E3SoHo

ICT for energy efficiency in social housings

Contract number: 250497

Best Technical and Cost-Effective ICT Solutions Identified

Author(s):	**Thomas MESSERVEY**	**D'APPOLONIA**
	Krzysztof DUSZCZYK	**ISEP**
	Nuno MARTINS	**ISA**
	Piotr DYMARSKI	**MOSTOSTAL**
	Haldor SAMSET	**TELENOR OBJECTS**
	Nicolas SALMON	**NOBATEK**
	Régis DECORME	**CSTB**
	Manuel RAMIRO	**ACCIONA**

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Contents

Summary

"D2.3 – Best technical and cost-effective ICTs solutions identified" is a public document delivered in the context of Work Package 2 – Specification of Users and Building requirements. It describes different ICT technologies and integration techniques identified for the set of requirements obtained in Task 2.1 (User Requirements) and Task 2.2 (Building Requirements).

At the project level, the results obtained from this analysis will enable the design of the specific ICT solutions for the pilot activities in E3SoHo. This occurs in Workpackage 3 – Design of the Integrated System Solution. Beyond the project level, this analysis will document the technologies utilized in E3SoHo, the considerations taken, and provide references such that the process could be replicated in order to develop a generic ICT solution for social housing across Europe.

This analysis includes networking solutions to interconnect clusters of Social Housings as well as the systems to control remotely these networks.

Abbreviations

AIM	Automatic Infrastructure Management
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
AMM	Automated Meter Management
AMR	Automatic Meter Reading
BACnet	Building Automation and Control Network
BAS	Building Automation System
BMS	Building Management System
BEMS	Building and Energy Management System
BTU	Basic Transmission Unit
ANSI	American National Standards Institute
BIOS	Basic Input Output System
CCD	Charge Coupled Device (sensor)
CENELEC	European Committee for Electrotechnical Standardization
CIM	Computer Integrated Manufacturing
CPU	Central Processing Unit
DDE	Dynamic Data Exchange
DDL	Device Description Language
E3SoHo	Energy Efficiency in European Social Housing
EDI	Electronic Data Interchange
EIB	European Installation Bus
EMS	Energy Management System
GUI	Graphical User Interface
HMI	Human Machine Interface
HTTP	Hypertext Transport Protocol (Internet)

HVAC	Heating Ventilation and Air Conditioning
IB	Intelligent Building
ICT	Information & Communication Technologies
IEC	International Electrotechnical Commission
IP	Internet Protocol
IT	Information Technology
JAVA	Object Oriented Programming Language for the Internet
LonWorks	Local Operating Network
M2M	Machine to Machine
PLC	Programmable Logic Controller
SCADA	Supervisory Control and Data Acquisition
WAN	Wide Area Network

Introduction

Information and Communication Technologies (ICTs) are the technologies used in the conveying, manipulation, and storage of data by electronic means [1]. Examples are wide ranging across many sectors. Examples can include telephones and their networks, computers and the internet, sensors and actuators that communicate or process data, building management systems, and generally all applications entailing the "smartening" of the things around us (e.g. smart cars, smart devices, smart materials, smart structures and so on). In Europe, the ICT sector accounts for 6-8% of GDP and is considered critical with respect to competitiveness, job creation, efficiency, innovation, modernisation, and quality of life [2]. For these reasons, €9bn is being invested in ICTs in FP7 in the following seven key research challenges to ensure Europe becomes a world leader in ICTs:

1. Laying Tomorrows Networks
2. Smarter Machines, Better services
3. The Nuts and Bolts of Tomorrow's Products
4. Digital Content & Learning
5. A Healthcare Revolution
6. Environment, Energy, and Transport
7. Access for All

Because the ICT sector is so broad and because it develops so fast, it is important to clearly define the intent of this report.

The intent of "deliverable 2.3" is to identify and document the most appropriate and cost effective ICT solutions suited for the needs of actors in social housing (tenants, developers, managers, and owners) with specific focus on the project E3SoHo.

In shaping this report, specific effort is devoted in identifying and documenting how to approach the ICT state of the art, where to find information, important companies and initiatives, and so on. For this reason, it is expected that the references and links will be equally valuable to the reader as the information directly provided. This approach has also heavily influenced the table of contents and overall organisation of the report.

With respect to the products and services of the particular consortium partners provided, the intent is not to become promotional in nature but instead to provide examples of the types of devices and functionalities needed. References are provided wherever possible such that the ICT solution is open source, replicable, and available to maximum possible audience.

The report begins (**Section 1**) with an overview of the ICT space related to Energy Efficiency with special emphasis on the residential sector. Trends, initiatives, platforms, providers, protocols, processes, and projects are identified.

Section 2 provides a synthesis of Tasks and Deliverables 2.1 & 2.2. These reports outline the user (2.1) and building (2.2) needs and considerations specifically for social housing. This intent of this section is to document the needs of the project.

With this background**, Section 3** provides the ICT solutions by category that should be considered given the needs established in Section 2 and the trends identified in Section 1. The intent of this section is to provide the knowledge of and examples of ICT solutions appropriate for social housing.

Section 4 makes use of the information in Sections 1-3 to develop the first draft of the E3SoHo system architecture(s). The intent of this section is to begin to develop the actual E3SoHo ICT Solutions.

Section 5 then lists for the technological offerings of the project ICT providers Nobatek, ISA, and Telenor to bring the system architecture to reality. Included in this section are power electronics specific to renewable energy sources (RES).

Lastly, **Section 6** identifies ICT solutions from within and outside of the project that will be utilized in E3SoHo. Justification for these choices will be provided and the integration activities necessary to ensure the interoperability of these ICT solutions will be detailed.

From these sections, conclusions are listed in **Section 7** and **Appendix A** provides listings of ICT providers as a starting point for further research.

1. ICTs and Management Systems for Energy Efficiency: Activities, Trends, and Solutions

1.1 Basic Definitions

ICTs for energy efficiency fall under the larger umbrella of building automation systems (BAS) or building management systems (BMS). Such systems may also include other building functions such as security, occupancy, fire, electrical, production, and other types of monitoring and control functions. When a distinction on energy is desired, an "E" is included (e.g. Building Energy Management System – BEMS). When a distinction on homes is desired, an "H" replaces the "B" (e.g. Home Energy Management System – HEMS). An "I" for information is also commonly utilised to draw emphasis to the growing importance of "Information" to the user, owner, or supplier and BIEMS – Building Information and Energy Management system may be utilized. As in any developing field, the language and terms are not yet standardised. However, the intent of all such systems is generally the same – to utilize ICTs to improve the management and efficiency of buildings and homes. It is therefore up each individual to become an educated consumer of information and to understand what any particular system does or offers. Within this context, the most common "systems" are defined as follows:

Building Automation Systems or BAS

Definition: BAS is a distributed control system composed by a computerized, intelligent network of electronic devices, designed to monitor and control the mechanical and lighting systems in a building.

Top Players and Top Products: Ordered by revenues (2001), not all strictly related to energy efficiency, but on building automation in general [3]

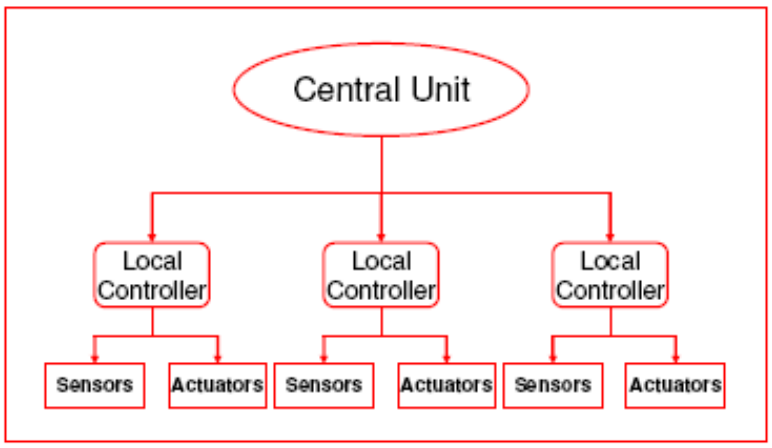
- Siemens (GER) - APOGEE
- Johnson Controls (USA) - Metasys
- Honeywell (USA) – EXCELL 5000
- Yamatake (JP) – Savic-netEV, Smart Screen, IDC, IDGP, ICC, IVC, IFC
- Invensys (UK) – I/A Series "R"
- GE Interlogix (USA) – Aritech, Caddx, ITI, Sentrol, Tecom, Cosmotron, ESL, CAsi-Rusco, Origin Data Systems, TEcom
- Novar plc (US) – Opus Series
- Matsushita-Denko (JP) – National, Panasonic, NAIS
- Mitsubishi (JP) – Alpha Series
- Schneider Electric – PowerLogic, ION, TAC
- Carrier (USA) – GEMINI

Application: Generic

Building Management Systems or BMS

Definition: BMS 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 systems. A BMS consists of software and hardware. The software program, usually configured in a hierarchical manner, can be proprietary using such protocols as C-bus, Profibus, etc. Recently vendors are offering BMSs that integrate using Internet protocols and open standards like DeviceNet, SOAP, XML, BACnet, Lon and Modbus.

A Building Management System is meant for saving energy and maintenance costs. It also aims to create a productive, cost effective environment through the optimization of systems, services and management. It executes temperature and humidity control, the measurement and control of electrical parameters (voltage, current, power), the monitoring and control of various water pumps, the switching on/off of compound light based on outside light level, etc, and other energy related function. A BMS may also provides a graphical display of the various heating, ventilation, and air-conditioning (HVAC) / electrical parameters/ water system parameters. A general and basic architecture of a BMS is shown in the following figure.



Clarification: the difference between BMS and BAS is subtle, formally a BMS is a BAS but not the opposite, made practically a BMS is BAS that involve hi-level human interaction with the system (friendly software interfaces and so on).

Application: Generic

Facility Management Systems or FMS

Definition: FMS is computer-based system devoted to the maintenance and care of commercial or institutional buildings

Clarification: FMS is composed by a BMS, for the building side, and a CAFM (Computer Aided Facility Management), for the administrative side. FMS are focused on commercial/institutional application.

Application: commercial or institutional buildings

Energy Management Systems or EMS

Definition: EMS is a system of computer-aided tools used by operators of electric utility grids to monitor, control, and optimize the performance of the generation and/or transmission system.

Clarification: The monitor and control functions are known as SCADA; the optimization packages are often referred to as "advanced applications". In a slightly different context EMS can also refer to a BMS designed to achieve energy efficiency (see below).

Application: Generic

Energy Management Control Systems or EMCS

Definition: EMCS is BMS specifically designed for energy efficiency.

Application: Generic

Integrated Building Management Systems or IMBS

shall include the following subsystems:

- Building automation (cooling/heating control, ventilation control, etc.)
- Lighting control of common areas
- Consumption measurements of water, electricity and cooling (heating) energy

Client Comfort System or CCS

Definition: CCS is an ECMS whose control strategy is mainly based on client comfort.

Application: residential, commercial or institutional buildings

Home management system

Definition: HMS is a BMS designed for residential applications.

Application: residential

Home energy management system

Definition: HEMS is ECMS designed for residential applications

Application: residential

Each of these systems can also be found under the umbrella of **Intelligent Buildings**. In accordance with The Intelligent Building Institute in USA, **IB** is productive and cost-effective environment through optimization of its four basic elements:

- structure
- systems
- services
- management

and the interrelationships between them [4]. Interoperability targets of **IB** are as follows:

- Comfort Control
- Energy Management
- Operational Management
- Indoor Air Quality
- Maintenance Management
- Fire – Life Safety Management
- Security Management
- Lighting Management

1.2 Intersection of the Information Age and the Green Wave

The most consistent trend across ICT services related to energy efficiency is empowering the consumer with information. This information can include:

- Consumption data beyond a monthly bill and down to the device/outlet level
- Options for where energy comes from and how it is produced
- The ability to interface with the grid in customer seller relationships
- Recommendations, references, and links for energy efficiency behavioural changes

For a variety of factors, the media and computing giants are becoming involved with home energy efficiency. It involves data transfer by phone or internet, it provides additional hardware/software/service revenues, and it can be argued that it matches corporate philosophy and social goals. On one hand, it seems awkward to begin a research report with Apple, Google, and Microsoft, but on the other hand, given the speed at which each of these companies dominated the computing, software, information, and phone markets, it is potentially irresponsible not to take note of the current activities and strategic pushes these companies are making into the home energy efficiency space. Also, given their vast financial resources, existing client bases, and advertising ability, these companies may be the most effective in reaching specifically the home energy efficiency market because a relationship must be established with each individual consumer.

APPLE Computer

In May 2009, Apple computer filed patents 20100007473 (Intelligent Power-Enabled Communications Port) and 20100010857 (Intelligent Power Monitoring) [5]. In relating to the public, these patents are for a "Smart Home Energy Management Dashboard System" and a "HomePlug Powerline Networking" solution as revealed in January 2010 on the website Patently Apple [6]. These patents outline Apple's intent to make every outlet a power, communication, audio, and data device. Then, a power management system analyses how devices operate, how they can interact, how they can manage consumption to off peak hours, and how their settings can be adjusted for energy savings through a user interface. Figure 1 shows an initial dashboard prototype and HomePlug patent figure.

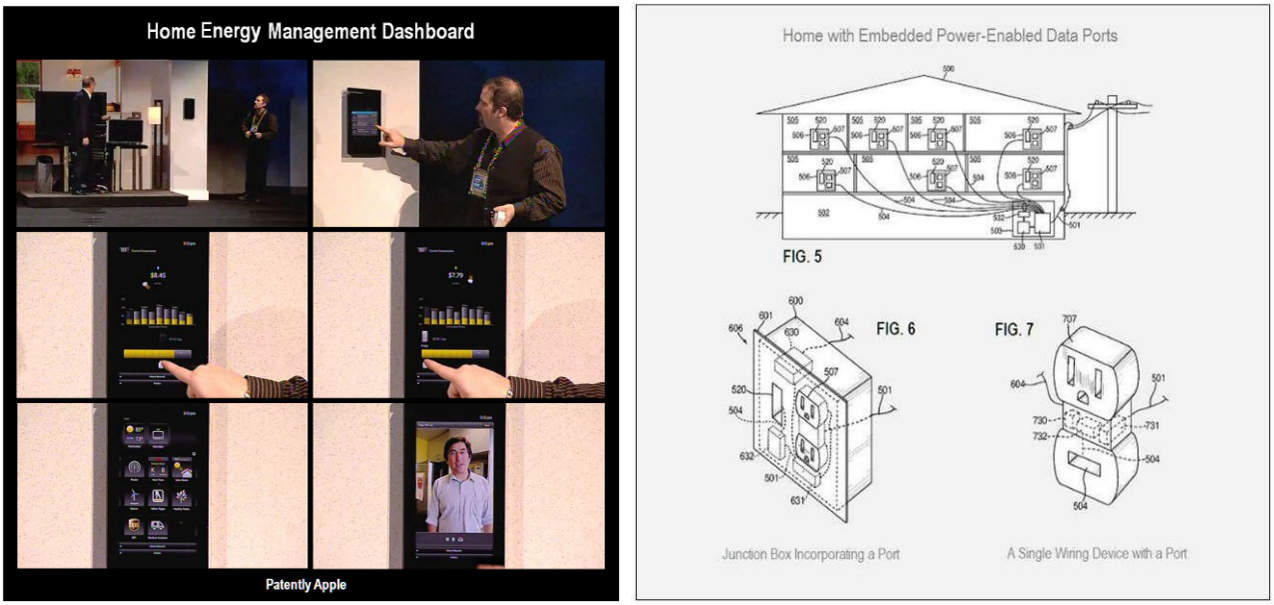


Figure 1. Apple computer "Energy Management Dashboard" and "HomePlug powerline networking" concept [6].

GOOGLE

Google's charitable arm www.google.org has developed and released freeware called "Powermeter." Powermeter is software that can monitor home energy use. It provides energy usage over time in several views, equates energy use to money spent, provides predictions on bills and potential savings, identifies constant vs. on demand energy consuming devices, and provides comparisons to a range of metrics (e.g. others like you or your past behaviour) [7]. Figure 2 shows an image of the display that can be sent to a phone or PC device. Although user response has been positive for those that have used/tested the software, its primary limitation is that it requires hardware (e.g. smart metering and an interface device) at the home level. Currently, and largely due to USA stimulus funding, about 10% of the homes in the USA have smart metering capability. Although this is a significant percentage in terms of international averages, ICT developers in the USA are concerned that utility companies are moving too slowly. In this regard, Google and The Climate Group have directly petitioned President Obama for universal smart metering and to "adopt the goal of giving every household and business access to timely, useful and actionable information on their energy use" [8]. One concern of utility companies is the accuracy of smart metering devices and other technical challenges. For this reason, Google has made its software available to independent ICT hardware providers that can provide smart metering capabilities such as The Energy Detective (TED) managed by a small firm named Energy Inc [9]. Google's intent is to enable ICT hardware developers to provide solutions that bypass the requirement for utility companies to provide smart meters by developing low-cost devices (currently in the range of 200 euro).

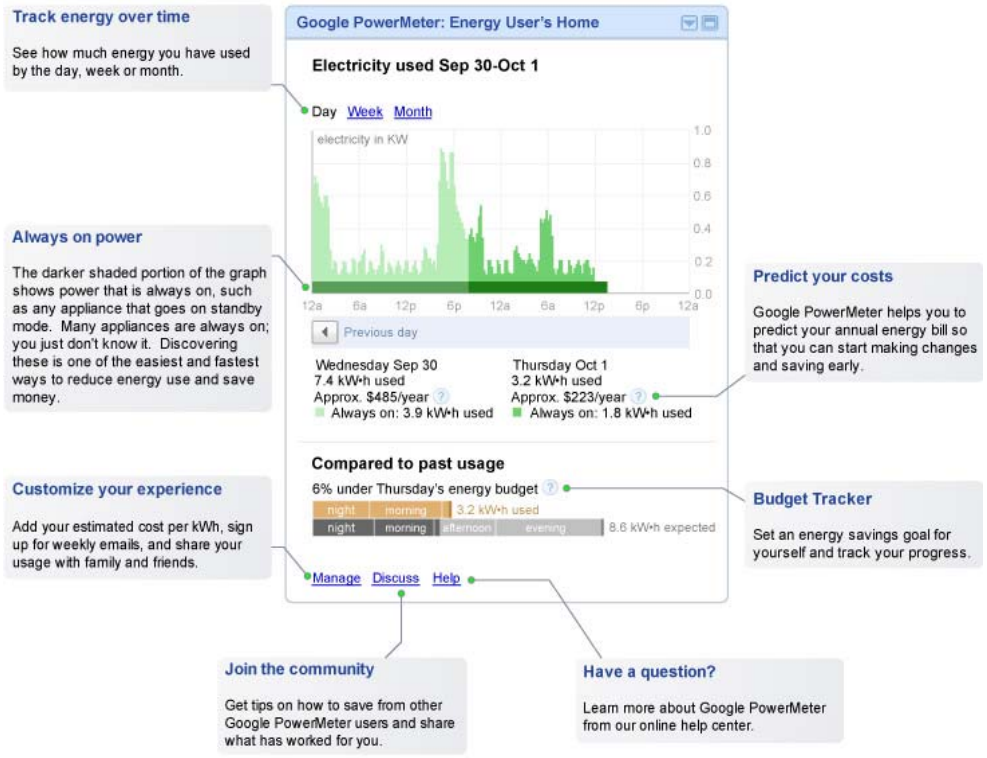


Figure 2. Google's "Powermeter" software [7]

MICROSOFT

Microsoft operates "Hohm" playing on the English words home and ohm as a (currently) free web service that helps users make smarter decisions about saving energy and money [10]. The beta version community links industry ICT professionals, large corporations, home professionals, and a growing user base of homeowners as shown in Figure 3. Hohm can be considered a direct competitor to Google's Powermeter. However, there are some sharp differences. Instead of building freeware tied directly to smart metering, Microsoft is building a user community focused on energy savings. Based on user input data, energy report recommendations provide pointed recommendations on how users can save money as shown in Figure 4. Also different than Google's Powermeter, which will reportedly remain freeware, Microsoft plans for hohm to become embedded into the future smart grid through its user base and then to begin selling services and software to both utility companies and its users.

