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Energy Smart Metering and Policy Approaches:

The E-Cube Project

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Abstract

Research and innovation in the ICT field is striving to offer applications and equipment tailored to the control of energy consumption, by means of several initiatives: development of new energy efficient appliances, air conditioning systems, meters, sensors and actuators, use of different kinds of proximity technologies, which wirelessly connect together the appliances to form Wireless Sensors Networks (WSN), energy management systems supporting the *efficiency* paradigm.

A scenario where ICT connections are exploited to support energy management systems, where all the domestic appliances are connected through wireless communication means, is one of the most appealing solutions. Domestic appliances (meter, washer, heather, etc) communicate through a local network while terminal devices (e.g. fixed and mobile phones, access gateways) act as gateways towards the TLC network. Thanks to broadband connections reaching nearly all the users, the networks puts in connection with platforms where management of energy can be optimized.

The E-Cube project, partially funded by the "Industry 2015 Program" promoted by the Italian Ministry of Economic Development, intends to create a system including components and scalable infrastructures enabling the control, optimization and dynamic management of energy consumption, both for residential and commercial/industrial facilities. The optimization efforts will be driven by energy efficient and effective policies, defined and exploited by the project. This project is supported by a consortium of 12 major Italian companies and universities that represent the complete value chain of the energy industry.

This paper will present the current results of the project. In particular, it will be focused on the critical issues related to the diffusion of smart metering. Solutions envisaged by the E-cube project, will succeed only if they can offer flexibility, modularity, capability to identify and authenticate the user, personalization of energy use, monitoring and local/remote control. Most of these features can be offered by the adoption of commonly used ICT equipment (as for example the mobile phone with its SIM card). Moreover, a balanced combination between requirements of the user, to let unaltered the comfort level usually experienced, and community needs (reduced environmental impact thanks to energy savings) must be ensured.

The technological solutions do not provide *per se* an efficient result in terms of energy efficiency. Therefore, the E-cube project, will assess also the public policies required to: a) raise awareness about power consumption, b) suggest the best way to diffuse these devices (voluntary vs. mandatory requirements); c) address the privacy and customer protection issues raised by the diffusion of these devices; d) guide by means of policies the use of energy and c) evaluate cost and benefits for all stakeholders (utilities, end users, communities).

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I. Introduction

Environmental degradation and global warming are among the major global challenges facing our societies. Strong action is needed at a global level to better manage water resources, halt the loss of biodiversity, increase prudent use of natural resources and rare materials, reduce green house gas emissions and tackle climate change.[1] Among these challenges, the most immediately pressing is to reduce the increase of green house gases in the atmosphere and possibly to decrease the absolute level of green house gases of all kinds.

A. ICT and climate change

ICT has a major role to play in improving environmental performance and addressing climate change across all sectors of the economy. ICT technologies can help reduce energy consumption and manage scarce resources, can improve efficiency and contribute to cut carbon emissions. Europe recognizes the importance of ICT solutions in achieving energy efficiency. This was clearly underlined since 2008 at the world's biggest computer trade exhibition (*Centre of Office and Information technology* - CeBIT) when the European Union Commission's President Barroso said that "Europe must more than double its rate of improvement in energy efficiency and there is tremendous untapped potential in using ICTs. The real gain in energy efficiency will come from ICT as an enabler to improve energy efficiency across the economy. ICT matters for energy reduction, especially in transport and the energy intensive sectors. ICT's ability to organize and innovate is a key factor."

On the basis of *Directive 2006/32/EC* on energy end-use efficiency and energy services, each EU member State has prepared its *Energy Efficiency Action Plan* (EEAP) which describes the energy efficiency improvement measures planned at national level to achieve the energy savings target, to be reached by way of energy services and other energy efficiency improvement measures. The full implementation of the EEAP can help in reducing energy consumption and is therefore an important tool to achieve the ambitious "20-20-20" goal by 2020: saving 20% of the EU's primary energy consumption, reducing by 20% the emission of greenhouse gases (GHG) and increasing to 20% the share of renewable energies.

Energy efficiency is both the result of policy developments and the application of concrete measures. Technology development, environmental legislation, taxation and other fiscal measures provide strong incentives for markets to realize cost-effective energy savings.

Governments along with energy industry are looking for better and greener ways to produce and use energy. User-friendly ICT-based energy monitoring and optimization systems can intelligently connect more energy efficient components and accelerate the changes in consumer's behavior. An important aspect in any attempt to tackle climate change is to promote energy efficiency in residential and commercial buildings and the introduction of smart applications is a key part of enabling consumers to use less energy and use it in a "smarter" way.

Smart Grids and Smart Buildings, are among the most important ICT-enabled solutions with the highest potential to reduce CO_2 emissions.

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[1] See on this Pupillo, Salanave & Vickery (2009), Introduction to Communications & Strategies N. 76 , 4 Quarter

- Smart Grid. The Climate Group[2] defines "smart grid" as a set of software and hardware tools that provides specific and real-time information to end-users, grid operators and distributed generators with the aim of reducing energy losses, improving network operational efficiency, achieving better quality and reliability of energy supply, allowing customer to control of their energy use and, finally, reducing GHG emissions.
  The smart grid is an innovation that has the potential to revolutionize the transmission, distribution and conservation of energy. ICT achieves this by: a) transitioning the grid from a radial system to an interconnected network, where distributed sources and end-users are connected; b) automating processes using distributed intelligence; c) enabling, through smart metering, two-way communication between customers and suppliers to create a real-time marketplace for energy consumption.
  ICT can help modernize the electrical grid reducing transmission and distribution losses, reporting real-time usage and cost data to increase consumption awareness and integrating renewable energy.

- Smart Building. Energy use in residential and commercial buildings is responsible for about 40% of EU's total final energy consumption and represents about 36% of CO_2 emissions in the EU[3] and about 40% in the US[4]. Therefore, buildings should be at the centre of any solution to GHG emissions. Ideally, new buildings should be built for energy efficiency from the outset. Smart buildings rely on a set of technologies that enhance energy efficiency and user comfort as well as the monitoring and safety of the buildings. Technologies include new and efficient building materials as well as ICTs. The energy efficiency improvements of smart buildings range from making better use of sunlight and natural ventilation to the proper sizing of heating, ventilation and air conditioning systems.

B. *Energy efficiency and Smart metering*

ICT can reduce electricity demand by communicating real-time electricity usage and price through a smart meter. Smart Metering refers to the use of intelligent energy meters and measuring instruments in order to make the energy consumption in buildings transparent and to realize automatic energy management. Smart meters bring about the end of estimated bills and home visits from meter readers because they can record and report electricity consumption information automatically. These new meters provide customers and energy supplier with accurate information on the amount of electricity (and gas) being used; instead of measuring energy use at the end of each billing period, smart meters provide this information at much shorter intervals. On the other hand, energy companies want to invest in smart metering infrastructure to become more efficient and effective in how they engage with their customers. Energy companies will also be able to innovate and offer their customers new types of tariffs that will allow customers to take advantage of potentially cheaper deals at off-peak times.

In the future, smart metering will play an increasingly important role in residential and commercial buildings. The reasons are: a) preparing monthly bills, as it is customary in some countries

[2] Climate Group, *SMART 2020: Enabling the Low Carbon Economy in the Information Age*, 2008. Available: http://www.theclimategroup.org/publications/2008/6/19/smart2020-enabling-the-low-carbon-economy-in-the-information-age/

[3] European Commission, *Energy Efficiency: delivering the 20% target*, 2008.

[4] Energy Information Administration (EIA), *Annual Energy Outlook*, 2008.

(e.g. USA, Sweden, Denmark) and is expected in the future in all European countries following the implementation of the EU Energy Performance of Buildings Directive; b) monitoring buildings for damage or non-standard conditions (e.g. burst water pipes); c) informing tenants about their consumption patterns, e.g. to save energy costs; d) preparing energy bills at short notice, when there is a change of tenants; e) obtaining comprehensive information about the use of energy in a building for the purpose of producing an energy certificate; f) obtaining information about the energy consumption patterns of whole properties (e.g. in order optimize the distribution of energy and avoid peak loads); g) complying with EC Directive 2006/32/EC on Energy End-use Efficiency and Energy Services (Article 13), which sets out that the energy bills for household customers have to be sufficiently detailed and served frequently enough for customers to be aware of their energy consumption and control it correspondingly. With smart use of smart technologies, we can all be winners in the transition to an energy-efficient sustainable knowledge based society.

