smartspaces

FINAL REPORT

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Authors:

Georg Vogt	EMPIRICA
Eriona Dashja	EMPIRICA
Strahil Birov	EMPIRICA
Mira Zöller	EMPIRICA
Werner B. Korte	EMPIRICA
Leticia Ozawa-Meida	DMU
Paul Fleming	DMU

Project coordinator name, title and organisation:

Werner B. Korte

empirica Gesellschaft für Kommunikations- und Technologieforschung mbH

Tel: +49228985300
Fax: +492289853012
E-mail: smartspaces@empirica.com

Project website address: www.smartspaces.eu

Executive Summary

Energy efficiency investments are a cost-effective means for decreasing energy consumption, reducing energy bills and reducing the likelihood for energy poverty. The SMARTSPACES solution offers Energy Management (EMS) and energy Decision Support and Awareness services (EDSS). The solution is based on ICT and smart metering. It achieved 14.5% (ranking from 4 to 58) savings for heating, 4.8% (0.8 to 49) for electricity and 15.8% (15 to 37) for cold water. Savings amount to 7,399 MWh which equals around 2,227 tonnes of CO_2 per year. Financial pay-off is achieved by most stakeholders during the first 3 years and by almost all stakeholders after ten year across seven eleven sites in seven countries. The socio-economic net benefit for the SMARTSPACES project – applying the worst case scenario, extrapolated for ten years – amounts to €4.2Million in pilot buildings alone.

Project Summary

In SMARTSPACES, ICT-based services for public buildings have been evaluated in 11 pilots in 8 countries across Europe. Almost 600 buildings were equipped with the ICT-solution. The services are designed to evaluate the impact on overall energy consumption in public buildings (non-residential). In each pilot site an integrated approach is followed, involving a team of different partners with corresponding skills and expertise working together to successfully implement and operate the different services. Typically, a pilot site team includes one or two municipality stakeholders (Department operating buildings and Council paying the bills), service providers (IT and / or Measurement) responsible for the development and implementation of the web-based services and in some cases energy provider. Lessons learnt are provided for all stakeholders.

The SMARTSPACES solution is based on Smart Meters measuring amounts of energy or water flowing through them and capable of communicating the readings autonomously to a centralised server. Two major service categories are distinguished: Energy Decision Support and Awareness (EDSS), which provide all users with greatly enhanced, timely feedback about their energy use, and Energy Management Systems (EMS), enabling selected users (professionals), energy departments, external service providers (ESCOs) and/or energy providers to manage energy consumption in smart ways, leading to greater efficiency and lower GHG emissions.

Three user levels are distinguished. Professionals have full access to the building and can manipulate settings of, for instance, heating systems manually or through EMS. Regular users such as staff have access to the service portal being provided with advice on saving energy and statics on energy efficiency improvements. Finally, visitors can see public screens in entry halls. In some cases they are provided with kiosk system or public website with advice on how to replicate energy advice at home. Some sites provide direct communication channels and forums giving any user the opportunity to point out wastage and discuss ways to improve performance.

Approach and Results

The first four work packages established a common technical documentation harmonising the documentation of all designs. Requirements, Use Cases (WP1) and Process models (WP2) were all mapped using the same reference list across all sites. This created a homogenous technical documentation (WP3) which could be tested using the same questionnaires (WP4). User recruitment (WP5) and Operation (WP6) ensured that the systems developed were successfully implemented in the field and building users as well as professionals have the necessary training to operate the systems. A key result of the project is the provision of a 'Guide for replication' following the project's work programme consisting of nine work packages of which three were horizontal activities such as evaluation, dissemination / exploitation and management.

Evaluation of energy savings is based on 24 months of baseline and intervention data accompanied by before / after surveys. The methodology used is based on the common practise agreed with all CIP-projects in this domain developed by empirica. Along with comprehensive analytical research models designed by DMU, the quantitative analysis was also performed using the EC-tool 'eeMeasure' which has to be used by all CIP-projects to assess and publish the savings achieved in the project on the same platform. eeMeasure was developed and hosted by empirica.

Exploitation was assessed using a standardised cost benefit analysis (CBA) widely based on the guidelines provided by the EC. The tool compares a 'do nothing' scenario with the installation of SMARTSPACES. Based on numerous implementation (CAPEX), operation (OPEX) and consumption indicators up to eight stakeholders can calculate (and model) their own cost and benefits as well as the socio-economic return for the entire pilot. The tool was developed by empirica.

Impact

The solution is based on ICT and smart metering. It achieved 14.5% (ranking from 4 to 58) savings for heating, 4.8% (0.8 to 49) for electricity and 15.8% (15 to 37) for cold water. Savings amount to 7,399 MWh which equals around 2,227 tonnes of CO_2 per year.

After the successful implementation of the project, it is believed that typical annual savings can be sustained and even improved through ongoing user engagement activities and continuous improvement of energy controls and management in the buildings. Over a period of ten years and assuming that no unforeseen changes take place, total savings attributable to the project would be 165,087 MWh and 47,622 tonnes of CO_2 emissions.

Economically, all sites proof to pay-off within a few years and almost all stakeholders achieve net benefits compared to the 'Do-nothing' scenario. In total, the SMARTSPACES project will create a net benefit of €4.2 Million over a period of 10 years. The sum is likely to increase with increasing prices of resources such as electricity, water and gas. Moreover, companies exploiting the solution are likely to collect further benefits with economies of scale and further experience on how to best and quickly engage with building users . Results are based on calculations for a period of 10 years. Results presented are net present values assuming 5% interest rate for financial cash flows and 3.5% for intangible benefits. This approach allows for simple and straightforward extrapolations for public buildings, regions and the EU.

Exploitation

The methodology implemented covers qualitative and quantitative means of analysis. The qualitative analysis is following the SWOT approach. Each site identified internal strengths and weaknesses as well as exogenous opportunities for and threats to the service. The input has been iterated multiple times and validated with the result of quantitative means using a cost-benefit analysis (CBA) realised as an Excel-tool. CBA follows EC guidance on metering deployment [2012/148/EU]. The tool collects a wide range of indicators in the areas of implementation (CAPEX), operation (OPEX) and consumption. The CBA tool compares the 'do nothing' scenario with the intervention measures implemented in SMARTSPACES. Detailed documentation can be found in deliverable D8.3. A 'Guide to Interpretation' to help quickly and easily understand key terminology and results generated as part of the analysis.

The project identified recommendations, barriers and scenarios which help exploit the SMARTSPACES Solution. Along with recommendations on policy levels, domains in need of research are identified. On the European level it is necessary to ensure that there will be enough skilled workers in the ICT domain. The skills are not only required for developers but also for other areas of the workforce; for example meter installers will – in the future – need to understand fundamental concepts such as the 'Internet of Things' (IoT). On a National level municipalities wishing to invest in SMARTSPACES need to have a budget flexible enough to allow investment today for return tomorrow or indirect means of funding through cheap credits. Building operators must ensure that their organisational structure allows for the flow of communication. Research must extend the concept of EMS to storage and to smart grids due to growing amounts of data and interdependency (e.g. IoT).

A key result of the project is the provision of a 'Guide for replication' (www.guide.smartspaces.eu) following the structure of the work programme. Each stakeholder has their own section summarising the most relevant content to avoid repetition. The Guide collects the most successful measures taken and provides stakeholders with checklists for key steps. Along with the organisational and process guidance, the Guide also provides technical documentation. The 'SMARTSPACES solution' use cases, process models and architecture enable the reader to select the elements most suited in any given environment and approach stakeholders with the elements to be part of the solution. The Guide is interactive and the content dynamic dependent on the requirements / preferences of the reader. Any interactive content (e.g. video, portals) available from projects is embedded in the Guide. Other ICT-PSP projects have been invited and other projects embedded in the documentation (and their pilots) are currently, BECA, eSESH, EDSON, VerySchool.

Conclusions and Recommendations

The SMARTSPACES solution can be applied in all circumstances. In cases where smart-metering is already available (to comply with national regulation) ICT-services should be deployed immediately. Major costs are already paid for and the payback is in all these pilots instant. This conclusion scales with the size of the pilot as some of the software fees might only be paid once and not per device.

In large consumers and typically wasteful buildings, the EMS element should be deployed first to collect "low-hanging fruits". The EDSS element has to be deployed as part of a long-term strategy and is ideally integrated with other web-based services. Both services help to detect faults and reducing costs of infrastructure maintenance along with reducing resource consumption.

Staff must also be made aware that working in a well insulated building does not automatically lead to low energy cost. In fact, their behaviour is of even greater importance: Speaking in relative terms of total consumption, leaving a window open does more harm in well insulated building. Smarter energy behaviour is also relevant in economical terms as the cost of insulation has already been paid for. Not fully "utilising" the insulation implies delaying the return on investment. SMARTSPACES services are a cheap way of detecting wastage, giving advice and identifying building users who might require additional energy coaching.

Barriers for SMARTSPACES-like services remain with the restrictions upon exploiting the full potential of smart-metering based services. This becomes even more relevant when existing (local) actors create restrictions regarding access to hardware or data hereby increasing cost and risk for service providers. Barriers on the demand site include a lack of trust in smart-metering. More detailed replication scenarios are outlined for certain sets of conditions covering Metering, Building, and Consumption levels.

Stakeholders should validate their approach with "their" section and the lessons learnt provided in the 'Guide for Replication'. The Guide contains technical and organisational documentation combined with checklists allowing stakeholders to efficiently plan steps and monitor their process.

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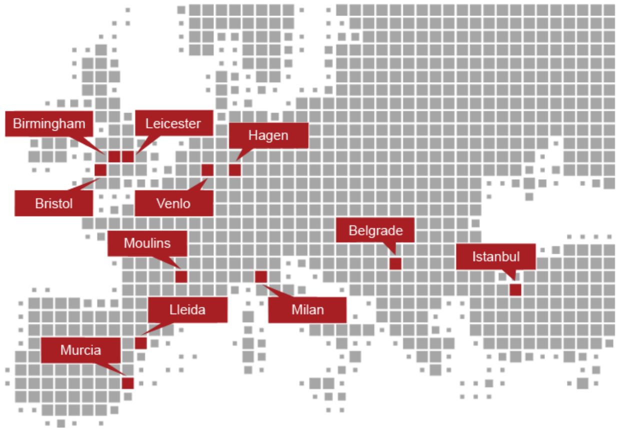
1 Project Summary

1.1 Project Objectives



The SMARTSPACES project started in January 2012 and aimed to enable sustained reductions in consumption of key resources across European public buildings by providing a comprehensive service comprising usable ICT-based components for directly controlling building equipment (Energy Management, EMS), supporting decision-making at central and local level and supporting appropriate building use and other energy-related behaviour (Energy Decision Support, EDSS) by building users (visitors and permanent staff). Supported financially by the European Commission under the ICT Policy Support Programme the SMARTSPACES project, comprising a consortium of 25 organisations, enabled public authorities in Europe to significantly improve their management of energy in the buildings they occupy, making best use of smart metering of energy consumption in the buildings, adding automatic control of building systems and giving evidence-based support to a range of energy-related decisions: from city-wide plans for relocation, new building and retrofitting investment to day-to-day usage behaviour by staff and visitor building users.

The SMARTSPACES service is adaptable to the requirements of a whole range of building stock, taking account a preponderance of public buildings with minimal central building automation and buildings with legacy building management systems as well as addressing opportunities presented by smart metering in the context of new public buildings. The service included components to provide effective ICT monitoring and control of local power generation and, for district/building systems, of the full heat delivery chain, as well as enabling energy managers to shape the demand curve in order to reduce peaks which leads to optimised tariffs and relieves stress on electricity grids. Decision support delivered to building managers enabled them to make better control and monitor energy consumption and losses in public buildings and also improved working conditions as HVAC and light systems can be more easily adjusted to building user needs.

The consortium, led by public authorities, included experienced and global players in smart metering and international players in building networks, working with specialists to carry out all steps in the project service implementation process.

1.1.1 Pilot Sites

Pilots of SMARTSPACES services are located at 11 sites in 11 cities in 8 countries:

- Belgrade in Serbia,
- Birmingham in the UK,
- Bristol in the UK,
- Hagen in Germany,
- Istanbul in Turkey,
- Leicester in the UK,
- Lleida in Spain,
- Milan in Italy,
- Moulins in France,
- Murcia in Spain,
- Venlo in the Netherlands.

1.1.2 Activities

Today the EDSS and EMS services are in full operation in all SMARTSPACES pilot sites. Comprehensive evaluation work was carried out in all pilot sites and this included energy consumption measurement, interviews with professionals and staff user survey data analysis. All results were reported in specific deliverables which are made available to the public.

An assessment of the viability and cost-benefits of the SMARTSPACES services and reporting about these for each actor group in the pilot sites was conducted on which the exploitation plans for future service operation and roll-out activities can be based.

Finally, an SMARTSPACES 'Guide for replication' of ICT-enabled services within pilot sites and very importantly by other actors from outside SMARTSPACES has been developed to support a Europe-wide demonstration, implementation and roll-out especially in public buildings but also beyond. A key achievement was to invite other projects to cooperate in the 'Guide for Replication'.

Partners

The consortium, led by public authorities, included experienced and global players in smart metering and international players in building networks, working with specialists to carry out all steps in the project service implementation process. The SMARTSPACES project was coordinated by empirica Communication and Technology Research, Bonn.

For further information the interested reader is referred to the SMARTSPACES website (www.smartspaces.eu) where the public outputs and deliverables of the project can be obtained including the portals and videos for each pilot.

1.2 Project Partners

empirica	empirica is a research and consulting firm based in Bonn, Germany acting Europe-wide and globally. empirica specialises in research and consultancy for both private and public clients into technology trends set against specific user requirements and organisational constraints and has long-standing experience in coordinating and managing EU research projects including SAVE@Work4Homes - Supporting European Housing Tenants in Optimising Resource Consumption and eSESH - Saving Energy in Social Housing with ICT. empirica is the coordinator of the project
Birmingham City Council	Birmingham City Council (BCC) is Europe's largest unitary local authority. Its approximately 50,000 staff provides services to over one million residents representing the most ethnically diverse city in the UK. BCC is one of the local authorities at the cutting edge in terms of integrating digital technologies into all aspects of its services in order to transform them and has undergone a radical business transformation programme that is on target to achieve net efficiency savings in excess of £1 billion over a ten year period.
Bristol City Council	Bristol City Council strives to be one of the most sustainable cities in the UK and Europe and is in the process of developing a holistic approach to sustainability, in particular with regards to regeneration-based activities and energy generation, supply and networks distribution. It is also hoped that a localised energy economy can be created which provides business opportunities and helps to improve the knowledge and skills base in this field. Bristol signed up to the EU's Covenant of Mayors Initiative in February 2009, which seeks to bring together Europe's most pioneering cities in a permanent network to exchange expertise and knowledge.
SystemsLink	SystemsLink develops and sells software solutions for the Monitoring and Targeting of Energy. The core Energy Manager product allows for storage of invoice, customer own meter readings and AMR data for full analysis. Full data validation, tolerance checks and alarms provide a full set of management information. Standard or user configured reports present the information in both graphical and tabular fashion with options to automatically email to site or view through a Web browser. The product is in use within around 200 organisations, approximately 100 of which are Local Authorities. Due to the close cooperation with Bristol City Council SystemsLink has detailed understanding of a large variety of public buildings and functions as technology

	partner and IT service provider in the project.
	The city of Hagen is renowned for its economy and for being a centre of shopping and culture as well as being the domicile for Germany's only open university. Hagen offers a vast number of services to its citizens and hosts institutions, which are accommodated in buildings and real estates, which are being maintained by GWH (Gebäudewirtschaft Hagen). Being a service provider for the city, GWH is not only responsible for facility management , energy management, controlling and cleaning of the existing buildings as well as their refurbishment and decontamination alterations, but also for the concept and planning of new constructions.
	envi Engineer and Consulting Company GmbH is a modern and innovative engineering office in Witten, Germany. The envi GmbH is an independent consulting and planning engineering company founded in 1990. Today, envi represents interdisciplinary cooperation from the disciplines of process, energy, and environmental engineering, mechanical eEngineering, computer science, and physics. envi develops, plans, and consults from base ascertainment to construction supervision with its focus on power supply, and building engineering including advise at all levels of the HOAI (Honorarium Order for Architects and Engineers) in the fields of building physics, heating, climate, and ventilation from the planning side. envi is one of the technology partners and IT service providers in the project with earlier experience in the project eSESH.
	Istanbul Sports Events Inc. was established by Istanbul Metropolitan Municipality in 1989. With over one thousand, many of whom have graduated from Sport Academies and speak foreign languages, Istanbul Sports Events Inc. is experienced in organising national and international sport events, managing sport facilities and sportive training activities. They have organised many national and international sport events, 36 of which were held in Istanbul in the year 2010 and more than 75,000 athletes and more than 1,500,000 spectators attended these events. Istanbul Sports Events Inc. is the pilot manager in Istanbul.
	Within the Leicester City Council the Leicester Energy Agency (LEA) is responsible for energy issues. It is the UK Secretariat for the Carbon Action Network for UK Local Authorities. LEA has been providing advice to all sectors of the community including businesses and community groups to promote renewable energy systems and energy efficiency and specific actions to reduce their environment impact. Leicester is Britain's first Environment City and the Leicester Energy Agency is a key player in helping the City meet its ambitious target of a 50% Energy Reduction of the 1990 Levels by 2025 and to obtain 20% of the City energy needs from renewable energy. Leicester City Council (LCC) is pilot manager in Leicester and co-operates locally with De Montfort University (DMU).
	The Institute of Energy and Sustainable Development (IESD) at De Montfort University is a highly multi-disciplinary research and post graduate institute with expertise in building physics, building energy modeling, ICT, electrical and electronic engineering, social science, energy policy and public engagement. The Institute offers Masters Courses, PhD programmes of study and undertakes research for industry, UK national government and the European Union. The Institute undertakes research and teaching in the analysis of electricity, gas and water data in buildings and industry. De Montfort University is also coordination partner and has the lead for the evaluation work in the project.
	The Lleida Energy Agency is a public body, originally created by the City Council of Lleida, and now also linked to Lleida's Provincial Government, giving the agency both a local and a regional remit. The Province of Lleida has an area of 12,028 km2, 229 municipalities and a total population of 439,000. The Energy Agency of Lleida, promotes the energy savings and efficiency and the production of renewable energy, in the line of the current trends for the reduction of the CO2 emissions, the prevention of the climatic change and the reduction of the global environmental impact caused by the overall increase of energy consumption. Sharing goals, the Energy Agency of Lleida has a close relation with the Catalan Institute of Energy (ICAEN). Lleida Energy Agency is pilot manager in Lleida.
	The International Centre for Numerical Methods in Engineering is an autonomous research and development centre, created by the Generalitat de Catalunya and the Universitat Politècnica de Catalunya (UPC) in 1987 under the auspices of the UNESCO, and dedicated to promoting and fostering advances in the development and application of numerical methods and computational techniques for the solution of

engineering problems in an international context. The Buildings Energy and Environment (BEE) Group is an independent research group of around 15 people within CIMNE, focussing their R&D activities on methodologies and tools for the reduction of CO2 emissions in the urban environment. CIMNE is one of the technology partners and IT service providers and is leading the local partnership with GASSO in Lleida.

Inergy is an organisation specialised in applications and services for energy management and efficiency. Since 2005, our solutions combine advanced energy engineering services and own software products. This allows us to quickly modify our applications adapting to the requirements of each client. We have a wide customer base in Spain, both from the public and the private sectors. Inergy aims at improving the energy management of large parks of facilities offering the energy manager service or providing tools, training and ongoing support for energy managers. We participate in projects funded by the European Union and drive partnerships and alliances with other companies to spread our services and products internationally. Innovation and technological developments are the main drivers of the company, pushing mainly through a technological partnership with the Bee Group, the Energy, Building and Environmental Group of the International Center for Numerical Methods of Engineering (CIMNE) at the Universitat Politècnica de Catalunya (UPC).

Inergy closely co-operates with CIMNE at the pilot site of Lleida. Furthermore, Inergy has the lead in task T8.2 Viability assessment for public authorities, utilities, facilities management and IT service providers..

Milan City Council is an Italian authority responsible for delivering a large number of services across the city (education, social services, economic development, etc.). The Municipality is involved in environmental policies and has adopted an action plan focused on improving energy efficiency in existing municipal buildings and on promoting sustainable mobility systems. Milan has also subscribed the Covenant of Mayors and the Local Governments Climate Protection Agreement. Milan is member of many EU networks such as Eurocities, and Cein and has been involved in transnational projects, e.g. V Framework Programme (Incore), Urban II, Interreg III B (Cadses), INTI (Benchmarking Integration Governance in European Cities). Milan City Council is pilot manager in Milano and co-operates locally with IBM Italia SpA (IBM), Cisco Systems International BV (Cisco) and BT Italia SpA (BT).

Cisco has shaped the future of the Internet by creating unprecedented value and opportunity for their customers, employees, investors and ecosystem partners and has become the worldwide leader in networking - transforming how people connect, communicate and collaborate. Cisco has a proven track record of successfully capturing market transitions. Cisco takes care of equipping three sites in Milano with their solution as one of the technology partner and IT service providers in the project.

BT is one of the world's leading communications services companies, serving the needs of customers in the UK and in more than 170 countries. Their main activities include the provision of fixed-line services, broadband, mobile and TV products and services as well as networked IT services. In Italy BT is one of the main communications services providers, serving business and public sector markets. Globally, BT supplies networked IT services to multinational corporations, domestic business and government departments.

The town of Moulins is situated at the center of an agglomeration of 26 communities with a total population of over 20 thousand inhabitants, a historical town, internationally renowned for its cultural dynamism. In coherence with its desire to reinforce the attractiveness of the territory, the town is in the process of revitalizing its town center, developing its economic activity in order to improve the quality of life for its inhabitants. The agglomeration of Moulins and the department of the Allier are committed to an agenda 21 type sustainable development approach. One of its objectives is to build, manage and maintain communal public buildings that respect the environment. Ville de Moulins is partner in the pilot site of Moulins and will be the connection to the public.

Moulins Habitat is a public office of development and building in the town of Moulins. Its main activities are renting social housing and building new housing as well as the development of activity areas.MH owns 3900 housing units, a few specialized homes and manages 2 activity areas and 4 housing estate building plots. Among other projects MH manages an urban renovation project for South Moulins and Yzeure, le Plessis, where about 30 % of the population of Moulins lives.

EDF Optimal Solutions is a 100% affiliate to EDF Group, which was created in 2008 to improve energy efficiency buildings and reduce environmental impact. The EDF Optimal Solutions approach follows the Kyoto Protocol and the Grenelle roundtables for environment. To reach these objectives, EDF Optimal Solutions provides global solutions including, conception, realisation, commissioning and maintenance and the financing of project linked to energy efficiency for local authorities and private companies including solutions to reduce their energy consumption and CO2 emissions. EDFOS is partner in the pilot site of Moulins and brings its technical knowledge to the pilot site.

Real Project Partner is an SME specialized in IT networks (fiber optic, PLC and Ethernet) deployments and services containing fiber and IP. For the last three years, RPP has developed services based on fibre which enable the customers to access DTT, SAT and IP based services in the social housing, as well as TV portal that enables tenants to have a view on their energy consumptions through the TV screen and also to correspond with the social housing company without needing paper or physical contact. RPP as one of the technology partners and IT service providers will assist Moulins Habitat in the deployment of the IT infrastructure, the installation of the Internet access through technologies which no electromagnetic radiation (fibre optic) and the display of the energy consumption and air quality through TV screens.

ALEM is the Energy Management Agency of the municipality of Murcia. It was created under EU-Intelligent Energy for Europe Program grant of 2006. ALEM is a public consortium linked to the Murcia City Council and has wide experience in European and cooperation projects (IEE, EU Grants and FP7). Murcia was the first Spanish city to sign the Covenant of Mayors and ALEM developed and elaborated the Sustainable Energy Action Plan of Murcia. In addition ALEM has assisted Murcia City Council in developing a network of zero emission public buildings, a bylaw of energy efficient buildings, solar thermal bylaws for buildings, energy efficient street lighting bylaws and other energy activities.

Local Energy Agency of Murcia is pilot manager in Murcia.

The City of Venlo has a population of close to 100,000 inhabitants. In 2001, the municipalities of Belfeld and Tegelen and in 2010, the municipality of Arcen en Velden were merged into the municipality of Venlo. The region accommodates one of the country's largest agribusiness parks, as well as various major educational and research institutes in the field of agriculture and horticulture. Having already adopted the principles of the Green City, Venlo has added a new dimension being the first region worldwide to embrace the cradle-to-cradle (C2C) philosophy, a concept for sustainability based on the reuse of raw materials, which renders products completely recyclable and turns waste into raw materials.

Belit ICT company is involved in numerous projects funded by the European Union to improve the functionality of the state sector, significantly contributed to the modernisation and standardisation of business in the country. Belit's team of experts and professionals covers all segments of the development of information systems: design, development, implementation and all aspects of customer support. The creative group of engineers and programmers using the latest technology create highly functional, expandable, easy to use and maximum secure software solutions. The team also provides training, system maintenance, industrial design, and consultancy services to its clients.

Beogradske elektrane is a Public Utility Company, which supplies heating and domestic hot water to Belgrade (Serbia). The company was established in 1965 in order to centralise the Belgrade district heating system. BeoElek possesses 65 heat sources with 2.574 MW heating capacity. It provides heating to 300,000 apartments and more than 8,000 office/commercial buildings for the total floor area exceeding 20,200,000 square meters.

The Faculty of Mechanical Engineering University Belgrade has been involved in a number of projects in different areas, among which, energy, district heating systems, heat flow metering, fuels, RES, energy efficiency in buildings, combustion, household appliances, energy monitoring and environment. It covers most of areas in mechanical engineering. There are approx. 250 teaching and research staff members and about 2800 undergraduate, graduate and PhD students. Members of the Fuels and Combustion Laboratory and Thermal Science Engineering Group have been very active through their research, which range from experimental and numerical, to development of systems and applied research.

1.3 The SMARTSPACES solution

1.3.1 What is Smart Metering?

Like conventional meters, Smart Meters measure amounts of energy or water flowing through them. While conventional meters must be read manually, and the consumption calculated since the last reading, Smart Meters provide specific information on how much energy or water was consumed, when it was consumed and at what tariff – a continuous calculation that conventional meters are incapable of. Provided with detailed operational data the network operator is also able to decrease the cost to service, by targeting investment in the network more accurately and thus maximising the benefits of system reinforcement. But Smart Metering offers more:

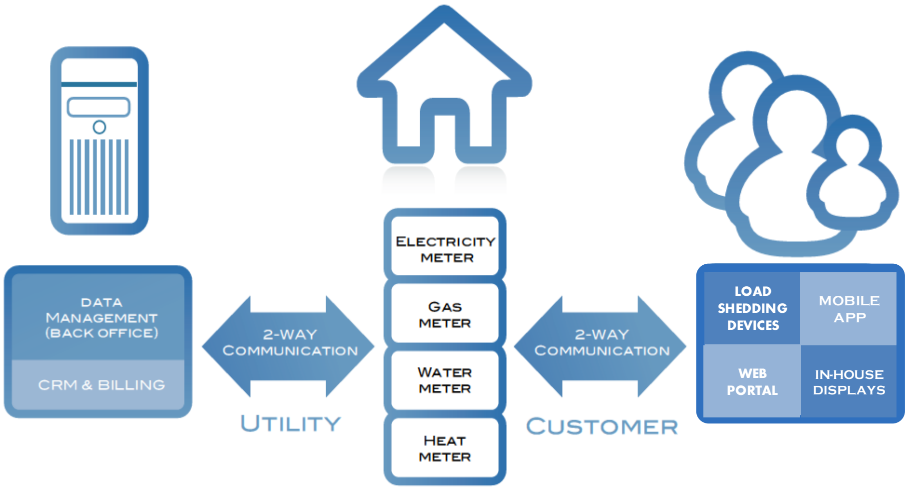
Digital technology: Smart Metering takes advantage of all the advances in modern digital technology; it enables data communication and can measure and deliver more information. More quantities and larger amounts of data can be stored until collected and meters can also be re-programmed or re-configured remotely.

Communications: Smart Metering enables long range communication with the energy company and short range links into the home. Consumption data can be read remotely and tariffs can be updated remotely. Smart Metering provides a communication gateway that functions as an interface between devices in the home and provides customers with real time data.

Control: Smart Metering allows for remote configuration and adjustment. This can be used in a number of ways, for instance, for supplier switching, remote reconfiguration of the meter as a credit or pay as you go meter, as the customer chooses to switch their supply contract. Finally, the meter can be used as the interface of a home automation network.

Better operation of networks: Smart Metering can greatly assist the network operator by providing detailed operating data from the ends of the network. Power quality can be measured by the meters and the network adjusted to improve its overall operation. Outages or leakages can be detected faster and system recovery monitored, minimising inconvenience to customers.

Exhibit 1 – Smart Metering service structure



Adapted from ESMIG (2011) 'A Guide to Smart Metering – Empowering people for a better environment'.

Using these functionalities Smart Metering can support a whole range of new services. Many of these features are already available and in use for large commercial or industrial consumers. The revolution in Smart Metering is seeing these features transferred to the residential and small commercial sectors with significant benefits to consumers, utilities, environment and society.

SMARTSPACES presents a complementary set of viable and effective Resource Awareness and Resource Management Services, further described in this section. The approach is based on a modular "toolbox" of components that have been developed in the project, and from which housing providers and related stakeholders can select according to their own specific needs and the priorities of their strategy for energy efficiency.

SMARTSPACES services include the following features:

- Automatic digital ("smart") metering for measuring electricity, heat, gas, water consumption;
- Non-invasive load monitoring to provide device-specific consumption data to tenants without per-device metering;
- Visualisation through analysis and presentation of consumption data for access by tenants on home displays, via the Internet and through other media;
- Simple "traffic light" feedback based on weather data adjusted comparison of heating consumption over time (historical feedback);
- Extension / modification of tenant portals in the Internet to present device-level information and meaningful trend information on energy use and add self management functions where appropriate;
- Optimisation and modification of invoicing and tariffs aligned with local legal requirements for allocating costs, particularly of heating and hot water, to building residents;
- Standards based in-building networks and gateways to transmit of consumption data in respect of electricity, gas, heating and hot water;
- Extension of schemes to provide network access to social housing buildings to channel metering information and give social housing tenants online access to consumption data and the wider internet;
- Monitoring the full energy delivery chain to identify investment priorities to optimise energy saving ROI in social housing;
- Aggregating and analysing data on energy use patterns in social housing across a region improve the targeting of public energy saving measures;
- Self-assessment scheme to assess the success of residents of a housing unit in reducing their energy consumption, including input of behavioural parameters by residents themselves;
- Automatic control (switching, dimming, adjusting operating parameters) of major domestic energy devices on timed signals with tariff incentives to even out the load and reduce peak demand with "fixed timing" defined by tariffs.

Two major service categories are distinguished: Energy Decision Support and Awareness Service (EDSS), which provide building users with greatly enhanced, timely feedback about their energy use, and Energy Management Systems (EMS), enabling end users and/or energy providers to manage energy consumption in smart ways, leading to greater efficiency and lower GHG emissions.

1.3.2 Energy Decision Support and Awareness Systems (EDSS)

The Energy Decision Support and Awareness Service (EDSS) delivers energy information and advice to residents, professionals and staff so that they can make savings day by day. In order to avoid wastage and bring about the hoped-for changes in behaviour, hints and guidelines for effectively saving energy are sent to PC, TV or smart phone; alternatively and where preferred, a set of personalised recommendations is presented by letter or in a personal conversation with an energy coach.

1.3.3 Energy Management Systems (EMS)

The Energy Management Service (EMS) exploits the capabilities of smart metering and installed equipment. Energy management includes actions upon pre-defined events or thresholds and - where possible - self-learning automation of systems to keep the building at an efficient level with changing conditions. Energy management covers any form of production (e.g. boilers, renewables), the distribution process as well as devices consuming energy.

1.4 Stakeholder descriptions

In order to represent a comprehensive overview of the structure at all pilot sites first, it is necessary to introduce a set of standard roles which have unique and essential function in the SMARTSPACES solution. Six roles and an 'other' group are necessary to accomplish a homogenous representation that has also been used in the process model flow charts (see D1.2). Roles have costs and benefits resulting from their activities in the SMARTSPACES solution (role) which are not necessarily the same at each site.

At some sites, numerous roles are played by one partner (stakeholder). Yet, the cost-benefit tool allows for separating these differing functions into different stakeholders. Even (vertically or horizontally) integrated businesses can be represented into two stakeholders allowing to determine which of the two roles generates the larger share of revenue and therefore also allows for finding further potentials.

It is suggested not to merge different roles in one stakeholder (such as the mother company) for the very same reason. However, depending on the overall exploitation plan and the processes necessary within one organisation, it can be done.

The following stakeholder definitions briefly describe the implicit function which only one stakeholder at a time can occupy. Instances, representing different commodities (electricity, heat, water), can be introduced and applied in the other category which leaves room for flexibility or focus on a particular partner at site, which does not fall under one of the five core stakeholders.

Staff / professionals

Staff, are building users who are employed to work in a building but are not the building professional. A staff user can be an office worker or a teacher. Often staff users occupy the same space and control the environment on a local level (e.g. thermostats, windows). Hence, they are able to pull and research information from the system to actively adopt their behaviour and consumption patterns. Professionals, on the other hand, are responsible for the management of energy consumption in the building, or remotely for several buildings. Depending on the pilot site strategy, this might be in the form of city energy managers to caretakers or janitors.

Municipalities

The municipality is responsible for providing services and facilities in order to develop and maintain safe and viable communities. For this purpose, among others, municipalities take over a number of activities in the areas of energy efficiency and environment protection, education, specialised social services, etc. The municipality is responsible for the public buildings under its administration. Usually, the municipality manages the facilities and organises, not necessarily performing, the billing of the public buildings or publicly used commodities.

Energy Provider

The energy provider is the last distributor / agent of the commodity. The commodity the energy provider sells to public authorities is used by the public authority itself. Usually, the energy provider either issues the bills directly to the public building authorities..

Measurement Service Provider

The measurement service provider is responsible for collection of (smart) meter data and making the data of individual meters available to some other parties. Usually, the measurement service provider owns the meters and charges another party for the meters and the services offered.

IT-Service Provider

The IT-Service provider is responsible for collecting all data from the measurement service provider and thus, providing the IT infrastructure in the public buildings to safely store data and analysis software. Usually, the IT-Service provider is responsible for the full process of the back-end data-stream, allowing tenants and social housing providers for a two-level access to their data.

Visitors

Visitors are users who are in the building, frequently or rarely, for long or short stays, from museum visitors to school pupils, nursery parents and hospital patients. Visitors rarely have immediate access to the system itself but are rather supplied with information prepared particularly for their purpose (e.g. displays in entry halls, posters, social media etc.). This information and the show case provides them with lessons and, in some cases, actions that can be replicated at home. Visitors have limited influence on the consumption of a building but have some choices (e.g. taking the lift or the stairs).

Other roles

Examples for actors which are not likely to be placed in any of the mentioned roles are communication providers or IT-equipment providers. Furthermore, some actors might be placed into one of the existing roles at some pilot sites but not in necessarily in others as well. For instance, the energy coach could be directly employed by the social housing provider or contracted from an external party.

1.5 Other definitions

The following lists of acronyms and the glossary have been developed during the project and have been used consistently across deliverables and by pilot sites.

1.5.1 List of Acronyms

Acronym	Definition
ACC	Accessibility; non-functional requirement group
AD	Architectural Description
AL	Alerts; functional requirement group
AMR	Automated Meter Reader
AN	Analysis; functional requirement group
API	Application Programming Interface; Application Program Interface; Application Programmer Interface
AUD	Auditability; non-functional requirement group
BA	Building Administration; functional requirement group
BAU	Building Auditing; functional requirement group
B&C	Building and Central application
BE	Benchmarks; functional requirement group
BECA	Balanced European Conservation Approach
BEMS	Building Energy Management System, see also BMS

Acronym	Definition
BMS	Building Management System: is a computer-based control system installed in buildings that controls and monitors the building's mechanical and electrical equipment such as ventilation, lighting, power systems, fire systems, and security.
BP	Building professional users
BPMN	Business Process Model and Notation
C(C)HP	Combined (Cooling,) Heating and Power
CEMS*	Centrally controlled EMS
CENF	Energy Factors
CEQE	Equivalent Factors Energy; conversion factors group
CEQW	Equivalent Factors Water; conversion factors group
CFR	Conversion Factors
CHP	Combined Heat and Power
CMMS	Computerized maintenance management system
CNF	Configurability; non-functional requirement group
CONF	Control factor; functional requirement group
CONU	Control unit; functional requirement group
CPRI	Prices; conversion factors group
DBAD	Building Auditing Data; data requirement group
DBED	Building Evaluation Data; data requirement group
DCS	Data Collection Side
DDT	Data Types; data requirement group
DMED	Measuring Data; data requirement group
DMG	Measuring Granularity; data requirement group
DMI	Measuring Interval; data requirement group
DMU	Measuring Unit; data requirement group
DR	**Demand Response**
DATR	Data Requirements
DRA	Range; data requirement group
EDSS	Energy Decision Support and Awareness Services; a category for SMARTSPACES service elements (PEDSS, SEDSS, VEDSS)
EDUF	Education Format; functional requirement group
EDUT	Education Topic; functional requirement group
EMIS	Energy Management Information System
EMS	Energy Management System; a category for SMARTSPACES service elements (CEMS, LEMS, PEMS, REMS)
EPC	Event-driven process chain
ERP	Enterprise Resource Planning
EXT	Extensibility; non-functional requirement group
FOR	Forecasting; functional requirement group
FR	Functional Requirements

Acronym	Definition
GSM	Global System for Mobile Communications
IDEF	Integration Definition
IOP	Interoperability; non-functional requirement group
LACC	Access; legal requirement group
LEMS*	Locally controlled EMS
LOBL	Measurement Obligations; legal requirement group
LPRI	Privacy; legal requirement group
LPRO	Protocols & Standards; legal requirement group
LPUB	Publication; legal requirement group
LR	Legal and regulatory Requirements
LREG	Regulation; legal requirement group
LSEC	Security; legal requirement group
NFR	Non Functional Requirements
OF	Output Format; functional requirement group
OMG	Object Management Group
P	Professionals managing the building and / or it's systems at site or remotely, one of the target groups for EDSS
PA	Portal Administration; functional requirement group
PE	Peak; functional requirement group
PEDSS*	EDSS for building professionals (e.g. energy/building manages)
PEMS*	EMS for Peak shaving
PER	Performance; non-functional requirement group
PERT	Program Evaluation and Review Technique
RE	Renewables; functional requirement group
REL	Reliability; non-functional requirement group
REMS*	EMS for Renewables (e.g. solar power, district heating)
S	Staff in a building such as regular office workers or teachers, one of the target groups for EDSS
SB	Staff building users
SCADA	Supervisory Control And Data Acquisition. A system that can be a part of the building automation system to store data and make set points to PLCs and RTUs. The system is located in the Management level.
SCAL	Scalability; non-functional requirement group
SEDSS*	EDSS for staff building users
SMARTSPACES	Project acronym, referred to as 'the' SMARTSPACES service (singular) which is the collection of singular and shared components and features independent of the pilot site.
SOA	Service Oriented Architecture
SOAS	Software as a Service
SP	Service Provider, company offering and running the SMARTSPACES service
TCP/IP	Transmission Control Protocol over Internet Protocol. A protocol for data transmission over IP networks
UFS	User Facing Service
UML	Unified Modelling Language

Acronym	Definition
V	Visitors of a building, one of the target groups for EDSS
VB	Visitor building users
VEDSS*	EDSS for visiting building users
VID	Visualisation Data; functional requirement group
VIF	Visualisation Format; functional requirement group
VIP	Very Important Person
WSDL	Web Services Description Language, an XML-based interface description language

** A service component of SMARTSPACES which might not be implemented at all sites and / or feature lists might differ.*

1.5.2 Glossary

Term	Definition
Actor	An actor is a person, organization, or external system that plays a role in one or more interactions with your system.
Associations	Associations between actors and use cases are indicated in use case diagrams by solid lines. An association exists whenever an actor is involved with an interaction described by a use case. Associations are modelled as lines connecting use cases and actors to one another, with an optional arrowhead on one end of the line. The arrowhead is often used to indicating the direction of the initial invocation of the relationship or to indicate the primary actor within the use case. The arrowheads are typically confused with data flow and as a result their use is avoided.
Branding	A strategy that describes how that brand is positioned in the market, which target public the brand is targeted at, and maintaining a desired reputation of the brand
Champion	Used to describe individuals who serve as role models to others and influence them through their actions and opinions. They therefore have the ability to easily persuade their peers and invoke behaviour changes. A champion can be anyone with good social skills – from the friendly janitor you see every day to the authoritative boss you admire at work.
Conversion Factors	Conversion factors put units into relation taking national differences (e.g. definition, values) into account.
Data requirement	The data requirements provide a detailed description of the data model that the system must use to fulfil its functional requirements.
Deployment View	Describes the environment and topology into which the system will be deployed, This view captures the hardware environment that the system needs, the technical environment requirements for each element, and the mapping of the software elements to the runtime environment that will execute them.
Development View	Describes the architecture that supports the software development process. Development views communicate the aspects of the architecture of interest to those stakeholders involved in building, testing, maintaining, and enhancing the system.
Dynamic Testing	Software Testing designed to assess the dynamic behaviour of software code, interfaces etc.
Experienced User	A user with experience of the system that they are operating, or other similar systems that have similar interfaces/functionality
Functional requirement	Functional requirements capture the intended behaviour of the system-or what the system will do.
Legal requirement	Legal requirements (e.g. data protection) that also include regulatory and standard (e.g. ISO) aspects of the system.

