The home is the city and the city is your home. Using this slogan all the citizen, the user inhabits of a city are involved to play this kind of game.	
Rules	Playing the game means that each participant has a relevant role in energy saving improving his own awareness. Sharing energy resources is wisdom. The more you play the more you decrease energy consumption, billing costs and help the world in energy saving. This play could be played by using PC, mobile or smart phone.	
Award - Benefit	Two different kind of award/benefit are foreseen: ▪ Individual: reduction of billing cost and energy consumption ▪ Social: the reduction of energy consumption by part of citizen could be used to satisfy the energy request done by another citizen of other cities, countries and so on	

Group on "Energy Management and Trading"

Moderator	ElisabettaDelponte
Note Taker	Johanna Nummelin
Experts	Alberto Moro
	Perrine Gautier
	AlfioGalatà
	Jean Claude Delvallet
	Jean Claude Clement
	Heidy Van Beurden

Description of the First Discussion Session: The First Discussion Session starts with a silent brainstorming where the experts identify key elements, related to the thematic area under analysis, following the paradigm ICTs (Impacts, Challenges, Technologies, and Stakeholders). While Figure 4shows the original A0 poster with sticky notes attached on it, Table 2 summarizes the results related with this discussion.

Figure 4: Image of the original A0 poster with sticky notes for Group Discussion

The discussion arisen after the silent brainstorming on sticky-notes is driven by a series of doubts that are already presented in the Table. Some of the most interesting points that have been highlighted are listed below with some of the comments that have been made by different participant during the discussion.

Challenges:

- o Is it really true that smart meter help user saving energy?
- o Who establishes the rules for the management of energy? This is one of the biggest questions arise during our discussion. Maybe one answer to this question could be provided by the use of an aggregator of profiles that will help identifying the optimal rule
- o Three concepts, three challenges: cheaper, lower emission, best investment planning
- o How to get customers involved? This concept generated a short discussion on the fact that to effectively communicate there is the need of effective communication campaigns. Therefore, maybe, there will be the need to involve communication experts that, on the basis of successful communication campaign, will help stakeholders to obtain customers involvement.
- o There is the need of reducing cables. As a paradox we could even think of eliminating the grid in favour of smaller and distributed generation of energy.
- o One of the big challenges is to bridge the gap between buildings and the grid.

Technologies:

- o Aggregators of user profiles could be useful to cluster behaviours and habits to allow identification of trends
- o There are no particular difficulties related with the technologies. All of the most useful technologies are already available: the key factor is now their integration and automatically management of different services (lightings, electric HVAC, energy storage management...)

- If we agree on the fact that there are no particular difficulties related with technology, we also agree on the fact that we need to decrease their costs.
- We need to work on multiservice storage systems.
- At the end of the discussion, we noticed that we forgot to mention nanotechnologies: there are different ideas on this issue, but one that is agreed is that we do not know if nanotechnologies will have an impact in the next 10 years.

Impacts:

- We need to obtain systems that are user friendly, non-intrusive and they need to be accompanied by a clear cost/benefit analysis.
- Other important aspects are related with the fact that if we obtain less invasive technologies we will be able to increase their acceptability.

Stakeholders:

- Do energy consumption data be owned by energy distributors or by the user? Who has the right to own the data?
- Are electric companies really interested in energy efficiency? Indeed we think that allowing more renewable will help more competitors entering the market, therefore it may happen that this side effect is not welcome by those who are already leading the market.
- Identifying stakeholders is not easy. But even if we don't know who the stakeholders are, we can identify their problems in relation with energy. Therefore our aim is that of **anticipating** them, to improve their welfare.

Description of a Scenario: With reference to the above key elements identified for "Energy management and trading" thematic area, each expert made up different stories based on what he thinks is the better description of a scenario collecting ideas from the sticky notes attached on the poster. Finally we have agreed on a common summary that takes into consideration different aspects arisen during the discussion. Our summarising scenario description is shown in Table 3 and described in the following "Question and Answer".

How to maximise the positive impacts of district energy management by meeting both technological and economic challenges AND ensuring stakeholders expression of needs and active involvement?

- There will be no revolution in 10 years (we cannot think to have another revolution similar to those of internet or mobile devices)
- There will be the need of better exploitation of existing technologies, organising and management
- There is the strong need of increasing public awareness (getting knowledge is important)
- Maybe, there is the need to concentrate on technologies for storage (multi-storage systems: location, energy source).

