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ICT FOR DEMAND SIDE INTEGRATION

REPORT ON TECHNICAL AND NON-TECHNICAL BARRIERS AND SOLUTIONS

D4-3

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Acronyms

µCHP: micro Combined Heat and Power
AC: Alternating Current.
CCGT: Combined Cycle Gas Turbine
DER: Distributed Energy Resources
DG: Distributed Generation
DLC: Direct Load Control
DSI: Demand Side Integration
DSI: Demand Side Integration
EMS: Energy Management System
EU ETS: European Union Emission Trading System
EV: Electric Vehicle
HEMS: Home Energy Management System
ICT: Information and Communication technology
ILC: Indirect Load Control
V2G: Vehicle to Grid
XML: eXtensible Markup Language

EXECUTIVE SUMMARY

WP4 focuses on the ICT that will enable the integration of different stakeholders with the end-users to facilitate Demand Side Integration (DSI) in the future. To this extent D4-2 suggested to develop an interoperable ICT Demand Side Service oriented Platform (DSSP). The work presented in this report identifies barriers to the deployment of DSI through the ICT and solutions to it and builds upon the results of the previous deliverable D4.2, as well as, the work done in different European and world wide projects and contexts, such as, OpenMeter, Smart-A, CRISP, CIGRE and others.

The barriers identified are directly linked with the end-user although a complete view of his interaction with other stakeholders is highlighted. The investigated barriers are of technical and non-technical nature.

- Barriers related with the availability of smart-equipment that include:
    - The lack of Smart Meter and the lack of agreement on a minimum functionality they need to support.
    - The lack of Smart appliances, the cost of replacing current appliances by new ones and the cost of retrofitting existing ones for DSI use.
    - The lack of Building management systems (BMI) and their standardization.
- Barriers related with interoperability are general, in the sense that they affect the Grid Operator, the intermediary entities and the end users. Interoperability issues are analyzed at the following levels:
    - Communication level, which looks at the physical logical and network connection aspects.
    - Message format level to guarantee the syntactic understanding of the messages exchanged.
    - Semantic level that provides the means for the understanding of the messages.
    - Services interface level to achieve uniform access to services independent of the providers.
- Additional ICT barriers for the deployment of DSI, that are not exclusive of the electricity field, such as, security, robustness and scalability have been analysed:
    - The barriers related with security of the information exchange are subdivided into:
        - Confidentiality of the information exchanged between the stakeholders and the possibility of external non desired access to it.
        - Integrity of the information to guarantee that the information exchanged is not modified in any way by any party.
        - Availability of the information that guarantees that every actor that needs has the access to the required information and there is not any denial.
    - Robustness and scalability are other barriers described related with the unavailability of services and slow responses.

- Privacy may be a significant barrier for the introduction of DSI services, especially if data protection measures are not included early in the system design. Legal regulations concerning data protection should not inhibit these services, provided that: 1) participation in DSI services is not mandatory; and 2) the data is sufficiently protected. The public image of DSI may become problematic, especially if people start to worry about 'Big Brother' looking into and controlling their house.

Possible solutions to the identified barriers have been described within the report, like the following ones:

- The roll out of smart meters.
- Retrofitting of existing appliances, although currently only exists at the level of thermostats but with the development of intelligent switches some other appliances could participate.
- The development of Building Energy management systems for homes.
- Allocation of financial benefits to customers willing to install smart appliances and to participate in DSI programs.
- One solution for eliminating the interoperability barriers appear to be the provision of standard solution at all levels previously described, but taking into account that the achievement of the standard should ensure the participation of all interested parties, have a clear scope, have common design principles based on agreed architectural solutions. The solution should build on the results achieved by the different standardisation initiatives and groups that already exist.
- Solutions to security barriers have been described, like: Using dedicated lines, using tunnels, using the available Internet protocols, the use of protocols being used for the session initialization of voice over IP and Instant messages, and some other approaches that are still at the research level.
- Solutions to robustness and scalability, that are being used in other domains, like hardware redundancy and virtualization are described.
- Possible solutions to eliminate the privacy barrier are presented, like: good communication with the public and the application of 'privacy by design' principles in the system design of DSI services.

National cases. The current status of the installation of the smart meters in European countries has been analysed. Different development stages resulted that go from still research/test (Denmark, The Netherlands and Spain), to more advanced situations, like partial installation in the UK or large extended coverage in Italy.

The proposed DSSP concept has to consider the above barriers and to provide the solutions of shared practises, including rules of governance of the DSI . To this extent, the DSSP has to be closely and carefully coordinated with the roll out of complementary infrastructures (as smart meters and smart appliances), addressing and supporting the related standardization initiatives.

The DSSP is expected to be the environment where solutions to security and safety issues of the system can be suitably addressed, thus contributing to overcome social hardnesses.

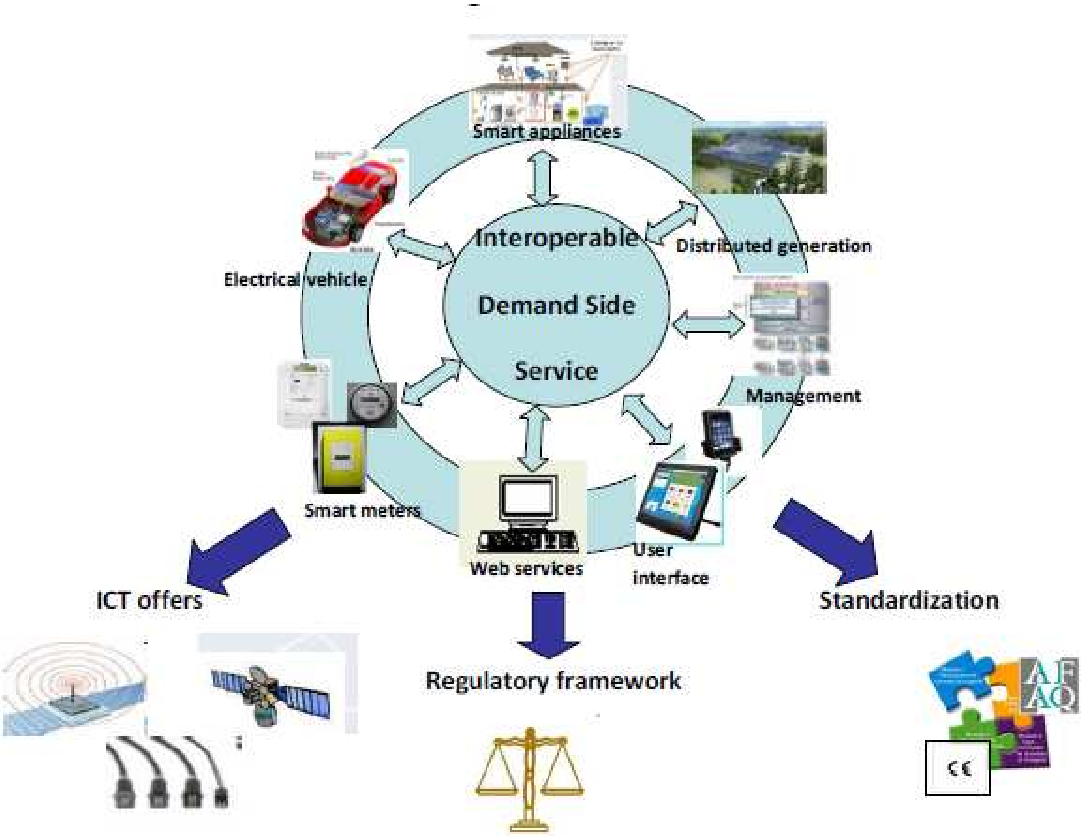

Figure 1: The concept of DSSP (ICT interoperable Demand Side Service oriented Platform)

The SEESGEN-ICT WP4 consortium recommends to develop the DSSP concept, through the promotion of research projects and pilots and demonstrations both at the laboratory scale and at the real scale and the creation of ad hoc working groups.

1 INTRODUCTION

The work done in this document builds upon the results achieved in the previous SEESGEN-ICT deliverable D4.2, which described the main stakeholders involved in the demand side integration operation:

- The end-users, who are the entities willing to offer their flexibility for improving the management of the network. The flexibility available at the end-user premises is mainly due to their electrical loads and to distributed generation/storage that the user operates.
- The Distribution System Operators, who are regulated entities responsible for the transport of the electrical power on the distribution networks. They provide access to the distribution network users according to non-discriminatory and transparent rules and ensure the quality and security of supply.
- The intermediary entities that are covered by the Aggregator, the Match Maker and the Clearing House. The Aggregator is in charge of gathering the end-users flexibility and negotiating services that it can provide in the electricity market. The Match Maker is in charge of facilitating the selection of the Aggregator by the end-user. The Clearing House is in charge of facilitating the market process, by collecting and coordinating interactions between market participants.

Deliverable D4.2 along with the identification of the main stakeholders and their roles, made a description of their requirements to allow the deployment of Demand Side Integration. The requirements identified can be classified into economical, social and technical requirements. The technical requirements can be further subdivided into equipment related, interoperability, security and confidentiality.

The economical requirements of the stakeholders are related with investments required by the automation of the process and the expected revenues. Questions, such as, which is the benefit of DSI?, How long is the return of the investment in the automation of the process? How are the expenses going to be shared?.

The social barriers are mainly related with the end user and its adaptation to a level of automation that is easy to monitor, that does not impose learning processes, that is plug and play like the existing devices, that is trustful and that ensures its privacy.

The technical requirements for equipments are related with the availability of devices able to communicate with other equipment and the end-user, and the existence of equipment able to take decisions based on the interaction with external equipment increasing the benefit and the comfort of the users.

The interoperability requirements are related with the world wide adoption of standards that are able to implement the communication between the different stakeholders and with the end-users' devices, covering the functionality required by DSI.

The security and confidentiality requirements are related with the need to ensure a safe operation of the electricity network when a variety of stakeholders participate in its management. This exchange of information should be guaranteed to be free of intrusion, attacks, denial of service and keep the required degree of confidentiality.

The unsatisfactory fulfilling of the requirements described in deliverable D4.2 becomes a barrier for the successful deployment of DSI.

In this report we identify the barriers related to ICT and also the possible solutions to them. The report has been structured in the following way: chapter 2 deals with the technical barriers, related to the equipment, to theinteroperability issues and and to additional risks for the safety and security. Chapter 3 deals with the non-technical barriers (regulatory and economical barriers and social barriers, Chapter 4 describes the current situation in some European Countries and chapter 5 provides the conclusions of the work.

2 TECHNICAL BARRIERS

2.1 Barriers related to the equipment

The DSI through the ICT requires different infrastructures:

- □ Smart meter: A mean to provide information about the energy extracted (or sometimes delivered) by the end-user on a usable form by the ICT is required.
- □ Smart appliance: to enable the load shifting through the ICT, flexible load need to be manageable thanks to remote control and automation.
- □ Smart devices for DG: in the same way, distributed generation (form RES for example) or distributed storage (from EV) should be manageable thanks to smart device
- □ Smart devices for the network: For a DSI technically and economically viable, the network should be able to use the services build from the DER. It involve that there are the required equipment for an auto-reconfigurable network (automation, sensor, ICT infrastructure)

A solution as the Demand Side Service oriented Platform,which will provide shared ICT practice and will lead to deply the ICT infrastructure need to take account the requirement of these equipments.

This section will discuss the equipment-related barriers and recommendations for demand-side integration. It will focus on smart meter and smart appliance, involved in the shorter term issue of the DSI on the end user side: the flexible loads. The information is taken directly from the deliverables of two EU projects, OPENmeter and Smart-A.

2.1.1 *Barriers related to the Smart Metering*

from http://www.openmeter.com

Smart meters are the visible face of a new ICT infrastructure promoted by the European Commission to improve energy efficiency. Smart metering allows electricity consumers to play a more active role in the functioning of the electricity markets, and allows distribution networks to be more active thus leading to early realisation of the Smart Grids. Metering services will represent the gateway for access to the new grid, and have a critical consequence on power demand, which will facilitate the demand-side integration. The potential benefits attributed to smart metering systems for different stakeholders include:

- For end users to increase the awareness of energy use, decrease their energy use and energy cost and facilitate a more efficient switching of energy suppliers.
- For energy suppliers to introduce new, customer made services and reduce call centre costs.
- For metering companies or energy suppliers to decrease meter operation costs.
- For Distribution Network Operators (DNO) to take better informed investment decisions by providing detailed consumption data.
- For grid operators to prepare their grid for the future.

- For governments to reach energy saving & efficiency targets and to improve free market processes.

It is anticipated that smart metering will radically change the way electricity markets work and networks are managed through demand-side integration. However, the lack of smart metering infrastructure poses a significant barrier. Although there are a large amount of meters installed that can be read remotely by automated meter reading systems, the vast majority of these systems would require significant upgrades to support more advanced functionalities for the AMI (Advanced Metering Infrastructure).

Nevertheless, the deployment of smart meters faces regulatory requirements, different market conditions, functionality requirements and Integration requirements to be solved first.

Actors involved

The actors affected by the deployment of the smart metering are: smart metering manufactures, DNO, TSO, retailers, energy suppliers, generators, the aggregators, the metering companies, the final customers, policy makers, and the standardisation organisations.

Solutions

The solutions to activate the deployment of smart metering will have to satisfy the following requirements:

- Regulatory requirements: These requirements will depend on whether there exists a regulated or liberalized smart meter policy. In the case of a regulated meter policy, the roll-out of smart meters seems the best approach for their deployment and in the case of a liberalized policy a customer could buy the meter from any provider and as a consequence the deployment is dependent on market rules.
- Functionality requirements: The minimum functionalities that a smart meter should have, according to the OPENmeter project consortium, include:
    - Remote meter reading.
    - Load profile data.
    - On demand meter data access for customer.
    - On demand meter data access for 3rd party.
    - Provision of variable time-of-use tariffs (time bands).
    - Remote meter management.
    - Remote demand reduction and connection/disconnection.
    - Price signal to customer.
- Integration requirements: The smart meter will have to be integrated with the transformation centre on one hand and with the network at the facilities of the end customer, on the other hand.
    - For the communication between the meter and the data concentrator, it appears that PLC could be the choice for communication.

- For the communication between the smart meter and the smart appliances, wireless technologies could be the most appropriate.

2.1.2 *Barriers related to the Smart Appliances*

from http://www.smart-a.org

Demand-side integration is a cornerstone of sustainable energy systems, which feature a higher share of intermittent generation, depending on the availability of renewable energy or demand for heat from CHP processes. Such systems require smart energy loads which can coordinate their operation with current levels of energy supply. Smart domestic appliances can offer a range of options for load-shifting, including delaying the start of washing or dishwashing cycles, intermediate interruptions of the operation of appliances, or the use of refrigerators and freezers for temporarily storing energy. However, currently there are very few smart appliances on the market. Retrofitting suitable controllers that incorporate ICT technologies to the existing household appliances, such as washers, dryers, and water heaters, which can respond to external signals, e.g. price signals, and user preferences via home automation technology will be a significant challenge. Only retrofits that are being used (again more as pilots) is automatic thermostat controllers that are being incorporated into space heaters. Further as the smart appliances are expensive replacing the existing appliances with smart ones are remote. More importantly to harness the maximum benefits from smart appliances for demand side management a good communication infrastructure should be in place.

Some utilities are considering home area automation controllers (or energy boxes), to coordinate all smart appliances in a home for effective demand-side integration. Such controllers offer visualisation and processing capabilities, and their settings can be modified by the user manually or by other controllers automatically through the communication infrastructure. However, except some pilot initiatives no utility is planning deployment of home area automation controllers. The widespread deployment of home area automation controllers are hindered by the availability of diverse technologies and ICT architectures. At present, there are no standardised home area automation controllers, no well-recognised home area automation architecture, and no communication technologies with absolute advantages although PLC, ZigBee, Z-Wave etc are all widely used.

Actors involved

The actors affected by the use of the smart appliances are: manufactures of domestic appliances, manufactures of local energy systems, retailers of domestic appliances, DNO, TSO, energy suppliers, generators of electricity from renewable energy sources and from cogeneration, the aggregator, the final customers, policy makers, and the standardization organisations.

Solutions

The recommendations to facilitate the deployment of smart appliances were provided by the Smart-A project consortium and they are assigned to three different categories of actions which have to be taken up.

- "Ad hoc " action

The recommendations in this category do not need an extensive preparation period and therefore might be implemented almost immediately.

- Shift of appliance operation: To promote this kind of energy shifting, appliance manufacturers should include an advice in their instruction manuals and energy utilities informing their customers about the benefits of having appliances operated during night e.g. by using timer control means.

- "Short-term" action

The realisation of the recommendations given in this category needs some time for preparation, but they have to be started at once.

- Off-peak period tariffs: As energy in off-peak periods may comes more likely from renewable energy sources, energy utilities should offer a variable tariff (fixed times or time of use dependent) with lower costs for off-peak electricity consumption. This would allow consumers to gain financial benefits when operating the appliance in off-peak periods. Energy utilities should be obliged to offer variable or time-of-use tariffs together with the availability of intelligent and in house communicating power meters. All these will facilitate the use of smart appliances
- Advanced smart meters: Smart metering is one obvious link between the energy system and the appliance itself and seen as a platform for an informed consumer with the capability to response to requirements set by the energy supply. Most types of smart meters installed do not provide this feature. Therefore the definition of smart meters should be extended. In addition the EU Commission should fix the requirements for smart meters in the Energy Service Directive.
- Credits for smart functions in Energy Efficiency calculation: As household appliances are regulated under the Eco-Design directive 2005/32/EC, options to enhance the use of renewable energy need to be included into this regulation. As an example a credit of 20 kWh on the annual energy consumption under the directive 2005/32/EC may be given to washing machines, dishwashers and tumble dryers when a timer function (e.g. start-time delay) is implemented. A credit of 50 kWh may be granted when the appliance can be connected to a remote energy management system. This would foster the introduction of timer and remote energy functions as the classification of the appliance in the Energy Label would be changed. The EU Commission should launch a specific study regarding the inclusion of smart functions in the Energy Label system for household appliances (EuP directive).

- "Long-term" action

The realisation of the recommendations in this category needs an even longer time for preparation in comparison to the short-term actions, but they also have to be started directly.