Term	Definition
Logical View	The logical view is concerned with the functionality that the system provides to end-users.
Non-functional requirement	Non-functional requirements or system qualities, capture required properties of the system, such as performance, configurability, accessibility, etc.-in other words, how well some behavioural or structural aspect of the system should be accomplished.
Novice User	A user with limited experience of the system that they are operating, or other similar systems that have similar interfaces/functionality
Process View	The process view deals with the dynamic aspects of the system, explain the interaction between the activity of the system
Professional Users	Service users who have the job of managing energy in the building from city energy managers to caretakers
Recruitment	In the context of SMARTSPACES refers to the way users (visitors, staff, professionals) are approached and made aware of the project with the goal to become involved in different ways.
Scenarios	An architectural scenario is a crisp, concise description of a situation that the system is likely to face in its production environment, along with a definition of the response required of the system
Service Provider	The service provider offers the service and is responsible for the operation of the system itself
Software Architecture	The structure or structures of that system, which comprise software elements, the externally visible properties of those elements, and the relationships among them [Bass 2003]. "Externally visible" properties refer to those assumptions other elements can make of an element, such as its provided services, performance characteris-tics, fault handling, shared resource usage, and so on.
Staff Users	Building users who are employed to work in the building but are not building professionals
Static Testing	Software testing which is not conducted on the software itself, generally conducted on the constituent parts of the software (e.g. code, interface etc.)
Training	Users need to be trained in how to use the developed services in SMARTSPACES. Apart from technical training (e.g. how to use the web service, how to react to alarms etc) users can be trained in best ways of engaging with other users and methods of communicating with them (social training).
View	A representation of a whole system from the perspective of a related set of concerns [IEEE 1471]. A representation of a particular type of software architectural elements that occur in a system, their properties, and the relations among them. A view conforms to a defining viewpoint.
View packet	The smallest package of architectural documentation that could usefully be given to a stakeholder. The documentation of a view is composed of one or more view packets.
Viewpoint	A specification of the conventions for constructing and using a view; a pattern or template from which to develop individual views by establishing the purposes and audience for a view, and the techniques for its creation and analysis [IEEE 1471]. Identifies the set of concerns to be addressed, and identifies the modelling techniques, evaluation techniques, consistency checking techniques, etc., used by any conforming view.
Visitors	Other individuals who are in the building, frequently or rarely, for long or short stays, from museum visitors to school pupils, crèche parents and hospital patients etc.

2 Approach and Results

This chapter presents key results across all pilots and the life-time of the project and operation in particular. Each lesson learnt presented below results from one or more pilot sites whereby repetitions were summarised.

2.1 Lessons learnt structure

The structure of lessons learnt is orientated on business approaches to establish knowledge databases[1]. Any given lesson can be found by stakeholder addressed, category and whether it is a inhibiting or a facilitating factor (Do or Don't). Any lesson learnt describes precisely which impact the issue has on the project and/or pilot and what measures should be taken to either avoid the problem or to ensure the success, respectively. The structure of the table is as follows:

- **Acronym** – The letter refers to the group and the groups follow the main stakeholders involved:
  - **S** – Staff / professionals
  - **V** – Visitors
  - **M –** Municipalities / Cities
  - **I-M –** IT provider and Measurement provider **–** the two stakeholders are joined to avoid ambiguity and replication since the division of responsibilities tends to depend strongly on the local consortium
  - **E** – Energy provider
- **Category** – Categories are used for each individual lesson. They allow the reader to find all lessons with a certain focus across all stakeholders.
- **Issue** – Summarises the initial observation (cause) as a given fact.
  - Typically, a **challenge** is a difficulty encountered at any stage which could or could not be resolved during the life-time of the project;
  - A **facilitating factor** is an (often unexpected) achievement or situation which resulted in a positive impact on the success of the intervention.
- **Impact** – Summarises the effect(s) of the observation enabling the user to estimate the risk and cost / benefit of addressing the challenge or exploiting the facilitating factor, respectively.
- **Recommendation** – Summarises key measures that need to be taken in order to achieve success address challenges and overcome barriers.

In addition to the list below, the lessons will be incorporated as part of the 'Guide for Replication' (D8.4). In the Guide the lessons are not only put into context where and when they need to be considered but also reflected in extensive checklists and procedures which enable stakeholders to ensure that confusion is avoided and potential problems are addressed effectively.

[1] PMI (2013). A Guide to the Project Management Body of Knowledge, 5th Edition.

2.2 Lessons learnt - Staff / professionals

Category	Issue	Impact	Recommendation
Partnership & buy-in	**S-1** Weak responsiveness and unwillingness to collaborate	➔ weak awareness ➔ not reaching a critical mass ➔ failure to recruit users ➔ risk of failure for entire pilot	✓ Executives are more collaborative and willing to help ✓ First discuss with managers and let them organise their staff ✓ Communicate with managers on a regular basis
	S-2 Lengthily procedures for involving staff / professionals into the project	➔ slowed down process to get staff / professionals on board ➔ bureaucratic procedures can hamper the progress and lose valuable time to engage the users	✓ The best way of reaching out to the staff members is through their superiors ✓ It is helpful to have good relations with heads of departments and to keep them informed about all project activities
	S-3 Weak engagement during holiday seasons	➔ most staff are away or on vacation ➔ for survey conducting, this means small iterations and lost time/opportunity	✓ Take holiday periods into consideration when planning any staff-related activities ✓ Even in administrative buildings this is a problem
	S-4 The dissemination of financial benefits through SMARTSPACES as facilitator for the service adoption.	➔ Experience showed that by sharing with users the reduction of energy costs, their interest towards the service grew stronger.	✓ Share positive information, especially financial benefits, through mail, telephone, brochures, etc. Energy managers can increase motivation with face to face interviews.
	S-5 Use workshops to identify potential champions	➔ Workshops are a good way of learning of the users' attitudes and opinions ➔ Champions facilitate the outreach	✓ Observe attitudes and approach interested and extroverted people first
Take-up and use	**S-6** Training and information sessions need to be tailored to the audience.	➔ Telling professionals what they already know and using too many slides with detailed information demotivates them and the session is perceived as waste of time	✓ Find out what the current level of knowledge is and focus on new learning. ✓ Keep it short (better 2 x 1hr sessions than 1x 4 hrs) for staff to digest the contents. ✓ Be clear about what it is that we want to achieve and why we need their help.
	S-7 Some managers prefer to control the access to energy information on a need to know basis.	➔ The information about energy consumption remains limited to a few staff that prepare tailored reports. ➔ This hinders other staff / recipients of this information to look at the raw data to come to their own conclusions.	✓ Negotiate with the managers to convince them of the benefits, such as empowering staff, getting people interested, etc.

Category	Issue	Impact	Recommendation
	S-8 It can be a great advantage having a professional organisation, like a university, on your side during debates / meetings with professionals and staff members.	➔ Institutions such as universities enjoy the confidence of the employees in the public sector and can achieve the advantage in your favour.	✓ Try to always have representatives from the public authorities on your side.
	S-9 Need to allocate responsibility to do the work and carry out the energy saving opportunities identified by the project.	➔ The EDSS tools in particular are very good at identifying waste and opportunities, but they then require actions by individuals, spread over the building portfolio (for Bristol it being 500+ buildings)	✓ Identify energy champions / building managers who can carry out at a building level. ✓ Have dedicated energy and other building professionals (e.g. engineers/surveyors) to carry out specialised works. ✓ Track all work through a database, with each task allocated to a specific person.
	S-10 Ensure maintenance staff of buildings are aware of the project and the potential for it to identify issues and faults	➔ If staff are not aware the potential of the tool will be less. The more staff that know and use the tool, the more effective it will be.	✓ Involve maintenance staff in discussions about the tool and demonstrate its effectiveness.
	S-11 Lack of authoritativeness when implementing the service	➔ The presence of a member of the department eases tension and avoids unnecessary conflict escalation.	✓ Involve, if applicable, the department of occupational risk prevention (worked in Lleida)
	S-12 Simple and specific information is always preferred	➔ Too much information overstrains people ➔ Avoid technical information for laypeople	✓ Less is more ✓ User groups expect different communication channels and different 'buzzwords'
	S-13 Frequent meetings with professionals	➔ Professionals must identify with the project	✓ Establish good relations with professionals from the start ✓ Keep regular meetings with them and inform them by mail
	S-14 Training workshops should be effective	➔ Group training at workshops is beneficial for all	✓ Organise trainings in small groups (a team of 6-7) ✓ Provide small gifts (e.g. mugs) that remind them of the project
	S-15 User training has a long term impact on energy savings that can be even greater than automatisation	➔ Once users have been trained, positive effects are seen in other municipal buildings or at home	✓ Training should not be underestimated and should be done for all users

Category	Issue	Impact	Recommendation
Data privacy & security	**S-16** Concerns about data privacy	➔ Surveys where people are asked to fill in personal information (e.g. their e-mail address) raise concerns	✓ Ask for personal information only if it absolutely necessary ✓ If personal information is requested, give a good explanation why it is needed and what it is used for. ✓ If no personal information is needed, announce that the survey is anonymous
Technical set-up	**S-17** Take user testing seriously.	➔ The review of the service portal by non-project users allows to respond to user questions and clarify the information and gives new perspectives that the project team might have missed	✓ During different stages of the project find test users that have not seen the displays before and ask them to do a sense check. ✓ Review their feedback and consider changes.
	S-18 Management of the system setup (implementation) should not hamper the use of the building by the users	➔ Complaints about the amount of time taken in the system setup within hours.	✓ Prioritise work in areas of the buildings that are not used by users during particular times. ✓ Flexibility in working hours – sometimes work needed to be done after the building closes for the public.
Outcomes	**S-19** documentation of the technical equipment and machines is important.	➔ When new technical equipment and machines are installed there often lack rules for adding information to the technical documentation.	✓ Make sure that all technical documentation is gathered at the time when the equipment is installed, because it causes much more trouble to gather everything years afterwards.
	S-20 Make sure the success in saving energy is perceived as teamwork.	➔ SMARTSPACES services also evaluate the current and past work of employees, who are responsible for energy efficiency. Improvements may raise the question why these improvements have not been reached before and can make the employees who are responsible for energy efficiency appear in bad light.	✓ It is important to point out that employees played their part in the achievements.
	S-20 The appropriate assistance, training and guidance is in place.	➔ If the service is not self explanatory (with minimal guidance / training) or requires the individual to have technical knowledge of energy efficiency you lose engagement.	✓ Ensure that the SMARTSPACES service is simple to use, simple to understand allows user to easily feedback / report energy issues.

2.3 Lessons learnt – Visitors

Category	Issue	Impact	Recommendation
Partnership & buy-in	**V-1** When approaching visitors, it is first necessary to consult with official representatives of the city council.	➔ This would be a safe and legal way to approach visitors.	✓ Take someone from staff with you when approaching visitors.
Take-up and use	**V-2** It is very useful to set up an information desk for visitors.	➔ Visitors will be intrigued to see what the project is about. ➔ This also allows interaction with them about various issues on energy efficiency measures, etc.	✓ Allocate the info desk in a place that would guarantee a high visibility for the visitors of the building, such as a lobby or a waiting room, etc.
	V-3 It is very important to have the right approach when interacting with visitors.	➔ visitors are a hard group to persuade because they do not live or stay for a long time in the building ➔ mechanisms to approach them in the right way are therefore very important	✓ Develop a clear strategy for approaching visitors
	V-4 User information helps to increase the acceptance	➔ Measures that are in conflict with the users comfort can lead to massive complaints. ➔ User information provided beforehand helps to increase the acceptance	✓ Inform users beforehand whenever they are concerned by a project action. ✓ Point out the positive effect of the measure (e.g. cost reduction).
	V-5 Visualisation of the consumption helps to motivate	➔ Visualisation gives quick feedback about successful measures	✓ People who are responsible for the consumption of a meter should know where they have to look in the service to get the information if the consumption is increasing or decreasing
Data privacy & security	**V-6** When dealing with personal information, the processes should be transparent.	➔ Users are alarmed whenever their personal data is requested. This was observed when performing the surveys in WP7.	✓ The process and explanation of the necessity for gathering the data should be made clear and in writing. The survey conductor has to be credible, i.e. from the team of professional users.
Outcomes	**V-7** Convince the public to apply and replicate good action in their homes	➔ Influencing behaviour of the public goes beyond the project's immediate focus, but is important for an overall energy saving in the city	✓ Along with building-specific information, provide tips and good practices that are relevant to the public and help save energy in their everyday lives

2.4 Lessons learnt – Municipalities / Cities

Category	Issue	Impact	Recommendation
Partnership & buy-in	**M-1** Involving just the energy department is not enough	➔ The project heavily involves IT aspects, the IT department should be involved from the very beginning	✓ Think of all the possible fields that are relevant to the project and effect / contribute to its effectiveness and success and approach the responsible people
	M-2 Changing political	➔ Depending on the change, it	✓ Survey the political scene in

Category	Issue	Impact	Recommendation
	situation (e.g. in Belgrade).	can be good or bad for the project ➔ The new situation needs to be analysed	order to take advantage when opportunities arise ✓ Seek to establish new contacts and influence when a change occurs
	M-3 Reporting to municipal authorities on the savings achieved translated into money	➔ Some municipal authorities don't believe in such projects like SMARTSPACES ➔ The monetary value usually awakens the interest of the sceptics	✓ Always translate into money ✓ A good way would be to have a tool in the service to transform kWh to €
	M-4 Public support of the City Mayor	➔ Helps to facilitate cooperation between the different departments	✓ Win the mayor on your side, convince them to make a public statement
Take-up and use	**M-5** Implementing a cross-cutting project from the middle of the organisation without clear Senior Management and political support can limit its reach.	➔ Working across so many service areas that have often competing priorities, separate hierarchies for sign off, different politicians as portfolio owners and different ways of working has led to additional effort and time being put into negotiating their buy-in and has led to some compromise solutions.	✓ Find a strong project sponsor in a senior position that can bring together different service areas from the outset i.e. project inception.
	M-6 Ensure the main budget holder for energy / utility costs has been identified and is on board.	➔ Energy/utility costs are dealt with centrally and not on a building by building basis. That means that investments in building changes, process changes and energy savings measures may have to be found by the service that uses the building or by the service that operates the building but that any reduction in energy costs will be collected centrally.	✓ Distribute energy/utility costs as a per capita / per m² charge to the service that uses the building so they receive the benefit of any savings achieved. ✓ Alternatively, the central budget should pay for the actual investment in energy saving measures
	M-7 Buy-in of senior management	➔ It is especially difficult to build relationships during organisational change. ➔ It can result in increased workload as the chance to use greater communication and leadership powers of the senior management is missed.	✓ More focused communication campaign rather than trying to reach all levels of the hierarchy.
	M-8 Energy bills for main office buildings paid by central finance, therefore no financial incentive for building users to save energy.	➔ Difficult to motivate general staff.	✓ Divest financial responsibility down to building level.
	M-9 Human factor and organisational structure are key points	➔ It is not possible to reach out to all without knowing their profiles and the organisational structure	✓ Explore how the municipality works, who influences whom, etc. ✓ Identify key people that are movers and will facilitate change

Category	Issue	Impact	Recommendation
	M-10 Internal communication	➔ If there is no internal communication, staff tend to forget about the project	✓ Regularly talk with the staff, even if there are no faults /issues, they should be on top of their game
Data privacy & security	**M-11** Loss / replacement of project personnel / handover of responsibilities.	➔ Loss of archived work/emails. ➔ Inconsistency in work after handover - not smooth transition. ➔ Ensuring workload gets reallocated; routine tasks aren't lost / forgotten.	✓ Record queries and allocate work in central database. Tickets with priorities and deadline dates. ✓ Regular checking of tickets by all team members.
Technical set-up	**M-12** Preliminary visits should be the most accurate possible.	➔ Especially in historical buildings, putting sensors can become tricky because they can alter the appearance of the rooms, which is not desirable, e.g. in museums (see Milan pilot)	✓ Work closely with the building staff to clear any misunderstandings ✓ Building staff are dealing with the building on day-to-day basis, so they know in many cases what is best because they have operational experience
	M-13 Separation of duties and clear plans.	➔ If duties are not clearly separated between the municipality and the utility companies, the installations can be delayed	✓ End meetings with clear decisions and allocated tasks ✓ Flow charts help to illustrate responsibilities and procedures
Outcomes	**M-14** Better personnel management for smoother work.	➔ If not accounted, staff shortages can occur which lead to slowing the progress of some project activities, the capability of the staff to speak English should not be underestimated.	✓ Good management of personnel ✓ English is a must, regular attendance of consortium meetings to not lose track of the tasks.
	M-15 Review progress	➔ If the progress is not reviewed, individuals may not continue using the service or their awareness campaign ➔ Means to review progress: identifying wastage, analysing behaviour change	✓ Involve staff and professionals in the progress review, to better understand what worked, what didn't work, if a different approach is required
	M-16 Project management	➔ All project participants are continuously engaged and work towards achieving all project objectives	✓ Develop a clear plan ✓ Organised regular meetings ✓ Record results and issues ✓ Always think of the three project dimensions: time, budget, scope

2.5 Lessons learnt – IT / Measurement Providers

Category	Issue	Impact	Recommendation
Partnership & buy-in	**I-M-1** Find and procure the best possible contractor	➔ For the service supplier, access to the energy data, knowledge of energy management and involvement in a previous EDSS development is not enough to be awarded the contract ➔ Web design and attractive visualisation is equally important	✓ Before starting the procurement consider not only the product but also what are the skills required developing it and what advice does the project team need. ✓ Then find the best supplier which could include splitting the contract into different job lots to

Category	Issue	Impact	Recommendation
		as the project is also about raising awareness and interest	get e.g. the energy management and the web design specialist separately.
Take-up and use	**I-M-2** Try to ensure minimal gaps in half-hourly data provision.	➔ Reduces the effectiveness of SMARTSPACES services e.g. harder to spot energy wastage, harder to engage staff.	✓ Direct contracts with data provider and meter operators, rather than indirectly through energy supplier. ✓ Contracts to include service level agreements on spotting and fixing problems with data provision.
	I-M-3 Visualisation of the consumption helps to detect malfunctions	➔ Malfunctions (e.g. usage of air-conditioning at out of office hours) can be detected if detailed information about the consumption is available.	✓ Machines with high electrical demand (e.g. heat pipes, air-conditioning) should always have a meter and the consumption should be controlled regularly.
	I-M-4 Share infrastructure and resources	➔ Sharing the existing infrastructure and resources in general benefits quicker and easier work	✓ Use existing infrastructure as much as possible (e.g. use existing communication contract)
Data privacy & security	**I-M-5** Impact of the policy landscape on the end requirements	➔ The requirements of the end user can change during the project due to policy / legislation changes. ➔ This triggers an ongoing change to the design of many of the reports/models.	✓ Plan workshops over the course of the project due to its length to refine requirements as policy / legislation landscape changes (in the UK this happens annually).
Technical set-up	**I-M-6** Data quality needs to be insured (all meters clearly labelled, working correctly and assigned to the right building).	➔ If the data is incorrect, any visualisations will be incorrect and the system will be faulty ➔ staff will stop using it or ➔ come to wrong conclusions based on incorrect data	✓ Invest in preparation effort such as site visits to check meters and verify any asset registers in use.
	I-M-7 Regular data observation allows for prevention of potential issues.	➔ Correctly interpreting the data provided by the system and learning from it might prevent future failures.	✓ Regularly monitor the data, analyse the flow when failures happen in order to learn from it and prevent it in the future.
	I-M-8 Service needs to be easily accessible.	➔ Identified compatibility issue with certain types of Internet browsers; cannot view all elements of the services with the older browsers	✓ Make sure that you investigate the IT Infrastructure that exists within your organisation / across the general population before developing the service; needs to be accessible across all / most platforms.
	I-M-9 Metering data is up-to-date and meaningful.	➔ Suppliers have changed the metering on some sites to meet government legislation, but have not re-instated customer access (Data Lost). ➔ Changes to fuel type (boiler conversion) have also resulted in loss of data.	✓ Ensure all metering data is available and up-to-date; engage with suppliers over meter changes; automate procedures.
	I-M-10 Meter and sensor data storage	➔ The data should be stored in the devices if the Wi-Fi connection	✓ When purchasing the necessary equipment, make sure it comes

Category	Issue	Impact	Recommendation
		is lost ➔ Data loss is avoided	with an independent data storage
Outcomes	**I-M-11** Evolving requirements for the end user	➔ The requirements of the end user have changed during the project due to a) Organisational changes; b) Financial changes behind the operation of the stakeholders. This can trigger an ongoing change to the design of many of the reports/models.	✓ Plan workshops over the course of the project due to its length to refine requirements.

2.6 Lessons learnt – Energy providers

Category	Issue	Impact	Recommendation
Partnership & buy-in	**E-1** Overall budget cuts and staff reductions meant that services did not have spare resource to engage with the project.	➔ Services try to give the least possible effort so as to concentrate on provision of the day to day service	✓ Better explanation of the benefits, preparing an estimated cost-benefit analysis re impact on service efficiency (rather than energy saving) for the hard pressed services before the project starts.
Take-up and use	**E-2** Review the KPIs when outsourcing energy management to include energy saving targets, not just maintenance of EMS.	➔ If the Energy Management becomes private and is delivered under a service level agreement, the project cannot influence the contract negotiations or changes such as workload of the energy managers.	✓ If possible, engage with the procurement manager to ensure the contract is flexible enough to allow for project work and implementation of changes that come as a consequence of the project. ✓ Set annual KPI reviews to ensure that KPIs agreed can be changed if they are not fit for purpose. ✓ Devolve some of the outcome target (actual energy / utility savings) to the contractor to ensure they are open to innovation.
	E-3 Contractors' conditions should be very clear to ensure high efficiency, e.g. through tough service level agreements (SLAs)	➔ When there is a system failure, the contractor has to deal with it. If the time is not specified in the contract, the contractor doesn't react as quickly as expected.	✓ Carefully negotiate service level agreements to ensure that there is proper maintenance and support. Seek advice from experienced people, even lawyers, regarding the SLAs.
Technical set-up	**E-4** Ensure data quality through correct entry. In some cases staff had not received EMS training and had used 'workarounds' to store information in fields that were supposed to hold other data.	➔ This has led to difficulties with exporting and re-using the data in a different system and limited the ability to publish as Open Data.	✓ Ensure staff are only given system access after at least minimum training. ✓ Staff need to be informed about the implications of finding workarounds for other system users ✓ Regular data quality reviews should be implemented to keep the data quality high and avoid high effort manual cleansing jobs

Category	Issue	Impact	Recommendation
	E-5 Take into account different building types	➔ Administrative use buildings have more energy saving potential than buildings with 24 hours/day work such as police stations and fire departments	✓ Allocate more resources for the service for administrative buildings as they have bigger potential to save energy
Outcomes	**E-6** Ensuring Energy information / reports gets received by site or right person for site.	➔ Energy information - usage data, billing and costs etc. contained in reports not being received will mean site is not aware of costs and usage - missed potential energy savings, loss of awareness and engagement.	✓ Regular communication with site, establishing a reliable/relevant contact at site level. Ensuring that contact is most suited to receiving information - site managers and budget holders. ✓ Continual review and update of site contacts.
	E-7 Provide necessary tools to support the staff, especially the Energy Managers.	➔ Sometimes, the energy manager is someone without energy knowledge so is very important to have tools to support him / her.	✓ Feedback staff + consumption profile (from meters) + basic audit = a very good and helpful tool for energy managers and maintenance staff.

2.7 Work packages

2.7.1 Summary of results

All work packages were successfully finalised at all pilot sites. Deliverables with public status are available on the project web-site (www.smartspaces.eu). Key results of all deliverables are summarised in the sections below.

2.7.2 Requirements (WP1)

There have been two iterations of requirement list in the course of the project to ensure that requirements are able to depict all pilot sites for which they are applicable. The requirements were divided in the following types:

- **Non-functional users' requirements** (task 1.1) mainly tackling the characteristics of the service (e.g. extensibility) and users (e.g. speech abilities, cognitive abilities, social context, age) among others.
- **Service requirements** (task 1.2), referred to as **functional** requirements, specifying the end users' needs (professionals users, staff users visitors and the service provider) and technical situations and possibilities
- **Legal requirements** (task 1.3) mainly focusing on the identification of elements of the future solutions that will raise legal / regulatory issues.
- **Data requirements** specifying the characteristics and attributes of data collected with services.
- **Conversion factors** to allow for translating recordings into other units different resources and sites

For each type, a full set of requirements for the SMARTSPACES service has been designed. Within each requirement type pilots sites checked whether the individual requirement is applicable for their planned services or not. The numeration and reference of each requirement remains unaffected and allow for adding any requirement at any point in time. In fact, the individual pilot sites do not necessarily have the same set of requirements depending on the focus of the proposed service.

The full SMARTSPACES requirement list works as an umbrella covering all individual pilot site requirements lists and allows for a common and consistent documentation of the architecture.

The entire set of Requirements was mapped against Use Cases. If a site adds a new Use Case it can base their requirement list on the experience of other pilots – this allowed for efficient exchange between pilots and simplifies replication.

Characteristics of requirements

The requirement characteristics can be resumed in:

- Unitary: The requirement addresses one and only one thing.
- Complete: The requirement is fully stated in one place with no missing information
- Atomic: The requirement is *atomic,* it does not contain conjunction
- Traceable: The requirement meets all or part of a business need as stated by stakeholders and authoritatively documented
- The implementation of the requirement can be determined through one of four possible methods: inspection, demonstration, test or analysis

Standards used

This documentation has been made following the indications of different norms related on definition of the SOAS (Software as a Service) for team and enterprises[2]. Can be highlighted EEE 1471-2000™ Conceptual Framework for Architectural Description[3] and ISO/IEC/IEEE 42010 System and software – Architecture description[4].

Overview of significant results

Several hundred individual requirements were collected which were applicable in varying combinations across sites. All sites mapped their requirements in one database allowing comparing sets across systems.

Example for Functional requirement definition

Exhibit 2 – Full list of functional requirements (FR)

ID	Group / Name	Summary
R1.1.	**Output Format**	Specifies the following requirements associated with the degree to which the SMARTSPACES service must allow for different output formats. Background: Data recorded needs a format to be visualised which might differ depending on environment and purpose of the selected information.
R1.1.1	Web-portal	The service shall be accessible via a web-portal based on menus.
R1.1.2	Web-portal - Dashboard	The service shall be accessible via a web-portal with a dashboard.
R1.1.3	Website	The service shall be able to display automatically updated information on a public website (e.g. Local Authority website).
R1.1.4	Mobile-App	The service shall be accessible via a mobile application.
R1.1.5	Social Networks	The service shall be able to push selected information automatically and /or upon request to social networks (e.g. facebook, twitter).
R1.1.6	Public Screen	The service shall be able to display automatically updated information on a public screen.
R1.1.7	TV	The service shall be able to display automatically updated information on a TV (which can be public).

[2] Dean Leffingwell: Agile Software Requirements: Lean Requirements Practices for Teams, Programs, and the Enterprise, 2011.

[3] IEEE 1471-2000™ Conceptual Framework for Architectural Description http://www.iso-architecture.org/42010/cm/cm-1471-2000.html

[4] System and software – Architecture description ISO/IEC/IEEE 42010 http://www.iso-architecture.org/42010/cm/cm-1471-2000.html

ID	Group / Name	Summary
R1.1.8	Email	The service shall send automatic emails depending on settings defined by user or admin.
R1.1.9	SMS	The service shall send automatic sms depending on settings defined by user or admin.
R1.1.10	Binary Signal	The service shall send a binary signal to devices indicating the status and / or proposed activity specific devices (e.g. LEDs attached to windows indicating with red that window should be shut and green that it should be opened).
[...]		

Trace list example for a Use Case

Please see below an example for the list of requirements and how they are traced by Use Cases:

UC_S_LOG_Rx.x.x: Login
UC_S_BAD_Rx.x.x: User has building administration page
UC_S_BAD_Rx.x.x: User can choose their climatic conditions
UC_S_BAD_Rx.x.x: User can choose their climatic conditions
UC_S_BAD_Rx.x.x: User can create or modify a building activity

2.7.3 Use case definition (WP1) & Service definition (WP2)

Approach

There have been two iterations of use cases in the course of the project to ensure that use cases are able to depict all pilot sites for which they are applicable.

A full set of use cases for the SMARTSPACES service has been designed. Within each use case type pilots sites checked whether the individual use case is applicable for their planned services or not. The numeration and reference of each use case remains unaffected and allows for adding any use case at any point in time. In fact, the individual pilot sites do not necessarily have the same set of use cases depending on the focus of the proposed service.

The full SMARTSPACES Use Cases and Process Models list works as an umbrella covering all individual pilot site use case lists and allows for a common and consistent documentation of the architecture.

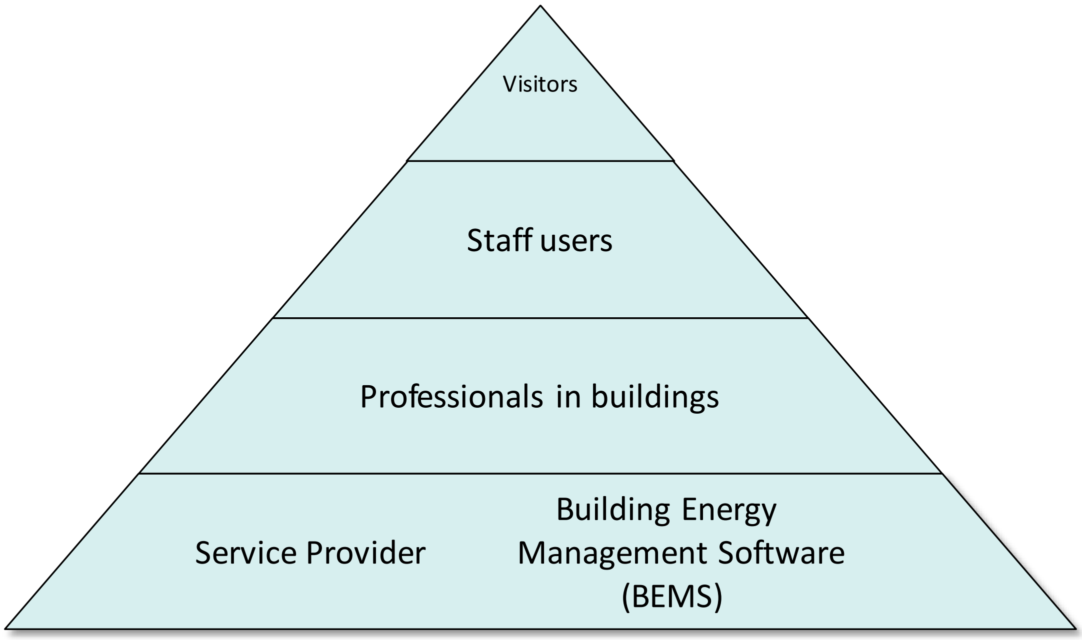
Assumptions for user profiles

In order to reduce the complexity of the use cases and simplify the notation (paths) of each use case, the following assumption is made for user profiles.

The right and their access to the system of all core target groups can be described as a pyramid. The higher the user is located on the pyramid, the smaller the number of uses cases applicable for this user. Vice-versa, the lower a user is on the pyramid the greater the access to the system.

It is assumed that users further down on the pyramid also have access to all use cases available to any user higher in the pyramid. Hence, though professionals are not listed in the paths of a use case for visitors, the professional is yet able to perform the very same use case with the system. The following figure depicts the pyramid:

Exhibit 3 – User profile pyramid



Characteristics of use cases

Basic use case characteristics can be summarised as:

- The system is treated as a "black box", and the interactions with system, including system responses, are as perceived from outside the system.
- A complete set of use cases specifies all the different ways to use the system, and thus defines all behaviour required of the system, bounding the scope of the system.
- In SMARTSPACES, each use case is described in full detail with one corresponding process model with the same name and ID.

Process model principles in SMARTSPACES

Process models for SMARTSPACES have to cover the necessities of eleven pilot sites using very different approaches and systems. In order to simplify the structure for the reader and to simplify the traceability of requirements among the many different approaches the following principles will be applied to process models:

- Chronological approach – the process models are oriented on a time line (from left to right);
- All tasks or activities are assigned to one of the actor types;
- Complex tasks/processes can be modelled in a hierarchical fashion (e.g., with Sub-Processes);
- The notation can make use of colours to suit the purpose of the modeller or tool;
- The BPMN elements can be of any size to suit the purpose of the modeller or tool;
- "Simplicity in modelling" approach:
    - New modelling elements are introduced only if there's no possible way of modelling a process with the basic elements.
    - If there are different ways of modelling a task or method, the most simple is chosen to minimise the size of the process.

The motivation for simplicity lies in considering that different standards of business modelling are being used in all participating and/or potential exploitation sites. Moreover, by reducing the necessity for training unnecessary barriers between IT-experts and involved or deciding personnel in municipalities (or social housing companies etc.) can be avoided and the chances of dialogue between both parties are higher. We are confident this approach helped to improve the solutions from the systems as well as the future users' point-of-view at least for SMARTSPACES.

Use Case development

- Identify all the different users of the system
- Create a user profile for each category of user, including all the roles the users play that are relevant to the system.
- For each role, identify all the significant goals the users have that the system will support. A statement of the system's value proposition is useful in identifying significant goals.
- Create a use case for each goal, following the use case template. Maintain the same level of abstraction throughout the use case. Steps in higher-level use cases may be treated as goals for lower level (i.e., more detailed), sub-use cases.
- Structure the use cases. Avoid over-structuring, as this can make the use cases harder to follow.

Process Model development

- For each use case, create a first outline of the process model set based on the developed use cases. Model as much details as possible.
- Refine the process model set based on feedback from the pilot sites (as by definition BPMN should be understandable and utilised by all business users). If needed, generalise or further specify models so that they fit all pilot site service processes.
- Create a final set of process models. Validate their technical accuracy against the BPMN specification.

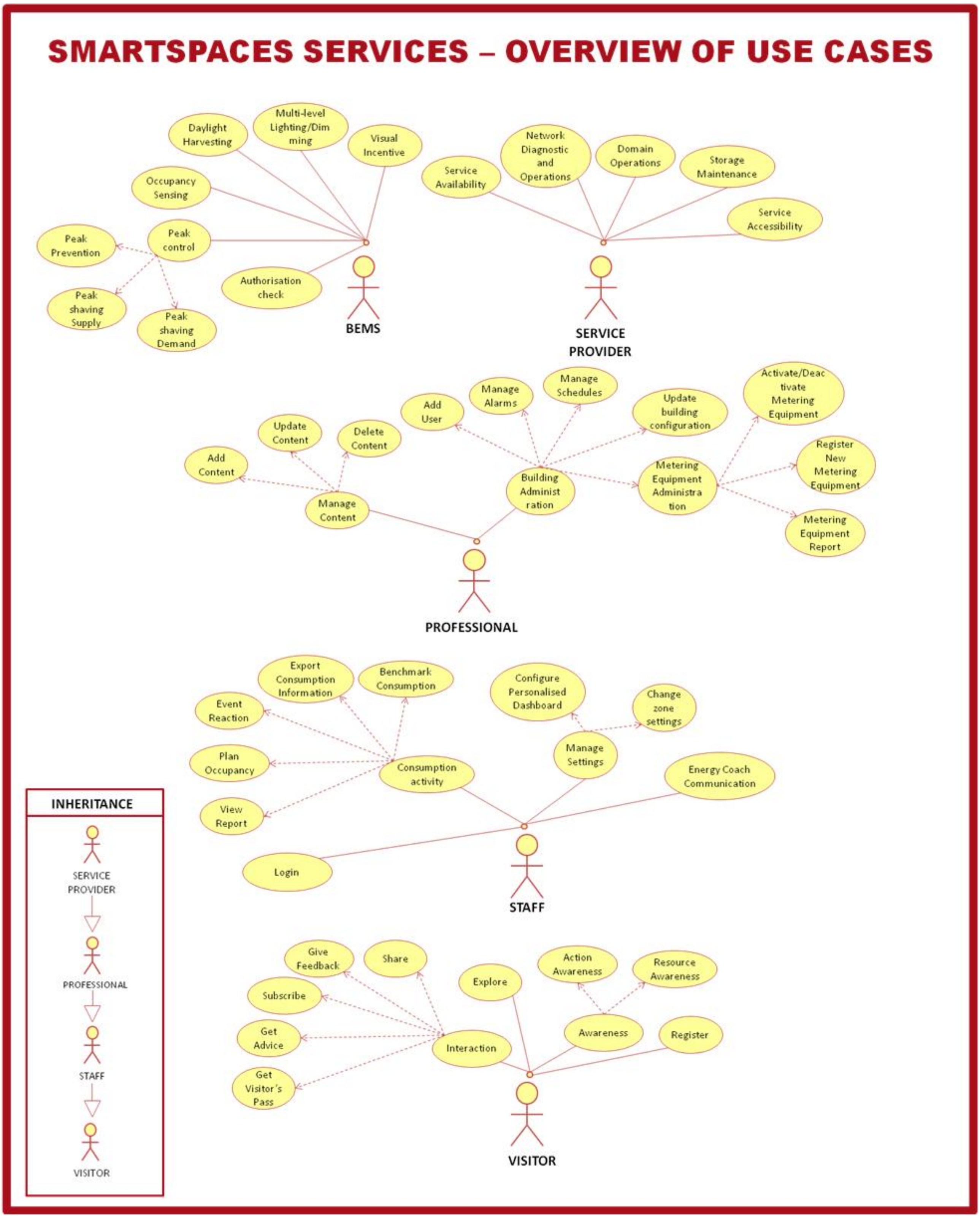
Use cases and process models

- Review and validate with users.
- Iterate the entire chain of events a second time.
- Cross examine whether updates to process models affect use cases and vice-versa.

Overview of significant results

The goal list summarises the hierarchy of Use Cases and Process Models as well as the entire goal list and connections. Each Use Case available to a user at the bottom is also available to the users profile higher up.

Exhibit 4 – Overview of Use Cases / Process Models



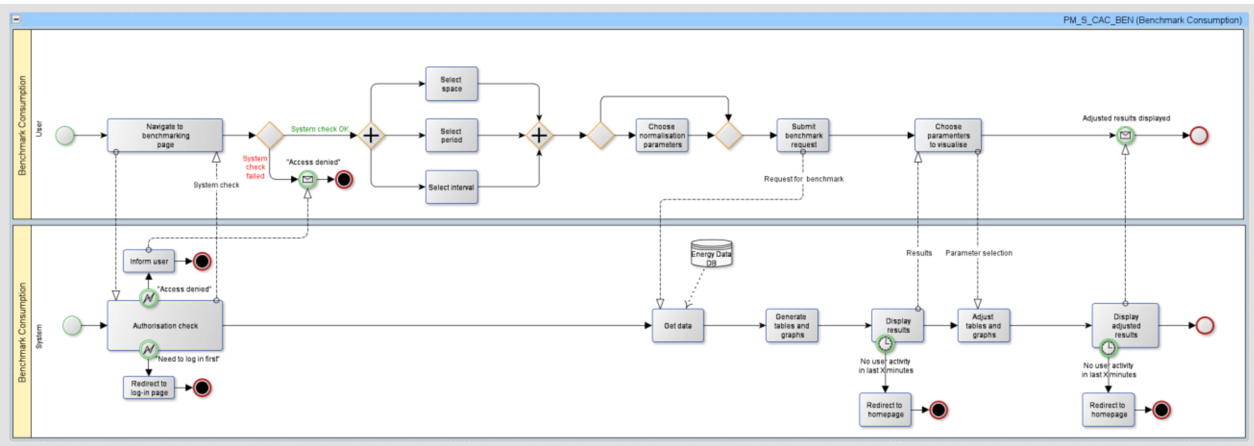
Use case and Process Model: View Consumption Data (UC_S_MON_BEN)

Exhibit 5 – Use Case Example

UC_S_MON_BEN	**Benchmark Consumption**
Summary	The user wants to benchmark consumption of a given space and time. By correcting for certain parameters the user is able to compare different time spans in an output format.
Actors	Staff, Professional, Service Provider
Base flow	1. The user navigates to the benchmarking page. 2. The user selects the option to benchmark consumption. 3. The system displays a benchmarking template. The template has minimum fields that have to be filled in. e.g. <space>, <period(s)>, <interval>. 4. The user fills in the fields. 5. The user chooses the normalisation parameters, if any. 6. The user clicks to see results (e.g. using graphs and/or tables). 7. The system performs a query with the input by the user and fetches data. 8. The system displays the requested data. It is in form of graphs or tables. 9. The user chooses parameters to visualize. 10. The system reads the parameters. 11. The system displays adjusted output.
Exception Paths	a) User enters an invalid space, period or interval System displays message that invalid parameter has been entered.

The user shall be able to benchmark consumption of either periods or spaces. By correcting for certain parameters the user is able to compare different selections in an output format. The possible options for selection can be provided by system and/or free user research (e.g. two different buildings).

Exhibit 6 – Process Model Example (PM_S_CAC_BEN)



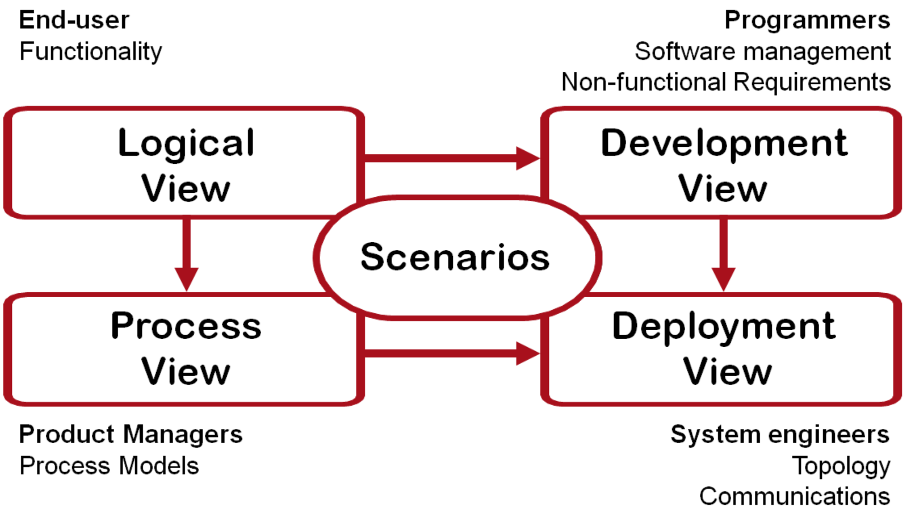
2.7.4 Service specification (WP3)

The final deliverable (D3.2) is public. This section will only present key results.

