

INTERNATIONAL SMART GRID ACTION NETWORK (ISGAN)
SMART GRID CASEBOOK 2017

SPOTLIGHT ON CUSTOMER ENGAGEMENT AND EMPOWERMENT

Version 1.0

International approaches and lessons learned in
Customer Engagement and Empowerment.



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INTRODUCTION

The objective of Annex2 is to assess outstanding examples of current case studies, develop and validate a common case study template and methodological framework, and then develop in-depth case studies using this framework. The template is currently the "Case Book" to contain descriptive information. The common framework for case studies will allow comparison and contrast of policies and technologies adopted in different regulatory, legislative, network (grid), and natural environments. The overarching aim is to collect enough information from case studies around the world to extract lessons learned and best practices as well as foster future collaboration among participating countries. The Consumer Engagement Case Book reflects one way that ISGAN brings together experts and stakeholders from around the world to increase the awareness of consumer engagement in the field of smart grid.

Customer engagement and empowerment offers opportunities to save energy for customers and to operate the grid in a more efficient and reliable way for grid operators. Grid operators want to shift or reduce energy consumptions during times of peak consumptions, so they have engaged and empowered customers to do that by proposing some benefits. Cases of customer engagement and empowerment in this book share lessons learned in developing and deploying these technologies to stakeholders.

In this stage, the Case Book includes 10 cases on Consumer Engagement & Empowerment of the top 10 winning projects from the 1st ISGAN Awards Competition. Countries that are included in the CaseBook are Belgium, Denmark, France, Japan, Portugal, Netherlands, and U.S.A.

Abbreviations

AMI	Advanced Metering Infrastructure
BEMS	Building Energy Management System
CEMS	Community Energy Management System
DEMS	Distributed Energy Management System
DER	Distributed Energy Resources
DMS	Distribution Management System
DR	Demand Response
DSO	Distribution System Operator
EMS	Energy Management System
HAN	Home Area Network
HEMS	Home Energy Management System
ICT	Information and Communication Technology
MCBs	Micro Circuit Breakers
OMS	Outage Management System
PV	Photovoltaic
RES	Renewable Energy Supply (Sources)
TOU	Time of Use
TSO	Transmission System Operator

Belgium: LINEAR - Local Intelligent Networks for Energy Active Regions

Project Title	LINEAR - Local Intelligent Networks for Energy Active Regions
Location	Ghent, Leuven, Genk, Flanders, Belgium
Time Period of Project	May 2009 - December 2014
Link to Project Website	www.linear-smartgrid.be
Key Word	Demand Response, Household, Energy Storage, Energy Consumers

Project Background

In Belgium’s electrical network, the generation of electricity corresponds closely to demand at any given time. This is the principle that underlies the functioning of the network. But it is becoming increasingly difficult to maintain. Our traditional generation capacity is dropping: energy producers are shutting down older and unprofitable plants, and we are also in the process of gradually phasing out nuclear generation. At the same time we bring additional sources of generation online, mainly in the form of wind and solar energy. But those energy sources are driven by the weather, not by the demand for energy. Sometimes this results in energy surpluses, as was the case in Belgium during the Pentecost weekend of 2012 and on Easter Monday of 2013, when we generated so much surplus energy that the power grid almost failed. By the same rule, this also increases the risk of energy shortages, which can arise on cold, grey and windless winter days when demand is high.

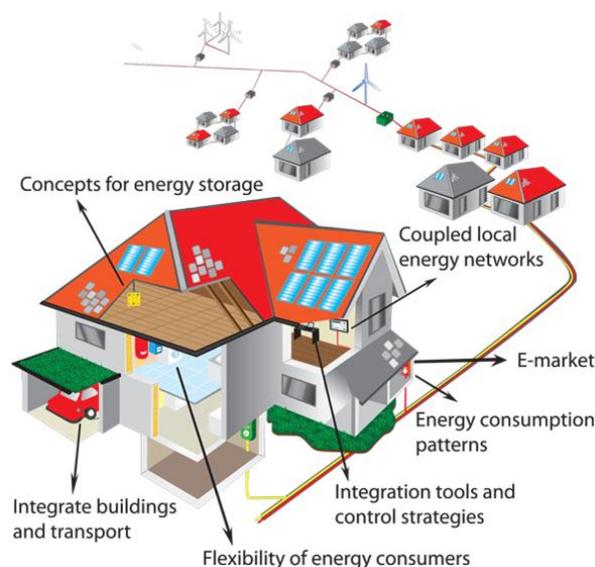


Figure 1. Household based Demand Response

With the help of two remuneration models and four business cases, Linear is studying ways for households and producers or power grid operators to better tailor energy consumption in relation to energy generation. Households can be encouraged to adjust their energy consumption patterns by providing them with a financial incentive (rate control) or by operating their equipment automatically (automated control) and rewarding the households for the degree of flexibility they provide. The future of decentralised generation presents power grid operators and energy suppliers with many challenges. The trick is to deploy the right solutions for the least amount of cost. Linear is studying four challenges for which demand-side management could be a sound technical and economically profitable solution. Throughout the entire field test, we will also be examining the best ways for energy suppliers to encourage consumers. We are encouraging participants by means of a financial incentive that corresponds to the actual cost savings.

The current changes in the production model can be solved in part by reversing the inherent logic: by tailoring energy consumption to the supply. Via the Linear project, twenty different partners are researching the best and simplest ways for adapting residential energy consumption based on the availability of solar and wind energy with the help of 250 test households. A Smart Grid integrates electricity, gas, heat and communication networks into a single system that maximises the generation and distribution of energy and which makes it possible to utilise a larger share of green energy. Smart grids do a better job of coordinating consumer demand with the supply of energy from producers. Linear is part of the larger global effort to study smart grids for supplying energy in the future, and is focusing on the consumer.

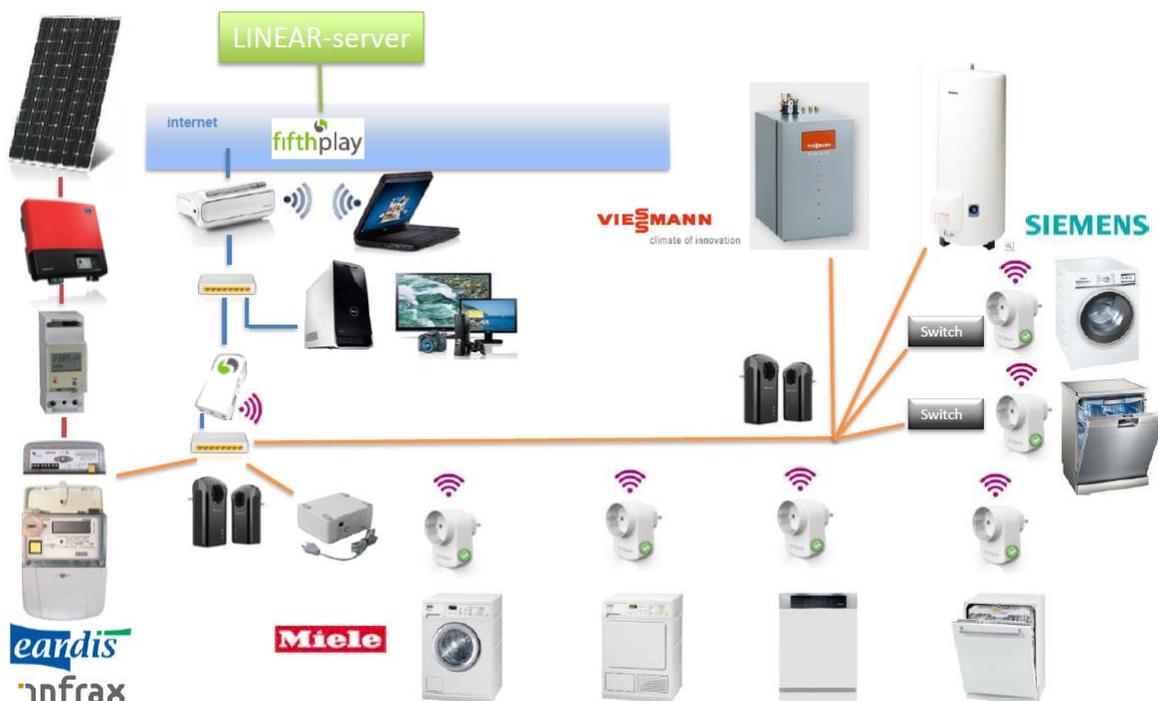


Figure 2. Connection of Smart Appliances

Linear Intelligent Networks is a research platform of residential demand response. The platform was built for multi stakeholder smart grid approach to demand response system. Demand response is seen as an important smart grid technology to contribute to mitigating the effects of

- the increasing share of intermittent renewable energy production,
- the increased electrical load due to the shift from fossil-fueled towards electrical equipment

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- and the decreasing investments in controllable (fossil-fuel) plants.

Although demand response (DR) is increasingly deployed in the industry, the large potential in the residential sector remains hitherto unused, as other criteria apply; comfort protection is a basic requirement to enable sustained participation of families in demand response schemes, the sources for flexibility are small in energy but their numbers are large,... As such, the technology needed for residential DR is fundamentally different from the industrial equivalent. Because of the comfort requirements, Linear selected and deployed 2 types of smart appliances that offer large amounts of flexibility and can be automated for a minimal comfort impact. First type are the postponable appliances, such as dishwashers, washing machines and tumble dryers, 445 of which are deployed in the Linear pilot. Second type are the buffered appliances, such as smart domestic hot water buffers (15) and electrical vehicles (7).

Additionally, 110 families are equipped with smart meters, appr. 2000 submetering points are installed and 94 houses have photo-voltaic panels, representing a total of 400 kWp. The architecture can support different Home Energy Management Systems and Balancing Responsible Parties, hence taking into account the complex European deregulated energy market. With standardized interfaces appliances can exchange information and constraints in order to optimize system operation and user comfort. The Linear system is a research platform designed and deployed by the Linear partners to investigate user behavior and acceptance. For 4 business cases, Linear also identifies the technical and economic challenges and opportunities to facilitate an increased share of renewable energy sources.

The 4 selected business cases are:

- Portfolio Management: can we make customers shift their energy consumption in function of the day ahead market and nominations?
- Wind Balancing: can we reduce unbalance costs for the retailer, caused by deviation between predicted and produced wind energy?
- Transformer Ageing: can load spread in time avoid accelerated ageing of transformers?
- Line Voltage Management: can we avoid issues with voltage deviations in local grids?

Many partners are involved in the project as shown below. The research project of Linear is a cooperation between the research institutes of EnergyVille (KU Leuven, VITO, imec) and iMinds and takes part in the Actieplan 'Vlaanderen in Actie'. It is financed by the Flemish government and receives considerable support of Belgacom, Eandis, EDF Luminus, EnergyVille, Fifthplay, Infrax, Laborelec, Miele, Siemens, Telenet and Viessman. Also Agoria, EWI, IWT, VOKA and VREG are involved.



Figure 3. Linear Partners

Case Description

Linear is a Flemish Smart Grid project focusing on solutions to match residential electricity consumption with the availability of wind- and solar energy. Research partners and industrial partners joined forces, in close collaboration with the government, to develop, deploy and evaluate demand response technology. This technology can be easily adopted by families and supports the operation of local distribution grids and energy markets. 240 families are participating in the demonstration project, evaluating 2 different consumer interaction models:

1. Variable Time of Use (ToU) is tested with 55 families. They are supported with a Home Energy Monitoring System and a display that shows market priced tariffs, scaled-up to 2020 wind and solar prediction. This model supports the business case of day ahead portfolio management.
2. The second model is defined in cooperation with the families and designed to operate intra-day, guarantee user comfort and generate flexibility for families, grid- and system operators. Where ToU appeals to financial reward, the flexibility system appeals to financial benefits, as well as ecologic and societal engagement. Here the families are equipped with a Home Energy Management System and smart appliances (s.a.: washing machines, dish washers, tumble dryers, electric heating applications and electrical vehicles). They are rewarded for the flexibility – time window for remote start/stop – they offer. The flexibility is used for the day ahead case portfolio management and the intra-day cases: wind balancing, transformer ageing and line voltage management.

For each of the business cases, Linear investigates to which extend residential Demand Response can offer a technical and economical solution to mitigate the effects of the increasing share of intermittent renewable energy production in relation to user behavior and comfort.

The Linear study is composed of nine different work packages, each of which forms a different phase of the study. Some packages involve fundamental research while others develop new technologies, and work package 8 consists of the preparation and implementation of the pilot project involving the households.

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- **Work package 1:** gathering data and administering surveys to get a better picture of the energy consumption of households. Based on the results of this sub-study, we examine what the best options are for creating flexibility in our test households.
- **Work package 2:** we develop realistic user profiles based on the data gathered in work package 1. These profiles can then be used in other work packages to design models that will allow us to simulate the effects of certain interventions.

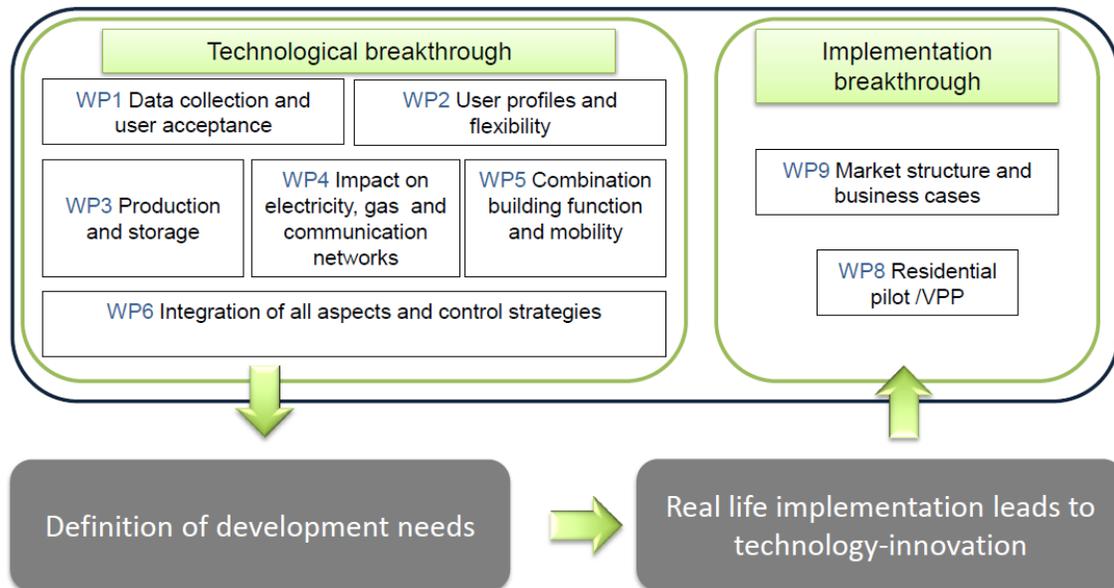


Figure 4. Work Packages

- **Work package 3:** studies the potential for energy storage. Temporary storage is key to incorporating more renewable energy into our power grids. We are conducting research into the storage of electrical energy in batteries as well as the storage of heat in buffers. By decoupling a building's demand for heat from a heat pump's demand for electricity, flexibility can be created. Research has also been done on combining cogeneration with district heating in order to support the power grid at the local level.
- **Work package 4:** studies the way in which electricity, gas and communication networks interact with each other when we implement our Linear solutions.
- **Work package 5:** looks at the impact and potential of using the batteries in electric vehicles to store renewable energy as it is generated and to then return this energy to the grid during times of peak consumption.
- **Work package 6:** combines the various technological insights and converts them into algorithms and simulations.
- **Work package 7:** overlapped to a large extent with the other work packages and was therefore eliminated. These tasks were allocated to other work packages.
- **Work package 8:** is the real-world test: we use the data that was gathered and the technologies that were developed in all the substudies to test out the theories on real households.
- **Work package 9:** focuses on the economic aspects. This involves research into the way the market currently functions, the changes to market functioning that will be required for the future, and potential business cases for distribution system operators, suppliers and customers.

Project Outcomes

The level of innovation of the Linear project is very high. The partners represent the whole value chain which allows for a combination of the know-how of DSO's, retailers, research institutions, manufacturers and telecom providers. This already resulted in highly innovative solutions to be developed and commercialized within the project, such as device controllers, new generation smart grid ready appliances, home energy management systems,... Linear not only developed unique solutions but also pushes the boundaries where real time interaction between user behavior and business case implementation is concerned.

One of the unique points in this project is the different ways in which the flexibility of the end consumer is exploited to solve the technical needs of the different underlying business cases. The whole concept of residential demand response would not be viable without active participation of the end consumer. Therefore one of the key aspects of this project is the co-creation of the flexibility interaction that appeals to comfort, societal, ecological and financial awareness of families and results in a stronger engagement than ToU. The flexibility interaction empowers families' concerns for a sustainable and reliable energy supply for the future. The Linear project influences the day-to-day behavior of the end consumers, enabling them to participate in the electricity market without exposing them to its complexity.

The ambition of the LINEAR project is not only to develop innovative technologies, but to set the stage for an implementation of these mechanisms on a national and European level. For this reason, regulatory policies, consumer behavior and market models are all considered. The objectives of the project are fully in line with the ISGAN mission. Different business cases and new market models are extensively studied, taking into account financial incentives for all market actors. Regulatory barriers are mapped out as well, and a set of regulatory recommendations is delivered to the authorities, based on the outcome of the project. Linear demonstrates that demand response is technically possible and that there are actual benefits for consumers and involved parties. In the near future, the smart grid ready appliances could become standards and residential demand response could find its way into the everyday lives of millions of European consumers.

Denmark: EcoGrid, consumer engagement in the future power system

Project Title	EcoGrid: Consumer engagement in the future power system
Location	Island of Bornholm, Denmark
Time Period of Project	March 2011 to August 2015
Link to Project Website	www.eu-ecogrid.net
Key Word	Residential Households,

Project Background

Worldwide, the share of renewable generation from wind and solar in the energy mix is growing and is expected to keep on doing so. There will be a higher need for fast balancing power in the future. Activating the electricity demand and bringing electricity consumers into the market create additional capacities to balance the power system in a secure and economical way. The purpose is in large-scale to test how much every tenth electricity consumers on the Danish island Bornholm can contribute with flexible consumption and how test participants equipped with demand response devices with smart controllers and smart meters will respond to real-time prices based on their pre-programmed demand-response preferences. One of the key challenges is to enable demand response of small-scale electricity customers through a real-time market based on five minute price signals. This would give the TSO/DSO a new, additional and important tool for balancing the power system on a very short notice.