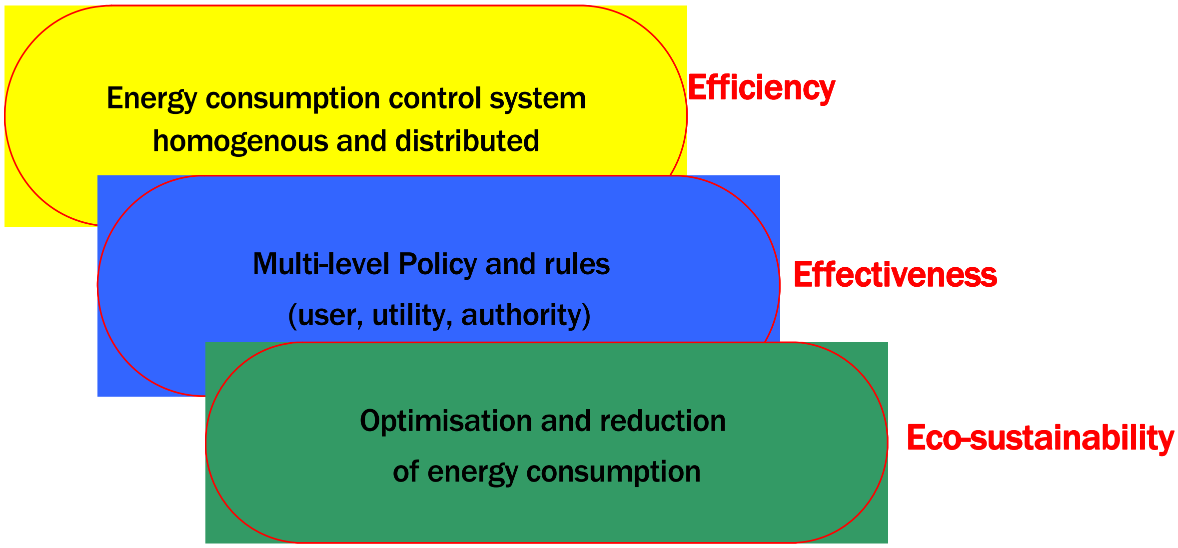
This paper presents the E-Cube project as an application of smart metering technologies. E-Cube is partially funded by the "Industry 2015 Program" promoted by the Italian Ministry of Economic Development- This project is supported by a consortium of 12 major Italian companies and universities that represent the complete value chain of the energy industry.[5] This work discusses the current results of the project. In particular, it is focused on the critical issues related to the diffusion of smart metering. Solutions envisaged by the E-cube project, will succeed only if they can offer flexibility, modularity, capability to identify and authenticate the user, personalization of energy use, monitoring and local/remote control. Most of these features can be offered by the adoption of commonly used ICT equipment (as for example the mobile phone with its SIM card). Moreover, a balanced combination between requirements of the user, to let unaltered the comfort level usually experienced, and community needs (reduced environmental impact thanks to energy savings) must be ensured.

The balance of the paper is organized into four sections. In Section II, we present the E-Cube project and the progresses made on the design of the technical architecture and the HW/SW components of it. Section III focuses on the energy metering experiences in the world**.** Section IV then discusses the policy issues related to smart metering diffusion and the policy approaches so far followed. Section V concludes and discusses the next steps of the project and the challenges for further research.

II. **E-Cube project**

The objectives of the E-Cube project are the creation of a system including components and scalable infrastructures enabling the control, optimization and dynamic management of energy consumption, both for residential and commercial/industrial facilities. The optimization efforts will be driven by energy efficient and effective policies, defined and exploited by the project. The full objective of the system is to rationalize power consumption, allowing energy saving simultaneously with perceived comfort increase, by balancing the user wellness and the environment advantages obtainable by applying the project outcomes.

[5] Telecom Italia, Edison Energia, Electrolux, Energy Team, Neohm, Nera, Ospedale S. Raffaele,STMicroelectronics, Telit, RPS(Riello) , University of Rome and University of Verona are members of the E-Cube Consortium.



The E-Cube project proposes to study, develop and implement innovative HW/SW technologies which enable the efficient management of energy in the components of the system. Special attention is given to the identification of architectures and solutions which ensure the identification and authentication of the user, by exploiting a service personalization which will take into account the requirements of both the user and overall community.

In its development phase, E-Cube focuses on the energy efficiency in domestic and industrial (commercial/public) scenarios. The reason of such focus becomes evident by considering the Action Plan for Energy Efficiency of the European Union: although energy efficiency has improved considerably in recent years, it is still possible to save at least the 20% of total primary energy by 2020. To help achieve that target, energy efficiency in buildings and industrial environments, which require almost 40% of the total energy used in the UE, has been identified as a top priority. Potential savings of up to the 30% have been estimated for both the residential and commercial building sectors.

A. The E-Cube System

Besides the pure development aspects, the E-Cube project aims at creating a broad network involving all the relevant stakeholders related to the energy at national level. This includes the providers of energy, the component and system manufacturers, the service creation and provisioning companies, all glued through network infrastructure offered by a telecommunication operator. An organic approach to the energy management and efficiency issue has the potential to offer relevant solutions only if it is able to be understood and supported at every level. For this reason, in order to harmonize the project objectives with the international trends, the E-Cube project aims also at analyzing the regulations not only at national level, but also with a look to the way the same issues are faced worldwide. A further outcome of the project is the definition and application of policies and rules for the efficient energy management, to help firstly at the national level the creation of a common perception and practice, and subsequently a uniform approach to the implementation of the energy efficiency techniques, systems and components.

E-Cube also intends to create specific synergies among management of energy sources: although the main scope of the project is centered around the electric energy, the same approach can easily be extended to other energy distribution networks in place for residential and industrial uses (gas, heating water, etc), thus improving the efficiency of overall energy consumption.

The technical challenges that have to be faced to achieve an efficient energy management system concern various aspects that are addressed in E-Cube. They can be summarized in the following key technologies:

- Energy management strategies (developing the strategies for efficient energy management)
- Energy-aware Systems (components, appliances and subsystems supporting embedded energy management solutions)
- Ambient Intelligence (providing interconnection and interfacing capabilities between the energy management system, the power sources and sinks and the final user)

Moreover, strategies for local energy distribution must be taken into account to maximize energy savings and promote the use of renewable generation. The implementation and effectiveness of such local strategies are based on control and actuation capabilities that are nowadays possible thanks to the pervasive integration of digital systems in residential and industrial sites. Indeed, building and home automation technology has gained a considerable momentum in the last ten years. However, so far little attention has been given to the exploitation of this technology to address the energy management problem, being mainly dedicated to improve building security, intrusion detection and to the automatic control of doors and lights. As a result, there is currently a lack of integration of sensors and actuators within energy management elements (e.g. uninterruptible power sources), limiting the intelligence and automation of the energy distribution and monitoring flow.

To provide full control and adaptation capabilities, sensors must be spread around the controlled area to detect environmental conditions inside and outside the building (such as temperature, light conditions, pressure, humidity). Wireless sensor networks (WSN) can provide these monitoring features in a very pervasive way, being composed of tiny and autonomous nodes (i.e. battery equipped) that can be installed everywhere independently from interconnection and power availability.

To fully enable integration and collaboration of monitors and control elements, standard interfaces and communication protocols are needed, so that all the control and actuation elements can interact with each other to provide an intelligent adaptation the energy consumption of the building to user needs and external conditions. The implementation of such an interconnection and coordination features within the energy management system and between the system and the user resort to the Ambient Intelligence technology.

Finally, in order to increase the effectiveness of energy management policies, energy consuming elements must provide knobs for tuning their power consumption. There are several power sinks in a modern building. Among them, the power consumption of digital equipment such as TV and media sets, computers is going to increase its contribution in the near future. As such, it is critical to provide means for controlling power consumption of digital systems without impacting their functionality. Moreover, the main sinks are represented by household appliances: it is therefore extremely important that also these loads can be controlled.

The Control Strategies for Local Energy Management Systems (CEMS) can be based on the concept of Energy districts. An energy district can be seen as a scalable concept, which can identify just a single residential unit, or a consortium of local entities such as industries, residential neighborhoods, urban neighborhoods, commercial activities and public institutions within one or more municipalities characterized by:

- Internal Generation Capabilities such as Co-generation plants, Micro Gas Turbines or Photovoltaic Cells (PV)
- Controllable Loads.

Based on the connectivity provided by the local communication infrastructure and the control capabilities enabled by a local computing control node (a PC or another unit with processing capabilities), in order to promote energy efficiency and thus reduce energy consumptions and CO_2 emissions, innovative and scalable control strategies can be developed and applied. Available controlling features should include the capability to switch on-off pure passive loads, the configuration of local generator (co-generation plants, PV, etc.) set points, the setting of heat pumps. On the other hand, available monitoring capabilities should include the capability to get setting points of local generators and heat pumps, reading the working status of passive loads and monitoring the power consumption on specific key power network points. Specific control techniques have to include optimal control, optimal power flow and non-linear control in order to maximize energy savings and the use of renewable generation. Optimal Load management techniques (both electric and thermal) can reduce energy consumption whilst assuring proper level of comfort to final users.