Approach

WP3 provides a technical documentation of the SMARTSPACES system. The architectural solution and specifications presented in the document is adopted by 11 pilot sites across Europe. Starting from different initial conditions and diverse environments the SMARTSPACES solution is implemented replicating a common architectural view and offering the set of specifications described.

Exhibit 7 – SMARTSPACES Model 4+1



A **4+1 architectural model** is adopted. This architectural model offers a global view on the entire building process focusing on the 4 different stakeholder views involved in the SMARTSPACES development: System Engineers, Product Managers, Programmers and Final users. The common and standardised views also allow for information collection across multiple partners and its analysis.

The **'Logical view'** describes the system's functional elements with a detailed description. A Functional view is the cornerstone of most Architectural Descriptions (ADs) and is often the first part of the system that stakeholders address. It drives the shape of other system structures such as the information structure, concurrency structure, deployment structure, and so on. It also has a significant impact on the system's quality properties such as its ability to change, its ability to be secured, and its runtime performance.

The **'Development view'** describes the architecture that supports the software development process. Development views communicate the aspects of the architecture of interest to those stakeholders involved in building, testing, maintaining, and enhancing the system. UML language is used. MockUpWebService is online.[5]

The **'Deployment view'** describes the environment into which the system will be deployed, including capturing the dependencies the system has on its runtime environment. This view captures the hardware environment that a system needs (primarily the processing nodes, network interconnections, and disk storage facilities required), the technical environment requirements for each element, and the mapping of the software elements to the runtime environment that will execute them. UML language is used.

The **'Process view'** describes how the system will be operated, administered, and supported when it is running in its production environment. For all but the simplest systems, installing, managing, and operating the system is a significant task that must be considered and planned at design time. The aim of the process viewpoint is to identify system-wide strategies for addressing the

[5] http://147.83.143.29/SmartSpacesWS/SmartSpacesWebServices.asmx

operational concerns of the system's stakeholders and to identify operative roles in the system. The Business Process Model Notation is used.

'Scenarios' describe how users interact with the system and how different systems interact with one another. Each chain of steps, referred to as a use case, is matched with one process model. Use cases are described by adopting the UML use case description language. Use cases connect requirements and the implementation in the process view

Finally, the implementation is presented across all sites as an overview following the 4+1 structure. The Annex contains some material used to record the input gathered at the pilots and can be re-used for replication. The instructions and experience gathered will be the basis for the 'Guide for Replication' to be developed as part of D8.4 containing, among others, a section on technical detail and lessons learned.

Overview of significant results

The full documentation is part of D3.2. Only the summarising graphics can be presented here.

Exhibit 8 – Conceptual application architecture scheme.

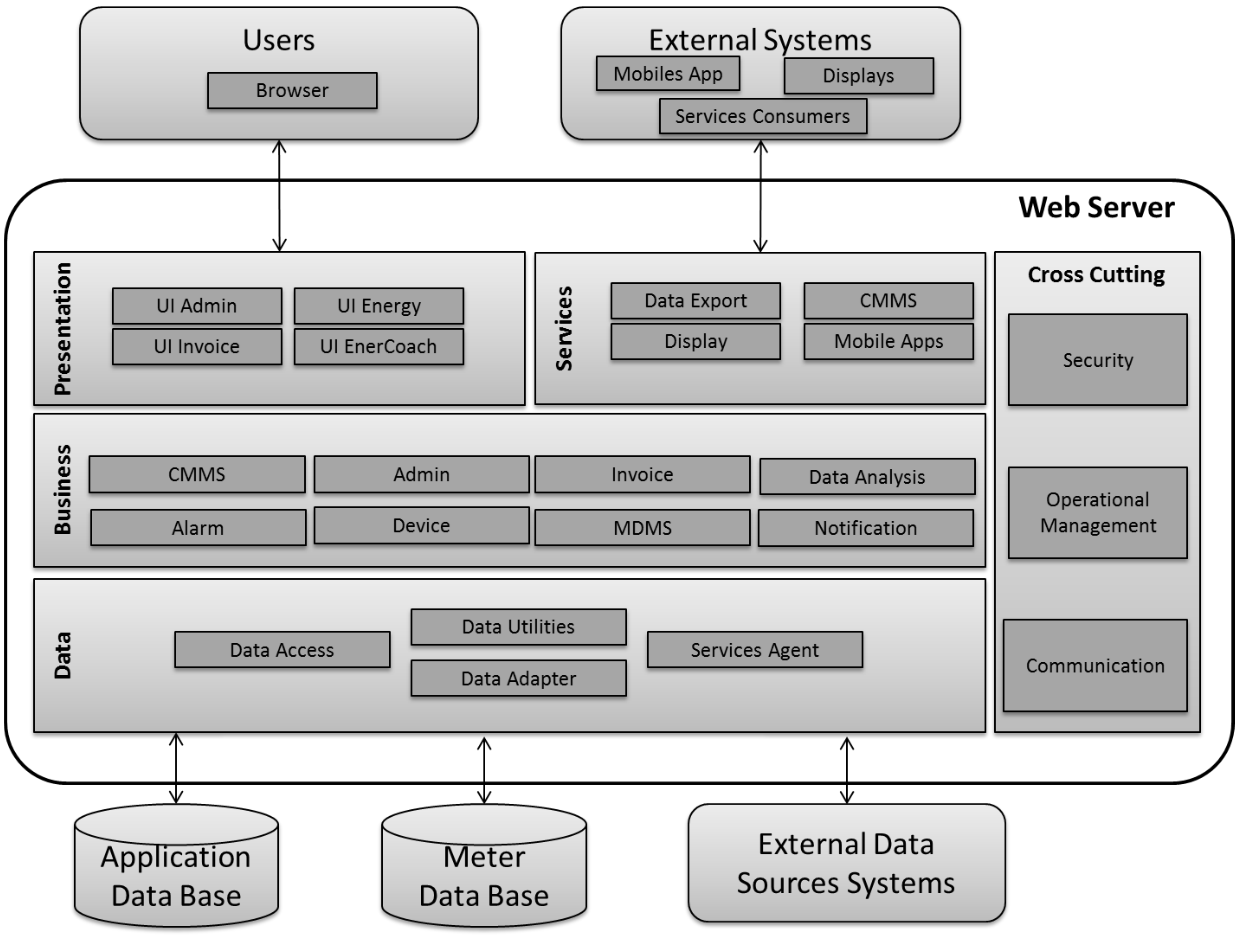


Exhibit 9 – Presentation layer components

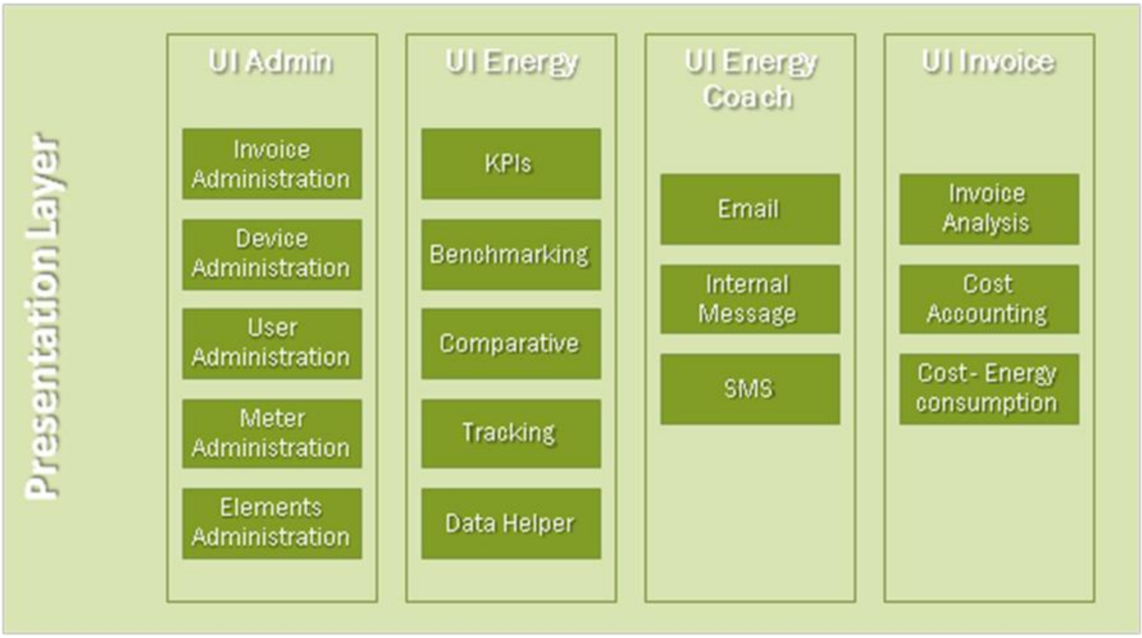


Exhibit 10 – Service layer components

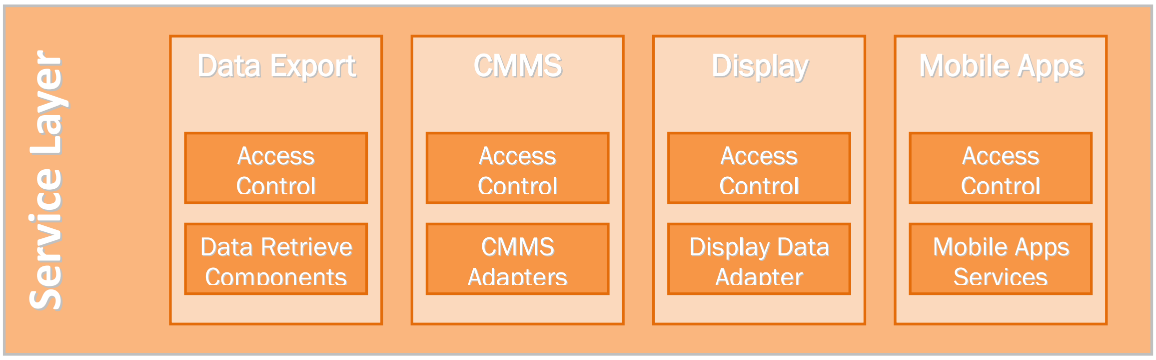


Exhibit 11 – Business layer components

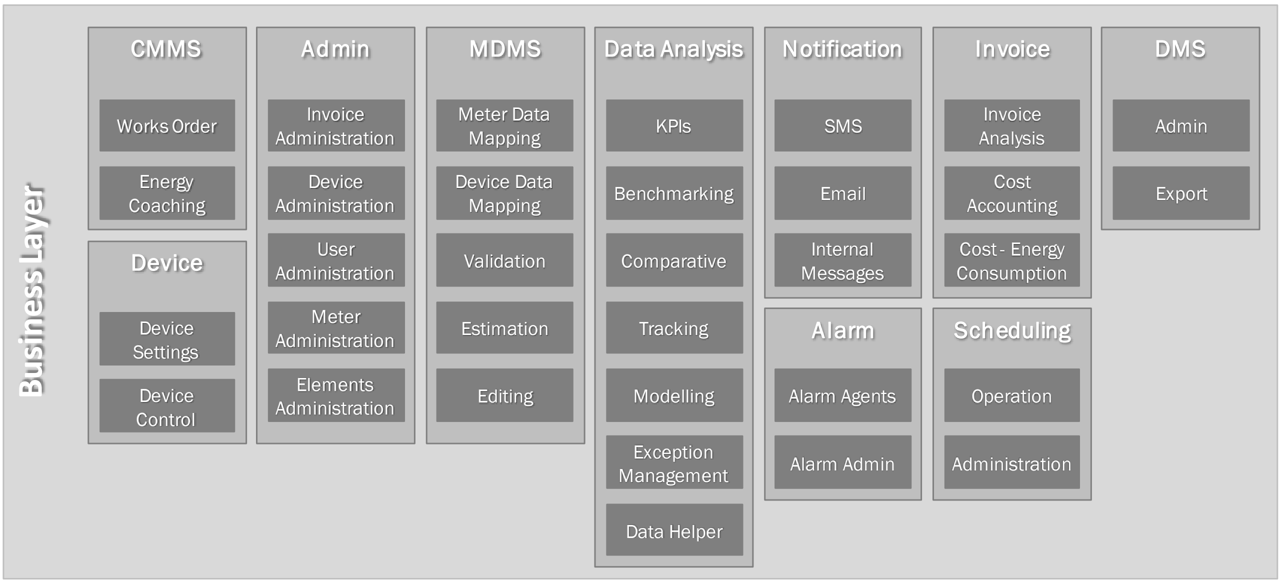


Exhibit 12 – Data layer components

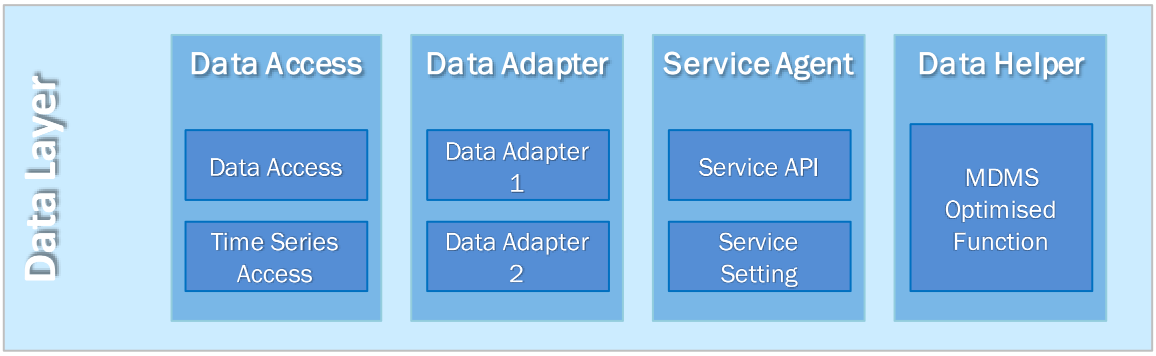


Exhibit 13 – Security layer components

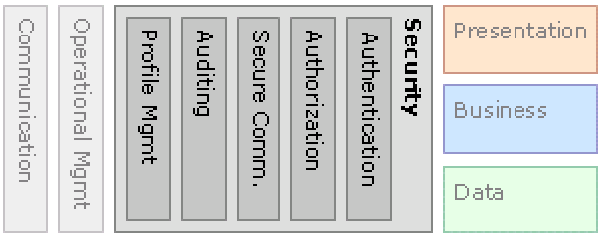


Exhibit 14 – Communication layer components

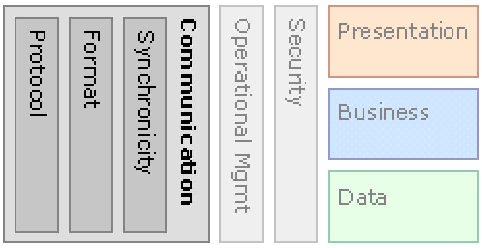


Exhibit 15 – Operational Management layer components

2.7.5 System implementation and test (WP4)

Approach

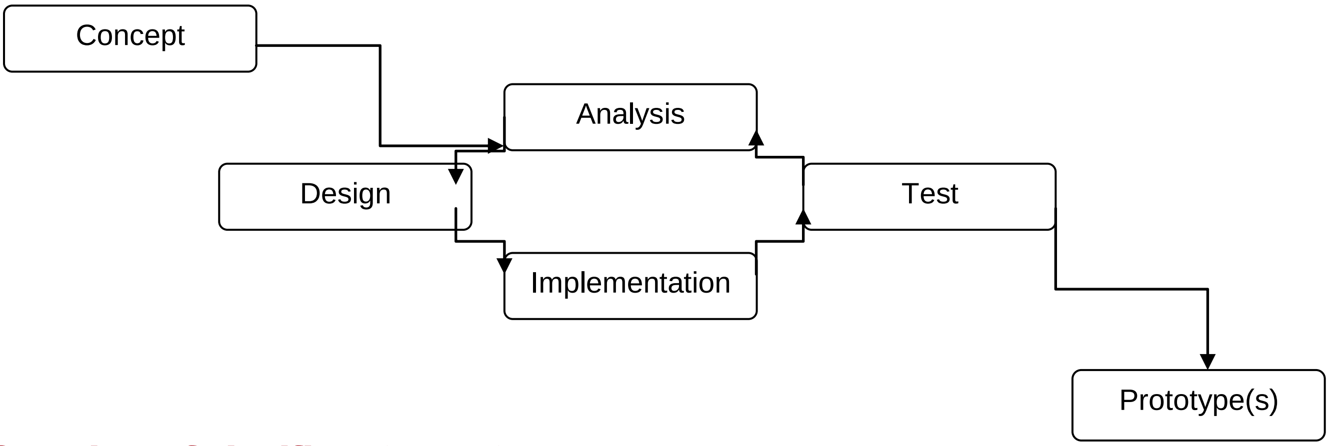
WP2 presents the results from the second iteration of testing for SMARTSPACES. It describes the testing methodology and goes on to introducing a summary of test results followed by detailed output for each pilot site.

The results of the testing have two parts: i) an assessment of the overall consortium position, and ii) the testing results for each pilot site's iteration of the SMARTSPACES service. The following detail summarises the consortium position towards testing.

Each test case has been met with an example interface, which are evaluated separately in this document. Overall, the services developed, seem to have a focus on Benchmarking, and exporting data for further analysis.

Overall, the services are geared towards providing an engagement, with energy coach and awareness being of particular focus. Combined with the other results that are display later, it can be seen that implementation in the consortium is approaching completion, ready for the pilot phase at the end of October, which is around schedule.

Exhibit 16 – Conceptual Process Diagram for Evolutionary Prototyping



Overview of significant results

The overall delivery by the consortium has been good at meeting requirements, and delivering a usable service. There are some significant lessons on a site by site basis from the testing programme (for example at Lleida, their system takes much longer on the first loading to cache, but afterwards is much faster, but this impacts user acceptance testing). Improvements in each pilot site over the entire piloting period are very achievable and the testing results have identified and depicted where those efforts should be directed.

Requirements across the consortium (ii) were assessed on the basis of their original priority. Of them, 70 were rated as high priority requirements and are the most notable points that needed to be fulfilled to ensure that the pilot can be considered a “proof of delivery”. The test cases show a positive result, particularly with improvement in the Visitor service since D4.1.

For each test category a selection of results can be found below. It is to be noted that in the pilot specific figures changes could have occurred since the testing.

Use Case Testing results

The results of use case testing and user acceptance were positive. Thirteen use cases have been selected to be representative, not all being available at all sites. Almost all users accomplished the target of any given use case and the average rating for acceptance is between 7 and 9 out of 10.

Functional Requirements

The results of the functional requirements testing were positive. In general, the consortium has delivered upon the user requirements identified, with an outcome that meets those specified. The main challenges for future iterations that lie ahead for the consortium are specific to the interface design, and the performance of the SMARTSPACES service as there was particular feedback on speed, and usability.

Non-Functional Requirements

For the most part, the legal implications of the SMARTSPACES service are simplistic, as there are limited data protection issues. Aside from this, the majority of non-functional requirements have been met/delivered.

Interface Testing

The results of the interface testing showed that the approach towards implementation of the SMARTSPACES service at the eleven pilot sites has a significant variation from site to site. The overall performance varied significantly, with some sites having speed/performance issues due to their authentication, or service caching, leading to a reduced performance for the site's service.[6] There were some very successful results, but overall the navigation of the service could be improved as many actions required quite a significant number of clicks to obtain the right "goal state".

Interface Evaluation

The interface evaluation outlined both the successful implementation of the services, and drew lessons from the interfaces that have been developed. Whilst overall the quality and performance of the interfaces was good for a pilot stage, there were some significant common characteristics that were important to address for example there was a common issue across iterations of the service with there not being a password reminder function on the login pages.

Test Cases and Test Case Traceability

The traceability matrix shows the link between the designed test cases, and the original requirements. The test case traceability, as with the interface tests, was conducted on the use case categories contained in the WSDL output from W3, contained in D3.2.

2.7.6 Pilot site preparation (WP5)

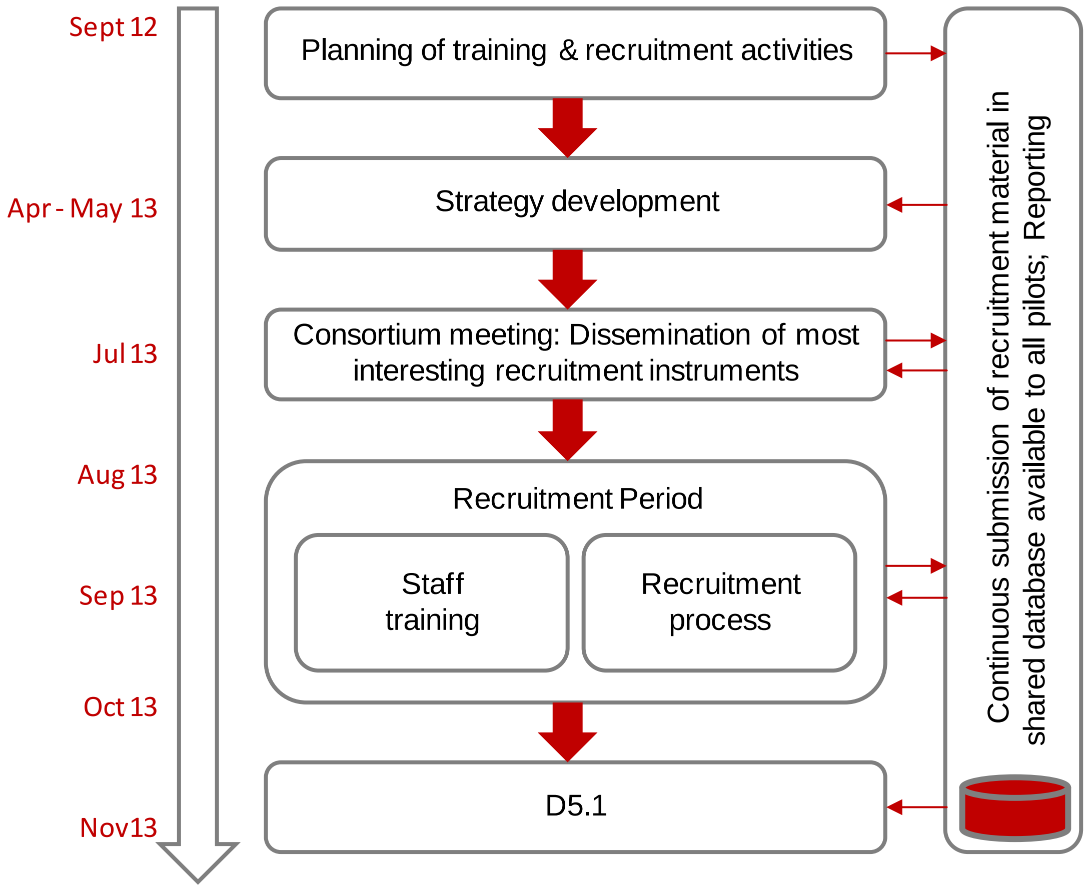
Approach

Deliverable D5.1 was submitted on 17 December 2013 and describes methodologies, strategies and measures for recruiting and training professionals, staff and visitors in SMARTSPACES pilot sites. Recruitment comprises various instruments that help to raise awareness and understanding about SMARTSPACES which together form a given pilot's individual recruitment strategy. Activities consist of training on how to manage the services, identifying champions and advice on how to best communicate with other as well as numerous printed material taking the local conditions at the pilot site into account.

User recruitment requires the **development of a strategy** covering numerous dimensions to ensure efficient and targeted communication. SMARTSPACES used a common approach, templates and documentation methods to gather and share the results across the consortium.

[6] In case of Lleida, the result can be explained with measuring first log-ins of a given user: The system performs various optimisations for the particular user to improve future performance in the background. Interface speed / performance, on a regular basis, is much faster / better than reported in D4.2.

Exhibit 17 – Consortium work as part of WP5



Recruitment strategies for each site are based on an overall approach consisting of different elements that have been identified to be suitable for recruiting new users and continuously raising awareness about energy saving. The building blocks include an as-is analysis of the existing situation to better understand the audiences and develop messages that are tailored to their expectations and circumstances on site. For instance, the organisational structure influences the way new ideas can be communicated: the chain of communication and hierarchies differ across sites and changing them only for the purpose of recruitment could be considered irritating.

Branding is necessary to sell an idea to users who are more comfortable with certain products / services than others. Putting an emphasis on the well-known technical partner and its innovative activities related to energy saving for example may be strategically a better choice rather than concentrating on presenting SMARTSPACES as a first-time action of the municipality. Such considerations and analysis through interviews and surveys help to align the SMARTSPACES services with the public's position and thus achieve a wider uptake. The resulting branding would then be strong enough to be used in future energy-related activities.

Various risks have been taken into account, both on project and pilot site levels. Ways of reducing or eliminating these risks have been included in the sites' strategies. Risks are mostly related to achieving a high number of recruits (compared to the building(s) number and size) and convincing users to use the services which have easy-to-use interfaces in order to accommodate all types of people in the buildings.

Overview of significant results

Pilot site recruitment strategies have been implemented for all pilot sites. Strategies involve up to seven levels for communication. 'Champions' in each building will continue to advertise for the SMARTSPACES service and remain as contact persons. In total more than 250 events have been organised and 90 different print materials have been distributed until the day of submission. **Pilot operation** has started at all eleven pilots.

Sharing of recruitment content

The centralised database contains items that can be either directly used by all consortium members, or provide inspiration and ideas for new content. The database is updated regularly with new content coming from the eleven pilots' recruitment activities.

Exhibit 18 – Front end view of the centralised database for sharing recruitment materials

Group	Item	Links with examples/resources			
Measures	Posters NEW! 08.08	Example 1	Example 2	Example 3	Example 4
	Brochures	Example 1	Example 2		
	Newsletters NEW! 19.08	Example 1	Example 2		
	Banners NEW! 08.08	Example 1	Example 2	Example 3	Example 4
	Magazines	Example 1			
	Events	Example 1			
	Articles	Example 1	Example 2	Example 3	
	Quizzes				
	Video/TV announcements	Example 1			
	Self-assessments NEW! 08.8	Example 1			
	Presentations				
	Web portals	Example 1			
	Stickers NEW! 15.08	Example 1	Example 2		
	Characters - Green Finger	Example 1	Example 2	Example 3	
	Tables	Example 1			

Summary

The following table presents all measures which were used by one or more pilot sites in SMARTSPACES as part of the sites' recruitment strategies. Many of these measures have been shared among the consortium partners through a centralised database (see chapter 3). In combination with the core elements identified and introduced in chapter 3, these measures aim at providing a comprehensive and unique information and assistance tailored to the interests and expectations of all stakeholders involved in the pilot.

Having the right mix of measures is not an easy task – too many measures by a pilot may overwhelm its audience. On the other hand, too few of them can result in low level of interest and participation. The following measures chosen by the sites are in line with their individual analysis (see as-is analysis in chapter 2). For an organisation wishing to replicate the overall SMARTSPACES recruitment strategy, this table can serve as a checklist that can assist in selecting the most appropriate measures for its plan.

Material	Belgrade	Birmingham	Bristol	Hagen	Istanbul	Leicester	Lleida	Milan	Moulins	Murcia	Venlo
Articles	X	X	X	X	X	X	X	X	X	X	X
Banners	X	X	X		X	X				X	X
Bonus/Award system										X	X
Brochures	X				X	X	X	X		X	X
Champions	X	X	X	X		X	X	X	X	X	
Chat/E-mail service/notification	X	X	X	X	X	X	X			X	X
Coaching	X	X	X	X	X		X		X	X	X
Common room/zone		X	X							X	
Conferences		X									
Dedicated hotline	X	X	X	X						X	
Designated contact person	X		X	X			X	X	X	X	
Focus groups	X	X	X	X	X	X	X	X		X	X
Free tickets										X	
Games	X								X		
Interviews		X	X		X	X	X			X	X
Intranet	X	X	X	X	X	X	X	X		X	X
Letters							X				
Magazines	X		X			X	X				X
Newsletters	X	X	X	X	X	X	X		X	X	X
Posters	X	X	X	X	X	X	X	X	X	X	X
Presentations	X	X	X	X	X	X	X		X	X	X
Quizzes	X									X	
Self-assessment		X		X						X	
Social media	X	X	X			X	X	X		X	X
Survey	X	X				X	X			X	X
Tutorials	X		X	X			X			X	X
User meetings	X	X	X	X	X	X	X	X	X	X	X
Videos	X		X		X	X	X			X	X
Web portal	X	X	X	X	X	X	X	X	X	X	X

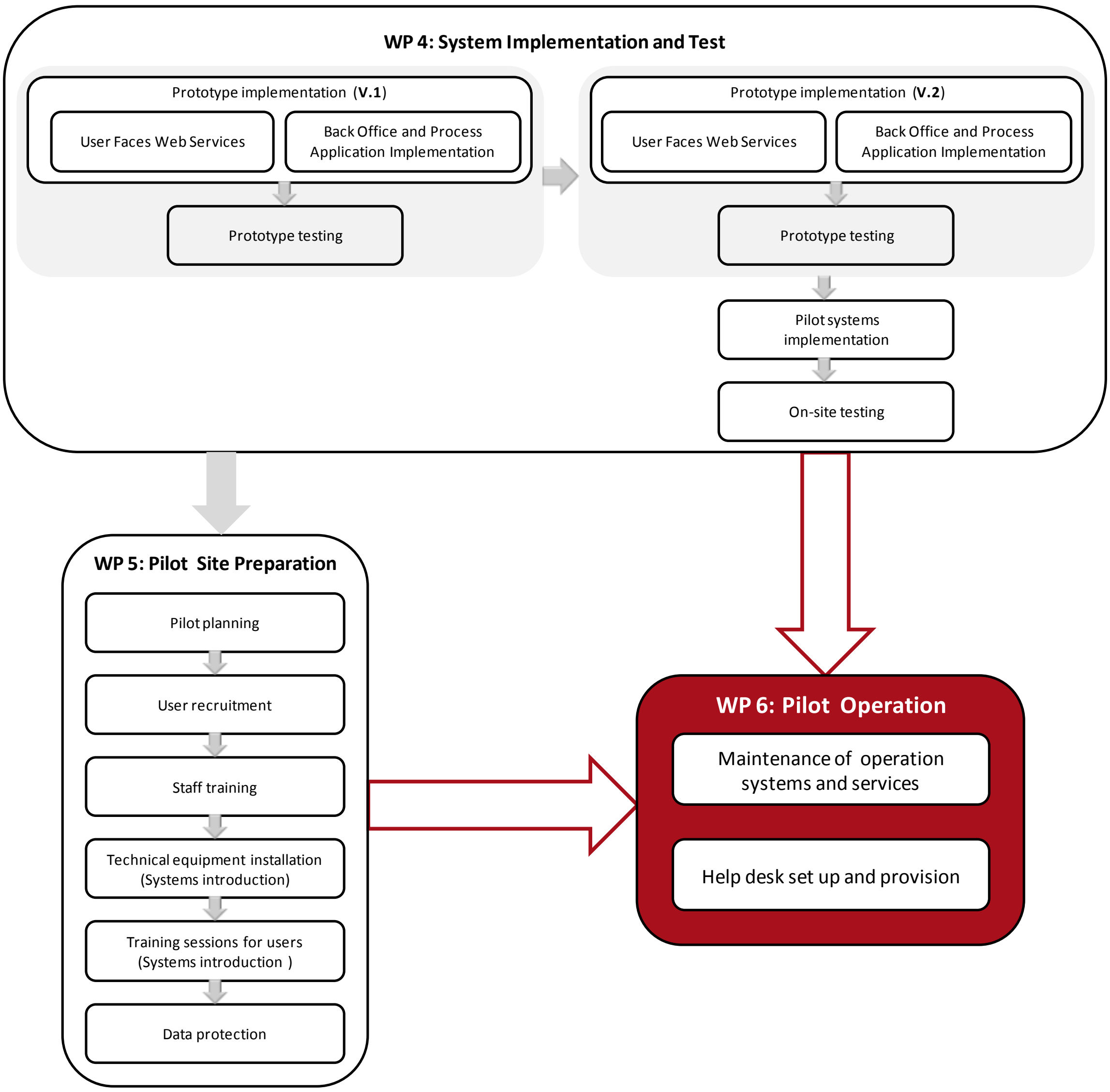
2.7.7 Operation (WP6)

Approach

Work package 6 encompassed the final executive phase of the project in which the services were implemented in the public buildings in real conditions at 11 pilot sites. Pilot site managers established a local team. The team was organised to provide maintenance and user support addressing operational and technical problems that might occur during operation. A help service was set up at each site to respond to problems faced by the service users.

The organisation of the pilot operation was supported by the responsible partners and the project coordinator by providing guidance regarding organisation and through supervision of ongoing processes.

Exhibit 19 – Overview of SMARTSPACES work plan approach to pilot preparation and operation and relation with other work packages



Overview of significant results

Deliverable D6.1 collected lessons learnt from operation as well as earlier deliverables. Lessons learnt were divided by stakeholders and described the issue at hand, impacts observed and listed recommendations based on the experience of the eleven pilots. The deliverable documents information about the pilot operation, processes, and structures implemented to ensure delivery and full maintenance of EMS and EDSS.

Lessons learnt targeting relevant stakeholders involved in SMARTSPACES are based on the overall issues / lessons identified at all stages of the project. Lessons cover problems encountered as well as success accomplished. For each issue one or more numerous impacts and recommendations are listed. Recommendations help to ensure that a wide range of issues can be planned for and dealt with. Sites often fail to achieve their full potential because difficult problems dominate and prohibit effort required in other areas. The entry point is the stakeholder; lessons are grouped by topic. Lists are prepared for the following stakeholders or stakeholder groups: staff/professionals, visitors, municipalities/cities, IT/measurement service providers, and energy providers. Selected different category groups, chronologically in line with the projects' main milestones are: Partnership & buy-in, Take-up and use, Data privacy & security, Technical set-up, and Outcomes. Lessons stem from all pilot sites' project coordination.

The **pilot site operation** captures information about the organisational environment at the pilot site level, by specifying and defining roles and responsibilities of each actor and body involved. In addition, it provides a checklist of various potential problem scenarios which might occur during service operation. For each problem scenario identified, the respective help service provided by each pilot site has been described, together with the communication means used to solve the issue(s). In total, 61 key scenarios were identified for the five groups of stakeholders.

The **activity reporting** has taken place in an Excel spreadsheet in a pre-defined standard. Activities reported belong to the following category groups: *user recruitment, user training (staff and professionals), user feedback, service maintenance, system malfunctions,* and *other*. User recruitment covers initial activities to initiate SMARTSPACES with users, such as workshops, preparation of educational materials. User training activities provide information about EDSS and EMS to new users as well as coaching. User feedback is used to improve the system according to experiences of the users and thus increase their satisfaction and involvement with the solution. System malfunctions most include system issues and how they are solved and documented, in order to be monitored through maintenance.

Apart from the summaries across the entire project, deliverable D6.1 contains a section for each pilot site. The entire pilot organisation, issues and lessons are documented.

2.7.8 Evaluation (WP7)

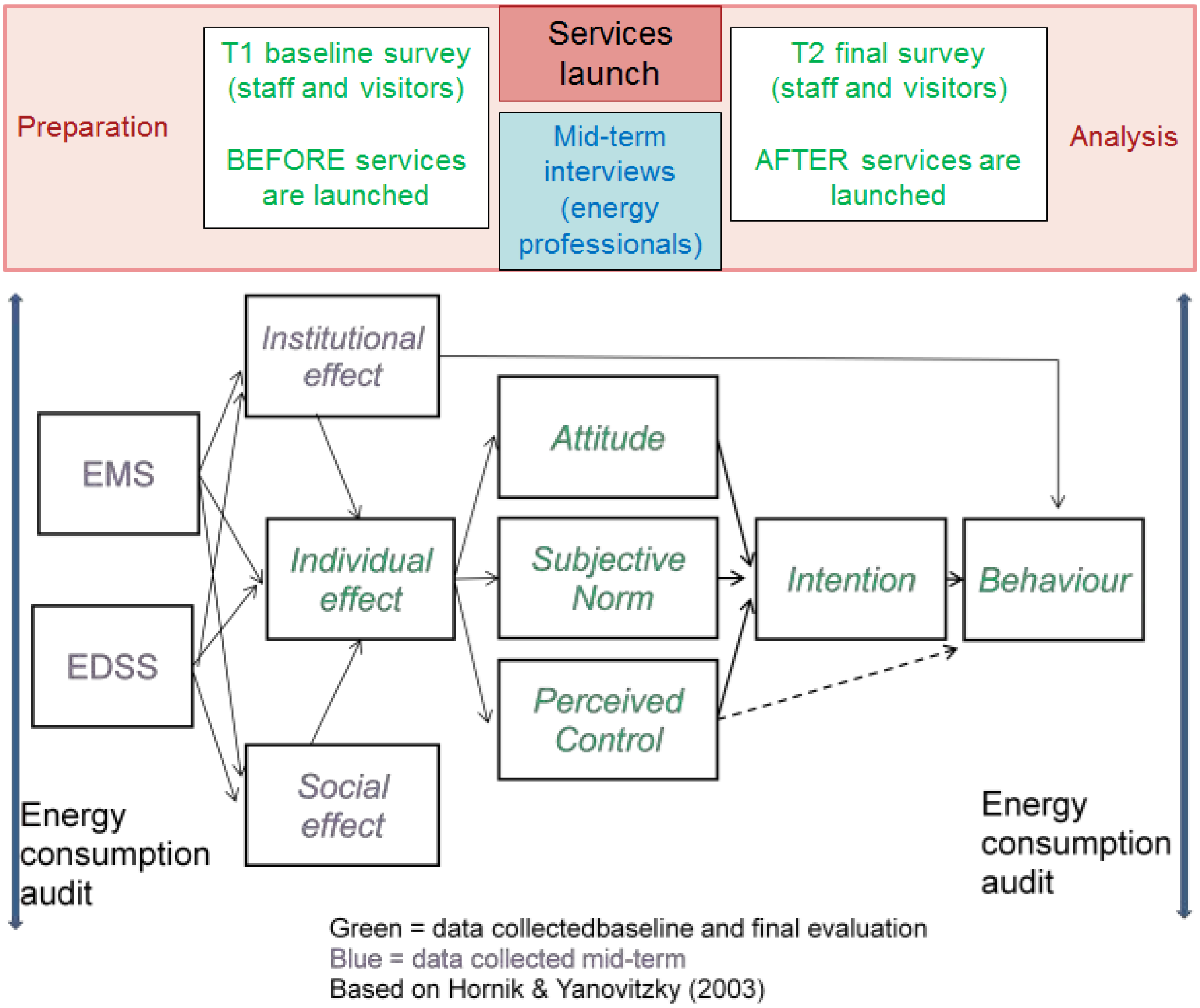
Approach

WP7 presents the evaluation of the SMARTSPACES project. The overarching objective of this work package was "to provide a demonstration of improved energy efficiency through an analysis of energy consumption at each pilot site both before and after the installation of the EDSS and EMS". A key element of the SMARTSPACES evaluation plan was to produce a measure of the impact (positive or negative) the project has on energy consumption at each pilot site. The analysis of energy consumption data was complemented with the identification and analysis of individual, institutional (organisational) and social factors and issues relevant to influencing the energy consumption-related behaviour options for action (and change) of EMS and EDSS service users from the different target groups (professionals, staff and users).

Deliverable 7.1 (D7.1), submitted in February 2014, describes in detail the SMARTSPACES evaluation framework. This evaluation framework was adapted to the specific requirements and service definitions at the pilot sites. Deliverable 7.2 (D7.2) presents the outcomes of the evaluation of the activities performed at the 11 pilot sites, including the metered energy and water data as well as the interviews and surveys of building users.

The following figures summarise the SMARTSPACES theory of change (explained in D7.1) and illustrate the data collected at different stages.

Exhibit 20 – SMARTSPACES theory of change and data collection



Energy consumption

The evaluation consumption data was split into two components: baseline and test (or reporting) period data. Baseline data covered an initial 12-month period from November 2012 to November 2013. Test period data started with the intervention period on November 2013.

Datasets were collected from each pilot to ensure that data were being generated and also to inspect the data file formats in use to ensure they were automatically readable. Secondly, a full list of all the datasets that were produced in the project was compiled to ensure that it was possible to map each file to a given building and evaluation unit.

A comprehensive list of buildings and data sets were collected from pilot sites. Issues such as coverage of different utilities (gas, electricity and water) and buildings with missing data sets were identified and resolved (e.g. some sites are not measuring water, some sites do not have any gas). This process also identified which datasets covered entire buildings and which were sub-meters covering only certain zones or floors of buildings. This process helped to establish clarity over the evaluation units to be assessed.

The impact (positive or negative) that the project had on energy consumption was calculated for each building at each pilot site using the IPMVP framework. The IPMVP offered several options for calculating savings and the project followed an approach equivalent to IPMVP option C where possible. For this, data for the whole building were separated into periods before the intervention (the 'baseline') and after the intervention (the 'reporting period' or 'test period'). A statistical model was fitted to the baseline data and was used to forecast forwards into the test period. Savings were estimated as the difference between measured values in the test period and the consumption forecast.