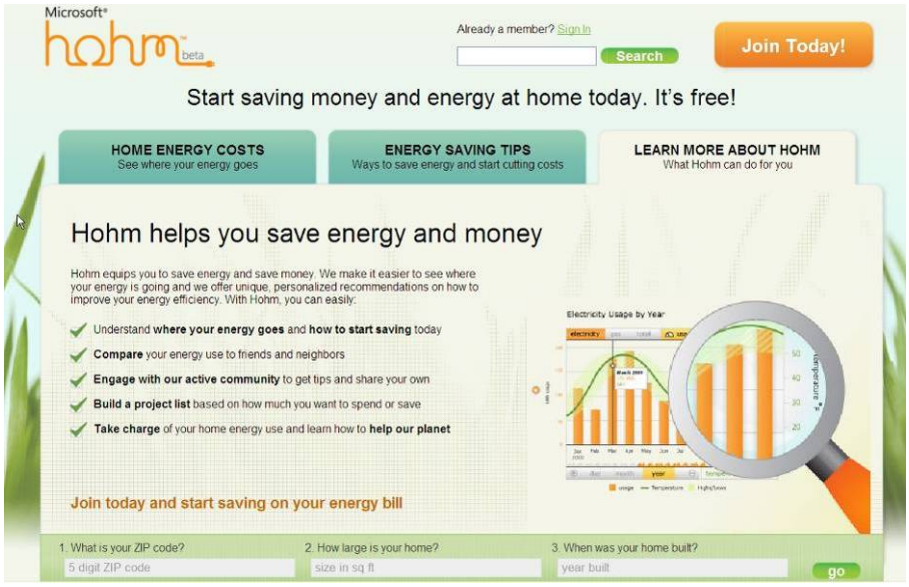


Figure 3. Microsoft's "Hohm" start page [9]

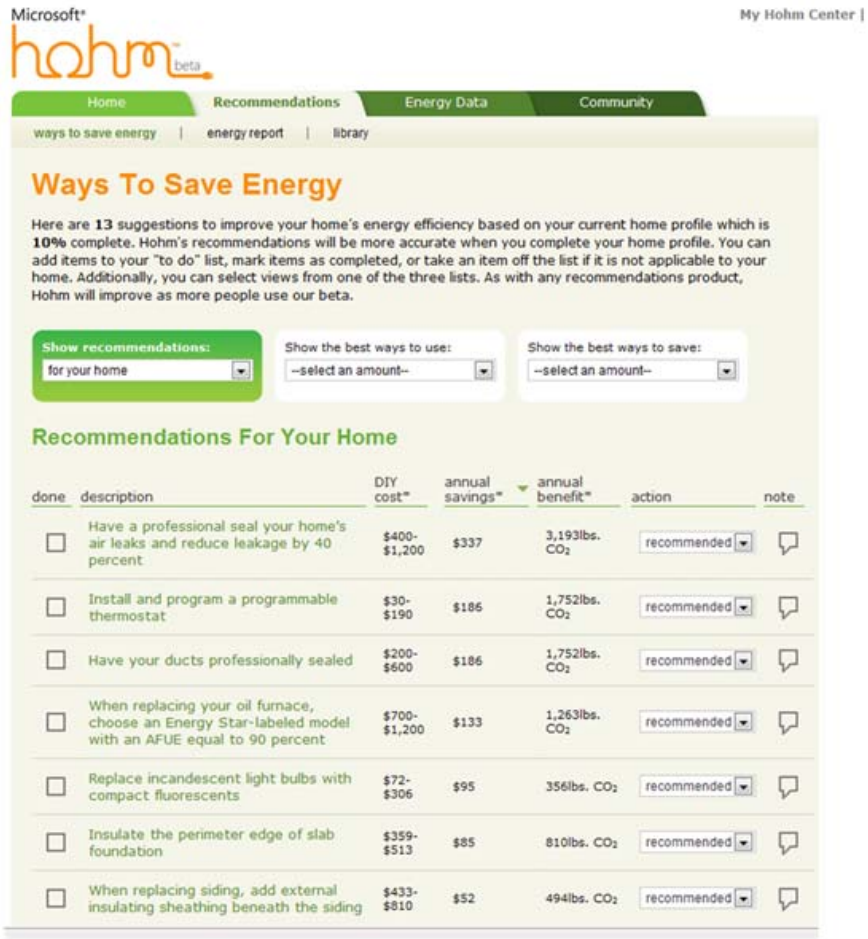


Figure 4. A "Hohm" Energy Report recommendation page [9]

A short conclusion to this particular section is appropriate. In no way are these three companies or their services being promoted and by no means are these the only such companies with energy efficiency initiatives and programs. To the contrary, this section highlights that many (if not most) ICT companies are turning their attention to the residential market. It is also interesting to note that the ICT phenomenon of the last 10 years such as web communities (facebook), touch screens (tablet PCs/IPad), on demand real time information (the internet/IPhone), messaging (Twitter) are all morphing into products and services focused on residential energy efficiency.

1.3 ICT Communities, Initiatives, and Platforms

In researching available ICT solutions, it became clear that communities, platforms and initiatives provide an invaluable source of information. It is certain that the ones highlighted herein are only a few of those existing worldwide. However, a few minutes on the webpages of any of these communities or the reading of the reports from these organisations provide extensive insights into the issues and efforts of the day across the ICT space. Furthermore, as this report is a point in time, the communities and platforms that follow are updated over time and can be considered as living resources/references.

DIGITALEUROPE www.digitaleurope.org

DigitalEurope is an important advocacy group of the European digital economy acting on behalf of the information technology, consumer electronics and telecommunications sectors. It is dedicated to improving the business environment, and to promoting industry's contribution to economic growth and social progress in the European Union. DIGITALEUROPE's members include 58 leading corporations and 40 national trade associations from all the Member States of EU; altogether 10,000 companies with 2 million employees and €1,000 billion in revenues.

The Homes Programme http://www.homesprogramme.com/

The homes program is an 88 million euro, 4 year (2008-2012) project, led by Schneider, that combines the skills of 15 industrial and research leaders in the ICT space. The goal of Homes is to create new control architectures for buildings' optimised energy management such that each building has the equipment necessary to achieve optimal energy performance. The webpage, news section, descriptions of products under development, and public deliverables are valuable sources of information.

Automated Buildings Community

http://www.automatedbuildings.com/index.htm

AutomatedBuildings.com is an 11 year **old** online magazine and collaborative platform. It provides the news and connection to the community of change agents that are creating the present definition of smart, intelligent, integrated, connected, green, and converged large buildings. The virtual magazine and web resource provides a searchable platform for discussion and exchange while creating opportunities for B2B for all new and existing stakeholders. Calendars of ICT events, forums, products, trends, commentary, historical data, case studies, and educational tools are available.

ICT for Energy Efficiency Forum (ICT4EE)

Following on the European Commission Recommendation "**on mobilising Information and Communications Technologies to facilitate the transition to an energy-efficient, low-carbon economy**" SEC(2009) 1315 of 9th October 2009, in a Memorandum of Understanding DIGITALEUROPE, GeSI, JBCE and TechAmerica Europe agreed to establish an ICT for Energy Efficiency (ICT4EE) industry Forum. The overarching objective of the ICT4EE Forum is to link digital technology more closely to EU climate and energy policies and economic development. The aims of the Forum are threefold:

- To demonstrate the commitment of the ICT sector to work in partnership to deliver energy efficient ICT solutions in other sectors of the European economy and leadership to improve the energy efficiency of its own processes through delivery of its three year Roadmap.
- To help ensure a coordinated global approach from the ICT sector to EU policy recommendations on ICT4EE and climate and energy efficiency policies more broadly; and
- To support the development ofinformed and coordinated policy making in the European Commission, European Parliament and Member States on the ICT4EE agenda

European ICT4E2B "ICT for Energy-efficient Buildings" Forum

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

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

The ICT4E2B Forum project aims at the following objectives:

- Bring together relevant stakeholders to identify and review the needs in terms of research and systems integration
- Update the REEB research roadmap
- Promote the use and further development of ICT for improved energy efficiency of buildings

By accomplishing these objectives, ICT 4 E2B Forum will map the sector-specific priorities into a common view and vocabulary, thereby enabling communication and understanding between experts in different sectors that need to join forces in order that fundamental improvements in energy efficient buildings can be achieved. All this coordination work will support in defining future research directions as well as in channelling efforts, while favouring consensus buildings on the roadmap itself.

REEB: The European Strategic Research Roadmap to ICT enabled Energy-Efficiency in Building and Construction **http://www.ict-reeb.eu/**

REEB focus in the improvement of energy-efficiency through innovative ICT, leading to the so-called "smart buildings" of tomorrow as a key challenge in our future world. REEB will also identify and structure the future R&D targets in terms of all ICT methods, models, applications and systems to support future energy efficiency in the Built environment. The REEB project will bring experts from the Construction, ICT and energy knowledge domains together to elaborate a common view of the current challenges, state-of-the-art, vision of a future state, and roadmap of future RTD (Research & Technological Development) in ICT support to Energy-efficient Construction.

Energy Efficiency in Buildings (E2B) Association **http://www.e2b-ei.eu/default.php**

E2B is an International not-for-profit Industry Association, Energy Efficient Buildings Association (E2B A) has been created to launch a European wide Initiative in the area of Energy Efficient Buildings E2B EI). This European Initiative is aiming at creating longterm cooperation with the European Commission, resulting in an industry led Public Private Partnership (PPP). This is initially being carried out within the EeB, PPP

launched within the framework of the European Economic recovery plan, as first step of a longer term and even more ambitious strategy, well coordinated with national and regional governments to achieve a large impact and engage and vast community of public and private stakeholders.
The budget of the E2B EI is €2bn over the next 10 years. The overall objective of E2B EI is to deliver, implement and optimise concepts that have the technical, economic and social potential to drastically reduce the energy consumption and decrease CO2 emissions in the European Union.

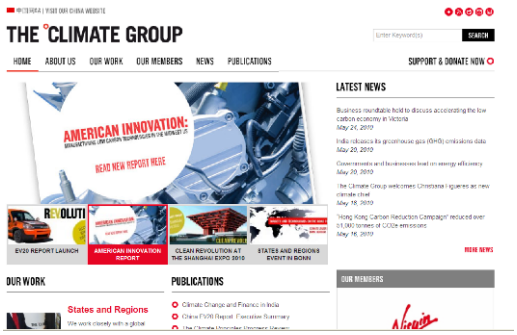
ICT Societies

http://ictssocieties.building-21.net/

This web site is the on line reference point of all public results and activities carried out under the tender entitled "**Role and impact of professional and scientific societies in ICT research, education and innovation**". This work was contracted in 2010 by the European Commission, Directorate-General for Information Society and Media to ASM - Centrum Badań i Analiz Rynku Sp. z o.o. (Poland) and APINTECH Ltd (Greece), following an open call for tenders **(SMART 2009/006)**

The Climate Group

http://www.theclimategroup.org/about-us/



The Climate Group is a growing consortium of over 50 influential companies and political agencies from around the world aimed at defining the policies of tomorrow concerning energy and climate matters. The website features news, events, publications, products, and other resources of interest.

GeSI (Global e-Sustainability Initiative) www.gesi.org

GeSI is an international strategic partnership of ICT companies industry associations and UNEP and ITU, United Nations organizations. GeSI is committed to creating and promoting technologies as well as practices that foster economic, environmental, and social sustainability and drive economic growth and productivity. Formed in 2001, GeSI fosters global and open cooperation, informs the public of its members' voluntary actions to improve their sustainability performance and promotes technologies that foster sustainable development.

TechAmerica Europe
www.techamerica.org/topics/regional-offices/europe

TechAmerica Europe (formerly AeA Europe) represents leading European high-tech operations with US parentage. Collectively we invest Euro 100 bn in Europe and employ approximately 500,000 Europeans. TechAmerica Europe Member companies are active throughout the high-technology spectrum, from software, semiconductors and computers to Internet technology, advanced electronics and telecommunications systems and services. Our parent company, the TechAmerica (formerly AeA and ITAA), is the oldest and largest high-tech association in the US.

1.4 Communication Protocols

Another way to gain insight into the ICT sector is through the machine to machine languages that bind ICT developers together. These languages, or protocols, form their own communities, webpages, support groups, etc. which largely define the space. A list of available open source protocols for building and home management systems is:

- BACnet
- LonWorks
- Modbus
- Profibus
- CAB
- ControlNet
- EIBnet
- DeviceNet
- WorldFIP
- N2Bus
- BatiBUS
- Konnex/KNX
- X10

In 2006, the Committee for European Standardization CEN TC247 approved the following Protocols and Levels of Operation:

Management Level:

BACnet

Automation Level:

BACnet
WorldFIP
Profibus FMS
EIBnet

Field Level:

EIB, BatiBUS, EHS, LonTalk, BACnet

These standards are constantly under review and a new listing is currently "under approval." Several of the most widely adopted protocols are now defined.

BACnet: www.bacnet.org

Developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), BACnet is an American national standard, a European standard, a national standard in more than 30 countries, and an ISO global standard. The protocol is supported and maintained by ASHRAE Standing Standard Project Committee 135.

BACnet is a data-transfer protocol for exchanging information between different systems and equipment in building automation systems. BACnet is license-free, open source, and maintained by ASHRAE to ensure and cope with present and future systems needs. BACnet specifies 5 types of networks

- Ethernet (10-100Mbps)
- ARCNET (2.5Mbps)
- MS/TP subnet (master-slave / tokenpassing); 76.8Kbps
- PTP (point-to-point / serial communications / modems
- LonTalk (exclusive LAN - does not mean that LonWorks devices can talk to BACnet devices)

BACnet is independent from any specific hardware, operating system or software platform. It can be implemented on devices of any size, is not tied to current technologies, and is designed specifically for building control. Several supporting vendors are shown in the following figure.

Supporting Vendor

KNX: www.knx.org

Konnex/KNX is the European open standard bus technology for Home & Building Automation Systems. Established by the convergence among the three former European technologies, "*BatiBUS*" (French), "*EHSA*" (Dutch) and "*EIB*" (German) - who felt to share their decades of experience in this market - Konnex has integrated three different mechanisms of system configurations and different physical media in the unique KNX protocol.

The technological convergence of these three standards of the European market consequently meant that the three European Associations, EIB Association (EIBA), BatiBUS Club International (BCI), and the European Home System Association (EHSA), were fused to form the Konnex Association, allowing a substantial expansion of applications in the home and building automation by extending the technology platform to a broader multi-vendor market.

As such, KNX technology has become one of the leading global protocols for home and building automation linking ICT devices. From promotional documentation and information found on the KNX website, the following KNX advantages are listed [11]:

- it facilitate designers, manufacturers and installers to "speak the same language" starting from components of different Vendors/Manufacturers,
- it allows to increase the opportunities for industry and end-users to have a range of components,
- it offers complete solutions for the residential sector as well as for large-scale building automation,
- it allows to implement in one system the best solution for software development and use,
- it is totally independent from any specific technological application hardware / software, with the application profiles incorporated as an integral part of the standard,
- it is characterized by a procedure of mandatory certification of products, leading to the release of the brand KNX devices, native to ensuring interoperability between products from different manufacturers,
- it is totally devoid of additional royalties for members of the Konnex Association,
- it has a single, integrated software tools for installation, design, engineering and commissioning,
- it ensures an appropriate cost-benefit ratio for all building types and applications

The KONNEX Association joins more than 200 manufacturers that employ KNX technology offering a wide range of interoperable products, solutions, and applications. Several are shown in Figure 5. Recently, all the associated companies that have contributed to the development and recognition of the KNX technology, agreed to release 61 patents necessary to implement products based KNX technology, version 1.0 [12]. In addition to manufacturers, Konnex Association includes among its members energy distributors and telecommunications operators. The Konnex Association has signed partnership agreements with more than 20,000 installation companies and with about 70 in technical

Universities. A collection of articles and case studies of using KNX for energy efficiency can be found in [13].

Figure 5. KNX members [12]

The national technical committees under the auspices of TC 205, CENELEC, have accepted the KNX technology as the standard for Home and Building Automation (recorded according to EN: 50090-3-1, 50090-4-1 , 50090-4-2, 50090-5-2 and 50090-7-1). To ensure the native interoperability of KNX systems, the certification process ensures that every KNX certified product can be integrated into a KNX system, regardless of the

presence of devices and / or applications made by other manufacturers. After certification, vendor products can display the KNX label.

Italy, Germany, France, Britain and Spain account for about 74% of the residential market in Europe. For these and other reasons (purchasing power per capita, technological development, infrastructure, etc. ..) these countries are leading the development and market penetration of home automation devices. It is estimated that the European market for home and building automation is around 300 million €, of which the KNX technology occupies about 50%, over a potential European market that is estimated to claim the € 2.5 billion [11].

LonWorks: www.echelon.com

LonWorks is a networking platform specifically created to address the needs of control applications. The platform is built on a protocol created by Echelon Corporation for networking devices over media such as twisted pair, powerlines, fiber optics, and radio frequency. It is used for the automation of various functions within buildings such as lighting and HVAC. The technology has its origins with chip designs, power line and twisted pair, signaling technology, routers, network management software, and other products from Echelon Corporation. In 1999 the communications protocol (then known as LonTalk) was submitted to ANSI and accepted as a standard for control networking (ANSI/CEA-709.1-B). Echelon's power line and twisted pair signaling technology was also submitted to ANSI for standardization and accepted. Since then, ANSI/CEA-709.1 has been accepted as the basis for IEEE 1473-L (in-train controls), AAR electro-pneumatic braking systems for freight trains, IFSF (European petrol station control), SEMI (semiconductor equipment manufacturing), and in 2005 as EN 14908 (European building automation standard). The protocol is also one of several data link/physical layers of the BACnet ASHRAE/ANSI standard for building automation. China ratified the technology as a national controls standard, GB/Z 20177.1-2006 and as a building and intelligent community standard, GB/T 20299.4-2006; and in 2007 CECED, the European Committee of Domestic Equipment Manufacturers, adopted the protocol as part of its Household Appliances Control and Monitoring – Application Interworking Specification (AIS) standards. During 2008, ISO and IEC have granted the communications protocol, twisted pair signaling technology, power line signaling technology, and Internet Protocol (IP) compatibility standard numbers ISO/IEC 14908-1, -2, -3, and -4. By 2006 approximately 60 million devices were installed with LonWorks technology. Manufacturers in a variety of industries including building, home, transportation, utility, and industrial automation have adopted the platform as the basis for their product and service offerings. Statistics as to the number of locations using the LonWorks technology are scarce, but it is known that products and applications built on top of the platform include such diverse functions as embedded machine control, municipal and highway street lighting, heating and air conditioning systems, intelligent electricity metering, subway train control, stadium lighting and speaker control, security systems, fire detection and suppression, and newborn location monitoring and alarming.

One of the keys to the interoperability of a networked system is the standardisation of the variables used to describe physical things to LonWorks. This standards list is maintained by LonMark International and each standard is known as Standard Network Variable Types (SNVTs, pronounced "sniv-its"). For example a thermostat using the temperature SNVT is expected to produce a number between zero and 65535 that equates to a temperature between -274 and 6279.5 degrees Celsius. Using such parameters, controllers, sensors, and actuators can communicate with each other and over different protocols such as Modbus.

Modbus: www.modbus.org

Modbus is also an open serial communication protocol which was published by Modicon in 1979 for use with its programmable logic controllers for industrial applications. It has become a de facto standard communications protocol in industry, and is now the most commonly available means of connecting industrial electronic devices. The simplicity of Modbus TCP/IP enables any field device, such as an I/O module, to communicate on Ethernet without the need for a powerful microprocessor or lots of internal memory. Due to the high speed of Ethernet, the performance of Modbus TCP/IP is excellent. Since Modbus is implemented on top of the TCP/IP layer, users can also benefit from IP routing enabling devices located anywhere in the world to communicate without worrying about the distance between them.

ZigBee Alliance: www.zigbee.org

The ZigBee Alliance is an association of companies working together to enable reliable, cost-effective, low-power, wirelessly networked, monitoring and control products based on an open global standard.

Objectives

The goal of the ZigBee Alliance is to provide the consumer with ultimate flexibility, mobility, and ease of use by building wireless intelligence and capabilities into everyday devices. ZigBee technology will be embedded in a wide range of products and applications across consumer, commercial, industrial and government markets worldwide. For the first time, companies will have a standards-based wireless platform optimized for the unique needs of remote monitoring and control applications, including simplicity, reliability, low-cost and low-power. The ZigBee Alliance defines its focus as [13]

- Defining the network, security and application software layers
- Providing interoperability and conformance testing specifications
- Promoting the ZigBee brand globally to build market awareness
- Managing the evolution of the technology

The ZigBee Alliance is growing and consists of hundreds of Promoters, Participants, and Adopters. ICT solution providers must pass through a certification process before being

able to display the ZigBee label. The website also serves as an information portal and collaborative platform for industry related news, events, and resources.

X10: http://www.x10.com/homepage.htm

X10 is a communication protocol, which works across home "power line" in an extremely low-bandwidth, which find a spread diffusion in millions of homes.

The main advantages of X10 technology, over other types of remote control products and systems, can be as following summarized:

- compatible products, able to talk each other using the existing electrical wiring in the home,
- inexpensive, due to the fact X10 devices "talk" over existing wires in the home no new wiring and no costly rewiring is required,
- powerful, flexible and affordable setup configurations,
- it is perfect for retrofit although it can be proposed for new homes,
- easy and simple to install, because it is based on the "plug & play" concept,
- an extremely large family of compatible products can be found on the market,
- commercial channels are stores and internet sellers,
- time proven technology, since it has been around for over 30 years.

The greatest recognized advantages about X10 are its flexibility and the large number of X10 components available.

To configure individual devices and groups of devices, X10 uses an addressing scheme that provides up to 256 unique addresses. House codes are written as a single letter in the range A-P. Unit codes are a decimal number between one and 16.

Examples of valid house codes are A1, J13, and P16. This X10 house code is something as the network portion of an IP address, and the unit code as the host portion. Unlike the IP addresses used on the Internet, X10 addresses do not have to be unique: it should give a single address for each group of X10 devices that it would like to respond to the same command.

For example, if a command to turn on two lamps with a single switch, it is necessary to connect an X10 lamp module to each lamp and configure both modules with a single address. If all of the lamps in a room are to be controlled by a single command, they should all be assigned a single address.

Installation of X10 compatible products is extremely simple: a transmitter plugs in one location of the home and sends its control signal (on, off, dim, bright, etc.) to a receiver which plays into another location in the home.

X10 devices send about one command per second, and the commands are as simple as "Device A1: turn on." These commands require less than 1/1000th of the bandwidth of a dial-up connection. Like every broadcast network, every command is sent through every

wire in the house; it's up to each individual device to decide whether it needs to respond to a particular command.

While most X10 devices are one-way (because they are only capable of either sending or receiving), some devices are two-way. For example, one-way X10 light switches can receive X10 commands to enable them to be turned on and off remotely. The other one-way light switch can be used to control the light locally, just as a conventional light manual switch.

Two-way X10 light switches can receive X10 commands, and can also transmit an X10 command when the switch is flipped. This allows to use the switch to control both the light and another X10 device simultaneously. For example, replacing the switch that controls the kitchen's under-cabinet lighting with a one-way X10 switch, and then replace the switch that controls the kitchen's overhead lighting with a two-way X10 switch, it could turn on both the overhead light and the under-cabinet light by using the overhead light switch.

Figure 6 shows some of the most common types of X10 devices: a two-way, hard-wired X10 wall switch, a wireless transceiver, and a battery-operated wireless wall switch.

Figure 6. some most common hard-wired and wireless X10 products.

Figure 7 shows a complete X10 configuration module to turn on/off a lamp.

Figure 7. A complete X10 lamp control module.