Alternatively, in order to promote reduction of energy consumptions and maximize the use of local generators, local spot markets based on real-time energy price and participants energy profiles can be adopted. Scalability can be assured by a proper Multilevel Control Approach aimed to guarantee controllability on proper classes and clusters of loads and generators. The adoption of control strategies will enable advanced energy-wise capabilities such as Demand Side Management (DSM) and Demand Response (DR), as well as will provide ancillary services to power grid system operators.

Regarding household appliances, in the past years the white goods manufacturers dedicated significant efforts to improve the energy efficiency and to reduce the water consumption of their machines. In the last 20 years, the energy consumption of refrigerators and freezers has been reduced by 65%; similarly important improvements have been reached also on the water consumption in washing machines and dishwashers.The customers are nowadays informed and influenced by the meaning of the Energy Labels. However, this achievement derives from a strong optimization of the working process (washing, drying, cooling…) of the machine itself and did not involve a system or a cluster of appliances.

B. *The Smart Grid Scenario*

The E-Cube activity progresses over two specific main directions, the first being devoted to the definition of the architecture of the systems and of its components, the second dealing with the analysis of policies.

The definition of the system architecture implies the capability to create an energy efficiency management solution easily adoptable by households and in industrial environments.

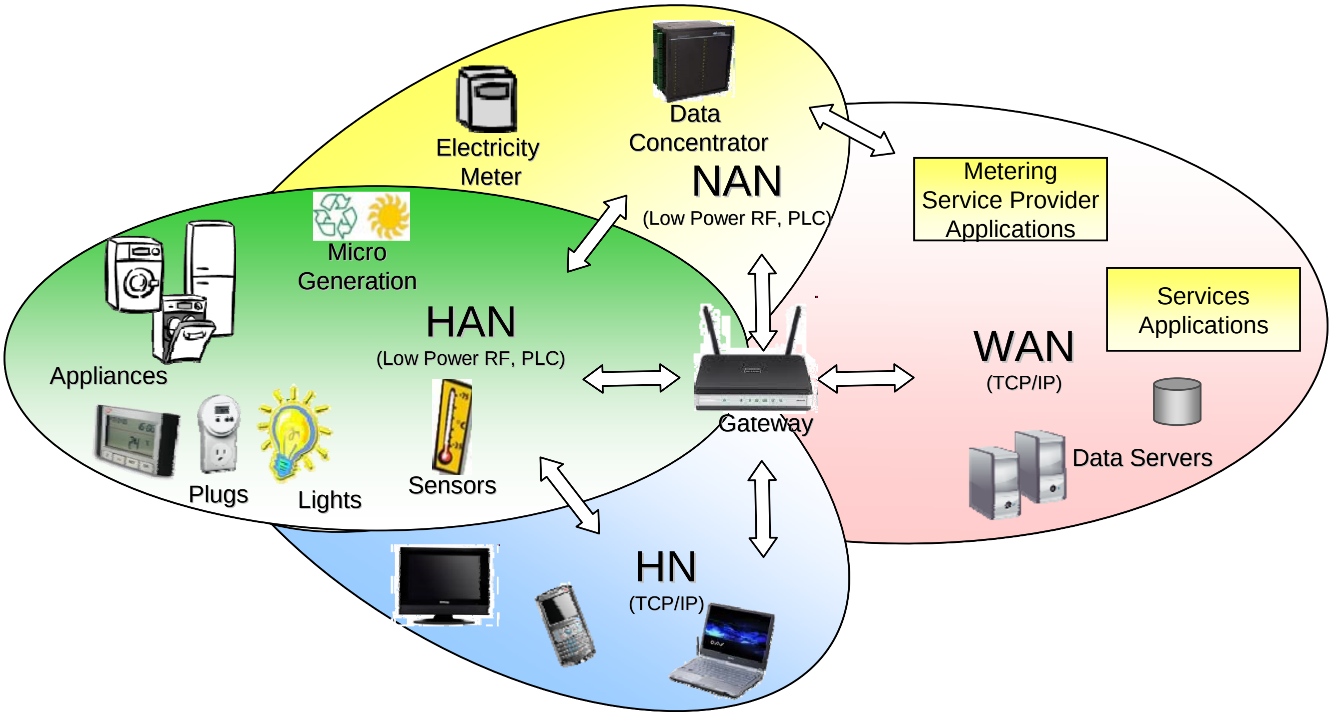


Figure 1: The Smart Grid Scenario

In a smart grid scenario, the architectural developments covered by the E-Cube project are concentrated on the Home Area Network (HAN), where many devices (smart appliances, smart plugs, home displays, micro-generation systems, etc) interact and a Gateway unit controls and manages the energy consumption, in connection with the smart electrical meter (being possibly part of a Neighbor Area Network, NAN) and the Wide Area Network (WAN). Further connection with a Home Network (HN) is provided to inform the user about the energy consumption.

The gateway device needs to satisfy specific requirements in order to perfectly perform its role: first of all it must be always on (24/7), to respond to every needs of the energy distribution in the domestic environment. Second, it needs to be connected to the communication network, to receive from energy retailer the energy prices which might dynamically change, and to let further entities (regulators, the distributor, the user themselves) to interact with the domestic system. Finally, it must communicate with all smart appliances using the energy.

In E-Cube, the device performing the role of the Gateway and satisfying the above mentioned requirements is the Home Access Gateway. This device is connected to a xDSL line, which represents an asset for a telecom company as Telecom Italia, and it is called Smart Home Controller (SHC). This role is strongly in line with the expectation that the smart grids of the future will benefit from a fundamental support from the ICT side in order to be successfully built.

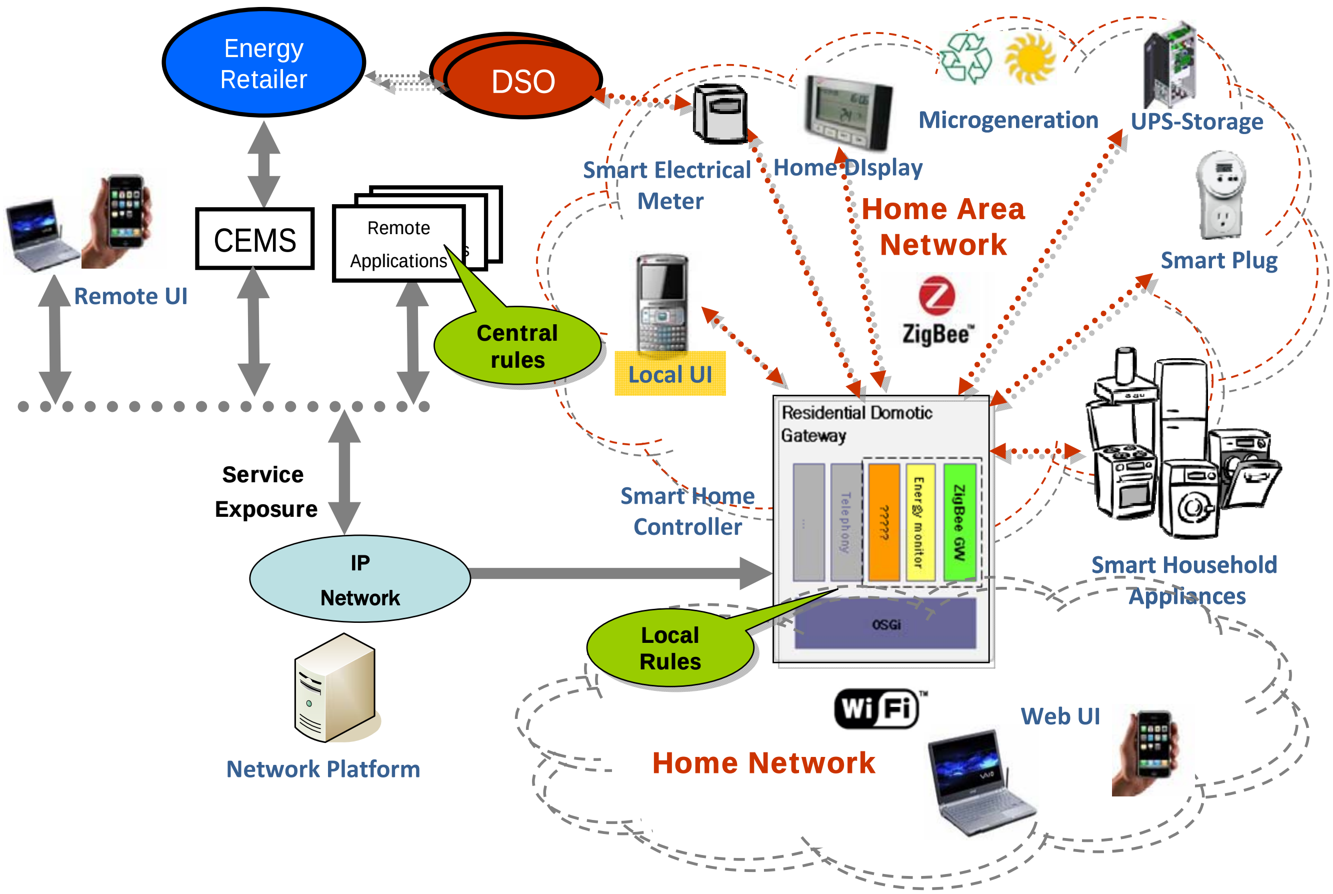


Figure 2: The E-Cube System Architecture

In the first project's period, the application scenarios and use cases envisaged for adoption of the E-Cube system were investigated, taking into account the role of the SHC. The resulting architecture is represented in Figure 2: most of the components belonging to the HAN are under development by the project partners.