Table 3: Flip Chart and sticky notes from First Group Session

Scenario Topic	Challenges	Technologies	Stakeholders	Impacts
Building Energy Management	**Smart meters** do really help on energy saving on the long period? **Smart grids and smart meters:** - Do energy consumption data be owned by energy distributors or by the user? - And what about the smart meter? - Problem of diffusion of this technologies **Smart grids**: - Are electric UN really interested to develop smart grids? (Allowing more renewable so allowing competitors to enter in that market?)	Non particular difficulties -> technologies well known Integrated solutions -> platform of service dedicated to buildings energy management. (BMS + information with electricity provider + communication tools with user) User Friendly more intuitive Cost/benefit positive impact	Regulation and public authorities Electric companies or companies that manage energy Are facing the energy price evolution Fix the rules of the management -> Who decides? Consumer of buildings Active role Expression of needs	Eliminate the grid Lower energy consumption and peak load in buildings/district Cheaper energy cost for the consumer Low gas emission for the community Better investment planned for networks Better awareness of all users of buildings leading to a better awareness on how the grid works Consumer adaption to grid availability -> change behaviours x habits

	Customer involvement and behaviour Business models readability Cost of technologies	Reduction of cables/wires based networks. Promotion of multi-service networks where energy, TLC safety, data are distributed and exchanged through one common network.	Need to better understand concepts of energy efficiency and optional management. Local/national public authorities can help through the use of metric which tackle also common people.	**Districts:** - light management - electric car management - energy storage management **Buildings:** - light management - sun management - HVAC management - computer management
	Who fix the rules of the management? (i.e. electric cars)	Load balancing techniques - Batteries	Should consider ENERGY as a vital good (like water and food) for the society	Automatic managed functions in building/district
	Service not available Fragmentation of buildings ownership	New concept of technology to store energy	Need to better understand concepts of energy efficiency and optional management	New business in neighbour level (between buildings and district)

	Straighten the concept of energy positive buildings connected to new grids to exchange / receive data and services Promote local (district) level business model under rules fixed by national authorities	Toward less invasive and transparent technologies in buildings	Home owners Building owners Local energy companies Communication companies Have to anticipate the future for the citizen welfare	Promote the use of multi sources storage system to facilitate RES and RET. Straighten the concept of solutions proposed at district level. Maximize the use of renewable energy produced on site
	Integration of different energy sources	Monitoring with mobile devices		
	Bridging the gap between the grid and the building = interactions of two networks			
	Are electric UN really interested to develop smart grids? (Allowing more renewable so allowing competitors to enter in that market?)			

Description of the Second Discussion Session:"Design the box"

Our team has not created a box, but it has created an envelope containing all the information about the service on which the experts have decided to focus on.

Name	Noah's Box – Recognise yourself. Which animal are you?
Kind of Product	Aggregation profiles service. Gathering a collection of users profile it is going to be easier to understand loads on the grid to estimate potential rules for grid management. The product will be composed by o Smart meters o Software for managing information o Data Server to collect information o Software for intelligent elaboration of profiles users
Potential customers / Stakeholders	End user like building owner, inhabitant, tenant, neighbour, energy provider. The service should be managed by energy supplier, but requires a strong awareness by end users.
Rules	The program aims to aggregate different user profiles in order to flat the electric bills with the load balancing of energy consumption. No particular rules are set. Each user will have a smart meter, communicating directly with a server on which data will be stored. Then profiles data will be analysed to allow the identification of optimal rules for the minimization of energy loads.
Award - Benefit	Save the money to save the planet. Balancing of electric load can help users to reduce electric bills and users' electric provider to save the planet.

The name of the service is Noah's box and it is a service aiming at aggregating users profiles. The information collected will be used to get information on the grid usage to improve the balancing of loads on the grid itself.

The envelope contains a letter that is to be sent to the final users to explain them why they have to join the Noah's box service. Figure 5 shows the envelope and the letter prepared by the group of experts who identified the Noah's box.

Figure 5: Result from Design the box discussion

6.4 Workshop on May 25, 2011, London

This section presents discussions from the London Workshop. The experts were divided in two groups focusing on Intelligent and Integrated Control and User Awareness and decision support. Both the groups focused the "Design the box" discussion on the thematic area of Integration technologies.

Group 1 on Intelligent and Integrated Control:

Moderator	ElisabettaDelponte Christian Mastrodonato (during Second Group Session)
Experts during First Group Session	Andrew Eastwell
	Tarek Hassan
	Chris Tuppen
Experts during Second Group Session	Andrew Eastwell
	Tarek Hassan
	Chris Tuppen
	Oskar Nilsson

Morning session: Intelligent and Integrated control: During the Group 1 morning session, the group participated in a creative brainstorming exercise to identify the breakthrough innovation in 10 years in the area of Intelligent and Integrated Control. Figure 6 shows the original A0 posters with sticky notes, describing the results of each group members' silent brainstorm and the subsequent group discussion and agreed scenario. Table 4 summarizes the results related to this discussion.

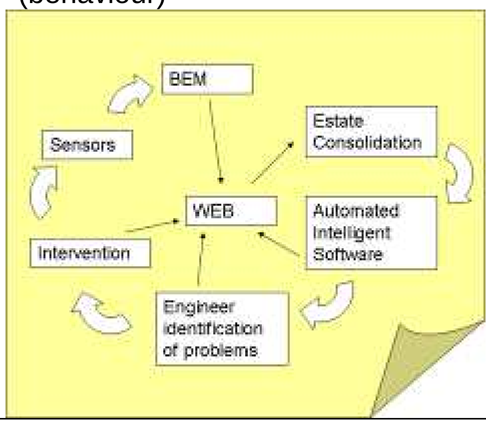
Key Idea from the discussion: The focus of all the ideas that have been identified during the brainstorming and the following discussion among the experts could be briefly summarized with the concept that there is the need of really making use of all of the systems and technologies that are already available. 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.