- Cross-sector communication: As the enhanced use of renewable energy by household appliances involves at the same time the sectors of energy production, energy distribution and household appliances itself it is of highest importance to enforce the communication between the sectors thus to build up mutual understanding and co-operations. A plan should be developed on how the volume of smart appliances in the market could be scaled up. The European

Commission should start a European wide large scale activity programme developing a roadmap for the introduction of smart appliances into smart grids. As many actors as possible should be included into such a kind of flexible demand network.

- Cross-sector standardization: It is very important that the European wide or even worldwide standards for communication signals about availability or demand of energy are in place. As by now communication standards are developed almost only within single sectors, but not between the sectors, a strong signal and engagement is necessary. Smart-A project suggested that the EU Commission should launch a study to investigate in detail the available communication standards and to outline a potential common communication standard between the sectors. Finally a mandate should be given by EU Commission to develop a joint communication protocol for tariff or availability signals between energy supplier, energy distributors and appliances.
- Allocation of financial benefits: Smart operation of appliances may in some cases request from the customer to accept some limitations in the flexibility of use. Achieving this acceptance needs some benefits, which can be done by
    - Offering special tariffs for smart operating appliances
    - Giving subsidies for buying smart appliances.
- Additionally, as economies of scale need to bring the costs for smart operations down, procurement programmes may be needed to generate a high demand for smart appliances and thus convince manufacturers to invest in the large scale production of such kind of machines. The EU Commission and national governments should investigate models to transfer financial benefits from the grid operator to the consumer (e.g. CO_2 tax) and should launch procurement programmes for smart operating appliances.
- Protect privacy of data: As a smart energy system with a sophisticated use of renewable energy by smart domestic appliances would request sharing of information about actual usage behaviours of millions of consumers the need to protect this information against misuse is obvious. The EU Commission and national governments should introduce a regulation for privacy of

In conclusion, previous working group give recommendation to support the deployment of smart meter and smart appliance. ICT use for DSI in general, and development of a ICT Demand Side Service oriented platform in particular, required:

- to be coherent with the technical specifications and integration conditions of these equipments
- to be coordinated with the efficiently supported roll out of these equipments

2.2 Barriers related to the Interoperability

The Interoperability is one of the core issues of the ICT use for DSI, and consequently of the Demand Side Service oriented Platform (DSSP) as solution to support the end-user participation. The DSSP has to provide ICT shared practices to enable the stakeholders of the DSI to interact efficiently, and pertinent standardization will be one of the main tools to reach this objective.

The starting point for the following analysis will be the information about interoperability barriers extracted from the previous deliverable. In D4.2, in fact, lack of interoperability is reported as a key technology barrier (including standard communication with smart appliances and standard architecture).

Then the discussion will go into details about standardization, in order to understand when standardization is a solution for these barriers and what are the main stakeholders involved in the standardization process with regards to DSI and what are the relationship among them.

At the end, it will be presented a real case.

2.2.1 *Interoperability barriers*

Looking at the previous deliverable D4.2, it is evident that lack of interoperability barrier affects all the different parts of the DSI architecture and all the actors involved [SEESGEN-ICT 2010]:

- The DSO, without an appropriate interoperable communication framework could be not able to guarantee the needed information exchange in due time and securely;
- The VPP aggregator "has to support and communicate with an array of different end-user systems with different properties". Lack of interoperability could hinder this capacity;
- The Match Maker "would have to support a great array of different end-users and be able to interface with a great number of different market aggregators." So it needs to overcome interoperability barriers towards both end-users and aggregators;
- Also the Clearing House has "to interact with many different end-users and other stakeholders"
- From the end-user point of view, joining a VPP aggregator should be an easy and quick process. What he desires is the ability to automatically set-up contracts with an aggregator and to automatically change his aggregator if another one will reveal to be more adequate for his needs. This ability requires the demolition of interoperability barriers.

Moreover, interoperability is needed not only for interfacing the actors, but also for interfacing them with appliances, smart meters and DERs:

- "Solutions and standards are needed for appropriate types of communication gateways in the household (connected to a smart meter or not), the communication between the utilities and the gateway as well as in-house communication between the gateway and individual appliances." [SEESGEN-ICT 2010]

Interoperability was already defined in [SEESGEN-ICT 2010], according to the definition provided by the "IEEE Standard Computer Dictionary", as "the ability of two or more systems or components to exchange information and to use the information that has been exchanged" [IEEE 1990]. From a more practical point of view it can be stated that "interoperability is achieved when the expectations of the user to exchange and use information among various devices and software applications from multiple vendors or service providers are met" [EICTA 2004].

In the context of DSI some scenarios can be imagined in order to better understand this definition:

Scenario 1: Various aggregators offer their aggregation services on the liberalized market. The end-user, which has previously subscribed a contract with one of them, using a service provided by a Match Maker is informed about an aggregator that fit better with his own requirements. Therefore the end-user decides to change his aggregator. Thanks to interoperability, he have not to install new software neither to buy new devices, but his devices are able to arrange into a new configuration and to automatically set-up the connection with the new aggregator. At the end, without any additional effort, his domestic network will exchange messages with the new aggregator.

Scenario 2: An end user buys an appliance. He brings it into his home and the appliance colleagues itself to the pre-existent domestic network. The network manager, through a plug-and-play approach, accepts it in the network, updates the configuration of the home network and communicates to the aggregator, for example, the increased demand-response availability due to the new appliance.

Scenario 3: A similar scenario can be thought for a prosumer that installs new generation capacity nearby his home or building or enterprise. The energy management system, which controls the decentralized generators of the prosumer, has to update the configuration and to communicate to the aggregator the increased generation capacity.

It is recognizable that end-user requires not simply overcoming lack of interoperability, but also that the solution to this barrier will:

- realize plug-and-play functionalities for integrating new loads and new generation into the management system [SEESGEN-ICT 2010];
- carry out home gateway for implementation of energy management and building automation functions, based on non proprietary technologies so to allow the integration of applications from different manufacturers [SEESGEN-ICT 2010];
- be based on stable standards so that every new release will not require purchase of new software or devices since they will enclose retro-compatibility capabilities;
- be usable, so that he will be able to use the resulting system without perceiving the standard stack hidden under the application level. It is important to note that lack of usability (and appeal) of the system could be itself a barrier increasing psychological resistance of the end-users.

A good way to overcome additional barriers, due to possible lack of satisfaction of these end-user requirements, is to involve the end-users in the standardization process.

An example of how users could be involved is the UCAIug, a user group that works strictly with standardization bodies, in order to influence standards development and to provide testing programs.

2.2.2 *Standardization as a solution*

Standardization has to involve different levels:

- communications: including physical, logical but also network connection;
- services interfaces: in order to consent uniform access to service from different providers;
- message formats: which means the syntactic understanding of message exchanged;
- semantic: in order to allow the correct understanding of concepts contained in messages;
- business procedures: e.g. for pricing, bidding, scheduling, etc.

It is important to highlight that standards facilitate interoperability, but "working on a standard and implementing a standard may not automatically lead to interoperability". [EICTA 2006] Moreover the standardization process itself could produce lack of interoperability, if the process was not focused on getting interoperability.

In [EICTA 2006] it is defined a set of principles for building standard having the objective of interoperability.

The most interesting, for our purposes, are:

- Openness and transparency of the standardization process: the aim is to involve the interested actors in the process so to get a standard that really satisfies their requirements. In this way the standard will be able to reach the needed critical mass of users that makes the difference between a loosing and a successful standard. The openness requirement implies also that specifications should be made available for free or at low cost, so to promote public evaluation and diffusion of the standard.

- Clear scoping of the standardization project on interoperability: the project should focus on interoperability requirements, possibly leaving all the other functionalities unspecified, so stimulating competition on these value-added functions. This focusing could also help in reducing the time needed to arrive at the definition of the standard. This one is an important goal, being the slowness one of the main weak points of the standard development process.

- Employ of common design principles: in order to get a set of standards useful for building an interoperable architecture, it should be desirable that each of will follow the same design principles. A good example are Web Service standards that are designed thus to be easily put together.

  An interesting approach of a common design model, in the context of DSI, is suggested by EPRI in [EPRI 2010]. The proposed model is called "REC&VEN concept". The main idea is to move the intelligence and decision making responsibility towards the product (appliances, distributed generators, etc.), since "smart needs to imply that the device/product itself is able to apply intelligence in the process of assisting the smart grid". Consequently a resource is defined as the technology or the system that "is able to receive the message and address the situation about which it has been informed" using its embedded intelligence. The White Paper refers to such a resource as Virtual End Node (VEN).

The logical driving of grid priorities and strategies belong still to the utility entity, but it does not need to know how each DER have to operate internally to get the result. The logical function that determine "when and why to send specific grid messages to the resources it manages" is called Resource Energy Controller (REC).

Following this model, each VEN provides to the REC generic capabilities (e.g. definition of itself as producer or consumer or both, amount of energy it can provide, amount of load curtailment it can supply, maximum duration of this supply and so on) so that the REC knows resources it can manage (in this sense it can be considered a VPP) but do not have to "be burdened with managing the resource minutiae".

This approach is scalable and recursive, so that the same entity could be seen from one side as a REC, from the other as a VEN. For example, the home energy management system is a REC for the appliances (the VENs) and a VEN for the aggregator (the REC). In turn this aggregator will be seen as a REC by the DSO. See figure below.

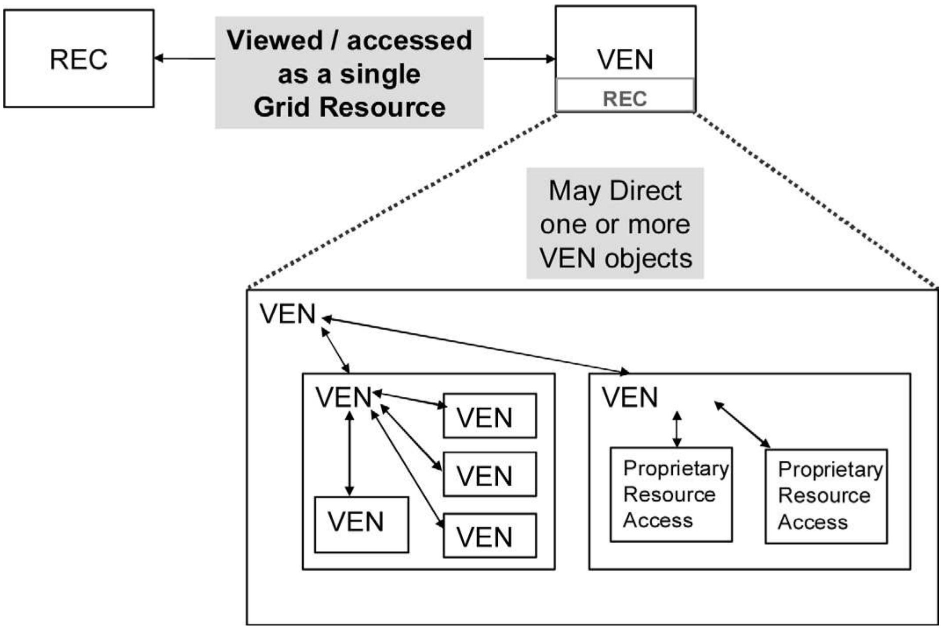

Figure 2. - Recursivity of the REC-VEN concept. [EPRI 2010]

- Execution of interoperability testing and prototype implementations: in the final phase of the process, prototypes should be built and testing of the reached level of interoperability should be executed. These can give a feedback about the maturity of the standard, so guaranteeing that in the produced specification there are not potentially lacks of interoperability. This can encourage the adoption of the standard in the real world.

Standard developers

In [SEESGEN-ICT 2010] a global vision about available standards was given. The resulting picture told about a diversified situation: there are interesting and mature standards that cover some parts of the DSI framework, but there are also gaps that have to be filled or, at the opposite, surplus of standards but no one completely satisfying.

What was really needed, at this point, would be a complete architecture in which these standards could be composed in an interoperable manner.

According [EICTA 2006] three steps would be needed to get this result. They are: “selection of standards, composition approaches and feature alternatives”. But in the DSI context, because of the problematic situation related to standardization, additional steps are needed. They are: survey of available standards and identification of gaps to fill and of lacking standards that need to be developed. In USA, NIST is already advancing on this way and it has produced a roadmap for Smart Grid Interoperability Standards [NIST 2010]. This could be a good starting point also for Europe. But having, the European energy framework, many differences from the U.S. one, it will be, probably, necessary at least a deepen analysis of NIST work in order to understand how much in it can be reused in Europe.

From the point of view of the definition of this complete framework, it is interesting to look at the main actors of standardization in DSI context, trying also to understand how they are combining their efforts in order to define the needed complete interoperable architecture.

To better understand what this architecture should be, it is remarkable the IEC point of view. According to IEC “what is realistic is defining boundaries where major progress can bring quick benefits without jeopardizing future successive improvements. And then at each boundary, the deepness of interoperability should be defined: Using the same dictionary? Talking the same language? Plug and play capability? Total interchangeability? Etc.” [IEC Web Site]

Relation between standardization stakeholders

The diagram below aims to give a picture of the main relations between these actors, in order to highlight dynamics in progress in the Smart Grid standard community.

Pink boxes represent the stakeholders, cyan boxes represent some standards (not all the standards are shown in this diagram, but only those involving more than one of the selected actors) and green ones are projects or initiatives.

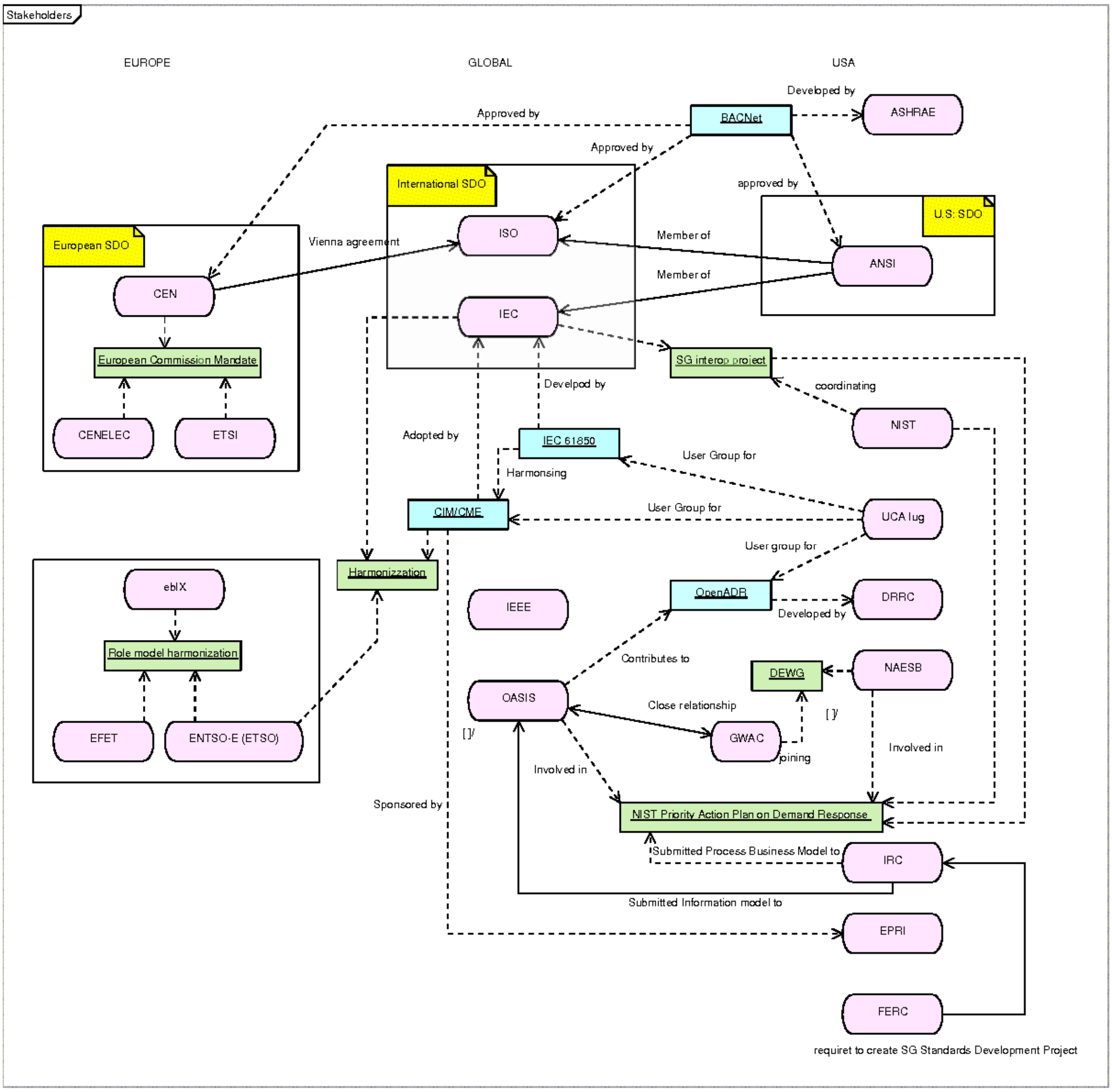

Figure 3. The main relation between the standardization stakeholder

List of the stakeholders

The list of stakeholders presented here does not aim to be exhaustive. It means only to show the complexity of the situation.