In general, X10 products work without any problems. However, because they talk over home's electrical wires they may have difficulties if:

- other home running appliance/devices generates "noise" onto the "power line"
- the X10 transmitter is on one "side" (phase) of the home's electrical wiring and the receiver is on the other "side";.

In the former case a noise filter may be required, while in the latter case a simple plug-in phase coupler may be required, to remove these interferences.

1.5 Ongoing EU Research Projects

Energy Efficiency Projects

Below a list of project dealing with ICT for energy efficiency participating to: "The Best ICT4EE Project Award. The aim of the competition is to promote innovation in ICT that will contribute to substantial and measurable improvements in energy efficiency, and that have the potential to provide visible and convincing showcases for investment by business, citizens or both. The Best ICT4EE Project Award is open to all publicly funded research and technological development projects that involve one or more participants having research and/or business interests in each of the ICT and energy domains.

AIM	www.ict-aim.eu
AmI-MoSES	www.ami-moses.eu

BeAware	www.energyawareness.eu/beaware
BEYWATCH	www.beywatch.eu
Build with CaRe	www.buildwithcare.eu
BuildingEQ	www.buildingeq-online.net/
Club Ecomobilite	www.urba2000.com/club-ecomobilite-DUD/
CombOLED	www.comboled-project.eu
Cool Silicon	www.cool-silicon.org
CRUTIAL	http://crutial.erse-web.it.
e4u	www.e4efficiency.eu
eDIANA	www.artemis-ediana.eu
Enercities	www.enercities.eu/project/
EnerInTown	www.enerintown.org
EPI-CREM	www.epi-crem.org
eTelligence	www.etelligence.de
EVITHERM	www.evitherm.org
GAD	www.proyectogad.com
GENESYS	www.genesys-project.eu
GERONIMO	dairyenergy.eu
Green Hydrogen	www.enersidus.com
Green+ICT	www.greenaddict.eu
ICT for Clean & Efficient Mobility (eSafety Project)	www.esafetysupport.org
ICT21EE	www.ict21ee.eu
IntUBE - Intelligent Use of Buildings' Energy Information	www.intube.eu

LAMPETRA	www.lampetra.org
OLED100.eu	oled100.eu
OLLA	www.olla-project.org
OPERA-Net	www.opera-net.org
PowerMatcher SmartGrid Technology	www.powermatcher.net
PROBIO	puntonet.csa.es/probio/
RESERVOIR	www.reservoir-fp7.eu
Saber	www.saberproject.se
SAVE ENERGY	www.ict4saveenergy.eu
SH/SG	www.smarthouse-smartgrid.eu/
Share And Move	www.shareandmove.fr
SMARTFREIGHT	www.smartfreight.info
TeleFOT	www.telefot.eu
TV Energia	www.tvenergia.tv

Social Housing Projects

Intelligent Energy – Europe (**IEE**) is a part of the EU's Competitiveness and Innovation Framework Programme (**CIP**) and represent the European Union's programme for promoting energy efficiency and renewables [15]. It provides financial support to international projects, events, and local/regional energy agencies, which promote the smarter use of energy and the growth of renewable energy sources.

The IEE Vertical Key Action VKA2 "Retrofitting of Social Housing" aims to accelerate activities for the retrofitting of social housing. In each country priority is given to the most relevant typologies of buildings and ownership in order to exploit the multiplication potential. Awareness raising, education and training, tailored financing schemes, advanced integrated retrofitting solutions and legal and institutional changes are the main target areas. The results expected are the contribution to the general objectives set out in the EPBD, in particular an increase in energy performance of social buildings, improved knowledge of problems associated with the retrofitting of these houses in order to provide

more appropriate solutions and examples and emulations of successful energy-intelligent solutions tailored to this sector.

Project Title	Project web site
Energy Intelligent Education for Retrofitting of Social Houses (EI-Education)	www.ei-education.aarch.dk
Energy Performance Integration in Social Housing - a strategic approach for portfolio management (EPI-SoHo)	www.epi-soho.eu
Tool-Kit for "Passive House Retrofit" (E-RETROFIT-KIT)	www.e-retrofit-kit.eu
Energy Strategic Asset Management in Social Housing Operators in Europe (ESAM)	
Programme of actions towards Factor 4 in existing social housings in Europe (FACTOR 4)	www.suden.org
Innovative Financing of Social Housing Refurbishment in Enlarged Europe (INOFIN)	www.join-inofin.eu
Improving the Social Dialogue for Energy Efficient Social Housing (ISEES)	www.isees.info
New Integrated Renovation Strategy to improve Energy PErformance of Social housing (NIRSEPES)	www.nirsepes.eu
Retrofitting Social Housing and Active Preparation for EPBD (RESHAPE)	www.reshape.social.housing.eu
Development and marketing of integrated concepts for energy efficient and sustainable retrofitting of social housing (ROSH)	www.rosh-project.eu
Social Housing action to reduce energy consumption (SHARE)	www.socialhousingaction.com/
Training for Renovated Energy Efficient Social housing (TREES)	www.cep.ensmp.fr/trees
Supporting European Housing Tenants in Optimising Resource Consumption (SAVE@Work4Homes)	www.atwork4homes.eu
Energy Exploitation and Performance Contracting	www.ecolish.com

for Low Income and Social Housing (ECOLISH)	
Sustainable Roof Extension Retrofit for High-Rise Social Housing in Europe (SuRE-Fit)	www.sure-fit.eu
Advanced Ventilation Approaches for Social Housing (AVASH)	www.brighton.ac.uk/avash/
European fuel Poverty and Energy Efficiency (EPEE)	www.fuel-poverty.org
Tackling Obstacles In Social Housing (TACKOBST)	www.tackobst.eu

1.6 ICT Providers

This section is composed of three tables reported within APPENDIX A of the present report. They have been removed from the report main body due to their length and the fact that they are listings.

The first is a table of several of the world's largest and emerging ICT providers. Their websites, affiliates, programs, and initiatives can provide valuable references. This list was created by consortium knowledge, the research associated with the compilation of this deliverable, and several searches with the keywords of: ICT, energy efficiency, social house, home management system and building automation. It is known that this list is incomplete and that the metric of "largest and emerging" is not specific. The list is a starting point.

The second table and third tables compile companies not listed in Table 1 that are active in the ICT4EE platform (Section 1.3) and also by cross referencing EU projects in the ICT and Energy Efficiency areas. It is also known that these tables are also a starting point.

2. The Results of Tasks 2.1 & 2.2 (User and Building Needs)

2.1 A Synthesis of the User Needs in Social Housing

User needs were assessed using a 45 question survey administered by each pilot owner (ICF, City of Warsaw and Vivienda Zaragoza). The intent of this survey was to collect information related to the tenants' attitude toward environmental issues and their behaviours towards energy consumptions and savings. The survey had 135 participants (56 Spain, 35 France, and 44 Poland). Although survey results must be handled with caution due to the sample size, questions asked, and differing pilot locations, they provide valuable insights. The main conclusions are summarized below:

- A significant majority of the respondents take interest in issues related to environmental protection and would be inclined to change their own behavior to more eco-friendly one under the influence of additional information. People were eager to participate in a meeting discussing ways of saving energy.

- A significant majority of the surveyed also declare that they save energy, mainly by turning off the lights when leaving home or a room or using energy efficient light bulbs.

- Not all of the respondents check energy use in their apartments on the basis of the bill – the smallest number of people to do so was in the Polish group, whereas the largest group which does it could be found in the French. Most of the people who took part in the survey would like to have a device installed in their home which would show energy consumption by different appliances in the household.

- Over half of the respondents did not have problems related to heating during the current heating season, but people who did report some problems mostly complained about the too low heating temperature or problems with adjusting the temperature.

- Almost all of the surveyed have the possibility to regulate the radiators' temperature and they usually reduce it for the night or when leaving home; it concerns mostly living room and bathroom. Most of the respondents would like to a device installed that would program daily temperature regulation at home for w week. Spanish and Polish respondents would like the temperature to be regulated automatically, whereas French participants would like to regulate it themselves.

- Most of the reported problems with hot water at home were observed by French respondents who complained about problems with adjusting the right temperature. The smallest number of problems was reported by Spanish participants. Most of the Poles complained about too low water temperature.

- Most of the respondents also attempt to save water mainly by turning off the tap as often as possible or limiting the bath time and over half of the people check water use on the basis of the bills. Most of the surveyed also realize that taking a bath requires more water than showering.

- A significant majority of the respondents would like to have at their apartments a device installed that would enable them to save water, energy, and gas; most of the respondents would agree to provide access to the data on utilities use for the purpose of the project.

- Almost all of the respondents assess their housing conditions as good regarding their apartments, whereas French respondents are not that happy with their dwelling conditions – they mainly complain about moisture in their apartments.

- Few respondents have access to the cable TV and the Internet at their apartments and they use the Internet more than 2 times a week. Internet users connect to the Web usually at home, and most of them visit social networking websites. Only respondents from Spain declared that they would not use a website with information about water, energy, and gas use in their apartment.

- In most of the apartments there it at least one person who spends most of his/her time away from home.

- A significant majority of the respondents is interested in environment protection issues. In addition, they declared they would adopt more ecological behavior if they obtained additional knowledge on the subject and would be willing to participate in a meeting about energy saving.

- The groups of respondents from France, Spain, and Poland differ in the way they save energy but it appears that they all massively combine the options and all adopt a global responsible behavior towards energy issues.

- It appears that people seems more disposed to restrict lighting (51% of the people choosing the "e" option declared to do so) than heating energy (18%) or water (8%) even if the comfort loss is more important in doing so.

- Most of the respondents try to reduce the temperature at night and when they are away from home.

- People in the sample don't seem to be very preoccupied by confidentiality on internet. But maybe their level of equipment can explain this relative (positive) passivity on this question.

2.2 A Synthesis of the Building Needs in Social Housing

Results from Spain and Poland of Energy Audit, compared in the table below.

Address of the building.	Poland, Warsaw, Szancera 5	Spain, Zaragoza, Antonio Leyva 92,	Spain, Zaragoza, El Globo 40,
Useful surface area (m2)	Office area: 304,76 Residential area: 1639,13 Total: 1943,89	Community Center: 898,29 Flats: 1.366,24 m2 Parking: 594,73 Total: 2859,26	Usable area housing: 3001,61 Usable area storage: 145,33 Usable are parking: 1187,63 Usable are local: 466,43 Total: 4801
Number of floors	Above: 5 Below: 0	Above: 4 Below: 2	Above: 8 Below: 2
Number of dwellings	45	38	43
Number of residents	111	40	?
Heating system	Natural Gas / Distributed automatic control	Natural Gas / Centralized control	Natural Gas / Centralized control
Cooling system	No	Electricity/ Distributed manual control	No
SHW	Natural Gas	Natural Gas /	Natural Gas / Centralized control

		Centralized control	/ Solar thermal / Distributed automatic control
Heat generating plant for the building heating system	88,3 kW	160 KW	?
Heat Generating equipment for SHW	88,3 kW	160 KW	?
Building occupation sensors	No	No	No
Bill structure	Poland, Warsaw, Szancera 5	Spain, Zaragoza, Antonio Leyva 92,	Spain, Zaragoza, El Globo 40,
Gas for kitchen	Counters are read every 3 months. Fixed monthly fee is calculated and paid based on the bill.	No	No
Electricity	Counters are read every 6 months. Fixed monthly fee is calculated and paid based on the bill.	Every single tenant has a contract with the company name supplier.	
Water flow	Fee depends on the number of tenants and it's included in the monthly rent. The adjustment every 6 months	Every single tenant has a contract with the company name supplier.	
Hot water	A fee paid advanced in rent, settled by the counters once a 6 months.	Not established	6,59 euro/month fixed rate. Consumption – month by reading meters expired.

Heating	Rate x flat surface, settled by the counters once a year	Not established	7,77 euro/month fixed rate. Consumption – month by reading meters expired.

2.3 Pairing User Needs and Building Data

The end result from project surveys and analysis is fairly simple and likely reflects the situation across Europe. People are aware of climate change. Provided information, incentive, and follow up, it is probable that social housing tenants would act to lower their energy consumption and to follow energy efficient behaviours. These tenants have expressed different desires with respect how they would like to interact with ICT energy savings systems and also the control measures associated with such systems. With respect to buildings, they are very diverse with respect to ownership, bill structure, age, and energy/water/gas utilities. Privatisation of social housing is a continuing trend across Europe. However, there are significant percentages of the market in each ownership category.

The implication on ICT solutions for social housing is that there will be no unique solution. ICT providers and consultants will have to be flexible and adaptive to adopt their technological solutions and business models across a variety of situations. What can be standardised is an approach and methodology to develop ICT solutions and to validate their results.

3. ICT Solutions by Category

3.1 Sensors & Smart Metering

Energy optimization of buildings requires the possibility to analyze the characteristics and the behaviour of buildings. ICT technologies can provide an ideal solution to perform the monitoring of several physical parameters (indoor temperature, %HR, lighting, etc.) and energy consumption parameters (gas, water, electric).

Sensors can be divided in two main categories:

- sensor for monitoring physic parameters: indoor and outdoor temperature, humidity, light, human occupancy, aperture, CO_2 concentration,
- sensor for monitoring consumption: gas, electricity, water

The following table summarizes the different measures we can perform and the automatic action the sensors can do.

Sensors	Use, collected data, operation	Priority
Temperature	It provides a comfort indicator for each room of the house or building. It allows to adjust the indoor conditions based on outdoor conditions. It allows you to transfer the excess energy from one room to another	1
Humidity	It gives data on comfort and indoor air quality It allows to activate ventilation for rooms in which the humidity varies greatly	2
Light	Control of aperture depending on external light conditions. Regulation of light depending on illumination.	2
Occupancy	Regulation of temperature, light and ventilation depending on room occupancy.	1

Opening	Heating and ventilation can be switch off in a room open to the outside.	1
CO_2	Control of ventilation depending on indoor air quality.	2
Consumption	It lets understand the consumption of each resource (water, gas, electricity).	1

The following sections focus on sensors and smart meters developed for both consumer and industrial applications. They provide a non exhaustive list of sensors and classify them by type and functionality. First, general characteristics are detailed. In the second part, existing sensor technologies for the measurement of each parameter (cited in the previous table) are described.

3.1.1 Generalities on sensors

A multitude of sensor technologies exist. Depending on the technology used, their characteristics like the response time, accuracy, sensitivity, uncertainty, reproducibility, and deviation vary.

All kinds of sensors are developed for both consumer and industrial applications. Consumer sensors are generally black boxes that provide a value and are poorly documented. Sensors for industrial applications have accurate descriptions concerning measurement method, precision, deviation, and so on. It allows to analyse the measurement protocol and to understand and account for measurement error and deviation, almost impossible with consumer products.

3.1.2 Temperature sensor

The temperature sensors are divided in three categories depending on the technology used: thermocouple, resistance temperature sensor, and thermistor.

3.1.2.1 Thermocouple

The thermocouples are inexpensive, robust and have a fast response time. Nevertheless, they are less accurate, stable and sensitive. A thermocouple only gives a temperature difference between two points while resistance temperature sensor and thermistor give absolute values.

3.1.2.2 Resistance temperature sensor

The resistance temperature detector is the best choice to have a good repeatability. It is stable and accurate. However, it has a slower response time and as it requires power supply. The Joule Effect can affect the accuracy of the measurement.

3.1.2.3 Thermistor

The thermistors are fast and relatively inexpensive, but they are fragile and have limited temperature range. They also require power supply and are more susceptible to heating (Joule effect) than the previous one. They are not linear.

3.1.2.4 Comparison of Temperature Sensor Characteristics

Criteria	Thermocouple	Resistance temperature sensor	Thermistor
Temperature range	-267°C _ 2316°C	-240°C _ 649°C	-100°C _ 500°C
accuracy	good	Excellent	good
linearity	very good	Excellent	good
resolution	good	Very good	Excellent
cost	Excellent	good	Very good

Consumer sensor (light, temperature, humidity).

Industrial sensor (temperature, humidity)

Industrial sensor (temperature and humidity)

3.1.3 Humidity sensor

Humidity sensors are in most cases integrated with temperature sensors. Stand-alone models exist but the market shows combined readings are preferred. Humidity is one of the more challenging measurements to obtain. Uses for such measurements include

comfort, the control of industrial applications (e.g. painting rooms, manufacturing plants, etc.), and the control specialised areas (e.g. museums, saunas, etc.).

3.1.3.1 Resistive hygrometer

This kind of sensor is based on the measure of the resistance of a hygroscopic substance. The value of resistance depends on both humidity content and temperature.

If this solution gives short response time, the response curve of such sensor shows a large hysteresis and a marked tendency to drift with temperature. The measure range is from 5% to 95% humidity for temperatures between -10°C and 50°C. The response time is about 10sec for a precision of about 5%.

3.1.3.2 Capacitive hygrometers

This kind of sensors is based on the capacitance change of a capacitor through its dielectric constant. The dielectric (few microns thickness) absorbs water molecules in indoor air.

The performance of these sensors are very correct from 5% to 99% HR for a wide temperature range (-40°C to +80°C). The response time is 2 to 3 seconds with accuracy about 3%.

3.1.4 Light sensors

There are two kinds of light sensors:

- Threshold sensor: they have two positions ON and OFF and operate above a threshold of light intensity
- Intensity sensor: it allows to measure intensity variation.

3.1.4.1 Photodiode

A photodiode is a semiconductor with the capability to detect a light radiation and transform it in electric signal.

3.1.4.2 Phototransistor

The same principle than the photodiode but more sensitive and slower.

The following table compares the advantages/disadvantages of both technologies.

	Advantages	Disadvantages
Photodiode	- Linearity - Wide illuminance range - Light adjustment capabilities	- Dark current - Filter needed to match human eye spectral response

	by dimming	- Temperature influence - Need additional amplification circuit for gain
Phototransitor	- Linearity - Wide illuminance range - Light adjustment capabilities by dimming - High internal gain (compared to photodiode)	- Dark current - Filter needed to match human eye spectral response - Temperature influence - Need additional amplification circuit for gain

Two examples of light sensors

3.1.5 Occupancy sensor

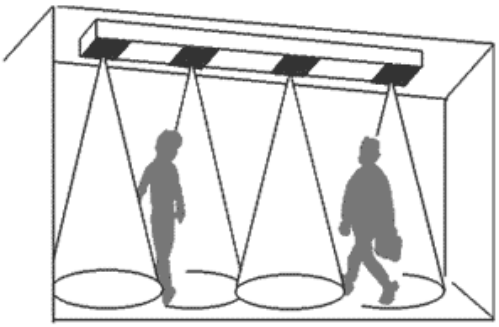
3.1.5.1 Infra-red sensor

This sensor measures changes in the infra-red flux. It is a capacitive captor, it cannot detect static presence.

3.1.5.2 Barrier or shower (infrared or charge coupled device)

A barrier can be composed by either a combination of infrared sensors or charge coupled device (ccd) sensors which allow to know the number of persons entering a room.

Example of a shower device:



3.1.5.3 Ultrasonic sensor

This kind of sensor is based on the principle of the sonar. The device sends impulses and monitors the time delay to get wave return. This sensor also cannot conduct static detection.

3.1.5.4 Smart ultrasonic sensor

The same principle of the sonar with a more complex treatment of the emanating wave and received information.

3.1.5.5 Camera

The camera monitors an image that is processed to detect static or dynamic human presence. It requests a very complex image processing which is disturbed by brightness variations.

The camera can be an infra-red camera that improve the information processing making it easier (no influence of light).

3.1.5.6 Other methods

Solutions combining different types of measurement (including infrared and ultrasonic method) are interesting to perform detection. For example, it can be possible to prevent the detection of pets' movements.

3.1.5.7 Occupancy Sensor Comparison Table

Sensors	Movement detection	Number of occupant	People localization	Physic activity	Price
Passive infrared	+	-	-	+/-	low
Barrier (ccd or infrared)	+/-	+	-	-	low
Micro-onde	+	-	-	-	middle

Ultrasonic (simple)	+	-	-	-	low
Ultrasonic (smart)	+	+/-	+/-	+/-	middle
Camera infrared	+	+	+	+	Very high
Passive infrared 360°	+	+	+	+	middle
Video camera	+	+	+	+	high

Infrared sensor

Infrared barrier

Ultrasonic sensor

Video camera

Infrared camera

Infrared 360°

3.1.6 Opening sensor

Opening sensors are divided in three categories:

- Limit sensor: It's a sensor of contact (open or close), as a switch. It's often used to know the position of a door
- Reed sensor.
- Pressure sensor: a sudden change in room pressure indicates that a window or door was opened or closed. Detection of multiple opening (windows or door) but less adapted to the control room by room.

Limit sensor

Consumer reed sensor

Industrial pressure sensor

Consumer pressure sensor

3.1.7 CO2 sensor

The normal rate of CO2 in air is 350-450 ppm. CO2 is an odourless, colourless and non-flammable gas. The CO2 has the characteristic to absorb infrared frequencies. Therefore, new sensor models use infrared light to measure the rate of CO2. We can also find electrochemical sensors. These are scarcely used because of their maintenance cost and their short lifetime.

The NDIR (non dispersive infrared) sensor is the most widespread and reliable CO2 sensor.

In the following, we present two examples of CO_2 NDIR sensors.

CO_2 sensor

CO_2 sensor

3.1.8 Consumption measure

Two different approaches can be used for monitoring resources consumption:

- Measure on the counter which gives general information
- Measure point by point which gives information of each room consumption.

3.1.8.1 Measure on counter

A box is connected on a counter to provide real-time consumption.

Consumption on water or gas counter.

3.1.8.2 Measure point by point

✓ Electricity

The electric consumption is determined from the value of (instantaneous or average) power. This value results from the product of voltage and current. Two strategies can be used:

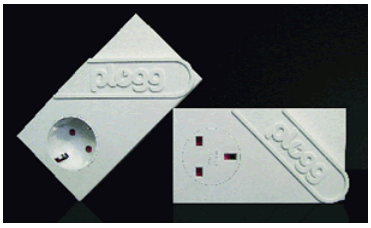
- Measuring only the intensity, considering that the voltage is stable (it's an approximation: in France, EDF guarantees a voltage about 230V +/- 10%).
- Measuring both intensity and voltage, more accurate measure.