Figure 6: Image of the original A0 poster with sticky notes for first group discussion

For instance, from the point of view of the **Impact,** the three experts of the group fully agree on the fact that there is a great potential for a considerable impact on energy efficiency. And the effect could be foreseen from different perspectives and at different levels (building, district and city levels). This could be achieved thanks to a high level of integration. As a potential backlash of the increase of use of energy efficiency systems, there will be the involvement of new stakeholders such as big companies (such as Sony, etc.).

Table 4: Typewritten version of the sticky notes on the A0 poster

Challenges	**Technologies**
• Domestic: (particularly) Suitability for network cabling • WSN power service @ sensors • ROI on energy efficiency (both commercial and domestic less than 2-3 years) • Dynamic control depending on users behaviour • Optimization of control with users comfort • Power management of users • Innovative forms of WS (wireless sensors) e.g. embedded sensors in materials, power management of sensors • Integration of all control mechanisms: heating lighting, presence, security, ventilation, etc... • Integration of building/district/city control • Commercial: Despite many Installations operative systems for managing energy are few • Domestic: Demonstration of value to owner • Ownership of data: Domestic-privacy Commercial-Society Trading of privacy • Commercial: commercialization of components parts including software apps • Legislation barrier to integrated data. Eg Fire • Tenants-Landlord: roles and responsibility	• Interface protocol • Standardisation: Sensors Control Equipment Appliances Smart grid • Location Driven control • Integrate building services (Telephone, security, fire, Data, Average consumptions • **Commercial**: Plug&Play technologies- remove individual engineered solutions • **Software**: Migration of inference engines to micro platforms (IBM Jeopardy, fuzzy logic, AI logic) • **All**: Need for self-powered sensors to match wireless operation • People detection for automated control • Remote Access • Personal preference mobile database (The Matrix knows our preferences)-> “Voted comfort” • Grid/BMS • Runtable sensors • Electrochromatic glazing • Remote intelligent Control over the internet mobile phones • Sensor integrated into lightings • Open source connectivity •
Impacts	**Stakeholders**
• Demand side management of renewable sources integration with smart grid or BEMs • Potential backlash (involvement of big companies Sony, Eg...) • Improved energy efficiency • Improved user comfort • Improved district energy management • Potential for considerable impact on EE • Outcome retrofit limited by building players (circa 75%) • Smart building as part of a smart society	• Simplicity of interfaces • ESCO’s to include ALL necessary DATA • Health agencies (quality of life sensors) • Insurance companies • Entertainment goods providers (Virgin, Sony, Google, Tesco, Cop...) • White goods supplier (performance in the data) CF, BMW • User: Automation vs. User control (behaviour)



Regarding the **Challenges** we have obtained a word cloud with the text obtained in the challenges issue and it is shown in Figure 7. Among the different arisen concepts there is the idea that we will need more innovative wireless sensors that are to be integrated in parts of the building such as for instance in the fabric, in the wall, in the lighting. This issue is strongly related with **Technologies:** indeed one of the recurring ideas in the discussion is that we need wireless sensors that are self-powered and with smaller impact on the end-users.

Figure 7: Word Cloud created with wordle.net on the basis of discussion realized for Challenges

To summarise the main concepts at the basis of the discussion on challenges we can say that all of the challenges emerged can be seen from different perspectives:

- From end-user point of view: the challenge will be that of minimizing sensors impacts on user thanks to miniaturized, self-powered and building integrated new wireless sensors. This will allow the achievement of a greater comfort for users itself, since mainly all of the systems in their home (security, fire, alarms for switched on lighting or open windows) will be integrated and automatically controlled on the basis of final user preferences.
- From commercial point of view: Systems that will be developed should allow Return of investments of 2 or 3 years at most. Services such as Apps will be made available increasing the business potential.
- From legislative point of view: one of the main issues is related with the ownership of data. Indeed there will be problems with privacy for confidential data. Moreover relationships among tenants and landlords should be taken into consideration when identifying possible business models, taking into consideration the fact that one of the biggest challenge is to demonstrate the value of energy efficiency to end-users.

From the **Technologies** perspectives main issues arisen from the discussion are related with standardisation, integration and development of commercially innovative systems. Indeed improving the standardisation of systems and tools will improve the feasibility of integrating buildings at district and then at city level. This issue is thus strongly related with Smart Grid development. This idea is well expressed by the concept that we need to reduce individually engineered solutions in favour of a diffusion of Plug&Play technologies that are easily available in most of the cases. Integrating data related with comfort in mobile devices may lead to systems that are capable of identifying the most ideal comfort situation for a group of different users. An example could be that there are several persons in a room and their mobile phones with integrated GPS will let the system know they are all together in that place and they will inform the systems their single preferences on comfort. In this way, the system will optimize a solution that is capable of preparing a comfort situation for mainly all of them identifying optimal heating and lighting conditions for the group of people in the room.