ISO	***International Organization fro Standardization***	**Type: Non-governmental Organization**	**Global**
About ISO	ISO is *"the world's largest developer and publisher of International Standards*" (from ISO Web Site)		
Role in DSI	ISO has published various standards related to DSI (e.g. BACnet, KNX, LoneTalk)		
Web site	http://www.iso.org		

IEEE	***Institute of Electrical and Electronic Engineers***	**Type: Professional association**	**Global**
About IEEE	IEEE is the world association of electrical and electronic engineers. Moreover IEEE provides a lot of standards.		
Role in DSI	The IEEE P2030 Working Group is developing guidelines for "Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System (EPS), and End-Use Applications and Loads".		
Web site	IEEE: http://www.ieee.org/ IEEE P2030: http://grouper.ieee.org/groups/scc21/2030/2030_index.html		

IEC	***International Electrotechnical Commission***	**Type: Non-governmental Organization**	**Global**
About IEC	IEC prepares international standards, for electrical, electronic and related technologies, as a basis for national standardization.		
Role in DSI	IEC TC57 *"develops and maintains International Standards for power systems control equipment and systems including EMS (Energy Management Systems), SCADA (Supervisory Control And Data Acquisition), distribution automation, tele-protection, and associated information exchange for real-time and non-real-time information" (from IEC TC57 Web Site)* In particular, Working Group 16 works on "Deregulated energy market communications" and WG 17 on "Communications Systems for Distributed Energy Resources (DER)". IEC has developed various interesting standards for the smart grid (e.g IEC 62325, IEC 61850)		
Web site	IEC : http://www.iec.ch IEC TC57: http://tc57.iec.ch/index-tc57.html IEC Global Standards for the Smart Grid : http://www.iec.ch/zone/smartgrid/		
Relations	• IEC 62325 specifications extend OASIS ebXML in order to get a framework for energy market communications • IEC has officially adopted the Common Information Model (CIM) standard. This one is a standard developed by the industry for exchanging information about the configuration and status of an electrical network. In particular CIM has an extension for Market Operations called CME (CIM Market Extension). This one could be useful in DSI Business Processes. • In particular it is in act an harmonization process between CIM and IEC 61850		

OASIS	***Organization for the Advancement of Structured Information Standards***	**Type: Not-for-profit consortium**	**Global**
About OASIS	OASIS develops standards for the global information society. For examples it produces a lot of standards for Web Services and for e-business.		
Role in DSI	OASIS Blue is developing standards for Smart Grids. Under OASIS Blue there are Technical commissions which are developing specifications useful for DSI: • Energy Interoperation TC: is developing data and communication models that enable the interoperable and standard exchange of signals for dynamic pricing, reliability, and emergencies. • Energy Market Information Exchange (eMIX) TC: defines open standards for exchanging energy price and product characteristic Moreover OASIS Open Building Information Exchange (oBIX) TC developed a standard for communication between control systems in buildings and enterprise applications.		
Web site	OASIS: http://www.oasis-open.org OASIS Blue: http://www.oasis-blue.org/		
Relations	• OASIS is collaborating with NIST, UCAIug and NAESB in the **NIST Priority Action Plan** on Demand Response and Distributed Energy Management Signal Semantics. • OASIS Interoperation TC in basing its work on (DRRC) OpenADR Specification. • OASIS Interoperation TC has close relationship with GWAC [OASIS 2009]		

CEN	*European Committee for Standardization*	Type: International non-profit organization	Europe
About CEN	CEN is a major provider of European Standards and technical specifications. In 2007 it has signed an agreement with ISO, which ensures technical cooperation and adoption of the same text, as both an ISO Standard and a European Standard.		
Role in DSI	CEN has published various standards related to DSI (e.g. BACNET and KNX). Moreover it has been invested by the European commission with a mandate, to create, together with ETSI and CENELEC, "European standards that will enable interoperability of utility meters (water, gas, electricity, heat), which can then improve the means by which end-users´ awareness of actual consumption can be raised in order to allow timely adaptation to their demands (commonly referred to as ´smart metering´)"		
Web site	CEN: http://www.cen.eu European Commission Mandate: http://www.cen.eu/cen/Sectors/Sectors/Measurement/Documents/M441.pdf		
Relations	• Involved with CENELEC and ETSI in the European Commission mandate for interoperability of utility meters.		

CENELEC	*European Committee for Electrotechnical Standardization*	Type: non-profit technical organization	Europe
About CENELEC	CENELEC mission is "*to prepare voluntary electrotechnical standards that help develop the Single European Market/European Economic Area for electrical and electronic goods and services removing barriers to trade, creating new markets and cutting compliance costs*" (from CENELEC Web Site)		
Role in DSI	CENELEC has been invested by the European commission with a mandate, to create, together with ETSI and CEN, "European standards that will enable interoperability of utility meters (water, gas, electricity, heat), which can then improve the means by which end-users´ awareness of actual consumption can be raised in order to allow timely adaptation to their demands (commonly referred to as ´smart metering´)"		
Web site	CENELEC: http://www.cenelec.eu European Commission Mandate: http://www.cen.eu/cen/Sectors/Sectors/Measurement/Documents/M441.pdf		
Relations	• Involved with CEN and ETSI in the European Commission mandate for interoperability of utility meters.		

ETSI	*European Telecommunications Standards Institute*	Type: not-for-profit organization	Europe
About ETSI	ETSI produces "*globally-applicable standards for Information and Communications Technologies (ICT), including fixed, mobile, radio, converged, broadcast and internet technologies*." (from ETSI Web Site)		
Role in DSI	ETSI has been invested by the European commission with a mandate, to create, together with ETSI and CEN, "European standards that will enable interoperability of utility meters (water, gas, electricity, heat), which can then improve the means by which end-users´ awareness of actual consumption can be raised in order to allow timely adaptation to their demands (commonly referred to as ´smart metering´)"		
Web site	ETSI: http://www.etsi.org European Commission Mandate: http://www.cen.eu/cen/Sectors/Sectors/Measurement/Documents/M441.pdf		
Relations	• Involved with CEN and CENELEC in the European Commission mandate for interoperability of utility meters. The figure below shows in details the scopes of this mandate.		

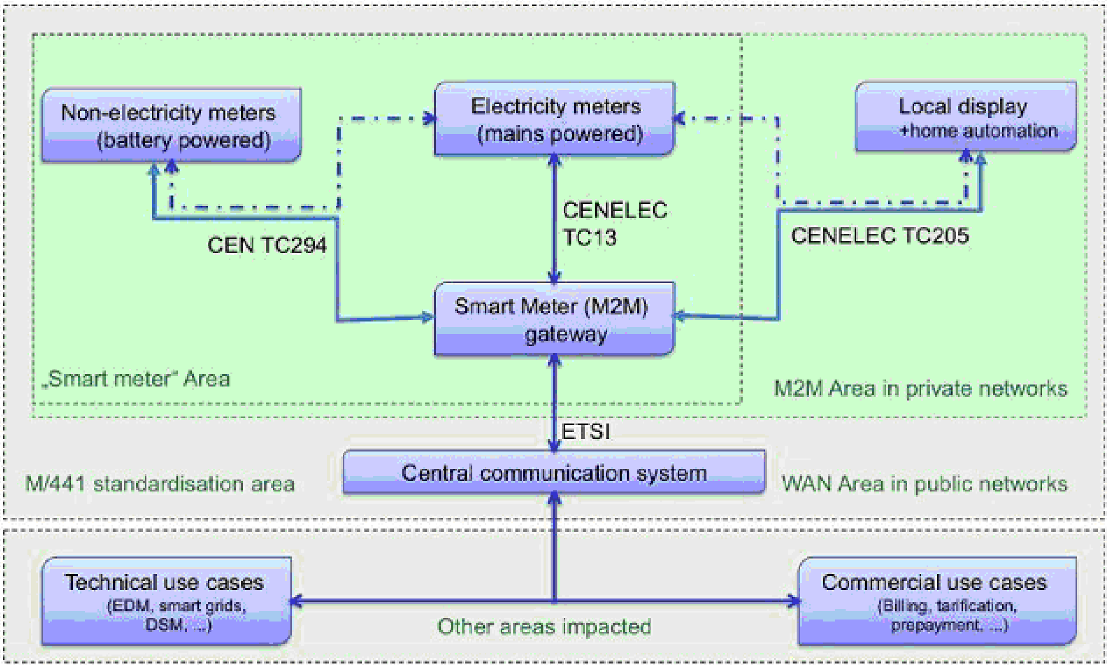

Figure 4. A detailed vision of European Mandate to CEN, ETSI and CENELEC [Stein 2010]

ebIX	***European forum for energy Business Information eXchange***	**Type: not-for-profit organization**	**Europe**
About ebIX	ebIX aims "*to advance, develop and standardise the use of electronic information exchange in the energy industry*".		
Role in DSI	The standardization of information exchange in energy market is a key point for DSI. Moreover under ebIX there are two interesting projects: • the CuS (Customer Switching) project that is about the model of the structuring phase of the energy market ant implies the definition of "*common procedures that make it easy for the consumer to change supplier in the common open European energy market*" [From ebIX Web Site] • the EMD (Exchange Metered Data) project "*for modelling the exchange of metered data between parties in the upstream electricity sector*" [From ebIX Web Site]		
Web site	http://www.ebix.org		
Relations	• An ebIX/ETSO/EFET harmonization group has been established and it is working in order to get a shared Role model.		

ENTSO-E	***European Network of Transmission System Operators for Electricity***	**Type: European TSO association**	**Europe**
About ENTSO-E	Its mission is to promote energy policy issues related to security, adequacy, market and sustainability.		
Role in DSI	ENTSOE took over the activities of existing TSO association, including ETSO. Among these, there are the standardization activities related to the energy market (now called ENTSO-E Market EDI). Even if it is more focused on the TSO, it provide a general method to define new business processes in the energy market.		
Web site	ENTSO-E Site: http://www.entsoe.eu ENTSO-E EDI library: http://www.entsoe.eu/index.php?id=73 ETSO Site: http://www.etso-net.org/		
Relations	• An ebIX/ETSO/EFET harmonization group has been established and it is working in order to get a shared Role model. • There is collaboration with IEC-TC 57, with the aim of integrating the European market standard defined by ETSO works into IEC. This collaboration, in particular, will provide an harmonization between ENTSO-E Market EDI and CIM Market Extensions (CME)		

EFET	***European Federation of Energy Traders***	**Type: Non-profit independent foundation**	**Europe**
About EFET	EFET aims i"*to improve the conditions of energy trading in Europe and to promote the development of a sustainable and liquid European wholesale market*" (From EFET Web Site)		
Role in DSI	EFET is defining and standard electronic data exchange for energy market.		
Web site	www.efet.org/		
Relations	• An ebIX/ETSO/EFET harmonization group has been established and it is working in order to get a shared Role model.		

ANSI	***American National Standards Institute***	**Type: Private, not-for-profit organization**	**USA**
About ANSI	ANSI mission is "*to enhance both the global competitiveness of U.S. business and the U.S. quality of life by promoting and facilitating voluntary consensus standards and conformity assessment systems, and safeguarding their integrity" (From ANSI Web Site)*		
Role in DSI	ANSI as developed and published an interesting group of standards (C12.18, C12.19, C12.21, C12.22) that enable sending and receiving of metering data in an uniform way. Ù Moreover it has approved various standards for building automation (e.g. BACnet, KNX)		
Web site	http://www.ansi.org/		

NIST	***National Institute of Standards and Technology***	**Type: Non-regulatory federal agency (within the U.S. Department of Commerce)**	**USA**
About NIST	Its mission is the promotion of U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology.		
Role in DSI	Under the Energy Independence and Security Act (EISA) of 2007 NIST is working at the Smart Grid Interoperability Project that is a project for the development of a "*framework that includes protocols and model standards for information management to achieve interoperability of smart grid devices and systems*." (From NIST Web Site) NIST is focusing on six Smart Grid functionalities: wide-area situational awareness; **demand response**; electric storage; electric transportation; advanced metering infrastructure; and distribution grid management.		
Web site	NIST: http://www.nist.gov The Smart Grid Interoperability Project: http://www.nist.gov/smartgrid/index.cfm NIST Smart Grid Collaboration Site: http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/WebHome		
Relations	• NIST has formed together with the GridWise Architecture Council (GWAC) the *Domain Expert Working Group (DEWG)*; • NIST is collaborating with IEC TC57, OASIS, NAESB, and AMI-ENT to specify a process for developing a common semantic model for standard DR signals.		

FERC	***Federal Energy Regulatory Commission***	**Type: Independent agency**	**USA**
About FERC	FERC mission is obtaining "Reliable, Efficient and Sustainable Energy for Customers"		
Role in DSI	FERC is involved in initiatives related to Smart Grids, Demand Response and Integration of Renewables. In particular it is preparing "a report by appropriate region that assesses electric demand response resources, including those available from all consumer classes" and is pursuing "market reforms to allow all resources, including renewable energy resources, to compete in jurisdictional markets on a level playing field".		
Web site	FERC: http://www.ferc.gov Demand Response page: http://www.ferc.gov/industries/electric/indus-act/demand-response.asp Integration of renewable page: http://www.ferc.gov/industries/electric/indus-act/integration-renew.asp		
Relations	• FERC requested to the IRC to create "the Smart Grid Standards Development Project" [IRC 2010]		

GWAC	*GridWise Architecture Council*	Type:	USA
About GWAC	GWAC was "*formed by the U.S. Department of Energy to promote and enable interoperability among the many entities that interact with the nation's electric power system*" (From GWAC Web Site)		
Role in DSI	GWAC aims to define an architecture for interoperability in Smart Grid. This architecture obviously involves also the demand side.		
Web site	GWAC: http://www.gridwiseac.org DEWG: http://www.gridwiseac.org/about/dewg.aspx		
Relations	• NIST, in is activities of coordination for developing Smart Grid Interoperability Framework, has "*joined with the GridWise Architecture Council (GWAC) to form Domain Expert Working Groups (DEWGs) to explore smart grid interoperability issues.*"		

EPRI	*Electric Power Research Institute*	Type: Independent non-profit company	USA
About EPRI	EPRI "*conducts research and development relating to the generation, delivery and use of electricity for the benefit of the public*" (From EPRI Web Site)		
Role in DSI	In EPRI there is a Task Force for Grid Operation and Planning. In particular it faces also issues related to demand response mechanism and the complexity in managing the grid with the addition of renewable resources. Moreover, "*EPRI has sponsored development of a number of international standards that provide the basis for information exchange to support power system management. One of the most important is the Common Information Model (CIM)*" [Becker 2006] EPRI is also built the IntelliGrid Initiative, a technical foundation for smart power grid. One of its main product is the IntelliGrid Architecture, "*an open-standards, requirements-based approach for integrating data networks and equipment that enables interoperability between products and systems*". This architecture provide results very useful for advanced metering, distribution automation, and demand response.		
Web site	EPRI: www.epri.com Grid Operations and Planning: http://my.epri.com/portal/server.pt?open=512&objID=396&&PageID=226109&mode=2 Intelligrid: http://intelligrid.epri.com/		
Relations	• CIM sponsorship.		

NAESB	*North American Energy Standards Board*	Type: Industry forum	USA
About NAESB	It "*serves for the development and promotion of standards which will lead to a seamless marketplace for wholesale and retail natural gas and electricity*" (From NAESB Web Site)		
Role in DSI	It is developing standards both for wholesale and for retail electricity market.		
Web site	http://www.naesb.org		
Relations	• NAESB is collaborating with IEC TC57, OASIS, NIST, and AMI-ENT to specify a process for developing a common semantic model for standard DR signals.		

IRC	***ISO/RTO Council***	**Type: industry organization**	**USA**
About IRC	"The ISO/RTO Council (IRC) is an industry organization consisting of representatives of North American ISO/RTOs." Its goal is "to balance reliability considerations with market practices, resulting in efficient, robust markets that provide competitive and reliable service to electricity users."		
Role in DSI	Following a FERC's request, IRC created the Smart Grid Development Project. This is "focused on the integration of ISOs/RTOs with Market Participants and other entities serving as aggregators for distributed generation and renewable resources, electric vehicles, demand response management, and regional coordination entities." [IRC 2010].		
Web site	http://www.isorto.org/		
Relations	• IRC has submitted the Business Process Model and Data Element Spreadsheet, developed in the Smart Grid Development Project, to the NIST Priority Action Plan 09 (about Standard Demand Response Signals); • Moreover IRC submitted the Information Models, developed in the Smart Grid Development Project, to the OASIS technical teams. In this way IRC aims to "ensure that common ISO/RTO issues related to the NIST smart grid standards efforts are considered simultaneously and in a timely and cohesive manner" [IRC 2010]		

DRRC	***Demand Response Research Center***	**Type:**	**USA**
About DRRC	Its main objective is *"to develop, prioritize, conduct, and disseminate multi-institutional research that develops broad knowledge to facilitate DR*" (From DRRC Web Site)		
Role in DSI	DRRC develop various interesting project related with Demand Response. In particular, it develop OpenADR, an open standard that provides "technology neutral communications specification and data models using Web Services to send DR signals to end-use customer systems".		
Web site	DRRC: http://drrc.lbl.gov/ OpenADR: http://openadr.lbl.gov		
Relations	• OpenADR development received contributions from OASIS and UCAIug		

UCAIug	***UCA International Users Group***	**Type: Not-for-profit corporation**	**USA**
About UCAIug	UCAIug consists of "*utility user and supplier companies that is dedicated to promoting the integration and interoperability of electric/gas/water utility systems through the use of international standards-based technology".*		
Role in DSI	It works on advanced metering and demand response developing testing programs in order to facilitate interoperability for systems based on standards like CIM, IEC 61850 and OpenADR		
Web site	http://www.ucaiug.org		
Relations	• It is a user group for IEC 61850, for CIM and for OpenADR (about advanced metering and demand response)		

ASHRAE	***American Society of Heating, Refrigerating and Air-Conditioning Engineers***	**Type: International Organization**	**USA**
About ASHRAE	Its mission is the "*advancing of heating, ventilation, air conditioning and refrigeration to serve humanity and promote a sustainable world through research, standards writing, publishing and continuing education*." (From ASHRAE Web Site)		
Role in DSI	ASHRAE has developed the BACnet (Building Automation and Control Networks) protocol (standardized by ISO as ISO 16484-6:2005).		
Web site	http://www.ashrae.org		
Relations	• BACnet became a CEN Standard		

Case: Enabling interoperability through the IEC 61850 standard and RESTfull web services

The following describes a project which was initiated at the Technical University of Denmark to investigate how a generic DER communication interface could be made by combining a standardized data model with a set of contemporary web protocols.

The outcome of the project was the demonstration of a server that used the resource oriented approach of REST services to allow clients, such as aggregators, to monitor and control the state of a DER, which internal components and attributes are describe using the data model of IEC 61850.

IEC 61850, which was originally made for substation automation, has with the -7-420 extension been expanded to include DERs. The standard can roughly be divided into the following component:

- The model that defines how data is described and formatted
- The protocol stack that transfers the data to a client.