Approach/project conduct related to consumer engagement and empowerment: The project wanted to recruit test participants who represent the 'average' electricity customer and not-only the 'first movers' (e.g. people especially concerned about environmental issues). Recruitment of minimum 10 % of the residential electricity customers was supposed to meet this criterion. Beside customer analysis, recruitment (acquisition) plan and measures the initiatives related to empowering and involvement of EcoGrid test houses include

- i) Establishment of educational and advisory customer services
- ii) Selection of EcoGrid ambassadors and an external reference group
- iii) Evaluation of customer satisfaction, participation and acceptance, and
- iv) Evaluation of efficiency benefits/demand response/bonus.

Case Description

The objective of the EcoGrid project is to allow small-scale/residential electricity consumers to participate in the power market and contribute to the balancing of renewable electricity generation by active demand response to five minute real-time price signals. And thereby it is trying to illustrate that modern information and communication technology (ICT) and innovative market solutions can enable the operation of a power system with more than 50% renewable energy sources (RES) such as wind, biomass and photovoltaic (PV). EcoGrid is a large-

scale Smart Grid demonstration project. The field test is located on Bornholm - a Danish island electrically connected to the Nordic electricity market. Approx. 1,900 residential electricity consumers and up to 100 commercial customers are participating in the field test. This represents almost every tenth electricity consumers on the island. The majority of the test participants are equipped with demand response devices with smart controllers and advanced metering infrastructure. One of the project focus/outcomes in relation to customer satisfaction is to maintain at least 80 % of participants interested during the entire test period (finalized autumn 2015). It is important to continuously manage participants' expectations. An ambitious EcoGrid/Smart Grid information and education program is one of the means to obtain consumer engagement and empowerment.

FURTHER SECURITY REQUIREMENTS

A bid-less, real-time electricity market based on five-minute price forecasts, and five-minute price signal resolutions pose new and complex requirements to data, data security and scalability that must be addressed in the development of ICT solutions. To ensure confidentiality, the security requirements considered in EcoGrid EU are related to:

- The origin price information must be trusted (authenticity)
- The price information is not altered while being transported (integrity)
- The source cannot deny published price information (non-repudiation)
- The price information distributed cannot get injected at a later point in time for another time period (non-replayability)

■ Why an EcoGrid EU Real-time Market?

Today, the electricity grid is primarily a road for moving electricity in a one-way flow from large power generation plants. Significant changes to the power system must be foreseen, as traditional energy resources are replaced by local renewable generation connected to the distribution system. Tomorrow's power system will include a variety of distributed and local energy resources as well as accommodating electric vehicles. This will require two-way flow of both electricity and information as new technologies enable new forms of generation, supply and uses. New solutions, including wider use of information and communication technologies (ICT) and automation will be necessary, as well as reinforced electricity grid and improved power trading opportunities. Without this, there is a risk of insufficient power system security and reliability, as well as inefficient utilisation of eg new wind power capacity. Generation of electricity from fluctuating renewable sources such as wind, biomass and photovoltaics poses a challenge to the power grid. Although generation from these sources can be forecasted, the availability of power fluctuates and always depends on weather circumstances that cannot be controlled (wind, rain and sun). Even if the energy generated follows the forecast perfectly, it may still not match the consumers' need for electricity.

THE WIND POWER CHALLENGE

Renewable energy in general and wind power in particular already plays an important role in many areas in Europe. In Germany, the share of wind power is 7.8% of electricity consumption (2012). A high concentration of wind power in the Northern part of Germany creates together with the import from north a surplus of electricity which must be moved to the west and to the south of Europe. In Denmark, the share of wind power is 30% of the total electricity consumption (2012). In 2020, the energy strategy of the Danish government is to increase the share of renewable energy to 35% of total energy consumption, implying that 50% of the electricity consumption in Denmark is supplied by wind power in 2020. Wind power already covers and exceeds the entire Danish demand for electricity in many hours the course of a year. This situation will appear more frequently in the future – significantly increasing the need for power balancing resources. Currently, international connections provide most

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of the balancing of wind power in the power system. In future, there will be more competition for power balancing resources and the costs of these resources are expected to increase significantly.

THE REAL-TIME MARKET MAKES ACTIVE USE OF PASSIVE RESOURCES

The development of a real-time electricity market is considered one of the most efficient ways to meet the challenges in operating a power system with increasing shares of renewable sources:

- The EcoGrid EU real-time market has a very high time resolution (five minutes), which improves the capability to manage high amounts of rapidly fluctuating renewable energy sources.
- The market price is set in the very last minute, meaning that very accurate forecasts of wind power and demand can be utilised when determining the market price. It means that problems with forecast errors inherently present in conventional markets are minimised.
- Compensate for traditional balancing resources: The real-time market will increase the demand-side market participation and thereby reduce the need for costly flexibility on the production side and/or compensates for traditional balancing power and services from conventional generation displaced by generation based on renewable energy sources.
- The EcoGrid EU real-time market will improve the utilisation of the inherent (free) flexibility in eg thermal loads (load-shifting potential).
- Activation of a large number of customers will improve the function and competition in the power market through increased market participation and by connecting the wholesale market with the retail market (increase retail competition).

Furthermore, the activation of the demand side, through the real-time market, enables locational pricing for congesting management. This will result in better use of grid capacity, reducing and deferring costs for reinforcements of the distribution network.

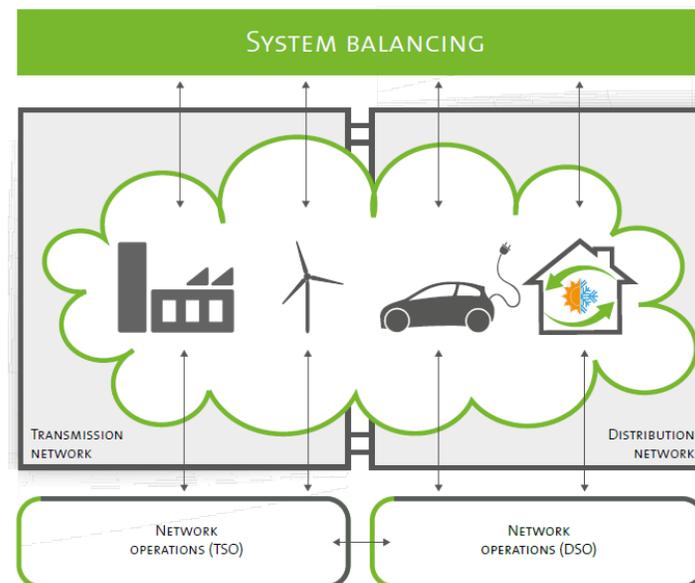


Figure 5. Demand-Participation in the System-Wide Market for Energy and Balancing in the Transmission Network

■ The Fundamentals of the Real-time Market Concept

The EcoGrid EU market concept is based on the publication of real-time price signals. Adapting the behaviour of flexible resources like electric heating and heat pumps will contribute to maintaining the balance of supply and demand in the power system. From the wholesale market perspective, this implies that a five-minute price signal is created by for example the TSO, by continuously monitoring the power system and adjusting the price signal to correct the balance of the system. To do so, it is necessary to create reliable forecasts of the expected response to price changes. These will be utilised when computing the marginal price change required to trigger a response of the right size, leading to a proper rebalancing of the system.

MODERNISATION OF THE POWER MARKET(S)

As the wind power and photovoltaics production increases, so will the need for more dynamics in the power system. The real-time market makes it possible to manage many resources, ie activate a great potential of flexible resources on the demand side that is currently inactive. Therefore, the introduction of real-time market will be an obvious step in the further development of the existing electricity wholesale markets and balancing markets that creates more favourable conditions for the future composition of renewable generation and energy resources. This will not necessarily require a replacement of, but an extension of the current market set-up. Today and in the future, most of distributed energy resources under the current framework face barriers to supply balancing services. The market operation is currently based on an hourly time resolution that does not reflect the actual dynamics in the power system. The EcoGrid EU real-time market approach means that the trades in the power market are based on what the market players actually do, rather than what they promise to do, which is the practise in the current markets like the day-ahead spot market.

The real-time market concept is based on a 'bidless' market with price announcement ex-ante. This implies that the final settlement price is determined by prediction of the real-time price responsiveness rather than on explicit bids as known from conventional auction based power markets. A bidless market minimises the efforts (transaction costs) put in by small-scale electricity customers or small power generation units, because they must not create bids and schedules, but simply respond to the actual market prices.

REAL-TIME IN FIVE MINUTES

The proposed real-time market concept operates with very high time resolutions (five minutes). It will increase the market based balancing options and will be an efficient supplement to more costly direct control options (eg congestion management).

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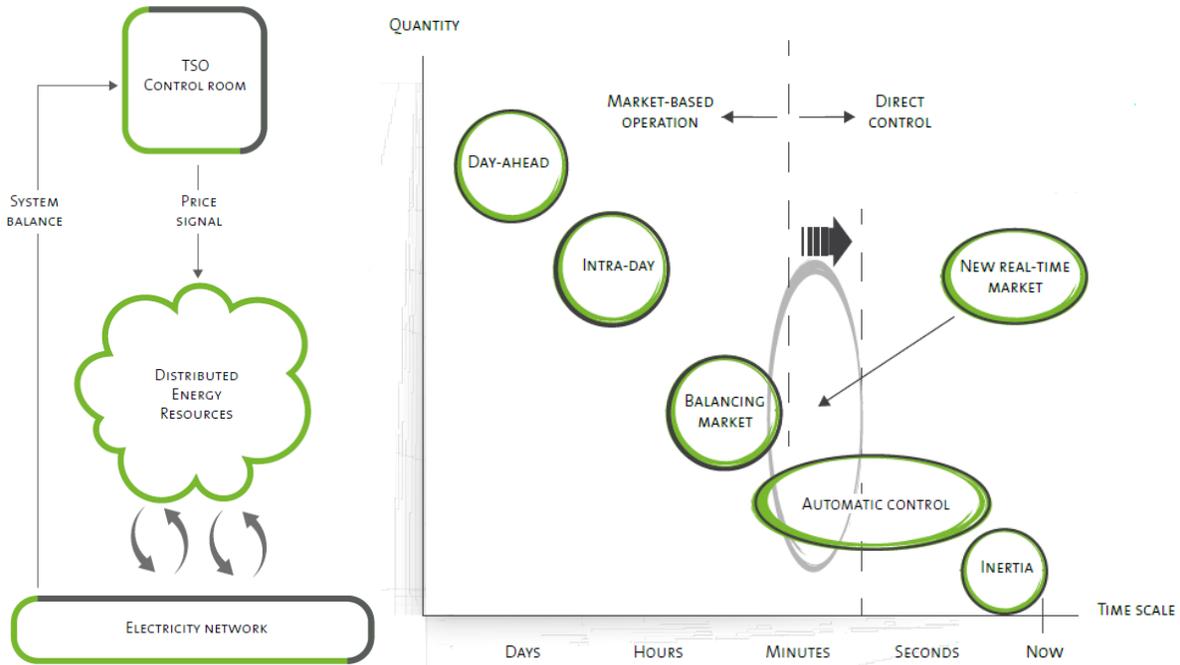


Figure 6. EcoGrid Real-time Market

THE CUSTOMER – AN ADDITION TO THE EXISTING POWER MARKET AND SYSTEM

The customer as we know him or her today wants to consume electricity, so they start the ‘money flow’ by purchasing such electricity from retailers. In addition, the customers pay the electricity grid company/distribution system operators (DSO) for the use of the electricity grid and for the meter and for billing. The market operator trades electricity by ‘buying’ electricity from producers and ‘selling’ it to retailers. In the EcoGrid EU market, the situation is identical with the situation today, but the EcoGrid EU customers also provide balancing power - a flexibility service to the transmission system operator (TSO). It is the retailer or the balance responsible partners that manages this transaction with the TSO on behalf of their customers. In the EcoGrid EU model, the relation between the retailer and the customer stays entirely in the liberalised market and the customer is free to choose a retailer and a contract model as offered by the retailer of his choice.

BASIC REAL-TIME PRICING VERSUS ADVANCED REAL-TIME PRICING

The first phase of the EcoGrid EU demonstration was initiated in May 2013. During this phase, the basic real-time pricing is tested through a so-called ‘open-loop’ approach. This implies that the real-time price only will be based on external price information from the Nordic power market (Nord Pool) and balancing markets, as well as system information about availability of wind power. Market rules of the Nordic power system prohibit publishing information reflecting the present power system balance. Therefore, the development of five minute real-time prices is based on the experience gained through the actual demand response of the test participants on Bornholm and realistic public information available about power prices.

Experience gained from the test participants’ reaction to basic real-time price signals provides valuable knowledge and input to forecast of demand response. This facilitates testing more advanced real-time pricing through a so-called ‘closed-loop’ approach that expands the market concept with forecasts of demand response in the second phase of the EcoGrid EU project. Based on the forecast of demand response, real-time prices are calculated and broadcasted to the market in order to obtain a certain objective, ie the amount of balancing

resources required by the system operator(s). The balancing services can include a certain net consumption/generation from the distributed energy resources, or a certain reduction of import of electricity with the neighbouring countries or the mainland.

This will facilitate testing the system's ability to follow an objective, eg a certain area or portfolio balance position, thus bringing the demonstration scenario one step closer to a full-scale implementation, where the objective is overall system balance. The price calculation will utilise advanced demand response forecast models to calculate the price corrections necessary to follow the objective.

The impact on the overall power system balance (ie the Nordic power system) will be negligible, and it is therefore not feasible to generate the price signal at the Nordic power system level, using the system-wide balance as feedback. Therefore, (live) feedback signal will be obtained at local area level (ie for the Bornholm power system area) and/or from live signals from the interval meters.

DIFFERENT WAYS TO TEST PRICE RESPONSIVENESS

The real-time price response can be realised in several different ways – with and without help from automatic control systems and home automation solutions. Four test groups will test different solutions to realise the demand response to real-time prices:

- The manual control group (500 residential consumers)
- The automatic control group with IBM/GreenWave home automation system (700 residential consumers)
- The automatic control group with Siemens/SyncoLiving home automation system (500 residential consumers)
- The group of industry/commercial buildings with Siemens automation systems (up to 100 companies)

The manual control group only has access to real-time price information, ie none of their electric household devices are automatically controlled. The manual control group will only receive manual response assistance, eg through training/energy advice and a feedback system with consumption and price information (see type A in the figure 4). The automatic control groups and the group of industry/commercial buildings will beside manual assistance also receive technical assistance. All of the automated households will have home automation equipment installed in order to optimise the operation of their electric heating, heat pumps or similar large appliances. Two main approaches are used to realise the demand response of the automated test participants:

1. Automatic control of individual electric devices/resources (see type B in figure 4)
2. Aggregated control of a portfolio of electric devices/resources (see type C and D in figure 4)

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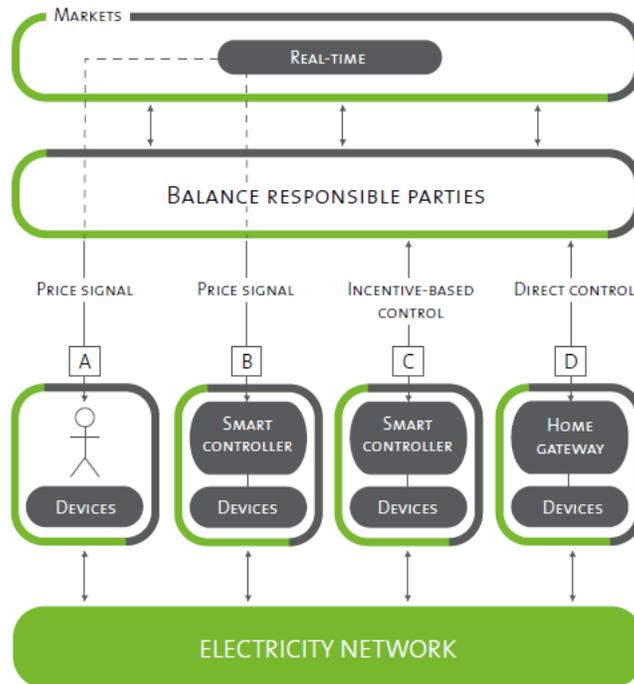


Figure 7. Four different ways to Implement Real-time Price Response

■ The ICT Platform and Software Solutions

The ICT system and software solutions supporting the Eco-Grid EU real-time market concept do not start from scratch. The ICT architecture is based on existing software solutions available on the market today, which have been tested in other field situations. The project demonstrates software, all developed to address the development of Smart Grid functions and in this case, the function of the real-time market.

KEY COMPONENTS OF THE ICT APPROACH

Real-time electricity prices are generated at the price generation module every five minutes. The ICT implementation consists of a price generation module and price distribution components. The price generation module takes input from i) TSO, ii) electricity spot market, iii) historical metering data, and iv) weather forecasts. The generation module sends prices and price forecasts to the price distribution system, which uses publish-subscribe technology to broadcast the real-time price information to the customers. The EcoGrid EU ICT concept describes a solution to combine publish-subscribe and so-called internet provider multicast technologies (a method for sending Internet Protocol datagrams to a group of interested receivers in a single transmission). This functionality is required for scaling the ICT system up for nationwide use. Different internet service providers (ISPs) of an area subscribe to the relevant price signals and within the ISP domains, relevant price streams are multi-casted. This means that the solution can be scaled-up, and in case of a massive deployment of the real-time market concept system across the EU member states, it could accommodate millions of residential electricity customers. Smart devices or end-nodes adjust their planned consumption according to the price information. All households are connected to a smart electricity meter, which measures the power consumption of the device(s) every five minutes. The measured power consumption data is uploaded to the historical metering data repository

once every 10 minutes. Figure 5 shows the implementation and the key components of the ICT architecture for real-time price distribution in Eco-Grid EU.