Stakeholders identified within the course of discussion comprise “white goods” suppliers that are two relevant typologies of stakeholders that should be inserted in a detailed business model for energy efficiency. Indeed, considering that even facilities could integrate sensors connected with the web, it is possible to estimate that in future there will be a holistic management of the facilities in a home, and in case of failings interventions will be directly suggested and managed by the control system itself. Moreover health agencies and insurance company will have important roles in the management of energy efficient systems. Entertainment goods provider should be considered as stakeholders in the value chain of energy efficiency since they have the power of involving end users.

Description of a Scenario: With reference to the above key elements identified for “Intelligent and integrated control” thematic area, each expert prepared a short story based on what they think is the better description of a scenario collecting ideas from the sticky notes attached on the poster.

Scenario 1 – Andrew Eastwell
The key to making local, neighbourhood or city-scale IT connected control systems rests firmly on open, interoperable standards.

In this way competition to supply hardware (sensors, intelligent plant & equipment etc.) as well as services (energy supply or control logic applications) can drive innovation but on an end-user value based proposition rather than a technology push or incentive led basis.

Scenario 2- Chris Tuppen
Buildings will be part of an integrated world of connected, ubiquitous sensors, built into the fabric of the building, that feed into self-learning systems using open source software solutions. The buildings will contain intelligent, plug and play appliances within an integrated building management network and will be populated by people/organisations that have reached contractual relationships that balance cost, comfort and confidentiality.

It will start in large commercial (ie non-domestic) buildings and gradually move into the residential sector. Governments will regulate to mandate implementation of energy efficiency measures at times of major refurbishment and in new build.

Scenario 3 – Tarek Hassan
- Buildings will be invisibly equipped with sensors (embedded and powered through the building materials and envelope) for automation and control.
- Users will be able to dynamically manage and optimise their energy usage, patterns and sources through integrated intelligent Building Management Systems.
- Users will be able to control their energy consuming services and facilities remotely with self-learning capabilities for patterns.

- o There will be seamless access to information on energy usage, loads, costs, etc. which could be provided via a shared network and open source software (OSS)

Afternoon Session dedicated to Integration Technologies:

During Second Group Session, the Scenario Topic analysed was dedicated to **Integration Technologies**.

In the first activity, **fill the box,** the participants were asked to brainstorm possible ICT4E2B products/services. Partly drawing on the group discussion from the morning session, the idea emerged from the discussion was a Box capable of integrating different services that are presents in home. What followed was a discussion about some of the key features of this **E^N Box**. Figure 8 shows the poster on which the team has presented their Box discussion results. In the following list there is a summary of the box description:

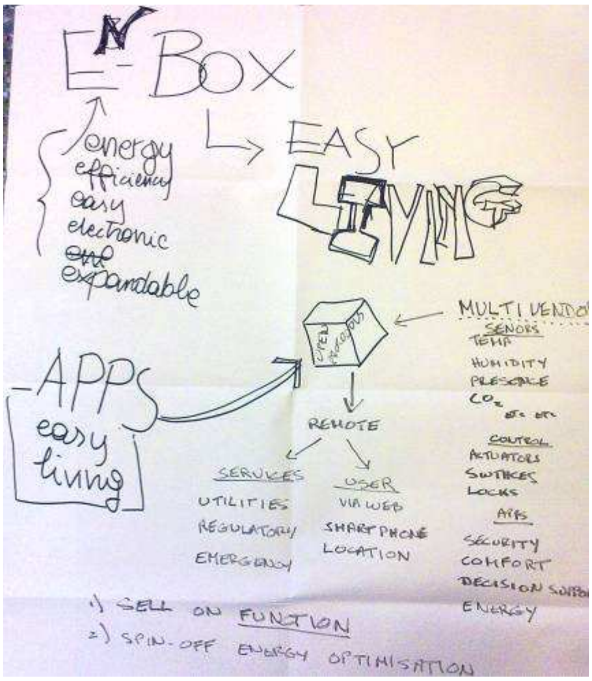


Figure 8: Poster describing main feature of the E^N Box obtained during the second group discussion

- o **Name: E^N Box**, where the N stands for energy efficiency, electronic, easy, expandable... This means that this box aims at really integrating all of the systems that are usually present in a home, to enable an efficient management of the different applications used by the end users.
- o **Tagline: Easy living**, this means that this box, integrating different services, will allow users to manage more easily the different systems that are present in their home (security, fire, water and energy management, lightings,...)
- o **Customers:** this box aims at been sold directly to end-users. One of the fundamental ideas is that the software at its basis should be based on open protocols so that multi-vendors could participate to the creation of different apps dedicated to integrate different services in the box. Among stakeholders that could be involved in the realization of this product there could be also entertainment goods providers such as Sky or Nintendo. We could even think to have a box similar to a Nintendo Wii device.
- o **Features and functions:** Instead of being a physical box, this could be considered as a software that is going to be integrated in already existing smart meters, so that it could be easily integrated as a service. The system could integrate different data from different sensors (presence, humidity, temperature, CO_2 emissions related to facilities). The information from **E^N Box** could be made available at different location on the web or via smart-phone. Also services could have remote access to perform activities related with security, legislation and other utilities.