Behaviour change

The evaluation logic for SMARTSPACES was to obtain pre-/post comparison of user attitudes and behaviour before and after the intervention. Validity was strengthened by the following means:

- In the case of staff, 'panel' survey data was collected (where possible) from the same identified staff members at baseline and final evaluation. In the case of visitors, consultations showed that only independent survey data was viable due to the nature of how and how often some buildings are used.
- Mid-term interviews were used to investigate other potential external factors (cofounding variables) that could offer alternative explanations for results, thus offering triangulation of evidence.
- The theory of change used in SMARTSPACES, with its focus on intermediate cognitive outcomes as well as behaviour, was used to establish that the model of the effect of the intervention is consistent with what is observed.

The first baseline survey was designed to assess attitudes and behaviours before the implementation of services (based on factors of the Theory of Planned Behaviour). The second final survey was designed to repeat the check on these factors, plus also to ask participants to review their impression of the information received (based on factors of the Elaboration Likelihood Model). Change at the social level was also assessed in both the baseline and final surveys. The surveys contained a measure for normative behaviour.

Likert-type scales were predominantly used, with a range of four and five-point options depending on the question. The statistical analysis required of 'panel' data to control for and measure the influence of the influence of each respondent's past behaviour. This led to a minimum number of responses sought at 50 per user group. Despite a large number of staff responses being received in the baseline survey and the efforts conducted by De Montfort University (DMU) and the pilot sites for the data collection in the final survey, none of the pilot sites achieved this minimum target. This was due not only to movement of staff to other buildings and staff redundancies, but also to time pressures of staff responding to external organisations such as DMU. As a result of the small sizes of the panel data samples, the differences between baseline and final evaluation assessed trends (rather than change) in attitudes, subjective norms, perceived control and intention. Behaviour (self-reported) served as the dependent variable. In this way the evaluation was able to assess not just trends of change, but also movement in the precursors of change.

Mid-term interviews with professionals having building and/or energy management responsibilities aimed to assess changes at the institutional and social levels. Sub-themes to investigate institutional effects were about how the SMARTSPACES message was framed and how well this concurred with institutional policy, about how the SMARTSPACES service was mobilised and the level to which it is or can become mainstreamed into the institutional culture. Change at the social level was also assessed in the mid-term interviews, which offered the opportunity to investigate social change in more depth. Questions included not only assessments of whether interaction and discussion had occurred at the level of the individual, but whether the institution now has stronger networks to engage in energy efficiency as a result of the SMARTSPACES project. The data gathered during the mid-term interviews was used to primarily assess institutional and social impacts, but also to triangulate the findings of the surveys.

Overview of significant results

Energy consumption

Preparatory work established a comprehensive list of metering points for each building at each pilot site. In addition to this, a data collection exercise collected a proportion of the baseline data for every single metering point. This process revealed a number of minor inconsistencies with the master list of meters as presented in D7.1. As such the accuracy of the master list was improved.

A small number of new meters were added to the evaluation and a small number were removed. Data files collected from pilot sites in multiple formats were evaluated for data quality and software was written to automatically extract data from these files into the evaluation database ready for analysis. Pilot sites uploaded their data files into a shared storage location and then if the data was in an adequate format, the software processed the files and energy consumption change was calculated.

All pilot sites demonstrated a working metering system and provided data which begins before the baseline period. Historical data were only available at monthly resolution for some pilot sites. The Moulins pilot site was treated separately as the building in question had only recently been built. In a similar manner, the Istanbul pilot site was also dealt separately as the participating building did not have metered data for the baseline period. Hence, savings for these pilot sites should be taken with caution as these were estimated using simulated rather than measured data.

Data quality remained an issue throughout the project. Initially this was collecting meter data and mapping utility meters to buildings and electricity, gas or water consumption. Then it was ensuring the data structure could be imported automatically into the analysis tool. Substantial work was involved in checking and verifying these data. Data requirements included both energy (and water data) and outside air temperature to undertake the analysis.

The greatest savings were achieved by those pilots with relatively low numbers of buildings. This was because the pilots could concentrate on engaging with building users more effectively than pilots with very large numbers of buildings. Those buildings with relatively complex control systems were able to show substantial savings once control problems were overcome. SMARTSPACES provided the necessary advice, guidance and knowledge to improve control strategies in these buildings, through the interventions and the energy visualisations.

SMARTSPACES was able to show energy consumption reductions through technical measures, reducing base load, peak and time of day. It was also able to reduce peak and base load through behavioural changes.

An analysis by building type was only carried out for part of the large Bristol pilot site. This showed clear differences between building types.

The following table shows the measured consumption during the monitoring period, the savings achieved compared to the consumption forecast and the emissions reductions associated to these savings for each pilot site and for the entire project.

All pilot sites showed savings, particularly (above 15%) in Belgrade, Hagen, Lleida, Milan, Murcia and Venlo. Istanbul and Moulins also attained significant savings based in simulated baseline data. Less savings than expected were achieved in Birmingham, Bristol and Leicester due to several unforeseen changes, particularly in the monitoring period. These changes included movement of staff due to rationalisation of the council's buildings portfolio (Birmingham) or closure of the council's headquarter building (Leicester), increased number of students and use of ICT and other equipment in schools (Bristol and Leicester), and extended opening hours in libraries (Leicester) among others. Nevertheless, all pilots showed examples of how engaging with buildings users, improving controls and providing feedback helped reduce consumption. Further details are provided in section 2.8.

Overall carbon dioxide emissions were reduced by an estimated 2,227 tonnes across all pilots.

Exhibit 21 – Savings Overview

Pilot site	Area	CONSUMPTION			SAVINGS						EMISSIONS REDUCTIONS	
	m^2	Electricity MWh	Gas/heat MWh	Water m^3	Electricity MWh	Gas/heat MWh	Water m^3	Electricity %	Gas/heat %	Water %	Total reductions* t CO_2	Per floor area kg CO_2/m^2
Belgrade	26,057	1,334	4,394	11,250	384.1	1,868.7	2,641	22.4%	29.8%	19.0%	680.9	26.1
Birmingham	58,928	2,268	-	-	126.7	-	-	5.3%	-	-	68.8	1.2
Bristol**	277,725	21,868	15,836	-	173.9	1,388.9	-	0.8%	8.1%	-	375.0	2.1
Hagen	33,300	1,817	1,689	-	325.9	133.9	-	15.2%	7.3%	-	203.4	6.9
Istanbul	22,000	929	647	-	63.5	384.3	-	6.4%	37.3%	-	118.9	5.4
Leicester***	88,724	7,482	5,476	92,115	117.8	236.0	16,579	1.5%	4.1%	15.3%	111.6	1.3
Lleida	32,000	1,765	3,349	-	241.1	806.0	-	12.0%	18.9%	-	268.9	8.4
Milan	3,724	148	-	-	143.0	-	-	49.1%	-	-	69.1	18.6
Moulins	1,640	77	34	349	-6.8	86.5	203.9	-9.7%	71.8%	36.9%	17.1	10.4
Murcia	11,942	1,335	-	-	245.4	-	-	15.5%	-	-	108.0	9.0
Venlo	10,000	452	389	-	182.7	533.7	-	28.8%	57.8%	-	187.3	18.7
TOTAL****	556,040	39,411	31,790	103,714	1,990.2	5,408.8	19,424.4	4.8%	14.5%	15.8%	2,227.0	3.9

**Heating-related emissions were estimated using the emission factor of natural gas (EF = 0.202 t CO_2e/MWh), electricity-related emissions were estimated using the emission factor of the electricity grid in the respective countries (sources: http://www.eumayors.eu/IMG/pdf/technical_annex_en.pdf and http://www.ebrd.com/downloads/about/sustainability/cef.pdf).*

*** Some buildings were excluded from the energy savings calculation due to problems with data quality for the forecast model. Calculations from these buildings were excluded in the floor area, consumption, savings and emissions presented in this table.*

**** Some buildings were excluded from the energy savings calculation in order to represent the savings attributable to the project, excluding buildings with significant unforeseen changes explained in section 2.8.8. Calculations from these buildings were excluded in the floor area, consumption, savings and emissions presented in this table.*

***** Total percentages of savings were estimated through the sum of savings of each pilot site divided by the total consumption forecasted by the model.*

Behaviour change

Mid-term interviews with building professionals aimed to understand the main benefits of the SMARTSPACES services perceived by the users at the institutional and social level that may have had an impact of changes in attitudes and behaviour of building users towards energy savings at the individual level. Individual-level changes as a result of the implementation of the EDSS SMARTSPACES services were assessed by analysing differences in awareness, attitudes, subjective norms, perceived control, intentions and self-reported behaviours of respondents (staff and visitors) to the baseline and final surveys.

What features of the EMS and EDSS had most impact?

The EMS is mainly used by building professionals and central energy management teams in most pilot sites. Only in Birmingham, was this service also used by other Council Departments, such as Climate Change and Environment. In general, building professionals perceived that the visualisation of the energy consumption and the automated and centralised collection of energy data hade facilitated the monitoring and control of the energy consumption in their buildings. This was particularly through the introduction of automated meter readings (AMRs) (Belgrade, Bristol, Istanbul). The accessibility and timely visualisation of data allowed them to quickly detect anomalies or wrong settings, such as rectification of water leaks or adjustments in heating schedules or temperatures. In Venlo, the visualisation of data also allowed the energy management team to improve the energy efficiency of equipment, such as heat pumps; and to test energy- and cost-efficient innovative control strategies (such as the activation of the building mass). In all pilot sites, these features of the EMS not only have facilitated the energy management for building professionals, but also raised awareness and prompted positive corrective actions from staff. In Lleida and Moulins, building professionals considered that the thermal comfort of building users has been maintained or improved while the energy consumption has decreased. As a result, several building professionals believed that the EMS has enabled actual reductions (Belgrade, Birmingham, Hagen, Lleida, Moulins, Murcia and Venlo).

In the case of the EDSS, not only building professionals, but also staff and visitors were able to access its information through the web portal, monthly reports (Bristol and Hagen), display screens (Belgrade, Birmingham, Hagen, Istanbul, Leicester, Lleida, Moulins and Venlo), staff newsletters or meetings, emails and in social media, such as Twitter (Venlo, Leicester), RSS feeds (Birmingham) or an online forum (Leicester). The main benefits of the EDSS mentioned by interviewees were the timely and easy access for all staff to the necessary information about the buildings' energy consumption and the recommendations they provide to save energy (Belgrade, Birmingham, Moulins and Murcia). It was acknowledged that the EDSS has increased the knowledge and skills of staff members about energy efficiency and IT (Belgrade, Bristol, Hagen, Istanbul, Leicester, Lleida, Milan, Murcia and Venlo) by providing resources to explain staff how to manage energy locally. In Lleida, the EDSS provided tools and resources particularly during the implementation of the "energy savings campaigns" in the Sant Francesc building related to heating (winter 2013), minimisation of electricity use and air conditioning. This is a good example on how all staff members were trained on different energy efficiency measures they could act upon and visualise in the EDSS the results of their efforts.

What were the institutional level effects and what drove them?

All pilot sites agreed that the SMARTSPACES project was consistent with not only the sustainability culture, but also with energy and environmental commitments they have made at the local, national or European level. Therefore, the project was supported by senior level management, such Mayors and Deputy Mayors (Belgrade, Moulins, Leicester, Lleida, Murcia) and it helped to increase coordination and cooperation between different departments in the councils (Birmingham, Murcia). In Birmingham, for example, the Sustainable Energy Strategy was in development using the experience gained in the project. Despite this support from senior management, sometimes the project suffered delays or obstacles due to particular internal policies related to IT in some pilot sites. In Hagen and Leicester, for example, the EDSS required the use of high speed web browsers, while the standard or default web browsers for all staff computers were older versions that could not display the energy data properly (graphs or animation). In Lleida, there were problems with security of the IT system for the EMS in the initial stages, but were promptly resolved.

The training and dissemination of the EDSS was also strongly supported by like-minded individuals “environmental champions” in Belgrade, Birmingham, Milan and Leicester, who implemented the project in different departments or buildings in their institutions. The main factors that drove teams and individuals to mobilise the project within the institutions were energy cost savings enabled by the EMS and visualised through the EDSS (all pilot sites), increasing skills and knowledge of their staff (Belgrade, Istanbul, Milan), sustainability values (Bristol, Venlo), emissions reductions or compliance with regulation (Istanbul, Lleida, Moulins, Murcia) and reputation (Belgrade). Some of the obstacles pointed out by interviewees to further embed the project into their organisational culture were lack of staff time and other work priorities (Birmingham, Bristol, Istanbul, Leicester, Milan, Murcia), aversion to new technologies or lack of appropriate staff skills (Belgrade, Hagen, Istanbul, Lleida).

In most of the pilot sites, the EMS and EDSS used the logos of SMARTSPACES and their institutions. Building professionals considered that using the logos as their branding is important to provide credibility of the information (Bristol, Leicester, Milan, Murcia, Venlo), reassurance of the methodologies used in the project (Birmingham, Venlo), ownership and recognition of the council services (Leicester, Lleida, Murcia) and as a guarantee of quality (Moulins). The credibility of the institutions providing the information in the SMARTSPACES services were further investigated in the final staff and visitors surveys.

Did the SMARTSPACES have effects at the social-level?

As to social effects, the emergence of new social groups was not identified by interviewees, but they highlighted that the project had strengthened internal and external networks. Building professionals also believed that the cooperation among buildings users to save energy and their interaction with energy teams had improved. Particularly in those pilot sites where an energy coach was available, such as in Bristol, Lleida and Venlo. In these pilot sites, building users communicated with the energy coach who interacted closely with the energy management teams and instructed users to implement necessary actions to reduce energy consumption. In Leicester, interviewees believed that the online forum and its discussions had empowered building users and motivated them to have more thoughtful consideration to reduce their energy use. The SMARTSPACES project developed or strengthened external networks with municipal bodies (Istanbul), community housing associations (Istanbul) and governmental departments (Belgrade).

What were the individual effects?

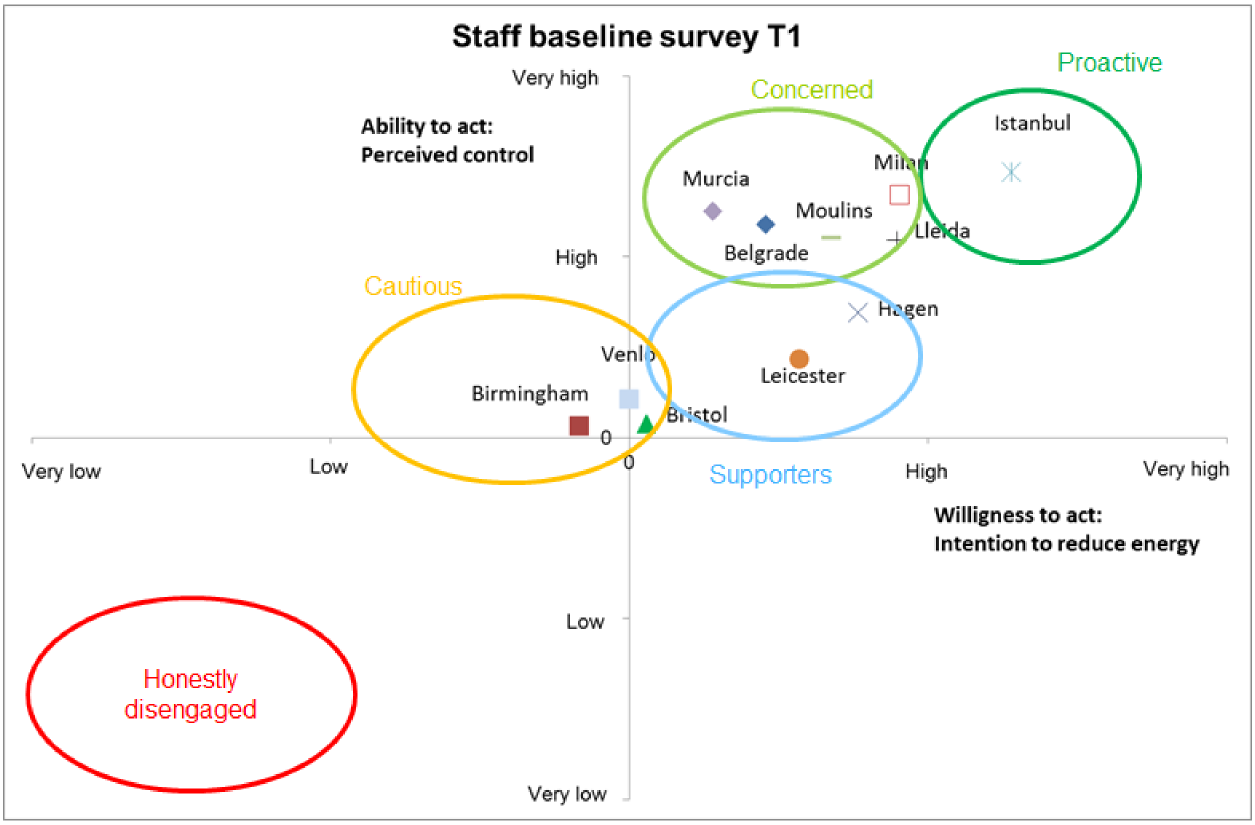
Staff and visitors were asked their views about the usefulness of the information provided by the EDSS in the final surveys. Most staff agreed that energy use in public buildings was a relevant topic for them, particularly in Lleida, Milan, Moulins and Murcia. Respondents generally agreed that the information provided by the EDSS was clear and credible as well as useful and engaging. This perception was stronger in Belgrade, Istanbul and Moulins than in other pilot sites. In other pilot sites where staff members were either neutral or slightly agreeing on the clarity or usefulness of the information, staff may have had problems visualising the data, they may have felt overwhelmed of the amount or technicality of the data or they did not have enough time to look the information. Respondents were inclined to agree that they perceived their institutions and project partners as experts and knowledgeable to provide the information. This was particularly relevant in Bristol and Murcia. As a result of using the EDSS, staff respondents in most pilot sites were inclined to agree on the likelihood to think further about energy use in their buildings or change activities in their workplace.

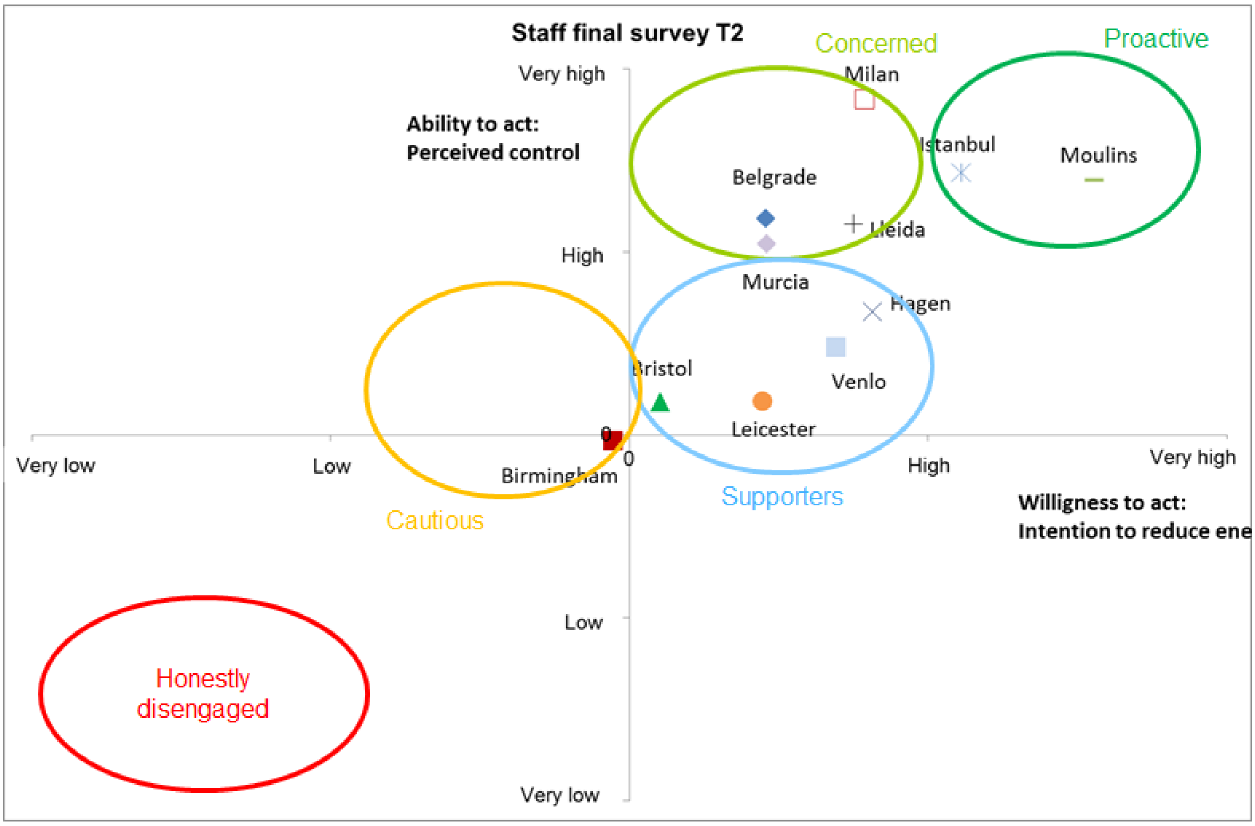
Individual-level change as a result of the implementation of the EDSS SMARTSPACES services were assessed by analysing differences in awareness, attitudes, subjective norms, perceived control, intentions and self-reported behaviours of respondents (staff members and visitors) to the baseline and final surveys.

The following figures summarise some of the most relevant trends of change at the individual-level based on a typology of behavioural segments developed by the UK Department for Environment and Rural Affairs (Defra). This typology explores pro-environmental behaviour by categorising people who are pro-environmentally aware (pro-active), those who are supportive but remain cautious in their behaviour (concerned, supporters or cautions participants), and those who are largely disengaged (honestly disengaged). These typologies were examined by plotting the pilot sites relative to their willingness to act (intention to reduce energy) and their ability to act (perceived control) for the baseline and final surveys.

Overall most of the pilot sites showed an improved trend in their ability or in their willingness to reduce energy use in their buildings or in both, attributable to increases in awareness and knowledge of their staff. After the EDSS was launched and different engagement activities took place, large improvements were observed in Venlo, Moulins (comparison of staff respondents in two different buildings) and Milan. With regard to UK pilot sites, climate and energy policies have been in place since 2008 from the Central Government to local authorities' level. Since several measures have been implemented as a result of these policies, respondents may appear to be cautious or supportive as further efforts to reduce energy use may be perceived as having to conduct radical changes in their work or personal activities. Nevertheless, small trends of improvement in respondents' ability or willingness to reduce energy use were observed in these pilot sites. In Istanbul, responses from the final survey seem more realistic when participants had better knowledge and awareness about energy use in their building through the project's communication and training activities.

Exhibit 22 – SMARTSPACES Effects





2.7.9 Dissemination and Exploitation (WP8)

Approach

Dissemination

Dissemination work and activities included regular communication activities undertaken by each consortium partner such as conferences, workshops attendance and organisation of own events, meetings, website updating, newsletters, press articles for general or professional publications for local government organisations and ICT suppliers.

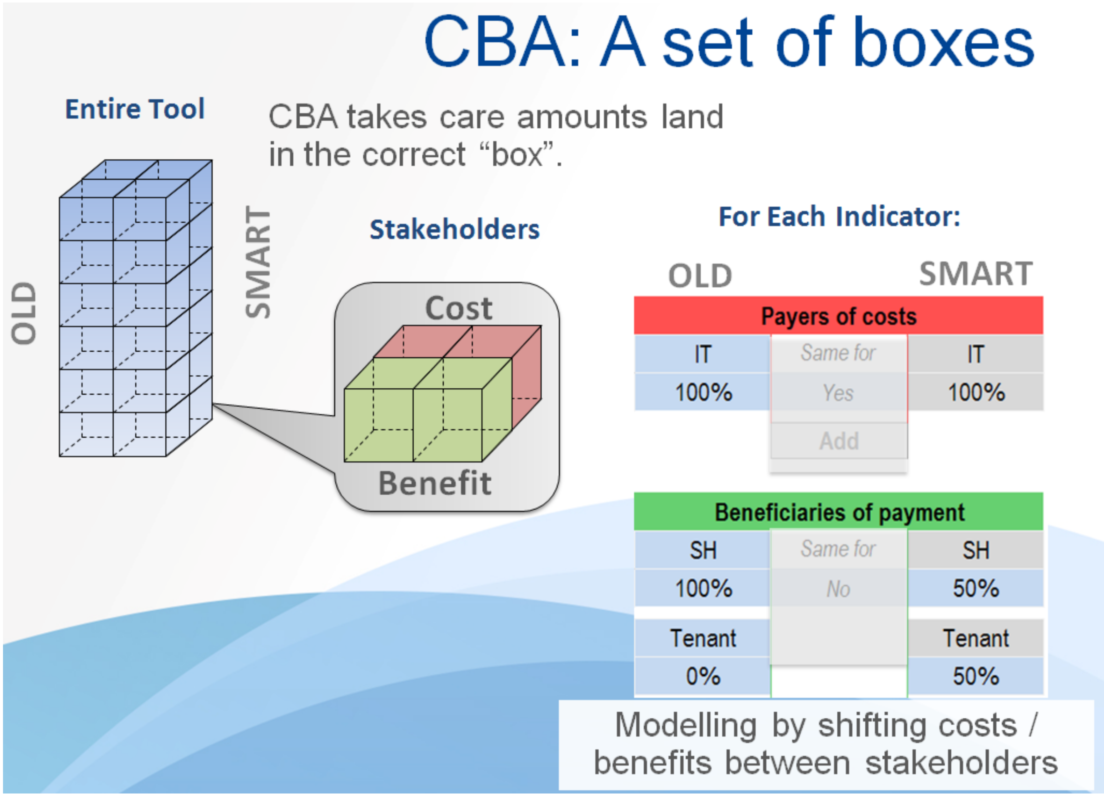
Exploitation

Exploitation was divided into qualitative and quantitative analysis. D8.3 documents the methodologies used. The EC provides guidance with regard to cost-benefit analysis of smart metering deployment in form of a 'Recommendation on preparations for the roll-out of smart metering systems' [2012/148/EU]. The recommendations were published to ensure that national assessments of smart-grids and electricity focused projects follow similar approaches.

The **qualitative analysis** of business models followed the SWOT approach. Sites were asked to answer numerous questions about strengths and weaknesses of and opportunities for and threats to the service implemented. This approach covered internal and external views onto the business case(s) at hand. To ensure that sites and partners could exchange insights, key stakeholders were described as well as numerous other terms standardised to the extent possible.

The **quantitative analysis** described a cost-benefit analysis (CBA) realised as an Excel based tool. The tool collects a wide range of indicators in the areas implementation (CAPEX), operation (OPEX) and consumption which allows to be applied to a wider range of business models as to be expected across eleven pilot sites. The CBA tool compares the 'do nothing' scenario with the intervention measures implemented in SMARTSPACES (as suggested in the reviewer and EC recommendations). The tool supports modelling deployment scenarios. The tool automatically generates various outputs in form of graphics and tables. D8.3 provides a user guide and a technical guide as well as a preliminary list of indicators.

Exhibit 23 – Cost-benefit Analysis Tool overview



Interpreting the socio-economic return ratio:
Any percentage above zero implies that the investment pays off and that for each Euro invested all investing stakeholders combined receive the according sum in Euro back. For instance, a value of 120% means that for each Euro invested the stakeholders get 1,20EUR as profit (+1 EUR for costs) back.

The following (simplified) formula describes how the result is depending on all indicators entered (i), the stakeholders (j) and the result for each year (k), which is cumulative over all years prior:

$$\frac{\sum_i^n \sum_j^s \sum_k^t b_{ijk} - \sum_i^n \sum_j^s \sum_k^t c_{ijk}}{\sum_i^n \sum_j^s \sum_k^t c_{ijk}} = Return_t$$

A more detailed explanations and formulae including depreciation can be found in deliverable D8.3. It has to be noted that overall results vary over time given that costs and benefits are not necessarily the same and can be subject of change each year. Consequently, the total socio-economic return may take different paths over years and a more detailed overview of the typical paths it can take is provided in the following sections. The graphs depicted below can be compared with the result for each individual hereby, helping to interpret the outcome.

Guide for Replication

The Guide is written using "reStructuredText" (reST). This approach ensures consistency independent of context and the repeated usage of text for different stakeholders. For instance, technical basics are available for both professionals and normal users but UML is only available for the professional.

The Guide has been developed over 5 years and is based on numerous projects including over 35 pilot sites. The content is continuously being updated and has been featured by several prominent energy associations including EnergyCities and Eurocities. For key steps of the development visit the Changelog.

New in version 3.0.0:

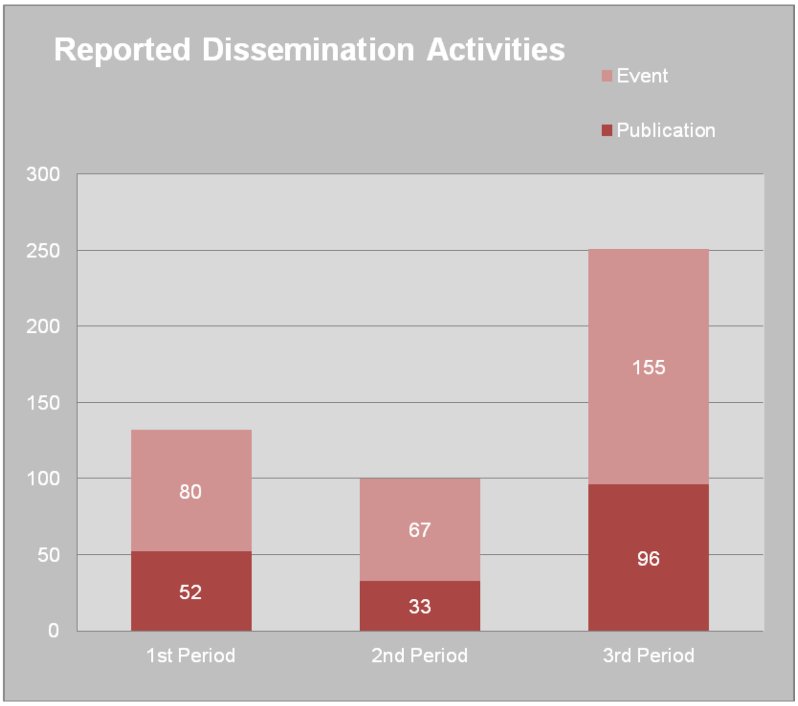
- Guide completely re-written and re-structured
- Guide made available as online documentation
- Guide extended phase view with stakeholder-specific view on replication
- Guide opened for other projects and all ICT-PSP projects invited with provision of at template for project and pilots
- Integration of non-residential projects
- Standardisation of technical documentation for residential and non-residential buildings

Overview of significant results

Dissemination

The dissemination activities of the project and project partners are described in detail in D8.4.

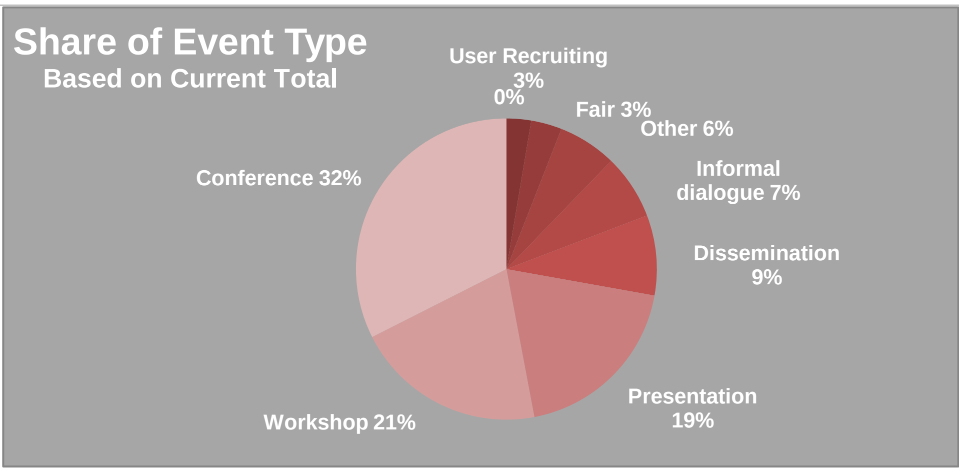
The table above does *not* include events and materials distributed which were designed for the staff and user training.



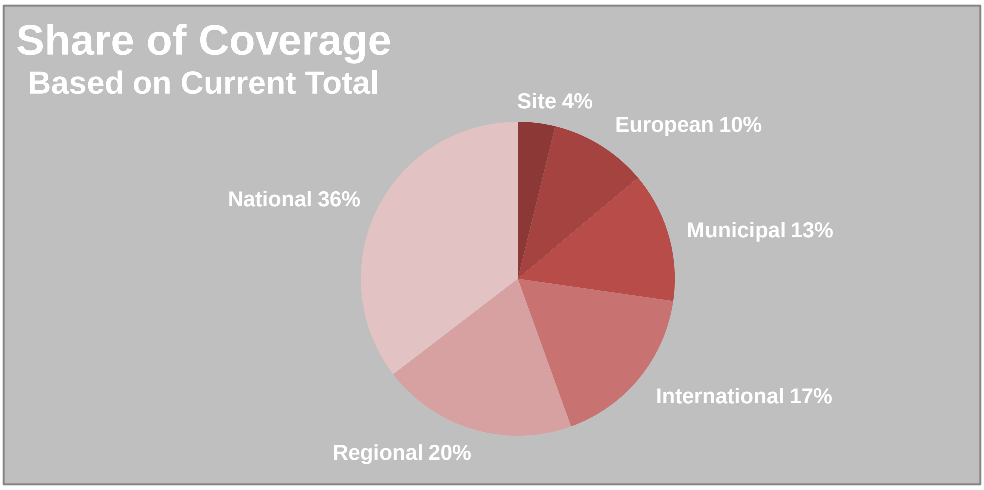
Within the events, mostly conferences (32 %), workshops (21 %) and presentations (19 %) took place. High numbers in these areas may be a result of intensive regional, national and international dissemination activities in the recent strongest reporting period as figure 4 shows. The international coverage became more than six times higher in the 3rd period (52) compared to the 1st period (8) where a stronger focus was - in line with the respective project status - set to site activities whereas in the 3rd year the focus was enlarged and a wider audience targeted. In the 2nd period numbers of events levels are balanced.

Coverage	1st Period	2nd Period	3rd Period	Total
Site	27	15	12	**54**
Municipal	8	13	28	**49**
International	8	21	52	**81**

Regional	20	12	42	**74**
European	34	17	34	**85**
National	34	18	74	**126**
Total	**131**	**96**	**242**	**469**



In the course of the third reporting period, almost 100 publications are counted and around 150 events took place. The numbers show strong efforts of all partners to raise awareness and present results and benefits of the SMARTSPACES project in the third reporting period since more than 50 % of the total events were held in the third phase. Compared to period 1 and 2, this last period was about disseminating results and successes. Thereby, efforts on a regional, national and international coverage came into focus whereby site coverage receded into the background.



Exploitation

Project Recommendations

To avoid repetition, recommendations were divided in policy levels starting on European and National level. City councils and building operators are addressed along with all market players. Since the choice of a business model also changes the applicability of (dis)incentives, other stakeholders are not addressed directly. (This is all done to increase the quality of the argument whilst being able to avoid repetitions and / or having to induce clauses such as if, when, etc.).

The recommendations are part of chapter 4.

Total net benefits after 10 years generated by project

The following table collects the net benefits for the zones equipped as part of the project. For both, the calculations are based on 10 years of operation assuming one additional year of implementation. The values are net present value corrected by 5% yearly (a rather high value given the current interest rates).

Net benefits in 1,000EUR after 10 years of operation	Belgrade	Birmingham*	Bristol*	Hagen	Istanbul°	Leicester*	Lleida**	Milan	Moulins	Murcia	Venlo
SMARTSPACES project	1,540	588	2.883	622	*97*	2,256	32	85.3	4.5	519	~0***

** Conversion rate applied for UK: 1.20; **Deployment of medium service alone*
****The solution is cost-neutral. Any residual values can change with price fluctuations etc. (see below).*
°Resource price volatility simplified.

Guide for replication:

The complete Guide can be found online under www.guide.smartspaces.eu or as part of the document and can be found in the ANNEX.

The 'Guide for Replication' presents how Information and Communication Technologies (ICT) can be utilised to improve energy efficiency (EE) in non-residential and residential buildings.

The Guide is interactive and the content dynamic dependent on the requirements / preferences of the reader. Any interactive content (e.g. video, portals) available from projects is embedded in the Guide.

The reader can follow the Guide following the necessary Phases or from the viewpoint of individual Stakeholders. Setting the Scene explains technical basics and the different concepts in more detail. Phases distinct necessary steps for successful development, implementation and operation. Stakeholders chapters selectively include content relevant for the stakeholder in question. Checklists and key lessons learnt are highlighted and introduced in context. This includes the References to specific projects and pilot sites for which detail including live portals and videos are provided. Comprehensive checklist, glossaries, tools for download etc. are collected also in the Technical Documentation and in the Annex.

2.8 Pilot sites

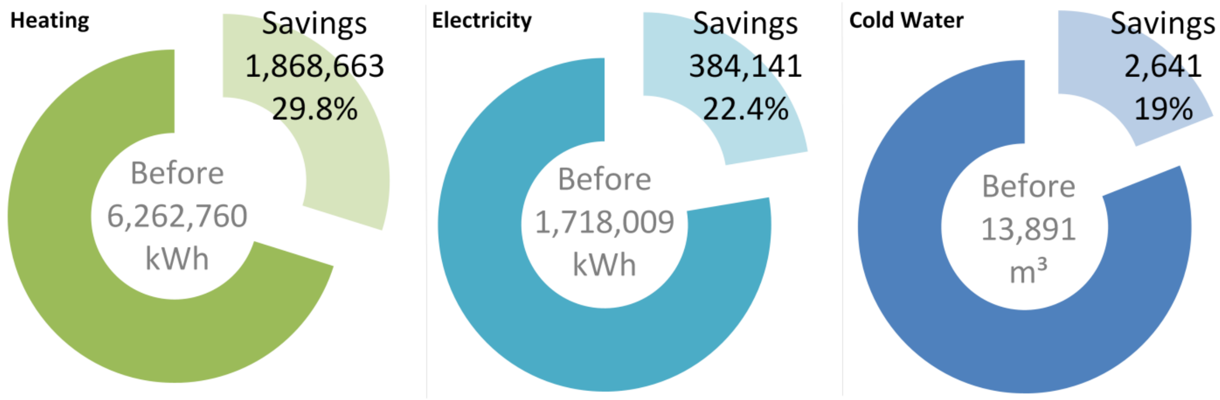
2.8.1 Summary of pilot results

All pilot sites successfully implemented the services while learning valuable lessons in the process as well as from each other. All staff and professionals of all sites have the possibility to access the SMARTSPACES service and the continuity of SMARTSPACES services is guaranteed. In fact, most sites have already deployed the solution to other sites or are planning to do so in the next years.

2.8.2 Belgrade (Serbia)

University of Belgrade (MEB)		JKP Beogradskeelektrane (BEOELEK)	BELIT
Buildings	2	Surface	26,057m²
Age	1960	Services	EDSS, EMS
Building Type	Administration	Resources covered	

Users	Staff	>1,800	Administrative Personnel
	Professionals	>22	Facility Managers
	Visitors	>60,000 / month(62941 in September 2014, 69928 in October 2014, 67334 in November 2014, 79125 in December 2014)	Various



Large savings were achieved for heating (29.8%), electricity (22.4%) and water (19%) consumption in the City Administration Complex. These savings were a result of physical building changes and behavioural change. Physical changes included installation of new burners and a regulating system for combustion through control of O_2 in flue gases, and the installation of a SCADA system for heat energy consumption monitoring. As to behavioural change, the recently elected City Government attempted to reduce energy costs to the minimum, therefore, drastic measures for energy saving were taken, such as decreasing the heating to a minimum level and controlling the switching on and off the lights. Whilst this was effective at reducing energy consumption, it caused some difficulties with the building user survey, with many users unwilling to complete the final survey due to insufficient time.

Further to the savings achieved in the project, annual savings of 15% for heating, 12 % for electricity and 15% for water are expected to continue as a result of the improved control of energy consumption in the building through the automated and centralised collection of energy data and the increased awareness of staff that their behaviour can influence significantly the savings capabilities.

Pilot Overview

The pilot site includes two buildings in which most of the administration of the city of Belgrade authorities is based. There are 1800 permanent employees, security workers and building staff. There are about 60,000 visitors per month, who also use the building's resources. There are about 1,500 computers, 900 IP telephones and 500 printers, numerous servers and the other equipment installed, necessary for their operation (UPS, electricity generators, and others).

The collaboration of public sector and utility companies in Belgrade has been very good for decades due to the fact that the utility companies have been founded and governed by the city authorities. In addition, the service provider and the University also have remarkable and successful collaboration with the Belgrade utility companies during the last 20 years.

Service summary

The service is available through smartspaces.eu as part of the pilot site description together with a video.

EMS– service description

All SMARTSPACES service components are assessed against a selection of the buildings in public occupancy in Belgrade and viable components taken on to pilot. The implemented EDSS and EMS services enables different types of users (building energy managers, staff members working in the building, visitors) to get information on consumption of the resources of the buildings, followed by numerous information on most effective methods how to use them more efficiently. This also includes the proper approach taken by the Belgrade site SMARTSPACES partners to make aware end users of their competence and power to act towards increased efficiency when using the resources. The approach also includes workshops, lecturing, distributing printed materials, choosing proper equipment for resources use control and others.

Through the developed services the building energy managers have at their disposal all necessary data on consumption of resources in these buildings. These services also enable energy managers, being on line connected to the Faculty of Mechanical Engineering, to get information on optimal savings of resources.