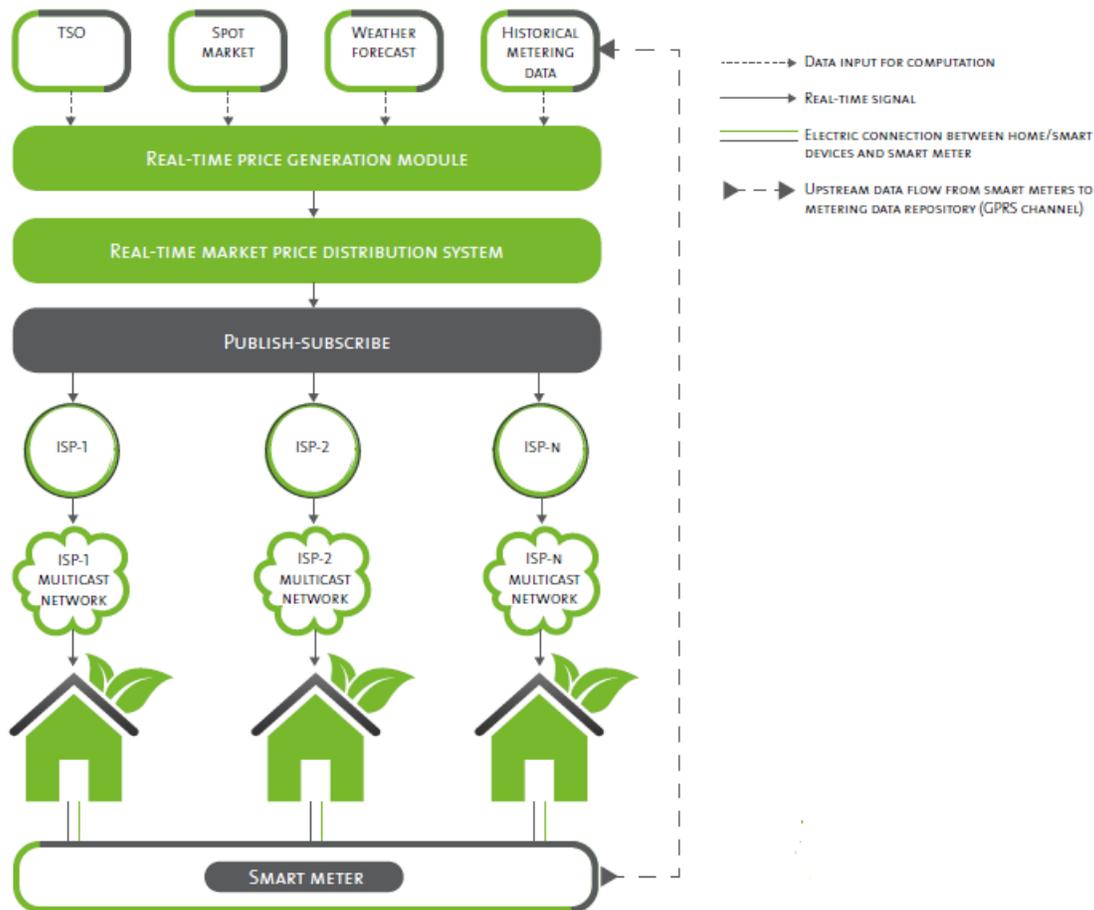


Figure 8. The EcoGrid ICT architecture

THE ICT MARKET SERVER FUNCTION IN ECOGRID EU

The central component for implementing the EcoGrid EU real-time market and interface between the existing power markets and the households is an IBM BladeCenter server, which is installed at an Oestkraft facility on Bornholm. In addition to hosting the EcoGrid EU real-time market, this server hosts the billing application, which is adapted to the real-time market price interval, database and asset management subsystems, user administration, as well as central components of the IBM and the Siemens solution solutions. The server is network connected with appropriate security mechanisms, including user authentication and firewalls. The ICT platform supports a number of user interfaces to allow the various actors to interact with the systems, e.g.

- Customers of Siemens and IBM houses are granted access to a portal to view the current status of the houses, including control parameters and temperature readings
- Customers are given access to billing information, including a view of their economic benefits
- Customers are allowed to see all aspects of price information, including historical, current, and forecasted values

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HOUSEHOLDS UNDER AUTOMATIC CONTROL

The test households under automatic price control will be tested in houses with IBM-GreenWave equipment and Siemens equipment respectively. The solutions are based either on individual-household control or so-called aggregator control. Aggregator control is a solution which aggregates the participants' consumption/generation and influences the behaviour (eg new temperature set points) of the connected appliances– depending on the flexibility of the individual participants on the one hand and the requirement of the power system on the other hand. In this way, the available flexibility in the aggregated set can be strategically operated to maximise the financial yield. At the same time, this maximises the impact on power system balancing as the available flexibility is used at the times when the imbalance situation is the most severe.

One part of the IBM-Greenwave houses can be configured into single-household price agent, and another part into aggregated control. All Siemens houses will be under aggregator control. Two types of aggregated price response methods will be tested. A distributed energy management system (DEMS) application from Siemens and a PowerMatcher application (PM) from TNO/IBM. The DEMS and the PM control the price response in an optimal way for both the power system and the flexible consumer or supplier.

IBM HOUSES WITH AUTOMATIC CONTROL OF INDIVIDUAL DEVICES

These houses are controlled by individual price agents implemented by IBM. This means that there is a smart controller connected to each household, containing a model of the individual heating system, household and inhabitants' requirements. The models receive input from archived historic power needs for seasonal ambient temperatures in the context of desired user settings. The one-way price agent embraces the model and predicts the optimal heating panel or heat pump control to stay over time within the desired comfort settings, while exploiting the five-minute real-time price signals. The control decision to optimise consumption/generation according to the price and the forecasts is then taken locally and under the responsibility of the customer/owner, who is then settled using this price.

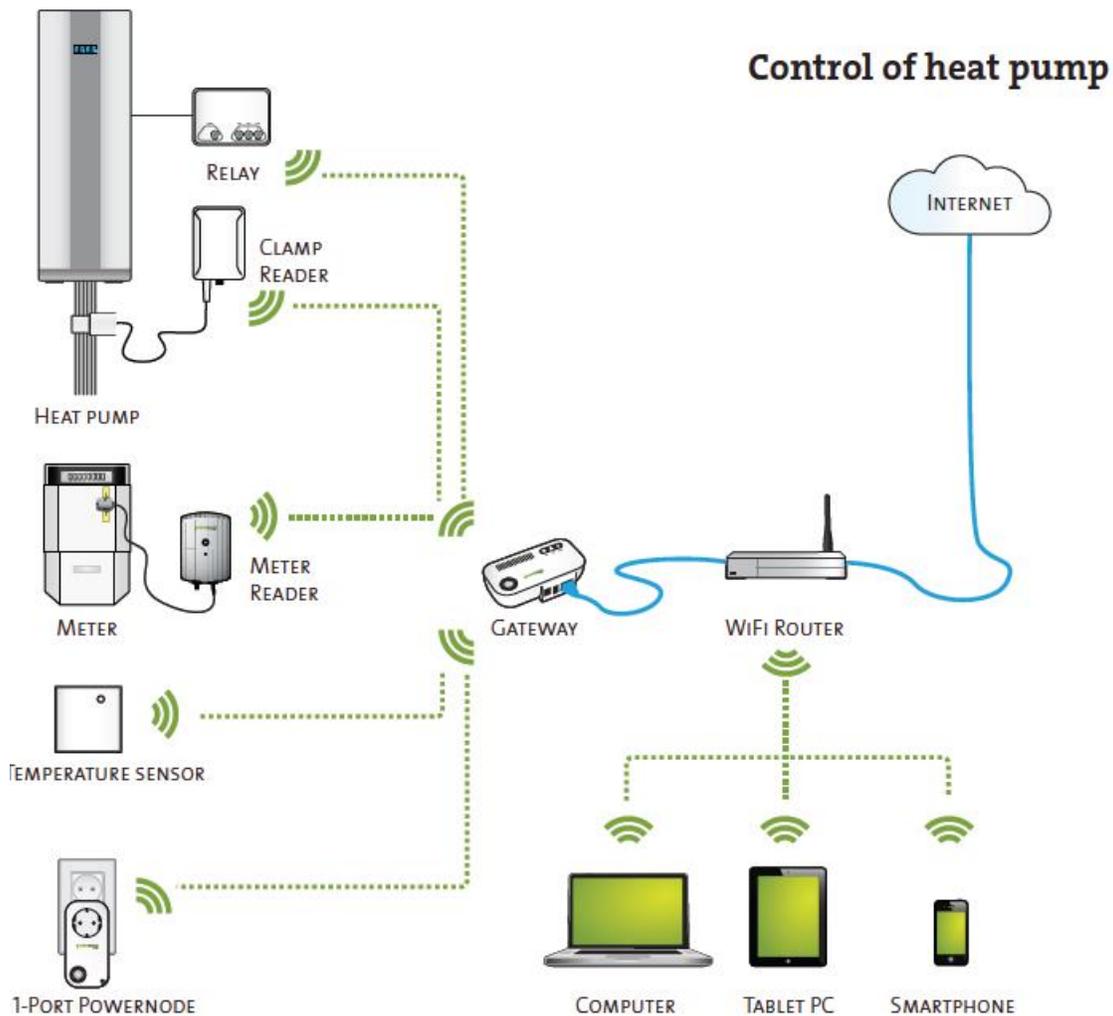


Figure 9. Example of the GreenWave Reality Smart Home solution

SIEMENS SYNCO LIVING SOLUTION

The Synco Living home automation solution – an already existing product portfolio from Siemens – is used to control the electric heating and/or domestic hot water boiler via contactors installed in the fuse box of the participants and thermometer probe in the boiler. Depending on the accessibility and wiring of the house, several heating zones, as well as control of the boiler control are created. The automation can be bypassed via manual switches on the contactors. The equipment package to the EcoGrid EU customers consists of a central unit/control panel that is connected to the internet. Settings can be made both on this unit as well on a web user interface. Micro circuit breakers (MCBs) provided by Siemens perform control of the electric heating. These MCBs are controlled from the central unit based on wireless temperature measurements from the inside and outside of the houses. By attaching an additional thermostat on the hot water boiler and by overriding the normal temperature setting, the electrically heated hot water can be controlled. Enabling control of the domestic hot water boilers is essential, as they can provide flexibility all-year round in contrast to space heating appliances.

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NEW SMART METERS

All test participants are equipped with new remotely read electricity meters provided by Landis+Gyr. Settlement of account and registration of the actual power consumption make it easy to get minute-to-minute overview of the power consumption in the course of the day and the month (in Eco-Grid EU, the price is settled every five minutes). The meter will send consumption data to a database from Oestkraft. Most of the meters will be read based in the mobile network which means that the meter data is sent to the database every 10 minutes. Some meters will also be read based on PLC or fibre optic. Real-time data can be provided from these meters.



Figure 10. Siemens SyncoLiving in-house control panel

THE SMARTNESS FROM THE PERSPECTIVE OF THE INDIVIDUAL CUSTOMER

The Smart Grid innovations in the EcoGrid EU project will be 'invisible' for most people. However, what is visible for the test-participants are the EcoHome equipment, eg how does the equipment work and what does it look like? A considerable share of the test participants have expressed that the motivation for participating in EcoGrid EU was the installation of new smart equipment. Once the customers have signed up for EcoGrid EU, one of the most frequently asked questions to Oestkraft has been: "When will my smart equipment be installed"?

SMART FEEDBACK SYSTEMS

An important part of the IBM/GreenWave smart solution is the user interfaces/feedback systems connected to the home automation system. The participants will have online access to information about the household's electricity consumption and more detailed information about their EcoHome controlled equipment, e.g. heat pump or electric heating. The participants with solutions from Siemens have access to a central control panel installed with the equipment in the house. Some customers prefer this kind of user interface, so they do not necessarily need access to a computer to control their heating. The settings can also, if preferred, be made on the web-based user interface. All EcoGrid EU participants (except for the statistical control group) will also be introduced to the common user interface 'My EcoGrid', which is the real-time price feedback system developed specifically for the project.

The recruitment process is considered a success. By August 2013, the objective of 1,900 test households on Bornholm was almost realised. Before starting the EcoGrid EU recruitment, the communication activities on Bornholm were targeted at raising general awareness of Smart Grid and the EcoGrid EU project among the entire public on the island. The media was informed through press releases and a press conference. EcoGrid EU folders were distributed at local events such as the annual Energy Days on Bornholm. Oestkraft was represented with posters and information material. Ostkraft's investment in the demonstration house, Villa Smart, represents an important part of the communication about EcoGrid EU and Smart Grid. The demonstration house is one of the

first of its kind that puts the ordinary electricity consumer in the centre. The house represents a 'normal' house, showing the visitor the equipment used in EcoGrid EU– called EcoHome.

PROMISING START-UP...

One month after the recruitment kick-off at the demonstration house Villa Smart (February 2012), approximately 366 households corresponding to 15% of the required households were signed up for EcoGrid EU. During the next six to eight months, almost 50% of the participants were enrolled in the project without very strong information activities, although more focused acquisition and recruitment efforts. For many, the enormous interest in participating in the pilot test was unexpectedly high. In a field test that will have to involve every tenth residential household on Bornholm, it is not realistic that you will find only enthusiasts, first movers or early adopters of new technology/Smart Grid solutions. The recruitment efforts must pay a lot of attention to the so-called mainstream group – people generally not especially interested in energy issues. This was also Oestkraft experienced during the recruitment process.

MEET YOUR CUSTOMER WHERE THEY ARE

The first EcoGrid EU survey and interviews of electricity customers on Bornholm – in advance of the recruitment – showed that a very large group of the respondents were positive towards real-time tariffs and wanted to be flexible and use electric equipment when electricity prices were low. A very high percentage of the respondents (72%) would accept remote/automatic control of their household equipment. Although the importance of financial incentives for end customers in the survey is clearly evident, a considerable percentage of participants in the survey rated environment very high. However, the 300 customers included in the survey are not representative for Bornholm. They have higher income than that of the average household and belong to a privileged group, which is supposed to be 'first movers', and were also the first customers who signed up to EcoGrid EU. It is estimated that approximately 90% of the customers in the first survey have signed up for EcoGrid EU. It was decided early in the project that the communication with the public should focus on the social values and environmental aspects rather than individual financial benefits of participating in the EcoGrid EU field test. In addition, the participants are guaranteed that they will not 'lose money' by participating in EcoGrid EU. In total, the participants will never pay more for the electricity compared to what they pay according to their normal contract.

ECOGRID EU RECRUITMENT CAMPAIGN(S) AND ECOGRID EU EVENT

Along with direct mails to electrically heated households, an ambitious information and recruitment campaign was initiated. On 3 February 2013, Oestkraft invited to public EcoGrid EU event on Bornholm. Aside from the goal of involving the existing participants, the objective was also to attract new participants. In order to create 'word-of-mouth', EcoGrid EU postcards and advertisements were distributed to 70% of all households on Bornholm through the local newspaper 'Bornholms Tidende'. The message of the campaign was: "We are still looking for more participants, particularly those with electric heating/heat pumps". The first part of the event was dedicated to the existing participants. The second part was an open EcoGrid EU café for all customers on Bornholm, where the visitors could ask questions and sign up for the demonstration. The visitors could enjoy free cake and coffee, exhibitions, short talks by the mayor of Bornholm, Energinet.dk and the Danish Consumer Council as well as entertainment by a local band. About 1,000 persons showed up and spent a great part of their Sunday at the event.

To attract the last participants, Oestkraft sent a second direct mail to 2,500 customers with electric heating. The message was: "If you want to participate – this is your last chance...". It proved to be very efficient. In one week, 100 more electrically heated households were recruited.

CHANGE IN RECRUITMENT CONDITIONS

At first, it was envisioned to control a whole suite of household machines. It turns out though that although such appliances have been on the market for years, there is still no standard protocol for automating them. Therefore, it was decided only to install EcoHome equipment in households with either electric heating or heat pump. This was

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also preferable in order to maximise the total volume of load-shifting capacity achieved during the EcoGrid EU demonstration. To put it in another way: the electric consumption of the heat pumps and electric heating devices are typically higher than that of other electric household appliances (e.g. washing machine, dishwasher etc.) – thus increasing the potential of flexible consumption. Furthermore, the customers are not expected to experience serious losses in heat comfort, if they are flexible in their consumption by shifting the use of heat pumps/electric heating in short periods in the course of a day.

Focus in the recruitment process changed, as the participants could not be randomly selected. It was also necessary to recruit participants who were not particularly interested in the EcoGrid EU project. In the direct-mail campaign targeted these customers, Oestkraft emphasized that they would offer individual service and support during the entire demonstration. The importance of allowing for personal contact with the ‘mainstream’ group of customers should not be underestimated.



Figure 11. interactive educational wall in Villa Smart

MANY HOUSEHOLDS ARE ON A WAITING LIST

By the end of August 2013 1,900 residential EcoGrid EU households had enrolled for demonstration, which was the amount required for the demonstration. Later on, it turned out that many of the customers who had signed up were not qualified for participation, e.g. participants who already had heat pumps installed that were not compatible with the EcoHome equipment. Also, many of the customers with electric heating who had signed up to EcoGrid EU did not use electric heating as their primary heating source. Therefore, many of the participants with heat pumps and electric heating have been signed out of the project.

All in all, the Bornholm citizens have shown an enormous interest in participating in the EcoGrid EU project. About 180 customers are on waiting list – and Oestkraft is continuously receiving requests from customers with heat pumps/electric heating who want to take part of the demonstration. Today most people on Bornholm have heard about EcoGrid EU. Information about the project appears regularly in local newspapers and TV. The local electricity company Oestkraft and EcoGrid EU families contribute with interviews and stories from every-day use in the media.

THE 'CHICKEN OR EGG' DILEMMA

Experience from similar demonstration projects shows, how important it is that the participants have their equipment installed relatively short time after signing up for the project. From the outset this was also the aim of Oestkraft and the project in general. The reality is that the recruitment for the demonstration project has taken place at a faster pace than the instalment of the equipment. In retrospect, it could have been wiser to start the recruitment at a later time and have taken the fact that not all components of the EcoGrid EU equipment are standardised products and that development takes time into account. On the other hand, it was impossible to know in advance whether enough participants would sign up for the project within the determined period of demonstration. The wait can feel long for the participants, which is why it is important that they are continuously being updated and informed about the project.

ECOGRID EU TRAINING

The primary information channel is e-mail and the website www.EcoGridBornholm.dk. Oestkraft also invites all participants (except for the statistical control group) to training sessions. The education of participants takes place in the demonstration house Villa Smart and communication and technical advisors from Oestkraft will give individual advice to the participants regarding their particular role in the project and the new equipment.