It is important to note that most metering approaches conduct discrete measures (e.g. they take instantaneous values at each time step), then build the signal point by point. As such, the choice of the time step is a key parameter for a well done measure (for example: if an apparatus works for a short time but consumes a lot of energy, such as electric smoothing iron, we have to be sure that its consumption is well counted).

✓ Water and gas

Flow meters need to be used for point by point measures. Ultrasonic flow meters appear to be most suitable because they measure both gas or water flows. Moreover, the installation and maintenance cost is low.

Voltage measure



Voltage and intensity measure

Ultrasonic flowmeter

3.1.9 All in one solutions

In this paragraph, we report examples of all-in-one solutions. They are very interesting for consumer applications when people don't have (or need) a deep knowledge of ICT technologies.

3.1.9.1 Onset's HOBO ZW

Onset's new HOBO ZW Series wireless data nodes provide centralized wireless monitoring of energy use and environmental conditions in buildings.

Best-suited for on-site facility monitoring applications where web access to data is not required, HOBO wireless data nodes transmit high-accuracy, real-time data from dozens of points to a central PC. This eliminates the need of having to manually retrieve and offload individual data loggers.

3.1.9.2 IO-Homecontrol

IO-Homecontrol is a platform that integrates different technological solutions using wireless technologies. Supported sensors include those for doors, roof windows, roller shutters and awnings, lighting, heating and cooling controls, security systems, garage doors and gates.

3.1.9.3 D-Link Home Monitoring and Home Energy Monitoring Kit

This kit connects to a residential internet router to allow the interface of home control functions over an internet web portal. These functions can be home security (smoke, joint, gas, water) or security intrusion (motion, door opening ...). Options are available with IP cameras to see and record what happens during your absence.

This kit may be supplemented with the "Home Energy Monitoring Kit" which will measure the power consumption of devices connected to the two jacks of the latter.

3.2 Building and Energy Management Systems (BEMS)

Fully equipped buildings need control and management systems in order to coordinate at least the various active systems working to produce heat, cold and clean air. Building management is also becoming compulsory for new buildings with low energy consumptions in order to insure their systems to work properly but also effectively.

BEMS are implemented systematically in tertiary buildings nowadays and have an increasing implementation in housing.

First developed as centralized management systems, BEMS are used now for the whole control of buildings and can include:

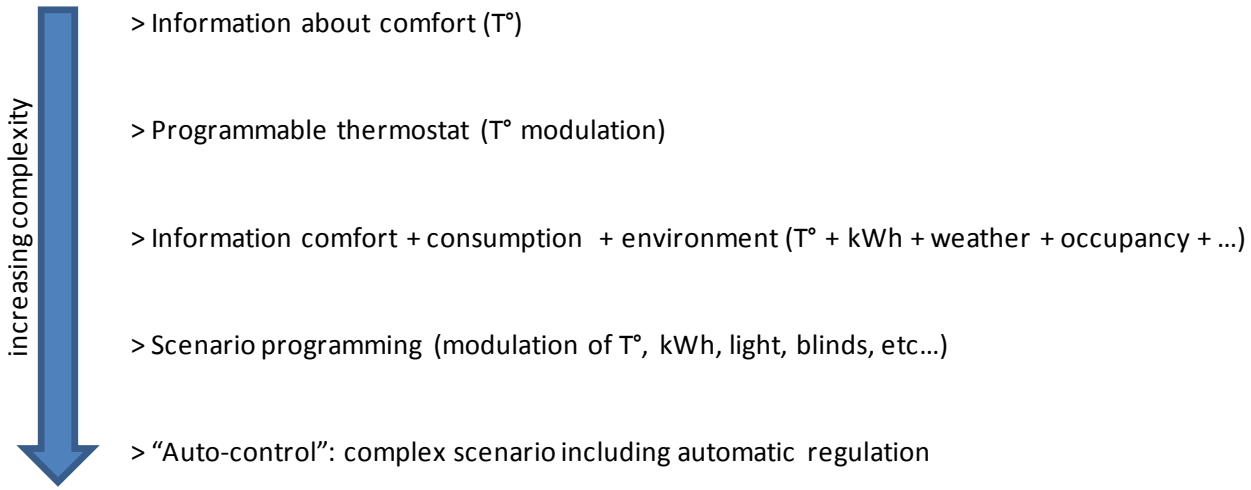
- Heating, ventilation and air conditioned
- Electricity (light and strong power)
- Lifts
- Plumbing (pumps, levels of fluids…)
- Access and security (including video)
- Lightings
- Blinds and openings
- Etc.

Management is dedicated to maintenance of the systems, coordination of their use, and more and more for energy consumption optimization and users comfort control.

The information to be delivered can be diverse:

- Alarm (breakdown, measure over threshold, ..)
- State information (working/not working, position, command feedback, …)
- Measures (T°, working time/frequency, consumption, etc.)

Levels of information / decision to the user can be very different depending of the complexity of the BEMS:



In housing the most used interface and control setup today is the programmable push-button controller. However, touch screens or "dashboards" which offer the opportunity for more detailed information, visualisation, and thus refined control are emerging.

3.2.1 BEMS for energy efficiency

The following parameters can be considered as potential leverage for energy efficiency by the use of BEMS (non exhaustive list):

- User behaviour modification by information
- Maintenance optimization
- Occupancy scenario
- Heating/cooling by zoning
- Relationship ventilation-occupancy and ventilation-temperature
- Relationship heating/temperature and heating/occupancy (considering building inertia and even weather forecast)
- Relationship artificial light-natural light
- Programming of sequential use of domestic appliances
- The negotiation of specialised contracts with energy providers

3.2.2 Communication protocol

Communication between sensors, actuator and BEMS are of particular importance to insure proper control and management of the building. Existing protocols are either owned by private technology providers or open communication languages.

Private owner protocols are often used for fully packed ICT solutions used in housing or for specific equipments in large buildings (for example lightings, or actuators to actuators communication etc.). They use to be cheaper but less adaptive. Open protocol give the possibility to use sensors from other providers and interoperability is now normalized (EN ISO 16484-5 and 6). Another alternative is "private interoperability" languages, for example IO-homecontrol initially developed by a consortium of 5 industrials (Assor Abley, Honeywell, Hormann, Velux and Somfy). Another option is communication by Ethernet (installed in the building for web access for example) and control by a specific web service (XML language) and a computer. This last option is proposed by the German company Beckhoff for example.

Examples of the most usual protocols:

>For the building sector among Europe

- BACnet (open)

- KNX (open)
- LonWorks (open)

>For more specific use:

- DALI (Digital addressable lighting interface > lighting)
- OPL (actuators to actuators communication)
- En Ocean (wireless communication)
- Z-Wave (wireless communication)
- Zigbee (wireless communication)

3.2.3 BEMS for buildings (tertiary buildings or large housing buildings)

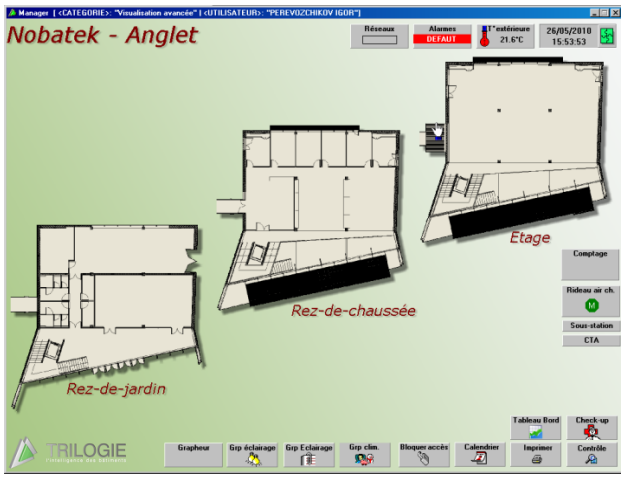
Building management is realized by facility management software linked to sensors and automation tools connected to all the equipments. These tools require a specific training and regular monitoring. Management can be realized considering one large building or also various buildings.

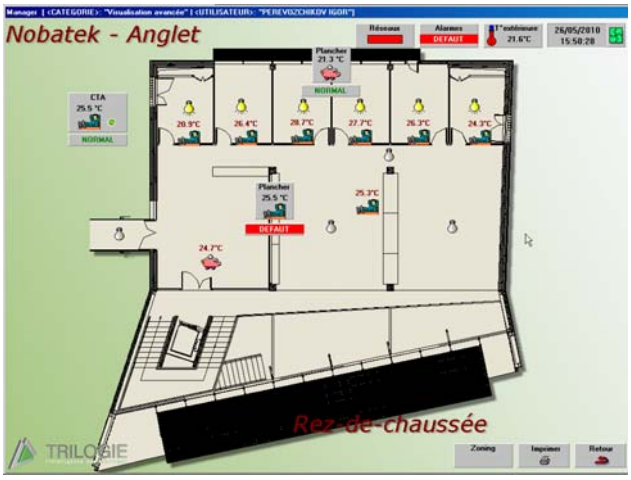
- Example of a system for a multi-zone building management (example of the Trilogie "Manager" system installed in the Nobatek building in Anglet):

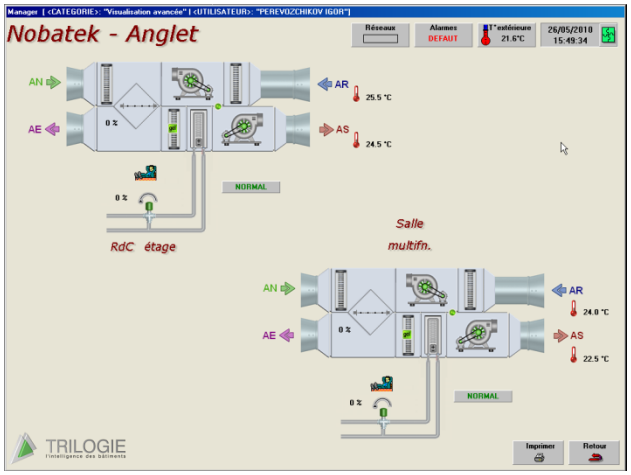
The system allows to manage all the HVAC equipments and lightings in relation to exterior and interior conditions, occupancy and pre-programmed scenarios:

The management software delivers information about the measurements (t°, consumptions, etc.) and the main parameters of the equipments (maintenance) with specific alarms, a synthesis of the building behaviour at real time and for the past periods and allows fine analysis of the energy / comfort parameters for the building.

Examples of the management software:







- Examples of commercial solutions for multiple buildings management:

➢ *Enerdis (Chauvin Arnoux) / E Online* http://www.chauvin-arnoux.com/PEE/HP/HP_PEE.asp

Software for multi-fluid management and electrical network monitoring, dedicated to energy efficiency. Management of 10 up to 4000 measurement points, on various sites. Propose analysis for different types of fluids or energies, performance comparison and allow real time control. Web based solution.

➢ *Areal / Topkapi 4.0* http://www.areal.fr/index.html

Modular software for monitoring and management of technical equipments in buildings, of real estate, public lightings, water networks, etc. It includes a specific module for energy efficiency, with indicators

on unusual consumption. It allows to managers to compare buildings and systems performance, control traceability, and prepare improvement scenarios.

3.2.4 BEMS for housing (dwellings or house)

While complex systems are required in tertiary buildings, housings are usually equipped by localized systems (adapted to 1 dwelling or a house), with simple user interface and in most of the case simplified information and management possibilities.

Here are three examples of BEMS for housing, with three levels of managing possibilities:

- *Delta Dore - Talco / Calybox série 200*

Energy manager with integrated radio emetor / receptor for housing. Diary or weekly scenario for 2 zones (C220), 3 zones (C230), or 3 zones with consumption information (C230WT). Dispensation of tempered zone from 15min to 72h.

- *Delta Dore - Talco / Tydom 410*

Wall terminal with touch screen allowing the control of all the technical elements of the house (heating, alarms, blinds, lights), but not ventilation.

Heating control by zoning, information on electrical consumption, dispensation function, and scenarios creation.

- *IO-Homecontrol*

Distant house control solution via web access for all electrical components matching with IO-homecontrol (internal and external blinds, windows, doors, alarms, heating, air conditioned, lights, etc.). Specific web box to be connected to a PC. Allows the configuration of the house for each room and equipment, and to create

scenario. The system gives feedbacks on the equipments (working or not, or at 50%, ..). It can be controlled either by PC or telephone or remote control for simple operations.

3.3 Machine to Machine

Machine to machine (usually abbreviated M2M) communication is a growing market for applied telemetry and telematics, allowing wired and wireless devices to communicate with applications and each other. M2M Machine to Machine communications involves the automated transfer of information and commands between two machines without human intervention at either end of the system.

3.3.1 Examples of M2M communications areas

3.3.1.1 Automated meter management

Automated meter management (AMM) is a generic term for intelligent metering services based on two-way data communication. AMM could be considered as the third generation of metering technology, in the last decade utilising cellular radio technology for network connectivity. AMM broadens the scope of AMR beyond just meter readings with additional features enabled by two-way real-time data communication, such as energy management and value added services linked to the customers' use of energy. The utility or energy sector is considered to be one of the early major sectors for M2M. Utility comprises of electricity, gas and water; and in some regions heating. Firstly, it is a sector which is already moving forward at an increasing pace through solutions for Automatic Meter Reading (AMR) and Automatic Infrastructure Management (AIM). Secondly, the sector is subject to regulations which force major changes. Both environmental and accountability, as well as competition issues in the energy sector is driving the regulation efforts.

3.3.1.2 Vehicles and transport

The vehicle and transport sectors are seen as the second fast growing market, it is well established as a sector where M2M solutions are already adopted and where developments are occurring rapidly. The sector is commonly divided into two sub sectors: Cars (meaning private or passenger cars) and Vehicles (meaning commercial vehicles of all sorts on wheels). These are quite different as the first will be partly enterprise (car manufacturers, leasing companies) and partly consumer (car drivers/owners); the second is purely enterprise.

3.3.1.3 Fleet management

Fleet management is an ambiguous term used in reference to a wide range of solutions for different vehicle-related applications. Berg Insight's definition of a fleet management solution is "vehicle-based systems that incorporate data logging, satellite positioning and data communication to a back-office application [18]". Today mobile networks can provide ubiquitous online connectivity at a reasonable cost and mobile computing technology

delivers very high performance, as well as excellent usability. All of these components combined enable the delivery of vehicle management, transport management, driver management and mobile workforce management applications linking vehicles and enterprise IT systems. The same technology platform can also be used for electronic toll collection. **¡Error! No se encuentra el origen de la referencia.**

3.3.2 M2M Technology solutions

There are currently several providers of M2M solutions in most parts of the world and the number of devices continues to rise. According to Harbor Research, a US based analytics firm specializing in M2M communication, the number of objects that could benefit from being connected far surpasses the number of people in the world as indicated in the figure below [19].

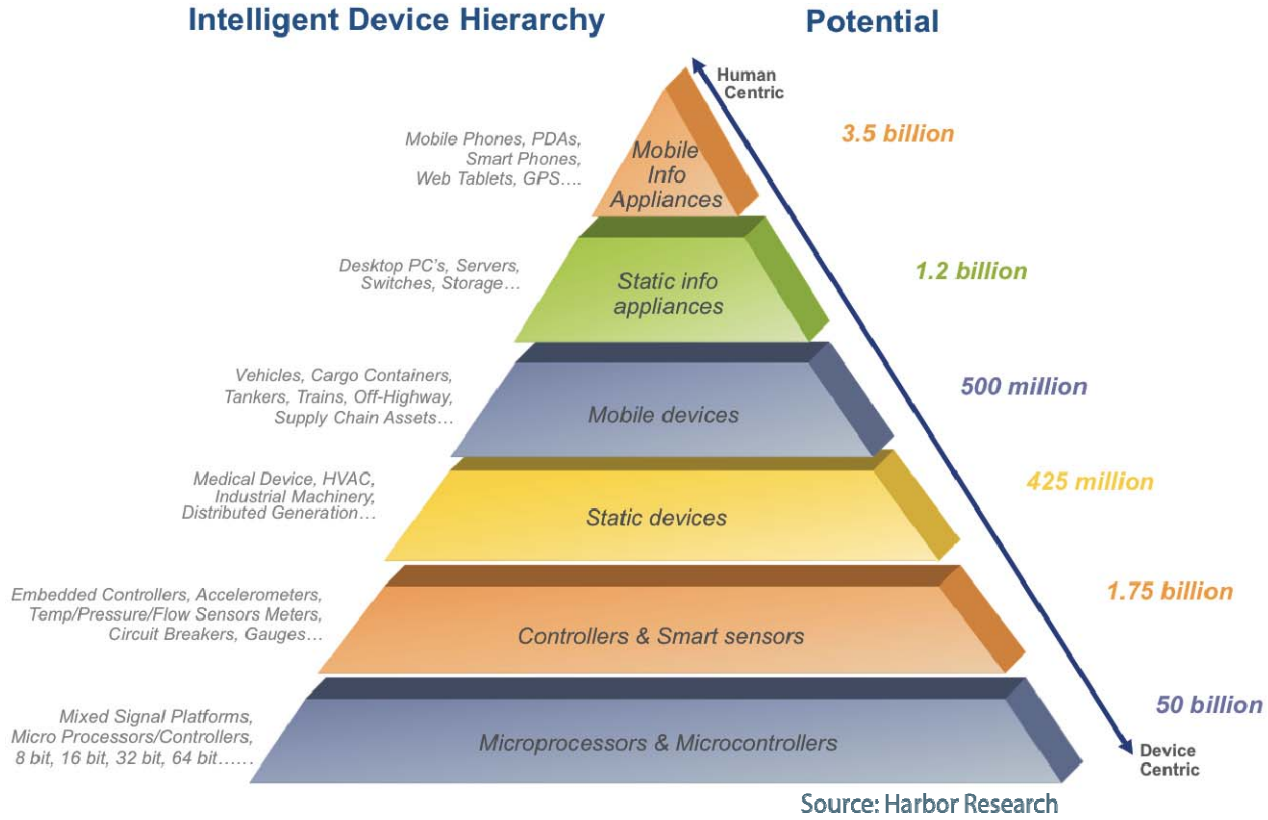


Figure 1 Potential number of connected devices in 2013 according to Harbor Research

3.3.2.1 List of Top 100 M2M technology providers

The list of Top 100 M2M technology providers is published annually by the M2M Magazine. "It is a list of the most important and influential machine-to-machine technology providers as determined by the editors of *M2M* magazine and its editorial advisory board. It is designed to provide a snapshot of the market as it exists today and the companies with

the greatest impact on its direction [20].” The list is reported within APPENDIX A of the present report

3.4 Machine to User

A user interface is a display, a screen, or any device witch purpose is to provide information to users and/or to allow him/her to take actions. This paragraph focuses on user interfaces used to display information about energy consumption and/or to control this consumption. These interfaces get data from sensors or smart meters set in house or building. Then the information is computed and displayed on by the interface. Depending on the kind of interface, the user is provided with one single type of information or is able to monitor and control a full house or building. The purpose of this chapter is to give a good understanding of this wide range of different user interfaces.

This section is subdivided in two main parts. The first part (3.4.1) is dedicated to a description of the main features of such devices and some particular observations (cost, etc…). Three main categories of products are detailed: interface using specialized sensors, feedback only interfaces featuring several sensors types, and feedback plus automation interfaces. This section aims to provide a general understanding of what can be done using ICTs user interface for energy saving. The second part is a list of some example products reported in Appendix A (3.4.2) and followed by a summary table (3.4.3).

3.4.1 Description and main features

The wide range of user interfaces makes it impossible to give a precise description of the different features provided. There are divides in three main categories:

- Specialized sensor interface
- Interface giving feedback possibility from various sensors collected information
- Interface giving both feedback and automation operation.

Yet, here is a broad view of the different characteristics of user interfaces.

Remark: Examples of the products mentioned in the following sections are placed in <chevron brackets> which are detailed in section (see 4.4.2).

3.4.1.1 Specialized sensor interface

Basic user interfaces commonly have a single LDC display that provide data collected by specialized sensors (e.g. only electricity, temperature, or lights). This kind of interface is typically used to get electric consumption feedback or to monitor heating <**Millennium** thermostat>. Although they are mainly dedicated to feedback, they can have basic control features (switch plug on/off or set the temperature). Most of them are very easy to set up. For electric consumption, the sensor can be directly plugged on the electrical circuit or more specifically on a plug to get information about the consumption of a chosen device. Commonly, the consumption is displayed in kWh and in €, sometimes in CO_2 emission equivalent <**BaroWatt** Baromètre énergétique>.

Data from the sensors are either shown as instant data or computed and interpreted to provide daily or monthly means with evolution information <**Avidsen** Spara>.

Plus	Minus
Low cost (80€ to 300€) Easy to set up	Few data collected Poor statistical tools Poor user interface

Remark: some products may not follow these Plus/Minus indications, they are mean observations

3.4.1.2 Various sensor, feedback only

This kind of interface has to display information from several types of sensors. As a result they are usually more ergonomic <**PRI** Consumer Information Panel> and user friendly than the previous one, in order to provide understandable information to the user. The most used sensors are electric consumption and temperature. Nevertheless, some solution offer larger possibilities (gas, water<**ISA** iMeter>) and even accept any sensor from a given protocol <**L.S Research** RATE$AVER>. Once again, the offer is very large. It goes from house dedicated device, with few sensors, to building control system, featuring web portal <**IJENKO** Service Web> and elaborated statistical tools.

These interfaces are of two main kinds: hardware interfaces (ie sold with the display) and software interfaces <**PRI** E-Watch>. Hardware interfaces are commonly used in home display interfaces, they are composed of a display (some of them are touch screen <**PRI** Consumer Information Pane>) providing information from sensors. On the other hand, software interfaces are not sold with one particular display; they can be installed on computer or users access it via a web portal. They are mainly used for building control.