EDSS– service description

EDSS services are implemented in order to provide consumption data, along with some educational material to the building staff, professionals and visitors. This is done in order to achieve a certain level of awareness among users. Services were presented to the users via different media to satisfy their needs and to try to correct their behaviour in order to achieve energy saving on pilot location.

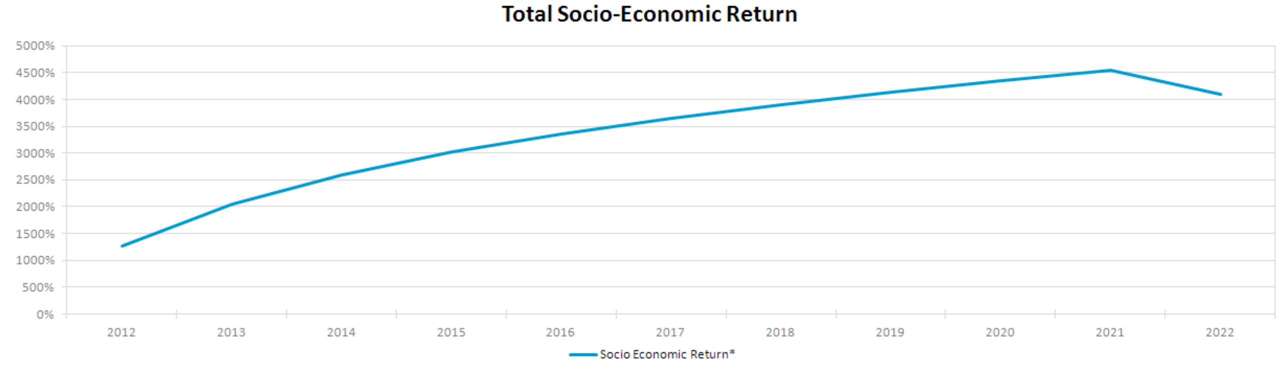
A Web portal has been implemented for all three groups of users. The portal has a public area with a lot of educational materials, information about consumption visualised for the non-professional group of users. Other parts of the portal are restricted and only registered users can approach that part of portal after an authentication and authorization process. The city government is responsible for the authorization and user activation process.

Info desk with touch screen display are placed in the lobby and in some corridors. On that media, visitors and building staff are able to find consumption data and educational material.

On the info desks, placed in the lobbies, visitors can find valuable information about energy efficiency and they can take a quiz/questionnaire in order to check their level of knowledge and to learn something new about efficient use of energy in their homes, which can help them to save a significant amount of money.

Quantitative Analysis (CBA)

The SMARTSPACES project has a positive socio-economic return paying off immediately (even if the consumption savings were lower) due to the high consumption of the buildings. All cost and benefits are covered by the *Council*, the *Energy* provider supplies the energy manager advising staff and professionals on how best to utilise the information gathered by the service. Without question, the buildings at the pilot are exceptional in size and consumption. Nevertheless, the analysis shows that a deployment of ICT-enabled services in similar buildings is beneficial for the public body.



* Stakeholders included in the Graph: , Council, Energy, IT. Discount Rates applied on Baseline for return on investment (e.g. equipment, operation): 5%, for intangible indicators (e.g. societal, non-financial): 3.5%.

Value Propositions

Professionals have, for the first time, opportunity to monitor and understand their building over time using the portal instead of running it on a “flat rate” setting to either avoid and complaints of comfort or to comply with expense limits set by the local government (see threats). The coaching service provided by MEB helped professional and staff users to optimise their energy consumption behaviour and understand the consequences of action on other rooms. A kiosk system in SMARTSPACES design was located in the entry hall of each building and the logging shows that the portal is being used several thousand times every month by visitors of the buildings. The kiosks are signs of transparency and education for the general public which has positively rated the usability and information provided. The complexity of the portal can quickly be adjusted depending on the expertise of the user which allows the team to provide the active ‘champions’ with additional information.

Future Exploitation

Based on the meetings organised with city governments of Belgrade and some other municipalities in Serbia, SMARTSPACES project should have a bright future. Currently, there are no comparable solutions in Serbia. Pilot locations that were operated during the project time showed great potential for energy, thus money savings. Replication will probably start in the city of Belgrade. Furthermore there is a strategy which includes an organisation named ‘Standing Conference of Cities and Municipalities’, which represent possibility of creation one cloud SMARTSPACES solution which will be online available to smaller cities and municipalities with fewer buildings. This is primarily because of the small budgets of the smaller cities and municipalities.

Furthermore, we already had some negotiations with neighbour countries regarding SMARTSPACES replication. Most concrete conversations during the past period were with Bosnia and Republika Srpska and cities like Banja Luka.

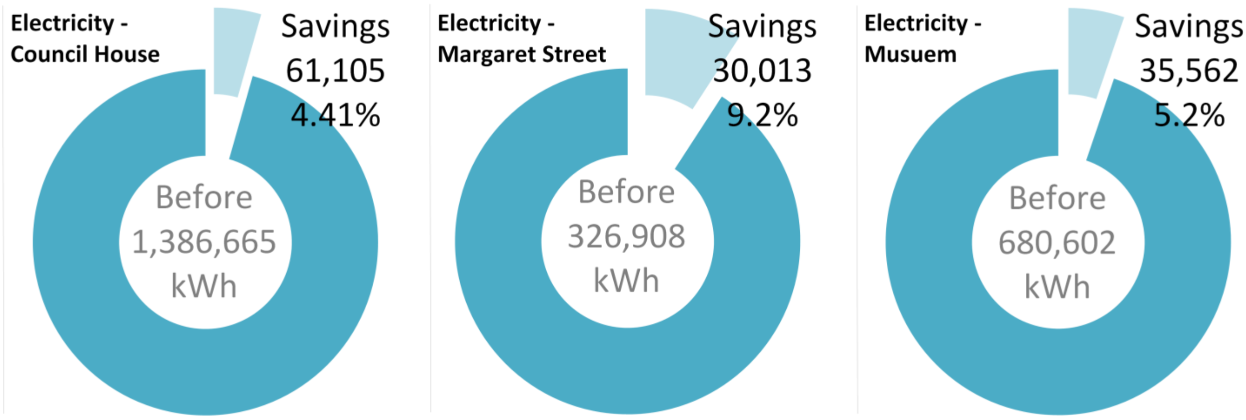
Selected publicity achievement

A SMARTSPACES meeting in Belgrade on 4 and 5 September 2012 was covered by several media institutions, including the **Serbian national TV**. One highlight was the attendance of Dejan Vasovic, the third major of Belgrade, who emphasised the relevance of SMARTSPACES for the green and technological agenda of Belgrade.

2.8.3 Birmingham

Birmingham City Council

Buildings	3	Surface	58,928m^2
Age	140 years	Services	EDSS, EMS
Building Type	Administration, Museum	Resources covered	
Users – Staff	>500	Division Heads, ACIVICO, Building Managers, City Council Officers, Staff, Building Users & Contractor staff	
Users – Professionals	>10	Directorate Heads, ACIVICO, Energy Managers, Professionals (i.e. Schneider Electric).	
Users – Visitors	>2,000	Various	



On average, electricity savings in Birmingham were 5.3% mainly due to the movement of staff with the largest savings achieved in the Margaret Street building (9.2%) where the number of staff based onsite decreased due to the council's attempt to rationalise the number of administrative buildings on its portfolio. Less savings than expected were achieved in the Council House, which was partially occupied during the baseline period and went to full occupancy in the monitoring period. Although the Council House benefited from the installation of a number of interventions on the staff offices such as LED sensor lighting for example, the increased number of users and their associated equipment (laptops, PCs, etc.) had an impact on the energy consumed and therefore the savings achieved.

As a direct result of Birmingham's participation in acquiring the data, knowledge and resources to deliver the SMARTSPACES project, the Birmingham Utilities Strategy was developed and has been agreed and approved by key senior management. This strategy sets out clear objectives to control and minimise heat, cooling, electricity and water in a cost effective manner and to obtain these utilities from renewable sources among others. As a result of the strategic and operational interventions currently functioning in the city, it is anticipated that the electricity savings of an average 6% will continue and gradually increase.

Pilot Overview

Birmingham City Council has the aim of reducing its carbon footprint by 60% by 2026 based on its 1990 baseline. The Council is also required to cope with the introduction of the ‘carbon tax’ (the UK’s carbon reduction commitment) by the Government and deliver required data. It is also working with social landlords and householders to offer energy efficiency measures in domestic buildings. Although SMARTSPACES develops technology in public buildings, its solutions can potentially be used in a domestic context – in particular awareness raising actions.

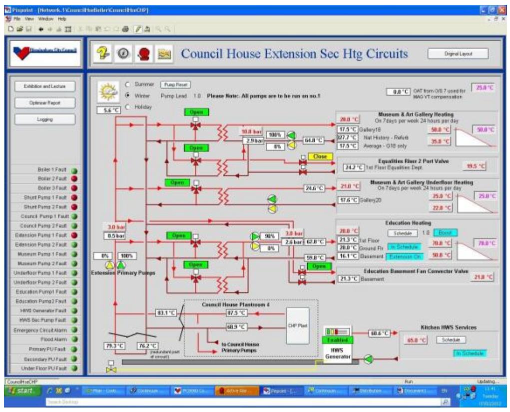
For SMARTSPACES Birmingham City Council selected several buildings for piloting the EDSS and EMS services. These included the Council House (plus a smaller ‘extension’ Margaret Street building) and Birmingham Museum & Art Gallery which both represent big buildings with a high resource consumption that offered many challenges regarding the existing installations, number of rooms, building age and the various user groups within. The Council House was already using a display screen in the public area to announce meetings etc, and a dedicated screen was installed to show the SMARTSPACES energy information.

Service summary

The service is available through smartspaces.eu as part of the pilot site description together with a video.

EMS– service description

Building Managers and Energy Managers previously received data in the form of bill statements about the actual gas and electricity consumption. The Building management systems were already in place but the delivery and display of real-time data was insufficient. SMARTSPACES helped to improve the information available, making it easy to request, easy to display in customised formats and more accessible through various channels (e.g. web-based, usable on mobile devices). The Council was required to meter sites over 100 KW usage half hourly by law and from 6th April 2014 AMR’s become mandatory for larger sites for both electricity (profile 5 to 8 – non domestic customers whose meters have a register system to record maximum demand) and gas (732 megawatt hours per annum) which provided an increased number of readings. The new data streams were fed into the existing BEMS (building energy management system). The pilot was used to explore how data could be integrated into the existing system. The additional readings are analysed and new intelligence is provided to the managers with a view to enabling corrective action.

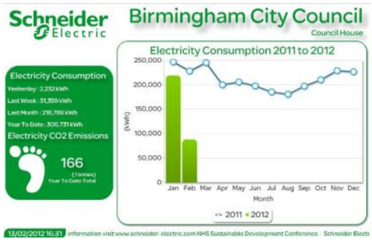


Collection of real-time energy consumption data enables generation of visualised consumption patterns for the public, staff members working in the building and building professionals through the SMARTSPACES EDSS – Energy Decision Support Service. These are displayed in the buildings and over the internet to raise awareness. Another aim was to publish this data as public open data as part of Birmingham's open data drive and now available through the SMARTSPACES portal for Birmingham at www.EnergySmartBirmingham.com as well as being published through the regions West Midlands Open Data Portal https://data.birmingham.gov.uk/. The project helped to link the new data display to behaviour change action with officers and the public for example through competitions, staff communication and displays at events.

Energy Managers are now in a better and more informed position to inform and support Building Managers of high consuming buildings in a more proactive way which enables them to work together to explore and identify supporting and behavioural measures to support energy reduction activities in their building.

EDSS– service description

Over 40% of Birmingham's carbon emissions is produced by schools – they tend to have big LED screens, pc's in most classrooms, manually operated light switches & electrical sockets, IWB's, etc. which all consume a lot of energy). The SMARTSPACES project has the opportunity to collaborate with The Carbon Trust, whom facilitate engagement with site staff (caretakers, site managers, bursars, etc.) and run Awareness Raising Workshops for the schools on Carbon & Energy Saving. There are currently 100 schools participating in the programme and of those 100, Phase 2 will include 26 schools participating in the Green New Deal (research indicates that also participating in the Green New Deal will push Schools energy savings from 15% to 40%).

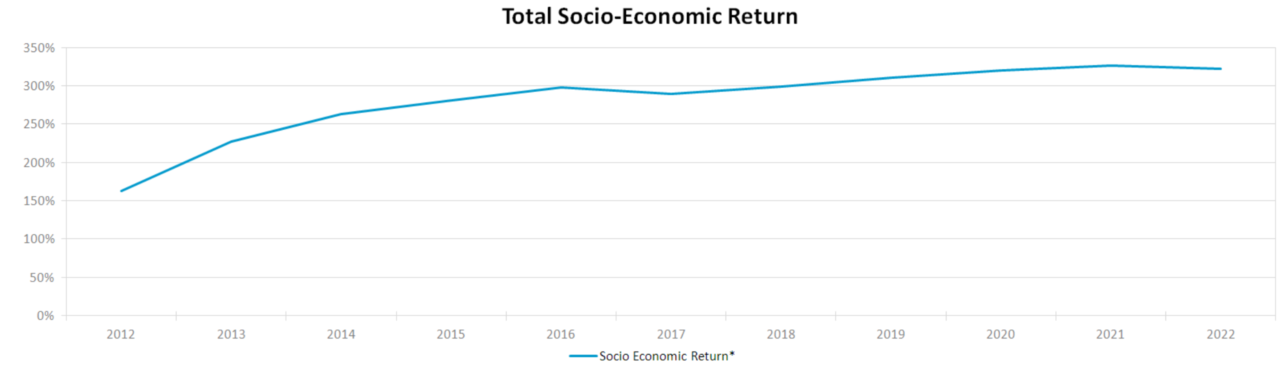


Therefore we were keen to ensure we had the ability to replicate key messages and practical advice applications could be easily transferred to School environments.

Visitor concept and impact outside of pilot buildings: Screen-savers to push out key messages, but these messages needed to be kept simple but engaging – therefore icon/image-driven and relevant e.g. The Council House consumed 1,234 kWh this month compared to 4,567 kWh this month and self-generated 345 kWh of electricity this month and therefore contributed 0.4 % towards Birmingham's Carbon reduction target of 60%.

Quantitative Analysis (CBA)

The SMARTSPACES project has a positive socio-economic return paying off immediately. Some of the metering is already in place (due to regulation) and additional cost result from sub-metering. Hence, the entrance barrier for basic service provision is already taken by many other buildings in Birmingham and other cities. The decision for additional metering is likely to pay off for large consumers or buildings where wastage results in large losses (e.g. old buildings). The business model for the site is simple as it is based on hardware acquisition and fees paid for service access whilst the energy management is operated by a specialised unit within the municipality.



* Stakeholders included in the Graph: Department, Council, Energy, Measure, IT, FreeRole. Discount Rates applied on Baseline for return on investment (e.g. equipment, operation): 5%, for intangible indicators (e.g. societal, non-financial): 3.5%.

Value Propositions

Through SMARTSPACES city Councils are able to optimise the process of investigating any energy saving potential and improve the consumption of a wide range of buildings, all requiring little IT knowledge whilst providing reports following guidelines. The process not only brought a technological approach to energy saving but was also able to put a corporately recognised system in place.

The investigative part of the process utilised all kind of existing information such as existing AMRs and sensors as well as re-usable data loggers to increase the resolution for analysis. All data is collected in one portal and the data sets are provided under an Open Government Licence. The key staff are effective in recruiting champions on-site who disseminate the results available online and on display on screens in the pilot site buildings (which follow DECC guidelines for the display of energy performance in public buildings). This includes the raising awareness to energy decision support/behavioural changes which can be applied at the pilot sites as well as at home.

Future Exploitation

As a result of the successful implementation of the SMARTSPACES Service, Birmingham is now able to explore how the newly generated data can be integrated into the existing building management system, particularly in relation to load and lighting management. The SMARTSPACES initiative has also proved to be a key driver to affecting behavioural change and in turn has helped to reduce energy consumption in the three pilot sites. Such is the success of SMARTSPACES and Birmingham's commitment to the Government's Open Data drive, its rollout has been extended to include an additional 40 Birmingham City Council buildings, which have been added to the service and feature on www.EnergySmartBirmingham.com (Birmingham's local SMARTSPACES portal).

Created by Birmingham's Smart City Commission, the publication of the Roadmap to a Smarter City provides a framework to demonstrate leadership and facilitate cooperation with citywide partners in the development of our City. This work is being coordinated by Birmingham's SmartGreen Commission. It is also essential that the City drives down their carbon dioxide (CO2) emissions so that it contributes to the national and global effort to tackle climate change. The development of a Birmingham Carbon Roadmap will also assist with this challenge, which will be co-ordinated by Birmingham's Green Commission..

The ICT-enabled solutions including the data portal, public data availability and the energy analysis is being run by Stark International and Schneider Electric. The City will continue to exploit the success of the SMARTSPACES service and look at to implementation across Birmingham's building portfolio with a view to engaging citizens and communities through Birmingham's Energy Savers programme.

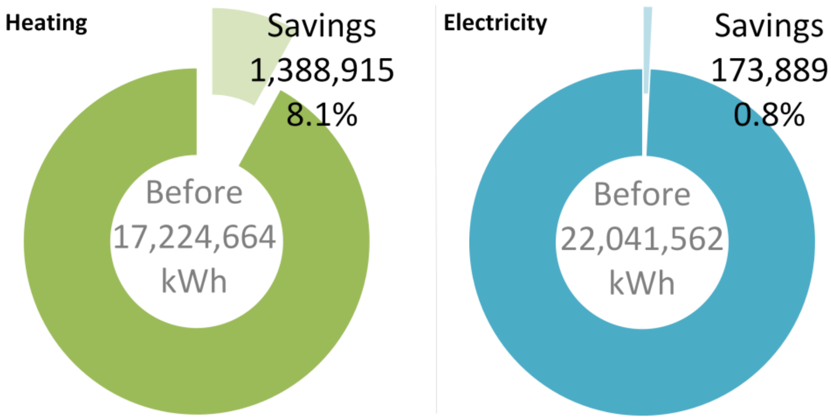
Selected publicity achievement

Climate Challenge Conference 2014

The SMARTSPACES pilot site Birmingham attended besides the other UK pilot sites Leicester and Bristol the engaging **Climate Challenge 2014** conference at Millennium Point on 3 and 4 March 2014 to showcase their respective EDSS platforms. The programme was truly international with presenters and around 1000 visitors from close to home in Europe to far off shores of China. SMARTSPACES was in good company amongst the inspirational exhibitors which showcased products, projects and programmes; demonstrating developments and promoting business, societal and cultural opportunities.

2.8.4 Bristol

Bristol City Council			SystemsLink	
Buildings		458	Average Surface	1,500m^2
Average Age		Unknown	Services	EDSS, EMS
Building Type		Numerous (see D7.2 for full detail)	Resources covered	
Users	Staff	6,000	'Core' building / offices vs. 'Non-core' schools / museums / etc.	
	Professionals	10	Directly related to their job	
	Visitors	>1,000,000	Various	



Bristol was the largest of the pilots with over 400 buildings including council's offices, children's homes, schools, nurseries, depots, museums, cemeteries, libraries, youth centres, hostels and community centres among others. Within this large building portfolio, three main types of building categories were identified: schools, facilities managed centrally by Bristol City Council (FM) and small locally managed single-team buildings (general).

The small savings in electricity control can be entirely attributed to the schools category. Electricity use in schools rises year-on-year due to increased use of ICT and other educational equipment. However, the larger gas savings can also be attributed to schools and the small locally managed buildings because building professionals have the ability to adjust timers and settings of the heating systems. However, in the centrally managed facilities they have little control over the buildings' gas use and also little engagement and ownership of energy savings as the bills are centrally paid.

The behaviour change responses could not be clustered by building type due to the low numbers of survey responses in the different buildings. However, interviews pointed out that most engaged users looking at the monthly reports and communicating with the energy coach were located in school and locally controlled buildings. Nevertheless, survey respondents tend to have higher intentions to report energy saving opportunities and increased self-reported behaviour to minimise energy use after the EDSS was launched. Due to the large building portfolio managed in the project, an effective engagement with building users could only be achieved in a set of buildings after the services were launched. In forthcoming years, with ongoing user engagement and without any change of use it can be expected savings of around 5% for electricity and 10% for heating.

Pilot Overview

Bristol site has 450 buildings in the SMARTSPACES project. These vary in age, size, construction method, usage, occupancy, and degree of central control. Because of this variance, there will be different SMARTSPACES services supplied to different buildings – with fuller services applied to buildings with higher energy consumption and higher degree of central control. There are over 11,000 staff involved in the project.

Bristol City Council has a long-term plan on carbon emissions in accordance with the CRC (Carbon Reduction Commitment) Energy Efficiency Scheme, which started life as carbon trading but has currently been modified to be a kind of carbon tax at £12/tonne CO_2 (rising to £16/tonne in 2014/15). Public buildings have to be the focus, as 75% of a total of around 56,650 tonnes comes from our building stock. This can be broken down by building type with the largest users being schools (42%) and corporate buildings (36%). The local authority has to pay for each tonne of carbon it uses and also for each public school that is in its area, even those it is not in direct control of.

Service summary

The service is available through smartspaces.eu as part of the pilot site description together with a video.

EMS– service description

Two key issues for building and energy professionals are determining what levels of consumption are considered problematic, and gaining swift notification when this occurs. The EMS profile alerts service addresses both of these issues.

Energy management software intelligently determines the tolerance boundaries for a building, using a variety of factors including previous consumption trends, building occupancy and type, and bank holidays. Where data values deviate outside of this, the building manager can be notified by an automatic email. The tolerance levels can be changed to make this system more or less sensitive, and other checks can also be carried out including for missing data and absolute maximum values.

The focus for CEMS is on remote control, rather than automatic. This is due to the nature of “Day plus one” recording, and the set-up of existing BMS and other energy management systems in the council’s buildings. Alerts notify the Energy Management Unit and the BMS operative to allow them to make remote changes to the building’s set-up.

At a local level, building managers receive information allowing them to make changes to the building’s set-up. Feedback from building managers also improves target-setting. Analysis of individual buildings’ data can determine which ones show unusual levels of consumption in peak periods, and investigative actions can be taken. Profile alerts are also triggered if a building's consumption in peak periods is outside of its normal consumption for that period

Improved software, and installation of AMR meters allows effective operation and accurate data collection from renewable energy sources, in particular biomass boilers and solar PV panels.

EDSS– service description

SystemsLink is the system that is used to house all this data which for the 450 properties is in the order of 18 million bits of information every year. SystemsLink has further integrated and developed their system to enable Bristol City Council's energy data to be analysed intelligently and provide feedback to allow energy savings to be made more promptly. Accordingly, data is analysed centrally by the energy management unit in addition to appointed and trained energy users at a building or department level (depending on the hierarchy within controllers of buildings). The information provided prompts action either locally at the individual building level or centrally at the energy management unit/BMS manager level.

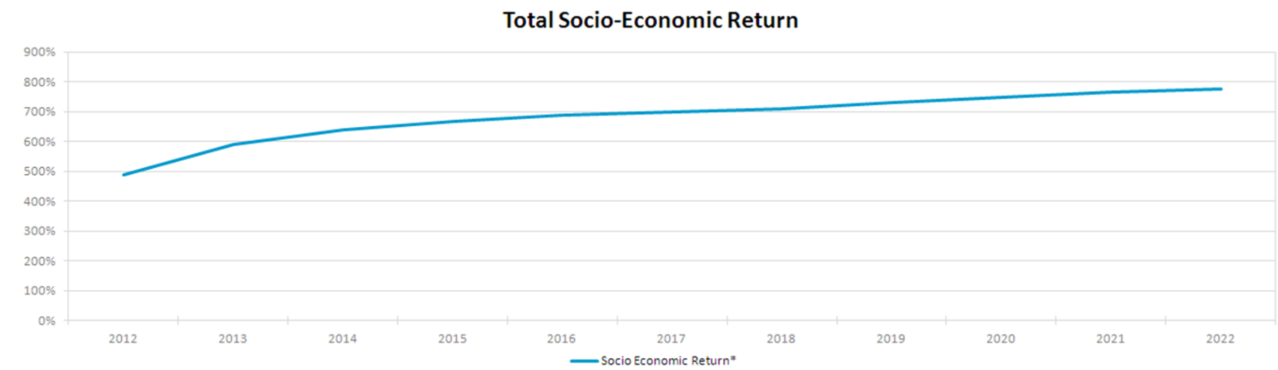
EDSS services are implemented in order to provide consumption data, along with some educational material to the building staff, professionals and visitors. This is done in order to achieve a certain level of awareness among users. Services were presented to the users via different media to satisfy their needs and to try to correct their behaviour in order to achieve energy savings.

Building Managers are encouraged to print out and display the Monthly SMARTSPACES reports, to allow visitors to engage with these, and learn more about energy consumption in the building they are visiting. For some larger buildings, there is still an ambition to have display screens with real-time energy data, though this has not yet been achieved.

Furthermore, there are two open data web portals run by Bristol City Council which contain further information on the Council's energy consumption: both at an individual building level and aggregated data.

Quantitative Analysis (CBA)

The SMARTSPACES project has a positive socio-economic return paying off immediately. As the majority of infrastructure is already in place, hardly any implementation cost occurs. Hence, SMARTSPACES utilises existing hardware against comparatively low implementation cost and fee increase. The 'Do-Nothing' scenario applied takes declining consumption into account. The clear relationship between *Department* and *IT-provider* can easily be replicated. Since many cities in the UK are to deploy smart meters, Bristol, the current European Green Capital, can work as model smart city with respect to ICT-enabled energy saving and further innovation might be triggered applying big data analysis.



* Stakeholders included in the Graph: Department, IT. Discount Rates applied on Baseline for return on investment (e.g. equipment, operation): 5%, for intangible indicators (e.g. societal, non-financial): 3.5%.

Value Propositions

The major focus of the SMARTSPACES service in Bristol has been to convert massive quantities of raw energy data into formats that are usable for a wide variety of end users. This has allowed staff across the council to visualise their energy usage, and easily pick up on energy wastage and poor performance. This in turn has greatly reduced the time windows between issues occurring and action being taken, resulting in lower energy consumption and usage. Furthermore, it has allowed the Energy team to identify and concentrate their efforts on the most serious problems and those with highest payback solutions. As an added bonus, the SMARTSPACES project – in particular the Energy Coach function – has resulted in better communication and the building of relationships between the Energy team and the rest of the council.

The solution was designed with local authorities and other organisations with large property portfolios in mind. The fact that the SMARTSPACES service has been rigorously tested on a large and diverse portfolio, with proven results at case study level, means that we are confident in its continued usage across the council and beyond.

Another major strength of the SMARTSPACES service is the breadth of tools available, from quarterly budget reports, to next-day alerts and 24/7 at-a-glance dashboard. This also means that it is accessible to a wide range of users: including ordinary staff, energy champions, caretakers, finance officers and senior management as well as energy professionals.

Future Exploitation

As part of the development of SMARTSPACES a number of modifications have been made to SystemsLink Energy Manager to allow its successful deployment. These have provided wider benefits to users across the client base. Additionally, in recent months we have been engaging with the client base on a wider basis, which has allowed us to review their requirements in more detail. This has allowed us to begin preparing the deployment to other users with a better foundation.

The existing SystemsLink clients are the initial target market, through purchasing an add-on to the Energy Manager software. The attraction of SMARTSPACES should also help attract new clients in the UK to the SystemsLink suite of products.

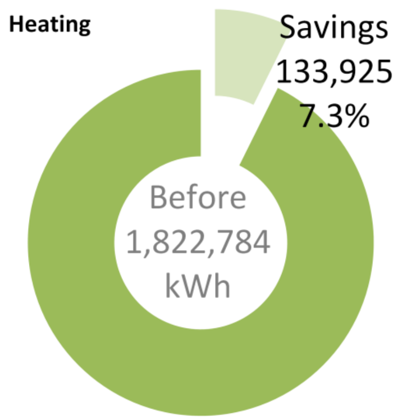
Bristol City Council is to setting up an Energy Service Company (ESCO) to supply a breadth of energy services, including demand reduction through SMARTSPACES tools, to other organisations.

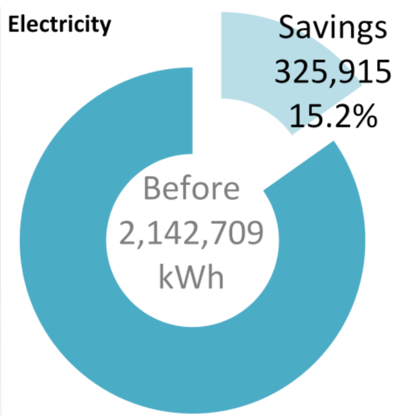
Selected publicity achievement

SMARTSPACES energy monitoring system in municipal buildings by Bristol City Energy Services in the UK as part of a European initiative implemented in 11 cities has been named a **“Project to Watch” by the United Nations’ Big Data Climate Challenge**. The Big Data Climate Challenge, hosted by UN Global Pulse and the Secretary-General’s Climate Change Support Team, aims to unearth data-driven climate solutions and evidence of the economic dimensions of climate change.

2.8.5 Hagen

STADT HAGEN City of Hagen (Hagen)			envi GmbH	
	Buildings	2	Surface	33,300m^2
	Age	1960	Services	EDSS, EMS
	Building Type	Administration, Museum	Resources covered	
Users	Staff	>600	Office workers, Technical staff	
	Professionals	>4	Facility managers, ESCO	
	Visitors	>20,000	Various	





Electricity savings can be mainly attributed to reductions in the Emil Schumacher museum where the SMARTSPACES services had a significant impact. For the museum, heating savings were possible due to the analysis of heat and cold flows of the additional meters installed in the building during the project. This analysis aimed to implement changes in the building control system to optimise the heat and cold production in heat pipes. In the Hagen City Hall, better energy management based on occupancy led to heating and electricity reductions. The energy analysis clearly showed the effects of Christmas and public holidays shutdowns. Although the survey responses showed a small increase trend in the self-reported behaviour, interviews highlighted that the main recipients of the benefits of the services have been building professionals who are responsible of the energy management of these buildings. Further annual savings of 10% for electricity and 20% for heating are expected through the continuous optimisation of energy flows in the buildings and increased awareness of staff.

Pilot Overview

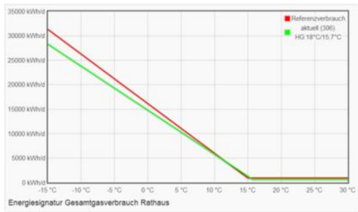
In Hagen two different types of buildings have been piloted as part of the SMARTSPACES project – a museum and Hagen's City Hall. In the museum a very complex heating and cooling technology and a powerful building control system are installed. The aim of the installed technology was the provision of heat and cold with a great part of renewable energy.

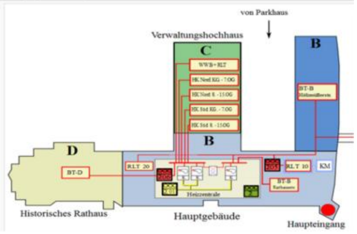
The real situation, however, proved to be different. The electrical energy demand was detected to be three times larger than predicted. After a first investigation of the technical installation it became clear that the installation is innovative and without any obvious mistakes, but the technical knowledge of the responsible staff was not sufficient to manage and optimise these complex systems.

Service summary

The service is available through smartspaces.eu as part of the pilot site description together with a video.

EMS– service description





Although we have only two buildings we have a remote reading of more than 30 heat and current meter for which visualisation is realised. For the main meter we have the usual application, showing the energy consumption in different time resolutions and can be assessed by comparison with computed values or measured values from similar buildings.

The “energy signature” summarises the daily energy consumption of parts of a building. Therewith we get an immediate response on energy saving measures. This is not only necessary to decide whether a measure was beneficial, but also for motivation of the staff.

This motivating effect was particularly to be observed in process of optimising technical devices like heat pumps or ventilators. But an assessment of a plant efficiency is often complex, so that an evaluation needs the computation of data from more than one energy meter. As an example we show on the following pages the application for the assessment of heat pumps.

This application enables us to create automatic efficiency alarms. The automatic alarm signals were very important to raise the efficiency of the work of the professionals. Instead of manual inspection of the energy demand they could concentrate their work on optimization.

The optimisation cannot be done only by knowing the results for efficiency or energy consumption. Therefore we present all results in the context to the use and function. The more the professional knows about the needs of the user or technical relations the greater will be the chance to detect saving potentials. This additional information was given in form of technical scheme or plan with declaration of the outfit or needed room conditions.

EDSS– service description

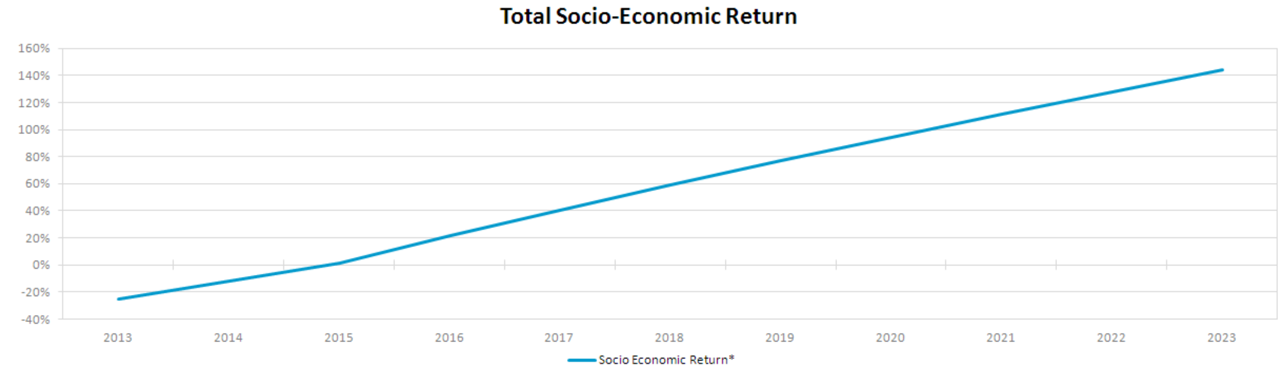
To increase the interest for the topics of smart spaces we show on two flat screens in the museum and city hall the monetary success of our project, give a very short project description and show the homepage of the city of Hagen where one can get more information about our activities.

We publish the current consumption data and give an assessment there. To show the impact of the change of heat and electricity consumption (regarding lighting or ventilation), we show the hourly consumption data for different use areas. So the office users are invited to be an active partner in the smart spaces project.

If a visitor is motivated to visit the “Aktuellen Energieberichte” (because he wants to know how we achieved such savings) he will find real examples for energy saving measures and their monetary and ecological impact. Because some of these measures can also be useful for the private environment and we further on give there additional saving tips, we will have also a positive impact on private sphere.

Quantitative Analysis (CBA)

The SMARTSPACES project has a positive socio-economic return paying off after three years of operation. As the buildings are new, the savings will occur without further investment for several decades. Due to the contracting model *Measurement* has to carry a considerable burden in financing the implementation, the payback for this stakeholder takes only four years. Without the ICT-solution, *Department* would have to continue to pay for modern but still inefficient buildings. The contracting (business) model implies considerable risks for the *Measurement* provider (ESCO) in fluctuating payback which could be reduced with larger number of buildings.



* Stakeholders included in the Graph: Department, Measure, FreeRole. Discount Rates applied on Baseline for return on investment (e.g. equipment, operation): 5%, for intangible indicators (e.g. societal, non-financial): 3,5%.

Value Propositions

Energy concepts of modern buildings are becoming increasingly complex and diverse. A good example for a building with complex technical equipment is the museum. Before SMARTSPACES the museum were operated way below the possible efficiency. This is typical for such buildings. Staff not trained, even professionals, are sometimes not capable of recognising the links between causes and effect. SMARTSPACES successfully provides the necessary information and achieved massive savings even beyond the theoretical capacity modelled in the design process. The technological ability is so developed that the service is (already) being extended to local storage and production. ESCOs provide owners of buildings a link to the expertise which designed the building. The planners are often engineers planning an “empty building in a fridge” only modelling extreme effects to make sure that the installations can deliver heat (cold etc.) when necessary. Though they do not model a building being used and regular wind shifting throughout the year, the owners loses the expertise once the building has been approved. Our ESCO provides engineers who understand the technology implemented and established this link cheaply via ICT-enabled services. The continuous observation allows for dynamic modelling based on actual values and covers the aspects the initial design could not deliver.

Our business model is based on contracting of savings (explained in more detail under ‘future exploitation’) which investors are willing to apply in highly controversial buildings such as the museum. Since this expensive building did not keep the promise of low operational cost, the media and public were not willing to invest more. The contracting model enabled the city to delay at least part of the cost.

Future Exploitation

envi, the ESCO, continue to offer our services as pure investments or in our contracting model in which we share the risk with the customer. Because the building a very different in their energy demand and technical equipment, we offer different level of services:

1. only the visualisation of energy meters,
2. visualisation extended with features to for limited control
3. full control over demand

Moreover we distinguish between cases were

a) we only provide the internet based building control system or

b) we also assist the professionals or

c) we take over the control and are responsible for reaching energy savings.

Investment cost start with 1,500 € for the most basic service. Furthermore, the effort for consulting services and system optimisation varies. Therefore we first estimate the reachable benefit: Depending on individual circumstances the saving potential reaches from 10% to 30%. We expect that at least three building will be equipped with the service on average per month.

Together with the customer we decide on the business model and estimate the investment necessary for the measuring and control equipment, to determine which of the service is suitable. On average, the costs for the ESCO are near €10,000. The cost can be fully paid with the saving achieved from the efficiency increase. For example, assuming the contract life-time of 20 years and savings of €1,000 each year, a fixed sum of €500 is reserved for the investor (which can be either party). The remaining savings – whatever sum remains – are shared with the ESCO. A regression over the years can be agreed.

Selected publicity achievement

The SMARTSPACES pilot site in Hagen took the chance to present their project during a round table discussion at the **Klima Bündnis Luxembourg**. In his presentation, Dr. Wilfried Ponischowski from envi pointed out why Hagen chose a museum and the city hall for the project, closing by mentioning the success of the project: energy savings of 30% for the museum and 10% for the city hall.

2.8.6 Istanbul

<table>
<tr><td colspan="3">SPOR A.Ş. Istanbul Sport Event Inc</td><td colspan="2">SIEMENS</td></tr>
<tr><td colspan="2">Buildings</td><td>1</td><td>Surface</td><td>22,000m²</td></tr>
<tr><td colspan="2">Average Age</td><td>2007</td><td>Services</td><td>EDSS, EMS</td></tr>
<tr><td colspan="2">Building Type</td><td>Sport centre and offices</td><td>Resources covered</td><td></td></tr>
<tr><td rowspan="3">Users</td><td>Staff</td><td>>120</td><td colspan="2">Facility staff.</td></tr>
<tr><td>Professionals</td><td>10</td><td colspan="2">Managers and subcontractors.</td></tr>
<tr><td>Visitors</td><td>>50,000</td><td colspan="2">Users of facilities</td></tr>
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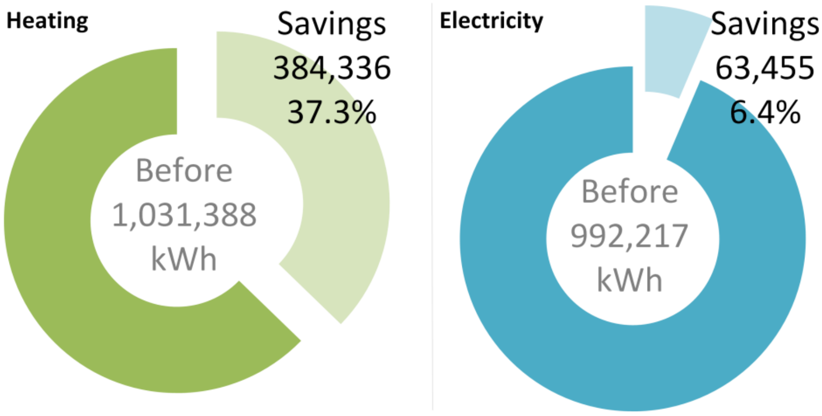


Large heating savings were achieved in Istanbul (37.3%) and electricity savings of 6.4% were estimated based on simulated data. Heating saving could be attributed to the prompt identification and solution of high energy consumption malfunctions through the monitoring and control system implemented in the project as expressed by interviewed building professionals. These interviewees perceived that staff awareness and knowledge about energy savings were low at the initial stages of the project, but increased with the SMARTSPACES services. Interviewees considered that staff and building professionals became more conscious of closing windows and doors when the air conditioning or heating services are in operation. This trend of increased awareness and self-reported behaviour to minimise energy use in the facility was also observed in the baseline and final surveys responses of the same identified staff. Ambitious energy and emissions reduction targets have been set at the institutional level that may encourage staff and the project team to conduct appropriate actions to achieve these targets.

Pilot Overview

The Fatih Sports Facility is a new building (2007) but the mechanical and architectural designs of the building are not adequately efficient. Various energy systems are being used within the building including products like chillers, lighting with semiconductor ballast, boiler systems, air conditioning centrals, swimming pool systems. As part of the SMARTSPACES project Siemens developed a system with associated services for efficiency management and building automation. The service implemented and operated in this pilot site is an EDSS – Energy Decision Support System which has been installed after a comprehensive refurbishment of the building had taken place ranging from insulation measures using valve jackets to the installation of coupling type pumps and lighting and air-conditioning automation.

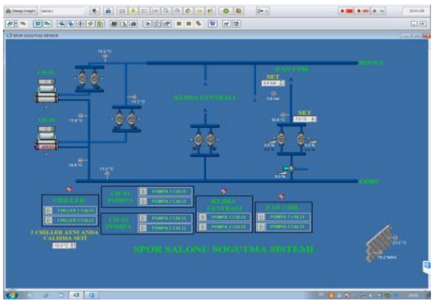
The facility's heating systems are used with natural gas and electricity whereas air conditioning and cooling systems are used with electricity. An automation system isn't used for heating, ventilation, air conditioning and lighting systems, so that energy consumption and carbon emission are increased.