The SHC is at the heart of the architecture, and performs the twofold functionality of coordinating the HAN communications and of connecting to HN and WAN (i.e. the IP network).
The smart appliances (washers, freezers, oven, etc) embed the capability to communicate with the SHC, and closely interact with the energy control applications to determine the optimal time for being activated; smart plugs are used to enable the control of small loads which do not include such autonomous power monitoring and control capabilities. UPS unit(s) can help in mitigating the effects of locally generated energy, and provide emergency power supply in case of energy failures. The user is always informed about the status of energy usage through visualization units either belonging to the HAN (Home Display) or to the HN (i.e. through a PC, a mobile phone or TV set).

The E-Cube CEMS provides the E-Cube system with two fundamental aspects:

- a functional system to manage the energy consumption in a scalable way (from local to neighbor to global level), which constantly monitors the energy consumption, availability and cost, to find

- the capability to support implementation of rules, both locally and remotely managed, in order to let the users provide the information to the system about their needs, such that they can avoid perceptible impacts on their lifestyle.

The Network Platform is the support through which the CEMS strategies can take place in the overall E-Cube system. The platform also offers a service exposure level of functionalities to let third parties develop further applications based on the same architecture.

The mobile phone (Figure 3) can interact with local devices in the HAN directly, when it is equipped with a ZigBee radio interface, or it can access the information of SHC through the HN connection, as well as connect remotely via the IP network. The traditional features offered by a SIM card embedded in the mobile phone, i.e. its security and its unique identification of the user, are strengths that improve the capability for the users to adopt the E-Cube solutions in a safe and transparent way.

Figure 3: The Mobile Phone as User Access Point to Manage Energy.

The configuration of energy management rules (e.g. for a single appliance of globally for the whole house) can be made accessible only to a set of specific users, while other users have the possibility to locally interact with a single appliance whenever necessary.

Moreover, this approach enables, through a different level of scalability, the interaction with a higher level, supervisory user (i.e. the provider, or the energy authority), in order to let the most sophisticated energy management techniques take place. For instance, as shown in Figure 4**Errore. L'origine riferimento non è stata trovata.**, the provider can inform the user about a lower cost of the energy at a given time of the day. The user can manually activate the adoption of standard user profile (i.e. no limitation to appliance activation), or the CEMS functionality can provide this switch in an automatic way.

From the strict development point of view, the next project's step consists of implementing the *pilots*, i.e. trials where the solutions generated by the project will be put in place in different environments, to assess their usefulness, usability and efficacy. The four pilots include domestic environments, a public environment represented by common areas of a hospital, a commercial environment through offices, and a telecommunication central exchange office.

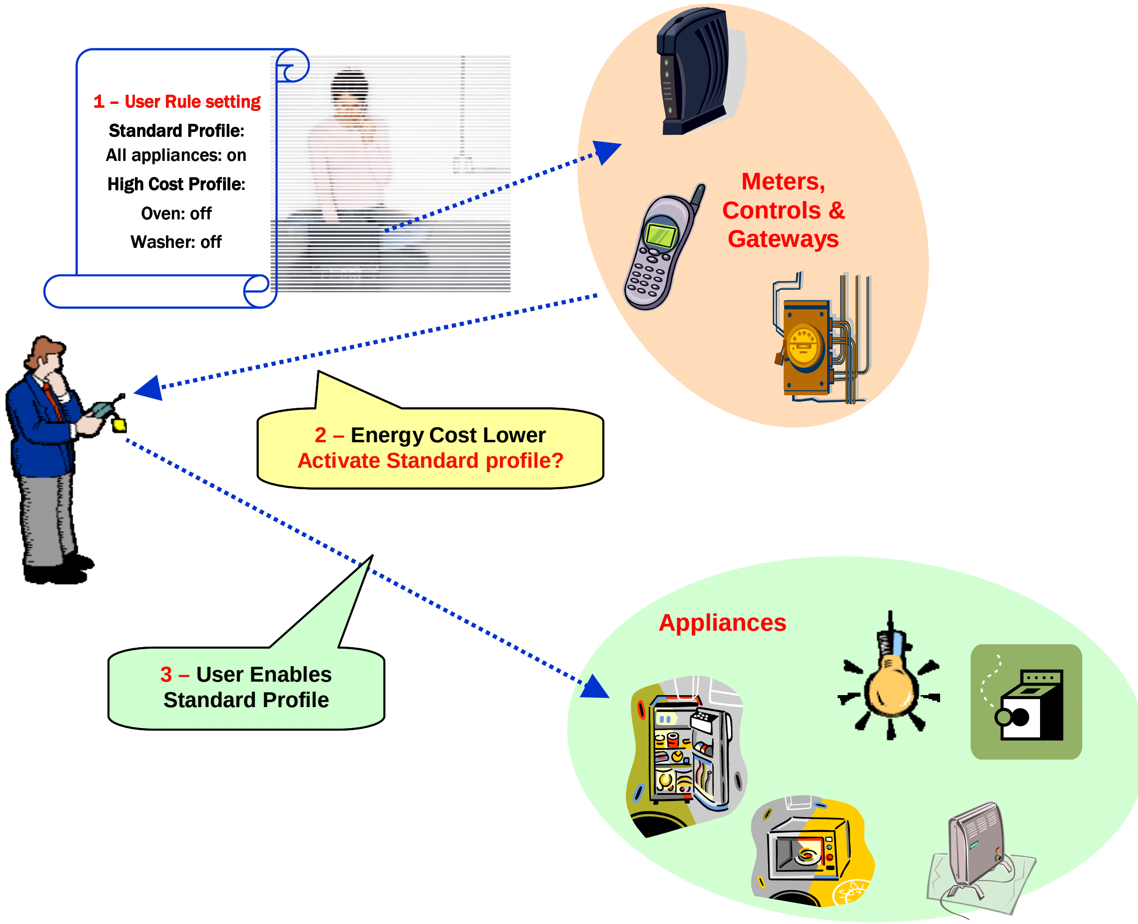


Figure 4: Setting and Managing Energy Usage Rules.

II. Smart Metering experiences in the world

After reviewing the architecture of the E-cube system, it is helpful to ask how the E-Cube project compare with the current smart metering systems in the world. The state of the regulation and implementation of smart metering varies across Europe on a country by country basis, eading to different players taking the initiative - regulatory agencies pull vs. utilities push. Two European Directives, one on Energy End-use Efficiency and Energy Services (ESD) and another on Measuring Instruments Directive (MID), stress the importance of installing metering and billing systems that allow consumers to regulate and manage their consumption.

The shift to smart metering is not just a European phenomenon, but also an American one. In January 2009, the Obama's administration in the United States has introduced a comprehensive economic stimulus plan, which includes massive investments in the smart grid. Just two months earlier, the State Power Grid Corporation of China decided to replace all electromechanical meters with smart meters within five years.

Actually, there are different initiatives around the world at a different stage of smart metering deployment, for residential customers and small businesses. To date, smart meters have been launched on a large scale only in few countries (e.g., Italy, Sweden and Finland - Fig 5). Hereafter, we present the status of smart meters deployment in the majority of OECD countries.