The training will be organised so participants in the different participant/equipment groups have training together. The training is planned to take 1-2 hours per session. The training session will be split in different topics depending on what is relevant for the type of group receiving the training. However, all participants will have a general introduction to EcoGrid EU. They will also be informed about the general energy transition happening in Denmark and the challenge this presents to our energy systems and how they, as consumers, can play an active role in overcoming some of these challenges.

MY ECOGRID

After the general introduction to EcoGrid EU, the participants are introduced to the customer feedback system 'My EcoGrid'. At 'My EcoGrid', the participants can find information about current prices and prognosis for the coming hours. They can also find data from the meter installed in their homes and compare price, consumption and cost over time. Once every month, the participant can find a report informing them about their performance for the past month, where the EcoGrid EU cost is compared to the cost of a non-Smart Grid product.

TRAINING FOR WHAT?

The purpose of the training session is to give the participants an understanding of Smart Grid in general and EcoGrid EU in particular. The concept of the real-time market is a complex topic to communicate, especially for the average power consumer. Until now, the normal consumer has not paid special interest to the timing of their electricity consumption, as time-of-use had no influence on the size of their bill. In Eco-Grid EU, the participants will have a radically different setup, as they not only get a lot of information about their consumption, but they must make up their minds about whether they are willing to compromise their normal comfort level in the prospects of saving money. Another challenge is to explain to the participants that they certainly cannot expect reductions in their electricity bill, if any at all. Therefore, it is important to tell the participants about the future benefits of EcoGrid EU and Smart Grid not only from an individual point of view, but also from the perspective of the society.

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INSTALLATION AND CONSULTATION

Some of the persons closest to the EcoGrid EU customers/participants are the seven electricians from Oestkraft installing the EcoHome equipment in households on Bornholm. It typically takes from one to three hours to install the EcoHome solutions and make it fit the consumers' wishes; the time spent depends on how many questions the consumer has. It is the electricians that together with the consumers define the comfort preferences and priorities, eg minimum temperatures in the house and flexibility in usage of electricity. The industry partners provide continuous support via telephone and email to ensure that the electricians become experts in the EcoHome equipment.



Figure 12. price speedometer from 'My EcoGrid'

Project Outcomes

The results of the overall project impact will be evaluated against Key Performance indicators (KPIs) of removable peak load reduction from 1,900 residential households and the peak load reduction of the 100 industry participants on Bornholm. The potential of demand response in Denmark has been estimated to 1290 MW in Denmark. Scaled-up to national level the impact of the field test of Bornholm would be considerable. In total there are approx. 2,5 million households/residential electricity customers in Denmark. The potential of involving 10 % of households alone (in Denmark and 'world wide') could contribute significantly to the increasing need of more and more costly power balancing capacity. It was decided early in the project that the communication with the public (and recruitment of test participants) should focus on the social values and environmental aspect, rather than individual financial benefits of participating in the EcoGrid field-test. However, it is guaranteed that the participants will never pay more for electricity compared to what they pay according to their normal contract.

One of the strength of the EcoGrid project is that ICT and software solutions supporting the real-time market do not start from scratch. The ICT architecture is based on existing software solutions available today or have been

tested in other field test situations. Also the project use different smart home solutions and ICT control systems. This means that the systems are vendor independent, allowing for competition and freedom of choice on the hardware and software component. The issue of replication and deployment is an ongoing task that runs in parallel with the field test. Standardisation and security issues constitute a very important part of the project. The lessons learned is the importance of establishing a broad public understanding of the Smart Grid before a broad roll out of Smart Grid solutions, including a EcoGrid real time power market.

The EcoGrid project considers and implements tools for electricity consumer engagement and empowerment throughout the value chain: From raising awareness of the Smart Grid vision among the public to the demonstration of tools and a real-time power market concept that enables many residential customers to actively contribute to balancing a power system with a high share of renewable energy sources.

■ Next steps and open questions

In the first part of the EcoGrid EU project, the task was to prove the sustainability of the market concept in theory. Much effort has been put into the establishment of a common understanding and consensus of the fundamental principle of the EU real-time market concept. The concept has continuously been challenged by ongoing discussions among the project partners and through interesting dialogues with external stakeholders, including discussion and workshops with the EcoGrid EU reference group.

THE ROBUSTNESS OF THE ECOGRID EU REAL-TIME MARKET

Will the EcoGrid EU market concept work 'outside' Bornholm? It will certainly not be possible to implement a single standard EcoGrid EU real-time market concept all over Europe without changes to the current regulation framework situation(s). An example of the current differences in market design is the choice of gate closure time, ie the moment from which the TSO does not allow action by market parties anymore and is resolving all remaining imbalances by himself. Another example is the imbalance settlement, ie imbalances are settled between the balance responsible parties and the TSOs using different pricing methods.

Nevertheless, in a deployment and replication scenario of the EcoGrid EU real-time market, it is important not only to focus on the barriers due to the current differences in market designs. The implementation of the real-time market mechanisms must also consider the harmonisation process of the electricity markets in Europe, eg a process of drafting framework guidelines and network codes aiming at providing harmonised rules for cross-border exchanges of electricity. Furthermore, some of the real-time market core elements are likely to be more easily integrated into some systems than in other.

THE FLEXIBILITY OF THE ECOGRID EU MARKET CONCEPT

Currently one of the open questions is whether or not the EcoGrid EU market concept can be replicated without replacing the existing markets or changing the fundamental principles of the current power balancing mechanism? Several parts of the EcoGrid EU concept are flexible, ie does not conflict with the current practises, e.g.:

- The EcoGrid EU project implements one specific retailer contract model in the Bornholm demonstration, but the concept does not endorse or rely on a specific contract model.

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- Likewise, the EcoGrid EU project uses different smart home solutions and different ICT control technologies. This means that the systems are vendor independent, allowing for competition and freedom of choice on the hardware and software components.
- The fundamental concept and the infrastructure allow a 'real time' market with lower time resolutions than five minutes. It is relevant in markets where, e.g. the smart meters with 15 minute or even hourly data readings have already been rolled out, although the dynamic response for balancing and congestion management will be reduced.

THE STANDARDISATION ISSUE

In the view of rolling out a smart grid solution that encompasses different vendors, standardisation on the communication and interfaces of the smart home devices need to be taken into account. Another important aspect is the security throughout the system and the use of existing standards for security as well as measures to put privacy in place. Based on the demonstration experiences, the industry partners in EcoGrid EU will provide a framework for standards in communication and device descriptions, so an interoperable system can be assembled.

RECRUITMENT OF COMMERCIAL CUSTOMERS

The recruitment of industry/commercial buildings is still ongoing. The commercial customers that Oestkraft has visited have been positive towards EcoGrid EU, but technical challenges prevent many from participating. At present, automating solutions are considered for the operation of manure mixers, electric fork-lift chargers and cold storage. The ferry terminal in Rønne is a good candidate for upgrading the existing building automation system. The project is also considering the energy storage potential related to e.g. electric vehicles and mobile cell mast batteries.

THE ROLE OF THE TSO AND THE BALANCE RESPONSIBLE PARTIES

An important task in the project is to define the role of the TSO versus the role of the balance responsible parties. So far two alternatives are discussed. In alternative 1, the TSO is responsible for organising the Eco-Grid EU market, in parallel with (or potentially replacing) existing balancing markets. In this case, the flexibility of EcoGrid EU costumers is directly offered to the TSO via the retailer and the balance responsible parties, allowing for system-level optimal dispatch. The TSO issues a fixed price for imbalances prior to each market time unit, which means that the TSO carries the whole risk of setting the price at a value that will balance the system. In contrast, the commercial stakeholders, eg BRPs and retailers, can choose their own risk level by responding to the prices or not. In alternative 2, the real-time pricing concept is used by balance responsible parties, retailers, or VPP operators to control a portfolio of customers, whilst still bidding into the present balancing market. This allows for implementation without altering or adding to the system-level markets. The caveat is that one real-time price signal would be generated per BRP/retailer/VPP, potentially leading to sub-optimal dispatch from a system-level perspective.

The risk of price setting is shifted from the TSO to the commercial stakeholders. In this scenario, the TSO operates the normal balancing market with firm bids, whereas the commercial stakeholders need to create the real-time price signal and thus carry the risk. The TSO may provide information about e.g. activated volumes and prices in the balancing market to reduce the risk, but at the end of the day, the risk stays with the commercial stakeholders.

The risk of choosing alternative 2 is that the EcoGrid EU flexibility is used to reduce the imbalances of the individual BRP, rather than reduce the system imbalance, because the system imbalance can be in the opposite direction than the BRP imbalance. This may lead to sub-optimal dispatch from a socio-economic perspective. On the other hand, this solution can be implemented without altering the present markets at all, thus providing a possible fast-track for utilising small-sale demand-side flexibility.

ARE PEOPLE READY FOR SMART GRID?

The experience from the EcoGrid EU recruitment process shows that communication and involvement of the participants are key elements to project success. It has proven successful so far to keep the participants interested and signed into the project. Now comes the even greater task of keeping them involved. Based on relevant theory on consumer behaviour and experiences, an ongoing task is to plan and initiate activities for the involvement of the participants during the demonstration phase. The project experience is that the great support of the Eco-Grid EU project from the public on Bornholm has been an important precondition for the recruitment to the EcoGrid EU demonstration and willingness to test the real-time market concept.

Therefore, perspectives for a wider implementation of Eco-Grid EU depend on the degree of 'Smart Grid readiness' among the electricity consumers. The support of the project from the public on Bornholm is probably due to the fact that the population already was aware of many of the challenges associated with wind power and that the goal of converting to a CO₂-neutral electricity generation is deeply entrenched among the people on Bornholm and the Danes in general. In other words, it will be easier to realise the EcoGrid EU project in areas where the environmental awareness is already high, and the challenges of handling more renewable energy and wind power are largest – and thereby also the wish for effective solutions for how to meet the challenges. One of the largest tasks, preceding the EcoGrid EU demonstration (and later: in a deployment perspective), has therefore, primarily been to establish a broad understanding of the Smart Grid vision behind EcoGrid EU and of how activating small-scale electricity consumption /electricity production via a real-time market can make a difference. The communication with the electricity consumers has furthermore appealed more to good citizenship rather than narrow financial gains.

NO SILVER BULLET

It is important to clarify that the EcoGrid EU market concept only represents one possible suggestion for a cost-effective activation of flexible consumption at household customers and/or smaller production units. The project's most important contribution is to demonstrate (or make plausible) that the EcoGrid EU concept – under the right conditions and with a reasonable effort – could be made to work in a long-term time perspective and to identify the necessary and sufficient preconditions, e.g.:

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- The real-time market concept must be accepted/understood by regulators and existing market players.
- The real-time market concept must prove its economic value for the society and for stakeholders, eg the 'retailer-balance responsible parties' must be convinced about the added value for him and his customer (good business case).
- The real-time market concept must prove its ability to provide reliable and efficient balancing services to the TSO without jeopardizing the grid security (at system level and at distribution operator level)

The issue of replication and deployment of the EcoGrid EU real-time market is an ongoing project task that runs in parallel with the field test. This is a key dilemma in relation to the replication of the Eco-Grid EU concept: It is hard to believe that radical changes can happen overnight in order to achieve a 'perfect EcoGrid EU real-time market'. On the other hand, a gradual introduction of the EcoGrid EU concept parallel to existing market – without dealing with this challenge – could be undermining the true effect of the real-time market.

France: NICE GRID, the French Demonstrator of GRID4EU

Project Title	NICE GRID the French Demonstrator of GRID4EU
Location	Carros, France
Time Period of Project	November 2011 – January 2016
Link to Project Website	www.nicegrid.fr and www.grid4eu.eu
Key Word	Photovoltaic Generation, Active Demand, LV Network, AMI, GRID4EU, DER integration, Storage, Islanding.

Project Background

GRID4EU is one of the most significant large scale demonstration projects of advanced smart grids solutions with replication and scalability potential for Europe. It is funded by the European Commission under the FP7 program. Financed to the tune of €25 M by the European Commission, and costing €54 M overall, it is one of the biggest smart grid project to be funded by the European Union. The project is led by six European DSOs covering more than 50% of the electricity supply in Europe: CEZ Distribuce (Czech Republic), Enel Distribuzione (Italy), ERDF (France), Iberdrola Distribucion (Spain), RWE (Germany) and Vattenfall El distribution (Sweden). Altogether 27 partners from several countries (including manufacturers, system integrators, research centers and universities) are collaborating in the project. GRID4EU comprises 6 Demonstrators. The French one is NICE GRID which is a pilot project on photovoltaic-powered neighborhoods funded by the French government and the European Union. The project started in November 2011 and will last 4 years with an overall budget of 30 million Euro. ERDF is the coordinator and project leader of the Project GRID4EU and manages also the French demonstrator involved in the project NICE GRID.

The NICE GRID project consists of a smart electricity distribution grid that harmoniously integrates a high proportion of solar panels, energy storage (electrical and thermal), load management devices and smart meters installed in the homes of volunteer participants. Making use of a high proportion of local intermittent energy sources, the project seeks to demonstrate an optimal approach to electricity management, at the level of a district or town, involving the large-scale integration of dispersed photovoltaic (PV) power generation systems load-shedding capacities (target: 3.5MW), and energy storage systems (lithium-ion batteries with 1.5MW total capacity), at different points in the overall system: the distribution grid, electricity producers and consumers. Some 2,500 potential residential and business customers will be involved with this project. Several of these customers will be equipped with PV roof top panels and connected to the same low voltage grid.

The project is designed to address potential network constraints that could be caused by a massive integration of photovoltaic (PV) generation into a low voltage network, with the help of flexibilities connected to the grid. In the case of NICE GRID, these flexibilities fall into two categories: load-shedding or load-shifting, depending on the context. Batteries located on the grid or at customers' premises are used, but the key factors are the involvement of customers and their ability to respond to signals from a grid energy manager through aggregators. For example, a signal could encourage private individual customers to use storage devices (thermal: hot water tank or electric: battery) or shift their consumption during photovoltaic high-production periods. Another example: in the winter,

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customers, who may be private individuals or businesses, are encouraged to delay or suspend their power consumption when the local demand is too high.

Thus, with the help of customers, four main use cases are tested:

- Reduction of power demand.
- Management of maximized PV production on an LV network with respect to constraints and flexibility programs.
- Encouraging consumers to adopt smarter habits in accordance with the network state.
- Islanding.

ERDF, the French electricity distributor is the coordinator and project leader. The other partners of the consortium are: EDF (electricity supplier and aggregator), Alstom Grid (develops the network energy manager), Saft (provides the batteries), Armines (develops a PV generation forecast tool), Socomec (provides inverters), RTE (supports load-shedding), Daikin (provides smart heating pumps), Netseenergy and Wateco (support the aggregators with telecommunication infrastructure).

Case Description

Purpose

The objectives of the project are to:

- Optimize the operation of a medium voltage / low voltage distribution grid with massive integration of Distributed Energy Resources (DER), mainly rooftop solar (PV) and storage.
- Island a portion of low voltage grid equipped with PV panels and electricity storage capability for a period of several hours.
- Turn consumers into proactive players with regard to their consumption/generation of electricity.
- Test new business models of various players providing new services.

The project, which makes use of a high proportion of local intermittent energy sources, seeks to demonstrate an optimal approach to electricity management, at the level of a district or town, involving the large-scale integration of dispersed photovoltaic power generation systems load-shedding capacities (target: 3,5 MW), and energy storage systems (lithium-ion batteries with 1.5 MW total capacity), at different points in the overall system: distribution grid, electricity producers and consumers.

NICE GRID will monitor different data in order to calculate the KPIs listed in the below table.

KPI Family	KPI Description
Load managing	Fraction of load effectively shed out of the total reduction capacity
Environmental	Increased hosting capacity of RES integration in the local LV grid
Forecasting	Error calculations related to forecasts of solar power generation
	Error calculations related to forecasts of consumption levels
Reliability	Voltage deviation at the LV grid level

	Total Harmonic Distortion Factor
Efficiency	Energy losses and ICT energy consumption of flexibilities
Societal	Fraction of consumers opting out during load shifting
Islanding	Voltage deviation during islanding

Table 1: KPIs used in NICE GRID

Architecture

To support these objectives, NICE GRID has developed an energy management system that optimizes the balance between power consumption and generation of electricity at the district level. This system communicates with three aggregators (one for private individuals, one for businesses and one for batteries on the grid) and technologies.

The following outcomes are expected:

- Study the technical and economic efficiency of storage (thermal: hot water tanks and electric: batteries) combined with load-shedding in the residential sector in order to assess the most effective solutions.
- Assess the efficiency of "packaged solutions" combining technical solutions with financial incentives, adapted to local PV generation, storage charge/discharge capacity and/or load- shedding potential in the residential and business/industrial sector.
- Test the behavioral response of consumers with a strong outreach approach to local stakeholders and customers; giving customers the possibility of adapting their production and/or consumption, while minimizing the impact on their comfort.

Some 2,500 potential residential and business customers will be involved with this project. Several of these customers will be equipped with PV roof top panels and connected to the same low voltage grid.