  One of the fundamental features of this concept is to have open software and open protocols at the basis of this box, in order to enable a free sharing of apps and devices that could be integrated in the system.
- o **Business models:** E^N Box could be sold on function and as a spin-off it is possible to think about energy optimization services. Moreover, as already mentioned it is possible to think to have multivendor for Apps and Controls and Sensors, but thanks to open protocols all of these could operate together.

Finally the **E^N Box** System has been presented to other participants to the workshops and Figure 9 shows an image of the “Sell the box” activity during which one of the member of our group has presented to the whole group the concepts behind our idea.

Figure 9:Picture of the “Sell the box activity” performed at the end of Second discussion

Group 3 User awareness & decision support:

Tashweka Anderson (moderator) Johanna Nummelin (note taker)	**First Group Session** Ben Croxford Matt Batey Steven Firth Oliver Kinnane **Second Group Session** Ben Croxford Matt Batey Steven Firth SomayehHeydari

Morning session: User Awareness and decision support: During the Group 1 morning session on user awareness and decision support, the group participated in a creative 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”, i.e. a positive side effect of other activities that are personal to the individual, fun and community-based.

Figure 10 shows the original A0 posters with sticky notes, describing the results of each group members’ silent brainstorm and the subsequent group discussion and agreed scenario. Table 5summarises the results related to this discussion.

Table 5: Flip Chart and sticky notes from First Group Session

Thematic area	User awareness and decision support		
Scenario	Personal, fun, community-based user awareness and decision support with energy efficiency awareness "in the background"		
Challenge	**Technologies**	**Impacts**	**Stakeholders**
Energy saving isn't fun for residents Information needed to change behaviour (holistic view) Think global, act local isn't working. No vision of consequence of actions Not building decision-making around people/business practice Creating Awareness What is energy consumption? Personal motivation; Why should I save energy? Enticing Involvement Culture / Habit Reducing energy whilst maintaining comfort & services Feedback – what, when, why, how and to whom? Presentation / Communication of energy consumption; user does not view use of facilities in amounts. How to communicate this?	Easy to use, funky interface with catchy icons that I can choose / customize Enhanced billing Ambient displays Technology boundary controls; Manual user ID More individual 'control' on energy use related to personal activities. But, use ICT to enable them to manage this efficiently without thinking Campaigns and offers targeted to me based on who I am, not just how much energy I use e.g. lifestyle Control devices easily, remotely from apps/mobile and web Feedback: Running costs, CO2 emissions, Energy consumption; Business profits? Technology – friendly, non-traditional display New business models Ability to trade e.g. if I need to use more energy one month but produce less waste, I can trade with someone Alternative methods of data presentation Homes with visible energy rating like postcode; driving by a home and able to see the energy rating on the home Smart meters; real time feedback; intelligent control; non-intrusive Integration software into mobile devices Technology that allows me to share with my neighbour – energy savings	Consciousness of energy use leads to yearning to reduce Conceptual understanding of scale of problem is difficult to convey; Social peer pressure, competitive energy saving Challenge model of EE <--> cost savings; Use ICT as low-carbon substitute or physical Infrastructure maintaining economic value Building users, householders, energy suppliers, estates managers To know personally how different choices affect daily energy use Integrate personal energy use management between different building contexts; home-work-leisure-transport Reduced energy use Stronger communities Money back or other offers/discounts for saving energy Coming together of entertainment, energy saving and stronger communities Behaviour / consumption influenced by context & fixed infrastructure; ICT replaces infrastructure → awareness individual management	Building designers Operation Mangers Occupants Energy suppliers Homes: private owned & rented and social housing Residents as users Any individual Software developers