These two components will be discussed in the following

The data model of the IEC 61850 Standard

In IEC 61850, a hieratical object path is used to reference specific information of a DER. The path starts from the 'logical device' and drills down to the specific attribute that is requested by the client.

The following shows an example of how an attribute is referenced in the IEC 61860 data model.

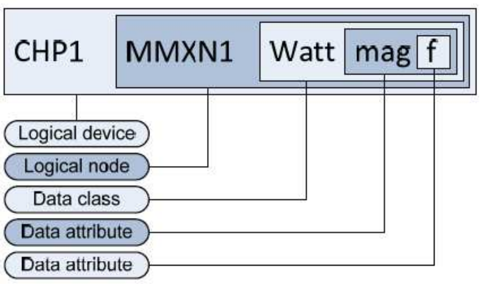

Figure 5. IEC Object Path

The specific example shows how the current power production (Watt) is extracted from a combined heat and power unit (CHP1). The logical node 'MMXN' represents a 'non phase related measurement'.

The protocol Stack

Besides from the syntactic level, a set of protocols is needed to carry the data over a network. The IEC 61850 standard proposes the use of the TCP/IP protocols in combination with the Manufacturing Message Specification (MMS) Replacing MMS with REST services could, however, ensure a higher degree of interoperability.

RESTful service, which is not a standard but rather a set of principles, was first presented by Roy Fielding in 2000.

The principles define that resources, in this case DER attributes, should be accessed through URLs using the stateless features of HTTP. REST sheds the overhead of the SOAP protocol, which is typically used for method invocation in Web services, to supply a lightweight resource oriented approach.

A closer coupling to the HTTP protocol gives a higher degree of interoperability since any http client can be used to access information.

The following figure shows how the data path of IEC 61850 can be mapped to a REST compliant URL.

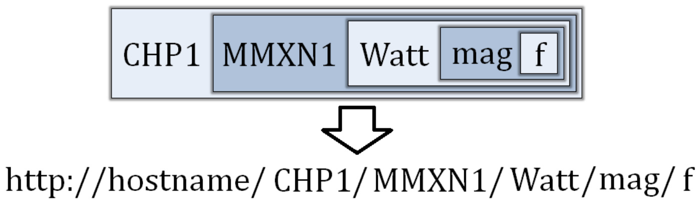

Figure 6. Data path to URL mapping

The resource of the above URL (current power production of a CHP unit) could be shown by simply typing it in a browser. The HTTP/HTTPS has built-in features for authentication and for securing the communication between server and client.

An IEC 61850 compliant Server

As proof of concept an IEC 61850 compliant server was built to accommodate the communication with various distributed resources. The setup can be seen in the following figure.

Figure 7. Demonstration setup

The IEC server (right part of Figure 7) dynamically detects and loads a series of ‘plug-ins’ which each represents a ‘driver’ for a specific DER. The server then makes the information available to a client via a RESTful interface.

The following shows how a client can request an attribute via an URL and how a response is sent back in XML.

A Request for a single data attribute	
URL	/EV1/ZCEV1/MaxRtDchPwr/setMag/f
Response	<?xml version="1.0" encoding="utf-8" ?> <DA Name="f" Type="FLOAT32" Ref="EV1/ZCEV1/MaxRtDchPwr/setMag/f">16800</DA>

Figure 8. IEC Server Request

A Client IEC monitor application was developed to display the information extracted from each DER.

Figure 9. IEC Monitor

The server was tested towards two CHP units, a wind turbine as well as a simulated EV.

<u>Summary on the interoperability barriers</u>

Lack of interoperability affects all the different part of the DSI architecture and all the actors involved.

In particular the end-user point of view is critical. If his needs and desires will not be satisfied new barriers will arise, due, for example, to the consequent psychological resistances about being involved in a not appealing DSI.

End-user does not want simply interoperability, but he wishes this interoperability was possible without efforts. Moreover he does not want to change its own devices and appliances when a new version of some standard will be released. If these things will not happen he could decide to not take part to DSI process.

Recommendation: the end users have to be involved in the standardization process in order to understand their needs and to verify their satisfaction.

Standardization certainly could facilitate interoperability, but “working on a standard and implementing a standard may not automatically lead to interoperability”. [EICTA 2006] Moreover the standardization process itself could produce lack of interoperability, if the process was not focused on getting it. For example standardization could generate specifications that did not satisfy end-user requirements, that were themselves affected by lack of interoperability, that did not reach a sufficient diffusion to guarantee real interoperability.

Recommendation: In order to get standards that help in resolving lack of interoperability, instead of generating new barriers, some principle should be followed in the standardization process:

- Openness and transparency of the standardization process;
- Clear scoping on interoperability of the standardization project;
- Employ of common design principles;
- Execution of interoperability testing and prototype implementations.

A good approach to common design principles in the DSI context could be provided by EPRI REC/VEN concept.

Many standards related to DSI have been devolved so far. What is still lacking is a complete architecture for interoperability.

Recommendation: the first step to get it should be a survey of standards available for Europe DSI, in order to identify gap to fill (as absence of standard for certain purposes or inadequacy of the existent ones) and then to compose the selected standards in an interoperable manner. A good starting point could be NIST work, but this one certainly will need to be contextualized for European DSI perspective.

At the end a real case was exposed. The case shows that the object reference path of the IEC 61850 data model can easily be mapped to the URL format in the resource-oriented approach used by REST and that a lot of complexity and compatibility issues can be shed utilizing the basic features of the HTTP protocol.

The suggested solution could thus serve to increase interoperability and simplicity in DER communication.

The ICT Demand Side Service oriented platform (DSSP) has to integrate shared practices which will refer to the standardization solution for the interoperability fully including the end-user side.

A very close coordination between initiatives for the DSSP and standardization initiatives will be required.

References

□ SEESGEN-ICT "Report on ICT requirements, offers and needs for demand side integration - D4-2", 2010

□ Institute of Electrical and Electronics Engineers, "IEEE Standard Computer Dictionary: A Compilation of IEEE Standard Computer Glossaries", New York, NY: 1990

□ EICTA "White Paper on Standardisation and Interoperability" Brussels, November, 2006. Available at: http://www.civ.utoronto.ca/sect/coneng/i2c/D-Base/On%20the%20Web-D/Policies/EICTA-Interoperability%20BP.pdf

□ EICTA "Interoperability White Paper", 2004. Available at: http://www.digitaleurope.org/fileadmin/user_upload/document/document1166548285.pdf

□ EPRI; "Concepts to Enable Advancement of Distributed Energy Resources", February 2010. Available at: http://www.mmidl.com/sgt/2010-Mar-02/1020432ConceptsAdvancementDER_2march2010.pdf

□ NIST "NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0", NIST Special Publication 1108, January 2010.

□ Available at: http://www.nist.gov/public_affairs/releases/upload/smartgrid_interoperability_final.pdf

- IEC “Interoperability to enable freedom and innovation”, from IEC Web Site: http://www.iec.ch/zone/smartgrid/grid_interoperability.htm
- Johannes Stein, “Update on the European context in the field of smart grids”, February 2010. Available at: ftp://ftp.cen.eu/CEN/News/Events/Innovation/Stein.pdf
- D. Becker “Harmonization of CIM with IEC Standards Draft Report for CIM and other IEC Working Groups”. March 2006. Published by EPRI.
- Available at: http://mydocs.epri.com/docs/public/000000000001013110.pdf
- William Cox “OASIS and Standardization”, January 2009. Available at: http://openadr.lbl.gov/pdf/tag_mtg-01-16-09_OASIS-UCA.pdf
- IRC, “IRC Smart Grid Standards Development Project – Phase I: Demand Response”, April 30, 2010.

2.3 Additional ICT risks

The following outlines the barriers to DSI which is introduced by the use of ICT.

2.3.1 *Security barriers*

In order to influence and optimize the behavior of DERs and controllable loads at end-users, a continuous stream of information will have to be sent between the end-user and some other stakeholder. The data could take the form of production/consumption data, price incentives and end-user information. Care should be taken if important and sensible information should be transported via the internet. It is vital that the main pillars of security, namely Confidentiality, Integrity and Availability (CIA) are guaranteed for all information and services between an end-user and some other stakeholder (An aggregator or EPU (Electrical Power Utility)).

Confidentiality issues

Typical network attacks on confidentiality are eavesdropping, packet capture and man-in-the-middle attacks. In these attacks a hostile third party would be able to read information sent to and from the end user. If the communication is not sufficiently protected against such attacks, sensitive information could be compromised. Examples of sensible data could be financial information or information that reveals the behavioral patterns of the end-user.

Integrity Issues

Attacks on integrity include packet dropping, packet injection and replay attacks. These attacks would in some way manipulate the data sent to and from the end user. The result could be undesirable behavior by the DER or controllable load that receives the data. In the worst case such attacks could jeopardize grid stability and the safe operation of the controllable loads or DERs of the end users.

Availability issues

The most common attacks on availability are Denial Of Service (DOS) attacks. There are many different kinds of DOS attacks but the purpose is always to hinder clients in accessing some resource on a network.

The end-user would need continues access to information from the power system or market to plan the operation of a local DER or controllable load. The information could be in the form of price signals or operation schedules that should be followed to service the grid. In an environment with many DERs and controllable loads, the lack of such information could destabilize the grid.

<u>Examples of additional risks</u>

According to the working group D2.22 of CIGRE [3], there have been many real-world cases where control systems have been compromised. Events have occurred in electric power control system for transmission, distribution, generation, as well as control system for water, oil/gas, chemical, paper and agricultural businesses. A part of these cyber intrusions managed to open breaker switches and shut industrial facilities down. In the USA at the beginning of 2009, there have been more than 125 industrial control system cyber incidents. Only a few of them have been documented as public industrial control system cyber incidents (probably less than 10, due to obvious reluctance from industry) [4]

The connection between the ICT of end-user and ICS (Information control system) from utilities can increase the risk of a cyber attack

- Intentional targeted attacks,
- Unintended consequences such as from viruses and worms,
- Unintentional impacts from inappropriate policies, design, technologies, and/or testing,
- Electro Magnetic Pulse (EMP),
- Electro Magnetic Interference (EMI),
- Other electronic impacts

All type of ICT may be threatened:

- Automated control systems (ACS)
- Distributed control systems (DCS)
- Programmable logic controllers (PLC)
- Supervisory control and data acquisition (SCADA) systems
- Intelligent electronically operated field devices, such as valves, controllers, instrumentation
- Intelligent meters and other aspects of the Smart Grid
- Networked-computing systems

In Europe, a blackout reached Italy in 2003. An unexpected quantity of data overloaded the information and communication infrastructure. The power system was unavailable for several hours: It exhausted the local non-interruptible power system and made the monitoring and control systems unavailable. Restoration came very late. This example in Europe show the impacts of the ICT infrastructure failure, that was create here by a power incidents and that similarly could be created by a cyber incident. [5].

This type of incident motivates academic work on developing a methodology for vulnerability identification and interdependence modeling. [5].

It follows that ICT for DSI require a special focus on information security [4].

Actors involved

Not only the end-user, but all power system stakeholders are affected by the security barriers since a breach in security can threaten the overall operation of the power system. The actors responsible for securing the ICT should be the entities with which the End-users interact – not the end-users themselves.

Solution to security barriers

There are different approaches that can be used to solve the security barrier listed above. This section proposes three specific setups as proposed in a master rapport [2] and explains the advantage and drawbacks of each. It then describes a methodology for ensuring security as suggested in the CIGRE project[3].

- Dedicated line: One approach for reducing the risk of security attacks is to bypass the internet and use a dedicated line for communication. This setup could be considered safe as it is a point-to-point link between server and client which it is more difficult for hostile parties to gain access to. It could also improve the security against availability attacks such as distributed denial of service (DDoS) attacks which are common on the internet and difficult to prevent. The line could for instance be a dedicated phone line or a GSM modem.

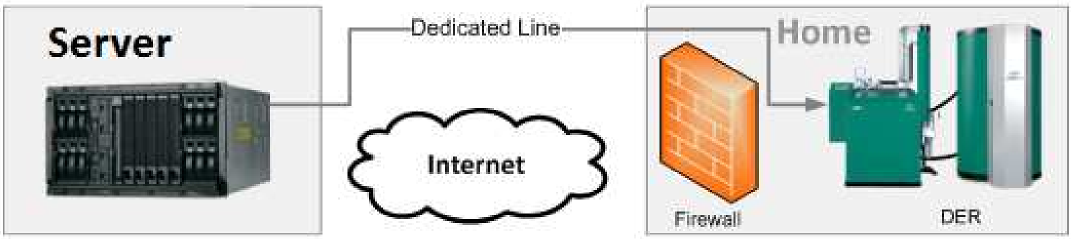

Figure 10. dedicated line [2]

The drawbacks of these solutions are the costs associated with the dedicated line. The price of such a line might not be justifiable.

- Using a tunnel

An alternative approach is to create a virtual 'dedicated line' through one of the many tunneling protocols available. These include Virtual Private Networks (VPN) and Secure Shell (SSH). Whatever protocol used between client and server would traverse the internet as encrypted payload data.

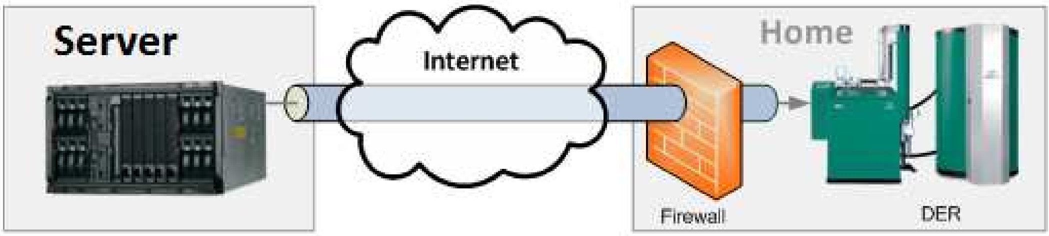

Figure 11. tunnel [2]

The drawback of using tunneling is the communication and data overhead required for creating a tunnel between the client and server. In a scenario with tens or hundreds of thousands of end-users communicating with a server, the maintenance overhead would be considerable.

- Using standard internet protocols

Using the internet without tunneling would in theory increase the risk of attacks against the confidentiality and integrity of the communication. Most mature internet protocols, however, have a multitude of ways of ensuring secure communication.

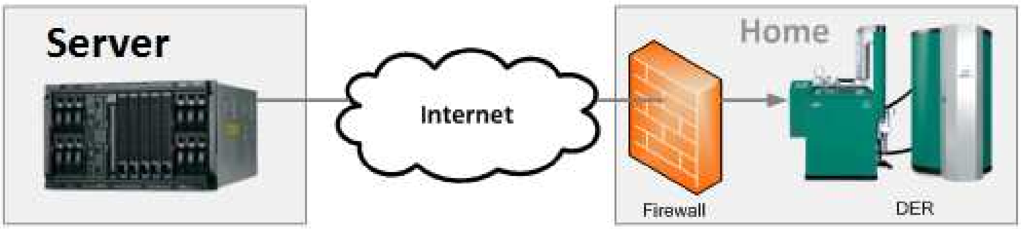

Figure 12. internet protocols [2]

Within internet communication the most important methods of supplying confidentiality and integrity are by authentication and encryption. HTTP for instance supports encryption by using the SSL/TLS protocols (HTTPS) and supporting certificates for server validation. HTTP also supports authentication of clients by the basic- or digest authentication methods.

Such authentication and encryption is already used to secure financial transactions and top secret information over the internet in a secure way.

Examples of security solutions in DSI

In the paper "Architecture and Communication of an Electric Vehicle Virtual Power Plant" (1), Bernhard Jansen et al. , IBM suggests using the Session Initiation Protocol (SIP) for communication between electric vehicles and an aggregator. SIP is commonly used for session initialization by Voice over IP (VoIP) and Instant messaging (IM). Bernhard Jansen concludes that SIP is suitable when communicating with a large number of electric vehicles due to its scalability combined with support of secure communication using standard security protocols.

A focus of the CIGRE project has been on the methodology and strategy of ICT security. The working group D2.22 of CIGRE gives one example of these methodologies to treat the information security for Electric Power Utilities [3].

The Cyber security is deployed into a framework, which where elaborated in an information security domain, a risk management domain and a risk assessment model supported by a risk categorization. This methodology is expected to enable a thorough analysis of the risk: the risk domains are defined according to the required level of protection (operational critical, business critical, corporate, untrusted,…). The risk assessment model enables the management of risk in and between risk domains, in particular by investigating interdependence (for example: risk acceptance criteria defined by power plant or power network on IT and control systems and reciprocally risk reporting from IT / control system to Power plant and network).

In summary the working group D2.22 of CIGRE defines a comprehensive and generic methodology, designed to address the complexity of systems such as the electrical power system. They give the following example.