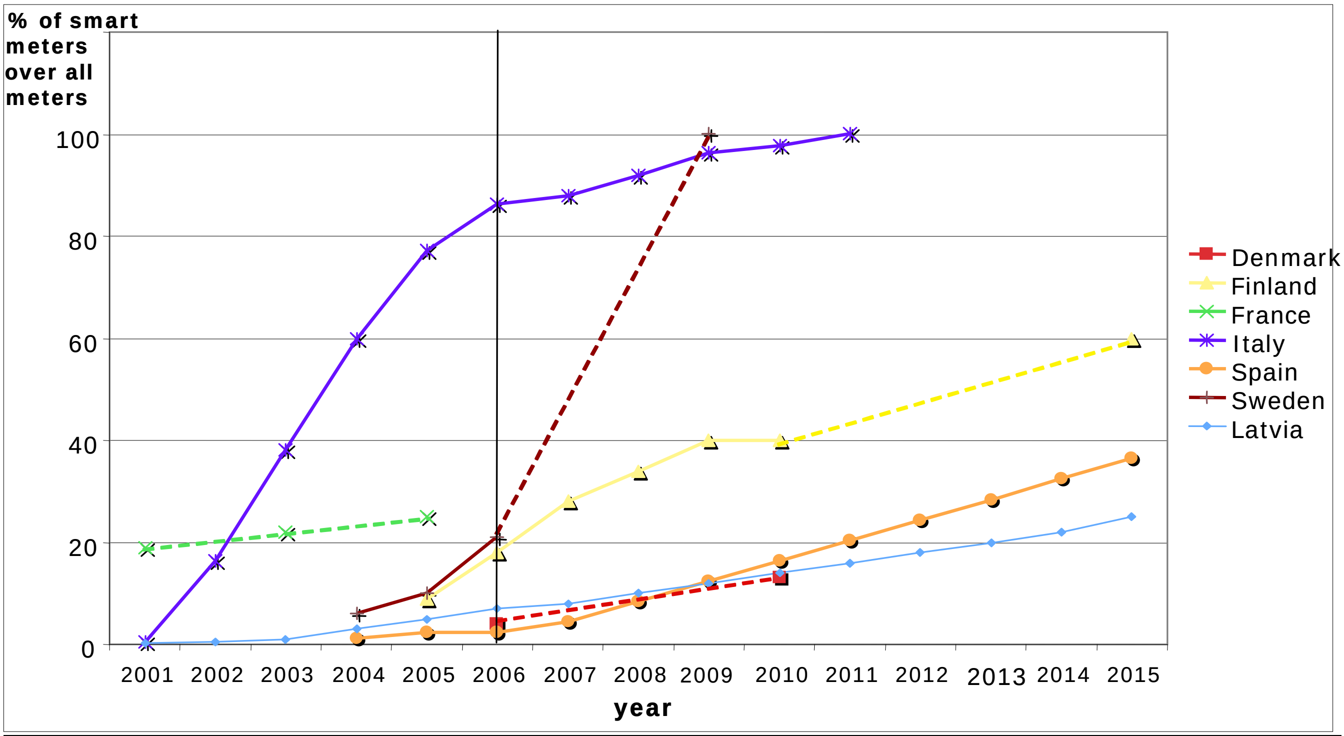


Fig. 5: Electricity Smart6 Metering
Source: ERGEG status review 2006

AUSTRALIA

In South Australia, ETSA Utilities has been conducting Direct Load Control (DLC) trials since 2005/06 in order to reduce summer peak demand. The largest trial was undertaken over the 2006/2007 involving 1100 residential and commercial customers. As part of the trial, consumers in the trial area were offered a $100 incentive payment to have their air-conditioner cycled off 15 minutes of each 30 minute period. The trial revealed a reduction of approximately 40 kW between 4 pm and 7.30 pm on day with a maximum temperature of 36°C[6].

Another initiative is the "Solar Cities programme" that involves all levels of Government and encourages industry, businesses and local communities to rethink the way they produce and use energy. It trials energy options to provide information to manage energy into the future, reduce greenhouse gases and protect Australia's environment. As part of the trials approximately 15,000 smart meters will be installed to help track consumer energy consumption and change behaviour patterns through the use

[6] Essential Services Commission of South Australia, *ETSA Utilities Demand Management Program – Progress Report*, 2007, p. 18.

of time-of-use pricing. Adelaide, Townsville, Blacktown, Alice Springs and Central Victoria are the five solar cities selected in Australia.

CANADA

In Canada, four smart grid projects have been selected for support from Canada's Clean Energy Fund. These projects concern:

- an energy management business intelligence platform development and demonstration led by Power Measurement Ltd;
- an energy storage and demand response initiative for near capacity substations led by BC Hydro;
- an interactive smart zone demonstration in Boucherville (Québec) led by Hydro-Québec's Institut de Recherche;
- an electricity load control demonstration led by New Brunswick Power Corporation will focus on the integration between smart grid technologies, customer loads and intermittent renewable in some regions (New Brunswick, Nova Scotia and Prince Edward Island) with potentially significant renewable electricity capacity. It should allow utilities to better understand how customers will react to smart grid and which loads can be controlled by real time demand balancing in up to 750 buildings, thereby assisting these utilities to capitalize on renewable resources in the region.

Ontario has also committed to rolling out smart meters to 800,000 large consumers (peak demand over 200kW) and industrial and commercial consumers (50-200kW) in order to achieve greater control of consumption peaks and reduce energy imports during those peaks. A progressive roll-out to consumers is planned to take place before December 2021[7].

The Ontario Energy Board has overall project management responsibility and is responsible for the regulatory framework, including license conditions and rates, and review of distributor plans.

Each of the several distributors will select the appropriate smart metering system and will be responsible for installation, servicing and reading of the meter. Metering systems will be required to meet specified minimum standards and functionality, which includes the use of hourly interval meters, two-way communications, and an "Open" data network interface. Six of the province's major urban electricity utilities are working cooperatively under the brand name PowerWISETM to implement delivery of smart meters to customers on a province-wide basis. They are all undertaking smart meter pilot projects that involve installing the meters in customer's homes in order to test the various technologies that will be required to deliver smart meter services. These include wireless communication and other technologies.

DENMARK

In 2008, Denmark utility HEF Net has concluded an agreement with meter manufacturer Kamstrup to supply almost 70,000 smart meters and wireless solutions from January 2009, through December 2011.

[7] National Electricity Market Management Company (NEMMCO), *Metering and Retail Market Development 2006 Annual Report*, 2006, p. 35.

FINLAND

Finland's largest electric utility - Fortum Oyj – has invested €170 million over a period of nine years in a smart metering system based on a two-way communication. The project is expected to connect to the system 550,000 small business and residential customers by the end of 2013.
Also Finnish legislation requires hourly meter reading by the end of 2013. The smart metering system provided to Fortum's customers includes a variety of features meeting and exceeding legal requirements such as automated consumption reporting via internet, possibility to access real-time meter readings and connection to future smart home systems via a local wireless interface in the meter.

FRANCE

A smart metering pilot project is being conducted by Electricité Réseau Distribution France (ERDF) involving 300,000 clients supplied by 7,000 low-voltage transformers. In June 2008 ERDF awarded the pilot project to a consortium managed by Atos Origin, including Actaris, Landis+Gyr, and Iskraemeco. The aim of the trial is to deploy 300k meters and 6k concentrators in two distinct geographic areas, the Indre-et-Loire department and the Lyon urban region. The experimentation phase has just started in March 2010. A key determining factor will be the interoperability of various suppliers' equipment. The general deployment phase, involving replacement of 35 million meters, will start in 2012 and continue through 2017.

GERMANY

The Federal Ministry of Economics and Technology embarked on the technological competition entitled "E-Energy[8]: a future energy system based on information and communication technologies" on 30 April 2007. This competition is designed to promote the development and testing of integrated concepts regarding the composition of approximately 3 to 5 E-Energy model regions. In this regard, the potential for modernising advanced information and communication technologies and the applications and services within the energy supply chain as a whole, from production to consumption via transport and distribution, which are based on this, are to be exploited.
Some E-Energy projects are the following[9].

- **MEREGIO –** Minimum Emission Region – project whose objective is to develop regions with power supply systems that are optimized with regard to their GHG emissions. Thus, smart metering is a key component of this project. 1000 customers, provided by meters that can be read remotely, can plan the use of their appliances and equipment at times when electricity is cheaper.
- **Mannheim model city** is a large-scale trial project with the aim to improve to improve energy efficiency. Therefore, consumers in the Mannheim region are provided with "Energiebutler" systems which furnish consumers with real time information on consumption, prices and rates. Consumers can then use this information to control and optimize their individual consumption of energy by deciding what time to use their electrical appliances, or by organizing the use of their electrical equipment around a variable price. The focus is on developing an open platform with a broadband power line infrastructure on the basis of which renewable and distributed

[8] The abbreviation "E-Energy" stands for "Internet of Energy" and comprises a broad range of ICT-based innovative concepts whose goal is to facilitate the intelligent management and control of the entire energy system across all value-added steps.
[9] Federal Ministry of Economics and Technology (FMET), *E-Energy: ICT-based Energy System of the Future*, 2008.

energy, above all, is fed into the main supply grid and this energy can be directly assigned to customers' current power needs in the network.

All these projects provide evidence that the greater transparency afforded by E-Energy can also motivate consumers to become actively involved with regard to pricing, energy providing, quality of the power on offer and associated services. This encourages power saving, stimulates competition across a far broader range of products and promotes better comparability and more advertising and marketing on the Internet.

ITALY

Italy was the first European country where smart meters were deployed at a massive scale (the Italian utility Enel introduced the first smart meter in 2001 and, by the end of 2005, had more than 27 million smart meters installed) in the first half of the 2000s. By 2011, all 36 million Italian electricity customers will be covered by smart metering. Enel was able to justify this deployment without regulatory support – most savings where obtained by the ability to perform various functions remotely, instead of having a service technician visit the customer site, and respond more effectively to customers. Enel estimates that it will make 6 million fewer field visits each year and respond to 98% of customer requests within 24 hours. In addition, the system has provided improved network planning and load balancing, while increasing fraud detection.