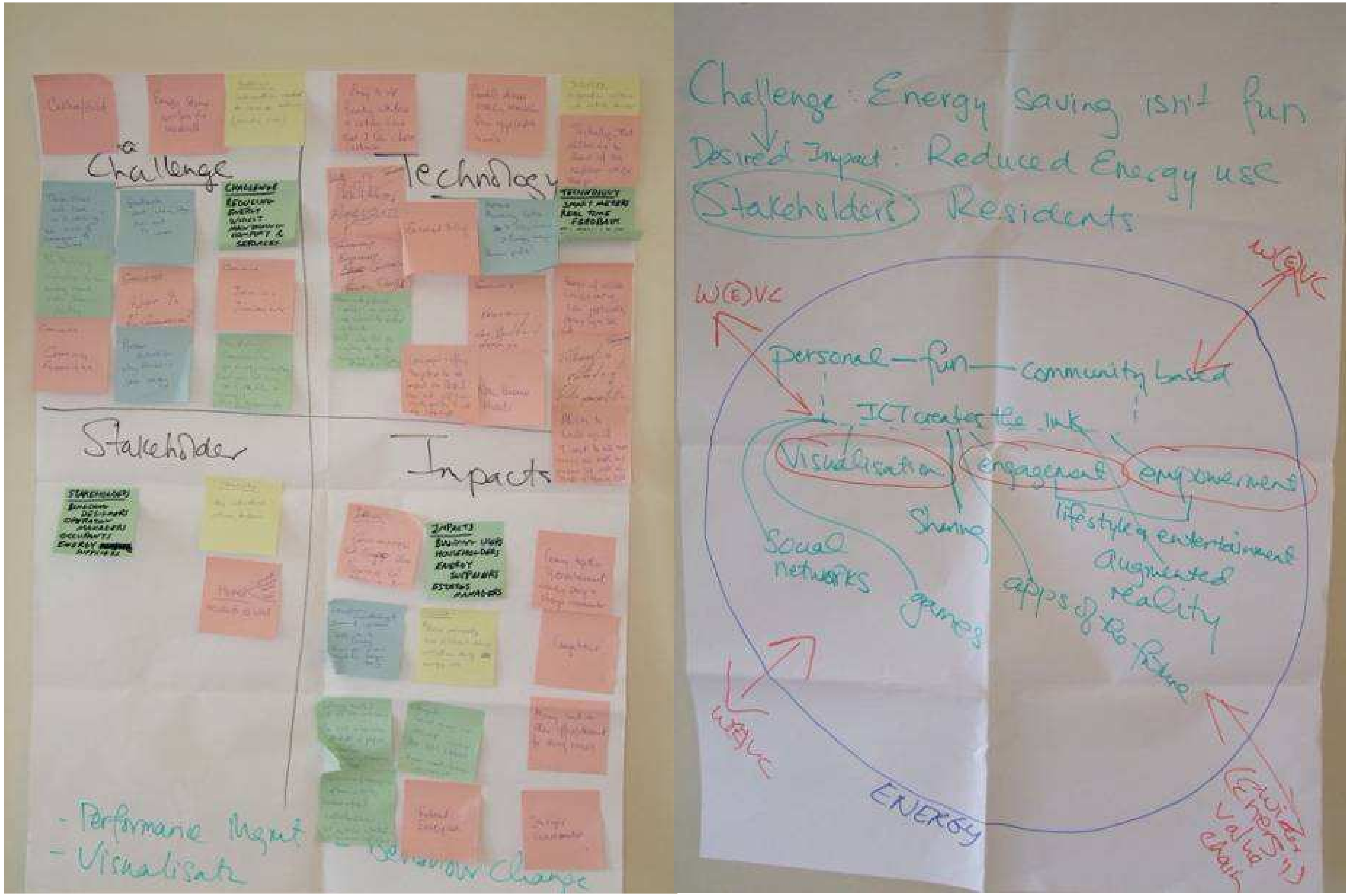


Figure 10:Image of the original A0 poster with sticky notes for first group discussion and a description of the group 1 scenario

The working group that worked on this scenario focused the attention on helping residents to reduce energy by making energy saving fun.

Key Idea and Keywords: According to our analysis, the main key ideas or themes identified are related to the following four areas:

Mobile devices & applications	**Technology**
Smart Meters	
Intelligent controls	
Friendly technology	
Enhanced billing	
Ambient displays	
Discounts & other incentives	
Real-time feedback	
Information sharing	
Developers	**Wider (Energy) value chain**
Designers	
Operation and Facilities Managers	
Energy Managers	
Raising the level of consciousness	**Personally relevant impacts**
Building stronger communities	
Individually-targeted behaviour change	
Lifestyle	**Motivation**
Fun	
Personalisation	
Community-based	

With respect to **Technology**, the main themes that arose were about:

i) finding the right balance between individual choice and automated, intelligent controls and

ii) ensuring that the technologies can accommodate personal lifestyle choices as well as enabling engagement with the wider community.

With respect to i), some participants of the group believe that the best way to achieve maximum energy saving is through automation, i.e. by intelligently controlling devices etc. in the home, workplace etc. There was recognition that this may be more easily achieved in a workplace setting than in a domestic, home setting, because of the privacy concerns of many individuals. This balance would in all cases allow for some level of personalisation by the user. Therefore, it was agreed that any EE technology for the home, would need to have built in the right balance between individual choice and automation.

With respect to ii), the group agreed that energy saving in and of itself was not a sufficient enough motivation for most individuals. 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 and 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. The work of the London-based green and lifestyle charity, and their 'Turn up the Style' campaign where, individuals are encouraged to put on their favourite or most stylish sweater in the house, turn down the thermostat, be stylish and save energy and money at the same time, was cited as an example. The use of games, whether social or individual, was also highlighted as a growth area. The group also agreed that '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.

Stakeholders: The group had a very interesting discussion about the range of stakeholders who could develop the breakthrough innovations in ICT for EE. The discussion started with a narrow, typical identification of the range of stakeholders, that is, ICT companies and utilities. However, as the conversation developed, there was agreement that to develop ICTs that different type of users will use, it would be necessary to engage with a wider range of stakeholders. This wider group could include (user-centred) designers, building designers, lifestyle and entertainment providers and others.

Impacts: 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. Although it does not come out strongly inFigure 10, 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.