Unlike previous interfaces, specialized in one sensor, this kind of interfaces must deal with a whole set of sensors. As a result, they need a specific protocol for information gathering. Standardized and open source protocols exist to allow communication between different sensor types and the networks they operate within. They can both be used for building or large area control and may often be provided with a unique access such as a web portal.

Plus	Minus
Medium cost (500/2000€) Energetic awareness Elaborated feedback Enhanced statistic tools	No automation feature Feedback only

Remark: some products may not follow these Plus/Minus indications, they are mean observations

3.4.1.3 Feedback and automation

These interfaces are designed to provide various information and let the user control its house or building (lights, heater, blinds...). The main part of these interfaces provides also other features related to home automation (multimedia, security, etc.) <**Iddero** HC1-KNX color touch panel>. Home automation designates the increased automation of house equipment, especially through electronic means and ICTs. Although some of the products shown in the "product overview" part (3.4.2) are full home automation solutions, only their energy-related features will be discussed here. Unlike the previous one, these interfaces and systems are more complex to set up and their costs mainly include equipment, furniture, components and installation.

Due to the large amount of information or options displayed, most of these interfaces provide large screens (even touch screens) with enhanced ergonomic features <**Delta Dore – Talco** Dombox>. The feedback provided by these interfaces is usually rich and user friendly, graphical and easy to understand. Many products feature elaborated statistics and large overview of past consumption <**Millennium** In Home Display>. On the one hand, these data increase user energy awareness. On the other hand, they allow proceeding to precise diagnosis in order to identify critical area.

Automation options are also very rich. For instance, lights management can be either very specific (switch on/off one single light) or global, thanks to scenario settings (holidays, diner, watching movie, etc) <**Philips** Dynalite>. These scenarios option are very interesting because they allow to apply several settings at once, either manually or automatically (blinds settings correlated to sun brightness).

Once again, the interface needs a communication protocol to communicate with sensors and actuators. Protocols must be selected carefully because they have neither the same transmission speed, nor the same range. The user interface can be either located in one place (common display) or acceded remotely to monitor distant localizations or process to remote diagnosis. Remote access is often via secured web portal.

Plus	Minus
Elaborated feedback Clean interface Full automation feature	High cost (2000€ to 15000€ and more) Hard to set up

Remark: some products may not follow these Plus/Minus indications, they are mean observations.

3.4.2 Product overview

This section introduces some example products. The list is not exhaustive and is provided only as a mean to understand the offer and to have a quick overview of the different kinds of existing products.

This list is structured as shown:

Company Name Product Name

Company logo	Picture of the product	Description of the product, main feature **Keywords**
Internet link to the product		

The main categories analyzed are:

- Specialized sensors interfaces
- Various sensors feedback interfaces
- Feedback and automation

Specialized sensors interfaces

AzTech In Home Display

AzTech Associates Inc.		This in home display provides precise real time feedback of the house's electric consumption. It is able to communicate directly with smart meters. It displays the electrical consumption in $ or €. **Feedback - Electric consumption**
http://www.aztechmeter.com		

Chacon Ecowatt

CHACON		Ecowatt display the electric consumption of a house. It is connected with a sensor plugged on the electrical circuit and display the consumption in €, CO_2, and kWh. **Feedback – Electric consumption**
http://ecowatt.monassoc.com		

BaroWatt Baromètre énergétique

The Barowatt is a plug and play device that gives you feedback of your electric consumption (kWh, €, CO_2 +-5%) and indoor temperature. It is only compatible with its native sensors

http://www.barowatt.com/le-barowatt/

Feedback - Electric consumption

Millennium Thermostat 7000 Series

The millennium Thermostat 7000 Series is a large LCD display and wireless thermostat device. It has been designed to optimize energy uses and comfort.

http://www.millec.com.au

Thermostat – Wireless – Task Planning

Avidsen Spara

Avidsen's Spara gives you a detailed overview of your electric consumption. It can display instant consumption but also daily mean or CO^2 emission equivalent.

http://www.avidsen.com/

Feedback - Electric consumption

Various sensors feedback interfaces

ISA iMeter

The iMeter is a full solution, including sensors and wireless transmitter. Its purpose is to help you saving energy through awareness. The interface display consumption feedback concerning gas, electricity and water and alarms can be set. The iMeter solution features also a web portal, for distant access.

Feedback – Wireless – Web portal

http://www.isa.pt/products.html

PRI Consumer Information Panel

The PRI Consumer Information Panel is designed to handle any ZigBee compatible sensor. It provides the user with feedback concerning electricity and gas consumption, including cost information.

http://www.pri.co.uk/default.aspx

Feedback - ZigBee - Graphical interface

PRI E-Watch

The PRI E-Watch gather information from any ModBus compatible sensor. It is designed to securely collect and store data in an Oracle data base. It is an online data acquisition software.

http://www.pri.co.uk/ewatch.html

Feedback – Energy consumption - ModBus

IJENKO Service Web

The IJENKO Web portal is an user friendly web interface that gathers several information about energy consumption. It is connected with the IJENKO energy suite ("pack énergie").
This product is not for sale yet.

http://www.ijenko.com/service/web

Feedback - Electric consumption – Web Portal

L.S Research RATE$AVER

The RATE$AVER is an in home display that gives the user feedback about its energy uses. This is not a monitoring device. It displays information about electric consumption and temperature.

http://www.lsr.com/products/smartenergy/

Feedback - Wireless – ZigBee

Landis+Gyr EcoMeter Energy Monitor

With precise and various feedback, from any ZigBee compatible sensor, the EcoMeter allow any energy user to manage its consumption better.
Landis+Gyr have many other energy related product, see the website.

Feedback - Various sensor - ZigBee

http://www.landisgyr.com/

GEO Quartet

Quartet is a all included solution to control the electric needs of a building. It can gather data about electricity, gas or water consumption and is designed to engage the building's users.
Feedback – Building scale

http://www.greenenergyoptions.co.uk

Feedback and automation

Millennium IHD (In Home Display)

The millennium In Home Display features a flexible screen design that can be modified for specific needs. It is compatible with any kind of sensors (meter agnostic). The interface provides both feedback and monitoring options.

Feedback - Monitoring - Web Portal – Task Planning
Business - ZigBee – Remote access – User accounts

http://www.millec.com.au

EcoBee Energy Management System

The EcoBee Energy management System is a home energy monitoring system, it deals with temperature, light, moisture and other additional sensors. Its web portal allows the user to monitor his house remotely after identification. It is designed for business purposes. Furthermore, it can monitor several locations and conduct remote diagnosis.

Feedback - Monitoring - Web Portal – Task Planning
Business - ZigBee – Remote access – User accounts

http://www.ecobee.com/

Control4 EC100

This product deals with lights and temperature. It gives feedback to the householder about it's energetic consumption and allows him to monitor the lights or the heater.

Feedback - Monitoring - Tactile

http://www.control4.com/solutions

Legrand Celiane 10''

This product is dedicated to home automation. It gives you feedback about lights or heater and allow you to remote control your house: lights, heater, windows... It is also possible to plan activities.

http://www.legrand-celiane.fr/

Feedback - Monitoring - Tactile – Home automation

Iddero HC1-KNX color touch panel

The HC1-KNX color touch panel is dedicated to home automation. It is standardized KNX which allows it to communicate with any KNX sensor or actuator. The built in web server allow the user to access the HC1-KNX with any PC, Pda or any device with a web brother

http://www.iddero.com/fr/products.php

Home automation - Tactile – KNX – Web brother

LemonQ Home Automation

LemonQ provide its customers with full home automation services. The user interface cannot be sold by itself. This home automation service allow the user to get information and control virtually anything in his house.

http://www.lemonq.eu/?site=offer

Home automation - KNX

Siemens KNX Building Automation System

Siemens Building automation service is an integrated automation service. It can control heater, lights, curtains, blinds, cooler or ventilation. Siemens provide this service for houses and commercial buildings.

http://www.knxstore.com/

Building automation – Remote control - KNX

Philips Dynalite

Philips Dynalite is a way to control the whole lightning in a house or a building. Light can be either controlled remotely or set on automatic mode based on different kind of sensors.

http://dynalite-online.com

Home automation – Light control - KNX

Hager Domovea Tebis

Hager Domovea is the user interface of the Tebis system, developed by Hager. Domovea is a feedback and monitoring interface dedicated to home automation. Thanks to it, you can control the whole building from a single computer.

Home automation – Computer

http://www.hager.fr/domotique

Delta Dore – Talco Dombox

The Delta Dore – Talco Dombox is a wireless TV display to control and monitor home equipment. It can control the heater, the lights and the blinds. It also provides information about energy consumption.

Home automation – TV display

http://dynalite-online.com

3.4.3 Summary table

	Feedback					Monitoring				Other Features					Compatibility			
	Electricity	Lights	Temperature	Gas	Water	Lights	Heater	Blinds	Home automation	TV display	Computer, Pda…	Web portal	Tactile	Wireless	Only native	Other sensors	ZigBee	KNX
AzTech In Home Display	X																	
Chacon Ecowatt	X																	
BaroWatt Baro. énergétique	X																	
Millenium Smart Ther			X				X								X			
Avidsen Spara	X																	
PRI Consumer Info. Panel	X			X									X				X	
ISA iMeter	X			X	X							X		X	X			
PRI E-watch	X	X	X	X	X						X	X				X		
L.S Research RATE$AVER	X		X											X			X	
Landis+Gyr EcoMeter	X	X	X	X	X									X			X	
IJENKO Service Web	X			X	X						X	X			X			
GEO Quartet	X			X	X						X	X		X			X	
Millennium In Home Display	X	X	X	X	X	X	X					X	X	X			X	
EcoBee Energy Management	X	X	X	X	X	X	X					X	X	X			X	
Control4 EC100	X	X	X			X	X						X	X			X	
Legrand Celiane	X	X	X			X	X	X					X					
Iddero HC1-KNX touch panel	X	X	X	X	X	X	X	X	X		X	X	X	X				X
LemonQ Home Automation	X	X	X	X	X	X	X	X	X					X				X
Siemens Building Automation	X	X	X	X	X	X	X	X	X		X	X		X				X
Philips Dynalite		X				X			X			X		X				X
Hager Domovea Tebis	X	X	X	X	X	X	X	X	X		X				X			
Delta Dore – Talco Dombox	X	X	X	X	X	X	X	X	X	X				X				

Key:
X → base feature
X → can be reached with additional sensors or actuators ()

4. Matching Research to Needs: E3SoHo System Architecture

This section begins marks the transition from general knowledge to project specific considerations. This section will in particular be useful in the E3SoHo project to the follow on Workpackage 3 where a detailed system architecture for each pilot building will be designed and developed. Section 4 is organised into three subsections. They are:

- System Architecture Considerations and Parameters to Monitor
- Building a Supporting Architecture for these Considerations and Parameters
- The Machine to Machine Considerations to make that Architecture Possible

4.1 System Architecture Considerations and Parameters to Monitor

A table is utilized to consolidate the critical information from the previous three sections and to draw conclusions that shape the E3SoHo System Architecture

Raw Data	Implication for E3SoHo
Over 100 million social housing units in Europe	No one company can provide equipment on such a large scale in time to make progress toward 2020 energy reduction goals. **Solutions must be open source and non-provider specific**.
Ownership varies: public, private, for profit companies, non-profit organisations. The shift from public to private began largely in the 1970s and is ongoing today.	The system architecture must be flexible/adaptable. **It makes sense to provide sub/smart metering to the level of who is paying for the service**. This implies if an individual is purchasing, it is not appropriate to monitor central systems (such as central heating). In contrast, if a building owner is purchasing, it may not be appropriate to monitor beyond the unit level (e.g. inside the home).
Access varies: Who occupies and has access to social housing is vastly different. In some countries, all citizens have access. In other countries, specific groups are targeted or are eligible.	There is **no single solution** for education and awareness – or for how users interact with the system.

Payment structures vary: What tenants pay for will vary from building to building	**Site specific data is required**. The system architecture must adapt to who is paying for what at each location. It is likely that a system architecture can be developed for 4-5 groupings or common scenarios.
Building types vary: Single houses vs. apartment complexes and groupings of each co-located.	Again, the system architecture must adapt to ownership and who is purchasing the service. **Synergy is possible for co-located structures** (e.g. one weather station for multiple residences). Apartment complexes and especially groupings/clusters may have **common areas** which are typically the direct responsibility of building owners.
The majority of social housing complexes were built Post WWII as part of the reconstruction effort.	Many **structures may be energy inefficient** (building fabric and energy consuming systems). Retrofitting of such structures is a common occurrence. Developing an **ICT solution may need to be complimentary and in parallel with improvements to the building fabric and internal components**.
Several EU countries are implementing tax incentives for the implementation of energy saving measures and many countries are undergoing urban renewal campaigns or low energy housing programs.	ICT solution providers need to become aware of the **local programs and incentives**.
Occupancy statistics show a large percentage of single parent families, elderly, and poor. In addition, clusters (by religion or ethnicity) are common.	User interaction, training, and awareness campaigns **must be sensitive to the audience being addressed**.
User interest, environmental savvy, and technical savvy vary. Some studies state users have no interest or desire to save energy. E3SoHo surveys suggest otherwise, that users are interested and would like to know more about energy efficiency and energy savings measures.	The ICT solution should **engage the user**. Training and awareness campaigns should be positive and fun. The **social aspect and user behaviour aspect will be the most important variables** in saving energy in social housing. The utility of automatic controls may be limited. **Automatic controls in common areas do make sense**.

There exists approximately 35% access to the internet and 75% access to cell phones.	For the residential market it is likely that a **DASHBOARD** will be the most effective method to interact with individual users. **For building owners, a PC interface** becomes much more plausible. Most survey respondents **expressed interest in having more and better detailed information related to energy consumption** and ICT solutions to help them improve it.
How electricity, water, and gas are consumed, provided, and paid for varies across the pilot buildings and across social housing in general.	Again, ICT solutions must adapt to who is paying for what. However, an analysis and common methodology/benchmark values are also required to develop energy savings priorities. For example, **what is the value of saving one unit of electricity vs. one unit of water vs. one unit of gas.** This must be considered **also in terms of CO^2 reduction**. At the holistic level, the EU goal is to consume resources optimally. Ideally, an ICT solution would also be holistic addressing each key actor in the value chain for the specific resource in question where it is distributed and paid for.
The amount of energy savings is likely not proportional to the cost of the ICT system in the near term.	ICT solutions must seek ways to **bundle services**, seek to offer information to service providers and owners (beyond the residential level), and take advantage of the possibility to extrapolate information from a small user base to larger amounts of users after observing trends.
Users want different control options. Some want automatic control, others want the ability to pre-program set points, and others want manual control.	The **ICT solution and user interface will be best served if it has different programming options** (automatic control, pre-programming, and manual control options). Options for user interface include the PC, phone, periodic paper statements, or a dedicated dashboard.
Users define comfort differently	It is likely a mistake to define or regulate comfort. That said, it is likely very beneficial to monitor comfort. This implies **measuring temperature, light, humidity, and occupancy**. This information can be correlated to user behaviours and provide data for benchmarking.

	In this same line of reasoning it is necessary to **record external weather conditions.** This can happen from internet weather websites (low cost but lower accuracy), measurements at a complex level (one unit for multiple residences), or directly at each residence of interest.
Electricity, Gas, and Water are the main parameters of interest.	ICT solutions should **consider and prioritize the measurements of electricity, water, and gas** at the appropriate user/owner level.
The consumption of Electricity, Gas, and Water occur at different rates.	The ICT solution should consider **at what frequency and in what units each parameter should be recorded, assessed, and displayed** to the user.

4.2 Building a Supporting Architecture for these Considerations and Parameters

The following section aims to describe the envisaged architecture for the E3SoHo project. In order to support both the definitions presented in Section 1 and to support the needs of the different pilots three levels of a system architecture must be considered.

The following scheme illustrates the envisaged modules that support the hierarchical architecture:

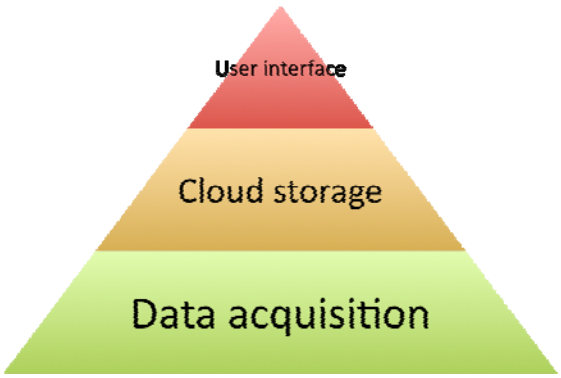


Figure 4.2 - Architectural main blocks

These three levels should address completely the following scheme depicted in Figure 4.2. Taking into account the features that we aim to implement at the project, we need to guarantee the communication between each level of the architecture and between each functionality in the block diagram.

In terms of a more detailed analysis we should describe each module and what is supported at it. The initial block, the Data Acquisition, will mainly address the sensing issues, and report the collected values and variables to a server that will fulfil the project services. Therefore we can describe the sensing block as follows, in Figure 4.4.

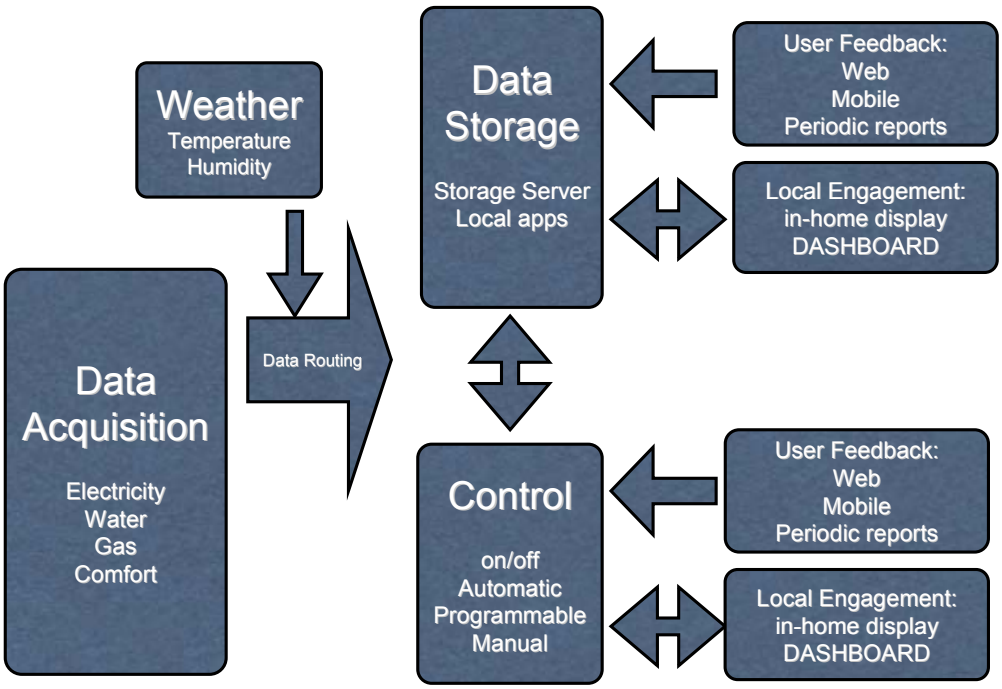


Figure 4.3 - System block diagram

At the first layer, we then have the sensing layer, where we will collect the needed data for the E3SoHo services. We should take into account the versatility of the system, and where we might not consider that all the parameters need to be collected, but in order to fully address a global approach the most typical sensing parameters are considered at the moment.

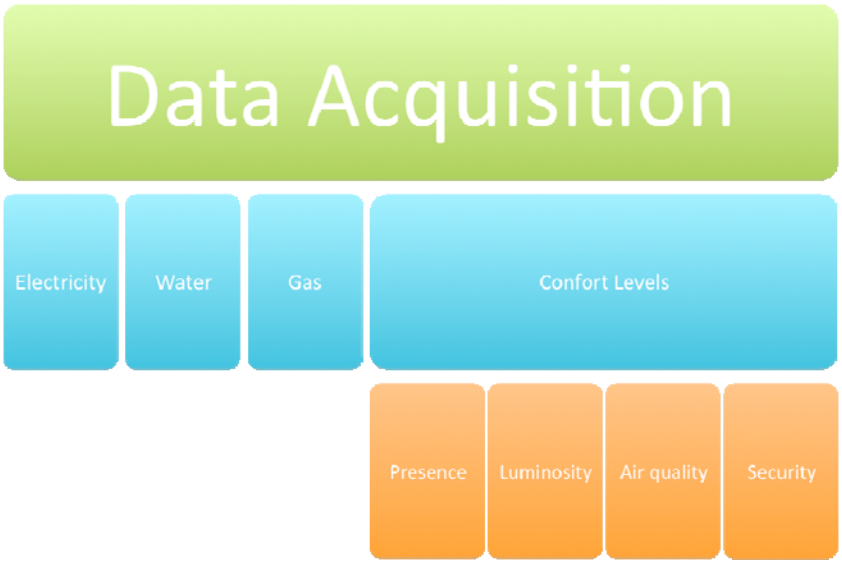


Figure 4.4 - Features from Data Acquisition module

Climbing up in the architecture, we need to forward the collected data to a storage server, and where we should be able, no only to storage the data, but also be able to operate over it. We should then describe the second level of the architecture.

The second level of the architecture is defined by two major components: the Control Module and the Data Storage Module. From the information flow point of view, only the Data Storage block will receive information from the sensing level. At the storage level, it will be then possible to establish a communication bridge with the control block. This communication layer should be bi-directional. Therefore the control module can enquire the data storage system and interact with the local applications, which can continue to run on the cloud (Figure 4.4).