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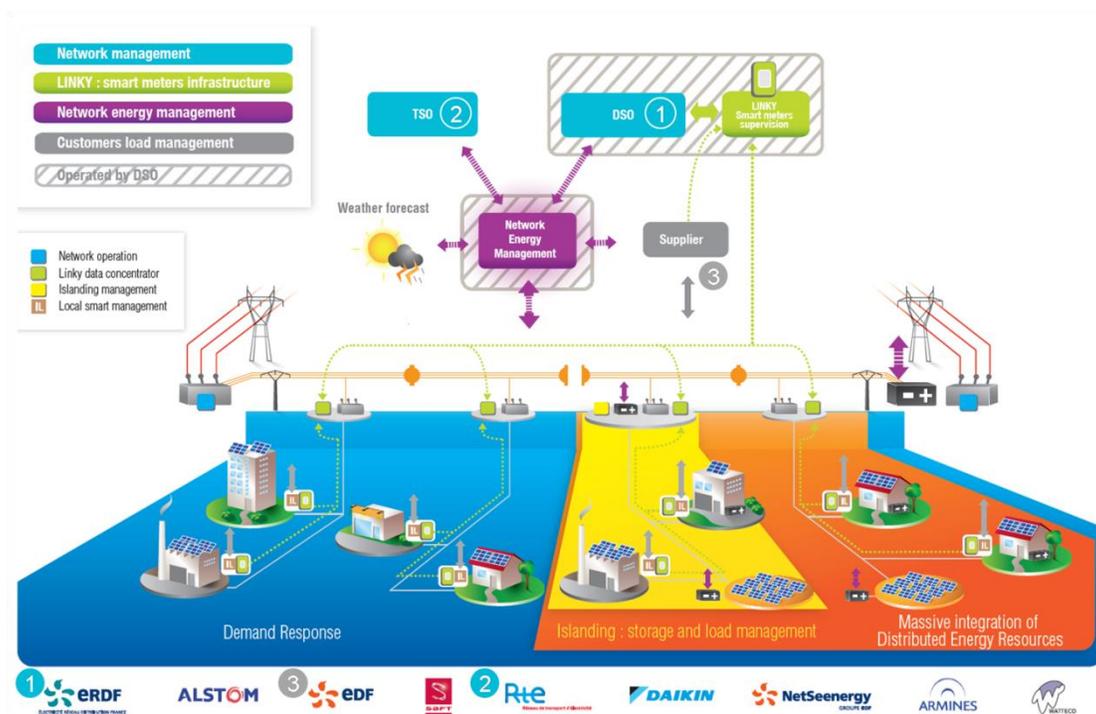


Figure 13. NICE GRID Demo Project

The architecture relies on AMI infrastructure and utilization of smart meters, which enable more accurate consumption forecasts and allow participating customers or aggregators to control and monitor devices such as hot water tanks and heating systems without additional internet boxes or parallel communication infrastructure. In particular, consumers will play an active role within the energy system by providing data on power use and consumption, storing energy in hot water tanks and/or batteries using controllable smart devices, generating electricity from PV panels and adapting their behaviours towards a better integration of PV generation. The metrics evaluated include load managing, environmental, forecasting, reliability, efficiency and societal KPIs.

Project Outcomes

In this section, we will deal in particular with the involvement of customers (consumers and producers) in the NICE GRID project. In NICE GRID, three main groups are identified: the two broad categories of participants, companies and individuals, and the local community. The entire consumer cycle is presented from the awareness and education stage to the sustainability strategy.

Awareness and Education

All awareness and education activities are based on the analysis of sociological studies realized during former similar projects in southern France and ad hoc interviews conducted prior to experiments. Awareness and education actions differ for the three categories identified. For individuals, from May 2012 to October 2012, community gatherings were held to provide information on the deployment of smart meters. At these events, a comic-strip presenting issues relating to an Advanced Metering Infrastructure for the general public was handed out and a presentation of the functionalities of the website was held.

From September to October 2012, communication in local publications about the deployment of smart meters was also organized to reach most Carros residents. In May-June 2013, the first enrollment campaign of the project took place. A teaser campaign was first implemented through posters in the designated solar precincts. Initially, communications did not focus on specific rational aspects of the project, but rather conveyed the overall benefits of the project: innovation, sustainability and territorial anchoring (cf. Figures 17, 18 and 19).



Figure 14: Example of an advertising board located in a crossroad



Figure 15: Poster used for the teasing campaign

The advertising boards displayed a countdown with the teasing messages :



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Figure 16: Advertising boards used for the teasing campaign

Then, to inform inhabitants of the identified solar areas about the launch of the load-shifting experiment in summer 2013, brochures were distributed, doors open days organized and promotional posters put up). To educate consumers about the project, a booklet (cf. Figure 20) comprising a description of the offers (cf. Figure 21) and a “prosumer guide” was handed out to participants of open door days. In September-October 2013, the second enrollment campaign of the project started the load-shedding experiment lasting from December 2013 to March 2014. This campaign targeted all inhabitants of the city equipped with a smart meter.



Figure 17: Scan of the booklet

3 EXPÉRIENCES POUR PARTICIPER AU PROJET NICE GRID

EXPERIENCE **3**



ÉQUIPEMENT SOLAIRE INTELLIGENT + INFOS

FAITES L'EXPÉRIENCE D'UNE GESTION INTELLIGENTE DE L'ÉLECTRICITÉ SOLAIRE EN 2014 ET 2015 !

Demandez dès maintenant à bénéficier d'un accompagnement et d'un soutien financier d'EDF pour devenir producteur-stockeur d'électricité.

EXPERIENCE **2**



BALLON D'EAU CHAUDE INTELLIGENT + INFOS

FAITES L'EXPÉRIENCE D'UNE GESTION INTELLIGENTE DE L'EAU CHAUDE SANITAIRE EN 2014 ET 2015 !

Demandez dès maintenant à bénéficier d'un tarif avantageux de l'électricité aux heures où l'électricité solaire est produite en abondance.

EXPERIENCE **1**



HEURES CREUSES SOLAIRES + INFOS

FAITES L'EXPÉRIENCE D'UNE GESTION INTELLIGENTE DES HEURES CREUSES PENDANT L'ÉTÉ 2013 !

Demandez dès maintenant à bénéficier du tarif Heures Creuses en pleine journée grâce à l'énergie solaire.

Figure 18: Description of the load shifting offers

To address the specific needs of business/industrial participants, the recruitment process is engaged through a visit by an EDF representative and a technical expert to present the experiment, both of whom stay in touch as key contacts to support the participating companies. These participant awareness-raising processes are supported by a broad awareness and education commitment to the local community and local, national and international press coverage.

This commitment to the community is one of the specificities of the project. Among other initiatives, this has taken the form of:

- a meeting with residential opponents of the deployment of smart meters in August 2013 to take stock of their concerns, understand their fears and engage in discussions to make them aware of the benefits;
- regular meetings with the local Chamber of Commerce;
- a step by step video aiming at explaining the smart grids and the NICE GRID project objectives and features (cf. Figure 22)• the opening of the Showroom in August 2013 (cf. Figure 23). The Showroom serves as a showcase of the project to recruit participants, as an educational tool to inform the local population about the project and about smart grids in general and as a help desk for participants who have already signed up. For instance, presentations to schoolchildren from Carros are held during school visits to the Showroom;
- a mobile version was designed as an e-book to bring the showroom closest to the largest audience (cf. Figure 24)

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NICE GRID, the French Demonstrator of GRID4EU

- an agreement with the local charity organization “La Passerelle” to contribute to the project by painting local LV/MV substations so that they are better integrated into the urban landscape while at the same time enhancing local young people’s awareness about smart grids.



Figure 19: Nice Grid video



Figure 20: Four pictures of the showroom

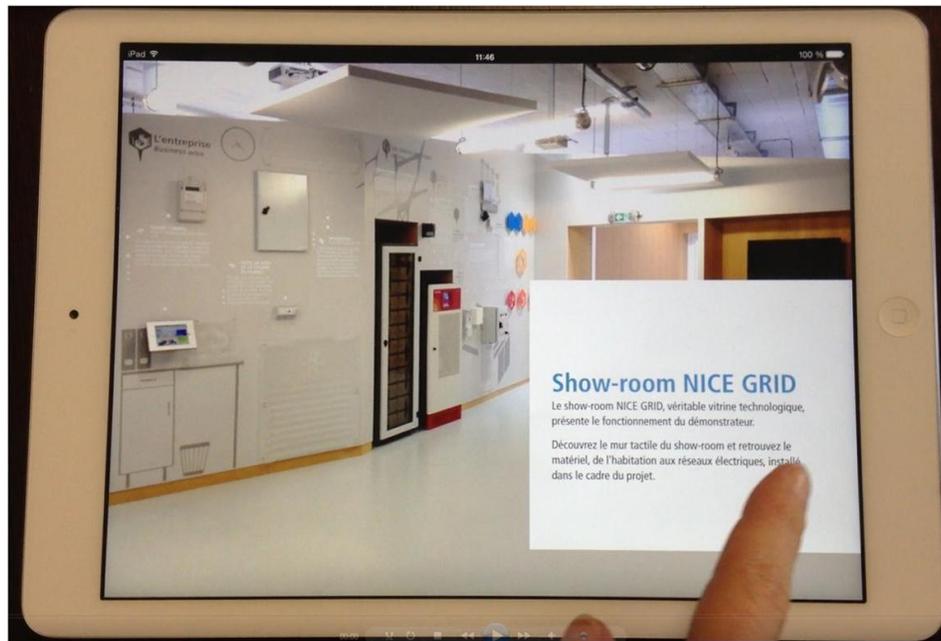


Figure 21: Screenshot of the Nice Grid e-book

Engagement

The contractual engagement lays the foundation for the relationships between the various stakeholders. At the highest level, a legally binding agreement has been signed by all members of the NICE GRID Consortium to clarify the role of each party and build a strong and effective partnership.

The quality commitment is also reinforced by exceptional safety measures taken with respect to service providers:

- PV roof panel installers are certified and supported by an independent body, the French national organization providing training and certification services in the construction industry
- the safety of residential battery installation is checked and approved by an independent body, recognized as acting in the public interest by the French state.

With regard to consumer participation in the project, the same principle has been applied and a contract has been signed between the participants and the energy provider (EDF), thus ensuring that both parties' engagement in the project is secured. Participants can opt-out throughout the duration of the project without incurring any extra cost. Recruitment is also possible up to the beginning of the last experiment. As a result, the recruitment measures mentioned in the Awareness and Education stage are effective up to the last experiment.

So far, 100% of the B2B (business/industrial participants) prospects targeted have signed up for the project (i.e. 7 companies with a load-shedding potential of 2.1 MW). Concerning the B2C (individual) participants, 50% of the target has been already reached and contributed to the first load management experiment. Targets were defined

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NICE GRID, the French Demonstrator of GRID4EU

to ensure a sufficient, representative sample of Carros customers with regard to the potential identified base located in the city. Beyond the direct benefits linked to load-shifting and load-shedding, the engagement of individual participants is incentivized through:

- a sign-up gift,
- a financial contribution to the PV rooftop panel installation,
- the free use of a web portal to monitor power consumption.
- a gift linked with behavioral change

The desire to participate in a cleaner and more sustainable world and become an eco-citizen turns out to be a key factor to stay involved in the project. This mindset was particularly prevalent at the public hearing with the citizens of Carros while the project team presented the project.

Empowerment

Participants were empowered to manage their load (shifting or shedding), generate PV power, or/and store energy in the batteries or in the hot water tank (thermal storage) (cf. Figure 25).

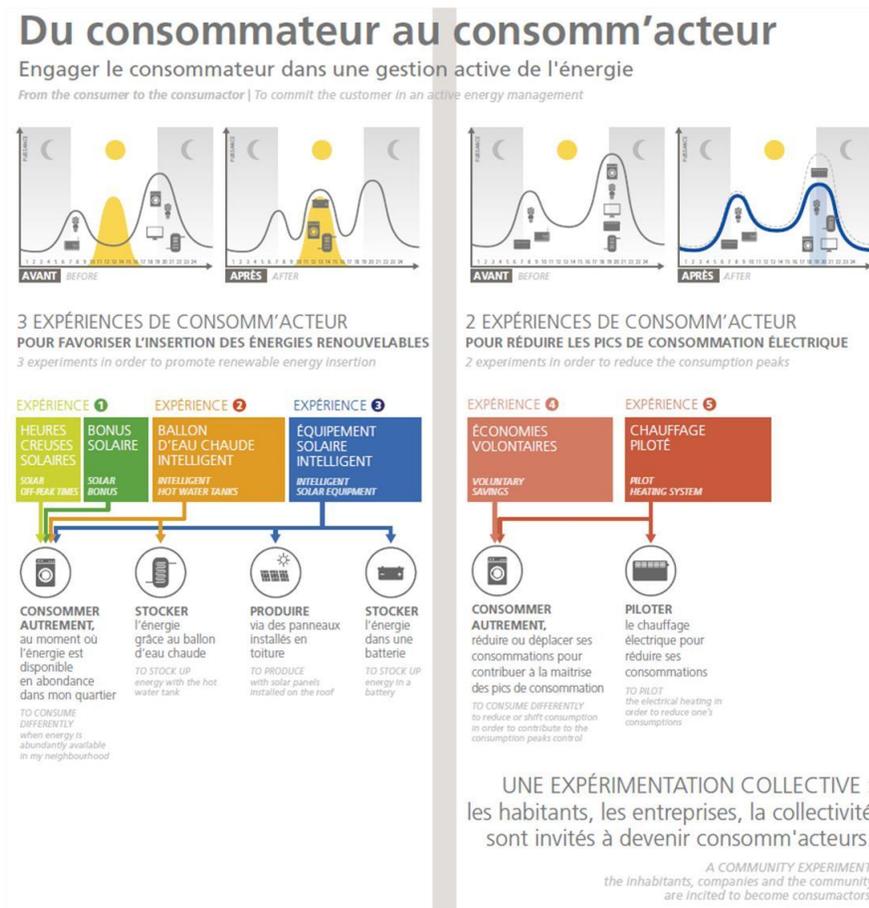


Figure 22: Poster explaining the offers

Participants are inspired to own the project through a communication system enabling them to report NICE GRID results. Two types of communications are performed:

- Individual communication through SMS, e-mails and a web portal called “Visibilité Conso”, available since summer 2013. SMS and e-mails provide information before the load-shedding or load-shifting takes place and give the opportunity to override the request (i.e. not to participate). These communication channels are also used to thank the individuals for their participation/involvement. The web portal is a consumption monitoring display that presents consumption for overall use, in euros and kWh, hour by hour, day by day and month by month. This portal enables participants to perform a day-to-day, month-to-month or even year-to-year comparison.
- Community feedback through “Carros Info”, the quarterly newsletter and the website are planned at the end of the first experiments (mid-year 2014). A meeting in the showroom is also planned at this time to reinforce the commitment of participating consumers and enroll new ones. These communications aim to add meaning to the project through community results.

Regarding the participants that would like to opt-out, a dedicated action framework has been realized to understand their concerns and to address them:

- dedicated public presentations of the project open to all citizens, and in particular opponents of the project, have been organized
- invitation in the showroom for groups of residential opponents to have the opportunity to discover, touch and play with the actual components of the project (meters, relays, batteries,...). This way of handling opposition has enabled:
 - opponents to change their minds about the project, even to become supporters,
 - a dynamic to be created in the city of Carros, thereby facilitating customer recruitment and project implementation.

For B2B participants, a business club of participating companies was created to foster synergies and discussions and share best practices. B2B participants asked for a specific tagline to highlight their participation in the project. In response to this demand, Nice Grid created a dedicated logo “engaged in Nice Grid” (“engagé dans Nice Grid”). Participants can use it to communicate on their engagement. They have the permission to use this logo in all of their communications (annual reports, presentations, signature of letters, email, etc.). (cf. Figure 26)



Figure 23: Logo « engaged in Nice Grid »

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NICE GRID, the French Demonstrator of GRID4EU

Sustainability

In order to sustain the momentum, the project undertakes two sorts of initiatives. First, at the end of each experiment, it emphasizes the results reached by all the participants in internal and external media (showroom, newsletter, local publications, etc.). Second, it highlights individual efforts realized by some participants through media interviews. For example, one participant has enthusiastically accepted to be interviewed by the Franco-German TV channel Arte to present his engagement in the project and his commitment for the future of the planet.

This approach is already effective. Participants of Nice Grid are already advocating the project. For instance, participating companies promote the project to their employees. They have also contributed to set up a club of business participants in the Nice Grid project to share best practices and create a virtuous circle of communication. They have even used this opportunity to share experiences beyond the project by organizing mutual visits of their industrial installations.

After experiencing the first experiments, participants are very enthusiastic about the project. As experiments are effective only in winter and summer, the level of excitement will likely to decrease. To avoid losing momentum, actions are planned to manage the time-lag between the experiments by maintaining the communication with participants:

- Meetings
- Quarterly newsletter
- Free interactive e-book for tablets and smart phones (cf. picture 10 of the Annex)
- Ongoing visits to the showroom for participants and also for the community (students, citizens, local authorities, etc.).

JAPAN: Share – Innovative Community and Energy System

Project Title	Share!
Location	City of Kitakyushu, Fukuoka Prefecture, Japan
Time Period of Project	2010-2014
Link to Project Website	http://jscp.nepc.or.jp/en/kitakyushu/index.shtml
Key Word	Energy Management, Active Consumer, Community

Project Background

The Higashida district of the Yahatahigashi Ward in the City of Kitakyushu, which is the target area for this project, is the birthplace of Japan's industrial revolution and the location of the government-run iron and steel works that started operations in 1901. Redevelopment of the 120ha area began in the mid-1990s, and as of 2013, about 70 companies and approximately 6,000 workers are located in the area. The area's population is about 1,000, and with visitors, the daytime population can be upwards of 30,000. After the Kitakyushu Expo in 2001 that was held in the Higashida area under the concept of improving urban infrastructure, the City of Kitakyushu developed the Yahatahigashi Ward Green Village Plan in 2004. This plan illustrates the concept of "sharing" in order to promote eco-urban development with an eye on the next 100 years, in cooperation with local residents and businesses, academia, NPOs, and governmental organizations. The co-existence of the city and local factories is being promoted as one of the concepts of this project. In the energy sector, in particular, the plan looks at optimizing the use of energy by utilizing the industrial structures of factories in the city. Specifically, this entails the effective use of energy and reduction of GHG emissions through a mechanism that supplies power to the urban area from a cogeneration plant located in the nearby iron and steel plant, and utilizes heat (steam) in factories within the iron and steel plant.

JAPAN

Share – Innovative Community and Energy System



Figure 24. Project Location

Demonstration projects are also carried out under the project in order to create a hydrogen-powered society by utilizing hydrogen byproducts that are generated during the manufacturing processes in the iron and steel plant as fuel for automobiles, and fuel cells for residential use by constructing the world's first hydrogen supply pipelines to the city center. The Yahatahigashi Ward Urban Planning Liaison Committee, made up of businesses located in the area, was established to stimulate the local community, and develops plans and activities, such as area beautification campaigns and events at various points within the local area. The committee is also involved in activities to introduce energy savings and renewable energy in the entire area, and activities to prevent global warming, such as tree planting. These activities are based on the idea of sharing, which this community has adopted as its local slogan (*omochiyori, wakachiai, osusowake*), and each stakeholder is sharing what they can offer with others. i.e., the stakeholders contribute to the project by what they can do and share benefit with each other. People started to relocate to the Higashida area in 2008, which changed the face of the local community that had originally been made up of factories that were located in the area, to a new type of local community in which the residents are active participants.