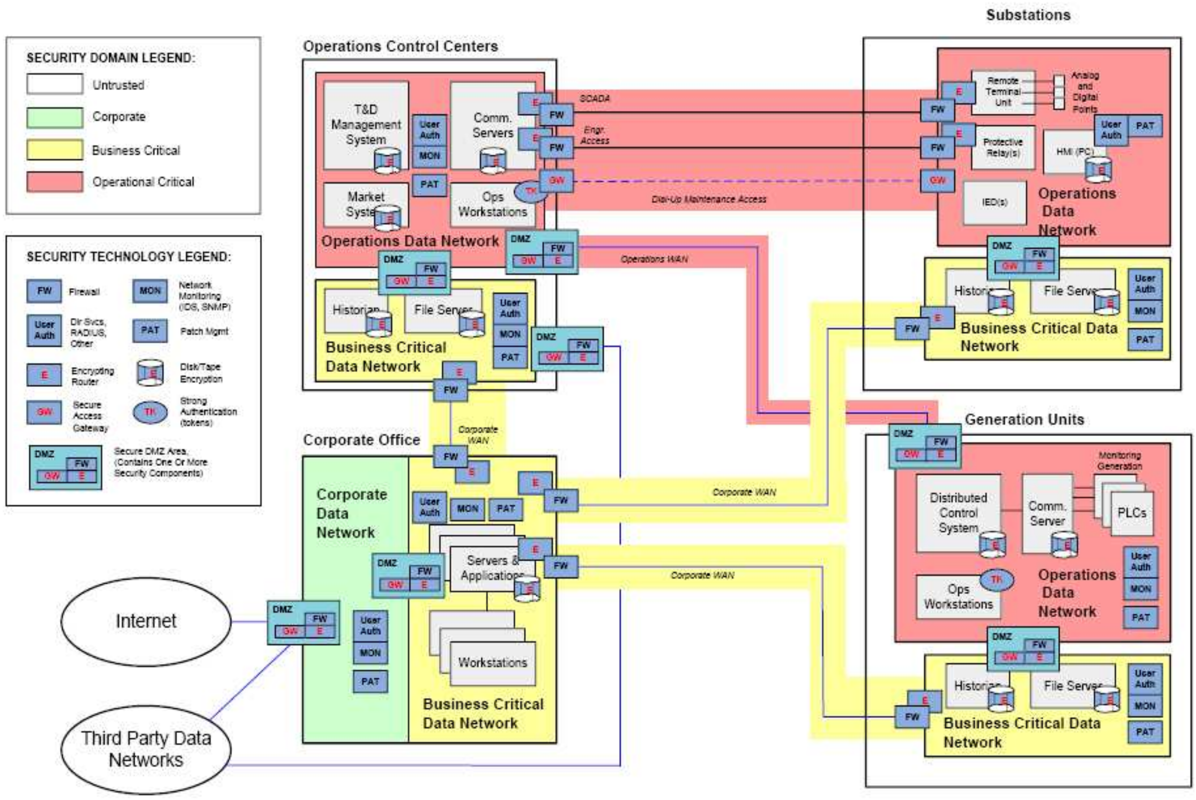

Figure 13. Example of Cyber Security Technologies Deployed [3]

To implement the DSI whilst preserving the information security, such methodologies have to be updated to integrate the end-user environment, from the risk assessment and the functional analysis up to the deployment of the security cyber technologies. Indeed ICT on the end-user side may create new interdependence, new threats and new vulnerabilities: for instance we can imagine that hackers will try to use an energy service web platform of several end-users to start a cyber attack against the SCADA of the DSO.

And symmetrically ICT environment required to be protected by cyber-incident from the others domains of the global system: for example spying of private life through smart meter or energy box, or shut down of industrial utilities through the electrical management system.

So the ICT used for the DSI is required to be integrated into risk assessment and risk management tools, and end-user environments are required to be investigated as additional security domains.

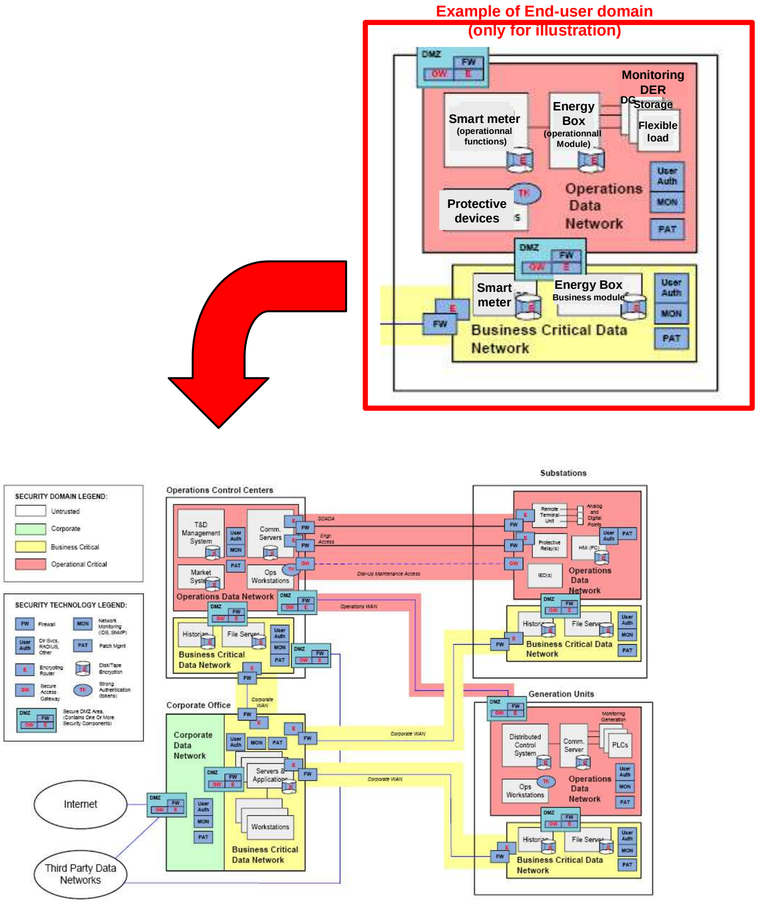

Figure 14. Example of Cyber Security Technologies Deployed [3]

This example show that the cyber security of the grid requires a specific strategy and methodology, which treat the whole feature of the global power system, for all types of features (operational issues, business issues, corporate or private life issues, etc…) and for all type of stakeholders (system operators, different type of end-users, eventually business entities, etc…).

2.3.2 *Robustness and scalability barriers*

While the power system and market adjusts to an increasing amount of DERs, so much the servers that support the communication. When end-users are relying on information from a single stakeholder, such as a clearing house or aggregator, the systems hosting this information can represent a single point of failure.

The ICT enabling DSI should not suffer due to server breakdowns, nor should services on a server be slow to respond due to high demand.

Actors involved

Not only the end-user, but all power system stakeholders are affected by the robustness and scalability barriers since missing or delayed information can threaten the overall operation of the power system. The actors responsible for robustness and scalability should be the entities which hosts the information needed by the End-users.

Solution to Robustness and scalability barriers

Modern server centers can guarantee close to 100% uptime and responsiveness even during highly fluctuating demand. This is made possible by virtualization technologies and hardware that supports redundancy:

- Hardware redundancy

A modern server is typically built so that the malfunction of no single component can threaten the overall operation of the system. Disks are typically in a RAID configuration so that data is duplicated and supporting server components, such as switches and power supplies, are typically 'mirrored' so a 'spare' is available. Most servers also have an UPS to secure against power failures.

- Virtualization

Most datacenters uses virtualization technologies to optimize hardware utilization. If a server runs on a virtual machine certain tools allows for the live migration of a virtual machine from one physical server to another if the first physical server malfunctions. This adds to the robustness of a server center.

Virtualization is also used as a cornerstone in cloud computing. Cloud computing allows access to computing resources while hiding the supporting hardware. The concept is often associated with 'pay as you go utility computing' where the term 'Utility' refers to the fact that you only pay for what you use. Most public cloud solution thus dynamically scales up the computing resources so that it follows demand. This supports almost unlimited scalability of services living in 'the cloud'

If the servers supporting DSI utilizes the above technologies, they will be better equipped to face the challenges of robustness and scalability.

Case: The CRISP project

The following description will give an example of an approach which could be pursued to facilitate integration of the ICT required by the DSI in the power system whilst ensuring the security of the system.

It gives a few outlines of the concept developed in the European CRISP project, for a more detailed description of the concept, please refer to the following reference [6][7][8][9]

The CRISP project developed a new approaches to securing software execution and information protection.

Secure software execution

Software execution could be represented by the following equation: Computation = code + execution

The classical approach is to secure the code. The CRISP approach is also oriented towards assuring correct execution, through mechanisms which support assessment and protection of the run state of execution, in particular for the execution of services in a service oriented architecture.

These protection mechanisms are:

- Immunization – The execution environment helps program which is attacked to continue normal operation.
- Detection -Detecting a weakness before the system has a chance of becoming exploited.
- Reducing system consequences - Modifying an execution environment to minimize consequence of exploiting.

Information protection

Information could be represented by the following equation: Information = representation + interpretation

The CRISP approach is also to analyze the dynamic interpretation by analyzing the overall coordination patterns, as described below. So The CRISP develop innovative solutions are used complementary to the classical solutions from the CIA model (Confidentiality, Integrity, Availablilty) which protects only the representation by means of cryptography, PKI and access control e.g. via password.

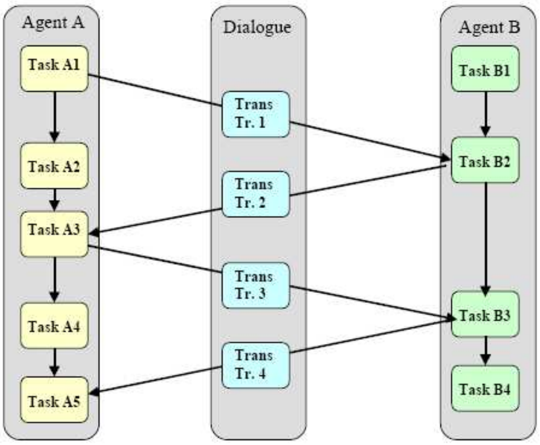

Figure 15. The general structure of a dialogue diagram

"A useful alternative approach is not to focus on the (static) representation side of information but on its (dynamic) interpretation, that is, on its computer processing. The backbone of such an approach is to analyse the overall coordination patterns, and then introduce constraints that disable system behaviors unwanted from the protection point of view. This can be modelled with the help of dialogue models familiar from agent communication and knowledge engineering" [7]

CRISP is an example of an innovative approach, which supports information security and which could be used to protect against new threats introduced by integration of ICT from the end-user environment into the global power system. In this example, the service oriented feature of this concept is an asset to manage this challenge.

Chapter summary

This chapter has aimed to outline the additional ICT related risk and barriers that demand-side integration will have to face. The identified barriers are:

- Confidentiality issues
- Integrity issues
- Availability issues
- Robustness issues
- Scalability issues

Different solutions are described:

- Integration of the ICT for DSI issues in risk assessment and management methodologies: an example describes how risks can be identified and analyzed by using a methodology as presented by CIGRE. Using this approach for describing the domains and specific security measures for DSI can help to counteract future security issues. Integration of ICT for DSI could be supported by the DSSP concept.

- Implementation of innovative approaches: This is describe into a concrete case, the CRISP project
- Core solutions : the use of different security technologies: Different technological tools are described:
    - Dedicated lines
    - Using a tunnel
    - Using standard internet protocols

It has been argued that if solutions like dedicated lines and tunnels are too costly or complex, mature internet protocols are available that can satisfy most confidentiality and integrity requirements. Availability issues will, however, be more difficult to prevent when utilizing the internet. For solving robustness and scalability issues it has been argued that modern server technologies such as virtualization and hardware redundancy can supply the required robustness and scalability for services used by end-users.

Finally, the case described how the CRISP project has achieved secure software execution and information protection, in particular by focusing on computation execution and information interpretation. It gives an example of the role of innovation for such critical issues, where the expertise and the competences from the ICT sector (both academic research and industry) are required. Industrial concrete cases are very difficult to investigate, due to obvious confidentiality issues.

References

[1] Architecture and Communication of an Electric Vehicle Virtual Power Plant - Bernhard Jansen, Carl Binding, Olle Sundström, and Dieter Gantenbein. IBM, ZRL submitted to: SmartGridComm, Gaithersburg, October 4-6, 2010

[2] Enabling distributed energy resources in a virtual power plant using IEC 61850 - Einar Bragi Hauksson, Anders Bro Pedersen. DTU, CET 2010

[3] Treatment of information security for Electric Power Utilities (EPUs), working group D2.22, june 2010, CIGRE

[4] The ISA99 Standards Vision, A Roadmap for Developing Secure Industrial Automation and Control Systems, ISA, EXPO 2008, Oct 2008

[5] Critical infrastructure protection: a methodology for vulnerabilities identification and interdependencies modelling, Benoit ROZEL. Master thesis, G-INP, July 2008

[6] Internet website of CRISP project http://www.crisp.ecn.nl

[7] CRISP Project, deliverable D5.5, Distributed Intelligence in Critical Infrastructures for Sustainable Power ENK5-CT-2002-00673, Final Summary Report, Gerrit jan Schaeffer and Hans Akkermand with CRISP contributors

[8] INTEGRAL Project, Integrated ICT-platform based Distributed Control in electricity grids with a large share of Distributed Energy Resources and Renewable Energy Sources, deliverable D3.1 ICT support for Control and Coordination, Rune Gustavsson and Björn Stahl

[9] CRISP Project, Distributed Intelligence in Critical Infrastructures for Sustainable Power ENK5-CT-2002-00673, Deliverable D1.6 , R. Gustavsson, P. Mellstrand, B. Törnqvist

3 NON-TECHNICAL BARRIERS

3.1 Social barriers

3.1.1 *Threat to privacy of customers*

The deployment of the ICT for the DSI (either in a general way or through the DSSP) involves the deployment of the ICT on the end-user premise, including the residential end-user (at the distribution level). So the social acceptance and integration of these ICT solutions and of the associated service is a major requirement for a successful DSI.

In privacy law 'personal information' refers to any recorded information about an identifiable individual. DSI services may transfer information about the energy consumption of end users participating in the programme. Energy consumption data may be used first of all to plan and execute the DSI programme. Secondly, some information may be needed to settle the bill. After all, the DSO that pays the customer to take part in a DSI programme does need some form of guarantee that the customer actually does change its energy consumption in response to the DSI signals.

Any transfer of energy consumption data that is linked to an identifiable individual is sensitive to privacy issues, as the energy use can reveal information on the presence of end users and on their behaviour patterns. The smaller the time interval of energy consumption data transmitted, the more privacy sensitive information it contains. For example weekly energy consumption data can be used to determine holiday periods (potentially useful for criminals), whereas data with a 5 or 15 minute time interval can reveal the usage of specific appliances and whether or not those appliances are outdated.

These privacy issues first of all have a legal side. For EU member states, these rights and obligations are laid down in the national transpositions of the EU directive on the protection of personal data [1]. All companies handling 'personal information' must comply with eight principles, which make sure that personal information is:

- Fairly and lawfully processed
- Processed for limited purposes
- Adequate, relevant and not excessive
- Accurate and up to date
- Not kept for longer than is necessary
- Processed in line with your rights
- Secure
- Not transferred to other countries without adequate protection

Also end users whose data is stored have rights, including the right to find out what personal information is held.

Apart from legal implications privacy issues may also influence the public acceptance of DSI services and smart grid in general. In Europe currently discussion about privacy issues of DSI (and broader smart metering and smart grid) is quite irregular, but can be fierce. For example, in the Netherlands there was strong opposition to the compulsory implementation of smart metering from the side of i.a. the Dutch consumer organisation Consumentenbond. It is worried about the privacy issues of smart meters. In reaction to this opposition, the minister has promised to the Dutch Parliament that consumers will not be forced to accept the smart meters. Also the start of the implementation has been delayed.

In addition to political controversies, privacy issues can also cause bad publicity during the introduction of DSI. End users may not be inclined to participate in DSI-schemes if they feel they are subjected to a 'Big Brother'-like system that monitors their behavior from day to day, hour to hour. In several countries campaigns against the installation of smart meters have started.

Figure 17. Some examples of campaigns against privacy intrusion by smart meters (source: Vrijbit, TURN)

Actors involved

All actors involved in DSI services are affected by privacy issues, as well as the national data protection authority:

- DSO: design and operate DSI services that protect the privacy of the end user and convince the end user about the protection of its privacy
- Intermediary entities: design and operate DSI services that protect the privacy of the end user
- Energy regulator or government: provide regulatory framework that takes into account the protection of the privacy of the end user
- Data protection authoritiy: check and approve measures to protect the privacy of the end user
- End user: it should be confident that its privacy is protected by the other actors

Solutions

Many practical solutions exist for the legal obligations under the Data Protection Directive. Some aspects of these solutions include:

- giving individuals the choice whether or not their information is recorded
- minimizing the amount and detail of data recorded
- pseudonymisation of data (replacement of identifying data by artificial identifiers)
- security of data in data communication systems
- security of data in data processing systems
- signing data protection agreements with all partners in the business chain

It is important that these privacy solutions are included in the design of the DSI service from the beginning (privacy by design). A lot of literature is available about these solutions, including recommendations by data protection authorities.

Solutions for privacy issues from the point of view of public acceptance are less straightforward. The key issue here is to prevent that end users get the impression that their privacy is being invaded. There is no clear-cut method to achieve this.

Removing privacy concerns is an important element of marketing of DSI services. An important aspect is not to force people to accept the recording of their data, as the following example suggests. Also clear communication with (future) end users seems important. Thirdly, a proper inclusion of data protection guarantees in the design of the DSI service (see above) will help to convince end users that their privacy is not being invaded.

Example

To illustrate the privacy issues surrounding DSI services one can look at the introduction of smart metering in the Netherlands. DSI services may use similar energy consumption data as those collected by smart meters.

In the Netherlands, the discussions about introducing smart metering started in 2005. The ministry of Economic Affairs decided that in the unbundled Dutch energy market it should be the DSOs that are responsible for the roll-out of the smart meters. At the same time the DSOs started a standardisation process to arrive at a common set of minimum requirements. [2]

In 2006 and 2007 the ministry of Economic Affairs prepared legislation aiming at a mandatory installation of smart meters at all end users within a period of 6 years, starting in 2008. When this legislation was introduced to the parliament, the parliament asked comments of stakeholders, including the Dutch consumer organisation Consumentenbond. After approval by the Lower House, the proposed law was forwarded to the Upper House (which has a duty to look at the quality of the law making process). In the debate in the Upper House many objections were raised, especially to the privacy aspects of the law.

One of the main inputs for the discussion about privacy issues was a review of the privacy aspects of the introduction of smart metering by the Tilburg Law School, commissioned by the Consumentenbond [3]. This review concluded that the proposed introduction of smart meters would lead to an invasion of the privacy of the end users. This invasion of the privacy was deeper than strictly necessary. It might violate article 8 of the European Convention on Human Rights [4]. The main concerns were:

- more and more detailed data was generated and collected than strictly necessary for the purpose at hand

- the mandatory installation of the meters was not required by the EU directive.

Finally the minister agreed to amend the law. The mandatory installation of the smart meters would be removed from the law; the ministry would require additional guarantees from the DSOs about data security; and the ministry would restrict the amount of detailed data collected. At the same time the ministry of Economic Affairs took on a more active role in informing the public about the pending introduction of smart metering. The amended law was introduced to the Lower House in April 2010 and adopted in November 2010. The law is now up for discussion in the Upper House. The ministry of Economic Affairs expects to start the installation of smart meters during 2011

From this example one can learn that collection of detailed energy consumption data can lead to fierce opposition from stakeholders organisations. In this case this was aggravated by the circumstance that the data collection was mandatory and was perceived as more invasive than strictly necessary for the purpose at hand. The fact that these privacy issues were not dealt with early on in the process caused several years of delay and much insecurity among all parties involved.