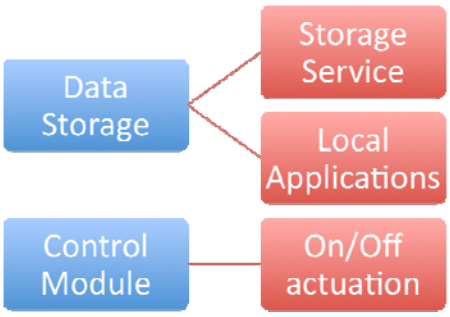


Figure 5.4 - Storage and Actuation level

At the highest level, it's necessary to provide the end user with a front-end, which, basically is the third layer of the architecture. From our point of view we should address different platforms, or different levels within the same platform, so that is possible to

distinguish between actions. The information flow, and bi-directionality needs are illustrated at Figure 4.6:

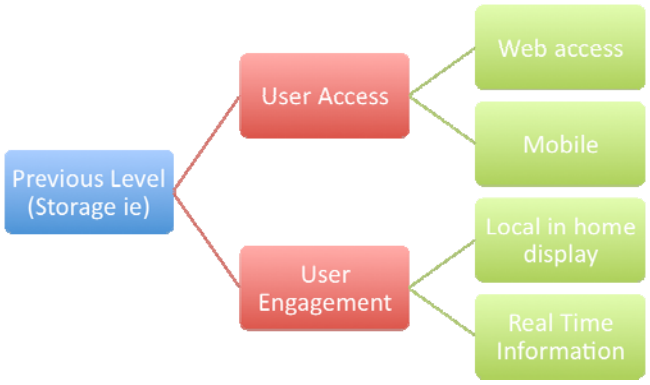


Figure 4.6 - Higher level layer, user interface

For the user level we should consider the same structure, presented above, replicated for each previous module, as in Figure 4.3. Therefore, we should describe the communication levels and flow, where within the user access the communication will flow from the user interface to the data storage. While in the user engagement level we should be able to have a bi-directional flow, so that we can guarantee the support and access to real time information displaying, for instance.

Summarizing the previous description we should take into account a few bullets:

- The previous description is a holistic platform that aims to encompass all the possibility for the project, and future works with it. This does not mean that we will considerer each on of the previous features at all the pilots;
- The system addresses the envisaged problems in different roads, where from one side we can tackle the pilot focused on the user, or for instance, focused at the energy manager personality. These options will generate different outputs in terms of information, reports and interfaces.

4.3 The Machine to Machine Considerations to make the System Architecture Possible

The following table lists some general M2M considerations for the proposed system architecture shown in Figure 4.2.

Standardize on data formats	The data formats for exchanging and storing the acquired data should be standardized to as high a degree as possible.

Decouple applications and services from data acquisition and storage	To a high degree, both data acquisition and the storage of the acquired data should be decoupled from the use of data, in other words the services and applications in the system architecture. Ideally, services and applications should not need to know what specific kind of device provided the data, supporting replacing devices with other types without needing to change the applications/services.
Fast and reliable data exchange and storage	The system architecture should provide the devices that acquire data with a fast and reliable way to store the data and relay them to subscribing applications/services. When data is submitted into the system from a device, the system should ensure that these data is kept at least until subscribing applications/services has got informed.

5. E3SoHo ICT Available Solutions

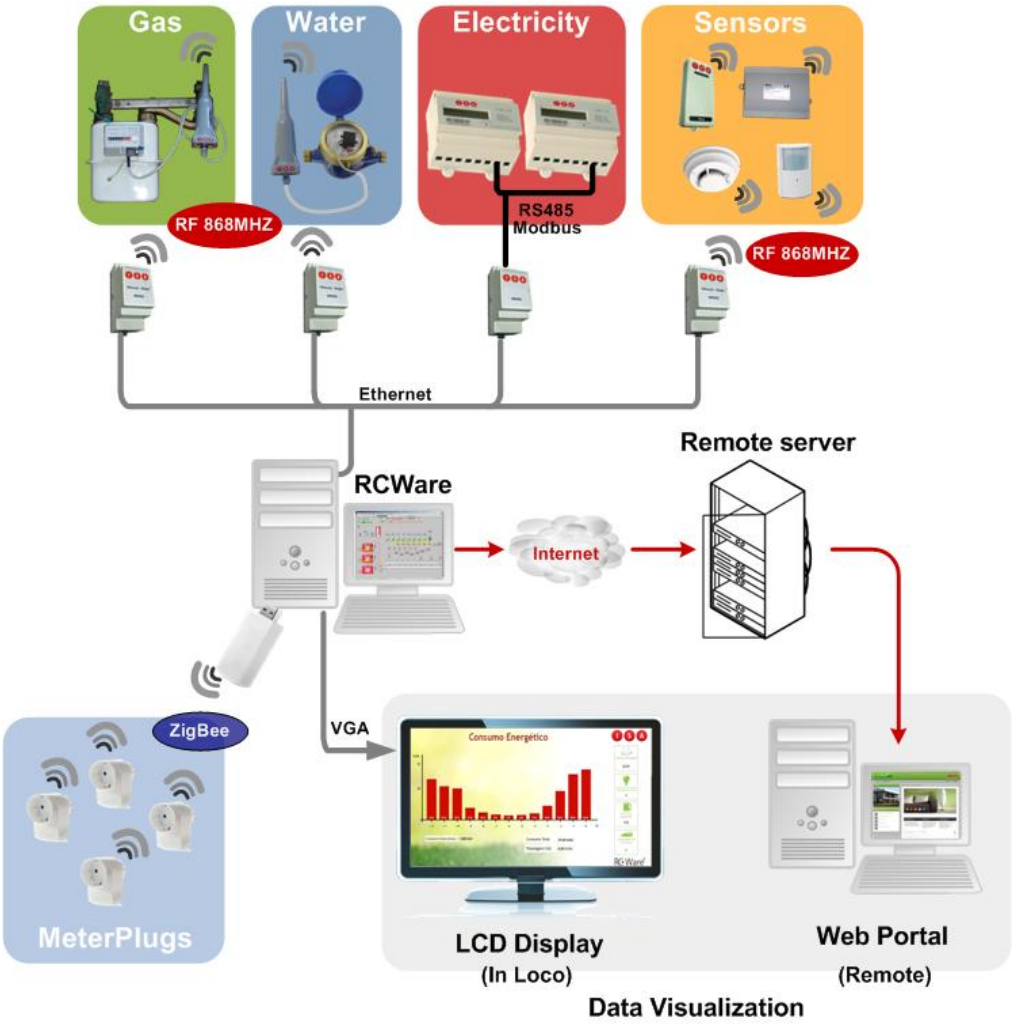
The intent of Section 5 is to list the ICT solutions available from the consortium partners. Although the project is not bound to these solutions, within the project they are provided at cost and these partners in specific were brought into the consortium for their excellence and technical solutions.

5.1 Intelligent Sensing Anywhere (ISA)

ISA provides an array of solutions dedicated to energy efficiency and multi-utility remote-metering. It comprises sensors, meters and all sorts of flagship devices that establish a monitoring network capable of remotely sensing parameters such as water, gas and electricity consumptions, air quality, presence, among other functionalities.

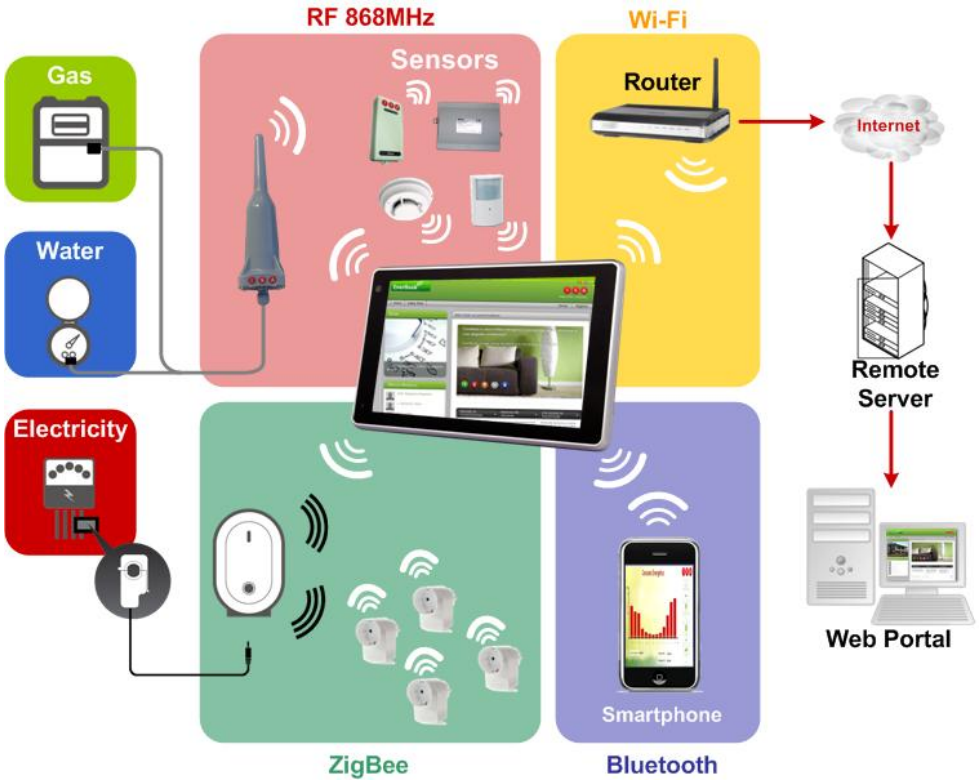
5.1.1 ISA's Energy Efficiency Range of Products

ISA has developed an entire line of products dedicated to the energy efficiency within a variety of services and residential buildings. The following diagram presents ISA's global solution for energy efficiency within services buildings (the collected information is more valuable to the Energy Manager, thus is not only applicable to service buildings), the *iMeter Industrial* solution.



The *iMeter Industrial* offers alternatives for energy management in buildings, such as industries, schools or even hospitals, whose manager will be able to access data regarding all consumptions in an easy way, through a computer or a dedicated LCD Display to involve all the building users, hence promoting economizing behaviors in common places. ISA's solution focus on the gathering of information on electrical, gas and water consumption in order to provide the tools for an intelligent management of those consumptions. This scope is reached primarily by the elimination of unnecessary consumption such as lighting or air conditioning in empty rooms or standby consumptions, the centralized control of temperature and lighting, the automatic scheduling of washing machines to lower cost periods during the day, for instance. Furthermore, the continuous monitoring of those variables may enable the detection of abnormal situations like the detection of leaks, which would immediately trigger an alarm and alert the energy manager, or system responsible to the abnormal consumption value. Besides those features, ISA's solutions can cross the energy monitoring with a wide range of ambiance parameters that, when combined with consumption information, enables the optimization of the comfort level within the installation. The information is then made available to the user that can remotely control appliances, configure default conditions and above all, be aware of its own consumptions, without reducing their comfort levels.

The global solution for in-home energy efficiency is somewhat similar to the one for services buildings. The main difference consists in a more direct presentation of data to the householder through a handheld display. The main objective of the solution is to give to the user the control of it's energy, bringing the control to its hands. The diagram of the *iMeter* solution is shown below.



The residential sector accounted for almost 26% of the energy consumption in the EU-27, by the final of 2006 [16]. The *iMeter* solution was created according the underlying premise that "It is not possible to reduce what you cannot measure". In fact, recent deployment of smart metering systems has demonstrated that appliance control and real time consumption feedback are mandatory to achieve the desired consumption reduction. Householders must be aware of their own energy consumption and how much they can reduce their bills.

Both *iMeter* and *iMeter Industrial* solutions thus make it possible to provide the consumer with real time information on the consumption of gas, electricity and water, in the comfort of their own home. This way, those solutions may optimize consumption strategies and as a result of these, minimize expenses and the ecological footprint, and still add to the safety and comfort levels. The information is collected by the diverse sensors (of presence, movement, temperature, humidity, etc.) installed throughout the building, forming a monitoring network that enables the user to control consumptions in each room, at each Plug socket or per consumption sector and simultaneously act upon the various appliances. The information is collected and stored in a central unit and finally made available to families or building managers through internet portals, informative displays, PDAs or mobile phones.

The set of devices that integrates those two solutions are described below.

Mono-phase and three-phase **Din rail meter**: resilient meter that provides information on the power status and the real-time electrical consumption readings of each phase (when applicable) independently through a local LCD display. Data are outputted through a RS485 port.

Bridge Ethernet - RS485: when connected to any RS485 enabled device, it forwards data through Ethernet to any node of the network.

RTU Meter: prepared to read gas and water meters through their pulse output or any other device with digital output. This device communicates the information through RF 868MHz using ISA's proprietary protocol.

iMeterClamp: high quality meter with a compact design and an easy installation process able to measure the consumption in a circuit. It is used to monitor electricity consumption either in monophasic and triphasic installations. Communication is performed by the transmitter through *ZigBee*.

PlugMeter: electrical socket that monitors energy consumption in each plug individually, increasing awareness of energy waste in a low-cost manner and without any permanent installation. Plugged-in equipment can be switched on and off automatically through commands sent from a PC, PDA or cell-phone in order to reduce expenses and optimize efficiency. Communication is made through ZigBee.

***ZigBee* stick**: enables any non-*ZigBee* endowed device to be part of the network of *PlugMeters*.

In-Home Display: gives the user real time and historical data about energy consumption values. The device communicates through RF868MHz with sensors, RTU Meters or any other 868MHz RF endowed device. It also is *Bluetooth* (e.g.: for communication with smartphones), *ZigBee* (bidirectional communication with the PlugMeters network) and Wi-Fi (for data sending to a remote server) endowed. The user benefits from direct information about savings and CO_2 emissions. The display also enables the configuration of new sensing devices and actuators as also as the access to a variety of useful applications (e.g.: weather forecast).

Enerbook: A new portal developed by ISA where consumers can access their electricity, gas and water consumption information. The portal also provides information about the users' carbon footprint, feedback about whether they are reducing their consumption or not, as well as a it prodvides a set of advices in order to reduce their energy consumption and consequently, save money. Enerbook creates a social network around energy efficiency, a typical user driven innovative service, that can easily create focus groups for Social Housing, where people can benchmark behaviours, consunptions among other things, since the social network will allow the user to recreat the network depending on its will.

5.1.2 Projects

5.1.2.1 Multy-Utility Quinta da Portela

A pilot project with 2000 homes in Coimbra, Portugal, clearly demonstrates that it is

possible to install, in a cost effective way, a multi-utility remote metering system that addresses in a scalable way the main concerns of the utility companies (network management, control of the supply, safety, invoicing and payment, losses reduction, etc.) and of the consumers (real time information on consumption, automation of saving procedures, safety alarms, etc.).

This pilot project, installed in *Quinta da Portela,* was promoted by the company *Águas de Coimbra*, with the support of Coimbra's City Hall, and with the cooperation of *EDP* and *Lusitâniagas*, main electric and natural gas utilities in Portugal. The most important and distinguishing feature of this project is that it provides the utilities with independent and transparent access to the meters while sharing the same data logging and communication infrastructure that is used to provide each consumer with real time and historical information about their energy profile.

5.1.2.2 EcoHome and EcoFamilies

EcoHome and *EcoFamilies* are *Quercus'* projects which intend to promote the reduction of energy consumption in households. An efficient energy management system involves not only the use of innovative technology and alternative energy, but also significant changes in individual behaviours. ISA's *iMeter* solution has then been selected as the ideal solution as it allows the monitoring of energy consumption, providing the information obtained through the Internet. After identifying less rational utilizations, the resident may opt whether to configure small automations, such as the automatic heating/lighting control and standby consumptions elimination, or to modify behaviours bringing the residence closer to the concept of a true *EcoHome*.

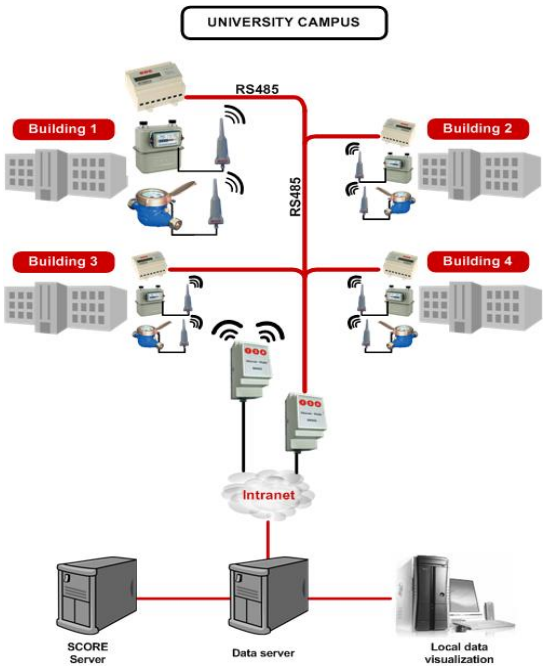
Currently, in households where the *iMeter* was installed, families access information on their energy consumption via the Internet. In some cases, the existence of simply monitoring the energy consumption data was enough to promote a decrease in consumption. The next step is to provide advice services for which *Quercus* will work in partnership with ISA, which will analyse gathered data in order to present effective suggestions for a reduction of the client's expenses.

5.1.2.3 EnerEscolas

The goal of this Project is to develop an energy efficiency platform especially designed for schools. Schools host, as a whole, a substantial fraction of the population for an extended period of the day. They are, therefore, responsible for an important component of the consumed energy. On the other hand, schools are the ultimate educational environment. Thus, an energy efficiency solution especially tailored for schools should not only strive to reduce consumptions but also to have a learning component that raises the students' awareness of energy efficiency issues, introducing their multidisciplinary components in the context of their school curricula. Thus, physics may use the topic of energy efficiency to introduce the concept of energy, chemistry may tackle the problems associated with the liberation of CO2 in the burning of fossil fuels, natural sciences may focus on alternative forms of energy generation, mathematics may use monitoring data to perform statistical analysis of trends and distributions, and geography may use meteorological data to study the effects of climate on energy consumption.

All the above components may also be the focus of an integrated approach in the Project Area class, where students would have the opportunity of tackling a subject where they would be able to integrate the knowledge they have acquired in a number of different classes.

ISA has developed EnerEscolas to face several challenges: promote efficiency, reduce real costs, provide information on consumption, the ecological footprint and an energy profile, add hands on and entertaining element to the students' curriculum. The information collected by the system is available to the school managers through an easy-to-use management platform.



5.1.2.4 University of Aveiro

This project aims the monitoring of energy consumptions, quality and allocation of costs in the buildings of university of Aveiro. It involves monitorization of:

22 buildings

130 electricity measure points

60 gas measure points

100 water measure points

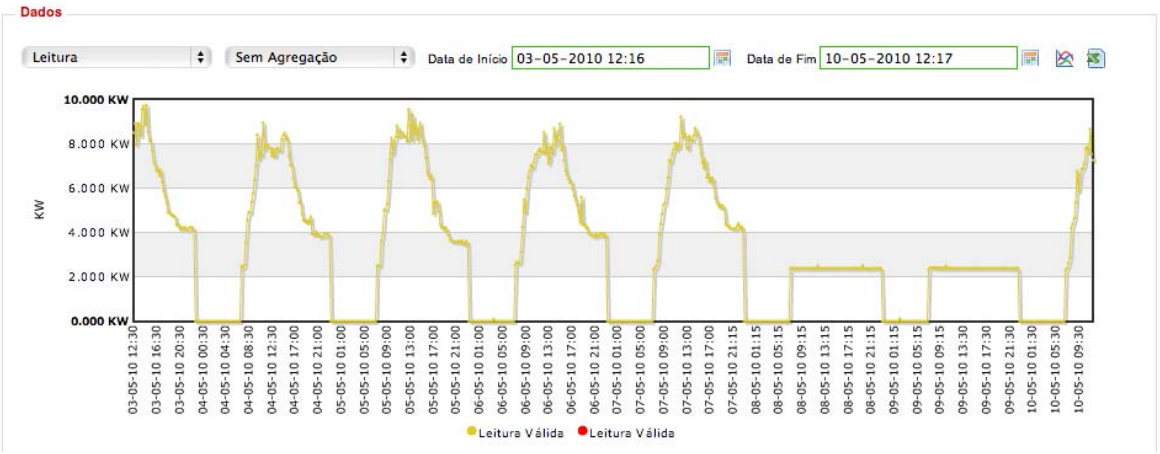
The implemented system consists of collecting all data relating to energy consumption in real time, gather data to help in allocation costs, elimination of standby consumption, adjustment needs and monitoring the quality of the energy.

5.1.2.5 Lisbon's Municipality main office building – PSP CIP ICT4SAVEENERGY

Lisbon Town hall in Campo Grande

SAVE ENERGY is a European project reference where the challenge is in promoting the behavioral changes of people through the concept ICT (Information and Communication Technologies) in order to increase energy efficiency in public buildings in five European cities - Helsinki, Leiden, Lisbon, Manchester and Lulea.

The installation of the pilot of Lisbon, allowed the analyses of the energy performance in the office building of the town hall located in Campo Grande. By the observation of results induced behavioral change of its users that have led to energy savings of around 13% in the first few weeks of use.



Analysis of consumption of building in Lisbon between 03/05/2010 and 10/05/2010.

5.1.3 ISA Technologies in the context of the e3SoHo Project

In E3SoHo context, ISA appear has a ICT provider, making possible a holistic approach. The solution guarantees us that we will be able to provide the complete building consumptions, ie: all the dwellings, common spaces, building lightning, and common building infrastructure.

The presented solution offers a bi-directional communication, between the utility and the user. It is possible to communicate the consumption data to service providers, such as water, gas or electricity companies, but not forgetting the user. If we want to reduce the building consumption is also necessary to involve the users. Thus the following ICT

contains a user layer, which will provide the user with the necessary information about energy consumptions and behaviours.

The reduction potential increases when the deployed solution involves the user. The iMeter is design so that, it is possible to know anytime how much you're consuming. One of the main drivers in the context of the E3SoHo is the social innovation of focusing on the committed user that will use the information not only to reduce it's consumption but can commit with the neighbourhood to reduce the whole building consumption, being stimulated to obtain reduction. Not only it will reduce the monthly bill but also it can improve the building energy performance.