Since 2012, the “Higashida Festival” has been held with the participation of the area’s residents based on the concept of “*omochiyori, wakachiai, osusowake*” to convey the idea of “sharing” with both the people who live here, and those that visit the area. Putting the idea of a “smart community” into practice in this target project area requires various types of both hard and soft infrastructure. The project started soon after the area was selected as a Next-Generation Energy and Social Systems Demonstration Project in 2010 based on its potential. In 2011, the City of Kitakyushu was selected as a unique, green growth city in Asia for the OECD Green Cities Programme; this project is positioned as a core activity within this report, and aims to share its know-how with other areas in Asia. As a result of the Great East Japan Earthquake, there has been a heightened social need for conversion to an independent, decentralized network for energy supply and community redevelopment. This project has been attracting attention from both within and outside Japan as a project that is the focus of even higher expectations for the identification of new roles and potential achievements.

Case Description

(1) Purpose

This project aims to create a new energy system in which consumers are active participants, and which utilizes a Cluster/Community Energy Management System (CEMS), which carries out the integrated management of local energy information, and smart meters as the gateway for this information, energy management systems (EMS) installed in the houses and buildings of consumers, and storage batteries. Specifically, the project aims at 15% peak cut for electricity demand in the area, the design of a system that uses energy wisely when renewable energies are widely introduced, and, by 2050, a 50% reduction in GHG emissions (compared to 2007 levels). These measures reduce the social costs associated with energy, and allow both energy suppliers and consumers to enjoy economic benefits. Furthermore, the project promotes international standardization in order to broadly expand the use of technologies and know-how developed through the project both inside and outside Japan.

The stable supply of power in Japan to date had been taken for granted until the Great East Japan Earthquake. Since the disaster, there has been heightened worry about stable power supply, and increased chances to promote the introduction of renewable energy. It has become necessary to replace systems in which only the supply side (power companies) assumes responsibility for stable power supply, with a new system (demand response) in which the demand side (consumers) are also active participants in reducing their own energy consumption. Both dynamic pricing and incentive programs are included in this project to promote demand response, and demonstrate a system in which the demand side, i.e., the consumer, controls demand according to supply on a particular day.

It is expected that the mechanism such as dynamic pricing will encourage consumers to reduce or shift energy consumption peak. This will reduce the duty of electric companies to control power generation to respond to changes in power demand, which will also lead to a reduction in power plant capacity. The reduction of electricity bills is an economic benefit for consumers that practice demand response activities. There has also been an increase in opportunities for exchange from various standpoints through interviews and surveys on electric power in communities by the local government and NPOs. The opportunities for the community to band together have increased, including discussions among residents on methods to reduce power consumption, and visiting public facilities together in time periods when power rates are high.

(2) Approach

In 2010, detailed plans were developed into a master plan with the participation of local residents, power suppliers, and companies participating in demonstration projects, academia, and governmental agencies. The contents of the master plan vary and include the introduction of renewable energy and instruments such as CEMS and smart meters, as well as the development of a next-generation mobility system, design for a rate system, implementation of environmental education activities, and overseas expansion of project outcomes.

JAPAN

Share – Innovative Community and Energy System

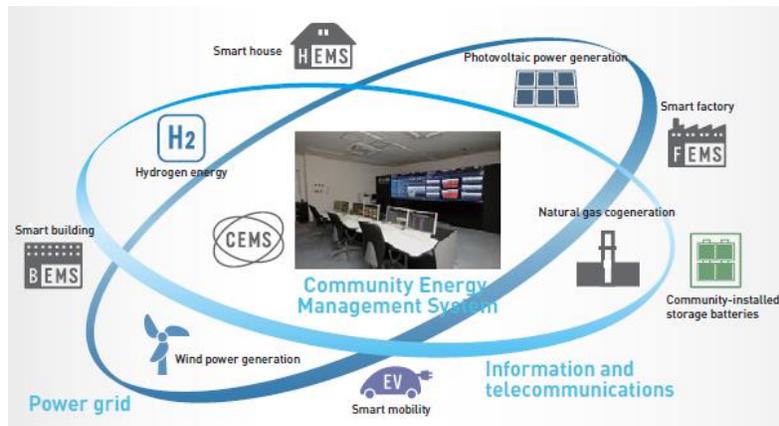


Figure 25. Smart energy management in the entire area centered around the

The Kitakyushu Smart Community Council was launched as the main implementation body of this project. This council established a board of governors and subcommittees as needed in order to smoothly promote project activities, and carries out activities, including confirmation of the project's progress and action policies, in addition to an examination of technical and administrative matters under each theme. Until FY 2011, the project developed and introduced energy management systems, such as CEMS, in the local community, and carried out detailed institutional designs towards the official start of the demonstration project from FY 2012. To start the demonstration project, the technologies of participating companies are brought to the table (omochiyori) to create multivendor, energy management systems built around CEMS. The project features dynamic pricing and incentive programs as mechanisms to promote changes in consumers' demand for electricity.

The community Energy Management System (CEMS) is managed by Fujitsu Electric and is located in the Kyushu Human Media Creation Center. This is where the data for all power produced and stored in the Higashida area is managed centrally, including Higashida Cogeneration, the area's power plant that uses natural gas, other forms of natural energy, and storage batteries. Demand forecasts and power generation forecasts for natural energy are developed based on daily weather information. Production and demand for power is predicted depending on changes in season, as well as daily weather and temperatures. This information is disseminated to "smart meters" that are installed in households and offices to create an optimal power generation plan. The demonstration project has also started a "dynamic pricing system" in which electricity prices fluctuate in response to demand that changes by season, day, and time period. This is a system in which electricity costs are set high for time periods in which the most amount of power is likely to be used according to prior electricity demand balances; in contrast, fees are set lower for periods when user frequency is low. Electricity costs are displayed on "in-home displays" installed in households and offices. This allows customers that access this information to decide



Figure 26. Community Energy Management System

The Higashida and Maeda Power Supply and Demand Unions are comprised of power suppliers and all the consumers that receive electricity in the Higashida area. At the general meeting of the union, the decision was made to take part in this project, with the participation of all the customers of the approximate 50 businesses located in the Higashida area. The project also confirms the participation of residential customers using methods that differ from business ones. Information exchange sessions and workshops are held a number of times each year in order to increase people’s understanding of the project. Because it may be necessary for the project secretariat to disclose personal information, such as about households, the project issued letters of consent regarding the intent to participate in the project; consent forms were received from 195 out of 225 households. The HEMS (Home Energy Management System) has also been introduced in several households that expressed interest.

Dynamic pricing system has been designed as a mechanism in which the unit price for electric power rates fluctuates in response to demand for electric power supply in the area for energy management. For example, rates are temporarily set high when demand is high, and are temporarily set low when demand is low. This encourages consumers to change the demand for electricity. Five levels were established in the project for electric power rates during peak hours, the world’s first demonstration project on variable peak pricing was carried out. The notification method for dynamic pricing is provided through the CEMS, which sends information to households via information terminals (display screens installed in households) on the previous evening and next morning.

The incentive program has been also developed as a mechanism that aims to maintain and increase the motivation of consumers to save electricity, and encourage changes in consumers’ demand for power, without being dependent on changes in electricity bills, for example. In this project, reductions in energy demand of the overall community have been encouraged by offering eco-points for the power conservation actions of consumers, establishing a commendation system based on these results, and offering discount sales or points for visiting stores in neighboring shopping centers during peak hours.

JAPAN

Share – Innovative Community and Energy System

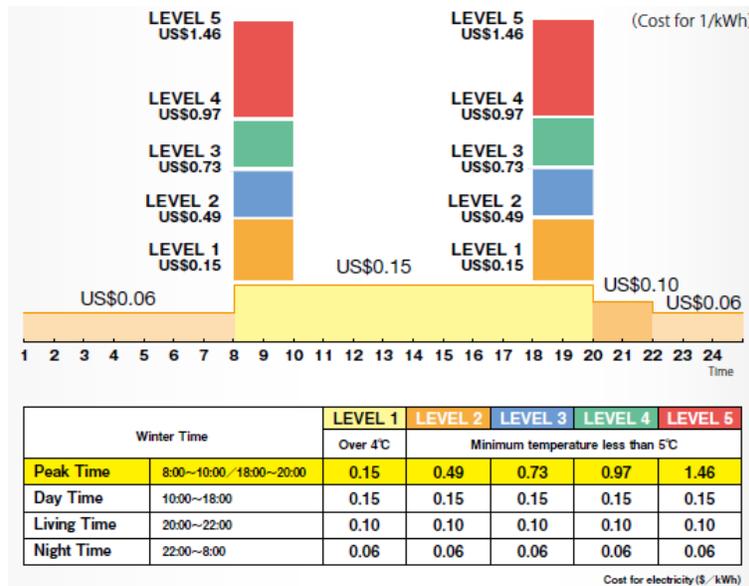


Figure 27. Dynamic pricing rate system (Winter 2013)

The project has implemented more than 100 briefing sessions and exchange meetings with the participation of about 10 people each time between the start of the project until 2013, as the understanding and cooperation of the residents are essential for the implementation of the dynamic pricing system and incentive programs. The project has also carried out surveys and workshops two or three times a year to help consumers gradually gain a better understanding of energy management. The project aims to improve systems year by year through these activities, in order to develop a system that is easier to use.

Professor Takanori Ida of Kyoto University, an economics expert, offers instruction on the peak cut effects in the dynamic pricing system, and evaluations are carried out according to the RCT (Randomized Controlled Trials) that are the guidelines of the U.S. Department of Energy to ensure that project data meets international standards. The RCT looks at three points: securing sufficient sample numbers, preparing a control group without price fluctuations, and randomization. Before the introduction of this system, multiple consultation meetings are held with Professor Takanori Ida’s research group to carry out the demonstration project in accordance with the RCT.

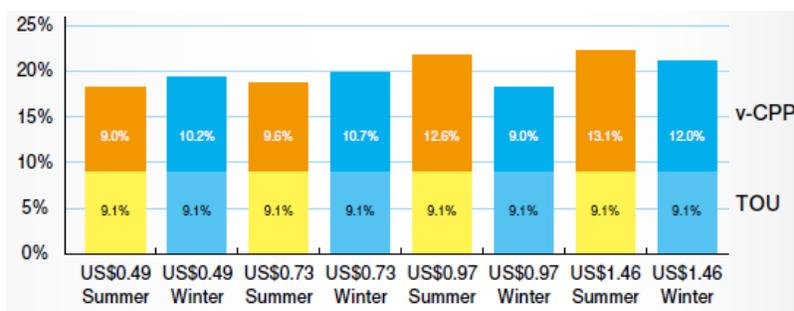


Figure 28. Result of demonstration project through summer and winter: Comparison of peak cuts

Project Outcomes

In order to encourage participation by consumers, it is important for both power suppliers and consumers to share information on energy. In this project, a smart meter and information terminal that displays information from the smart meter is installed in each household and office, which allows information to be shared between the power suppliers and consumers through CEMS. Consumers are able to obtain information, such as the amount of electricity supplied to the area, the amount of electricity used, their own electricity bills, and number of ecopoints. This has become an opportunity for consumers to think about the balance between their lifestyles and energy (energy savings, power conservation actions).



Figure 29. BEMS screen showing current state of energy demand in businesses located in the area

Generally speaking, consumers are assumed to consider the idea of electricity as “natural” and “available to be used when wanted,” and do not care of energy. As a result of promoting information sharing, such as the visualization of energy, through this project, the implementation of energy management by consumers is leading to the efficient utilization of energy in the entire community, and to the identification of solutions for mitigating the depletion of energy resources and global warming, which is being better understood by consumers. It is also important for consumers to take action as key stakeholders that make up energy systems as “prosumers” (both producers and consumers). In a survey, more than half of the area’s residents responded that their understanding of environmental and energy issues has increased as a result of the project, and it shows that consumers are planning to participate in energy systems.



Figure 30. Introduction of HEMS and BEMS in various places

JAPAN

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In this project, electricity rates are raised temporarily during seasons in which electricity demand reaches (or is expected to reach) higher peaks, such as in the summer and winter; this stimulates energy-saving actions by consumers. Consumers receive an electricity rate table for the next day via the smart meter in their homes or offices, and upon viewing the price table, consumers can change the preset temperatures of air conditioners, shift times for washing and cleaning, or leave the house during peak hours. In addition to self-checking electricity usage in hourly increments, consumers can also compare results with previous days and get information on the total amount of electricity consumption in the entire area. Checking this information allows consumers to carry out their own energy-saving actions. In households where HEMS has been installed, household appliances for which peak shifts are possible automatically turn off when dynamic pricing is triggered. HEMS can also assess situations by combining information on electricity use and information from temperature and humidity sensors, illumination intensity sensors, and motion sensors, and propose specific energy-saving actions. There is a dorm for single people in this area as well, and energy savings and peak cuts are coordinated by BEMS. Specifically, the project considers not only the amount of electricity used, but also the development of models to reduce CO2 emissions by installing water conservation devices and introducing heat transfer that is interlocked with BEMS. Through these actions, the project confirmed an approximate 20% peak cut in the summer and winter of 2012, and the summer of 2013, respectively.

Netherlands: PowerMatching City

Project Title	PowerMatching City
Location	Groningen, Groningen, Netherlands
Time Period of Project	2007-2014
Link to Project Website	www.dnvgl.com/powering-the-future
Key Word	demand side management, Smart Meter, , demand response, distributed generation, multigoal optimization

Project Background

PowerMatching City's aim is to enable the transition from centralized fossil fuel based power production to decentralized sustainable power production, by developing and demonstrating a smart energy infrastructure with related customer-focused smart energy services, as well as by validating the costs and benefits of such a system in practice. The project started in 2007 as a 3 year EU demonstration project (EU FP6-038576). Phase II (Sept 2011 - Sept 2014) is part of the Dutch IPIN program (intelligent network programme, see also <http://www.rvo.nl/subsidies-regelingen/intelligente-netten>). Within PowerMatching City, consumers, energy supplier and grid operator are equally important and cooperate to actively balance the demand for and supply of energy in the grid. A multi-goal optimization algorithm has been developed to balance all stakeholders' needs.

The project focuses on enabling end-users, energy suppliers and grid operators to benefit from a smart energy infrastructure. To this extent, a local energy market has been created, that uses dynamic energy and transport capacity prices. The local market is coupled to the national energy market and integrated in existing wholesale processes. Peak loads in the grid can be actively managed by influencing energy demand and supply in the participating households. The project is unique in the way it engages and empowers customers to become active prosumers. In a co-creation process with the participants, energy supplier, technology providers and grid operator, two new customer energy services have been developed that make optimal use of possibilities of a smart infrastructure. The first service enables users to create a self-supporting energy community. The second service focuses on reducing electricity costs by applying an optimal buying and selling strategy on the local energy market.

NETHERLANDS

PowerMatching City

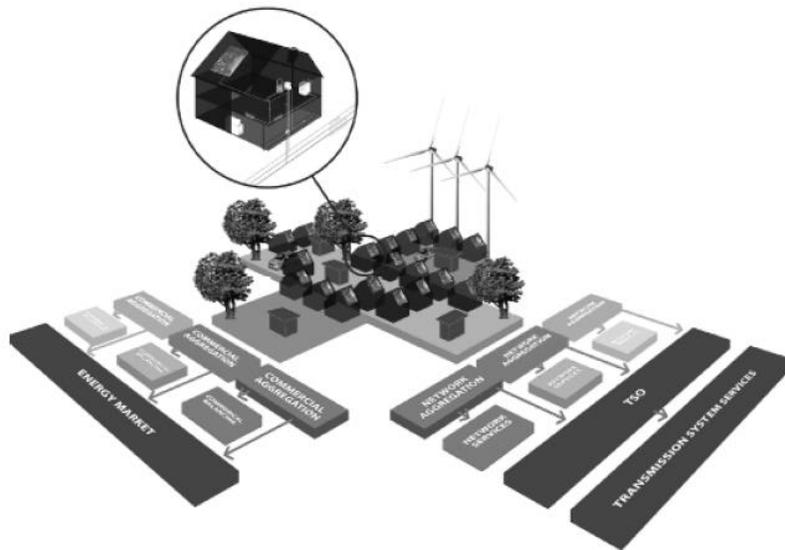


Figure 31. Optimization Goal of Power Matching City

Customer interaction is key in this project. During the course of the project, quarterly information sessions were organized and multiple surveys were submitted aimed at getting a profound understanding of customer drivers and needs. This information was used to create an interactive energy management system, the Energy Monitor. This is an integral platform for smart energy services, which not only educates users about their smart appliances and their energy use, but also helps them to meet their personal energy targets. The user focus of the project was reflected by the fact that all of the participants volunteered for phase 2.

The project was set up with large scale replication in mind. USEF (Universal Smart Energy Framework (www.usef.org)) guidelines were consulted for the design of the smart grid. Cloud computing was used for easy expansion. The control mechanism for the local energy market is based on distributed intelligence and can be scaled up easily. Smart appliances were developed in cooperation with manufacturers to create market-ready solutions. Cost-benefit analyses are made to determine market potential.

Case Description

PowerMatching City is an internationally recognised lighthouse project that demonstrates our future energy system in an existing neighborhood in Groningen, the Netherlands. This project is a typical example of what democratizing the energy market looks like in real-life. It gives a practical and replicable example of how a more sustainable energy future can be achieved using existing energy infrastructures.

The forty participants of PowerMatching City are people like you and me. With help of a fully integrated smart energy system, they are inspired and empowered to become active energy prosumers. The system enables them to control where and when they want to buy or sell energy. A home energy management system with smart apps educates them about the status and meaning of their energy use, and helps them to save energy and reduce costs. The smart system controls the indoor climate in their homes and charges their electric vehicles in time, providing

them with an enhanced level of comfort. The user's comfort and freedom of choice is of primary concern and is always guaranteed.

Central and local energy systems are equally important in this smart city. Multiple stakeholders, including energy suppliers, network operators and consumers, cooperate to actively balance the demand for and supply of energy in the grid. PowerMatching City's main goal is to pinpoint and quantify the added value of a smart energy infrastructure to these stakeholders. The results of these analyses are used to enable and accelerate a large scale roll-out of smart grids.