Summary

Privacy may be a significant barrier for the introduction of DSI services, especially if data protection measures are not included early in the system design. Legal regulations concerning data protection should not inhibit these services, provided that: 1) participation in DSI services is not mandatory; and 2) the data is sufficiently protected.

The public image of DSI may become problematic, especially if people start to worry about 'Big Brother' looking into and controlling their house. Possible solutions to avoid this are: 1) good communication with the public; and 2) application of 'privacy by design' principles in the system design of DSI services. Removing privacy concerns is an important element of marketing of DSI services.

References

[1] Directive 95/46/EC on the protection of individuals with regard to the processing of personal data and on the free movement of such data.

[2] NEN, Netherlands Technical Agreement, NTA 8130 (e), "Minimum set of functions for metering of electricity, gas and thermal energy for domestic customers", August 2007 (unofficial English translation), available at www.nen.nl

[3] C. Cuijpers, B. Koops , Het wetsvoorstel 'slimme meters': een privacytoets op basis van art. 8 EVRM , Universiteit van Tilburg, October 2008 (in Dutch)

[4] Convention for the Protection of Human Rights and Fundamental Freedoms, ETS 5.

3.2 Lack of regulation

Note of the Editor: This Section, developed within the SEESGEN-ICT WP5 "Business Models" activities (Deliverable D5-3, has been deemed also pertinent with the present Deliverable.

This chapter not only describes the barriers and solutions to barriers in a close regulatory context (legislative requirements referring to Regulators as stakeholders), but chooses a more comprehensive view in terms of what is to regulate (to standardize / to harmonize) in the context of SEESGEN-ICT.

Therefore we have to identify the borderline between regulation and standardization as there are different levels in the SmartGrids:

- The technical level (e.g. covering SCADA, smart metering, communication with field equipment, communication with the HAN …)
- The business/commercial level (e.g. communication and cooperation among stakeholders (contracts, offerings, orders, invoicing, bilateral or via data hubs, as well as tariff models, pricing models, market models, fostering of investment and prosumer participation, providing incentives / cost recovery)
- On both levels cyber security and authentication is relevant

This is shown in the concept of the Energyweb in Figure 18:

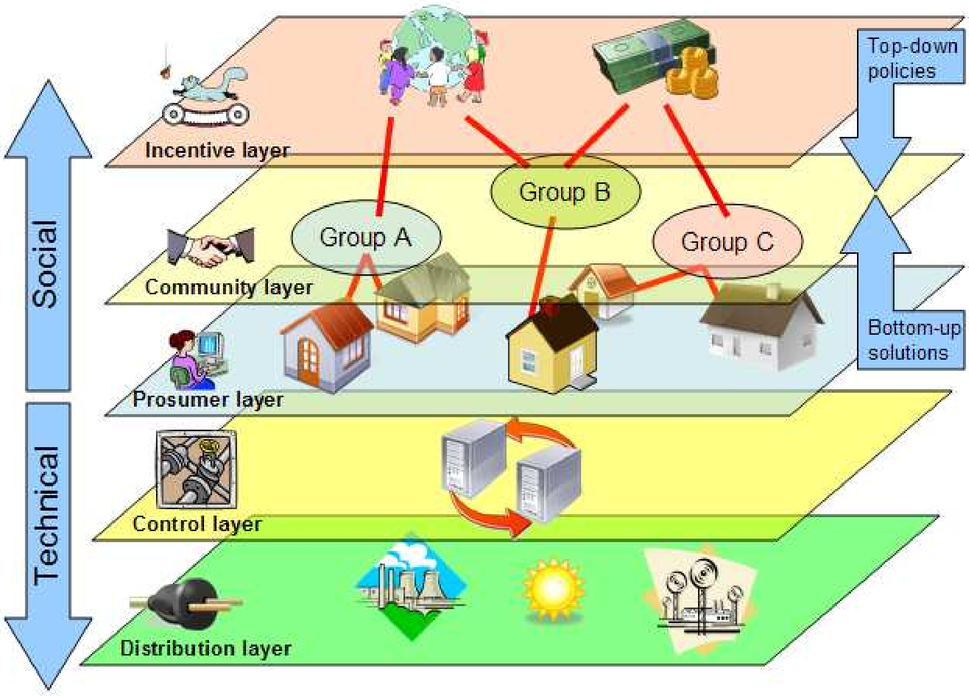

Figure 18: Different layers in the Energyweb concept [1].

Or, from an ICT application point of view, in the following chart:

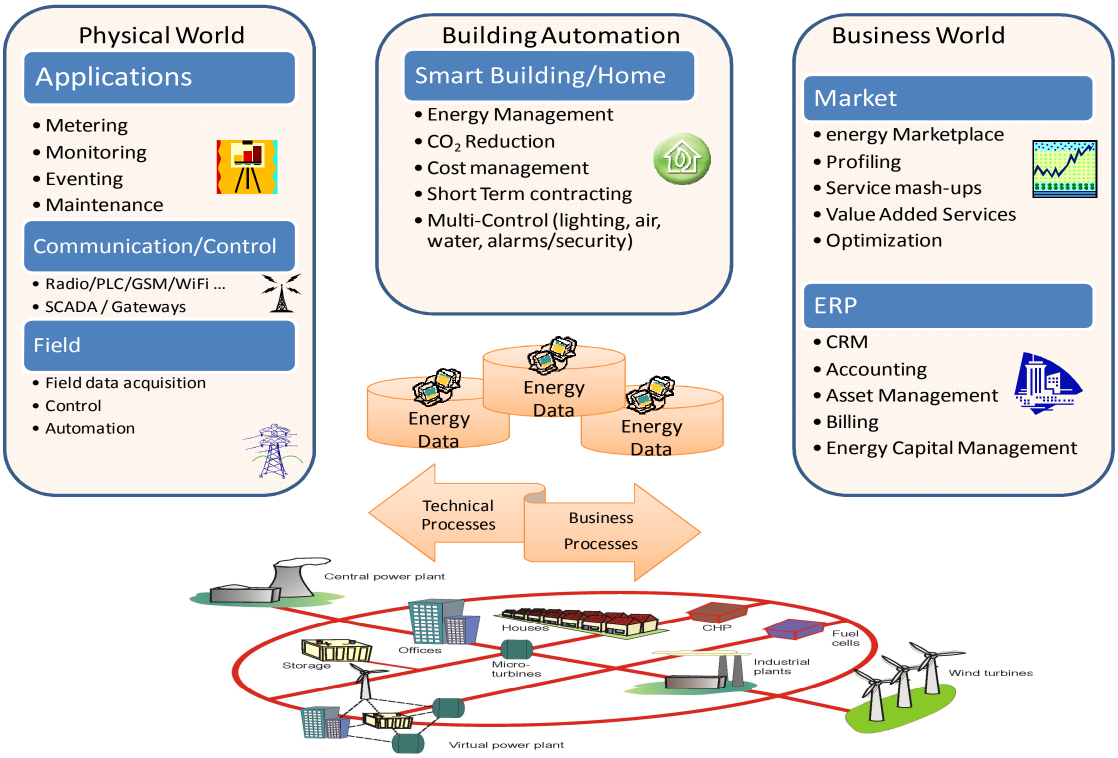

Figure 19: Information flow in physical world applications and energy markets [2].

In the first area we act fully in the world of pure standardization which is already covered and handled by the standardization bodies worldwide supported by different industry organizations like ESMIG, in the EU and NAESB in the US. Here we can see a good progress with very good results. The remaining gaps are identified and the future work is scheduled.

The main contributors / resulting documents are:

- NIST, Smart Grid Interoperability Standards [8]
- IEEE, P2030 [3]
- IEC, SmartGrid Standardization Roadmap [4]
- NIST, Guidelines for SmartGrids Cyber Security [5]
- UCAIug , Home Area Network System Requirements Specification 2.0 [7]

In the EU there is a clear Mandate to CEN/CENELEC/ETSI:

EU Mandate M/441 on Smart metering from march 2009 focusing on an open architecture for utility meters, communications protocols (bi-directional), interoperability, secure data exchange, allowing advanced information and management & control systems for consumers and suppliers. Standardization in this context does not mean imposing identical solutions on all projects in the Member States but to ensure that what a Member State may want to do in smart metering is covered by suitable standards.

This topic is further covered in detail in the section 2.2 “Barriers related to Interoperability”.

A remaining main barrier here is the harmonization of the existing sets of standards (and standards to come) for the use in the EU to provide a stable framework for the software and technology vendors to develop required ICT tools and technology to secure their investments (also to enable mass production and to reduce costs which will help in the large scale deployment – reduction of economic barriers)

In the commercial area it is different, as we have to cope with completely new business models and roles in the market which have a much higher variability beside new technology. Here we are still in the phase of pilot projects like the EU project address, the e-energy model regions in Germany or the new EEGI initiative. There are several approaches that will be explored and investigated but we are still far away from "market standards".

Here we also find organizations working on standardization like ebIX (together with ENTSO-E) in the EU or OASIS in the US beside the activities of regulatory bodies like ERGEG, ACER in the EU and FERC, NERC in the US.

Their main work so far was focused on

- regulation and modelling for the liberalization of energy markets and regulations for the remaining monopole areas;
- regulations, policies and market models to foster renewable energy generation and energy efficiency;
- positioning for requirements in the SmartGrid area and for the roll out of smart meters.

Even in the above areas we are still in a state of national regulations and market models. So there are a few countries with liberalized metering markets (e.g. UK, Germany) beside regulated metering markets (which will require a different approach when it comes e.g. to implement energy services by "aggregators"). Also the rules and the extent of market communication differ from country to country with a first region (the Nordics countries) that started a process of harmonization.

In the commercial area there is even a competition between "standardization" approaches. So there is some discussion e.g. in Germany positioning ebIX "standards" against CIM. This is also mentioned in [5]; that there is an interest for further development of the (technical, asset-oriented) CIM-standard towards general market communication.

So the main question is "is the lack of regulation" a main barrier for the deployment of large scale distributed (renewable) generation storage and DSI?

In the EU taskforce on Smartgrids (EG3 on regulatory requirements) the consensus among the stakeholders was: "There is no need for new Directives or Regulation but there is a need for a harmonized and effective implementation of the 3rd Package"

This is also one finding from the conclusions on ERGEG'S public consultation on their positioning paper on smart grids [6].

So the following section describes the needs for standardization/harmonization in the area of smart grids and DSI and not necessarily the needs for regulation (legislative). Even if there is no absolute need for pure legislative acts, ERGEG and ACER should support in the definition of guidelines and in the harmonization of rules derived from pilot projects and industry initiatives. This will help and promote to deploy the market models in a standardized way. This is also an experience shown in the liberalization of the German energy market. As long as there was no regulator the development and deployment of processes and tools for the market communication based on voluntary agreements among the industry took a very long time (with open end). With the support of the regulator it was a process of approximately 3 years.

What are the main areas for standardization (regulation) in the commercial area and therefore main barriers when it comes to deployment, as this will discourage market participants and consumers to participate if they have no clear vision and benefits?

- The extension and definition of new market and business models including appropriate business communication and (logical) interfaces
- The definition (regulation) of access to this new markets
- The implementation of communication hubs and central market platforms
- (Regulation) of security and privacy for the final customers
- Definition of Products and services
- Policies for fair split of costs and benefits and recommendations for funding

3.2.1 *New market models and interfaces*

New market models and interfaces are a prerequisite to develop standardized business processes and use cases that can be used by the market participants in a highly automated way. Otherwise the business will be restricted to few manual cases (as experienced in the liberalisation of the energy market, e.g. regarding change of supplier process). In the existing business models (see first deliverable) there are already good approaches that can be used for a generalisation. An already very generic approach is given in the architectural model of the ADDRESS project [1]. Similar approaches can be compared from other R&D projects to derive a generic market model for DSI and to further develop the existing generic ebIX model.

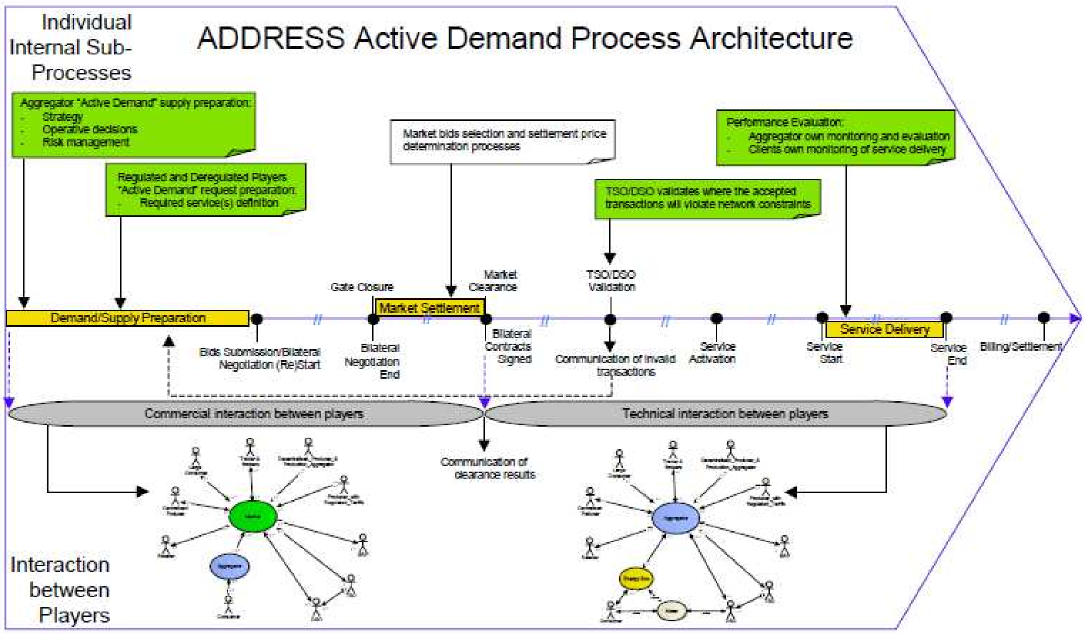

Figure 20: Commercial and technical process of active market partipation of small consumers according to ADDRESS.

Based on this model generic business cases, market processes and communication processes can be developed.

Regulatory authorities should promote maximum standardization and interoperability and establish level playing fields that encourage the market participants to work efficiently and to secure customer participation and market integrity. These interfaces should also include the access to wholesale market and the customer integration.

ADDRESS project (ADDRESS 2010) defines the market model in their commercial architecture shortly as follows:

> the commercial architecture ("contract negotiation" and "settlement" stages) deals with all the interactions, players structures, processes involved in the "negotiation" and "agreement" phase of the AD services (including the preparation of requests and offers) until the market clearance or the signature of the contracts (depending on the case). It also deals with the settlement stage after the end of the service.

Beside the market model and the communication processes there has to be also a standardization of the semantics for he exchanged messages. According to NIST [5] the main areas for standardization are:

- Common Pricing model to traverse the whole value chain including price, currency, delivery time and product definition
- Common time synchronization and management
- Common semantic model (to unify models of CIM, IEC61850, ebIX)
- Common meteorological and geospatial models
- Common scheduling mechanism

3.2.2 *The definition (regulation) of access to these new markets*

To establish a functioning and competitive market for DSI / Aggregator services as well as distributed generation/storage that attracts new participants, the access to the market has to be defined in a non discriminatory way, so that they get access to required data (e.g. from DSO's) and to required platforms (e.g. wholesale market). This is also a matter of harmonization among the EU, as access for distributed generators (or aggregated production) is limited to the produced power in some cases (e.g. Spain).

3.2.3 *The implementation of communication hubs and central market platforms*

To establish the appropriate market communication there has to be a guideline on the communication principle. Either bilateral which could be an approach in markets with few players or a central communication hub for many players. (in the EU we can see a trend in terms of market communication for liberalized markets towards central hubs that speed up deployment and which are easier to maintain).

3.2.4 *Regulation of security and privacy*

This is a clear regulatory requirement. Here fundamental work is accomplished with the report from NIST: Guidelines for SmartGrids Cyber security [29]. This is a prerequisite for the consumer to decide to participate in DSI activities and for smart metering. If security and privacy is not given he might fear that his data (e.g. consumption behaviour) could be misused. In Germany for example there is a current discussion if consumers only have to provide aggregated data (e.g. ToU consumptions) instead of interval data. This could endanger the whole market model. This is also an area of enlightenment of the consumers.

3.2.5 *Policies for fair split of costs and benefits and recommendations for funding*

This is also a clear regulatory area. The costs emerging from the introduction of new services or solutions in the grids today are mainly paid by the actor who requires these new services and who is the main beneficiary of them..

For the roll out of smart meters as one enabler of future services in the smart grids there have to be clear policies regarding who has to cover these costs and how the payback on the investment has to happen (e.g when the DSO covers the investment by considering in the incentive regulation or in cases where the consumer or the retailer owns the meter by ways of subsidising or offering clear benefits e.g. for DR-participation). A pure recovering of the investment based only on process efficiency improvement at the DSO and retailer side will not suffice. Therefore the cost/benefit analysis required from the "3rd package" at national level has to take into account a broader approach including e.g. energy savings, energy efficiency, reduced investments in grid extension as well as savings for balancing energy and based on this policies for a fair sharing of the costs have to be developed.