Description of Second Group Session dedicated to Integration Technologies: During Second Group Session, the Scenario Topic analysed was dedicated to **Integration Technologies**. While Figure 11 shows the original A0 poster with the ideas of the group discussion and the final product or 'box' and **Table 6**summarizes the results related with this discussion.

Table 6: Summary of the key point from the second group session

Thematic area	Integration Technologies		
Product / 'Box' name	FLOSS or FleX		
Product pitch	**Technologies**	**Key words / features**	**Target users**
Need high quality, personalised space for meetings, occasionally? FLOSS finds you a place and personalises it. FLOSS finds you an office WHEREVER YOU AREA with the people you want to be with	Smart App phone with application of the future Flexible working of the future Location-based services	No desk No computer No fixed days/time of work Preferences Schedule Save energy Save operational cost Location Habits / Lifestyle Personalised	Individual energy users Building owners Owners of cafes or flexible workspaces

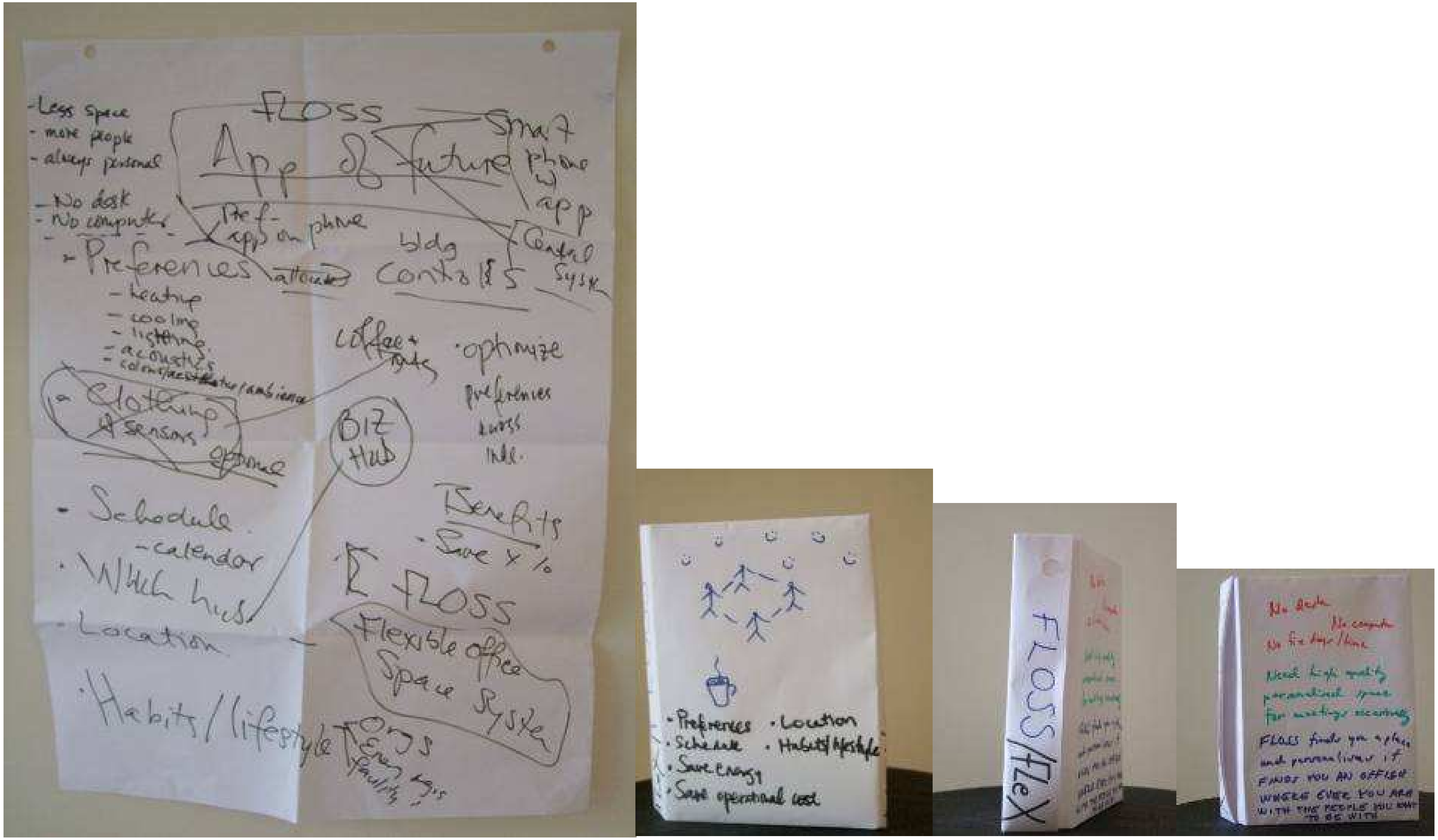


Figure 11: Picture of the original A0 poster with the ideas of the group discussion and images of the final product or 'box'

During the second group discussion, the group focused on **Integration technologies.**
In the first activity, **fill the box,** the participants were asked to brainstorm possible ICT4E2B products/services. Partly drawing on the group discussion from the morning session with its focus on personalisation and individual choice, the group quickly decided to focus on 'Apps of the future" to frame their brainstorming. What followed was a discussion about some of the key features of this 'App of the Future'.