5.2 Nobatek

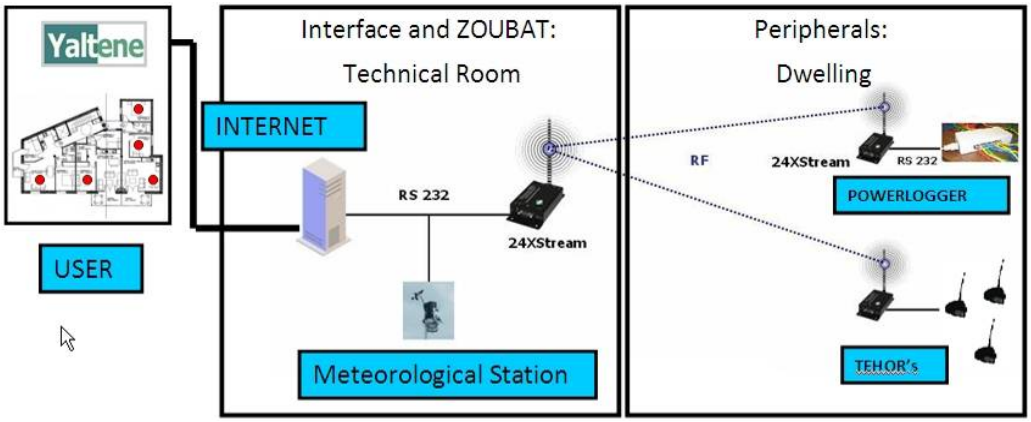
Nobatek is a research center specialized in sustainable construction and energy efficiency. As a support to low energy buildings design studies and R&D activities on buildings real performance Nobatek has developed a range of tools allowing full monitoring of energy/comfort related parameters.

5.2.1 Nobatek Technologies

Nobatek has constructed and employs a monitoring platform called **SMBE**. It is a hybrid wireless-wired solution that consists of:

- Sensors measuring comfort parameters and occupation: Tehor sensor
- Metering systems to measure detailed energy consumption: Powerlogger
- A Weather station
- A data integration and treatment system: Zoubat
- An interface for specific uses: Yaltene

The general SMBE system architecture is shown in the following figure.



The SMBE solution is dedicated to experts in energy efficiency in buildings and aims at understanding buildings, systems and users behaviors. It allows realizing a full and long term diagnostic of energy efficiency and comfort related parameters in buildings by measuring their performance. It can be used either:

- in new low energy buildings in order to validate the design and implementation process of high performance buildings
- in old buildings in order to define the most efficient leverages to implement for improving energy efficiency
- for specific systems/projects in order to understand their impact on energy efficiency: ventilation, heating, storage systems, particular wall conception, particular user awareness, etc.

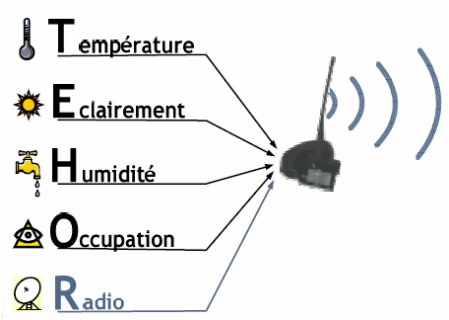
The main data to be delivered and analyzed are:

- External conditions: T°, humidity, wind
- Internal comfort parameters: T°, humidity, light, occupancy
- Energy consumption (separately): for heating, for ventilation, for lightings, for other specific uses

Other specific data can be measured for specific systems and specific conditions (energy storage, energy production, inner wall behavior, etc.).

Detailed specifications

TEHOR sensors: measuring comfort and use parameters



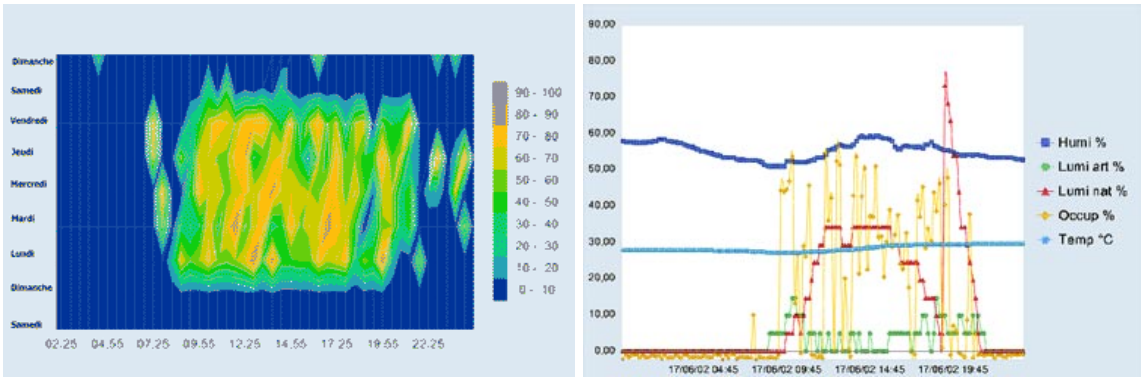
Tehor is wireless macro-sensor measuring ambiance parameters in a room: temperature, lighting (natural and artificial), humidity, and occupation.

It allows easy and fast real-time measurement of most important parameters to assess internal comfort. With 3 years autonomy it can be used either in new or old buildings. It is independent from the electrical red of the dwelling and data acquisition is realised through radio signal. Hence it is a totally independent system, allowing not disturbing either the physical system of the dwelling and the users.

Data treatment is realised by the Yaltene software. It is based on "Hot plug and play" technology and allows immediate acquisition/treatment. Automatic treatments are proposed: data history, medium temperature, lighting running time, etc. It is compatible with most actual ITC standards.

Technical Specifications:

- Temperature: from -10°C to 50°C, ± 0,3°C
- Humidity: from 0 to 100%, ± 3%
- Lighting: from 0 to 4000 lux, ± 5 lux
- Radio signal range: 40m
- Data acquisition frequency: 5 s mini
- Autonomy with batteries: 3 years
- Graphic interface for exploitation: application or internet
- Real time monitoring
- Data history analysis
- Coordinated sensors red management
- Interoperability: ODBC, OPC, Web service
- Dimensions: (mm) : H 270 x 70 x 110
- Weight (with batteries) : 161 g



Examples of application: *comfort parameter measurements in one room (left) and weekly mapping of the occupation of a room (right)*

Power Logger: measuring energy consumption

Power logger is a 16 channels data recorder for electric consumption measurement. Each channel can get data from external sensor of from each channel of the dwelling electrical box. It allows then to follow energy consumption separately for each type of applications inside the dwelling.

Power Logger has internal memory able to record 110376 data, equivalent of 1 month autonomy with 16 active channels and 1 minute acquisition step. Each channel can support tension up to 16 A, and two channel can be set up to receive tensions up to 80 A.

Main technical characteristics:

- Dimensions (mm): H 50 x 230 x 110
- Weight: 494 g
- Connexion: RS232
- Power: 12V

Powerlogger hardware

Meteorological Station

A DAVIS meteorological station has been selected for its price, reliability, and ease of integration. This system measures:

- Environment and Floor Temperature
- Relative Humidity
- Direction and Wind Speed
- Radiation
- Precipitation

System Interfacing

Sensor information, database management, routing through a web server to a client userface is conducted using ZOUBAT and YALTINE.

- ZOUBAT: it is a system that runs on the server; it manages two Relational Database Management Systems. ZOUBAT does the data consolidation, in accordance to installation conditioned parameters and data exploitation.
- YALTENE: it is a web service of which data tier is ZOUBAT. YALTENE can be described following a Multi-tier Application Architecture model, so that YALTENE groups both the server or middle tier and the client tier, in order to present real time data or its history to users on a friendly user graphic interface.

5.2.2 Nobatek Technologies in the context of the e3SoHo Project

Nobatek technologies will be used in the context of the E3Soho project as a tool for the impact assessment of the technologies to be implemented in each pilot building. This wireless (for the end users) solution is adapted to short-medium term monitoring of building performance and user behaviour regarding comfort, occupancy and energy consumption.

It can be quickly implemented into the dwellings and removed after the monitoring period, and it does not require direct interventions for data acquisition/transfer. No interface is proposed to the final user (inhabitant) so that the system is transparent to its daily life and the user should not modify its habits.

Feedbacks on comfort parameters, energy consumption and the whole dwelling/building performance in its climatic context can be delivered to the user via specific reports. But the ideal target for such information is the building owner or facility manager who will be able to interpret detailed analysis including:

- climatic conditions
- building composition and architecture
- performance of HVAC systems
- user occupancy and behaviour
- comfort quality

5.3 TELENOR

Telenor is Norway's leading supplier of telecommunications- and data services, distributed over both fixed and mobile network infrastructure. The Telenor Group is now the 7th largest provider of mobile communications – represented in fourteen countries across the world. As part of the Telenor Group, Telenor Objects delivers a managed service for connected objects. The aim is to increase the number of devices connected to the network infrastructure so that the customers can benefit from real time information on their assets.

Telenor has over the past three years been running several successful pilots with Norwegian corporate customers, connecting their RFID-readers and sensors to our platform. Information from these devices have been processed and forwarded to third party applications.

5.3.1 Shepherd® - Managed services for M2M Solutions

Telenor Objects has launched the Shepherd platform for M2M Services to facilitate quick and easy development of innovative applications connected to a range of M2M enabled objects. Shepherd enables any device to communicate with any application. Infrastructure monitoring and an extensive library of supported devices and service enablers allow fast, cost effective and simple deployment and operation of new M2M services.

The Shepherdplatform allows continuous device monitoring from Telenor Objects' centrally located operations center. Telenor Objects operates a stable platform and supplies secure and reliable exchange of messages between M2M devices and applications in a highly scalable environment. The platform is an open and future proof architecture, which allows customers to freely choose the most suitable combination ofdevices and applications. Shepherd is designed to telecom principles of scalability, reliability and security.

Figure 7 Shepherd Platform Overview

This new infrastructure provide functions common to many applications, thereby reducing complexity, development effort and maintenance costs for these applications. There will also be significant operating cost savings, because the costs for such a managed service infrastructure will be shared across many independent applications.

However, the largest innovation potential lies in allowing sensor information to be shared in a safe manner across any application and allowing any device to connect to any application - which means that new applications can be created on the basis of installed devices, and new devices can easily be connected to existing applications.The value of such object networks increase exponentially with the number of nodes.

Shepherd services make it quick and easy to capture, deliver and process data, control and monitor devices, and exchange information:

- Managed service (solution monitoring, device configuration, SLAs, support)
- Data capture, handling and storage
- Managed connectivity
- Service enablers accessible through open application programming interfaces (APIs)
- Message engine which securely captures, processes, routes and stores messages
- Notification services to inform about device and application status
- Device library, interfacing tools and services
- Flexible commercial terms ensure a cost effective service for small and large systems.

5.3.1.1 Open and Future Proof

The Shepherd architecture design philosophy is openness: we deliver an open system to connect any device(s) to any application(s) (and vice versa and none-exclusively). The Telenor Object vision is that of a "horizontal" service architecture shielding the complexities of the devices from the applications, and the other way around.

In order to encourage experimentation, testing and further development, a basic version of the platform is available as open source.

5.3.1.2 Freedom to choose

Open APIs and device interfacing tools create separation and independence between applications and devices. Such independence means that the service provider can at any time choose the best supplier of each solution element and thus achieve freedom of choice, efficient competitive tendering and risk reduction.

5.3.1.3 Scalable, reliable and secure

Shepherd is designed on the core principles of carrier grade telecom services: scalability, reliability and security. Reliability is provided through redundancy and monitoring of the infrastructure. Data generated by the devices is securely stored in redundant databases

behind firewalls until the applications require them. Communication between devices and application uses SSL encryption and public keys of trusted certificate publishers. Encryption, authentication and authorization are used to ensure that information stored is reliable and not compromised.

5.3.1.4 Message engine

At the core of Shepherd is the Message Engine, which handles the two-way information flow between devices and applications including capturing, routing, security, queuing and storage. It also handles information exchange allowing authorized third parties to access data generated by device.

5.3.1.5 Device interfacing

A core functionality of Shepherd is to allow applications to communicate with, monitor andcontrol devices. The Shepherd Device Library includes a range of devices which has already been integrated with the platform: GPS, RFID readers, temperature sensors, industrial scale, gateway. This library is continuously being added to by us and our partners.

Devices that are not yet in the library can be integrated using the Shepherd Plug-in Framework – an easy-to-use device integration toolkit allowing anyone to develop device drivers. Using this framework ensures best monitoring and configuration of the device. Furthermore, a tool to deploy businesslogic locally (ActorFrame) on the devices is also available. A certification process will ensure interoperability with Shepherd and allow developers to signal this to their customers.

5.3.1.6 Service monitoring

The infrastructure and devices are monitored at all times. Errors (e.g. devices which are not reachable or those that report a problem) and faults are detected and the owners are notified.

5.3.1.7 Service level agreements

Service level agreements cover our managed platform from the APIs, across the infrastructure and to the interfaces with the devices. This includes service availability, alerts and notification, quality of service, incident response time, and disaster recovery.

5.3.1.8 Notification services

The Notification services are a set of messaging services available for the application partners. Notification can be generated by devices and applications. The service is intended for event handling.

5.3.1.9 Customer Service

Telenor Objects offers a single point of contact to handle faults and queries for our services and services sold through us. Customer services are provided in English and Norwegian be contacted via phone and email.

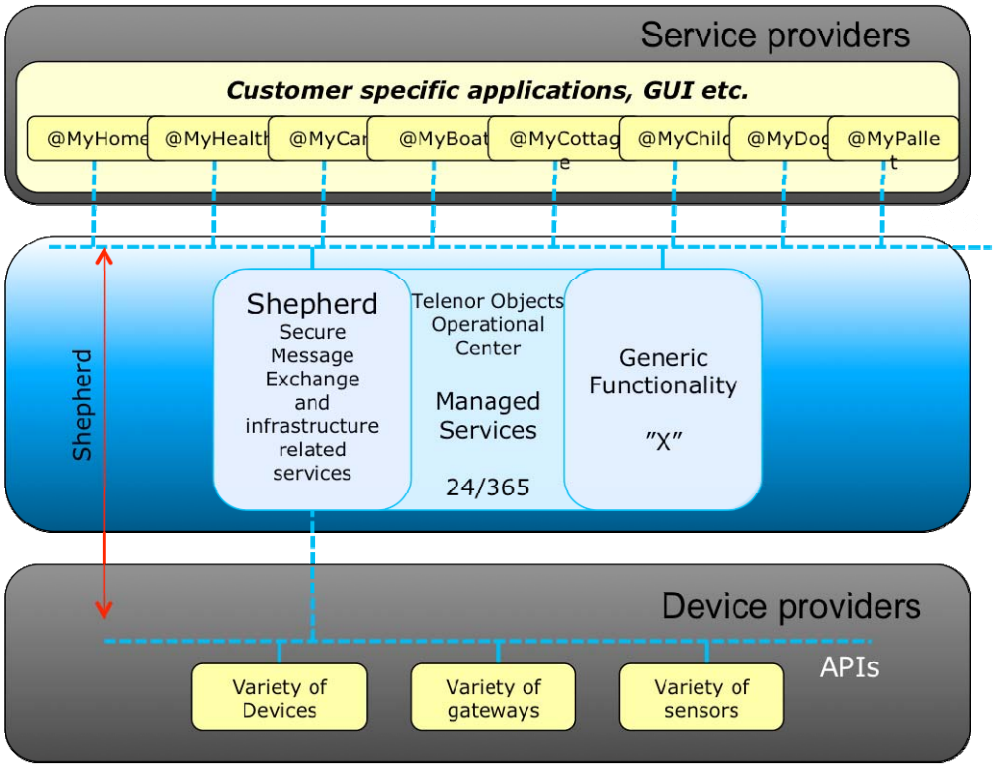


Figure 8. How applications and devices can utilize Shepherd

5.3.2 Shepherd Enablers APIs

5.3.2.1 Generic Data Enabler API

The Generic Data enabler is used for communication to/from all kinds of devices. This allows the application to exchange raw data to and from devices. Raw data can be configuration parameters sent to the device or data generated from the device such as sensor values, notifications or other messages from the device.

This API provides the following functionality:

- Send data to device
- Get data from device
- Subscribe to data from device

5.3.2.2 RFID Enabler API

The RFID enabler is used for communication to/from RFID readers. It allows the application to continuously receive RFID events from RFID readers or to request

information from RFID readers when needed. The application can send predefined standard RFID commands to the reader and a general "Send Command to …" opens for more device custom command to be sent to the RFID reader.

The API supports the following commands:

- Get/Send messages
- Subscribe to data from device
- "Set read mode", "list devices", "Send Command to…"

5.3.2.3 Location service API

The Location service is used to reports device locations. It supports GSM location for devices with a Telenor SIM cards located in Norway and GPS locations for devices reporting their GPS position. This means that it is possible to get an approximate location even for devices without built-in GPS, as long as they have a SIM card, and for GPS devices temporarily not able to receive GPS signals.

The API supports the following functionality:

- Get location for single or multiple device IDs or GSM numbers
- Subscribe to locations at specified intervals.

The location information contains latitude, longitude, timestamp, altitude, accuracy and GSM/GPS location information.

5.3.2.4 SMS Enabler API

The SMS enabler is used for sending and receiving SMS, and notifies subscribers with actual SMS. Applications can subscribe to SMS messages from a MSISDN number. Incoming SMS messages will then be sent out to all the applications that have a valid subscription. It is also possible to subscribe to messages based on keyword inside the SMS message itself.

Examples:

- Send SMS from application: An application can send an SMS message to a device or terminal utilizing the SMS Enabler.
- Send SMS from a device: A device that is used for SMS for reporting of data can do this through the SMS Enabler. The device can for example put location data in the SMS message. The SMS can be sent to other enablers on request.
- Subscribe to SMS messages: An application that is interested in receiving messages from a terminal with a specific MSISDN number can establish a subscription with the SMS Enabler. When a SMS is sent from the device to the Telenor Objects SMS Gateway number, the message will be forwarded to the application.

5.3.2.5 How to connect an application to one or several Shepherd APIs

Applications that connect to Shepherd are identified by Application IDs issued by Telenor Objects. These IDs are acquired by sending a request for Application IDs to Telenor Objects. The application IDs are stored in a database together with all Device IDs. The Telenor Objects access control system secures valid access between applications, devices and services.

5.3.3 Shepherd Plug-in Framework

The Shepherd Plug-in Framework is a collection of functionality that offers an easy way of connecting to the Shepherd Platform. The Shepherd Plug-in Framework is applicable both for device integration and application development, and is currently implemented in Java. It includes a Software Development Kit (SDK) which provides template code that serves as a starting point for connecting the device to the Shepherd messaging bus, making it quick and easy to connect a new device to the platform and leaving the device/application developers to focus on the device/application logic. Using this framework rather than HTTP allows two-way communication easily and ensures best monitoring and configuration of the device. It also saves the programmers hassles around maintaining and monitoring connectivity to the devices. Furthermore, a tool to deploy business logic locally (ActorFrame) on the devices is also available.

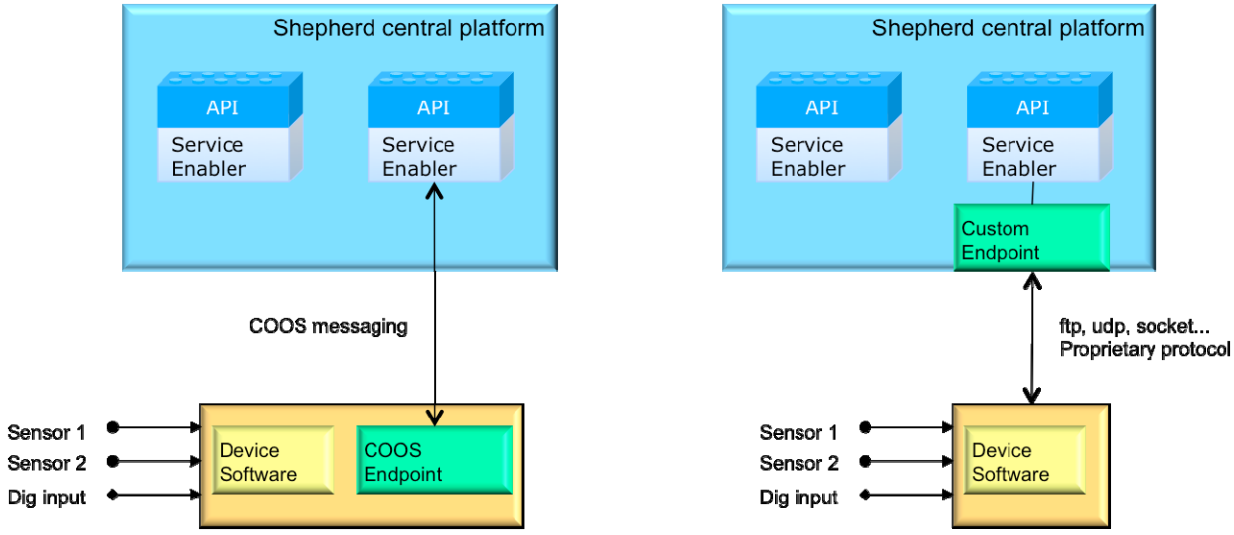


Figure 9. Two approaches to using the Shepherd Plugin Framework for device integration

5.3.4 Open Source Community

Telenor Objects do not only see open source as an excellent way to develop new services faster and to a lower cost, but believes that open source can contribute to the standardization of M2M communication. This is why we support the development of Connected Objects Operating System (COOS) at coosproject.org.

The Connected Objects Operating System (COOS) is a general purpose, modular, pluggable and distributable, open source middleware platform written in Java. It is designed for connecting both service- and device objects that communicate via messages. One may find lots of ways to use the COOS software for connecting M2M devices to standalone applications. Telenor Objects has also made interfaces so that devices running COOS may easily communicate directly to our managed services platform, Shepherd. Thus providing the ability to monitor and manage M2M devices with minimal need for integration.

Within this context, the core functionality of the Telenor Objects Shepherd platform is exchanging messages between devices (objects) and applications. Data provided by devices are put into Shepherd by sending them as messages to the platform, either by using the COOS messaging bus or by HTTP GET or POST requests.