Service summary

The service is available through smartspaces.eu as part of the pilot site description together with a video.

EMS– service description

In Turkey, energy efficiency measures are new and their adaptation processes are not easy. Energy managers should be supported by top management not only in a financial way but also with respect to motivation. It is inevitable to realize the implementation budgets prepared in this field and to build an Energy Management System (EN 16001).



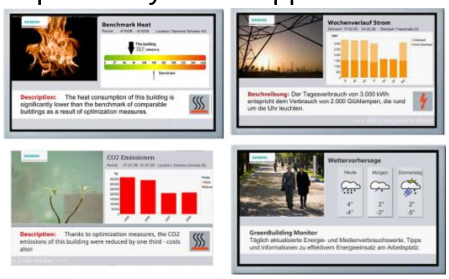
At management level, Desigo Insight provides an overall user interface for operating, monitoring, and analysing of all connected systems and plants.

At automation level, primary plants are controlled by Desigo PX and operated by PX Web via a Web client. Desigo Total Room Automation and Desigo RX also enable individually tailored solutions to provide comfort control in individual rooms plus control of lighting and shading. Desigo I/O modules provide the interfaces to actuators and sensors. The BACnet® Testing Laboratories (BTL) Mark is trademarked and its use strictly regulated.

Siemens products that have consistent compliance with EN 15232 and been successfully tested by the BACnet Testing Laboratories are eligible to display the BTL Mark as part of the listing process.

EDSS– service description

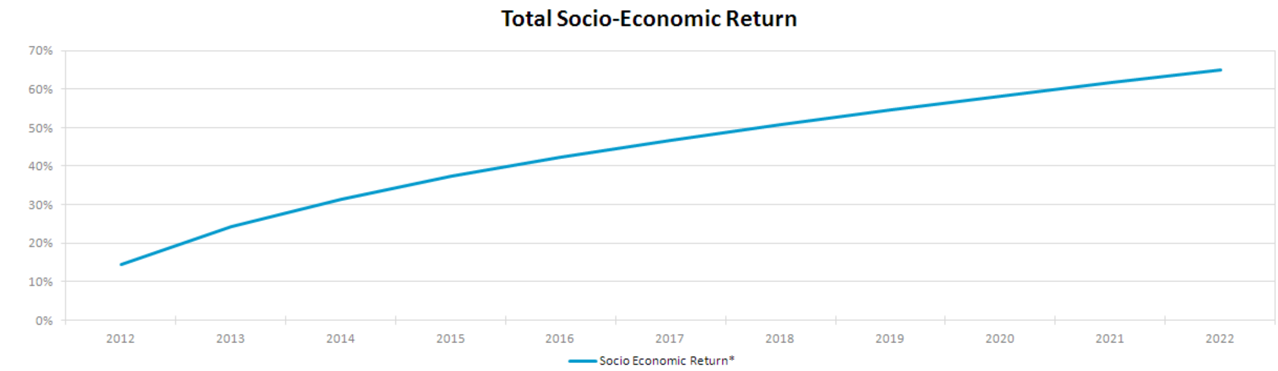
The Fatih Sports Facility provides a good pilot site providing experiences for energy managers in Turkey hereby surpassing language barriers. It demonstrates the possibility of an application for energy efficient solution based on an EDSS - Energy Decision Support System in an existing building.



Siemens as the technology partner has been included in the project through a tender process. The Energy Monitoring and Controlling Solution (EMC) is an Internet-based application for monitoring and controlling energy consumption in buildings (see above screenshots). You can use the EMC application for a range of activities, from simple logging of data to complex analysis of a variety of consumption control features. By keeping a continuous record and analysis of consumption data, the application helps you identify potential savings and evaluate the success of your energy optimization measures. Consumption data is logged manually or via a Web browser on a central Internet server, accessed through secure, personal user accounts. You can operate the EMC application and run reports from any standard computer with Internet access. Because the EMC application is modular, you can add as many auxiliary modules and options to the standard EMC package as needed for your specific energy-related concerns.

Quantitative Analysis (CBA)

The SMARTSPACES project has a positive socio-economic return. As the building is new, the savings will occur without further investment for several decades. The modelling displays the worst case possible for the *Department* and takes best case assumptions for the IT-provider. The worst case criteria are price changes assumed, no consumption increases modelled in Do-Nothing and the assumption of high fees for ICT although the energy features are an “add-on” for hardware with other purposes. Regardless, the building is a very large consumer and the savings achieved have are relevant.



Value Propositions

The system enabled the professionals to detect wastage and optimise the system of a very large consumer given the site includes an Olympic pool among others. The public displays are, in Turkey, a usual transparency with regard to energy consumption and educative. The system can be controlled remotely so that outage time can be reduced and the supplier – SIEMENS – involved whenever required.

Future Exploitation

The experience is frequently being exchanged with other departments of the Municipality in order to apply new energy saving project. In the next years, we will work very closely with these departments in particular energy saving project.

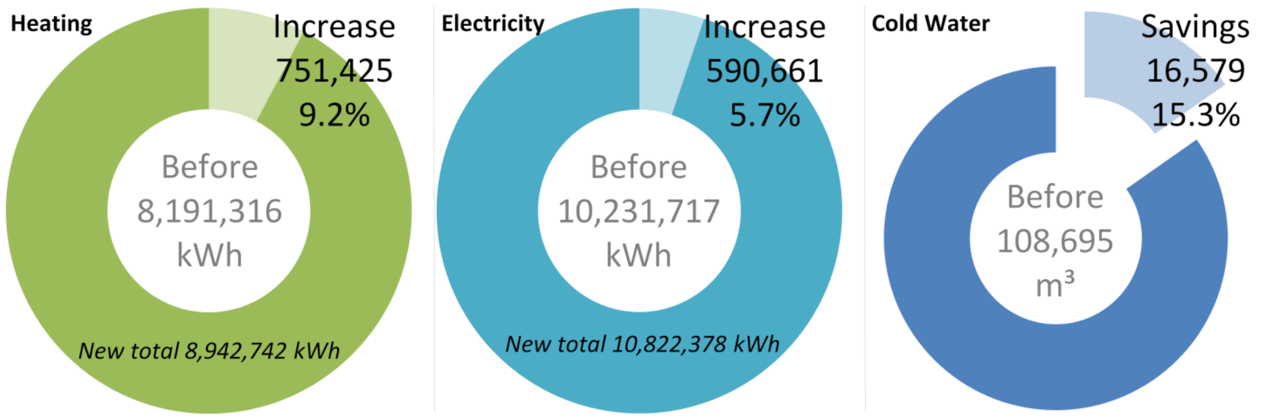
SIEMENS is replicating the solution in various sites in Turkey and across the globe. The company is also competing for large public developments in the country in which public energy displaying would be one of the features. Unfortunately, the figures for the company cannot be disclosed.

Selected publicity achievement

The SMARTSPACES project partners in Istanbul - SPOR AS - received an **award for their commitment in the SMARTSPACES project** at the ICT PSP programme award ceremony that was hosted by the Ministry of Development in Istanbul.

2.8.7 Leicester

	Leicester City Council		De Montfort University Leicester	
	Buildings	134	Surface	110,000m^2
	Average Age	1954	Services	EDSS, EMS
	Building Type	Numerous (see D7.2 for full detail)	Resources covered	
Users	Staff	>75	Office workers, General Staff, Teachers, etc.	
Users	Professionals	27	Managers	
Users	Visitors	>350	Users of facilities	



In Leicester, water savings of 15.3% were achieved, but the electricity and gas consumption increased by 5.7% and 9.1% respectively. Unforeseen changes in several participating buildings caused these increases in gas and electricity use. These changes in council and university buildings included modifications in space use (e.g. Queens Building), migration of council staff due to the closure of the main Headquarter building (more than 200 staff moved to 16 New Walk and Neighbourhood Centres), movement of IT infrastructure into a single central location (John Whitehead), extended opening hours (New Leicester Central Library and Kimberlin Library), the need to use extra equipment after an unexpected flooding (African Caribbean Centre) and the need to rent mobile classrooms to accommodate increasing number of students (Coleman Primary School).

By filtering the above mentioned buildings in calculations, electricity and heating savings of 1.5% and 4.1%% respectively were measured. The small electricity savings may be attributable to the schools in Leicester that are going through major changes to accommodate growing number of places required and higher IT demand. Schools are currently up to full capacity.

Engaged individuals, such as environmental champions, participated actively in the online forum posting enquiries about the energy consumption in their buildings or reporting energy saving opportunities to the energy management team. The innovative on-line discussion forum associated with the publically available energy and water consumption data was well received by decision makers, professionals and buildings users. Without any significant change of use in the buildings and with ongoing user engagement, such as reminders to look to the website in a regular basis, participate in the online forum and regular interventions, it can be expected that typical annual savings of 5% for electricity and 10% for heating could be achieved.

Pilot Overview

Twenty public buildings drawn from the City Council portfolio are included in the project. These include seven leisure centres, seven primary schools, two community centres, a concert hall, a museum, an office building and a library. The City Council buildings have 2,000 staff users and 33,000 monthly visitors of which 23,000 are students. Additionally, at the University, the Campus Centre houses the student union offices, a pub, nightclub several shops and a restaurant. The Kimberlin library is the universities' main library and the John Whitehead building is a university building with a larger proportion of administrative offices. There are 600 staff users and 18,500 visitors to these buildings each month.

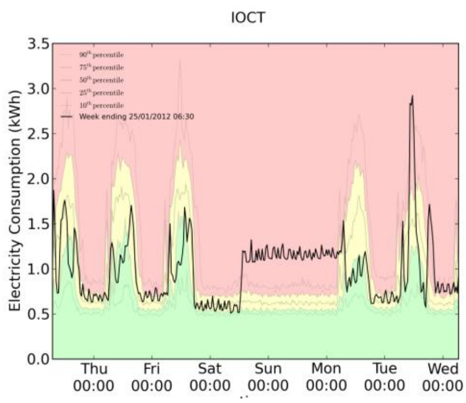
The unique aspect of the Leicester approach was the combination of the publically available, simple (or detailed) presentation of the half hourly gas, electricity and water data, combined with the on line discussion forum. That is, the combination of metered data with people discussing these data and maintaining or improving comfort conditions in their buildings, whilst minimising energy and water consumption.

Service summary

The service is available through smartspaces.eu as part of the pilot site description together with a video.

EMS– service description

There were two main mechanisms where SMARTSPACES services influenced automated control settings. The first was to provide services directly to energy professionals who in turn have access to control settings. The second was to provide building users with the facility to engage in discussions about the performance of their building from within the SMARTSPACES services. This capability was also provided to building energy professionals so that building users had a direct link to the experts and the experts had access to the observations and opinions of building users. That is, there was an on-line dialogue between building users and energy managers and also an on-line dialogue between different building users.



Professionals had access to the BEMS and used information provided by the SMARTSPACES EMS to alter the BEMS settings and configurations. BEMS configuration impacted on the following:

- Occupancy schedules and calendar (to apply different settings depending on occupancy)
- Temperature settings
- Night cooling regime
- Lighting control (time until off using PIR sensors)
- Change ventilation rates (including opening and closing windows)

All of these settings were already controlled remotely from a central energy management office, but the feedback from the building users via the on-line discussion forum resulted in further alterations to the control settings.

The energy and water consumption information provided on the website showed the expected range of consumption (clearly highlighted in the coloured zones) and contrasted this with the actual consumption (black line). This also included a clickable navigation pane at the bottom of the page which showed a summary of performance over the latest year. This pane allowed the user to easily identify historical periods where performance was good or bad and navigate directly to them by simply clicking and dragging the cursor across the time period of interest.

An energy performance league table was provided and linked with the detailed diagnostic reports. For each period (e.g. each day or week) consumption was compared against that predicted by a baseline consumption model for each building. This was then used to generate a performance indicator showing the current building performance. Buildings were listed in order of performance and this list was directly linked to the more detailed reports.

EDSS– service description

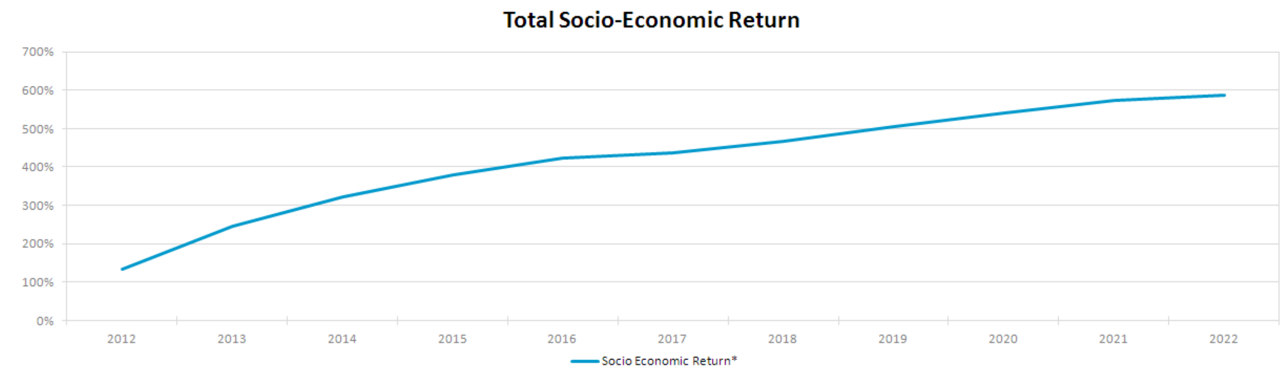
With so much data it was very easy to alienate the non-technical user by presenting them with complex graphics like those above. In the Leicester SMARTSPACES services building users were initially presented with a very simple view of energy performance**.** The first thing they see is the simplest possible view and this included no charts, simply smiley faces. A building user can then understand the overall performance from this smiley face and many users just used this as their main source of information.

Energy data, analysis and visualisations provided were a resource available within the service. But, the service itself needed to be wider than this if it was to be truly engaging. The users should not be simple passive consumers of data/information but must also provide content.

A key idea here was to give building users ‘ownership’ of the issue by them identifying the issue (excessive consumption) and, through the discussion forum, helping to resolve this issue with the energy manager. It was also important to ensure a balance of communication so it is not perceived as ‘them and us’ with ‘the authorities’ imposing a regime of energy vigilance. The approach was to ask questions of building users with the implicit assumption that they are the experts about their own workplace. For example, there were different “threads” in the online forum for different buildings and different issues arising within each building.

Quantitative Analysis (CBA)

The SMARTSPACES project has a positive socio-economic return paying off immediately. The model presented here is assuming a ‘worst-case scenario’ in which no hardware exists. However, all buildings in Leicester are already equipped with metering hardware and only a limited amount of infrastructure and public TV screens would be needed for full deployment (along with training etc.).



* Stakeholders included in the Graph: , Council, Energy, IT. Discount Rates applied on Baseline for return on investment (e.g. equipment, operation): 5%, for intangible indicators (e.g. societal, non-financial): 3.5%.

Value Propositions

Smiley Faces displayed on screens in public spaces are an easy way to interpret for anyone without training. Publically available, web based Smiley faces and more detailed time series graphs are able to engage with building users over the energy use in their buildings. This makes a relatively "boring" subject more "exciting". The graphs explain daily and seasonable shifts and are able to inform the public about changes in building energy use due to temperature, events and faults. As soon as any type of user thinks that they can contribute with information (e.g. observed an open window), they can participate in the on-line forum to share their experiences and enter into a dialogue with other buildings users and with building energy managers. They can act as champions, as peer educators, to discuss their experiences with other buildings users. The system is scalable in number of buildings and resolution.

Up-to-date data is available for download and future analysis by citizens that might produce further insight. Since the solution is being developed on campus, students can be involved in playing with ideas to develop more features creating a community not only for geeks but also researchers. The team already succeeded in publishing the evaluation methodology in a renowned journal[7] and is keen to make further insights from this large and (beyond the project's life-time) on-going pilot to the research community also contributing further evidence to the 'Guide for Replication'.

For further expansion of the services, the solution is scalable and able to meet the growing demands of the buildings in Leicester City Council and De Montfort University at an affordable cost. This cost is mainly related to staff time, as the AMR is already installed. Costs would include things such as monitors, cables etc In certain places there would also be some staff resource required to introduce the service and encourage people to get engaged.

Future Exploitation

Leicester City Council is currently looking at extending SMARTSPACES in three ways. Firstly, the Council plans to expand the services to other appropriate City Council buildings. Buildings where there is considerable interaction with building users, such as administrative buildings, neighbourhood offices and libraries. This is dependent on the available financial resources and the effects of the forthcoming, local, national and mayoral elections. Secondly the Council would like to extend this service to school buildings as part of wider initiatives to reduce carbon emissions in schools, using energy data in the curriculum and engaging with school governors over energy and water use in school buildings. This would be useful to monitor the implementation of renewable energies, monitor the use of Schools outside of School hours and see whether the new BSF schools are really making the savings they have been designed to make. The Council are also keen to offer SMARTSPACES to local businesses as part of a greening business project which will be submitted for ESIF funding in the summer of 2015.

Leicester City Council and DMU have also been active in submitting further proposals for funding. These were to extend the Leicester SMARTSPACES concept of the combination of the publically available meter reading and building user data. This has included UK and EU proposals in big data and the internet of things using social media data and BEMs data to offer additional services. This work is ongoing.

De Montfort University is extending SMARTSPACES to all DMU buildings, from the original 5 buildings to approximately 18 buildings. DMU is in discussions with a Student Accommodation provider to offer a SMARTSPACES service to Halls of residences. DMU are also in discussion with an energy purchasing company to offer a SmartSpaces type service to them. Finally DMU is using the SMARTSPACES approach in its carbon budgeting work.

Leicester City Council and DMU have had discussions with several Local Authorities and Universities who have all expressed an interest in using a SMARTSPACES type service. Leicester

[7] Wilson, C., Evaluating communication to optimise consumer-directed energy efficiency interventions. Energy Policy (2014), http://dx.doi.org/10.1016/j.enpol.2014.08.025

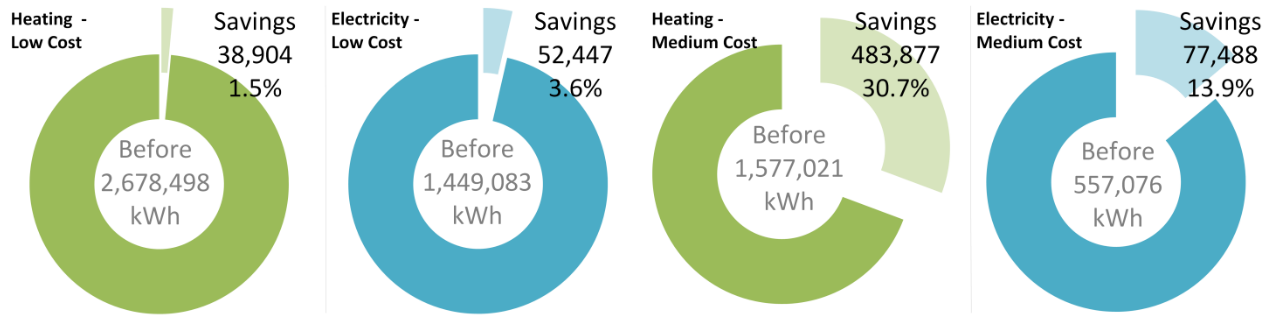
City Council actively promoted the service to English Local authorities at Carbon Action Network events which are specifically aimed at local authority officers working ion energy, climate change and fuel poverty. Work is currently underway to define the detail of potential services and to then be able offer some services commercially. Finally, the Leicester exploitation work also looked specially at extending the work from Public Buildings to private buildings - in particular to SMEs. This work has resulted in discussions with the Leicester and Leicestershire Enterprise partnership to use a SMARTSPACES type service in the EU SIF (European Structural invest Fund) projects looking at local carbon support from businesses.

Selected publicity achievement

In their 10th year, the **Green Gown Awards**, sponsored by the CISCO and BT education partnership, recognise the exceptional sustainability initiatives being undertaken by universities and colleges across the UK. With sustainability moving up the agenda, the Awards have become established as the most prestigious recognition of best practice within the tertiary education sector. The Leicester SMARTSPACES pilot was selected as a finalist in this years' Green Gown Awards in the Technical Innovation for Sustainability

2.8.8 Lleida

Lleida Energy Agency		CIMNE	Inergy
Buildings	22		32.000m²
Average Age	1950-2003	Services	EDSS, EMS
Building Type	office buildings, sports halls, schools, cultural centres and nursing home	Resources covered	
Users – Staff	150	Technical staff, office workers	
Users – Professionals	15	Technical responsible	
Users – Visitors	>200/day	Various	



In Lleida the evaluation of energy savings considered the medium cost services in buildings at Lleida City and low cost services in the municipalities' buildings. The largest electricity and heating savings were achieved through the medium cost services (13.9% and 30.7% respectively), whereas the electricity and heating savings in the municipalities' buildings were in average 3.6% and 1.5% respectively. The large savings in the buildings using the medium cost savings may be attributed not only to the decisions and actions quickly prompted by the energy data visualisation (almost in real time) provided by the EMS, but also intensive energy campaigns related to heating, electricity use and air conditioning conducted between winter 2013, spring and summer 2014. Staff respondents in the City of Lleida and the municipalities were already highly aware and supportive of energy savings.

Building professional interviewees agreed that the EDSS had provided tools and resources (particularly during the implementation of the "energy savings campaigns") to enable actual energy savings, increase the awareness and engagement of staff members, and improve the communication and cooperation of users with the energy teams. Interviewees considered that overall the SMARTSPACES project has increased the knowledge and collaboration from different departments within the City Council, while the energy and economic savings as well as the associated emissions reductions achieved can encourage other departments to further embed the goals of the project into the organisational culture. As a result of the implementation of the project, annual savings of around 5% for the low cost services and around 30% for the medium cost services are anticipated. It can be expected that several public buildings at the municipalities could implement the low cost services due to the low investment costs and the potential savings attained in the pilot buildings. Larger savings can be achieved through the medium cost services. Although larger investments are required for these services, the payback period for the investment is around 3 years. Identified savings could be materialised using ESCO models.

Pilot Overview

There are 22 buildings in the Lleida pilot, comprised of six office buildings, six sports halls, five schools, four cultural centres and one nursing home. The biggest office building is Sant Francesc, used for administration, with 101 staff users and 21,000 visitors per month. Overall savings planned are 15% for buildings with SMARTSPACES services at medium cost, and 5% for low cost model. These buildings are occupied by approximately 700 staff users and 50,000 visitors per month.

Two service levels were deployed: Low with almost no cost (SIE) and Medium with some implementation cost (BEIS). The first service automatically collects monthly billing information in one database. The second service provide more precise, detailed and intelligible information allowing energy managers to make more informed decisions, detect anomalous operation of energy systems earlier and react faster, develop reports and arguments to justify investments in further energy efficiency improvements. The services also provide benchmarking and normalization enabling performance to be compared and therefore rated.

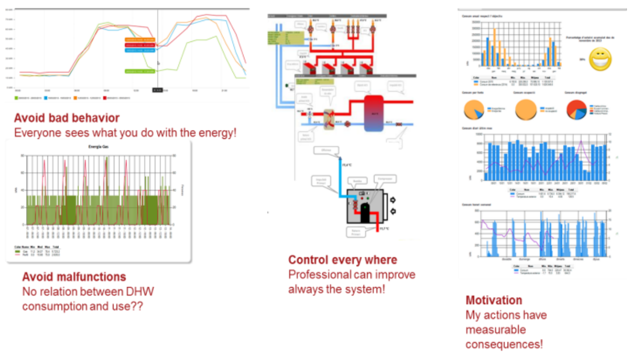
Service summary

The service is available through smartspaces.eu as part of the pilot site description together with a video.

EMS– service description

Implementation of EMS in Lleida follows the logic of two levels of initial economic investment. For the case of Medium cost service (based on hourly data) all buildings has received the complete set of our EMS. In case of Low cost service (based on monthly data) the implementation of this type of service is more difficult due to the data granularity. However, some specific EMS Service has been given in particular Low cost service buildings, optimising the regulation and the control system of some buildings, and providing alerts and personalized advice.

The medium cost service can gather all the energy data in one point with internet access, i,e. facilitates centralised control of data. The building professional can control through the visualized dashboard or alarm system. In some cases, the alarm signal could be one signal that is necessary to act over some facility of the building, this actuation can be do it manually or automatic.

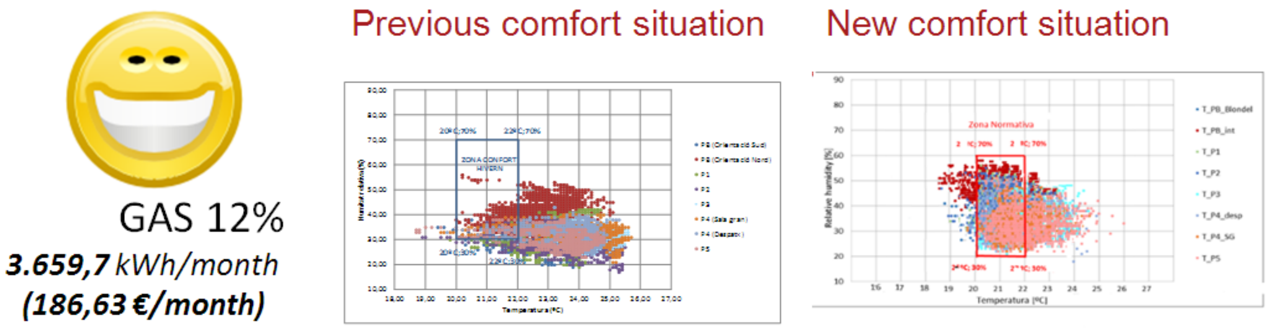


The system allows control some parameters of the facility that can be do it in a local level, for example, some staff building or building manager people can have access to control in only one zone of the building, whereby the system can give them access to control the temperature, the electric consumption, etc, only for their own zone. The system can be extended by prediction and management of renewables (production) resources.

EDSS– service description

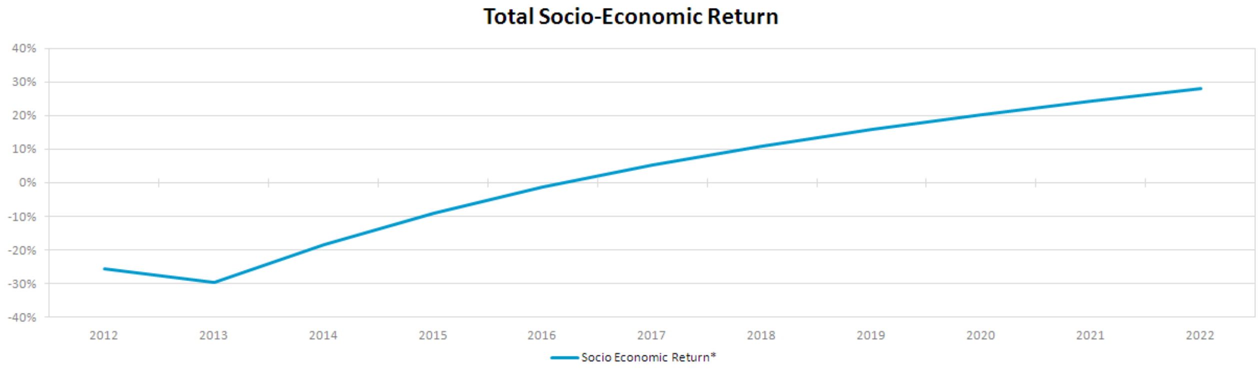
EDSS services offered in Lleida differentiate by levels of users and within this level are also differentiate in terms of cost of service. The main EDSS services offered can be split in the following parts:

- Energy data visualization: to know what is the consumption of our buildings
- Comparison between periods in the same building: to know if we are improving or worsening the consumption of the building.
- Benchmarking between other buildings (same typology): to have some references to know if the consumption that we have are in the correct range.
- Alarms: to control the deviations of the consumptions.
- Reports: to processed information of the consumption of the buildings.
- Energy coach: communication with energy experts that help the users to implement the necessary action to improve the building consumption.



Quantitative Analysis (CBA)

The SMARTSPACES project has a satisfactory socio-economic return after the implementation of the EDSS and EMS in the buildings of the Lleida pilot site. The business model is based on the *Council* financing the investment of additional equipment during implementation and consulting cost via fees displacing (currently non-competitive) fees paid to the *Energy* stakeholder. The absolute savings can easily be increase by upgrading the buildings to a EMS service based on energy smart remote energy management devices which requires additional investments but can double the saving potential.



* Stakeholders included in the Graph: , Council, Energy, Measure, IT. Discount Rates applied on Baseline for return on investment (e.g. equipment, operation): 5%, for intangible indicators (e.g. societal, non-financial): 3,5%.

Value Propositions

Independent of the number of buildings a council wants to pilot the system with it will immediately allow comparison with, currently, over 200 buildings. The cloud based system is open to any kind of data and provides one output for all professional (and staff) user independent behind which "closed shop" they are sitting with regard to hardware. The comparability is also available for administrative staff, executives and all other staff. For instance, the predicted cost and the actual spending are available at all time. This enables the definition of KPIs and automatic alarms for measuring the performance of buildings. All this can be achieved without involving the measurement provider(s).

Behavioural decision support is rolled out in waves targeting certain aspects of energy (e.g. natural ventilation) as well as being always available in the portal. Since cause and effect are explained and visible in the portal many staff have learned the link to their personal decision. Moreover, the staff learnt to recognise smaller faults and other causes which might only be detected much later by professionals. Since staff now know how and when to contact professionals almost all kind of wastage can be detected early even if the resolution in the number of zones remains small.

Future Exploitation

The goal of the service provider (CIMNE, Inergy) is to extend the implementation of the SMARTSPACES energy services to the whole of the Catalan public sector, and particularly to the local administration. The business approach is to offer an optimal cost-effectiveness combination of the services developed in the pilot project of Lleida: (a) the low-cost EDSS based on SIE; (b) the medium-cost EDSS and EMS based on monitoring solutions; and (c) the EMS based on energy smart remote energy management devices.

The approach to the customer will be made by an initial offer of the low-cost EDSS for 100% of its buildings. This first implementation will permit to achieve savings in the energy bill that will generate customer confidence and financial resources to invest in other measures. On the other hand, this first implementation will allow having a full energy accounting of all the park of buildings to identify those with more global consumption and potential savings.

In a second step we provide both, a medium-cost EDSS and EMS for 20-30% of the buildings of the client and the EMS based on energy smart remote energy management devices for another 5-10%, which will be chosen according to consumption and identified potential savings.

We are proposing two different schemes of remuneration according to customer requirements: (1) fixed rate according to the level of service performed; (2) variable remuneration linked to savings achieved (ESCO scheme). This second option is proposed exclusively for EMS based on energy smart remote energy management devices to reduce the uncertainty and risk of the financial investment.

It is planned for 2015 to extend in the city of Lleida the implementation of the SIE for the whole of the buildings of the city council, and gradually expand for the next years to 50 buildings with medium-cost EDSS and EMS, and up to 10 buildings with EMS based in intelligent energy smart remote energy management.

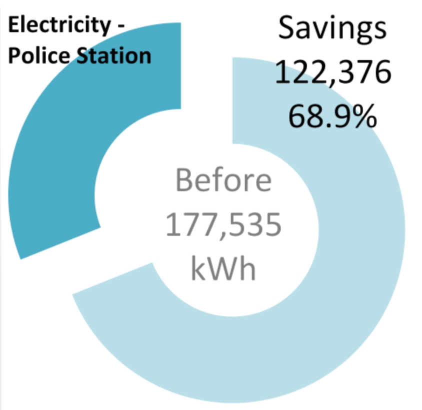
At the Catalonian level, the business goals for the next three years is to achieved the implementation of the low-cost EDSS based on SIE in 200 municipalities, the implementation of the medium-cost-EDSS and EMS in the 20% of those municipalities, and the introduction of the EMS based on energy smart remote energy management devices to a 10% of those municipalities with SIE.

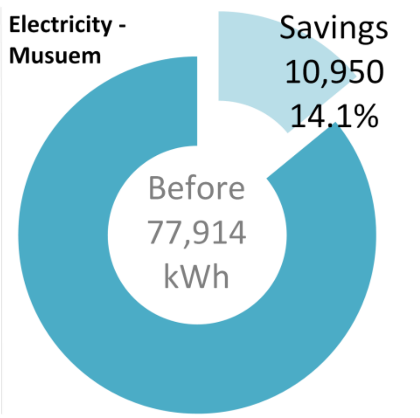
Selected publicity achievement

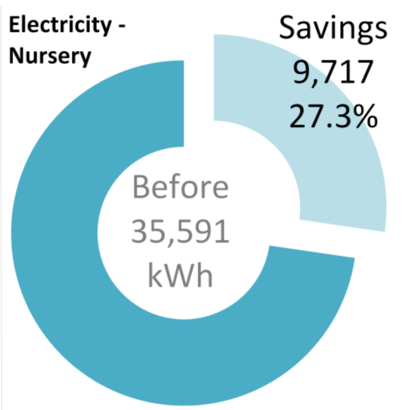
CIMNE of SMARTSPACES in Lleida presented the project at the international **World Sustainable Building 2014 Conference**. The conference is the largest meeting on a global level on sustainable building where the most important and influential international institutions, experts in this field, will meet for the first time.

2.8.9 Milan

Commune di Milano		Cisco		BT
Buildings		3	Surface	3,724m²
Average Age		1885 - 1930	Services	EDSS, EMS
Building Type		Police Office, Museum, Nursery School	Resources covered	
Users	Staff	>170	Police officers	
	Professionals	12	Nursery school, service technicians	
	Visitors	>68,000/month	Museum visitors	







Large electricity savings of 49.1% in average were observed in Milan. Electricity savings were 68.9% in the Police Station, 27.3% in the nursery and 14.1% in the museum. Prior to the installation of the services, facilities were not visible remotely, hence energy professionals needed to go physically to the buildings. With the EMS, the maintenance and solution of the problems could be conducted quicker. According to the interviewed building professional, the EDSS has also enabled reductions through the awareness raised by the feedback provided about the energy consumption in the buildings. Results from the surveys showed higher levels of knowledge, awareness, perceived control, intentions and self-reported behaviour by the respondents of the final survey compared to the baseline survey respondents. As a result of the project, energy saving opportunities were identified such as substituting electric chillers by heat pump chillers. These opportunities may be implemented in the future. After the successful implementation of the project, annual electricity savings of around 10% based on previous consumption are expected to continue through further engagement activities so that staff members become more aware that their actions effectively reflect on the energy use.

Pilot Overview

The pilot is comprised of three buildings. A Local Police Offices with three-floor building, 140 employees (on shift work); 2,400 visitors estimated per month; the ICT infrastructure is composed by a MAN, a LAN (Foundry technology for the core and HP for the access) and VoIP network (Siemens technology); Museum of Risorgimento, a four-floor building, 50 employees and 66,000 visitors estimated per month; Nursery School: two-floor building, 60 permanent users and 130 visitors estimated per month.

All sites selected by 'Comune di Milano' have been provided by sensors and meters in order to send information to the aggregators. The linkage between data of consumption and internal and external events is possible thanks to BT Energy Management platform, that allows the EMS system to monitor the energy consumption data real-time and in every building selected as a pilot. Features are predictive analysis, reports about energy consuming, dashboard for displaying and IP-based control of the energy use using CISCO IoT technology.

Service summary

The service is available through smartspaces.eu as part of the pilot site description together with a video.

EMS– service description

The design and communication is orientated on a two layer structure: the field layer, local, containing metering systems, and the application layer, centrally located. The field layer contains power meters, heating probes and data concentrators (smart servers). In the Police Office, two systems are in parallel: the first focusing on the building's infrastructure such as lightning and heating (BT); and the second on the ICT domain targeting all appliances such PCs, desktop switches and IP phones offering more than only energy management services (leveraging CISCO EnergyWise technology).

Cisco® EnergyWise is an energy management architecture that allows IT operations and facilities to measure and fine-tune power usage to realize significant cost savings. Cisco EnergyWise focuses on reducing power utilization on all devices connected to a Cisco network ranging from Power over Ethernet (PoE) devices, such as IP phones and wireless access points, to IP-enabled building and lighting controllers. It uses an intelligent network-based approach, allowing IT and building facilities operations to understand, optimize, and control power across an entire corporate infrastructure, potentially affecting any powered device.

At a central level, both solutions send information to the centralised monitoring platform, provided by BT (developed by Eudata), that integrates IT, physical infrastructure, and facilities energy management into a full service management platform.

EDSS– service description

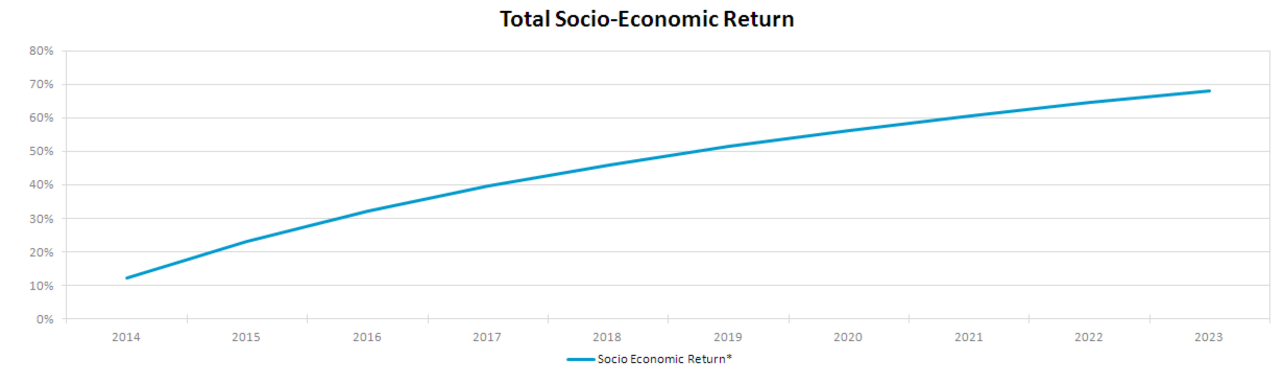
By using the sheet "User Display", there is the possibility to display, set, and modify the graphs in the dashboard view, in order to screen the graphs most relevant for the customer's aim. An example is shown in the figure below:

Greeny delivers views, creates and administers dashboards and analysis, accessed through web interfaces: Administration Panel. The web-based administration provides a complete view of system activity as well as system metrics and thresholds so that organizations can resolve potential issues before being a business impact.

Greeny Platform is built on a web-based service-oriented-architecture (SOA) that is designed for scalability, availability, and openness. This kind of platform provides optimized access to all data sources, including relational data sources and online analytical processing (OLAP). The Greeny Architecture provides the full integration between the Greeny Platform and external system such as Business Intelligence and in general for any kind of interaction and integration.

Quantitative Analysis (CBA)

The SMARTSPACES project has a positive socio-economic return paying off immediately. All cost and benefits are covered by the *Council*. The scenario modelled can be assumed the Worst-case as no cost were recorded for the *Do-Nothing* scenario and very low increaser of electricity cost was assumed. The buildings modelled are neither large consumers nor otherwise exceptional and therefore represent a wide share of the municipality buildings. Deploying SMARTSPACES to larger consumers first would pay off quicker and create profits which can be used in other buildings.



* Stakeholders included in the Graph: , Council, Measure, IT. Discount Rates applied on Baseline for return on investment (e.g. equipment, operation): 5%, for intangible indicators (e.g. societal, non-financial): 3,5%.

Value Propositions

The pilot was opportunity to test the combination of numerous technologies in a regular pilot. Two major IT suppliers, BT and CISCO, were cooperating to make the solution work across various levels of administration and professional building management. The CISCO EnergyWise energy management architecture optimises power utilisation on all devices connected to a Cisco network ranging from Power over Ethernet (PoE) devices, such as IP phones and wireless access points, to IP-enabled building and lighting controllers. A centralised platform (BT) collects data from various meters and sensors and makes them available for the individual systems to optimise, for instance, heating and lighting patterns and defines thresholds for alarms. The information is also used to provide individualised data streams for screens in public spaces for visitors as well as staff.

Future Exploitation

EnergyWise has been adopted for the global event EXPO2015 and will be used by Milan Municipality after the event. The monitoring system developed in SMARTSPACES will be used for the project EU-GUGLE co-financed by FP7

Further replication by the Municipality (Milan and others) is hindered by the budget lockdown due to austerity measures. The ICT based energy decision support (EDSS) was shared with Lombardy Region and will be replicated where existing hardware will allow the application.

CISCO is deploying EnergyWise as a new product in their portfolio. This will include marketing the solution as a new way to utilise IoT as a way to increase energy efficiency. Such a solution is a paradigm shift for CISCO as it goes beyond the backend towards the device directly touched by the end customer.

BT is deploying Greenergy as a new product in their portfolio. This will include marketing as a way to utilise existing hardware in a modern IoT architecture. Such a solution is a paradigm shift for BT as it does not only cover the communication between grid and customer but also data within a local network on the customer's site.