The above topics are also reflected in the recommendations from ERGEG in ERGEG Position Paper on Smart Grids (after public consultation and Conclusions) [30]

1. Ensure, as appropriate, a long-term stable regulatory framework and reasonable rate of return for cost-efficient grid investments;
2. Consider and further analyse decoupling between grid operators' profits and volumes of electricity they deliver taking into account the introduction of performance indicators and performance-based incentive regulation;
3. Pursue regulation of outputs as a mechanism to ensure value for money paid by network users and to investigate metrics for the quantification of the most important output effects and benefits ;
4. Promote mechanisms favouring an improved consumer awareness of their electricity use and market opportunities through actions of suppliers and other market participants and an improved engagement of network operators with their network users;
5. Encourage the deployment of Smart Grid solutions, where they are a cost-efficient alternative for existing solutions, and as a first step in this direction, to find ways of providing incentives to network companies to pursue innovative solutions where this can be considered beneficial from the viewpoint of the society;
6. Evaluate the breakdown of costs and benefits of possible demonstration projects for each stakeholder and to take decisions or give advice to decision-makers based on societal cost-benefit assessment which takes into account costs and benefits for each stakeholder and for the society as a whole;

7. Ensure dissemination of the results and lessons learned from the demonstration projects in case they are (co-)financed by additional grid tariffs or from public funds to all interested parties, including other network operators, market participants, etc.;
8. Participate in Smart Grids discussions and cooperation activities among stakeholders and especially to consider an active cooperation with European and national standardisation organisations, grid operators and manufacturers, for example on open protocols and standards for in-formation management and data exchange, in order to achieve interoperability of smart grid devices and systems;
9. Clarify the difference between regulated grid activities and market opportunities for new services under a competitive regime (e.g. aggregation of resources, Electric Vehicle (EV) recharging) and to carefully monitor and prevent the possible presence of cross-subsidies between network activities by TSO's or DSO's and market-based activities;
10. Continue the exchange of expertise at European level, in order to learn as soon as possible from best regulatory practices.

References

[1] ENERGYWEB, no author, untitled, from networking session at ICT2008 event, Nov. 2008, Lyon available at: http://ec.europa.eu/information_society/events/cf/ict2008/item-display.cfm?id=679

[2] SAP, internal presentation, author Stamatis Karnouscos

[3] P2030, IEEE P2030 Draft Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System (EPS), and End-Use Applications and Loads, available at: http://grouper.ieee.org/groups/scc21/2030/2030_index.html

[4] IEC, IEC Smart Grid Standardization Roadmap, June 2010, SG3 working group

[5] NIST Cyber Security, NIST Guidelines for Smart Grid Cyber Security, Vol 1-3, NISTIR7628, August 2010

[6] ERGEG, Position Paper on Smart Grid, draft, public consultation and conclusions, E09-EQS-30-04, E10-EQS-38-05, E10-RMF-23-03

[7] UCAIug, UCAIug Home Area Network System Requirements Specification 2.0, August 2010

[8] NIST Special Publication 1108, "NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0", January 2010

4 COUNTRY ANALYSIS

4.1 Demand side integration in Spain

The existing programs for load reduction in Spain are contracted in the electricity market and there exist some rules for being able to participate in them.

A customer willing to participate in the load reduction program needs:

- To be connected to the high voltage network.
- To have a minimum reduction capacity of 5 MW.

There is not any possibility to participate in any other way (the concept of aggregation is not allowed for participation).

Apart from this an R&D project is being worked out to investigate on the technologies required to manage the consumption of small consumers.

Plan for the roll out of Smart Meter

According to the Orden ITC/3860/2007, dated December 28, a plan for changing all the meters for consumers with a contracted power of up to 15 kW was established:

New meters must be able to have hourly metering and to be remotely managed

Each distribution company must change at least a given percentage of its consumers' meters in some periods (no aggregation can be done, i.e., if the minimum percentage is exceeded in one period, it cannot be used to reduce the percentage to be installed in the next period):

- Between 01/01/2008 and 31/12/2010: each distribution company must change the meter to at least 30% of its consumers
- Between 01/01/2011 and 31/12/2012: each distribution company must change the meter to at least 20% of its consumers
- Between 01/01/2013 and 31/12/2015: each distribution company must change the meter to at least 20% of its consumers
- Between 01/01/2016 and 31/12/2018: each distribution company must change the meter to at least 30% of its consumers
- Distribution companies must have their systems for remote management ready by 01/01/2014

In June 2009, the Government proposed to speed up the process of changing residential meters, but the regulator refused, argueing that:

- The Ministry for Industry did not establish the conditions for remote management in due time
- Therefore, DSOs could not define their systems for remote management
- In addition, there was not an European standard for smart meters. The Commission sent a request to CEN, CENELEC y ETSI in March 2009 to create a communication standard within 9 months and a functional standard within 30 months.
- Hence, meter manufacturers could not have the physical equipment ready

- So the first milestone (30% in 2010) will be difficult to meet
- As a result, there is no point in speeding up the changing plan

<u>Future Active Demand in SmartGrids</u>

There is a project partially financed by the ministry of Industry of Spain whose objective is to facilitate the active participation of customers in network management.

<u>This project has the following objective</u>:

The project aims at using the flexibility of end-customers to solve network problems, by being able to demand consumption reductions to selected customers and to limit their consumption by modifying the allowed consumption in the meter.

<u>The project involves the following actors</u>:

- The TSO that is able to demand a load reduction to the DSO according to the contracted reductions from small consumers from the residential sector.
- The DSO that can sign contracts with the aggregator and order directly a load reduction from the participating consumers.
- The aggregators that establishes the contracts with the end-customers and negotiates the participation with the customers and with the TSO and DSO.
- Meter manufacturers and household appliances manufacturers that look forward to the automation of the processes in the houses.
- Communication companies that work on solving the communications problems at different levels.

<u>The project aims at solving the following barriers</u>:

- Reaching the meter of the customers from the dispatch control room of the DSO:
    - Communication media to be used.
    - Protocols to use.
    - Data models to use.
    - Standards.
- Smart meter and Home Energy Management system (HEMS):
    - Functionality of the smart meter.
    - Functionality of the HEMS.
    - Interfaces between the Smart meter and the HEMS.
- Integration of the HEMS and the appliances:
    - Communication media.
    - Protocols.
    - Data models.
    - Standards.
    - Interfaces between the HEMS and the appliances.
- Household appliances:
    - Additional functionality.

- Required hardware and software.

- Equipment cost:
  - Embedded HEMS with a minimum price, minimum functionality and an associated display.
  - Low cost of additional hardware and software for appliances.

4.2 Demand side integration in Denmark

The Danish DFR project investigates how a broad array of loads, such as electric heating/cooling, fridges and freezers can sensor the system frequency and change their behavior to help balance the grid.

The Danish system frequency is 50 Hz with a tolerance of 0.1 Hz. Each load is equipped with a small piece of hardware that monitors the frequency and reacts if it deviates from the 49.9 – 50.1 Hz range. The hardware can react by controlling a relay or, for thermostatically controlled devices, by controlling temperature set points.

The first phase of the project was initiated in 2006 and focused on the theoretical analysis and prototyping. This phase has been financed by the Danish TSO (Energinet.dk) and the participants are EA energy analysis (a Danish energy consulting company), the Technical University of Denmark and the research laboratory PNNL (USA).

The conclusion from Phase 1 of the DFR project is that the concept can supply a fast and reliable service to the grid at a low cost compared to traditional reserves.

The second phase of the DFR project is devoted to field testing where 100+ DFR enabled loads will be tested and monitored. The Phase is sponsored by the Danish energy authority EUDP and the partners include the phase 1 partners as well as the companies Danfoss and Vestfrost who will supply test equipment and the distribution system operator Østkraft. The second phase started in 2009.

The full project will conclude in 2012.

Technical barriers to the concept include:

- **Hardware cost** The hardware used in the solution must be small and inexpensive. If the DFR equipment represents too high a cost, it will represent a barrier to widespread usage of DFR.
- **DFR optimization** The power grid will have to adjust to the usage of DFR. If the technology is not sufficiently understood and integrated into the operation of a distribution system operator, it will not meet its full potential. A distribution system operator must have the ICT to measure and monitor the effects of DFR.

Nontechnical barriers of the concept include:

- **User acceptance** End-users must understand and accept the concept of DFR. A skeptical attitude to the concept among end-users can represent a substantial barrier.
- **Sufficient incentives for both OEMS and end-users** A lack of incentive to develop or purchase DFR-enabled equipment is another barrier to DFR. Good business models must be developed to satisfy OEMs and end-users.

4.3 Demand side integration in Italy

In Italy ENEL Distribuzione, the main Italian DSO, has implemented Telegestore, an innovative system to manage residential and commercial meters remotely, via Power Line. [1]

The implementation of the system has required the installation of smart meters nearby all the Italian commercial and residential end users.

The installed meters support remote operations (disconnection, remote set-up of parameters, etc.) and enable load profile recording (with interval time of 15 minutes), downloading of application software, self diagnosis, anti-tamper and anti-fraud features, multi-rate tariff support.

In ENEL strategy, the smart meter is seen as the starting point towards demand response. In particular, it enables the following functions (fundamental for every demand response program):

- **interaction** with consumers: remote readings and management
- use of **tailored tariffs**
- management of prosumers: **bidirectional** meter

The installation program has been notable: 40000/5000 meter installed per day.

Moreover it was needed the implementation of an entire new architecture with concentrators that concentrate data from the meters, public GSM (or satellite where needed) connections between concentrators and acquisition centers (access servers called Automatic Mater Management - AMM) and a Customer Information System, fed by the AMM.

The Telegestore has several features for customer Relationship management (CRM):

- remote management of the contract (disconnection, remote set-up of parameters, etc.)
- billing based on real meter reading
- support to flexible tariff;
- real time contract changes
- support to demand side integration

From the regulatory point of view, the implementation of this system was enabled by two important directives that carried into effects, in Italy, the Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services. "*The purpose of this Directive is to enhance the cost-effective improvement of energy end-use efficiency in the Member States*" [2].

The above quoted directives are:

- o **D.P.R n. 115 del 2008 art 17 comma 1 lettera c**

DSOs shall provide clients with instruments to monitor their energy consumptions, such as ad-hoc displays or by using electronic devices already available in their homes.

- **Delibera ARG/com 56/09**

Already ongoing a procedure to issue a directive in response of D.P.R n. 115 del 2008 art 17 [4]

The project aims to solve the following barriers

- **Technical barriers**:
  - ***Lack of automation infrastructures****:* providing the infrastructure to build the demand side integration, as starting point for Demand Side Integration
- **Economical barriers:**
  - ***Investment and revenues:*** showing that the savings in the operational costs, got through the implementation of this system, justify the needed monetary investment.
  - ***The entity on investments:*** showing that the use of public telecom network is the correct solution to avoid opex and capex extra-cost.
  - ***Hardware cost:*** with the adoption of narrow band solution after estimating different modulation methods. The result was that narrow band solution is the simple one and therefore this choose can optimize the cost of transceiver and coupling devices.
- **Social barrier:**
  - ***User acceptance***: providing new interesting services for the end user.

Next step

The next scheduled step, in this process of implementation of Demand Side Integration by ENEL, is the Smart Info project. The Smart Info will be a device that will make the data collected from the smart meter accessible to different end user interfaces (PC, TV, custom display, appliances, etc.). Therefore, it will enable the communication between the smart meter and the indoor appliances (see figure). Moreover, it will be able to provide and support energy services to incentive the customer **consciousness on energy consumptions**

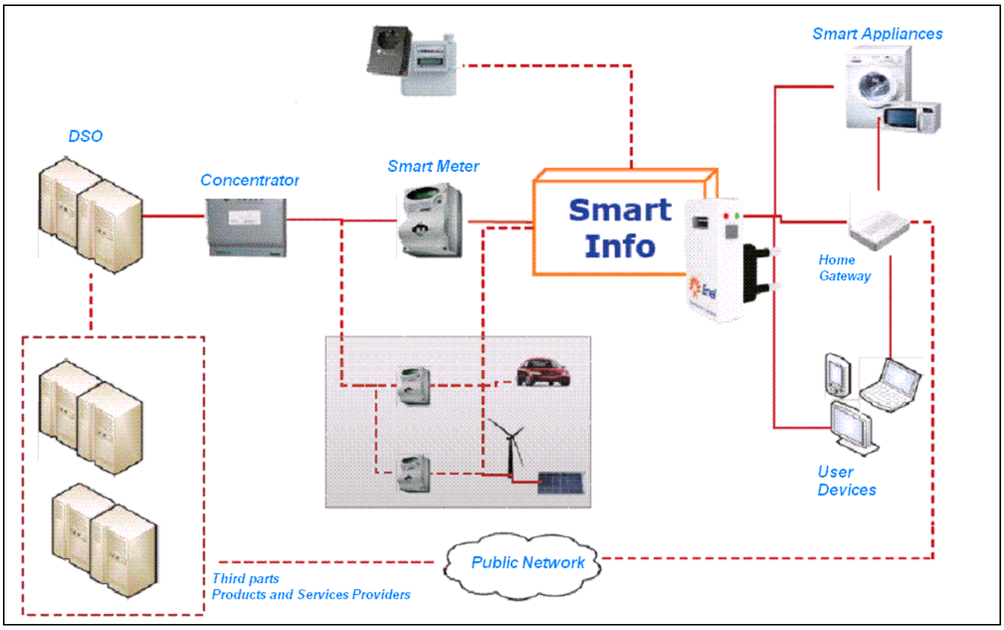

Figura 21. Smart Info Architecture [5]

It aims to solve the following barrier:

- **Technical barrier:**
    - o ***Lack of automation infrastructures***: providing the infrastructure to build a networking with smart appliances
    - o ***Interoperability***: defining a <u>open</u> and <u>standard</u> platform for the indoor communication between home appliances, smart meter and broadband gateways to enable energy efficiency services
- **Social barrier:**
    - o ***User acceptance:*** making the end-users aware, in a friendly way, of their consumption and longing for reduce them.

References

[1] Botte, Cannatelli, Rogai, “The Telegestore Project in ENEL’s metering system”, in 18th CIRED proceedings

[2] Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC. Available at: http://www.less-en.org/_assets/client/files/1257-full%20text.pdf

[3] DECRETO LEGISLATIVO 30 maggio 2008 , n. 115. “Attuazione della direttiva 2006/32/CE relativa all'efficienza degli usi finali dell'energia e i servizi energetici e abrogazione della direttiva 93/76/CEE”. Available at: http://gazzette.comune.jesi.an.it/2008/154/2.htm

[4] Delibera ARG/com 56/09. Available at: http://www.autorita.energia.it/it/docs/09/056-09arg.htm
[5] Marina Lombardi, “Demand Response: ENEL experience”. March 2010.

4.4 Demand side integration in the UK

Background Information

UK generation, transmission and distribution systems were considerably expanded in the late 1950s and early 1960s. These assets are now approaching the end of their useful life and it is expected that a significant proportion of these assets will need to be replaced in the next two decades. This opens up the question of the strategy for infrastructure replacement, in particular the design and investment in future electricity networks and the role that enabling technologies, such as DSI, will have in designing future electricity systems. There have recently been some major advances made in ICT, which in principle could enable the deployment of various DSI options.

Smart meters can be looked as the enabling technologies for DSI. The initiatives in the UK to deploy smart meters are listed below.

- Between 2005 to 2007 “Energy Watch” proposed to introduce smart meters to benefit energy suppliers, consumers, energy distributors and finally the environment. From the consumers, it is expected to have a behavioural change using the updated information provided via a smart meter. Also it analysed the cost benefits of smart meters.
- In 2006 February “Offgem” issued a consultancy to find out the actions to be taken to introduce smart meters in the context of the UK’s competitive domestic metering services market and also to realise the benefits of smart meters.
- In 2006 November, the DTI issued the energy review consultation to mandate and consult the provisions on detailed bills and smart meters. The response was issued on 2007 July.
- In 2007 April, the BERR issued a report on costs and benefits of roll out options of smart meter and discusses various technology options of meters, displays, communications and roll out scenarios.
- In 2007 May, the DTI issued the White Paper on Energy which expected to introduce smart meters for saving energy within next decade. In 2007 August BERR issued consultation on policies presented in the White Paper and in 2008 April issued the Government response to the consultation.
- The Energy Demand Research Project (EDRP) managed by “Ofgem” conducting trials from 2007 expecting to complete in 2010. Out of four trials two are being conducted by installing visual displays for 8,500 households and smart meters for 18,000 households.
- The Government has decided to roll out of smart meters from 2009 January for the large scale non-half hourly metered customers whose annual consumption is above 732 MWh and complete installation by 2013. The BERR issued the final consultation on the above in 2008 January.

- The BERR issued consultation on smart meters for the medium scale customers in 2008 July. Decisions will be made after the second report from EDRP which is due in November 2008.
- Even though the White Paper expected to mandate the real-time electricity display devices to all new and replacement electricity meters, after the consultation on policies of the White Paper, the Government has decided not to proceed with the mandated requirements, but intend to work with suppliers to reach a volunteer agreement to provide displays in short and medium terms.

Practical Applications and Pilot Demonstration

Schemes have been in place with large, industrial consumers for about 20 years in the UK. But the interest is now focusing on domestic and commercial consumers.

There are pilot demonstration of smart metering being undertaken by Ofgem (www.ofgem.gov.uk) as mentioned before. There are two important issues: (i) to demonstrate and gain experience of the smart metering technology, but also (ii) to determine the functions required of smart metering. The latter remains unclear and greater clarity is required before national implementation of smart metering should be implemented.

Barriers

The concept of DSI is not new and the key technologies for its implementation have already been developed. However, the implementation of DSI has been slow. One of the main reasons is lack of ICT infrastructure.

Advanced metering, communications, control methods and information technologies are largely absent from electricity systems. In order to support the implementation of DSI in system operation, much more significant deployment of various sensors and advanced measurement and control devices will be required, accompanied by much more sophisticated energy metering and trading functions. This will lead to wide-ranging deployment of information and communication systems to facilitate the control of generators, loads and various network devices. Implementation of ICT for the control of electricity networks will lead to the development of an integrated energy and communications system architecture that is intended to integrate two systems in the power industry: the electrical delivery system and the information system (communication, networks and intelligence equipment) that controls it.

There needs to be a comprehensive analysis of the costs and benefits of installing such a sophisticated infrastructure. Commitment to its implementation would make the case for DSI significantly stronger.