Figure 32. PowerMatching City

The added value of smart

Upgrading a power system to a smart energy system potentially brings a variety of benefits to different stakeholders. PowerMatching City's main goal is to demonstrate and quantify the added value of a smart energy infrastructure to energy producers, distributors and end-users. For each stakeholder, a smart energy system brings different benefits. To quantify the effectiveness of the applied smart grid solution in managing required transport capacity, peak-power consumption is measured at a transformer level. PowerMatching City's energy supplier has developed a new wholesale system based on real-time electricity prices, and has developed two new energy services for their clients. The first service enables users to share electricity and create a self-supporting, sustainable energy community. The second service focusses on reducing electricity costs by applying an optimal buying and selling strategy on the local energy market.



Figure 33. New Energy Services for Smart City Users

NETHERLANDS

PowerMatching City

A total solution

When people talk about smart grids, what they often really refer to is advanced metering infrastructure (AMI) technologies. The smart energy system of PowerMatching City however goes much further than this. It is a total solution, that combines smart technologies like AMI, distributed intelligence, grid capacity management, near real-time wholesale processes and customer energy services in a real-life environment. Using PowerMatcher technology, a local energy market has been created. This local market is connected to the national power exchange using an auctioneer service. In this way, local and central energy supply systems can supplement each other. This generates the required flexibility to be able to integrate large shares of renewable energy in our energy systems, both at a central as well as at a local level. A multi-goal optimisation algorithm is used to balance the needs of the energy supplier, grid operator and end-user simultaneously. In this way, freedom of choice can be guaranteed while keeping peak loads in the grid within reasonable boundaries. The homes in PowerMatching City are outfitted with a variety of smart appliances that can be monitored and controlled by the user's smart energy system. These appliances range from smart washing machines to intelligent heating systems and smart thermostats. Gas-fuelled appliances ensure the integration of gas and electricity on a household level. By using local heat buffers to store any surplus of heat for use at a later moment in time, the system creates flexibility for managing peak loads in electricity demand. An advanced home energy management system makes optimal use of the smart infrastructure by bringing more insight, control and automation to the users with custom smart energy services.

Engaging people: smart & green without hassle

PowerMatching City's inhabitants are ordinary people, who live ordinary lives. Although they volunteered to take part in the project, they do not want to be bothered with their energy use all the time. The users want to save energy and contribute to the smart grid, but not to the point where it hinders their comfort or increases their energy costs. Guaranteeing comfort and reducing energy costs have been key starting points in the design of PowerMatching City. The system always ensures the user's comfort. It automatically manages smart appliances based on current electricity prices. The system can always be overruled by a user; devices can always start when a user wants them to. Depending on the user's personal energy service, the system strives for the lowest energy costs or the largest share of locally produced electricity, without the need for any input. In this way, PowerMatching City's inhabitants are contributing to an extraordinary green and affordable energy future, whilst living a very ordinary and comfortable life.

Project Outcomes

PowerMatching City's main goal is to demonstrate and quantify the added value of a smart energy infrastructure to energy producers, distributors and end-users. The project's outcomes are best-practices for building a smart grid, cost-benefit analyses for all stakeholders, and replicable technical solutions for building, managing and monitoring a smart grid. Also, innovative apps for user education and interaction have been developed. To ensure a private and secure infrastructure, the Universal Smart Energy Framework (USEF) has been consulted as a guideline for developing the smart grid. The project is currently in its data-collection phase. To quantify the impact of the applied solution in managing required transport capacity, power consumption is measured at a transformer level. PowerMatching City's energy supplier has developed a new wholesale system based on real-time electricity prices and two new energy services. The first service enables users to share electricity and create a self-supporting sustainable energy community.



Figure 34. Real-time information through street display

The second service focuses on reducing electricity costs by applying an optimal buying and selling strategy on the local energy market. To date, PowerMatching City has been a great success. The applied smart technologies add flexibility to the electricity grid and at the same time increase the overall comfort for end-users. The developed control mechanism can be expanded as needed as it is based on distributed intelligence. The total system acts as a virtual power plant that can produce electricity using combined heat and power units and can consume electricity using heat pumps. Preliminary results show that this virtual power plant responds quickly and correctly to fluctuating demands on the energy market. Consumer feedback has been positive. The smart grid offers tangible benefits, including more control for users over their energy use, the ability to live a greener lifestyle and cost savings. The participants indicate that they have become much more aware of energy in their daily lives. They form a community, both in the digital and in the real-world, which is pro-actively working on a greener neighborhood. The users' home energy management system has enabled them to take control over their energy use and costs. The next step is a large scale roll-out of smart energy systems, building on the solutions and services that have been developed in PowerMatching City. This next step, "PowerMatching City to the People" has already been initiated. Smart energy systems and services will be made commercially available to interested national and international parties.

Portugal: Inovgrid

Project Title	Inovgrid
Location	Evora, Alentejo, Portugal
Time Period of Project	2011-2014
Link to Project Website	https://www.inovgrid.pt/
Key Word	Energy Efficiency, Smart Meter, Home Area Network (HAN), etc.

Project Background

From the beginning of the Inovgrid project in Evora, EDP understood the crucial impact of energy efficiency gains on the value of the project. Considering the critical role that customer engagement plays as a prerequisite to change behaviours and increase energy efficiency, EDP implemented in Evora a mix of initiatives aimed at raising awareness about the project and creating a special dynamic. Key stakeholders were identified and multiple initiatives were designed to target specific customer groups and other stakeholders, such as schools, energy professionals and local authorities. Several activities of communication and dissemination of the project were crucial to obtain the involvement of different stakeholders: the InovCity showroom, the Energy Bus, the information spread around the city of Evora, the organization of Conferences and events, the presence in the local press or even the several public sessions held for customers’ clarifications of the project. Additionally, surveys were used to continuously monitor customer attitudes and guide communication decisions.

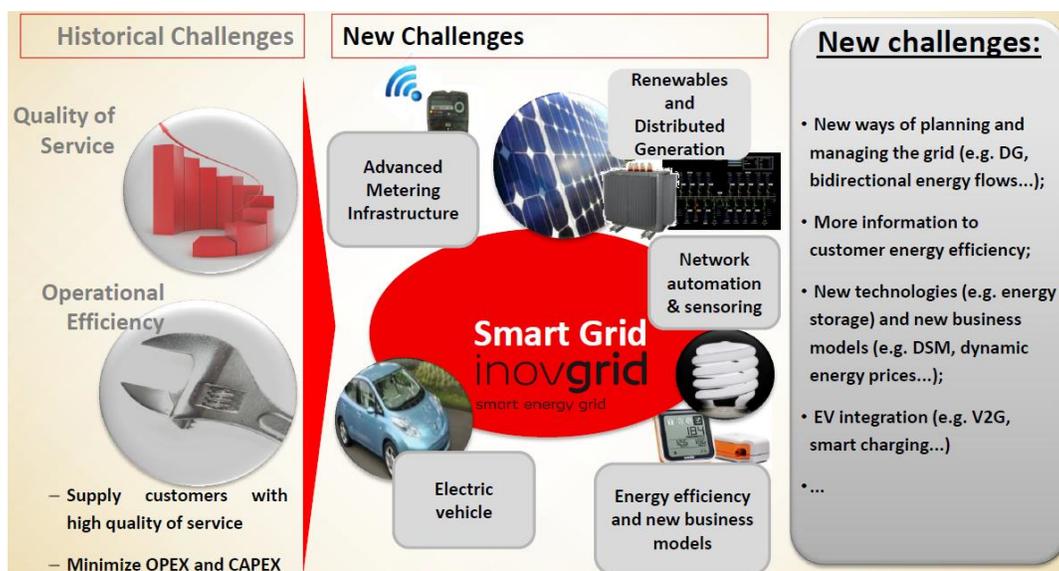


Figure 35. Composition of InovGrid Project

EDP’s desire to have impact in terms of customers behaviour reflected in the technical specification of the smart meters, which include a Home Area Network (HAN) module that allows the flow of information from the system

to the customer premises, supplying in-home displays where customers can have real-time access to their “electrical” information. InovGrid technology is used as an open platform, based on public standards, facilitating the development of new in-home tools and services supporting customers’ involvement, which allow to deeply empowering consumers to make smart decisions about electricity consumption. Customer innovative products are under test, leveraging on InovGrid platform, and developed by independent companies like uMeter from Tekever, Mordomus, or RE:DY that allows monitoring consumption and production (for micro-generators) and promoting a more active behaviour of clients towards an efficient energy consumption.

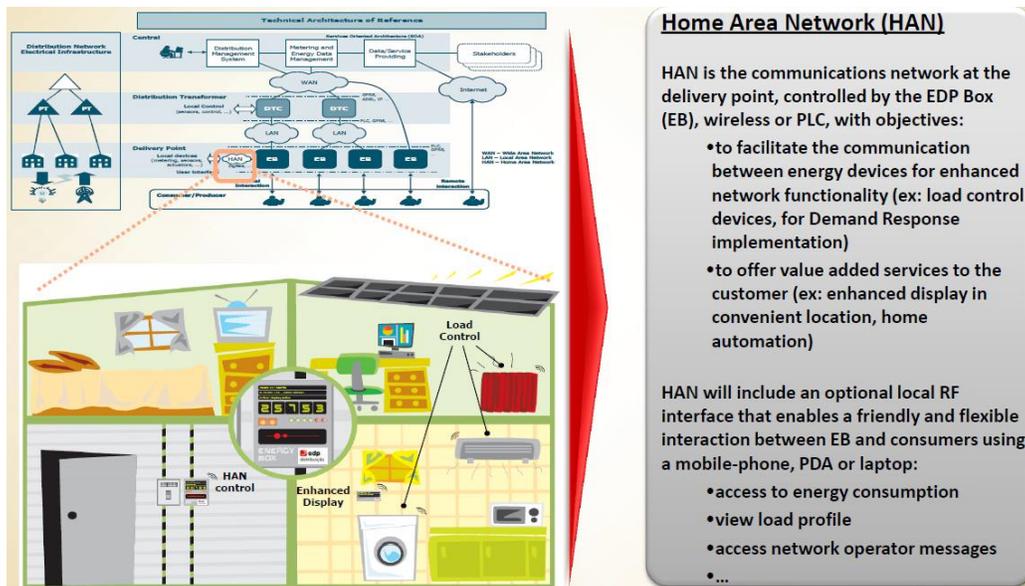


Figure 36. Home Area Network

After compiling the 2011 catalog of all European Smart Grid projects, the Joint Research Center (JRC) of the European Commission has recognized the unique positioning of InovGrid by choosing it as the single case study on which to base the development of its “Guidelines for Conducting a Cost-Benefit Analysis of Smart Grid Projects” [Report EUR 25246 EN]. In 2012, InovGrid was labelled as “EEGI Core Project” by the European Commission EEGI Team, demonstrating that is fully in line with the EEGI objectives. The project was also the choice of the EU as a success story, for the Campaign launched in 2013: “A world you like, with a climate you like”, recognizing the strong impact that the project has in changing consumer habits and behaviours towards an improved electricity landscape.

Case Description

InovGrid, the smart grid project, and InovCity, the city where all the 50 thousand electricity consumers have stepped into the next level of electricity control, are two real examples of the importance and crucial impact that customers have in the development of Smart Grid projects. Having the customer at the center of its strategy, EDP Distribuicao designed an approach for the implementation of the InovGrid project in the city of Evora (Portugal), having in mind that, on the one hand clear value creation for customer must be achieved, and, on the other hand, that customers must perceive this value. Not only technology educated customers, but mainly ordinary electricity customers, whose focus is mostly on the reduction of the electricity bill arriving month after month. With project InovGrid, EDP Distribuicao seeks to transform its distribution grid and position it as the answer to several

challenges, including: the need for increased energy efficiency; the pressure to reduce costs and increase operational efficiency; the integration of a large share of dispersed generation; the integration of electric vehicles and the desire to empower customers and support the development of new energy services. Results are very encouraging, as a unique study in the European landscape, held by a renowned University, allowed concluding that energy efficiency increased up to 6.6% for sophisticated residential consumers with access to a Home Display. InovGrid is currently being used as a reference demonstration site for several European projects (SuSustainable, S3C, evolvDSO, etc...), that will further allow exploiting active consumer participation in the management of the electricity grid, giving a strong contribution to tackle the present challenge of a renewable energy fueled Planet.

Project Outcomes

- (1) InovGrid enables an active participation of customers with innovative solutions, and is of utter importance because its holistic approach to the different involved aspects and its central role acting as an integrated platform, can leverage the development of new business models, that will allow to reduce CO2 emissions, inject more renewable energy in the grid and promote energy efficiency, having a significant impact in contributing to the European Energy targets. An ecosystem was created, where third party companies can develop energy-oriented products and services, that further allow to reach consumers' needs.
- (2) EDP Distribuicao is at the front line where customer involvement is concerned, by including in the smart meter, since the beginning, a gateway that allows a real time flow of information from the system to the customer premises, enabling the use of data for their own benefit: average energy efficiency improvement of 3.9% for 30 thousand consumers in Evora, almost doubling the estimated by Portuguese Regulator in its CBA supporting the national roll-out decision, after more than one year of data certified by an independent specialized company. Some individual consumers even get gains over 20%.
- (3) Replication potential is increased by setting a standard and open platform that can leverage innovation. Currently InovGrid project is expanding across Portugal to 6 new locations, covering about 150 thousand consumers, and is participating in large European projects, which allows to have a good vision and an active participation in replication procedures in the international space. The project is being developed in close cooperation with several organizations including Research Institutes and Universities across Europe, Industrial Partners, Local and National Authorities, Energy Sector Associations and Regulators, the involved Communities and other relevant stakeholders. More than 1500 visitors from all continents, have visited Evora InovCity, including several prominent personalities: Mr. Dominique Ristori EC DG-ENER Director or Prince Charles from the UK.
- (4) The main innovation of the project InovGrid is the fact that is based on a Smart Grid concept of an open platform supporting market services, making energy users aware of the amount of energy/money/CO2 emissions inherent to each activity in their home/office, namely the ones that consume more energy (e.g. heating). Detailed consumption information, presented in a timely and user friendly way, enables more efficient use of electricity and increased awareness of the environmental impact of each consumption choice. In-home displays are one of the goals of this project which develops a device that has enough flexibility for the customers in the market to choose the most suitable interface for them.
- (5) The next developments of InovGrid project focus on i) integration of interoperable standard solutions coming from different suppliers; ii) testing of new technologies developed in close cooperation with R&D organizations, within the different dimensions of the project iii) integration in international projects, contributing with solid results to form future smart grid policy.

U.S.A (1): Pacific Gas & Electric's Green Button

Project Title	Pacific Gas & Electric's Green Button
Location	San Francisco, California, U.S.A.
Time Period of Project	2011-Present
Link to Project Website	
Key Word	Green Button, Energy Use, Customer, Green House Gas

Project Background

With the ongoing success of Green Button, PG&E released Green Button Connect (GBC) Beta on October 1, 2012. This platform gives customers even greater control over their energy use by offering a simple, one-time authorization to automate the secure hand-off of their energy data to the third-party energy application developer of their choosing. GBC Beta was launched with three initial application developers: PEV4Me, Leaffully, and Unplug Stuff. The success of the initial three developers led PG&E to publish an application in January 2013 to expand the third party requestor pool. To date, PG&E has received 50 plus applications with vendors ranging from a student implementing a social gaming app to more experienced companies performing analysis for business customers. PG&E selected eight vendors for the first round of expanded third parties, which was implemented by the end of August 2013. This platform provides developers the opportunity to continuously develop innovative tools aimed at helping customers manage their energy usage and reduce their energy bills.



Figure 37. Web Interface of Green Button

Case Description

PG&E is deploying Smart Grid technology and education programs to help customers better manage their energy use, helping them in many cases to save money and reduce greenhouse gas (GHG) emissions from electric

generation. For example, with backing from the White House, PG&E launched its “Green Button” initiative in 2011. This program provides customers access to standardized energy usage and historical billing reports that they can share with energy service providers in order to help them find ways to reduce their energy consumption and save money.

Project Outcomes

This project works to create an Engaged Consumer – customers interested in viewing and sharing their energy usage data with third parties are more engaged in managing their energy usage and controlling costs. From July 2012 through June 2013, approximately 36,600 energy usage files have been downloaded via the Green Button application. Through September 1, 2013, almost 15,000 customers have enrolled in the Green Button Beta program in order to share their usage data with an authorized third party. Additionally, as of September 2013, more than 85,000 residential customers are enrolled in PG&E’s Energy Alerts program, a program that notifies customers when their energy usage may move them into a higher rate tier. These alerts help reduce the chances of bill surprises and allow customers the opportunity to more effectively manage their energy bills. Pacific Gas and Electric Company (PG&E) has also won numerous awards for implementing elements of the Smart Grid, including being named one of the nation's most "intelligent utilities" in the third annual "UtiliQ" ranking by Intelligent Utility magazine, and being named a top utility for Smart Grid implementation by GreenTech Media and GTM Research. In addition, PG&E has hosted numerous international delegations for tours of its Smart Grid Lab, located in San Ramon, California. The lab is dedicated to conducting cutting-edge smart grid research and the work being conducted there, along with the utility’s experience as an early adopter of the Smart Grid, has provided the utility’s customers with enhanced safety and reliability, more insight into energy use and improved customer service by ensuring that Smart Grid components are thoroughly tested and piloted before being deployed onto the grid.

U.S.A (2): Advanced Building-Scale Smart Grid Demonstration at Mesa del Sol

Project Title	Advanced Building-Scale Smart Grid Demonstration at Mesa del Sol
Location	Albuquerque, New Mexico, U.S.A.
Time Period of Project	June 2010- Present
Link to Project Website	
Key Word	BEMS, microgrid, Consumer, demand response, PV, etc.