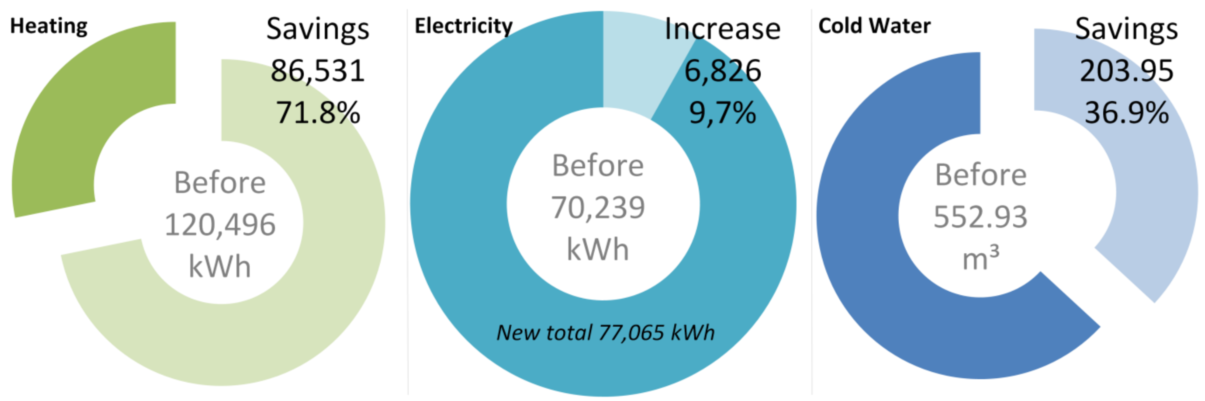
Selected publicity achievement

SMARTSPACES Milan presented the project at the SMAU Milan. SMAU Milan is the most important ICT exhibition and conference in Italy that is totally dedicated to Information and Communication Technology. The event is designed to help leading domestic suppliers and international suppliers of ICT solutions engage in networking opportunities with entrepreneurs, corporate and public administration decision makers and the channel of network operators and service providers in Italy.

2.8.10 Moulins

Moulins Municipality	Moulins Habitat (MH)	EDFOS	Real Project Partner

Buildings		1	Average Surface	1,640m²
Average Age		2013	Services	EDSS, EMS
Building Type		Hospital/Nursery	Resources covered	
Users	Staff	20	Nursery and city staff	
	Professionals	20	Directly related to their job	
	Visitors	>200 / day	Children, parents, family and childminders	



At the start of the project, the “Maison de l'Enfance et de la Famille” nursery building was under construction and start operating on January 2014. Therefore, savings were estimated using simulated baseline data. Large savings were achieved for the heating and water consumption (71.8% and 36.9% respectively), but the electricity consumption increased by 9.7%.

The benefits of the EMS highlighted by building professionals were that the system has allowed them optimising the energy consumption in each zone of the building and improving the thermal comfort for the users (particularly babies of the nursery). Professionals also considered that the EDSS has helped to inform and raise awareness among users on the relevance of saving energy not only through the energy data, but also through advice on good practices. These benefits have enabled actual energy reductions through identification of energy wastage in unusual periods and prompt correction of high consumption anomalies, such as leaving doors opened during the weekend or adjusting temperatures overnight or weekends.

Responses for the baseline survey were gathered in a building with similar characteristics (Bellerive nursery). Differences between surveys showed that staff from the “Maison de l’Enfance et de la Famille” (participating building) had higher levels of awareness, knowledge, intention to report energy savings and self-reported behaviour to minimise energy use compared to the staff in the Bellerive nursery. Staff from the “Maison de l’Enfance et de la Famille” also display a more pro-environmental behaviour compared to the Bellerive nursery. As expressed in the interviews, “cooperation among building users has increased by showing them that the evolution of the energy reductions have been materialised through everybody’s efforts”.

Annual savings of 8% for heating and 5% for water are expected in forthcoming years because a significant optimisation in their consumption took place during the project, while electricity savings of 10% are anticipated based on observed improvements in measured data of 2015 compared to 2014.

Pilot Overview

The Moulins pilot is a highly modern, newly build nursery. It has 58 staff members and 360 visitors per day. The building is divided in three parts: Hospital nursery: 300 m²; Association Entraide nursery: 580 m²; and RAM (Childhood coordination of the city): 160 m².

The challenge is to achieve the theoretically possible energy efficiency by avoiding losses caused by (undetected) wastage or due to behaviour. The nursery building respects the thermal regulations 2012. It means the conception and realisation of the building is linked to energy efficiency with solutions to reduce energy consumption and CO_2 emissions. Realisation concerns heating, ventilation, air-conditioning, electricity, building monitoring system, to get a better comfort and environment for users, staff and visitors. With the thermal regulations 2012, an air-tightness test took place during and after construction.

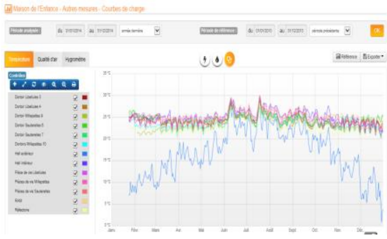
Service summary

The service is available through smartspaces.eu as part of the pilot site description together with a video.

EMS– service description

The AMR technology captures data in real-time, those data are stored in a database management system. The web portal of EDFOS (Netseenergy) will enable to visualize the collected energy consumption data and to analyze them (energy performance diagnostics).

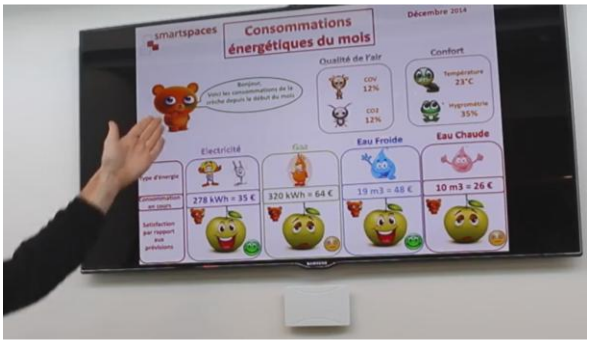
Netseenergy software is a global and integrated solution dedicated to real estate management and energy performance. All the sensors data, for energy as well air quality and temperature, are centralized in a box which enables data communication in the software thanks to an IP protocol.



For temperature and air quality, various sensors are located in the rooms of the entire site. For energy, sensors are positioned on main meters (energy provider) and submeters (in electrical switchboards). The system allows measuring the heating produced by a district heating grid (wood-fired power plant). Professionals are notified about any peaks and leakages via SMS or email.

EDSS– service description

The solution aims to ensure parents and staff that the conditions are the best possible for the vulnerable children spending a good part of their day in the building. For this purpose visitors and staff members with limited access to a desktop computer needed to be addressed.

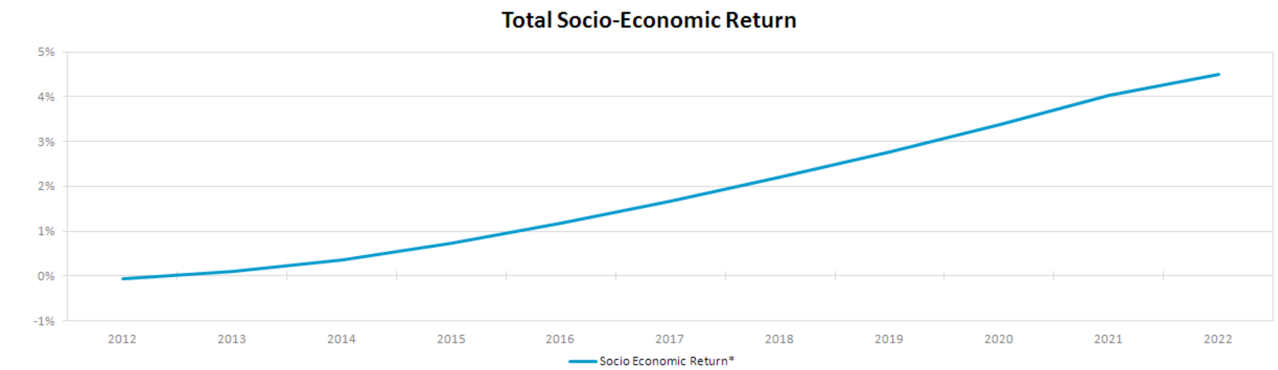


A TV set informs the user about the current status. The graphics developed are not only accessible to adults but also to the young ones. In fact, it has been observed that the children react to changing characters which are associated with good or bad performance of the building.

Changes allow interaction and interplay with children for education and awareness raising. As children react, parents can be involved in the discussion of why the results are not as good they could be and the learning effect reaches beyond a generation. This is also achieved be providing advice and tips along with the screen connected to the current reason of underperformance.

Quantitative Analysis (CBA)

The SMARTSPACES project is cost-neutral. As the building is new, the savings will occur without further investment for several decades. The cost is mostly covered by the building operator (*Department*) as part of the acquisition of the building. The technology applied is innovative and availability limited so prices are likely to decline. SMARTSPACES is a combination of features from several SMEs which can easily be replicated by other public or private investors.



* Stakeholders included in the Graph: Department, Council, Measure, IT. Discount Rates applied on Baseline for return on investment (e.g. equipment, operation): 5%, for intangible indicators (e.g. societal, non-financial): 3,5%.

Value Propositions

French communities demand high standards with regard to the environment in which new-born and children are raised (e.g. no-wave, climate, transparency). The pilot successes in satisfying such requirements and due to its transparency using every day technology such as public TVs worries are taken away from parents. Moreover, as the data shared on the screen such as temperature objectives otherwise subjective feelings it reduces the number of discussions about the environment in which the children spend a good portion of the day. Environmental control optimises not only the comfort but also ensures that automatisation achieves the conditions in the most energy efficient way. Usage of data on the “edge” also simplifies the monitoring process across the entire building enabling professionals to stabilise the conditions in neighbouring zones before the effects of any incident influences larger parts of the system.

Future Exploitation

The Municipality has decided to build a new structure with three entities (RAM, Mutual Aid and Hospital nursery) replacing three old separate entities hereby centralising and making public services more efficient. The new building meets the standards of current French thermal regulation, respecting environmental managers and building low energy consumption. With the nursery being the pilot for a “smart building” the ICT-solution is to be applied to the rest of the structure. For the near future, one more public building has been decided upon named “Maison de l’Enfance” (details below). The council reviews a student residence in close connection with a residence for senior citizens which must be realised on the territory of the city of Moulins in/after 2017. Moulins Habitat will be the prime contractor for the project and will then help future residents to explain how to use new technologies to save energy.

The dedicated portal and display system provided by IT partner RPP completely compliant with the needs of other kind of structure like residential buildings (energy display and communication messages), industrial sites, and also public buildings (e.g. schools, exhibition centres). The concept can easily be replicated as similar hierarchies (visitors, staff / tenants, professionals) exist in other buildings and the UI can easily be embedded into the environment of the building operator. The solution is being used by numerous housing operators in France but also applied by partners in Switzerland and adopted by technology partners around the world.

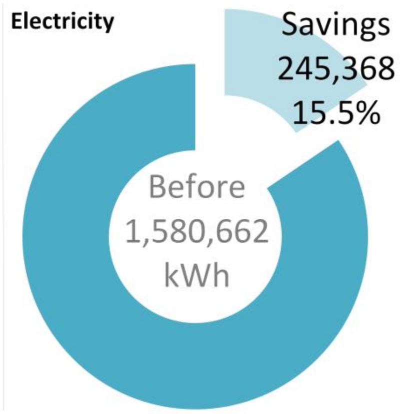
EDF OS has implemented the SMARTSPACES service in schools in Paris and industrial customer in Poitiers. Replication is possible in residential buildings, public building (school, offices etc.) and the private sector. Costs depend on the sector (residential or public) and how many meters and information channels are to be installed.

Selected publicity achievement

The project partner Ville de Moulins presents in a 5-minute **pilot site video** the specific features and advantages of participating in the SMARTSPACES project for the City of Moulins. The building manager Arthur Almartine presents the structure of the pilot site buildings and the benefits of the developed web portal. David Devernes, Energy Coach in Moulins Habitat, shows how the technology works in the building.

2.8.11 Murcia

<table>
<tr><td colspan="5">City of Murcia – Energy Agency</td></tr>
<tr><td colspan="2">Buildings</td><td>6</td><td>Surface</td><td>11,942m²</td></tr>
<tr><td colspan="2">Age</td><td>1846-1970</td><td>Services</td><td>EDSS, EMS</td></tr>
<tr><td colspan="2">Building Type</td><td>Administration, Security Complex (Police, Fire Department, Civil Protection)</td><td>Resources covered</td><td></td></tr>
<tr><td rowspan="3">Users</td><td>Staff</td><td>>200</td><td colspan="2">Heads of department, office workers, security staff</td></tr>
<tr><td>Professionals</td><td>>10</td><td colspan="2">Energy managers, Building responsible, Maintenance companies (electricity, HVAC)</td></tr>
<tr><td>Visitors</td><td>12,000</td><td colspan="2">Various</td></tr>
</table>



Electricity also used for cooling

Overall electricity savings in Murcia accounted for 15.5%. Large energy savings were achieved in the “Ayuntamiento” and “Anexo Ayunatmiento” buildings of around 20% mainly achieved over the Christmas and summer periods. Significant savings of 13% were also attained in the “Bomberos” and “Tráfico y Multas” buildings and of 9% in the Police station building. Building professionals considered that these savings has been realised through a comprehensive electricity and building management/control systems implemented in the project that have facilitated in great extent the control of the energy consumption in the buildings. In the interviews, it was also acknowledged that the EDSS has raised the staff awareness, knowledge and skills about energy efficiency and IT as well as the cooperation of buildings users to save energy and their interaction with energy teams. In general, staff in the baseline and final surveys appeared to be supportive to reduce energy use in their buildings.

However, the user engagement was not very successful in the “Protección Civil” building, where an increase of electricity of 9% was observed. The number of volunteering staff in this building increased during the monitoring period. High electricity consumption was detected in the summer period at nights because the air conditioning was left on for the entire day. Despite efforts conducted by the local energy agency (ALEM) to increase their awareness, these volunteers were difficult to engage due to the nature of the work they are conducting (temporary young people working for free in short shifts). They felt justified in having lighting, air conditioning or heating overnight.

Typical annual electricity savings of around 16% are expected to continue through the continuous improvement of energy controls in the buildings and further engagement with staff to raise awareness and increase their cooperation to reduce energy use.

Pilot Overview

Murcia participates in SMARTSPACES with two groups of public buildings selected for the pilot Nowadays, these buildings are among the largest electricity consumers of the city, are well known by the citizens, and are used by hundreds of people every day. Among which is a 9,191 m² large complex made of 4 buildings of 6,788 m². Hundreds of people use the offices 24 hours a day (officers, policemen, firemen, visitors, etc.).

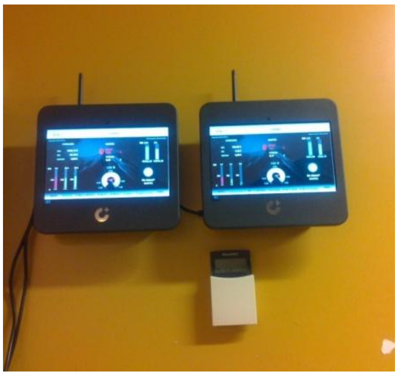
In terms of energy control, these buildings used analogue metering systems before SMARTSPACES. Therefore no real time analysis of the energy consumption was possible for to the control of the technical operating efficiency of the technical equipment. SMARTSPACES deployed smart metering and other sensors.

Service summary

The service is available through smartspaces.eu as part of the pilot site description together with a video.

EMS– service description

The system operates like an operative system for tablets and smart phones concerning the specific software applications. Depending on what we need to check, those applications were downloaded and installed in the system for the following purposes:



- Voltage Failure: E-mails are sent to the person in charge of solve the problem immediately.
- My Energy Invoice: Permits to detect if the Utility Company is invoicing correctly or not.
- Zones of Temperatures: Real time temperature of zones and rooms with registration and alarms. Permits to program actions depending on the pre-programmed temperature ranges.
- Consumption and Incidences: For monitoring KWh and € in specific lines or equipments and incidences in consumption.
- Energy Audit: Automatic analysis of energy consumption, reactive energy, over-consumption, peaks, contracted power suitability, etc. Software suggests how to improve on them.
- Climate Control: Registers and controls air-conditioning and heating systems.

Smartjumper permits to save the peaks on demand of energy because the system integrates hardware elements to filter the electricity and balance the reactive energy. Furthermore, EMS generates alarms when a peak of energy overcome and report by e-mail to the responsible person in order this will not happen again. General reports are printed periodically with more information regarding energy audit improvements suggested.

EDSS– service description

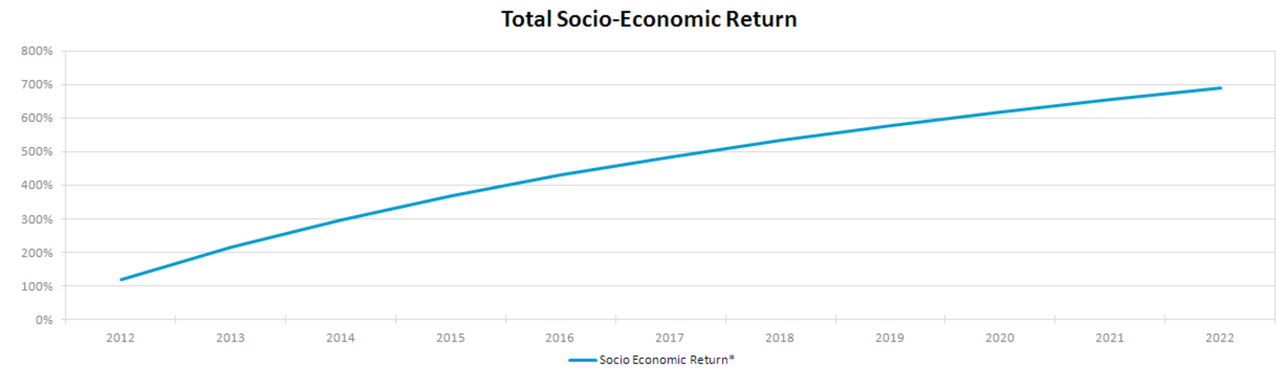
Building Professionals are expected to impact widely on energy consumption but almost have no impact on awareness on energy saving. They can control and have a wide range of features to check the performance and adjust what can be adjusted remotely.

However, in buildings – partly occupied 24/7 – the focus lies on staff behaviour. Numerous recruitment efforts were undertaken including training for champions and key personnel. All staff was reminded with advice using stickers were action is possible. Reminding them of SMARTSPACES itself also helped to induce users to check the platform and the right setting in their offices. Reminders included:

- Cumulative electricity consumption: in order to identify the cause of these over consumptions. Cumulative energy consumption is also showed in Euro so that can be previously known the amount of the next bill.
- Comparative electric consumption: actual month / previous month
- Historian of consumptions: It is shown graphically by months and years comparing with precedent years.
- Temperature Indicator: Over selection of temperatures (over 21ºC in winter or below 24ºC in summer).
- Energy Audit: with recommendations to be implemented in order to improve in energy efficiency.
- Control – action: Staff in charge of area receives automatic mails when over-consumptions occur or when machines/lights are on when they should be off. They must solve incidences.

Quantitative Analysis (CBA)

The SMARTSPACES project has a positive socio-economic return paying off immediately through a reduction of savings and operational optimisations. The model is based on the worst case, assuming no change in consumption (despite probably rising temperatures) and only a limited increase in electricity prices. The simple business model of buying equipment whilst avoiding fees for metering can easily be replicated in other cities provided the *Council* has a department responsible for installations and energy.



* Stakeholders included in the Graph: , Council, Measure, IT. Discount Rates applied on Baseline for return on investment (e.g. equipment, operation): 5%, for intangible indicators (e.g. societal, non-financial): 3.5%.

Value Propositions

The increase of data resolution in existing buildings from one single point to various zones and to frequent intervals allows for automation of climate control (time and temperature) etc. depending on, for instance, occupation. Data also allows for establishing causality and evaluation of piloting new energy saving measures (e.g. exchanging filters, presence detectors) which might be useful in some but not all circumstances. This allows for optimising tenders across several buildings. The solution as a whole has been customised as a service for the municipality using existing communication contracts and providing one platform for all user types. Accountability through data is also within zones with regard to user behaviour and decision support is presented in a way so that it can be replicated at home.

With the early decision for one platform, the pilot collected and standardised all training materials and documentation which is applicable to all buildings including those to which the solution can easily be extended due to its scalability.

Future Exploitation

In 2015, due to the good results obtained, the service will be replicated to the ALEM site municipal building, the Local Energy Agency Municipal Department which was leading SMARTSPACES.

Service provider and ALEM have worked together since the beginning of the project to implement the better solutions and the appropriate equipments for each needed. The continue evolution of the equipment performance thanks to ALEM inputs has been an ongoing task during the duration of the project. Due to the austerity measures, only a limited number of investments have gone through although the original attempt was to equip around 40 buildings should SMARTSPACES proof successful (which it did, see also threats).

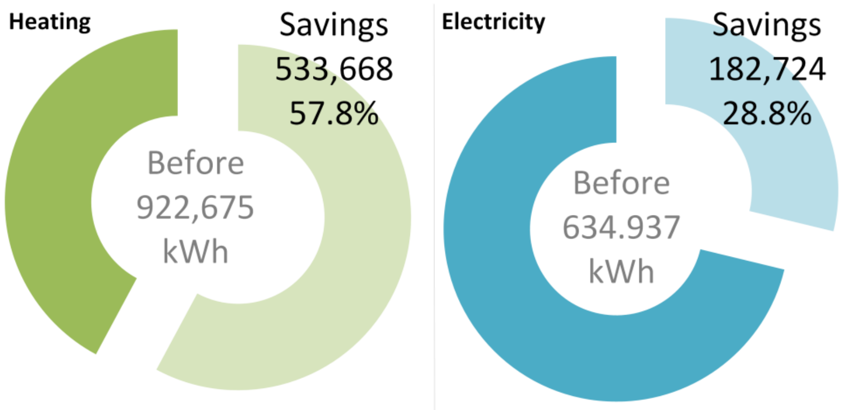
A new generation of equipments has been developed in cooperation between manufacture company (IDEA ENERGY LAB) and user (MURCIA CITY COUNCIL), thanks to SMARTSPACES project. In addition, the service provider has benefited of promoting and dissemination actions within the framework of SMARTSPACES project.

Selected publicity achievement

The SMARTSPACES pilot site in Murcia was chosen again as a one of the three finalist of the II call of the **enerTIC Awards 2014**, in the category “Smart Cities”. These awards represent a public recognition among the ICT companies actively involved at enerTIC Platform. Furthermore, all finalist projects have been published at ‘III enerTIC Reference Guide: ICT for Energy Efficiency Improvement’, intended to be a reference document for executives, both private and public sectors, who want to use ICT technologies to make their organizations more competitive and sustainable by saving energy.

2.8.12 Venlo

City of Venlo			
Buildings	1	Surface	10,000m^2
Age	2011	Services	EDSS, EMS
Building Type	Office, Exhibition Space	Resources covered	
Users: Staff	>80	Office workers	
Users: Professionals	3	Energy managers	
Users: Visitors	>150/day	Consumers (shopping)	



Large hot water and electricity savings were observed in Venlo, while the same identified staff respondents showed higher levels of awareness, knowledge and self-reported behaviour to reduce energy in the final survey. This indicates that staff members moved towards a more pro-active behaviour in the final survey compared to the baseline survey. Interviews highlighted that the EMS and EDSS have predominantly benefited building professionals who have utilise the services to optimise the energy performance of the new building by improving the energy efficiency of equipment (such as heat pumps), reacting quickly to faults or consumption anomalies and testing energy- and cost-efficient innovative control strategies. On the other hand, the visualisation of energy data in the EDSS and the interaction of building users with the energy coach aimed to increase their awareness and engagement on energy savings.

Typical annual savings of 10% for heating and cooling demand as well as electricity use are expected through the continuous optimisation of parameters and controls and through further education and engagement with staff.

Pilot Overview

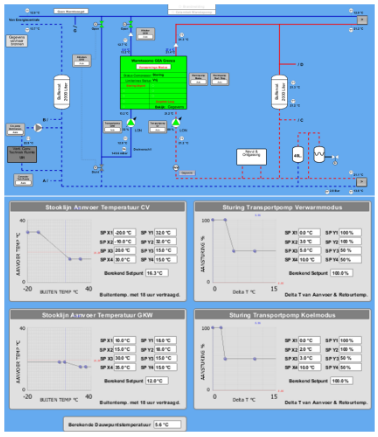
Villa Flora is also known as 'the greenest office in the Netherlands'. With its combination of state-of-the-art environmental technologies it is also a landmark of sustainability. It hosts offices and public meeting rooms as well as a greenhouse. The Venlo region has been designated one of the Netherlands' Greenports. Venlo was the first region worldwide to embrace the cradle-to-cradle (C2C) philosophy, a concept for sustainability based on the reuse of raw materials, which renders products completely recyclable and turns waste into raw materials.

The building is heated and cooled using heat pumps. Even though it is theoretically green, the volume of water being pumped has to be controlled and the project showed that ICT-solutions involving the staff on sight are needed to ensure maximum efficiency is kept. The objective of the EMS solution is to gather rough data and to transfer it into intelligent data. The objective of the EDSS system is to analyse data and create intelligent dashboards, reports and steering information for the building systems.

Service summary

The service is available through smartspaces.eu as part of the pilot site description together with a video.

EMS– service description



The EMS allows building users (in this case workers and staff members) to set and modify controls for energy use for the parts of the building they are occupying. While building managers have full access, normal staff members are able to manipulate local systems such as lighting, heating, ventilation and cooling per room. The energy service ICT application (EMS but also EDSS) run from a web application providing insight into the actual energy use and other parameters of the space in which the users are located. It also offers the possibility to adjust these parameters. The application provides feedback on the user's energy consumption and for which purpose this energy is consumed. The system offers functions for viewing and / or controlling:

- Heating, Ventilation and Air-conditioning (HVAC)
- Room climate
- Central generation of heat and cold through Fiwihex solution
- Biomass energy generation
- Re-use of water

The performance is monitored by approximately 300 data points. These 300 data points will generate data sets relating to heating, cooling and ventilation (HVAC) that will be stored and used for in-depth analysis. This is illustrated in the following schema describing the installations for heating with various data points and controls.

Another important aspect of the EMS development is the monitoring features of the innovative control strategy. This strategy is innovative because uses forecasting methods for the determination of the heating and cooling load and offers options for reducing peak loads by activating the mass of the building during the night. The overall goal is to achieve an optimal balance between comfort, energy use and peak loads.

EDSS– service description

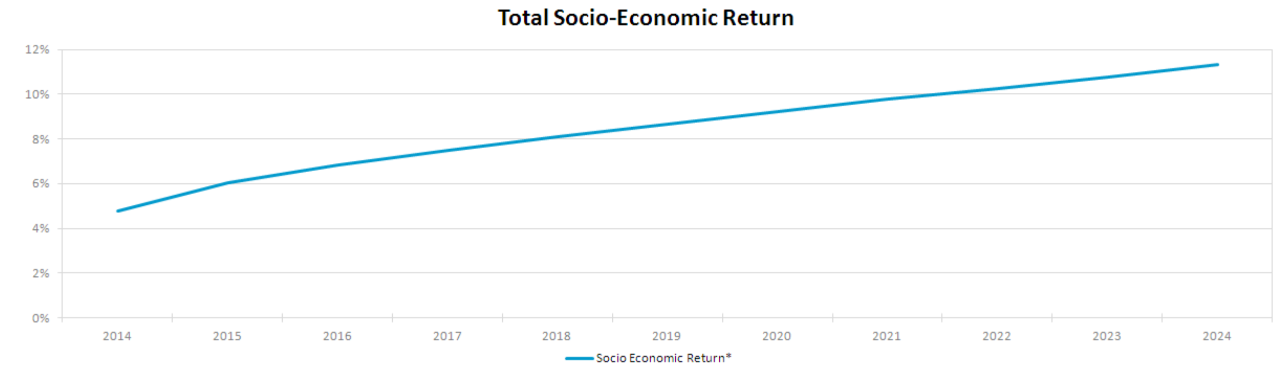
The EDSS is accessible by building users by web browser. The building user can log in to their own account which gives information about the energy use of their own zone. Also information is provided about the comfort.

The green box is the savings counter. It will be coloured red if there is no savings. At the bottom the comparison of the energy use of the last month and the same month in the last year. Reports are generated to give a weekly overview. These reports are shown at the information screen in the office space about energy usage of the whole office.

Visitors are made aware of the green image of Villa Flora through different methods. Throughout Villa Flora the QR-codes can be scanned. This links the user of the scanning device (cell phone, tablet) directly to the website of the portal (http://smartspaces.volantis.nl:4900/). On this website users can view up-to-date information about energy consumption and get information about saving energy. They are also made aware of the SMARTSPACES project and can obtain a link to the project on the intranet. An example of a visitors screen is displayed in the next figure. This screen is exposed at the entry of the office of Volantis.

Quantitative Analysis (CBA)

The SMARTSPACES achieves cost-neutral socio-economic return. As the building is new, the baseline scenario of consumption resembles an ideal case but more wastage becomes more likely with time. Hence, the absolute saving might be higher in the future. Most of all, primary energy consumption is being avoided as other building operated (by the service provider) without SMARTSPACES consume more gas to compensate for incorrect settings of (green) heat pumps.



* Stakeholders included in the Graph: Department, Council, FreeRole. Discount Rates applied on Baseline for return on investment (e.g. equipment, operation): 5%, for intangible indicators (e.g. societal, non-financial): 3,5%.

Value Propositions

The Villa Flora, by design, is a very energy efficient building utilising various non-IT high-tech solutions. Still, SMARTSPACES could show that such buildings have energy savings potential by optimising settings with a flexible EMS and avoiding wastage due to behaviour with EDSS. Every building is unique with its own parameters and quality of build, piping connections etc. is not identical throughout. The analysis engine in SMARTSPACES provides makes sure that the parameters are working for *this* building and not only the default average value which is set by the provider of hardware. Moreover, the service does not only detect larger mechanical or hydraulic faults early but is smart enough to point at smaller leakages. “Dumb” EMS would only tune certain variables to reach the target parameter without narrowing down the area in which the anomalies occur.

Future Exploitation

The SMARTSPACES concept has a great potential, the concept of monitoring by professionals on the energy use and performance of the HVAC systems will reduce the energy use of an average building drastically. With the project we learned that building users have more influence on the total consumption than originally anticipated and the service cannot stop with automatisation. Therefore the concept will be disseminated and further developed. The expectation is to implement the service in 25 building in the next 3 years.

As the supplier of the software is just entering the market and not partner in the consortium, the majority of the marketing and exploitation efforts is not yet public.

Selected publicity achievement

Antoin Scholten, mayor of the Venlo City, received a **cradle-to-cradle frontrunner award** for the Venlo region. The C2C PII handed over this unique award to the Venlo region because of the commitment and dedication of this region to Cradle to Cradle and the vision for the future involving the SMARTSPACES saving energy project.

3 Impact

This chapter describes the impact of the SMARTSPACES project also quantifying various aspects relevant for further exploitation. To standardise the results and to make the calculations retraceable, assumptions are kept as simple as possible. Calculations are based on the figures collected as part of evaluation and the exploitation planning.

3.1 Environmental impact

3.1.1 Resource savings

Overall all pilot sites showed savings, particularly in Belgrade, Hagen, Lleida, Milan, Murcia and Venlo. Istanbul and Moulins also attained significant savings based in simulated baseline data. Less savings than expected were achieved in Birmingham, Bristol and Leicester due to several unforeseen changes during the monitoring period. These changes include movement of staff due to rationalisation of the council's buildings portfolio (Birmingham) or closure of the council's headquarter building (Leicester), increased number of students and use of ICT and other equipment in schools (Bristol and Leicester), and extended opening hours in libraries (Leicester). Nevertheless, all pilots showed examples of how engaging with buildings users, improving controls and proving feedback helped reduce consumption.

The following table presents the absolute and percentage annual savings that could be achieved as a result of the successful implementation of the project. These savings were estimated by comparing the actual measured consumption to the consumption forecast. For most pilot sites, savings remain the same as presented in section 2.7.8, with the exception of Bristol and Leicester Here it was assumed that savings of 5% for electricity and 10% for heating could be achieved across the entire floor area including those buildings where unforeseen changes took place. In other words, once these changes occurred, buildings occupancy or space use patterns will remain the same.

Exhibit 24 -- Typical annual savings as a result of the successful implementation of the project

Pilot site	Area m²	TYPICAL ANNUALSAVINGS			SAVINGS in per cent			Emissions reductions
		Electricity MWh	Gas/heat MWh	Water m²	Electricity	Gas /heat	Water	Tonnes CO_2e **
Belgrade	26,057	384.1	1,868.7	2,641	22.4%	29.7%	19.0%	680.9
Birmingham	58,928	126.7	-	-	5.3%	-	-	68.8
Bristol	687,000	1,858.8	7,988.2	-	5.0%	10.0%	-	2,623.0
Hagen	33,300	325.9	133.9	-	15.2%	7.3%	-	230.4
Istanbul	22,000	63.5	384.3	-	6.4%	37.3%	-	118.9
Leicester	110,000	471.1	708.2	16,579	5.0%	10.0%	15.3%	398.9
Lleida	32,000	241.1	776.7	-	12.0%	18.9%	-	268.9
Milan	3,724	143.0	-	-	49.1%	-	-	69.1
Moulins	1,640	-6.8	86.5	203.9	-9.7%	71.8%	36.9%	17.1
Murcia	11,942	245.4	-	-	15.5%	-	-	108.0
Venlo	10,000	182.7	533.7	-	28.8%	57.8%	-	187.3
TOTAL	996,591	4,028.5	12,480.2	19,424	6.9%	12.3%	15.8%	4,762.2

Figures presented in the table above are conservative. Several pilot sites expressed that after the successful implementation of the project, further savings can be achieved year on year.

In Belgrade, annual savings of 15% for heating, 12 % for electricity and 15% for water could continue as a result of the improved control of energy consumption in the building through the automated and centralised collection of energy data and the increased awareness of staff. In Moulins conservative annual savings of 8% for heating and 5% for water are expected in forthcoming years because a significant optimisation in their consumption took place during the project, while electricity savings of 10% are anticipated. Through the gradual implementation of Birmingham Utilities Strategy and operational interventions currently functioning in the city, it is anticipated that the electricity savings of an average 6% will continue and gradually increase. In Hagen, further annual savings of 10% for electricity and 20% for heating are expected through the continuous optimisation of energy flows in the buildings and increased awareness of staff. Annual savings of around 5% for the low cost services and around 30% for the medium cost services are anticipated in Lleida. It can be expected that several public buildings at the municipalities could implement the low cost services due to the low investment costs and the potential savings attained in the pilot buildings. Larger savings can be achieved through the medium cost services. Although larger investments are required for these services, the payback period for the investment is around 3 years. Identified savings could be materialised using ESCO models. Typical annual savings of around 16% are expected to continue in Murcia through the continuous improvement of energy controls in the buildings and further engagement with staff to raise awareness and increase their cooperation to reduce energy use. While in Venlo, further savings of 10% for heating and cooling demand as well as electricity use are expected through the continuous optimisation of parameters and controls and through further education and engagement with staff.

3.1.2 CO_2 savings

Based on savings shown in the table, if typical annual savings continue to take place after the successful implementation of the project for **ten years** and assuming that no changes will take place due to exogenous factors, total energy savings and emissions reductions attributable to the project would be 165,087 MWh and 47,622 tonnes of CO_2 emissions.

The 10-years emissions reductions of 47,622 tonnes of CO_2 across all sites are slightly higher than the yearly community-wide emissions of the municipality of Concordia Sagittaria, Italy, which has a population of around 10,549 inhabitants and per capita emissions of 4.2 tonnes.

The total expected electricity savings of 40,424 MWh across all sites after ten years resemble the annual production of a combined heat and power plant of 5.8 MW_e capacity operating for 7,000 hours per year.

The total expected heating savings of 124,033 MWh across all sites after ten years equates to 10,665 tonnes of oil equivalent (TOE).

3.1.3 Pilot overview and comparison

In Belgrade, large energy savings were achieved for electricity (22.4%), heating (29.8%) and water (19%) in the City Administration Complex. These changes were result of physical building changes and behavioural change. Physical changes include installation of new burners and a regulating system for combustion through control of O_2 in flue gases, and the installation of a SCADA system for heat energy consumption monitoring. As to behavioural change, the recently elected City Government attempted to reduce energy costs to a minimum, therefore, drastic measures for energy saving were taken, such as decreasing the heating to a minimum level and controlling the switching on and off the lights. Whilst this was effective at reducing energy consumption it caused some difficulties with the building user survey, with many building users unwilling to complete the second survey, due to insufficient time.

On average, electricity savings in Birmingham were 5.3%, with the largest savings achieved in the Margaret street building where the number of staff based onsite decreased due to the council's attempt to rationalise the number of administrative buildings on its portfolio. Less savings than expected were achieved in the Council House, which was partially occupied during the baseline period and went to full occupancy in the monitoring period. Although the Council House benefited from the installation of a number of interventions on the staff offices such as LED sensor lighting for example, the increased number of users and their associated equipment (laptops, PCs, etc.) had an impact on the energy consumed and therefore the savings achieved.

Within Bristol’s large portfolio of participating buildings, three main types of building categories were identified: schools, facilities managed centrally by Bristol City Council (FM) and small locally managed single-team buildings (general). Overall heating savings in the pilot site were 8.1%, while electricity savings were only 0.8%. The small savings in electricity can be entirely attributed to the schools category. Electricity use in schools rises year-on-year due to increased use of ICT and other educational equipment. However, the larger gas savings can also be attributed to schools and the small locally managed buildings, because building professionals have the ability to adjust timers and settings of the heating systems. However, in the centrally managed facilities people have little control over their buildings’ gas use and little engagement and ownership of energy savings as the bills are centrally paid. The behaviour change responses could not be clustered by building type due to the low numbers of survey responses in the different buildings. However, interviews pointed out that most engaged users looking at the monthly reports and communicating with the energy coach were located in school and locally controlled buildings. Nevertheless, survey respondents tended to have higher levels of intentions to report energy saving opportunities and self-reported behaviour to minimise energy use after the EDSS was launched.

Reductions in electricity and heat consumption of 15.2% and 7.3% respectively were achieved in Hagen. Electricity savings were mainly attributed to reductions in the Emil Schumacher museum where the SMARTSPACES services had a significant impact. Heating savings were possible due to the analysis of heat and cold flows of the additional meters installed in the buildings during the project. This analysis aimed to optimise the heat and cold production in heat pipes. Although the survey responses showed a small increase trend in the staff self-reported behaviour (1.2%), the mid-term interviews highlighted that the main recipients of the benefits of the services has been building professionals who are responsible of the energy management of these buildings.

Large gas/heating savings were achieved in Istanbul (37.3%). Electricity savings of 6.4% were also estimated. Prior to the SMARTSPACES services, measured data were not available; hence savings were calculated using simulated data. Heating saving could be attributed to the prompt identification and solution of high energy consumption malfunctions through the monitoring and control system implemented in the project as expressed by interviewed building professionals. These interviewees perceived that staff awareness and knowledge about energy savings were low at the initial stages of the project, but increased with the SMARTSPACES services. Interviewees considered that staff and building professionals became more conscious of closing windows and doors when the air conditioning or heating services are in operation. This trend of increased awareness and self-reported behaviour to minimise energy use in the facility was also observed in the baseline and final surveys responses of the same identified staff. Besides, ambitious energy and emissions reduction targets have been set at the institutional level that may encourage staff and the project team to conduct appropriate actions to achieve these targets.

In Leicester, water savings of 15.3% were achieved, but the electricity and consumption increased by 5.7% and 9.1% respectively. Unforeseen changes caused these increases in gas and electricity use. These changes in council and university buildings included modifications in space use (e.g. Queens Building), migration of council staff due to the closure of the main Headquarter building (more than 200 staff moved to 16 New Walk and Neighbourhood Centres), movement of IT infrastructure into a single central location (John Whitehead), extended opening hours (New Leicester Central Library and Kimberlin Library), the need to use extra equipment after an unexpected flooding (African Caribbean Centre) and the need to rent mobile classrooms to accommodate increasing number of students (Coleman Primary School). By filtering these buildings in calculations, electricity and heating savings of 1.5% and 4.1%% respectively were measured. The small electricity savings may be attributable to the schools in Leicester that are going through major changes to accommodate growing number of places required and higher IT demand. Schools are currently up to full capacity. Engaged individuals, such as environmental champions, participated actively in the online forum posting enquiries about the energy consumption in their buildings or reporting energy saving opportunities to the energy management team. The overall increase trend of self-reported behaviour to minimise energy use was 1.7%. The innovative combination of an online forum and publically available energy and water data (in both smiley faces and graphical forms) was particularly useful to both energy managers and engaged building users.

In Lleida the evaluation of energy savings considered the medium cost services in buildings at Lleida City and low cost services in the municipalities' buildings. The largest electricity and heating savings were achieved through the medium cost services (13.9% and 30.7% respectively), whereas the electricity and heating savings in the municipalities' buildings were in average 3.6% and 1.5% respectively. The large savings in the buildings using the medium cost savings was attributed not only to the decisions and actions quickly prompted by the energy data visualisation (almost in real time) provided by the EMS, but also intensive energy campaigns related to heating, electricity use and air conditioning conducted between winter 2013 and summer 2014. Staff respondents in the City of Lleida and the municipalities were already highly aware and supportive of energy savings. Nevertheless, staff respondents mainly from the St Francesc offices (using the medium cost service) showed a higher level of self-reported behaviour (6.7%) in the final survey compared to respondents of the baseline survey (mainly from the municipalities).

Large electricity savings (49.1%) and self-reported behaviour change (33.2%) were observed in Milan. Electricity savings were 68.9% in the Police Station, 27.3% in the nursery and 14.1% in the museum. Prior to the installation of the services, facilities were not visible remotely, hence energy professionals needed to go physically to the buildings. With the EMS, the maintenance and solution of the problems could be conducted quicker. According to the interviewed building professional, the EDSS has also enabled reductions through the awareness raised by the feedback provided about the energy consumption in the buildings. Results from the surveys showed higher levels of knowledge, awareness, perceived control, intentions and self-reported behaviour by the respondents of the final survey compared to the baseline survey respondents. In this pilot site, environmental champions mobilised the project in their departments and buildings.