References

[1] Domestic Metering Innovation. Consultation Report 20/06, Ofgem. (February 2006)

[2] Get Smart: Bringing Meters into the 21st Century, energywatch. (Aug 2005)

[3] Getting Smarter: Improved Energy Information for Consumers. energywatch. (January 2006)

[4] Eoin Lees Energy. Smart Meters - Costs and Consumer Benefits. energywatch. (July 2007)

[5] Energy Billing and Metering: Changing the customer behaviour, An Energy Review Consultation, Department of Trade and Industry. (November 2006)

[6] Mott MacDonald, Appraisal of Costs & Benefits of Smart Meter Roll Out Options, Department for Business Enterprise and Regulatory Reforms. (April 2007)

[7] Meeting the Energy Challenge - White Paper on Energy, Department of Trade and Industry. (May 2007)

4.5 Demand side integration in The Netherlands

At the moment there are no commercial applications of demand response for residential customers in the Netherlands. This contrasts with the application of demand response at larger customers, such as industries and the greenhouse horticulture sector, which is beginning to see some interesting applications. Especially in the greenhouse horticulture sector suppliers such as Westland Energie and De Vrije Energie Producent have special tariffs for customers that adapt the power generation in their CHP units in response to the variations in the market price and imbalance. Another (more traditional) application in the greenhouse horticulture industry is curtailment of assimilation lighting.

These kinds of demand response services are currently lacking for residential customers. This is caused by various barriers including:

- Minimum size requirements for controllable power (5 MW for the APX day ahead market, 10 MW for the TSO bidding ladder for regulating power);
- Lack of mechanisms for verification and settlement of DR actions;
- Split of DR responsibilities between DSOs, retail suppliers and service providers.

PowerMatchingCity Hoogkerk

For residential customers in the Netherlands the largest DR application so far is the PowerMatching City demonstration in Hoogkerk (near Groningen, in the Northern part of the Netherlands) [PowerMatching City]. In PowerMatching City 25 households are virtually connected. In each of the houses power is not only consumed, but produced as well. The PowerMatcher coordination mechanism is used to reduce grid power imbalances, optimize local power and energy management in a grid with a high share of distributed generation [PowerMatcher, Roossien 2009]. Each of the households in PowerMatching City has some controllable forms of demand and local generation, such as washing machines, heat pumps and microCHP units (see Figure 22). The PowerMatcher coordination mechanism serves both as a mechanism for control and for aggregation of these small demand response sources.

PowerMatching City is implemented by a consortium consisting of ECN, KEMA, ICT and Essent, with support from the European Commission, Gasunie, Gemeente Groningen and Energieconvenant Groningen [Integral].

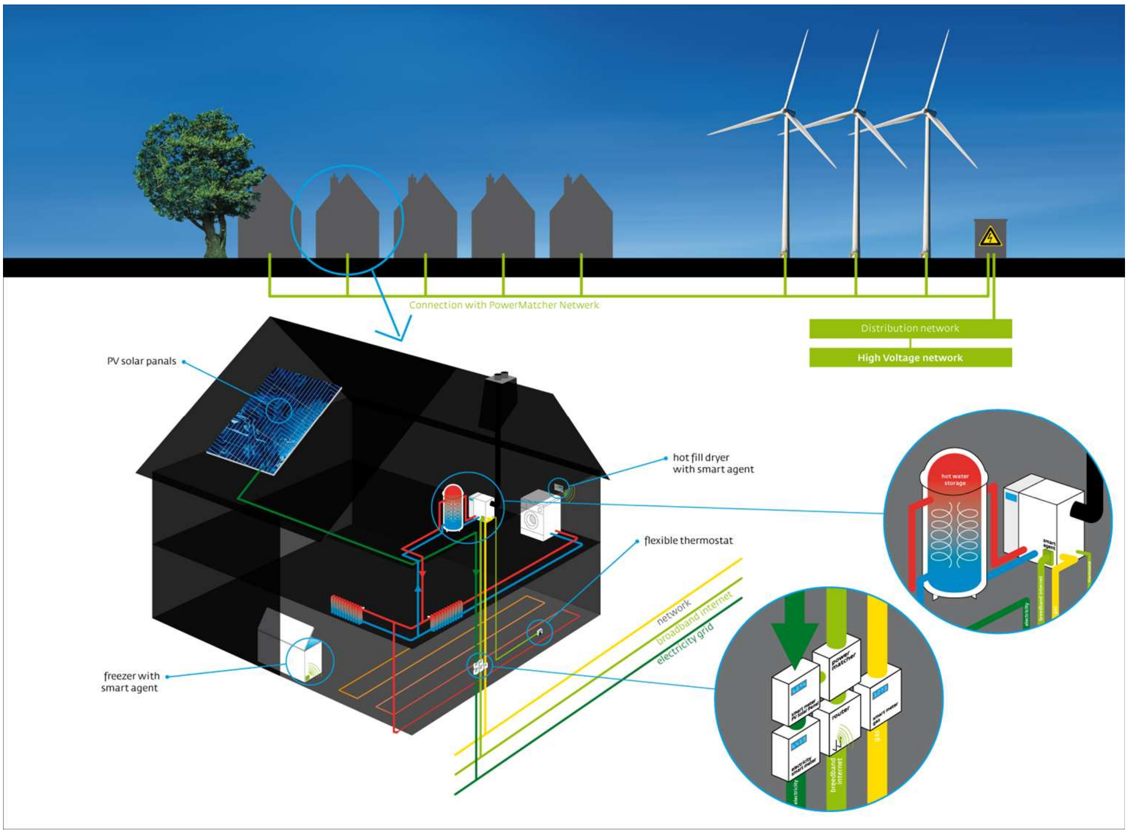

Figure 22. Schematic picture of controllable supply and demand in PowerMatching City.

References

[PowerMatcher] www.powermatcher.net

[Integral] www.integral-dc.com

[PowerMatching City] www.powermatchingcity.nl

[Roossien 2009] Roossien B., Field-test upscaling of Multi-agent Coordination in the Electricity Grid, CIRED 2009 Prague, 8-11 June, paper 0009.

4.6 Demand side integration in Germany

Current situation

In Germany, regulation has only recently required metering utilities to – if technically possible and feasible – install meters which reflect the real energy consumption and real usage times of energy in buildings newly connected to the low voltage grid or buildings that undergo a major refurbishment with the goal of enhancing energy efficiency[1]. Metering utilities also have to offer

[1] German law for the energy economy sector (Energiewirtschaftsgesetz, EnWG, §21b)

according metering solutions for exchange of existing meters. This new regulation is valif as from Jan 1st 2010.

It is commonly accepted that such metering solutions are a prerequisite for realizing active demand programs. Regulation also requires energy providers to offer – if technically possible and feasible – a tariff to the end customer which sets an incentive to save energy or to control the energy consumption, latest until Dec 30th 2010. The law mentions load-variable or time-variable tariffs[2].

However, there is currently still a lack of market-ready technical solutions for remotely readable meters. One of the main reasons for this is that there is no agreement on a common standard for implementation of all needed ICT interfaces. Unlike other european countries, e.g. Italy (Enel), there is currently no mass roll-out of smart metering solutions to end customers in germany.

Major activity is however currently taking place in running R&D programs financed either by industry initiative or public funding. Activities are currently bundled in the "E-Energy" technology program [1] which covers six model regions where different solutions for active demand response, integration of decentralized and renewable generation, electronic and ICT based markets for energy ("Internet-of-energy" approach) are developed and field tested. Results from these projects are mostly not yet available.

Example cases

Example case for a running project

As an example case, the project "Modellstadt Mannheim" ("model city mannheim") [2] is outlined which is one of the six model projects of the "E-Energy" technology program. This project was preceded by a field test in the city of Mannheim where a field test with 18 households equipped with energy management devices was conducted led by the local energy supplier, MVV Energie AG. These devices are called "energy butlers" and are based on the "bidirectional energy management interface" (BEMI), a technical solution for variable-tariff based automatic management of load and generator optimization in buildings connected to the low voltage grid. The latter technology was developed by Fraunhofer IWES (formerly ISET e.V.) and firstly introduced in 2004 [3].

Model City Mannheim aims at continuing this approach by implementing a swarm of locally controlled loads and generators. In a field test currently under preparation, more than 100 end customers will be included. The field test is scheduled to start in August 2010. The technology involved comprises a new implementation of the BEMI approach based on the reference implementation of a standard developed within the "open gateway for energy management alliance" (OGEMA) [4].

Example case for a completed project

Despite the fact that there is currently no smart metering or active demand enabling technology broadly available, there are several small research projects in germany already completed which can be considered as "proof-of-concept" or making first experiences. One of the first

[2] EnWG §40

projects is a field test in the city of Eckernförde conducted in 1994-1996. There, 1000 households were equipped with a device indicating three different levels of a variable tariff ("Stromampel" (electricity traffic light)). The devices could be installed at every power outlet of a building. This approach is known as the "Eckernförder Tarif". A social study resulted in a number of 78% of all customers preferring the Eckernförder Tarif over a standard tariff. It can be assumed that this high rate of agreement was achieved because of a best-proce- gurantee granted to the customers. Evaluation indicated load shifting effects on washing machines, tumble dryers and dish dryers. Evaluation of the shifting effects indicated small load reductions at an average of 24 W per household (maximum 60 W) in the year 1995; however, it was not possible to confirm an absolute saving in energy consumption when figures from field test regions were compared with households not receiving the Eckernförder tariff [5].

<u>References</u>

[1] E-Energy - ICT-based energy system of the future, http://www.e-energy.de/en/ (April 2010)

[2] B. Buchholz, D. Nestle, A. Kiessling: "Individual Customers´ Influence on the Operation of Virtual Power Plants", IEEE Proceedings for IEEE PES General Meeting, 2009

[3] C. Bendel: „Dezentrale Energieeinspeisung ins Niederspannungsnetz - Information über das Forschungsprojekt DINAR", Presentation for VDE Kassel, Kassel, September 2004

[4] D. Nestle, J. Ringelstein, H. Waldschmidt: "Open Energy Gateway Architecture for Customers in the Distribution Grid", Information Technology 2/2010, p. 83-88

[5] M. Duscha, E. Dünnhoff: "Innovative Stromrechnungen als Beitrag zur nachhaltigen Transformation des Elektrizitätssystems", Study for the Project „Transformation and Innovation in Power Systems" (TIPS), Heidelberg, November 2007

5 CONCLUSIONS

In this report we have analyzed the barriers, as well as possible solutions, to the deployment of ICT for the integration of end-users, grid operators and intermediary entities, thus exploiting the potential of the Demand Side Integration.

The main technical barriers that have been identified, along with the possible ICT solutions, are the following ones:

- Relevant to Smart metering: The minimum functionality required for DSI to the Smart metering has not been agreed yet and the installation of equipment has not taken place in many cases.
  - □ Solutions include the specification and sharing of the minimum required functionality and the preparation of plans for the quick installation of equipments in every Country.
- Smart appliances: Currently there are not commercially available smart appliances and building energy management systems with a minimum agreed functionality, although intelligent thermostats exist and some intelligent switches are being built which could be used for retrofitting existing appliances. On the other hand, the end-user will not accept any extra cost for behaving smart unless the benefits are clear.
  - □ Solutions may come from the specification and sharing of a minimum functionality for the building energy management systems and the commercialization of low cost smart equipment. Launching procurement programs for smart appliances together with offering subsidies for buying them and providing financial benefits to end users for their participation in DSI programs, through the design of business models that transfer the financial benefits from the grid operator to the end-user (e.g. CO_2 tax).
- Interoperability: Lack of established standards for ICT enabling DSI at all levels for the complete integration of all parties, starting from end-users up to the grid operators and intermediary parties.
  - □ Solution may come from the design of standards agreed and accepted by all the stakeholders, whit a clear focus, which will have to grow from already existing work performed by different organizations.
- Security: The problem of security, which can be subdivided into confidentiality, integrity and availability are not specific of this domain, although the damages associated to any break on it may be catastrophic.
  - □ Solutions like dedicated lines, tunneling, using the Internet protocols or the session initialization of voice can be used and have to be tested for this domain to decide on the best option based on cost of the security solution and risk associated to it.
- Robustness and scalability: A system which foresees the participation of thousands of participants and that has to continuously match offer and demand can not be subjected to loss of services and to having the deliveries late in time.
  - □ Solutions like redundancy and virtualization already exist and should be adapted to the specific needs of the domain.

- Privacy: The information that the end-user makes available for DSI purposes, has to be private and only used for the purposes he makes it available, any other use of the information will hinder his participation. Removing privacy concerns is an important element of marketing of DSI services.
  - □ The solution may come from the application of “privacy by design” during the design of the system and through a good communication with the end-user.
- The survey of the situation of DSI in different European Countries shows that the plans for the deployment of DSI in Europe go at a different pace in every Country and this may create problems of interoperability in the future. The most Countries have started to provide solutions to the first barrier, by making plans for the installation of smart meters (most of the Countries) and having them installed (Italy and, partially, the UK).
  - □ The UK is working in the solution of the smart meter barrier, by preparing the plans for their installation and installing partially smart meters and in the solution of other barriers (e.g. tied to the costs and to the limited awareness of the benefits) at a research and pilot project level.
  - □ Italy (through ENEL) has worked to the solution of the smart meter barriers by installing a large amount of smart meters. The development of smart appliances is at a research level.
  - □ Demark is working in solving issues related with the smart appliances barriers at a research level.
  - □ The Netherlands with an initial law for the installation of smart meters has had to delay it due to their concerns about the privacy barrier until a satisfactory solution is reached. Amendments have been introduced to the law and it is expected that in 2011 the installation of smart meters will start. At a research level solutions has been worked out to remove the smart appliances barrier
  - □ Spain has an initial law for the installation of smart meters but it appears that the first stage of installation is going to be difficult to meet. On the other hand it is working from a global point of view at a research level by trying to advance in solutions to each of the barriers.

All these national case show both the potential of the DSI and the needs of interoperable ICT tools to exploit the DSI

<u>The DSSP concept as a solution to the barriers</u>

The previous SEESGEN-ICT deliverable D4.2 highlighted how the concept of a Demand Side Service oriented Platform (DSSP) could enable ICT solutions shared by the different stakeholders, so as to deploy the DSI potential, . This deliverable D4.3 has identified barriers and solutions that may prevent or delay the full deployment of ICT. DSSP is expected to help overcoming these obstacles, identifiying and supporting best practices, providing interoperability solutions, supporting standardization and enabling the DSI governance.

To this extent, the DSSP has

- to be coordinated with the roll out of required infrastructures as smart meters, smart appliances (enabling flexible load on the end-user side), but also with the roll out of smart devices for DG and on the network side
- To be actively and closely coordinated with the standardization initiatives The most pertinent standardization solutions will enable the DSSP to ensure the indispensable interoperability of the ICT tools for the DSI
- To implement solution for the safety and the security solutions, to prevent communication failure, cyber attacks or cyber failure, multiple infrastructure failure. Different technological solutions and risk management strategies have already been investigated into research project or industrial works. But a "system solution" will have to be implemented into the DSSP.
- To integrate specific rules to prevent threat of the privacy of the end-users (and probably to be coordinated with new regulatory framework). Is is indispensable for the social integration of the DSI through the DSI.
- To be supported by further investigation about social barriers, involving sociological, ergonomic expertise, results of demonstrations at the real scale. Probably a "well-informed" selection of the end-user and of their electrical uses involved into the DSI through the ICT (and through the DSSP) will be necessary.

These issues are outlined below.

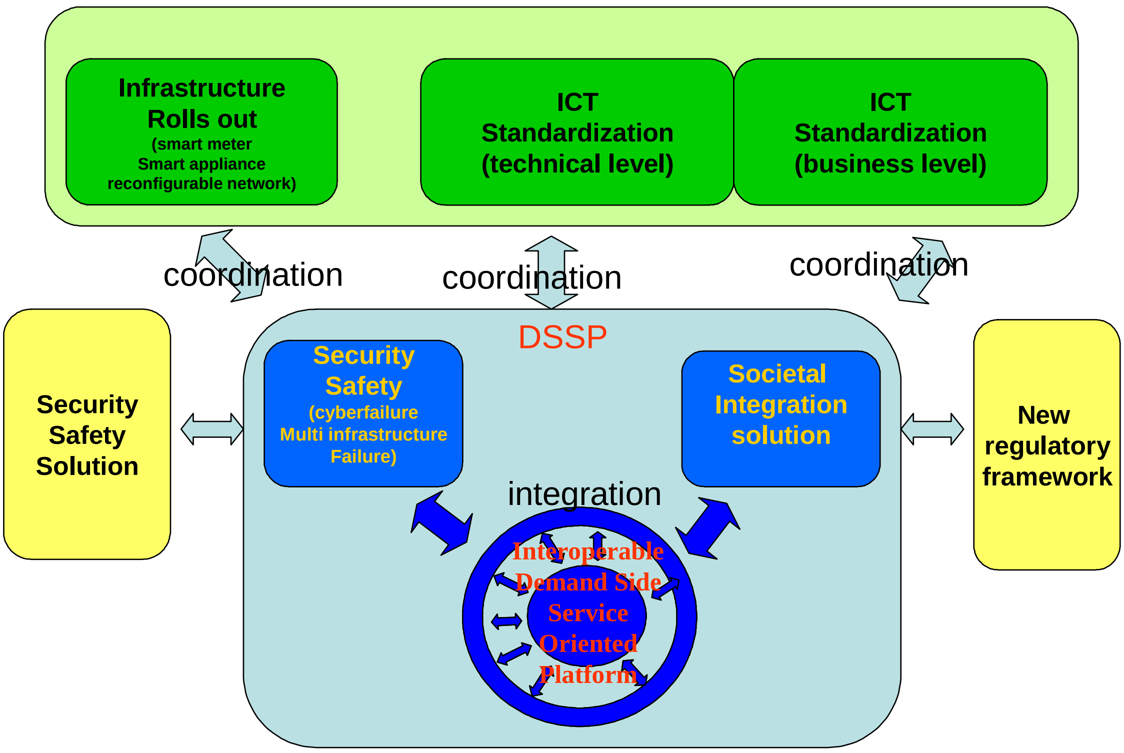

Figure 23: Framework for the building of the DSSP

In the next step of WP4 activities, the consortium will prepare recommendation:

- to promote research project focused on technical ICT platform (according to the DSSP), including imperatively both research projects at the laboratory scale and demonstrators at the real scale.
- to create working group, including supervisory group and specialized group
- to prepare further investigations on the governance of the DSI, particularly relying on the results of the research project and on other investigations of the working group.