JAPAN

Tokyo Electric Power Co has just launched trials of smart meters with the aim to start the full-fledged introduction in two or three years. The company has planned to gradually install smart meters for its 27 million customer households free of charge. In the trials, the company will install smart meters in around 90,000 houses mostly in Kiyose and Kodaira, western Tokyo. Residents will be able to check their power consumption data, updated every half hour, on the company's website and receive advice on how to save energy based on the data. Among other regional power utilities in Japan, Kansai Electric Power Co had installed smart meters in about 300,000 houses by the end of February, 2010. Kyushu Electric Power Co intends to boost the number of smart meters to 600,000 by September of this year.

NETHERLANDS

The Netherlands Country are expected to roll-out advanced metering to all consumers (roughly 6 million) by 2013[10]. Smart metering is mandatory for all new electricity contracts[11]. The first smart meter for both electricity and gas was introduced by the company Oxxio in 2005.
In 2007, the Dutch government proposed that all seven million households of the country should have a smart meter by 2013, as part of a national energy reduction plan. In August 2008 the roll out of these seven million meters was delayed for several reasons (e.g. limited possibility foreseen to register small scale local energy production and uncertainty in the parliament on future developments in smart meters). Thus, instead of a mandatory roll out of smart meters, there will be a voluntary-based roll out.

Amsterdam has recently begun implementing a wide-ranging "smart city" program, which will involve energy saving systems in households, including a new "smart grid" platform, household solar

[10] Rousseau Y., *Assessment for the Launch of a Smart Metering Project: Illustration with the Drench Business Case, Capgemini*, 2007, p.5.
[11] This decision is based on a cost-benefit analysis conducted by KEMA, who identified a Net Present Value of €1.2 billion.

panels and wind turbines, as well as power hook-ups for electric cars, making its already carbon conscious infrastructure more eco-friendly. Many households (1,200) installed an energy saving system designed to cut energy costs and in Utrechtsestraat, a major shopping avenue in the centre of the Dutch capital, solar-powered panels on local bus stops were installed to transform the road into a “Climate Street” piloting clean technology. Amsterdam aims to create a “smart city” by 2012 and hopes to use the smart grid infrastructure to boost energy production (a “virtual power plant” will enable households to sell excess energy from house and community solar panels, wind turbines, and biomass plants back to the city for a profit). Other cities are looking to Amsterdam as a model for how to reduce CO_2 emissions.

SWEDEN

Sweden will become the first country to achieve 100% penetration in July 2009 when monthly collection meter values become mandatory. Currently 71 out of 164 distribution network operators (DNOs) are reported to be done with the deployment. While the requirement is to deploy equipment for monthly reading a few large DNOs are actually going beyond that. Sweden’s mandate is accelerating the deployments in Denmark, Finland and Norway, where installations are steadily growing.

UNITED KINGDOM

A trial by energy supplier E.ON and Kettering Borough Council put dual-fuel smart meters in almost 500 homes, along with in-home monitors which provide information to householders on energy consumption, carbon emissions and electricity and gas costs. The pilot, which began in 2008, showed homeowners cut their energy consumption by an average of around 9% - which would save the average household around £109 a year on their gas and electricity bills. Those taking part in the trial had an extra incentive to cut their energy use, with Kettering council offering residents a discount of up to £100 on their council tax bill for reducing consumption. Of 454 participants in the trial, 365 made a reduction in their year-on-year energy bills. The Government has announced plans to roll out smart meters, which would provide real-time information about energy use to both suppliers and households, to all homes by 2020.

UNITED STATES

In the US there were announcements of pilot and demonstration projects of smart metering. In particular we can focus attention on the following projects.

- **The Olympic Peninsula GridWise Project**, developed by the Pacific Northwest National Laboratory of the Energy Department in 2007, provided insights into how customers might adjust their energy consumption based on changes in prices. Smart appliances, including thermostats, water heaters and clothes dryers were installed in 112 residential homes.
- **SmartGridCity,** launched by Xcel Energy in 2008 in the city of Boulder (Colorado) with the aim to reduce energy consumption, brownouts and outages.
- **The Building Owners and Managers Association** (BOMA) of Chicago intends to create the first commercial office building smart grid program in the US. The program will deliver a utility scale, green, “virtual generator” by installing smart grid technology in up to 262 BOMA/Chicago member buildings in Chicago’s central business district.
- Google has launched **Google Power Meter**, a free energy monitoring tool that helps consumers save energy and money. Using energy information provided by utility smart meters and energy

monitoring devices, Google Power Meter enables individuals to view their home's energy consumption from anywhere online.

In conclusion, the present situation and the implementation plans for smart metering differ significantly from country to country. Clearly, it is a result of different national factors, including climate, consumption patterns, deregulation path etc. Even in the Nordic countries, where national electricity sectors are in many ways very similar and cooperate closely, there are quite different requirements and plans for implementation of Smart Metering. It is unlikely that these differences will diminish in the close future, considering that Energy Services Directive (2006/32/EC) does not provide very concrete definitions and implementation requirements.

B. *E-Cube as a second generation smart metering system*

Being Italy one of the leading country in energy smart meters penetration, E-cube will attempt to bring some additional features to the smart meters already in place, to allow for a greater customization of the services and a broad implementation of different setting and managing of energy usage rules. (***Second generation smart metering system*)**. In fact, the information on energy use will be provided through a hand-held display device, via the internet or through a mobile phone. Through the smart plugs, appliances will be able to interact with the meters and the mobile devices. Customers will be able to compare the amount of electricity they use today against what they used the day before, the week before, the month before and even the year before. So they will be able to monitor their energy use in real time, as well as to make informed choices about how to manage energy and react to prices, thus giving providers the information on how to structure and price electricity to optimize efficiency. Moreover, smart meters add the possibility of two-way communication and supply between providers and users, thus playing a vital role in making energy and environmental issues visible to the household consumer, thereby informing and empowering consumers and enabling behavioral change[12].

Furthermore, to create awareness on the social impact of energy consumption behavioral changes, the E-cube system will feature on the display the ***Carbon Meter,*** to link the changes in energy consumption to the customer CO_2 footprint. In 2009, Telecom Italia together with Price Waterhouse Coopers developed the "Carbon Meter"[13], a CO_2 calculator that measures carbon dioxide emissions. Thanks to this tool it is possible to calculate CO_2 emissions coming from daily life activities that fall into four areas: home, work, purchases and administration paperwork. The simulation aims to make consumers more responsible and improve the sustainability of their daily behavior. The awareness of consumers' negative impact on emissions represents an important stimulus for change and for using solutions that respect the environment, improving the quality of life at the same time.

Moreover, there are other projects comparable to E-Cube.

Last year, *Cisco and Yello Strom* (among Germany's ten electricity companies) announced the launch of a small smart grid pilot program. This will cover about 70 German homes and businesses, which will be outfitted with smart meters (called **Yello Sparzaehlers** and provided by Yello Strom) and Internet Protocol networks designed to transmit data about energy consumption to the utility and its

[12] Access Economics, *The economic benefits of intelligent technologies*, 2009.
[13] This tool is available on Avoicomunicare (http://www.avoicomunicare.it/carbonmeter/) (Telecom Italia's blog that encourages discussions on environmental and sustainable development.

customers in real time. Also, a home energy management system will allow customers to set appliances such as washing machines to operate during off-peak periods when electricity is cheaper, via the use of smart plugs.

The American initiative **Energy Smart Miami**, launched last year, will deploy more than 1 million advanced wireless smart meters to every home and small businesses in the Miami area. Consumers will be provided with in-home energy displays to help manage electrical loads and lower power use during peak periods. Smart meters will be able to communicate with appliances to reschedule high-energy functions or switch to a lower consumption mode during peak demand periods. Smart meters will also control thermostats.

E-DeMa[14] **project** in Germany, proposes a system integration of smart meters into an intelligent gateway that controls both energy consumption and energy supply on the basis of price signals from the energy market. Thanks to the gateway's wireless interface, customers can configure the system to meet their specific needs and set all this up on their laptops. In the future, washing machine will be able to provide customers with pricing signals – through an incentive system - so customers can choose the cheapest rate and be more efficient in their use of energy. In reality, in this project the concept of a consumer does not exist; E-DeMa deals with "prosumers", which are active consumers who both generate energy and upload it to the distribution grid (producers) and also consume energy (consumers). In this case, the system uses Power Line Communication (PLC) while E-Cube uses ZigBee standard.

Finally, the **Newington Smart Village project** in Australia shows that, thanks to smart meters with two-way communication, utilities can communicate with customers via tailored household websites or in-house displays. Also, households can remotely turn smart appliances on and off using iPhones or via a tailored website. This will help homes control energy using appliances and equipment, reducing running costs and greenhouse emissions.