Messages sent into Shepherd are securely stored and can be forwarded to subscribing applications, and messages can also be retrieved later through APIs. Hence, Shepherd can in a system solution act both as the communication exchange and as the data storage.

General requirements for integrating a system solution with the Shepherd platform would be as follows:

Requirement id	Description
D1	Devices in the system solution will need Shepherd object ids.
D2	Devices (or software agents reporting data on behalf of devices) must either be capable of issuing HTTP POST/GET requests or support COOS messaging (for instance using the Shepherd Plugin Framework).
D3	Shepherd has a limit on the size of a message from devices, which is 8 kilobytes. Data larger than 8 kilobytes must be spilt into chunks and delivered using several messages.
A1	Applications that are to access data from devices will need a Shepherd application id.
A2	Applications must either be capable of issuing HTTP POST/GET requests or support COOS messaging (for instance using the Shepherd Plugin Framework).
A3	Applications must understand the data structures provided by the devices they are to access. Except for data offered through specific service enabler APIs, Shepherd is in principle content-agnostic, meaning that the data delivered from devices are just bytes without any content metadata.

5.3.5 Telenor Objects technologies in the context of the e3SoHo Project

Telenor Objects was brought into the e3SoHo projects for their managed service platform, Shepherd, which is technology and device independent and easily adapted to new application areas. The Shepherd platform can be utilized for the integration of the specific application and device solutions offered by ISA and Nobatek into the applications and/or services that will be the e3SoHO solutions.

Designed on the core principles of carrier grade telecom services, the Shepherd platform offers a scalable, reliable and secure environment for hosting e3SoHo services and data.

5.4 Power Electronics to Control Renewable Energy Sources Integrated in Buildings (Solar)

Power electronic converters can be found wherever there is a need to modify a form of electrical energy (i.e change its voltage, current or frequency) [201]. Various converter topologies (power electronics) are used for a solar systems. The price of the power electronics system can be comparable to the price of solar panels so care must be taken in evaluating and selecting this particular hardware. In selecting a converter, two important tasks have to be considered:

- The solar module should operate at the maximum power point
- A sinusoidal current should be injected into the grid.

Converters can be categorized into four group according to:

- number of power processing stages in cascade
- type of power decoupling between the solar module and the grid
- consist or not a transformer (line transformer or high frequency transformer)
- type of grid connected power stage

The converter systems currently used for solar panels are based on IGBT or MOSFET power electronics technology. Since the power electronics converter is connected to the grid, the standards given by the utility companies must be obeyed. In particular, the future international standard EN61000-3-2, and IEEE1547 are worth considering. These standards deal with issues such as power quality, grid connected or islanding operation, grounding, etc.

A large number of vendors were identified as offering products suitable for the residential market as home solar systems are fairly mature. A list of 54 vendors is provided below:

1. Aixcon Elektrotechnik GmbH
2. Alpha Energy
3. Atersa
4. Beacon
5. Conergy
6. Delta Energy
7. Diehl
8. Dorfmüller Solaranlagen GmbH
9. EAI
10. Elettronica Santerno
11. Exendis
12. Fronius
13. G&H Elektronik GmbH
14. Hardmeier
15. Ingeteam

16. KACO new energy GmbH
17. Kostal
18. Kyocera
19. Latronic
20. Leonics
21. Magnetek
22. Mastervolt
23. Mitsubishi
24. Motech
25. NKF Electronics
26. Oelmaier
27. Omron
28. Outback Power Systems
29. Pairan
30. Philips
31. Phoenixtec
32. Power Solutions
33. PV Powered
34. Sanyo
35. Sharp
36. Siel
37. Siemens
38. SMA
39. Solar Fabrik
40. Solar Konzept
41. SolarStocc
42. Solectria
43. Solon
44. Solutronic
45. Solwex
46. Steca
47. Sun Power Solartechnik GmbH
48. Sunset
49. Suntechnics
50. Sunways
51. Trace
52. Victron
53. Wurth Solergy
54. Xantrex

More information about vendors and their products are available on the internet

6. Identified Technologies: Selection and Justification

6.1 Assembling the skills of the consortium partners and components that must be outsourced

6.1.1 Technological Partners skills

6.1.1.1 Intelligent Sensing Anywhere (ISA)

The market survey detailed on the Deliverable 2.3, created a clear scope of integrated solutions for integrated building monitoring. Under the E3SoHo umbrella we intend to get a clear picture of the energy profile of each monitored pilot.

In order to comprise all the sources of energy consumption an integrated approach is favoured. Due to its competences in automated metering, ISA, in the last 20 years has established itself as one of the market references in multi utility metering. While many of the experiments try to put the focus on the electricity consumption, we intend to generate a broader framework, including in the measurements, water and gas consumptions.

Energy efficiency in social housing gives us enough leeway to develop a project focused either on the end user, or in the technical user of the building. Thus ISA can provide us with a range of options where we can aim to induce experiments at different levels, either on BMS systems, or in in-home energy monitoring systems. Thus we can expect a competitive project that will encompass user behavioural change, and also include energy management optimization from the technical services of the building.

ISA is able to provide a series of equipment, products and services at these two levels, since it's a B2B traditional company, and in the last two years is earning competences at the B2C market. The envisaged equipment ranges from electricity meters, to water and gas pulse meters, which the signals will be collected and properly stored at a database, from where the data can be analysed and conclusions are easily extracted.

Apart from the equipment extended knowledge, on of the main reasons that justifies the choice of on the consortium partners is definitely the multi-utility capability demonstrated by ISA, which has been refined over the last decade, and where a wide knowledge extent as been obtained due to some large scale pilots, such as universities or even beta testing pilots with end users. The experience either on the equipment either on the business, determines our partner, ISA as the best choice for the pilot implementation at the E3SoHo project.

6.1.1.2 Nobatek

Nobatek works on sustainability in construction and have an experienced group of engineers focusing on low energy buildings design and energy efficiency in existing buildings. Several technologies are used for such activity from the design phase to the

construction process and building exploitation. For this last one, Nobatek analyses buildings performance whether for new buildings, to understand how low energy buildings behave in reality, as well as existing buildings in order to define cost-effective solutions for improving their comfort and energy performance.

These analysis are realised either via energy audits for gross analysis or via monitoring tools when much details and a real understanding of the building are needed. For that purpose Nobatek uses sensors and meters from ICT brands (Wago, Hobo, etc.) but has also developed its own tools responding to specific demands:

- THAI: it is an autonomous temperature and humidity sensor allowing also metering electric impulsion and other electrical signal. It allows evaluating the main performance parameters of an apartment or a house with a simple tool.

- ECOLOGGER: it is a data recorder able to record up to 16 signals of temperature and humidity coming from specific sensors.

- TEHOR: it is an autonomous sensor measuring temperature, humidity, lighting and presence in a room. It offers the advantage of an unique system recording 4 main comfort parameters at once and a radio communication for non intrusive data exploitation.

- POWERLOGGER: it is a data recorder allowing to record up to 16 electric signals. These signals can correspond to the various electric energy consumptions in a house (heating, domestic water heating, lighting, plugs...)

These tools are dedicated to energy and comfort evaluation in buildings and have to be used with other specific tools depending on the study and the building (pliers, signal amplificator, computers, specific sensors, weather station, etc.). Data exploitation is realised with the application Zoubat developed specifically for that purpose in Nobatek. This application is not dedicated to allow communicating clear information to tenants but is only an expert tool.

Monitoring process most often requires to adapt both equipments and data acquisition process; that is why Nobatek uses all the available tools, including commercial tools, depending on the environment in order to fit to the analysis needs in a cost effective way.

6.1.1.3 Telenor Objects

Telenor Objects believes in a shift from vertically integrated closed solutions to a layered open approach where devices will communicate using a wide range of communications systems with software applications. The Shepherd platform offered by Telenor Objects will support this shift by offering efficient services for data exchange with telecom quality.

This new infrastructure will provide functions common to many applications, thereby reducing complexity, development effort and maintenance costs for these applications. There will also be significant operating cost savings, because the costs for such a managed service infrastructure will be shared across many independent applications.

However, the largest innovation potential lies in allowing sensor information to be shared in a safe manner across any application and allowing any device to connect to any application - which means that new applications can be created on the basis of installed devices. The value of such object networks increase exponentially with the number of nodes.

Telenor Objects believes in an open approach to services; open Application Programming Interfaces (APIs) are provided for devices and gateways, software applications, and will work with likeminded partners to make it as simple in the future for devices to communicate with applications as it is today for humans to communicate with anyone anywhere using cellular phones.

6.1.2 Envisioned systems

6.1.2.1 ISA

The envisioned system for the E3SoHo pilot is set up for be a multi-utility system. We intend to monitor: electricity, water and gas. This will give us a general framework of the building energy profile.

To the building level, the envisaged system comprises, electricity, water, and gas, on energy variables measurement. It is also considered several comfort parameters, such as, CO2 levels, presence, temperature and humidity. The following scheme illustrates the information workflow for a propose of architecture at pilot level:

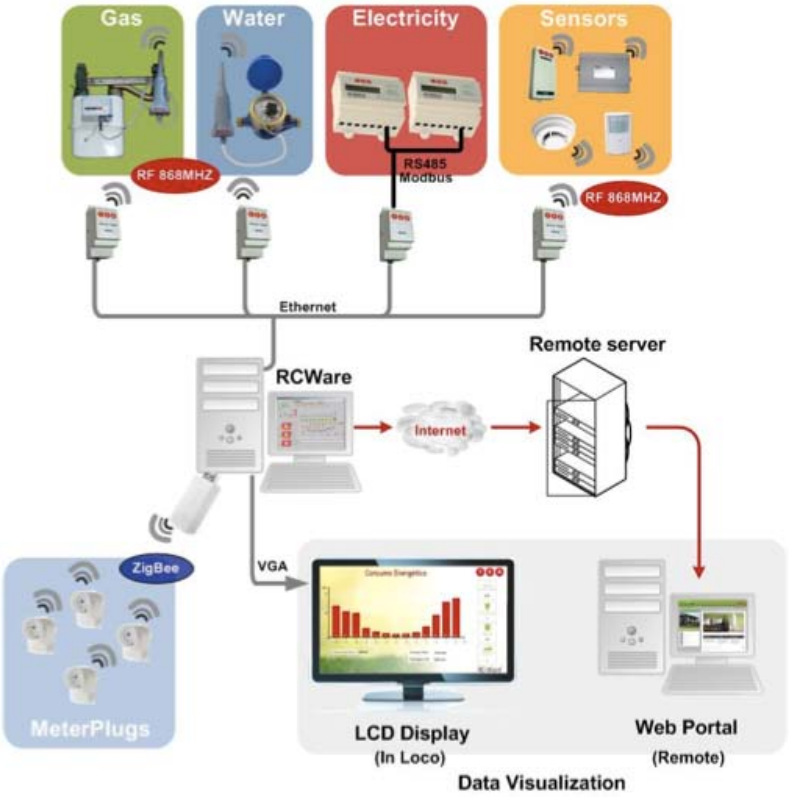


Figure 6.10 - Envisaged architecture at building level. The illustrated architecture is design for energy management at building level.

Depending on the needs there are several blocks that should be refined after a more clear understanding of the building and experience, such as the MeterPlugs, or even the aggregator, might be a different equipment, instead of the RCWare block. It should also be left in discussion the type of comfort parameters that should be monitored.

In terms of end user architecture, it should be defined what should be important to address, either in terms information to make available, either in terms of measured variables. The first proposal for a flat level monitoring, is illustrated in the following picture.

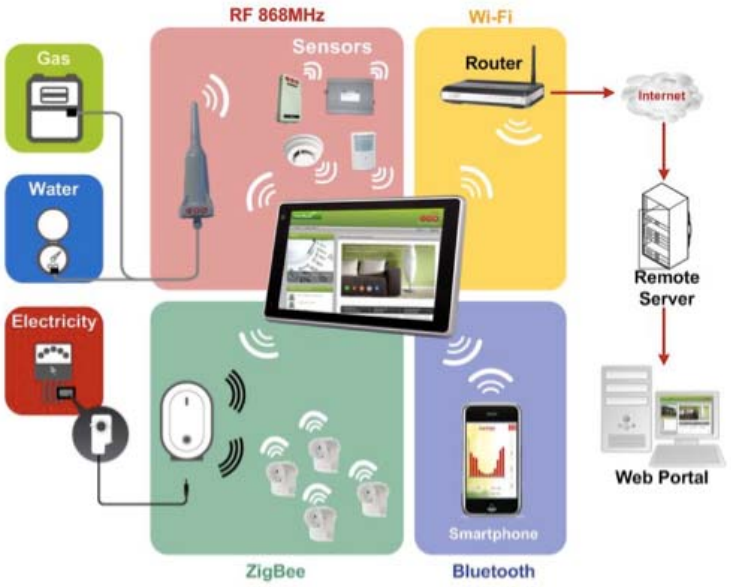


Figure 6.11 - Envisaged architecture for end user monitoring and flat level.

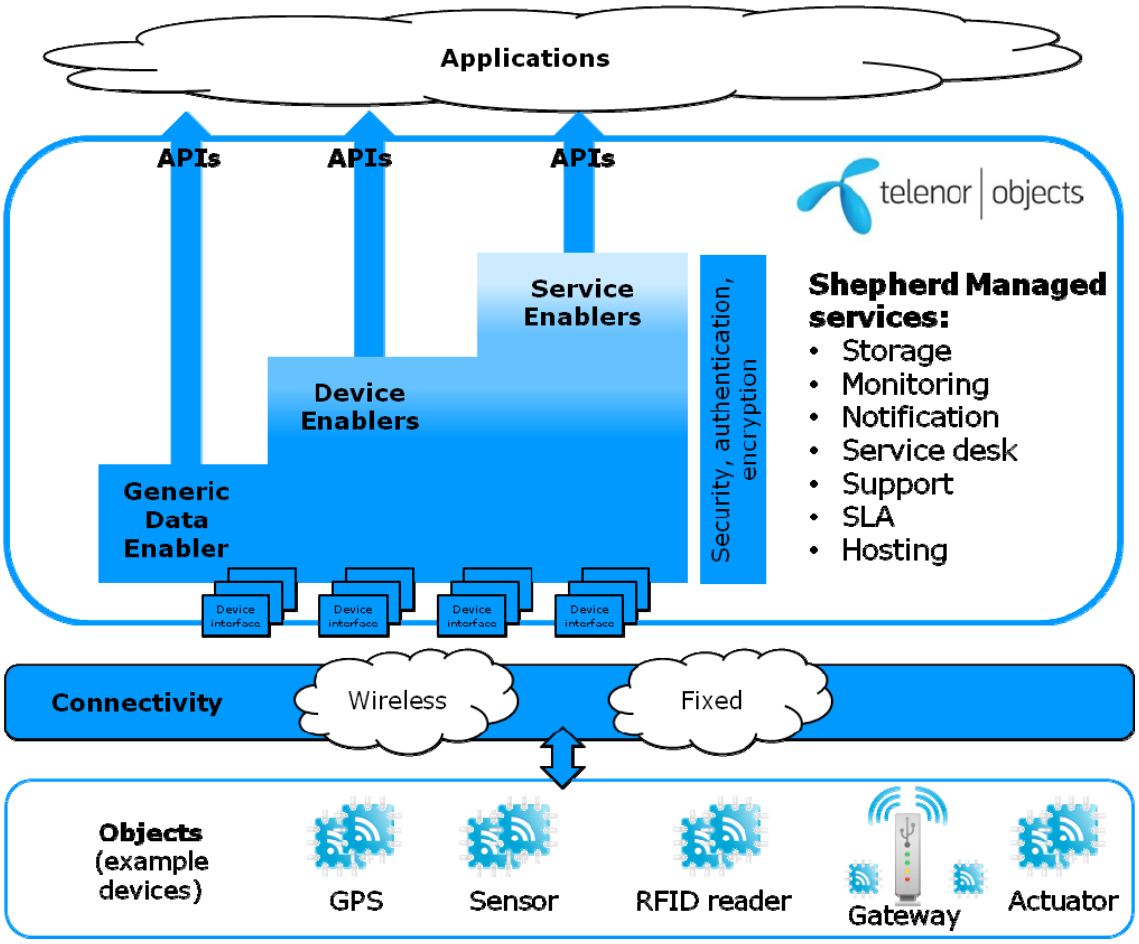
The previous approach may have some weak points, such as the need of Internet connection, and familiarization with social networking. Although the illustration clarifies quite well the possibilities for energy monitoring and access.

6.1.2.2 Nobatek

Nobatek proposes its experience of building monitoring for expertise analysis of their energetic behaviour within the project. For that purpose and depending of each pilot site situation, sensors and meters, either commercial and from Nobatek's production are available for the project. However these tools are dedicated to short term measurements (6 months to 3 years) and not for permanent use, they are then well adapted as monitoring tools and not as an user focused ICT. Hence they can be used ideally to establish the baseline of energy/comfort situation in each pilot and to follow building performance once the ICT will be installed in the timeframe of the project.

6.1.2.3 Telenor Object

The data collected in the E3Soho system need to be efficiently and reliably transported and stored, as well as easily accessible for the applications that are to use them. The latter includes also possible future applications from other vendors not participating in the original system design. The Shepherd platform offered by Telenor Objects is a natural choice for connecting the devices and applications in a loosely coupled manner by acting as a message exchange. Shepherd ensures that messages containing device data delivered into the platform are safely stored until delivered to the appropriate applications or service enablers according to corresponding Service Level Agreements (SLAs).



Devices can deliver into and receive messages from Shepherd in the following ways:

1. By using one of the available Shepherd Enabler APIs for delivering messages into Shepherd and receiving messages from Shepherd.

2. By utilizing COOS software at the device (or at a gateway that the resource constrained devices connect to), thereby enabling receiving and sending of COOS messages directly from/to Shepherd.

3. By implementing a device type specific edge that supports the corresponding transport mechanism and understands the messages received from and sent to this type of devices, and after agreement getting it deployed into Shepherd by Telenor Objects.

Applications can send to and receive messages from connected devices through Shepherd in the following ways:

1. By using one of the available Shepherd Enabler APIs for sending and receiving messages to/from connected devices.

2. By utilizing COOS software in the application, connect to Shepherd and receive and send COOS messages directly from/to the connected devices through Shepherd.

3. By implementing an application specific edge that supports the corresponding transport mechanism and understands the messages used by the application, and after agreement getting it deployed into Shepherd by Telenor Objects.

6.1.3 Technological Gaps & COTS alternatives

6.1.3.1 ISA

In terms of technological gaps, it's worth to referrer that even with such a large spectrum of technology, ISA might need to recur to off the shelf products (OSP) products, namely at the comfort level sensoring. In a time of technology transition, namely in terms of communication protocol, ISA might require to access the market to order equipment like:

- CO2 Sensors;
- IR Presence;
- Temperature & Humidity Sensors.

Nevertheless, the integration process is a very well consolidated process. Over the years, while recurring at third party technologies ISA has gathered the know how for rapid integration capabilities.

6.1.3.2 Nobatek

Nobatek does not offer equipments dedicated to final user permanent information but only expertise tools to be used for short term analysis.

6.1.3.3 Telenor Objects

The Shepherd platform is released in September 2010, and as a result the Shepherd device library of already integrated devices is rather limited. At the time of writing the list mainly includes a set of GPS devices, RFID readers and a RFID portal, a gateway box and a remote IO relay. The set of device and service enablers is also limited to a Generic Data enabler for raw data exchange and storage, a RFID enabler for RFID automation, a SMS enabler for sending and receiving SMS and a Location Service enabler for accessing GPS and GSM positions of devices. Devices and applications used in the E3Soho project solution will have to either use the Generic Data enabler, or partners together with Telenor Objects have to implement device/application type specific edges for the power metering and home automation domain. The benefits of the latter is that the result will be a generic and open solution to rapidly building power metering and home automation solutions as managed services with telecom grade reliability.

7. Conclusions

The intent of this report was twofold:

- to investigate the state of the art of ICT technologies for energy savings in residential applications within the social housing context
- to begin to shape the E3SoHo system architecture in light of the available technologies and needs of social housing

From this investigation, the following main conclusions are drawn:

- The ICT space is rapidly developing. With respect to BMS and BEMS, there is a clear trend of progress from the office and commercial space to the residential space. One way to keep abreast of the technologies and products offered is through associations, portals, and societies dedicated to ICT.
- One common statement or assumption is that the tenants of social housing are not likely to change their behaviour with respect to energy consumption. E3SoHo survey data contradicts such statements. It seems climate change and social responsibility toward the issue are mainstream, well published, and understood. Surveys conducted within the E3SoHo project suggest that social housing tenants would like to have more information about their energy savings and means to reduce energy consumption through ICT.
- The social housing market is very diverse and ICT solutions will have to be flexible enough to adapt to it. Building ownership, utility types, physical structure, tenant profiles, and tenant desires vary widely. Privatisation and renovation are common themes across this space.
- Users want to interact with ICT in different manners. Most social housing tenants do not have internet in their homes. Most social housing tenants do have cell phones. Indicators in the market suggest a dedicated in-home dashboard (e.g. a smart energy thermostat) may be the most appropriate device.
- Users want different levels of control and/or control actions. Options are manual, automatic, and programmable. ICT systems should offer all three options to be adaptable to different user demands.
- Open source protocol is essential to meet the diversity of the social housing market. Associations that support such protocols now offer 1000s of products and link open source technological providers.
- A system architecture that includes data acquisition, weather input, data storage, control, and user interface has been developed. How the project technological

partners fit into this architecture is proposed. The integrations considerations and technological gaps are identified.

- In developing an ICT solution, it makes sense to provide sub/smart metering to the level of who is paying for the service. This implies if an individual is purchasing, it is not appropriate to monitor central systems (such as central heating). In contrast, if a building owner is purchasing, it may not be appropriate to monitor beyond the unit level (e.g. inside the home).

- ISA, Nobatek, and Telenor are well suited to address the ICT requirements of the E3SoHo project. Known technology gaps are related specifically to commercially suited comfort sensors. ISA is addressing this challenge with respect to its product line and OSP choices for the pilots will be selected in Deliverable 3.1.

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