Features – App of the Future

- **Preferences**: The 'App of the Future' would take an individual's preferences into account. It would store these preferences and interact with any building an individual walks into and personalise the space according to these preferences. The range of preferences that this 'App of the Future' would take into account and optimise for the individual might include:
    - Heating
    - Cooling
    - Lighting
    - Acoustics
    - Colours/Aesthetics/Ambience

- **Schedule**: The 'App of the Future' would integrate a person's schedule and would personalise their experiences in any building according to it. For example, an individual would have a meeting scheduled in the diary at 10am for example, the 'App of the Future' would book a meeting room / space for you and use your preferences to personalise the space

- **Habits/lifestyle:** The 'App of the Future' would also understand an individual's habits and customise his/her experience accordingly. For example, although an individual's official starting time for work is 9am, over time, the "App of the Future" would learn that an individual generally arrives to their workspace / desk etc. at 8:30am on average. Therefore, the "App of the Future", which would be integrated with an individual's computer or other productivity device, and would turn on an individual's computer at 8:30am. If the "App of the Future" were integrated into smart appliances, it could also switch on the kettle and boil the water needed to make the individual's tea!

- **Location:** The 'App of the Future' would track an individual's location. This feature or functionality of the app would enhance the others, such as lifestyle, habit and preferences. It would also allow for social and community aspects. For example, an individual using a social media application on their phone such as Facebook integrated with location-based software could see that they are within 1 mile of a potential client they have been trying to meet up with for some time. They contact this person (via Facebook, text, phone etc.) and they agree to meet at workspace 1 a few blocks away. At the same time, the "App of the Future", accessing the same location-based software, identifies that the individual is also within 1 mille of its most frequently visited workspace (the individual had previously set up preferences which asked them to be notified whenever they are within 1 mile of the workspace). The "App of the Future" prompts the individual, asking whether it wants to book at desk at workspace 1 and set up have the space personalised according to their personal preferences. The individual says yes. However, after 10 seconds, the "App of the Future" notifies the user that workspace 1 is full, but that workspace 2, just 3 streets in the other direction is free and places a provision booking. The individual contacts the person they are due to meet to confirm if the new location will work. Upon receiving confirmation, the individual confirms the booking at workspace 2 via the "App of the Future". When (s)he arrives at workspace 2, the contact is waiting and the space has been personalised.
- **Clothing with sensors**: There was an initial discussion about the "App of the Future" integrating with clothing with embedded sensors. The idea is that there would be sensors in

clothing that would hold a range of information, such as material type, the insulation properties of the clothing etc., and would measure body temperature. The clothing sensors would communicate with the "App of the Future" which holds information about an individual's preferences, as well as the building management system and would personalise their workspace accordingly. However, after some discussion, the group agreed that such advances were unlikely in the next 10 years.

The **benefits** identified included saving in energy costs for building owners as a result of the optimisation of preferences across various individuals. However, the group agreed that the largest benefits were likely to be in operational cost for owners of commercial office buildings and other workspaces such as business hubs. Owners of buildings can close buildings that are not operating at capacity, consolidate into other buildings or create new streams of revenue by renting space in buildings that are below full capacity on a flexible basis. The greatest benefits for individuals were likely to be around comfort and convenience.

In the second activity of the exercise, **make the box**, the participants began to formalise and hone in on central questions such as:

- **Who is the "App of the Future" for?** : There was a lengthy discussion about this question. In order to answer that question, the group had to tackle the question of target users. It was clear from the discussion that there were at least three distinct components of the "App of the Future" and as a result, at least three distinct groups of users. One component is a customer-facing application that would be accessed from a users' smart phone which would target individual users; The second component is for organisations who own one or more buildings, in which case the target users would be energy and facilities managers and others who would operate the BMS (Building Management System); The third component is for owners/managers of coffee shops, workspaces and business hubs. The group agreed that for the purpose of this exercise, we would focus on the customer-facing application, however, there is an acknowledgment that building management systems would need to be improved and enhanced in order to integrate with the "App of the Future". Interoperability is an issue that was touched on but not explored in detail.

- **What is the tagline or slogan?:** While the group did not agree on an official tagline, the following key slogan was agreed – "No desk, no computer, less space, more people, always personal"

- **What is the "App of the Future" called?** The group agreed that the most compelling proposition was that of a **FL**exible**O**ffice **S**pace **S**ystem or FLOSS. The name was not universally accepted in the group, because of the association with teeth, dentistry etc. Another proposed name was FLeX.

The third activity of the exercise, **sell the box**, was initially meant to be an opportunity for each member of the group to present the box that each had individually designed to the group. However, the group designed a common product and therefore, presented their product in the larger following session where all the groups convened. The key selling points were captured in the product pitch with a focus on high quality, personalised space that revolves around the location and preferences of the individual.

7 Appendix B - Template for scenario description

Scenario title	
Keywords	
Classification	
Beneficiaries	
Impacts	
Key ICTs	Expected progress (2020) beyond State-of-the-Art (2010)
Scenario description	