IV . Policy approaches

ICT applications can make environmental impacts positive or negative and the balance of these outcomes can be strongly determined by incentive structures and policies that shape behaviors.
The implications for households of smart metering will vary according to the specific household's characteristics. For instance, the implications of smart metering for vulnerable consumers may be of particular concern. Furthermore, while smart metering can produce positive impacts such as reduced energy use and better environmental management in primary production and household activities, it raises also new consumer protection concerns and may produce negative impacts on privacy from potentially exploitative applications. Therefore, in order to guarantee a successful smart meters deployment it is necessary to address all these issues.

The policy analysis in E-Cube, is carried out according to the following steps:

1) Benchmarking analysis of the adoption of similar systems.

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[14] The abbreviation stands for "development and demonstration of decentralized integrated energy systems on the way towards the E-Energy marketplace of the future"

2) Evaluation of the policy options available: mandatory rollout of smart meters vs. incentive based strategies.
3) Assessment of the role that policies can play in shaping rules and incentives, taking into account that in many areas bottom up strategies are extremely important..

Hereafter, the paper presents the preliminary results of this analysis.

A. *Policy assessment for the adoption of Smart Meter*

The European electricity market went through a significant transformation during the 1990s. It transformed from a monopoly structure to a structurally unbundled market with the related changes to company configurations. Although this transformation started in the United Kingdom it has been adopted, with country specific variations, across Europe. In 1996, the European Parliament and Council issued the Internal Electricity Market Directive 96/92/EC that set goals for a gradual opening of national electricity markets and rules for transmission access in the 15 member states at that time.
In the last five years there has been a major policy shift from keeping the electricity price as low as possible in a free and competitive market to reducing carbon emissions. This shift has also resulted in decisions to look at the deployment of smart meters to help customers understand when they use electricity and to help them plan savings. Today, smart metering and smart grid initiatives are forcing another major transformation in the utility industry. Many utilities are rethinking their business models and processes as a result of the shift in the way energy is generated, delivered and consumed.

The drivers of smart metering policies have been: 1) liberalization of energy markets - in particular full retail competition, as introduced in the EU in July 2007 - and evolution of regulatory frameworks supporting more competitive market environments; 2) technology developments; 3) increasing electricity prices and consequent growing consumers' interest on possibilities of reducing their electricity bill; 4) the need to curb energy consumption levels, dictated by international policies and commitments related to energy efficiency and GHG emissions.

Market players (energy suppliers, consumers, Authorities, metering companies, etc.) face many different challenges to the large-scale implementation of smart meters and infrastructures (see Table 1).

Technical and organizational obstacles
▪ Need for interoperability: appliances, home networks and the grid should automatically recognize and communicate with one other. ▪ Need to protect personal data and adopt consumer protection measures. ▪ Define roles and responsibilities at each level of the value chain before, during and after the smart meter implementation. ▪ Need to invest more in energy management skills.
Economic and Regulatory obstacles
▪ Low tolerance for errors: due to the severe economic penalty from unreliability, there is limited experimentation and a disincentive to be a "first mover". ▪ Energy suppliers have few incentives to invest in the Demand-side management. ▪ Regulated and non-regulated energy markets. ▪ Smart meter technology is more expensive than that of traditional meters.
Behavioral obstacles
▪ Lack of awareness about the economic and energy-related savings. ▪ Need to define the ownership of the meter in order to prevent the situation in which a meter will have to be changed when changing a supplier.

Table 1: What stands in the way . Source: GeSI (2008)

In order to focus government intervention on smart metering deployment and reduction of GHG emissions, a number of policies can be identified. These policies (see Table 2) should also overcome the different problems that stand in the way for a massive implementation of smart meters.
In particular, Governments can play a regulating or a promoting role. The former concerns the framework in which smart metering infrastructure could be built and the decision to regulate or not the meter market. Instead, the latter considers the contribution to pilot projects and exchange of knowledge. An effective policy should encourage each country to give utility companies an incentive to invest in solutions that will reduce energy consumption.

Policymakers should not underestimate the impact of demand side interventions. In fact, pilot studies have shown that imperceptibly small changes in behavior can create significant system-wide saving, without diminishing the quality of life for the consumer. It is important to encourage utilities to give customers transparency, ownership and control of their usage information. Regulators should promote open competition and encourage partnerships across the value chain.

Moreover, governments should send a strong signal to the relevant stakeholders, showing commitment to grid modernization. Finally, the ICT industry should educate consumers on the benefits of smart grid and smart meter investments. Greater consumer awareness of both the environmental and economic benefits of smart grid will help put pressure on regulators and utilities to make ICT investments. Industry should also embrace open platforms and interoperability, a necessary step to gain the full benefit of a smart grid.

Create an enabling regulatory framework
▪ Commit to a long term strategy for reducing GHG emissions and aim for clear and consistent legislation ▪ Create a level playing field (open competition and partnerships) that supports market-based solutions ▪ Promote international standards in order to avoid extra costs on final users
Enable the development of solutions
▪ Conduct fundamental research benefiting all stakeholders (industry, consumer, etc.) ▪ Encourage innovation, not specific technologies ▪ Invest in required infrastructure
Support the business case when markets do not produce the desired outcome
▪ Provide the right incentives for utilities to invest in energy efficiency ▪ Ensure that market mechanisms create the desired environmental and social outcomes
Encourage positive behavior change
▪ Lead by example, publicizing benefits and the lessons from experience ▪ Facilitate and coordinate the sharing of information ▪ Support pilot projects

Table 2: Recommended policies
Source: GeSI (2008)

It is important to understand what are the best policy solutions for smart meters deployment and for the development of consumer's awareness about energy saving. Two different strategies can be taken into account. The first is the mandatory roll-out of smart meters; the second one is the incentive based roll-out.

The table below shows the different policies adopted by each country in the diffusion of smart meters.

Mandatory roll-out	*Incentive based roll-out*	*Voluntary based roll-out*
▪ Canada ▪ Denmark ▪ Italy ▪ Germany ▪ Finland ▪ France ▪ Netherlands ("smart city" program) ▪ Sweden ▪ Japan	▪ Australia ▪ United Kingdom ▪ United States	▪ Netherlands

E-Cube will assess the best policy instruments available to make possible an incentive based roll-out of the smart components designed by the project.

B. *Meter adoption: the consumer's view*

For utility companies to succeed in this new scenario of smart meters, they must have the ability to understand the different consumers' features and their profile. Demand response involves encouraging consumers to cut back or shift their electrical use in response to power grid needs, economic signals from a competitive wholesale market or special retail rates. Demand response has revolutionized the way we manage our energy consumption, allowing us to reduce our overall energy use and generate new cash streams that can be directed towards future energy efficiency efforts.

Although the positive impact of smart meters on energy efficiency is widely recognized, the diffusion of the technology is still retarded. Among others, an important reason for the slow diffusion lies within the unexamined acceptance of the smart metering technology by private consumers. According to Kranz (2010) [15] smart meters' acceptance is based on perceived usefulness, perceived ease of use, and subjective control. The pilot of the E-Cube project, will shade some lights on this issue.

C. *Cost-Benefit Analysis*

Projects in Europe, the US and other countries show that smart metering is technical feasible. Main issues are the actual value of the benefits, the costs involved, and the distribution of costs and benefits of smart metering between market parties involved.

In E-Cube, a specific work-package called the "socio-economic impact" will carry out the cost-benefit analysis of second generation smart meters' deployment. The cost-benefit analysis is required in order to assess project feasibility.

D. *Critical issues: Privacy and Consumer protection*

Although smart grid technologies can significantly increase energy efficiency and help in reducing carbon emissions, they also raise numerous privacy and data security concerns. As explained by the US National Institute of Standards and Technology (NIST), data privacy is the "Achilles' Heel" of the smart grid[16]. Therefore, privacy concerns arise when there is the possibility to discover personal information – habits, behaviors and lifestyles – inside dwellings and to use this information for secondary purposes, other than for the provision of electricity. Electric utilities and other providers may have access to information about what customers are using, when they are using it, and what devices are involved.

In particular, the NIST has identified 10 critical issues concerning privacy protection of smart grids:

- Identity theft
- Determine personal behavior patterns

[15] Kranz J. *et al*., *Power Control to the People? Private Consumers' Acceptance of Smart Meters*. The key variables able to influence users' consumption pattern are: Environmental and Knowledge awareness, Acceptability of Energy saving behaviors, Interpersonal influences (friends and parents) and External sources' influence (media), Gender, Age, Education, Income, Household size, perceived usefulness, perceived ease of use, privacy protection, Trust in the smart metering technologies, Energy price consciousness

[16] NIST, *NIST Framework and Roadmap for Smart Grid Interoperability Standards Release 1.0 (Draft)*, 2009. Available: http://www.nist.gov/public_affairs/releases/smartgrid_interoperability.pdf

- Determine specific appliances used
- Perform real-time surveillance
- Reveal activities through residual data
- Target home invasions
- Provide accidental invasions
- Activity censorship
- Decisions and actions based upon inaccurate data
- Reveal activities when used with data from other utilities.