Project Background

This commercial-scale microgrid was built as a result of US-Japan collaboration on microgrids, funded by Japan's New Energy and Technology Development Organization (NEDO). Since the system was commissioned in March 2012, Japan's Shimizu Corporation and Tokyo Gas, the University of New Mexico, Public Service Company of New Mexico (DSO/TSO), and Sandia National Laboratories have used the infrastructure to conduct research and demonstration, sponsored by NEDO and the US Department of Energy. The technical objectives directly empower commercial-class consumers to more effectively manage electricity and thermal demand, improve supply reliability, and become an active distribution network resource. The following technical capabilities were demonstrated:

- (1) Scheduling of the building's net power flow at the utility interface, by compensating short-term PV and load fluctuations.
- (2) Stable operation of the entire commercial building in islanded mode.
- (3) Uninterrupted transition between grid-interconnected operation and isolated operation
- (4) Demand response control connected with the commercial system
- (5) Load tracking control by air conditioning heat source utilizing hot and cold thermal storage

The system's host building, known as the Aperture Center, anchors a new residential community called Mesa del Sol (Table of the Sun) in the City of Albuquerque, New Mexico, USA. The Aperture Center is a three-story commercial building housing stores and offices, with total floor space $\sim 7,000\text{m}^2$. Peak building demand is $\sim 300\text{kW}$. The site is in a high desert location, at an elevation of 1,600 meters above sea level. Even though the building is to the highest energy efficiency standards, heating and cooling loads are significant given that ambient temperatures vary widely throughout the year, from a monthly average low of $-5\text{ }^\circ\text{C}$ in January to an average high of $35\text{ }^\circ\text{C}$ in July. The microgrid consists of a 240kW gas engine generator with heat recovery, an 80kW fuel cell, a 50kW PV system, and a 160kWh lead-acid battery. The thermal system consists of a 70 USRT air-cooling type chiller, a 20 USRT absorption-type chiller, two 75m^3 chilled water thermal storage tank, and two 110m^3 hot water thermal storage tanks. All components are controlled by building energy management system (BEMS) that manages both electrical and thermal supply to the commercial building. The system also has a 100kW load bank that can be controlled in 5KW microgrid devices according to the control objective selected by the consumer. A smart meter is used to monitor the building grid interface. The BEMS also has the ability to process supplemental control signals from the utility.

Case Description

The objective of this project is to demonstrate full integration of distributed resources (configured as a microgrid) and a commercial building. The system enables the building owner (consumer) to manage its energy demand and enhance reliability and resilience. In addition to supplying electricity and thermal (hot and chilled water) to the building, the microgrid allows for scheduling of net demand (importing or exporting), participation in demand response, and smoothly transition to and from islanded mode. The microgrid controller has the ability to interact with the utility (DSO), enabling the consumer to also provide dispatchable grid support services. Although the microgrid is in a region with limited market participations options, the key technical capabilities have been successfully demonstrated at full-scale. In addition, the project enhances the environmental sustainability core values embraced by the host (commercial customer/customer).

Key outcomes related to consumer engagement and empowerment of commercial-class consumers are:

1. Provides an efficient and fully integrated self-supply option for thermal energy and electricity
2. Enables commercial consumer to engage in market transactions (where that option exists) or provide grid support services that require dispatch of net building load
3. Provides higher supply reliability and resiliency to the consumer by enabling the building to island in case of a grid outage
4. Allows the consumer to host a large amount of variable renewable variable resources without degrading power quality at the utility interface

Project Outcomes

This project has generated outcomes that exhibit excellence from several points of view. The impact is well beyond successful completion of the stated technical objectives.

- (1) Potential Impact: By involving the consumer, utility and research entities, the project has found solutions for complex technical and nontechnical challenges that, in other settings, represent barriers to deployment of customer-owned microgrids, including technology integration, interconnection requirements, and regulatory treatment. The project is impactful because it successfully demonstrated, in a real scenario, the range of benefits that commercial microgrids provide to consumers and to the grid. Also, the project's safety and performance track record is an excellent example for the industry.
- (2) Consumer Benefit: Customer-owned grid-interactive distributed resources are often deployed to enable demand response flexibility (e.g. peak shaving). This project goes well beyond. By coordinating generation resources, demand response and electricity/thermal storage, the consumer has the ability to dispatch net demand within a wide range (importing or exporting). The capability can be used by the consumer to maximize market participation opportunities. The system also provides higher supply reliability to the consumer.
- (3) Potential for Replication: The system is implemented in a medium-scale high-efficiency (LEED Gold certified) commercial building with standard utility service and thermal load. This project demonstrates how a system consisting of several generation technologies, heat recovery and storage can supplement building efficiency and demand response measure to make future zero-net-energy buildings possible.
- (4) Level of Innovation: The project has a state-of-the-art building energy management system (BEMS) that controls all aspects of the microgrid operation. It dispatches the microgrid assets to meet both electricity and thermal demand to an occupied commercial building in the most cost-effective manner. The highly innovative



feature is the ability to smoothly transition the building from grid connected to islanded mode, in which the microgrid is responsible for controlling voltage and frequency. Another innovative feature is the use of low-cost secured communications to enable microgrid interaction with the utility for real-time control.

- (5) Alignment with ISGAN Mission: This aligns with ISGAN’s mission to “accelerate progress on key aspects of smart grid policy, technology and related standards. It deploys commercial products from the US and Japan, which required identifying and resolving gaps related to policies, standards, certification and interoperability of smart grid equipment. This project also provided valuable experience with the integration of a wide range of generation, protection, measurement, control technologies, and data management technologies.

U.S.A (3): Borrego Springs Microgrid Demonstration

Project Title	Borrego Springs Microgrid Demonstration
Location	Borrego Springs, California, U.S.A.
Time Period of Project	September 2012- September 2013
Link to Project Website	https://www.smartgrid.gov/sites/default/files/pdfs/project_desc/
Key Word	Smart Meter, customer-centric approach, microgrid, etc.

Project Background

Microgrids have been demonstrated successfully for single customers but have not been designed and demonstrated across multiple customers as a utility asset. For utilities to adopt microgrids as an operating option, a utility microgrid needs to be designed and demonstrated to establish utility operational practices and show the benefits for multiple utility customers. The Microgrid Demonstration focused on the design, installation, and operation of a community scale “proof-of-concept” Microgrid demonstration. The site of the Microgrid was an existing utility circuit that had a peak load of 4.6 MW serving 615 customers in a remote area of the service territory. The key aspects of the Microgrid Demonstration were the integration and operation of the following types of equipment and systems:

- Distributed Generation
- Advanced Energy Storage
- Price-Driven Load Management
- Fault Location, Isolation, Switching and Restoration
- Integration with DMS/OMS and Microgrid Controls

The overall objectives for the Microgrid Demonstration were to:

1. Demonstrate the ability to achieve a 15% or greater reduction in feeder peak load
2. Develop a strategy and demonstrate the integration of the Automated Metering Infrastructure (Smart Meters) system into Microgrid operations
3. Develop a strategy and demonstrate ‘self-healing’ networks through the integration of Feeder Automation System Technologies (FAST) into Microgrid operations
4. Develop a strategy and demonstrate the integration of an Outage Management System / Distribution Management System (OMS/DMS) into Microgrid operations
5. Demonstrate the capability to use automated distribution control to intentionally island customers in response to system problems
6. Develop information/tools addressing the impact of multiple DER technologies

The scope of the project was conducted in two phases. The first phase established the design and demonstration plan for addressing four fundamental and interrelated goals:

- o Integrating utility and customer based energy resources
- o Enhance management of customer resources
- o Identify and evaluate key technical and operational aspects of design, implementation and management of an integrated energy portfolio of utility and non-utility interconnected resources
- o Improve power reliability and quality through utility asset management

The second phase applied the lessons learned in Phase 1 to implement the solution. The key elements of the Microgrid resources implemented for the project were:

- Two 1,800 kW Diesel Generators
- One 500 kW / 1,500 kWh lithium ion energy storage unit
- A Fault Location, Isolation and Service Restoration system
- A Microgrid Visualizer to support control and monitoring of the Microgrid resources
- An automated demand response system with pricing based event capabilities

Approximately 60 residential and small commercial customers were provided home-area-network energy management systems to display real-time energy use and pricing information and provided education and training to use the convenient options to manage energy use remotely. These customers were provided incentives for participating and actively managing their energy usage to moderate heavy electrical use during peak demand periods to prevent electrical supply emergencies during the operation of the Microgrid.

One of the highlights of the Microgrid Demonstration was the ability to effectively island the entire Microgrid supporting more than 600 customers. The islanding demonstration transition into and out of the island mode without affecting the quality of service to the customers (seamless transitions without an outage or flicker).The Microgrid on-site generation was able to deliver power to a large portion of the local grid during a planned outage, reducing the scale of the outage and the corresponding impact to customers. This demonstrates in a tangible way the great possibilities that exist when we use technology and customer engagement and participation to overcome operational challenges on the ground.

Case Description

Using Smart Grid and Smart Meters as the foundation, San Diego Gas and Electric (SDG&E) is developing innovative demonstrations that create an individualized, two-way relationship between the utility and the customer, engaging customers in active participation for improving grid operations and empowering them with information about energy usage and new opportunities to conserve electricity and receive value for it. This customer-centric approach is now a part of the utility's 'Connected' brand, which emphasizes its connection to customers.

In cooperation with the US Department of Energy and the California Energy Commission, SDG&E along with multiple public and private sector partners developed the Borrego Springs Microgrid Demonstration Project. Microgrids have the potential to provide multiple benefits to customers including enhanced reliability, promoting renewable energy integration and encouraging customer involvement. This project studied how to best respond to a system disturbance and maintain power to a local area, allowing customers to potentially "ride through" the disturbance by having enough local generation and local energy storage and utilizing customer participation to meet the critical energy demands of the area. Microgrids have the potential to be an alternative service delivery model for some of those hard to reach customers or potentially those requiring higher degrees of reliability. They potentially have broad applicability and scale across utility service territories and terrains.

U.S.A

Borrego Springs Microgrid Demonstration

This demonstration project brings customer systems and utility circuit system realities together. While a few microgrid trials have taken place in the US, they have typically been of a smaller scale and not directly applicable to the real operating environment.

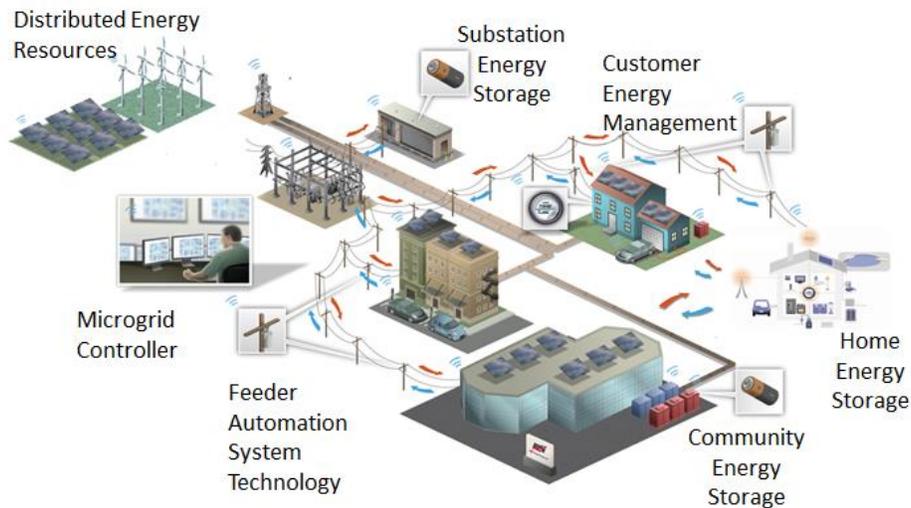


Figure 38. Borrego Springs Microgrid Demonstration Project

Project Outcomes

This project designed and demonstrated a utility operated microgrid that incorporates sophisticated sensors, communications, and controls to explore microgrid islanding (temporarily disconnecting from the grid) of multiple customers along an entire distribution feeder. The Borrego Springs Microgrid Demonstration successfully incorporated customer participation into the operations of the electrical delivery system by enabling coordinated demand response concurrent with Microgrid operations. In addition, the Microgrid integrated and controlled multiple distributed generation and electrical energy storage devices to operate the grid in the most cost-effective and reliable manner, benefiting customers by reducing overall outage time during very adverse conditions. Overall, the Borrego Springs microgrid achieved a greater than 15 percent reduction in feeder peak load and improved system reliability.

As one of the world's largest and most complex microgrids, this installation experienced a real-life test demonstrating its reliability when thunderstorms and flash floods knocked down transmission and distribution power lines, creating an outage affecting 2,700 customers. The microgrid was able to island and provide power to more than 1,056 of the affected customers for over 20 hours.

In September 2013, the San Diego Union Tribune, a local newspaper in San Diego, California, highlighted the importance of the Microgrid Demonstration as "a first of its kind in the area...a more robust, resilient grid that can dynamically react to the changing environmental and system conditions... giving SDG&E and its customers a glimpse of a possible "utility of the future – one in which the grid itself can respond to outages by routing and restoring power where it is most needed, bringing vitally needed energy to residents and quite possibly saving lives in the process." Such a grid protected those in need during outages by supplying energy where there would



otherwise be blackouts. A coordinated automated switching plan for restoring power to critical public accessible areas like the Community Library (designated a 'cool zone'), the local high school (a primary evacuation site), the fire station and sheriff's station, and the Borrego Springs Airport, gave the community the flexibility to adapt to the 100 plus degree weather, and aid to those with critical life support systems. A copy of that report can be found on the following url:

<http://www.utsandiego.com/sponsored/2013/nov/10/sgde-repair-crews-storm/>

This effort allowed those customers directly benefiting from a Microgrid to be engaged and empowered through awareness and education on how their actions support a "self-healing" dynamic grid through community involvement.

U.S.A (4): Entergy New Orleans "SmartView" AMI Pilot

Project Title	Borrego Springs Microgrid Demonstration
Location	New Orleans, L.A., U.S.A.
Time Period of Project	May 10, 2010 - September 30, 2013
Link to Project Website	www.energy.com
Key Word	AMI, Pilot, low-income customers, community partners

Project Background

ENO's intent is for the SmartView pilot to serve as a customer behavior study to be used in potentially developing future programs that will assist and empower the low-income demographic segment in managing its energy consumption. The pilot included rebates and incentives for enrollment, peak load reduction/control. In addition, the pilot provided the availability of near real-time energy usage information through a table top in-home display, a programmable communicating thermostat, and/or a web portal that measured the impacts to customer's energy consumption patterns. The primary measures for gauging the success of these initiatives were: customers' overall energy use, changes in customers' load profiles and reduction in peak usage, and the customers' overall satisfaction and involvement with the programs. Secondary measures included the relative impacts that differing levels of program education had on the primary measures and customer satisfaction.

Customer research began in September 2010, stakeholder training and education began in November 2010, and customer solicitation and enrollment began in December 2010. ENO's participation goal for this pilot was approximately 10% of the target population. In order to achieve this aggressive goal, the company employed a number of outreach strategies, including working with local community outreach organizations to help solicit, enroll, and educate low-income customers in the pilot programs. As a result, the pilot included 4,500 participants in the various programs.

ENO invited 18 New Orleans area nonprofit and community development organizations to participate in the solicitation, enrollment, and customer training aspects of the program. Seven nonprofit organizations were contracted at various levels to support the project. The contracts provided a cost structure to incentivize high enrollment rates and covered the cost of materials, supplies, and equipment. These organizations enrolled 39% of the participants.

ENO used a variety of other methods to reach out to its customers and build awareness of the program, including TV, radio, print, and web media; Customer Care Center presence; neighborhood events; a dedicated support call center; bill inserts; outbound phone calls; and targeted mail.

All participants were asked to identify their preferred level of training from three choices:

- Face-to-Face training ("High Touch"): ENO and partners conducted 32 training sessions at various contracted nonprofit locations. 518 customers participated.

- Over-the-Phone training (“Medium Touch”): ENO held ten conference call training sessions. 170 customers participated.
- Mail Instructions (“Low Touch”): All customers who requested mailed instructions or did not specify a training preference were mailed an instruction manual, quick reference guide, and FAQs. 2,000 customers received mail.

Online tutorials, Customer Care center representatives, and a dedicated call center were available to all participants for training and ongoing program support. Please refer to the project final report for additional details.

Case Description

Entergy New Orleans (ENO) developed and implemented the Smart Grid pilot program to evaluate customer behavior and the impacts of peak time rebates, air conditioning load controls, and other enabling technologies with the potential to reduce low-income customers’ electricity usage and peak demands. The pilot provided the company with valuable information regarding customer acceptance of AMI technologies.

ENO’s SmartView pilot was the only DOE Smart Grid Investment Grant program exclusively focused on low-income customer segments. The program serves to inform future Smart Grid technology programs about the benefits and challenges associated with targeting low-income energy customers. The pilot program’s measurement period began in June 2011 and ended in September 2012, with approximately 4700 participants, or about 10% of the target demographic population.

Pilot Objectives:

- Educate low-income customers on the use of new technology in an effort to promote lifestyle changes that lead to lower energy use.
- Engage community partners in order to enhance enrollment.
- Measure customer behavior (including demographics).
- Measure energy-use impacts.
- Measure the value of in-home display devices to customers.
- Assess the level of customer support necessary for broader AMI programs.

This program utilized the active participation of the company, its regulator, and community outreach organizations to successfully introduce AMI technology to the city, to educate the participants, to produce energy savings, and to provide a platform for future AMI implementations.

Project Outcomes

Although energy savings varied among the treatment groups, 78 to 90% of participants believed they saved money as a result of the program, and the data indicates that 58 to 67% of customers actually saved energy. Post-pilot surveys found that participants had a very positive experience during the SmartView pilot. Almost all respondents (99%) felt that customer service representatives were "Very Helpful" or "Somewhat Helpful," with the majority of every treatment group responding "Very Helpful".

This evaluation also showed that ENO achieved some of the highest rates of customer satisfaction among DOE-funded Smart Grid Pilots. Approximately 92% of SmartView participants would be interested in participating in the program on a permanent basis. Additionally, regarding participant perception of the usefulness of technologies in managing energy consumption, SmartView compares favorably relative to other programs, especially in the IHD category. Beyond the energy savings, peak demand impacts and customer experience benefits, there are several key benefits and lessons learned:

- ENO leveraged its existing relationships with a diverse group of community partners for solicitation and education, for the benefit of the company and its partners and customers.
- The SmartView pilot raised awareness throughout the New Orleans community of the capabilities and benefits of AMI technologies.
- The SmartView pilot provided evidence that the low-income population can benefit from the use of smart grid technologies.
- Low-income customers are very diverse (in terms of education, housing, etc.). A wide variety of contact methods was employed to reach and support the participants throughout the pilot.
- Customer motivation can vary greatly (e.g., some used the IHD every day; others did not). ENO's extensive customer support contributed to the most effective use of the equipment possible.
- Sufficient training was a key success factor, especially for advanced devices and technology.