In Moulins, large savings were achieved for the heating and water consumption (71.8% and 36.9% respectively), but the electricity consumption increased by 9.7%. At the start of the project, the "Maison de l'Enfance et de la Famille" nursery building was under construction and started operating on January 2014. Therefore, savings were estimated using simulated data. The benefits of the EMS highlighted by building professionals were that the system has allowed them optimising the energy consumption in each zone of the building and improving the thermal comfort for the users (particularly babies of the nursery). Due to the same reason, responses for the baseline survey were gathered in a building with similar characteristics (Bellerive nursery). Differences between surveys showed that staff in the participating building (final survey) had higher levels of awareness, knowledge, intention to report energy savings and self-reported behaviour to minimise energy use compared to the staff responding the baseline survey. Staff from the "Maison de l'Enfance et de la Famille" also display a more pro-environmental behaviour compared to the Bellerive nursery. Interviews indicated that the SMARTSPACES services not only allowed optimising energy consumption in the new building with an improved thermal comfort, but also allowed for the provision of information and energy saving advice to staff and visitors.

Overall electricity savings in Murcia accounted for 15.5%. Large energy savings were achieved in the "Ayuntamiento" and "Anexo Ayunatmiento" buildings of around 20% mainly achieved over the Christmas and summer periods. Significant savings of 13% were also attained in the "Bomberos" and "Tráfico y Multas" buildings and of 9% in the Police station building. An increase of electricity was observed in the "Protección Civil" building. The number of volunteering staff in this building increased during the monitoring period. High electricity consumption was detected in the summer period at nights because the air conditioning was left on for the entire day. Despite efforts conducted by the local energy agency (ALEM) to increase their awareness, these volunteers were difficult to engage due to the nature of the work they are conducting (temporary young people working for free in short shifts). They felt justified in having lighting, air conditioning or heating overnight.

Large hot water and electricity savings were observed in Venlo (57.8% and 28.8% respectively), while the same identified staff respondents showed higher levels of awareness, knowledge and self-reported behaviour to reduce energy in the final survey. This indicates that staff members moved towards a more pro-active behaviour in the final survey compared to the baseline survey. Interviews highlighted that the EMS and EDSS have predominantly benefited building professionals who have utilised the services to improve the energy efficiency of equipment, react quickly to faults or consumption anomalies and test energy- and cost-efficient innovative control strategies. On the other hand, the visualisation of energy data in the EDSS and their interaction of building users with the energy coach aimed to increase their awareness and engagement on energy savings.

3.2 Economical impact

Results collected e based on a standardised calculation of Cost and Benefits using a comprehensive Analysis tool (CBA) differentiating multiple stakeholders. The tool allows for modelling various installation variants and cost distributions at pilot level as well as projection of costs and benefits. The tool allows for modelling distribution of costs and benefits among the eight relevant stakeholders identified (by changing the share of individual indicators paid / received). This enables all stakeholders to agree on a common (or design an individualised) business plan. The benefit of SMARTSPACES is calculated as the difference of all costs and benefits for SMARTSPACES subtracted by all costs and benefits of the status quo ('Do nothing' scenario).

Results are bases on calculations for a period of 10 years. Results presented are net present values assuming 5% interest rate for financial cash flows and 3.5% for intangible benefits. This approach allows for simple and straightforward extrapolations to the relevant level for public buildings, regions and the EU.

The socio-economic return is presented for the entire pilot site. It has to be pointed out that the vast majority (95%-100%) of indicators used are directly linked to cash flows and only a small number of indicators are intangibles measuring societal benefits.

3.2.1 Project benefits

In total, the SMARTSPACES project will create a net benefit of €4.2 Million over a period of 10 years. The sum is likely to increase with increasing prices of resources such as electricity, water and gas. Moreover, companies exploiting the solution are likely to collect further benefits with economies of scale and further experience on how to best and quickly educate tenants.

3.2.2 Pilot benefits

Depending on the setup, more or less functionality is offered to either the staff, professionals or as an automated system. Degree of functionality correlates with technical requirements and costs. This correlation is particularly strong for implementation costs but also holds for operation costs since financing the investments is often based on future payments. In many pilot sites SMARTSPACES does not only add benefits through energy savings but also in the operation of the service itself, by either optimising processes or allowing for revenue streams which have not been possible prior.

Total return on invest - all stakeholders in the pilot site together - is reached across all sites within a few years. This does not imply that an individual stakeholder might require a few more years to get investments back. In fact, some service providers need longer especially if they enter the market as 'newcomers'.

3.3 Societal benefits

Aside of purely environmental and socio-economical benefits achieved with the SMARTSPACES service various societal benefits should be also considered as part of the contributions to society. This part of the population is likely to have no access to and limited experience with the internet which – depending on the service design – is required to achieve the maximum impact. Examples given were partly developed as part of SMARTSPACES.

3.3.1 IT-literacy

The SMARTSPACES service helps to reduce existing barriers regarding IT-equipment and the internet experienced by elderly and others. This is achieved by educating users basic concepts of control, navigation and conventions used on tablets and PCs as well as in the cloud and on web sites.

3.3.2 Empowerment and e-Inclusion

IT-literacy can be improved by empowering selected individuals to become local energy coaches who not only receive but also teach. ICT-based energy efficiency projects should consider selecting individuals having difficulties to enter the primary labour market due to long-term unemployment or disabilities as energy coaches fulfilling a central and socially valued role in their local community.

4 Exploitation

This chapter presents tools and results developed for exploitation. The focus starts on the guide for replication on stakeholder level over business plans that could create the paths for implementation.

4.1 Guide for replication

The '**Guide for Replication**' presents how Information and Communication Technologies (ICT) can be utilised to improve energy efficiency (EE) in non-residential and residential buildings.

> ***Innovation triggered**: The Guide is interactive and the content dynamic dependent on the requirements / preferences of the reader. Any interactive content (e.g. video, portals) available from projects is embedded in the Guide.*

The reader can follow the Guide following the necessary Phases or from the viewpoint of individual Stakeholders. **Setting the Scene** explains technical basics and the different concepts in more detail. **Phases** distinct necessary steps for successful development, implementation and operation. **Stakeholders** chapters selectively include content relevant for the stakeholder in question. Checklists and key lessons learnt are highlighted and introduced in context. This includes the **References** to specific projects and pilot sites for which detail including live portals and videos are provided. Comprehensive checklist, glossaries, tools for download etc. are collected also in the **Technical Documentation** and in the **Annex**.

4.2 Energy Efficiency using ICT: The business case

This section presents three key exploitation scenarios based on the experience from SMARTSPACES as well as BECA and eSESH. This section cannot replace more detailed replication scenarios presented in chapter 4 and lessons learnt for individual stakeholders which are listed in the 'Guide for Replication'.

Exploiting energy management potentials (EMS)

No metering

Results from three ICT projects, SMARTSPACES, BECA and eSESH, have shown that energy management services (EMS) have large savings potentials. Many systems, heating and renewables in particular, are often not set to the optimal level and / or faults and wastage is only being detected after some dealy. In the mean-time avoidable monetary cost has occurred and, in some cases, the life-time of installations was reduced. ICT-enabled EMS provides "quick and easy benefits" in consumption reduction and back-office administration.

Building operators and service providers have following options for EMS:

- Identify buildings with highest average consumption for service implementation and analysis. Ideally, a group of buildings is chosen which were built to the same standard to allow evaluation.
- Service providers should consider simple cost models creating incentives for extensions and energy contracting as financing scheme for implementation costs.
- Create transparency about the EMS service to be installed and advertise such systems with communicating which savings have been achieved as an entry point for EDSS extensions.

Smart metering present: EDSS if support for EMS is not sufficient

If smart-metering is already present but the will does not suffice to acquire an EMS, the recommendation is to deploy EDSS. The requirements are rather low as the database already exists. Moreover, economies of scale apply fully: The portal only needs to be acquired once and the size of the data will increase costs only slightly.

Focusing upon heating and water consumption first

High relative savings for heating and water are being achieved in many pilot sites. Initially, SMARTSPACES, BECA and eSESH projects considered that saving potentials are equal across resources, but this does not seem to be the case. Moreover, for electricity a recent study by Ernest&Young[8] considers the market potentials for smart-metering to be low in Germany. Though the study does not cover a number of ICT-enabled services such as local energy storage and potential benefits for increasing micro-generation, it has to be assumed that any service provider focusing on electricity has to consider strong headwind. On the other hand, Google acquired the IT-company Nest[9] producing, for instance, smart thermostats.

Measurement and IT-providers should consider the following remarks on future design:

- Services should be able to support heating and (cold / hot) water metering input, visualisation and advice.
- In highly insulated buildings, any wastage leads to a high relative increase of consumption compared with the performance possible.
- In many countries participating in the SMARTSPACES project, consumption based billing for water and heating is not the standards yet (see also the next recommendation).

Market potential in countries without consumption based billing

In many countries, especially among the 'new member states', it is not yet standard to bill resources based on the consumption of individual dwellings. This is particularly true for heating and, in some cases, water. No consumption based billing implies that metering equipment is often only present for the entire building and that there is little incentive for individuals to increase resource efficiency.

Pilot sites in which the billing standard has been changed (as part of the project) show that break-even is being achieved later. One reason being generally lower resource cost. Also, it is an up-hill struggle to implement a service without public discussion. In general, SMEs have the chance to enter this developing market and play a disruptive role increasing competitiveness. However, there is a considerable risk competing with oligopolistic (in some regions monopolistic) utilities with large resources and capacities to create barriers.

Following remarks for service providers and SMEs should prove helpful:

- Consider a two-step approach or contracting models to the level of service in order to achieve sooner break even for investing parties.
- Enter the market as a measurement provider for which service fees are likely to become standard (as in old member states) and advertise SMARTSPACES service as an additional feature.
- Ensure that access to infrastructure and metering is granted and ensured at all times (see also 'Guide for Replication' lessons learnt).

Monitor regulatory and law development for measurement / billing standards very closely in each country the service is to be sold to. This helps to avoid misunderstanding with service users for whom everything about the service is new and have often no prior knowledge about their own consumption or terminology usually used

8 Ernest&Young (2013), Kosten-Nutzen-Analyse für einen flächendeckenden Einsatz intelligenter Zähler.

9 https://investor.google.com/releases/2014/0113.html

Value propositions for ICT-enabled energy saving services

This section summarises key value propositions for the SMARTSPACES solution and the targeted stakeholders which have been developed in SWOT and CBA analyses and are being used in marketing and exploiting the SMARTSPACES solution.

SMARTSPACES overall

ICT-enabled energy services help stakeholders to:

- manage energy consumption in city buildings
- take decisions on the energy consumption based on real-time or high-frequency information
- constantly reduce costs
- improve service performance and support
- scale up innovative solutions to a city level
- involve citizens through interaction and awareness delivery
- provide rapid access to new technologies
- implement more complex applications
- demonstrate clear return on investment

Specific value propositions are:

- reduce total cost of ownership
- provide a predictable expenditure model
- take well-grounded decisions based on up-to-date data
- deliver greater service performance
- introduce rigorous process efficiency
- maximize innovation and technological agility
- deliver transparent ROI

Departments

- reduce cost of energy and water consumption
- reduce cost of network connection (e.g. fees for metering)
- reduction of energy poverty and dependence on state
- positive impact on environment
- positive feedback for own activity
- positive influence on behaviour and self awareness
- improved communication channel with end users

Council (Building Occupiers / Owners)

- reduce cost of metering
- reduce cost of grid connection
- faster detection of malfunctions
- future proofing for own energy provision (e.g. local storage)
- potential to market energy to tenants
- ICT integration of energy processes into management procedures
- facilitated communication between departments

IT-service and measurement providers

- innovative business model based on service and energy contracting
- reduce cost of metering
- reduce cost of grid connection
- faster detection of malfunctions
- future proofing for own energy provision (e.g. local storage)
- integrated data collection for further analysis (e.g. big data)

4.3 Replication scenarios

4.3.1 Metering availability

Two options are available depending on whether the reader already has smart meters.

No (smart) metering: Upgrading the building portfolio

The majority of buildings in a municipality do already exist. Only a fraction (<2%) is being renovated every year. Even if the rate would increase it would take decades before the consumption of the existing building portfolio would be reduced. ICT-enabled services are an option to reduce the consumption by several per cent often paying off without additional costs. Any savings will reduce the environmental impact of the municipality and make the public body ‘lead by example’. The common misconception is that ICT-services wish to replace potentially higher savings achieved with measures requiring construction efforts: This is not the case. Both efforts have their justification and contribute to savings in different ways (see 4.3.3).

A key requirement is a sufficient amount of metering infrastructure of which the data recorded can be linked to a heating / cooling system or the consumption behaviour from a certain group of people. This is usually achieved by dividing the building into zones (*Hagen*). Depending on the resource a different number of zones might be advisable. Decide whether the metering is to be kept in-house (see business model) or provided by a third party. If another party is involved (e.g. ESCO) try to create an incentive for the company to achieve savings with the infrastructure (e.g. contracting) hereby also ensuring that not more hardware is installed than necessary.

Business model to consider

Some municipalities are paying large fees for measurement and billing. In some pilots replacing these external devices by council owned meters paid of within a few years avoiding fees. This would also ensure that data access as well as (temporary) increase of frequency is easier to accomplish (Murcia).

In some countries (and resources), smart metering is / will be compulsory (e.g. UK). Make sure the investment does serve another purpose but to meet regulation. If you still have influence on where and how many meters to install, consider questions above and based on the building type (see below).

Smart metering already available

The conclusion is simple. Deploy an ICT-enabled EDSS service. The data is already available and the municipality is paying for it: You need find the party storing the data. The frequency of the meter readings might be adjustable for your needs without changes to the contract.

There are numerous energy platforms already available on the market and flexible to adopt existing data based minimising the development effort (*Bristol*) and cost. The centralised platform can be made available to the staff within in the municipality network. The graphics provided will enable professionals to understand their own building better. Try to recruit ‘champions’ who will search for irregularities and act upon it. Once buildings with unusually high consumption are identified, raise awareness with campaigns.

EDSS can also be used for transparency regarding consumption and to educate the wider public about energy consumption. Provide a kiosk system for visitors and tell them on how they can reduce energy at home (*Belgrade*). This might be especially useful in countries in which individualised metering is unknown.

A basic form of EMS should also be implemented. Allow professionals to set alarms notifying them about irregularities regarding consumption (and production). This will increase the speed with which wastage is detected. Utilise the data gathered also in future planning such as decision on where and how to modernise buildings.

> ***Business model to consider***
>
> *The majority of cost is due regardless of whether you provide a service (meters, communication fees). Find a supplier, maybe a local start-up / SME, to implement and host a portal, and make energy consumption data available based on a simple licence fee.*

4.3.2 Building

Depending on the building type / quality different cases can be made for a deployment of ICT-enabled services.

Old / wasteful buildings

Older buildings are often heritage sites and therefore protected (*Birmingham*). These buildings coped with weather and requirements for a long time. Those wasteful buildings which are modern (e.g. concrete structure from the 60-70es) have not been renovated for a number of years so it might be worthwhile applying services to reduce the wastage and smoothen the consumption patterns. ICT is replaceable should the day come in which the building is going to be replaced.

Any of these buildings probably suffer from large heat losses. Since the piping is older the probability of any water leakage also increases. In old buildings any work on walls is met with regulation and usually higher costs as more labour and selective materials must be ordered. As for renovation, the outside facade of a heritage building can, often, not be modified. Savings have to be achieved with other means and the higher the consumption the larger are the benefits of any savings even if it is only a few percent.

As these buildings are probably larger (museums, administrative buildings) it is recommended to divide the buildings into several zones so that a leakage cannot only be detected but also tracked down. The data gathered for several zones might also bring evidence on how to heat/cool the building as consumption can strongly depend on the impact of sunlight and wind.

New / highly managed constructions

Most new buildings have to have smart-metering installed. Hence, it is wise to make the technology part of the overall concept and ensure that the EMS can control the services installed.

> ***Business model to consider***
>
> *If the design and planning contractor is not capable of providing the ICT, employ a specialised SME such as ESCOs as these are also open to fixed price and / or contracting models.*

New buildings are also likely to have a consumption target defined by the architects and designers. Such targets are not always met. The SMARTSPACES service can be used to verify and to identify possible wrong doing and correct any errors enforcing accountability or promises made. Examples show also that the service makes re-adjustments of heating systems etc more successful (*Hagen*).

Buildings which need to be managed (e.g. swimming pools) might already have the ability to also manage the energy consumption (*Istanbul*).

Green buildings

Extremely efficient buildings consume less in total and any percent savings is therefore a smaller absolute amount. However, in relative terms behaviour plays a much more important role than in regular buildings. Leaving the window open will increase the total consumption dramatically as a single hole in the insulation will let a lot of hot air escape.

Another issue arises with the different systems interacting to achieve the efficiency. Often two systems divide the work: one for the base load, the other for the peaks. If the systems are not adjusted properly, the peak system might jump in too often. As it is not designed to be turned on often or run long, it is also more likely to break down sooner and add to the cost (*Venlo*).

Renewables

In the future it is more likely that the market will create incentives for those operating renewables also to consume the energy locally. This has a stabilising effect on the grid as the renewables are often produced at similar times (e.g. noon). This can be achieved by smart devices controlled by an EMS or by signals received or by small local storage. The latter can be charged during peak supply and emptied during peak demand.

High number of visitors

Administrative buildings and sport facilities have a diverse range of visitors. It is advisable to provide the general public not only with transparency regarding the consumption of the building but also offer a 'Kiosk' system on which the visitor can play an energy efficiency quiz or learn about how certain building systems at home work. The waiting time would then be translated in to an awareness raising campaign (*Belgrade, Leicester*).

4.3.3 Resource consumption

Depending on the total consumption, ICT-enabled services provide benefits for varying reasons. Total consumption can be driven by various factors (e.g. size, visitors, age, for heat/cold insulation/piping/technology etc.) which can be combined in many different ways. Trying to cover all combinations would reduce the number of cases in a city. Since the total number of public buildings in one municipality is already small, coherency is much more important than (pretended) plausibility.

The following table is applicable to any resources. The first step is to decide whether a building is low, middle or high in its consumption of a resource compared to similar buildings (or the portfolio as a whole). In the second step the most relevant propositions are to be chosen so that these can be validated and used to convince the relevant staff. The value propositions are described in more detail across this chapter depending on context. Overall, technologies listed are only examples (see note) to describe the thinking process needed.

(selected) Propositions relative to consumption	Total consumption level		
	Low	Mid	High
Regular savings	Low	Mid	High
Leakage / waste detection	High	Mid	Low
Other savings from operation	Equipment to last longer* (e.g. secondary firings can be avoided)		
Highest impact on peaks in grid	Heat pump*	Fridges*	Cooling / Fridges*
Minimum service recommended	EDSS	EDSS+EMS	EDSS+EMS

** Technologies listed are only examples. Which benefits are achievable depends not only on consumption of a building but also on the comparative consumption of device (e.g. old, less-efficient, cooling technology could be used in an otherwise modernised building).*

Heat / Cold / Ventilation

Heat and cold and air are being produced on site (or pumped through a grid). This also means that the boilers and associated equipment are within the permit of the building. The market for these products has increased dramatically over the years as more and more heating concepts exist. More buildings are now heated by a heat pump (consuming electricity) and a small gas boiler only exists to cover when it turns very cold. However, empirica observed in residential and public buildings that the error of gas boilers frequently firing seems to persist. With regard to programming it is rational to assume a worst case scenario if measurement values are not reliable and boilers often only rely on their own sensors.

ICT-enabled services can ensure that data is always available and any firing of the planned traced back so, should another fault exist, this can be identified. As for larger and often smarter boilers, the adaptation of heating curves (*Hagen*, *Venlo*), can bear huge saving potentials as any wrong setting will automatically have a huge effect on consumption in large buildings.

Electricity

Modern appliances are often connected to IP-networks or can receive signals through the plug. For instance, IP-telephones in office buildings can work as a measure of occupancy. The worker needs to turn off the phone and as a result all devices linked to the phones are also shut-down (*Milan*).

With advances in LED street-light and lighting concepts, a wide range of solutions is possible. The challenge is now more in integrating other services into the lamps which can work as network access points and wireless repeaters in sensitive environments such as hospitals (*Moulins*).

Water

In any regular public building, water consumption should be somewhat a constant. Consumption is limited to restrooms and maybe smaller kitchens. Hence, metering does not need to be divided into many zones unless different parts of the building are sometimes shut-down (e.g. weekend) whilst others remain operational. For instance, a sports hall might be used all week for competitions whilst the school is closed. In such a case, no consumption should occur in the school whilst showers and restrooms are being used in the sports hall even on a weekend.

Regardless, metering on wider level helps to identify whether any wastage occurred by using simple alarms (EMS) and / or regular checks of consumption (EDSS). Moreover, comparison between buildings allows identifying whether there are considerable differences of average per head consumption. This might be interesting in schools to check which one has the best approach to educate their pupils etc.

Public display of consumption – at least in a portal – will also act as social control and maybe remind the individual to close the tap whilst washing their hands.

5 Conclusions and Recommendations

This section presents recommendations facilitating the exploitation of ICT-enabled services and remarks on existing barriers for which various solutions have been outlined. The analysis is based on the pilot results but also the observations made in other work packages including Evaluation and Operation. The rationale will often be based on describing (dis)incentives or market inefficiencies.

To avoid repetition, this section is divided in policy levels starting on European and National level. City councils and building operators are addressed along with all market players. Since the choice of a business model also changes the applicability of (dis)incentives, other stakeholders are not addressed directly. (This is all done to increase the quality of the argument whilst being able to avoid repetitions and / or having to induce clauses such as if, when, etc.)

5.1.1 Europe

European legislation is a success in pushing smart-metering as well as individualised metering and billing. There are still many member states in which this is not yet the default option but by creating a European market with a certain (target) deadline those countries deploying ICT-based solutions do not have to overcome certain market inefficiencies such as device availability and prices completely by themselves.

However, the lack of certain regulation is endangering the momentum of smart-metering deployment and increases the risk for certain stakeholders, particularly those having to tick all legislation boxes at once (Councils) and those investing in innovation or business models (e.g. IT, Measurement providers).

eSkills – How different (energy) trades need to learn to work together

A European initiative is needed to raise awareness on how eSkills are becoming increasingly relevant. Economic growth is strongly linked to increasing efficiency and the progress of efficiency is increasingly driven by, and can only be achieved with ICT.

The electrical worker and mechanical engineer (professional)

Trades with lower skill levels will be installing metering and sensors which will communicate data wirelessly. This does not require full knowledge of network design but for an independent installation workers and plumbers must be able, for instance, to realise why signals do not reach the gateway and how to find a remedy by installing a repeater in the right spot. The current project has been performed with support by high-skilled workers also advising the regular mechanical engineer how to use the portal. For a wide roll-out, the availability of these high-skilled workers will decline. Facility managers will have to be able to perform basic data analysis and understand where the data comes from and how it interacts. They will not have to program features but they must be able to adapt to automated systems and modify their own routines to not create contradicting instructions.

The ICT developers and specialised service provider

ICT developers and service providers also have to learn to understand the input they receive from the engineers. The project developed numerous use cases and a comprehensive list of requirements but service providers cannot rely on the fact that the local customer will speak their language. To achieve full understanding and the efficiency possible, the ICT staff must be able to implement what is required. The building is still often the overall responsibility, and under the overall control of the facility manager. If the EMS is creating trouble he will find ways to override it to make his own job easier.

Moreover, ICT staff will also have to understand that the regular user (e.g. staff, tenant) has an impact on the consumption of buildings. Even very sophisticated buildings have shown that automation alone will not be sufficient. People have preferences with regard to comfort and routine.

One must be able to explain the reason why certain rules have to be applied and accommodate for some flexibility if it does not matter too much.

The regular user (staff, tenant)

It might be an obvious fact but a normal user needs some eSkills to get the most out of an EDSS service. Even if the EDSS service is simplified and boils down the information to a key measure, any further own investigation (or the contribution of observations to the forum) will require interaction with the service.

Technologies and research

The domain of sensors, data management and data analytics is going to change dramatically in the coming years also in the main stream, not only specialised companies. Some aspects have been presented above.

Further detail on research topics is presented in the research section (see 5.1.4), in particular:

- Local (volatile) storage services (extension of EMS)
- Internet of Everything (IoE) and (Big) data analytics
- Extending the smart city to the average city and not only a metropolis

Regulation in measuring frequencies and data packages

The documentation provided by member states in the Concerted Action on implementing the Energy Efficiency Directive and smart-metering regulation shows already that individualised metering of, for instance, heat will not become the standard in all countries. Among many reasons there are climate and traditional building design (e.g. pipes) etc making it not feasible.

Even if automatic measurements will not become the standard everywhere, the EC should set a minimum level of measurements for smart-meters. A half-hourly reading as applied in the United Kingdom seems a good compromise (hardly any evidence on costs and benefits of measurement frequency exists).

Moreover, the EC should also make recommendations on the limits of what a meter should be capable of or how it is handling data recorded. High reading frequencies might not necessarily be a danger in public buildings (divided only into a few zones) but in the residential sector, an electricity meter can be used to analyse behavioural patterns or even the TV show currently being viewed. One option is to limit the reading frequency smart meters are capable of. Alternatively the number of data queries to the meter can be limited to, for instance, ten times per half an hour. Another alternative could be the way data is being stored and communicated. For instance, data can only be send to (or requested by) other devices as a burst of data items in package which needs to be strongly encrypted. The frequency with which data in the package has been recorded can vary.

Such passive measures would not only increase data privacy but also reduce the number of attack vectors, or making attacks on the grid easier to spot as they disturb the usual patterns of data communication. This would also assist in increasing acceptance of this technology to an averse consumer.

Hardware validation

It is not the place to discuss hardware requirements for metering devices but the recent example of electricity meters which could be utilised to attack the grid[10] shows that Europe needs a centralised system to exchange and validate equipment and the requirements they need to meet. After all, the electricity grid as well as heating and water are the infrastructure which needs to be protected.

[10] http://www.reuters.com/article/2014/10/07/us-cybersecurity-spain-idUSKCN0HW15E20141007

Harmonised data protection

The revision of data protection legislation (see deliverable D9.1) has been announced several years ago. Clarification is needed not only for the individual but also for market players and developers in particular as they need to know which procedures are legally necessary. SMEs struggle to act outside of their “home market” as they cannot be sure whether their implementation holds in other countries. This reduces competition across the European market as well as the exchange of innovation, for instance, by lack of transparency regarding the ownership of data.

Data ownership

Municipalities are good customers and utilities / measurement providers are aware of the fact. Nevertheless, it can be observed in SMARTSPACES that municipalities increasingly want to become masters of their own (metering) data. Some pilots incorporated measurement into the city administration which, in some cases, is already saving money by itself as the fees due were high even for yearly or monthly frequencies.

In similar projects implementing EDSS and EMS services in the residential sectors, it has been observed that measurement provider can refuse access to metering information, thus increasing the cost or even withdrawing services. It has to be concluded that the market for SMARTSPACES is not free if data access can be denied or withdrawn at any time.

A major step would be to introduce a ‘right of consumers’ to access their data being recorded with metering equipment either by downloading it directly from the metering equipment, or by access to a server providing the information in an ideally standardised and open format. Given access to metering data, most building operators (residential or public) would be capable to ‘upgrade’ smart metering equipment with at least EDSS services provided by a third party.

5.1.2 National

The project observed a few barriers which can only be resolved on federal (sometimes regional) government. The observations have been phrased broadly so that recommendations act as policy advice for any government.

Enact clear rules on when to implement smart metering

Regardless of whether the metering devices are already available, the companies currently in control of this market, are likely to remain with the (traditional) devices they know best as they are not only cheaper but there is also no training required either for the electrician installing devices (see eSkills) or the backend for adopting new billing routines etc. New market players, on the other hand, will only be able to enter in large buildings as a large consumption makes a pay-back through savings etc. more likely.

empirica has just started a study on best practise across Europe in EED Art. 9-11. If another generation of the ‘Guide for Replication’ were to become possible in a project, the goal would be to also translate lessons from the study into the Guide hereby extending it by other solutions to overcome national barriers / disincentives.

Threshold on when meters have to be installed are a way to make sure that the size of the measurement and service market has a healthy size. Starting from the top – with the large consumers – is advisable. Over the years the threshold can be lowered.

One example is the 2014 AMR Legislation in the United Kingdom. Suppliers are not permitted to supply non half-hourly meters with a profile class 05-08 and gas meters with annual consumption more than 732,000 kWh other than through an AMR meter. It is important to implement such as policy quickly, as otherwise old meters might be replaced and protected for some time.

Public buildings: Fees as another incentive

CO_2 or generic energy efficiency targets can be created for any portfolio of buildings, and given monetary incentives. In the United Kingdom this was achieved by the CRC Energy Efficiency Scheme, including an uplift which penalises estimated consumption through an extra 10% penalty charge. The cost of CRC allowances is scheduled to increase each year, thus providing further incentive to reduce consumption and estimated bills.

As the penalty is always due, any form of savings contributes to it and if a larger building stock needs to get there smart technologies also become an option along with deep measures and boiler replacement etc.

Any form of consumption rules / targets would also be much easier to enforce if data is digitally available and measuring frequent. The scope can at first be the most energy efficient and wasteful buildings, with standards then raised over time.

Fixed / Closed council budget limit innovation

Fixed and closed yearly budgets make contracting models with long life-time almost impossible. Hence, the flexibility of smaller ESCOs (with small revenues) is limited. A contracting model would require that some of the initial investment is paid up-front by the council as a young SME cannot finance equipment in several buildings whilst having to wait for the pay-back in savings over a stretch of years.

In some countries (e.g. Spain) each department (sometimes even building) has a fixed yearly budget and even if savings are ensured over the next decades, the budget manager cannot spend money (already) budgeted for the future.

As a result, larger facility management companies – not SMEs – have a competitive advantage as they have a sufficient size to finance any efforts with yearly fees alone. This, however, will lead to less innovative solutions. Most obviously, the energy efficiency efforts will be limited to predicable measures. Moreover, awareness measures involving any operating cost (e.g. energy coaching) are likely to be avoided.

At least within the energy domain, some flexibility (e.g. percentage of total budget) should be enacted so that councils can invest in energy efficiency measures which will reduce the size of the budget in the future. If a revision of budget rules for municipalities is a federal (or regional) act and unlikely to be imposed as other disadvantages might be assumed, indirect measures could be taken. One option is energy efficiency funding as described in more detail below.

Make smart services an eligible measure for energy efficiency funding

Numerous states operate a “Green Bank” providing reduced interest rates and / or offer tax breaks for measures which reduce consumption / improve energy efficiency. The investing party is usually bound to install a set number of measures for which an average saving target is predicted. One of the prominent examples is the German ‘Kreditanstalt für Wiederaufbau’ (KfW).

However, the KfW and many others do not acknowledge smart energy services. Insulation and more efficient boilers are accepted but EDSS and EMS strategies to optimise behaviour and equipment, are not eligible.

The issue is not only that there is no funding but also that these lists work as references for many investors or building owners willing to spend money. A measure accepted by, for instance, the KfW is almost like a guarantee that there is something to achieve with this measure not only financially but also with the primary goal of acting green.

In combination with the contracting model, ESCOs could create jobs and the customer would receive a pay-back over time as solar panels do. For the KfW and similar institutes to recognise SMARTSPACES as an eligible measure it would require public pressure. Highly marketed solutions such as Google’s NEST are bringing automation to the public attention but ESCOs and SMEs are not the obvious choice without being listed by organisation such as KfW.

5.1.3 Building operators

Building operators can be municipalities (*Council*) or *Departments* of a city as well as any other form of public institution operating buildings for the general public including social housing.

Case studies on when and why to deploy ICT-enabled services are presented in section 4.3.

This section makes general recommendations with regard to organisational matters.

Organisation: Establish / promote an energy agency

The majority of municipalities in this project is represented by staff members working for an energy agency. What makes these agencies so relevant is the direct access to information from different departments and direct communication channels to the staff members.

In many municipalities, there is one department for energy contracts, one department for maintenance and one responsible for the building e.g. facility managers. As none of these parties has full access to information, inefficiencies are often not spotted or it is impossible to communicate effectively. A central contact person could help to make sure that any kind of waste spotted in the consumption could be directed to the responsible maintenance worker. The pilot sections below give numerous more examples how concentration of knowledge can lead to quick and easy savings.

When setting up an 'agency' it is important to communicate to all employees that this organisation is to take over a new role which is not going to displace existing departments. In times of austerity the first association could be that this is a measure to cut jobs elsewhere. As these departments need to work together and are future customers, it might be worth considering to pull one staff member from each of the independent departments to work as a link.

The staff members should have (or learn) access to / knowledge about:

- Mechanical knowledge of piping and electric systems
- ICT handling of data and rudimentary skills on interacting with portals
- Reading of building plans and engineering terminology about HVAC etc. installations
- Contracts with energy, measurement and other providers

See also eSkills on European level.

Incentives for professionals

Unfortunately, the majority of facility managers consider installing insulation as a smaller risk as the pay-off can be clearly predicted. In some minds, awareness measures cost money even if they believe in them achieving some savings. The assumption is that once a certain number of people have been trained, the saving potential reaches a ceiling and training any other person is a waste of money.

One can easily spot certain logical flaws such as the assumption that the application of insulation is always without costly hick-ups or that a door can be left by anyone.

However, this is not the core issue. The issue lies in the lack of incentive to achieve the best possible goal. If some of the wage and / or the freely controllable budget by the department are linked to consumption levels, no saving measure would be too cumbersome.

Reducing costs of metering equipment by increasing demand

Old meters and other non-smart metering equipment currently have a significant price advantage. From market observation, especially for electricity, it could be concluded that some utilities consider re-installing old meters with long calibration intervals, which might push the EC-target of smart metering covering 80% of all buildings in 2020 out of reach (as ongoing investments would be legally protected). Consequently, demand and product innovation for smart metering equipment might remain on a low level while prices remain high regardless of the nearing deadline.

Legal and regulatory bodies have the following options:

- Making smart metering not only compulsory for new buildings, but also permitting re-instalment / re-calibration of old meters once their calibration interval has ended
- Increasing efforts to validate and certify smart equipment in order to reduce uncertainty, increase trust, and ensuring correctness of readings over the maximum length of calibration intervals possible
- Recommending public authorities to (jointly) replace old metering equipment with smart ones as part of the national action plans.

5.1.4 Research

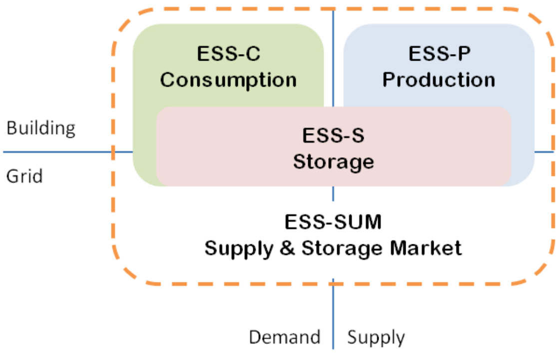
(Local) Storage linking supply and demand

Further research needs to develop and pilot innovative systems and services to radically reduce local grid congestion, applicable to both residential and public buildings across Europe's climate zones and adapted to a full range of market and regulatory frameworks. The concept of innovative dual-mode storage and (virtual) power plant models is designed to optimise and balance local supply and demand for heat / cold energy and electricity. Complementary new support to improved demand management centres on rich paths for customer feedback and really usable decision support to energy end-users.

Energy storage services (ESS) services comprise an integrated set of building and storage management processes and components empowering and involving management in individual buildings and teams responsible for off-site management of entire neighbourhoods, cities or other grid segments. This service can be linked to EMS which comprise ICT-based systems able to directly switch, control and adjust a range of storage capacities as well as production plants. Advanced management systems anticipate future conditions and / or optimise outcomes outside the envelope.

In a summary, four service classes can be defined:

- Consumption (**ESS-C** / EDSS&EMS) – local management of demand
- Storage (**ESS-S**) – local management of storage
- Production (**ESS-P** / EMS) – local management of supply
- Energy Supply and Storage Market (**ESS-SUM**)



Services interact with the grid on the demand and on the supply side. Storage capacity plays a key role in handling discrepancies in demand (consumption) and supply (production) within a city area and its interaction with the grid. ESS-S services provide complementary control over consumption and production, essential during protracted periods of high demand and peak supply as well as at times of low supply (from renewables).

In the integrated approach, ESS services are fully linked to a set of Energy Management Services (EMS) and Energy Decision Support Services (EDSS) developed in ICT-PSP projects SMARTSPACES, BECA and eSESH. ESS services would apply a common reference structure for all collected requirements, process models and architecture, providing a common framework for all services and markets.

Documentation for replication could be integrated into a single dedicated guide, extending the SMARTSPACES 'Guide for Replication', targeting stakeholder groups to implement ESS, EMS and EDSS (combined or independently) while ensuring that future extensions are supported. SMARTSPACES demonstrated that cooperation between city councils, mayors, utilities and the R&D community, can engage citizens, as energy users, thus linking cities with energy stakeholders whilst inducing exchange across Europe and lead to 11 portals having learned from one another.

European cities, the majority of which being below 500,000 inhabitants, need to effectively address climate and energy challenges, providing them with technologically innovative and highly adaptive approaches to integrating renewables, exploiting CHP and empowering housing providers to use their infrastructure for their own benefit as well as for the public good by making our grids smarter. Such concept and approach are fully in line with recent recommendations by the European Commission on improved flexibility in the electricity grid[11].

Beyond the 'Cloud': IoE, the Edge and (big) data analytics

Internet of Things (IoT) or better called Internet of Everything (IoE) is without doubt the new hype after big data. (Big) Data analytics are already being applied to data recorded from web-sites and to homogenous infrastructure available to either one large industry company (e.g. UPS) or service provider. Hence, data analytics have been limited to specialised domains.

The future lies in increasing heterogeneity of data which will be achieved by cheaper means, using IoE, to connect any kind of device to the internet and therefore collect data. Once the data (and the context) is in one or some connected database the statistics can be used to identify patterns and improve models. The data, however, is currently not available.

SMARTSPACES observed that some of the IoE research is already becoming relevant and the lack of knowledge might lead to additional cost. For instance, metering devices need to become smarter themselves. Thousands of meters communicating data packets every few minutes will either lead to a network collapse themselves or – sooner or later – some database problem will occur and the data not recorded will be lost. (This occurred in several pilots during the project.)

These devices at the "Edge" of the Internet need to be able to temporarily store some data. Ideally, they should be able to send only data which truly contains new information: If the consumption value did not change significantly, a data package might not be needed even though the value has been measured more often. The database, at the same time, needs to be able to translate this selective signals into a coherent database.

Finally, devices will become smarter and probably also carry some computing power. Ideally, some calculations could be performed in the meter and the results directly made available "on-site". This could also be a way to increase data privacy in the residential sector: A small server in the meter for the tenant provides the EDSS portal but less frequent data is transferred to the measurement provider. This server could also send commands to the local production and storage (see above) such as renewables and water tanks reacting to signals send from the grid hereby reducing peak consumption.

Large amounts are currently being spent to meet the EC regulation on individualised (smart) metering. It would be better to make sure that the devices available and being installed are meeting the requirements of Energy Management Services and not only the requirements of a more frequent bill alone. Otherwise, an opportunity will be lost to improve energy efficiency as the life-cycle of these devices is long and a replacement is unlikely any sooner.

Smart city (outside of a metropolis) – research for the average city

Smart city concepts are strongly linked to the research questions described above but it also strongly depends on being able to analyse data, without jeopardising privacy, in a timely fashion to

[11] EC SWD(2013) 442 final, Incorporating demand side flexibility, in particular demand response, in electricity markets

make changes to the grid as well as provide advice on scenarios for the coming days and even analysis for city development at the right spot.

Another statement must be made with regard to what kind of smart cities are currently being funded in research. The majority are large cities with extensive infrastructure and often rather rich cities. Some of the infrastructure used and the modern concepts applied might not be needed for the "average city" as smaller cities do not have as many inhabitants and not the same network.

If the smart city concept is to be replicated across Europe, technology must be identified which is affordable and can be deployed even in municipalities without specialised departments with own (ICT) resources in each field (e.g. energy, transport, buildings). Such services must be manageable by a few members of staff linking – as learned in SMARTSPACES – next to buildings also some departments and their data and connect the dots to make the right investments.

The cities active in SMARTSPACES aim to deploy smart city concepts by linking buildings in a neighbourhood or model consumption across town within district heating grids etc. A smart city concept for the "regular city" will start with some buildings and extend its wings from there.

Funding is needed to allow smaller cities to invest into research which might bring benefits in many years. After all, these small cities will always be overshadowed by high-tech concepts in cities such as London or Amsterdam. With work limited to such a small number of similarly thinking Councils probably holds back innovation and does not allow SMEs to play their role as the big players are all present in the metropolis.

Future Research for EDDS / EMS

Although the current project provided many insights into design, implementation and operation of energy efficiency services, it must be also observed that many issues are not fully understood. Projects in the following domains would help to increase the necessary knowledge for ICT-based energy efficiency services:

- What share (and when) are users able to shift or reduce consumption? This topic helps to optimise:
    - EDSS: How can users be better targeted to understand and make the necessary steps?
    - EMS: How can be ensured that the user's actions do not challenge optimisations or even cause adverse effects induced by automated systems.
- What are the minimum requirements for a working smart grid? The following dimensions would need to be covered:
    - Is it possible to use existing buildings for local energy storage?
    - Which share of housing units need to be equipped with smart meters?
    - Which share of load must be manageable to ensure benefits for all stakeholders?

How could the business model of energy efficiency services be extended to independent living and Telemedicine issues using similar technology?

6 ANNEX

6.1 'Guide for Replication'

The Guide is available online under: www.guide.smartspaces.eu

It is also provided as a separate document which, however, cannot be kept up to date as the online version.