The use of identifiable information beyond the primary purposes for which it was originally collected requires special considerations from a privacy perspective. There may be the temptation to bundle such information into several different data products such as energy usage or appliance data. Moreover utilities and third parties may use the data to seek consent for other services or to engage the user directly for commercial gain (e.g., targeted advertising). It is not yet clear who along the grid will have access to a user's personal information and where on the grid such access will be possible.

There are a number of important and necessary uses of personal information in the Smart Grid context, such as by a utility provider in the provision of service, price notification, connecting and disconnecting power remotely, and detecting the theft of devices. In addition, the use of personal information may be used to offer beneficial services to consumers, such as energy efficiency analysis and monitoring, and load management. However, other uses of consumer information - those not directly tied to the primary purpose of collecting the data - may raise privacy concerns if consent from the individual has not been obtained.

Back in the 90's the Ontario Privacy Commissioner Ann Cavoukian developed a new concept – *Privacy by Design* (*PbD*) – to address the ever-growing and systematic effects of ICTs and of large-scale networked data systems. Thus, utilities and manufactures should integrate the principles of *PbD* into the construction of their data infrastructures. These principles can ensure that key privacy concerns are taken into account before millions of dollars are spent and before Smart grid technologies are deployed. *PbD* advances the view that the future of privacy cannot be assured solely by compliance with regulatory frameworks; rather, privacy assurance must ideally become an organization's default mode of operation.

Foundational principles of *PbD* (see Table 3) may be applied to all types of personal information, but should be applied with special vigor to sensitive data such as medical information and financial data. The strength of privacy measures tends to be commensurate with the sensitivity of the data.

1. *Proactive* not Reactive; *Preventative* not Remedial
The *Privacy by Design* approach is characterized by proactive rather than reactive measures. It anticipates and prevents privacy invasive events *before* they happen. *Privacy by Design* does not wait for privacy risks to materialize, nor does it offer remedies for resolving privacy infractions once they have occurred - it aims to *prevent* them from occurring. In short, *Privacy by Design* comes before-the-fact, not after.
2. Privacy as the *Default*
We can all be certain of one thing – the default rules! *Privacy by Design* seeks to deliver the maximum degree of privacy by ensuring that personal data are automatically protected in any given IT system or business practice. If an individual does nothing, their privacy still remains intact. No action is required on the part of the individual to protect their privacy – it is built into the system, *by default.*
3. Privacy *Embedded* into Design
Privacy by Design is embedded into the design and architecture of IT systems and business practices. It is not bolted on as an add-on, after the fact. The result is that privacy becomes an essential component of the core functionality being delivered. Privacy is integral to the system, without diminishing functionality.
4. Full Functionality - Positive-Sum, not Zero-Sum
Privacy by Design seeks to accommodate all legitimate interests and objectives in a positive-sum "win-win" manner, not through a dated, zero-sum approach, where unnecessary trade-offs are made. *Privacy by Design* avoids the pretence of false dichotomies, such as privacy *vs.* security, demonstrating that it is possible to have both.
5. End-to-End Lifecycle Protection
Privacy by Design, having been embedded into the system prior to the first element of information being collected, extends throughout the entire lifecycle of the data involved, from start to finish. This ensures that at the end of the process, all data are securely destroyed, in a timely fashion. Thus, *Privacy by Design* ensures cradle to grave, lifecycle management of information, end-to-end.
6. Visibility and Transparency
Privacy by Design seeks to assure all stakeholders that whatever the business practice or technology involved, it is in fact, operating according to the stated promises and objectives, subject to independent verification. Its component parts and operations remain visible and transparent, to users and providers alike. Remember, trust but verify.
7. Respect for User Privacy
Above all, *Privacy by Design* requires architects and operators to keep the interests of the individual uppermost by offering such measures as strong privacy defaults, appropriate notice, and empowering user-friendly options.

Table 3: 7 Privacy by Design Foundational Principles
Source: SmartPrivacy for the Smart Grid (2009), page 19.

V. Conclusion and open issues

This paper has featured the E-Cube project and the working progresses made in the design of he system architecture and in the assessment of the best policies to be used for the smart meters deployment.

From the international benchmarking, E-Cube stands as a strong innovative project, and with a characterization as second generation smart meter system. Being Italy one of the leading country in energy smart meters penetration, E-Cube attempts to bring some additional features to the smart meters already in place, to allow for a greater customization of the services and a broad implementation of different setting and managing of energy usage rules. In fact, the information on energy use will be provided through a hand-held display device, via the internet or through a mobile phone. Through the smart components of the E-Cube system, appliances will be able to interact with the meters and the mobile devices.

Furthermore, E-Cube will provide practical implementation examples and trials of energy efficiency systems, with the aim of gathering further information about their usability, user acceptability as well as technology feasibility and robustness.

The policy assessment suggests preliminary options for E-Cube smart system diffusion and emphasizes some critical issue related to privacy and consumer protection that need to be considered by policy makers, companies and regulators.

There are no doubts about the potential benefits of smart metering:

- metering companies to decrease meter reading costs;
- grid operators who want to prepare their grid to the future
- energy suppliers who want to introduce new customer made services and reduce call centre cost;
- governments to reach energy saving and efficiency targets and to improve free market processes;
- end users to increase energy awareness and decrease energy use and energy cost.

Introduction of smart metering seems also a logic step in a world where all communication is digitalized and standardized (Internet, E-mail, SMS, chat boxes etc.) and where cost of digital intelligence are still rapidly decreasing.[17]

However, there are important issues that need to be addressed. Some are already considered in the future work plan of the E-Cube project but others are new issues for further research, such as industry coordination, standardization and adoption of national and international rules based on a solid energy policy.

[17] In the National Broadband Plan, presented last March, the FCC suggests as goal number six “ To ensure that America leads in the clean energy economy, every American should be able to use broadband to track and manage their real-time energy consumption.

References

Access Economics (2009), *The economic benefits of intelligent technologies*.

Bomhof F., Hoorik P. and Donkers M. (2009), *Systematic Analysis of Rebound Effects for "Greening by ICT" Initiatives*, in "Communication & Strategies", No. 76.

Climate Group (2008), *SMART 2020: Enabling the Low Carbon Economy in the Information Age*. Global e-Sustainability Initiative (GeSI).

Pupillo L., Salaneve J, Vickery G.(2009), "Communication & Strategies", *Green ICT, energy and climate change*, Introduction.

Davis F. (1989), *Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology*, MIS Quarterly, Vol. 13, No. 3, pp. 319-340.

Department of Energy, United States (DOE, 2003), *Grid 2030 - A Vision for Electricity's Second 100 Years*, Washington DC.

Department of Energy, United States (DOE, 2003), *The Smart Grid: An Introduction*, Washington, DC.

Electric Power Research Institute (EPRI, 2006), *IntelliGrid^{SM} Consumer Portal Telecommunications Assessment and Specification*, Technical Report, Palo Alto, CA.

Energy Information Administration (EIA, 2008), *Annual Energy Outlook*.

Essential Services Commission of South Australia (2007), *ETSA Utilities Demand Management Program – Progress Report*, p. 18.

European Commission (EC, 2008), *Energy Efficiency: delivering the 20% target*.

Federal Ministry of Economics and Technology (FMET, 2008), *E-Energy: ICT-based Energy System of the Future*.

Fraunhofer ISI *et al.*, *Study on Energy Savings Potentials in EU Member States, Candidate Countries and EEA Countries*, preliminary results.

Information and Privacy Commissioner (2009), *SmartPrivacy for the Smart Grid: Embedding Privacy into the Design of Electricity Conservation*, Ontario, Canada.

Kranz J. *et al.*, *Power Control to the People? Private Consumers' Acceptance of Smart Meters*.

National Electricity Market Management Company (NEMMCO, 2006), *Metering and Retail Market Development 2006 Annual Report*, p. 35.

National Institute of Standards and Technology (NIST, 2009), *NIST Framework and Roadmap for Smart Grid Interoperability Standards Release 1.0 (Draft).* Available: http://www.nist.gov/public_affairs/releases/smartgrid_interoperability.pdf

NERA Economic Consulting (2008), *Cost Benefit Analysis of Smart Metering and Direct Load Control*.

Siderius H., Dijkstra A. (2009), *Smart Metering for Households: Costs and Benefits for the Netherlands*.

Siemens (2008), *Sustainable Buildings-Smart Meters: Stabilizing the Grid*. Available: http://w1.siemens.com/innovation/en/publikationen/publications_pof/pof_fall_2008/gebaeude/zaehler.htm

The Boston Consulting Group (2008), *SMART 2020: Enabling the low carbon economy in the information age*, Global e-Sustainability Initiative (GeSI).