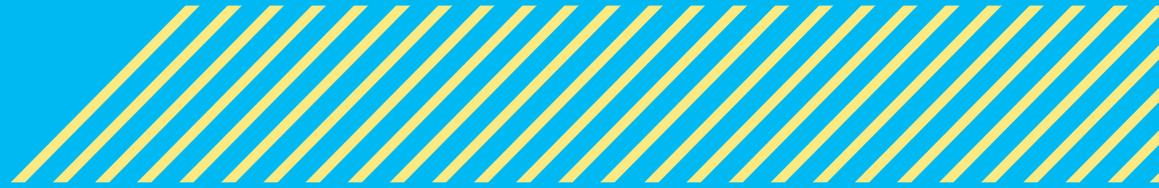


# 2014

**CASE BOOK**  
INTERNATIONAL  
SMART GRID ACTION  
NETWORK (ISGAN)



# SPOTLIGHT ON DEMAND SIDE MANAGEMENT

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**Version 1.0** International approaches and lessons learned in Demand Side Management.

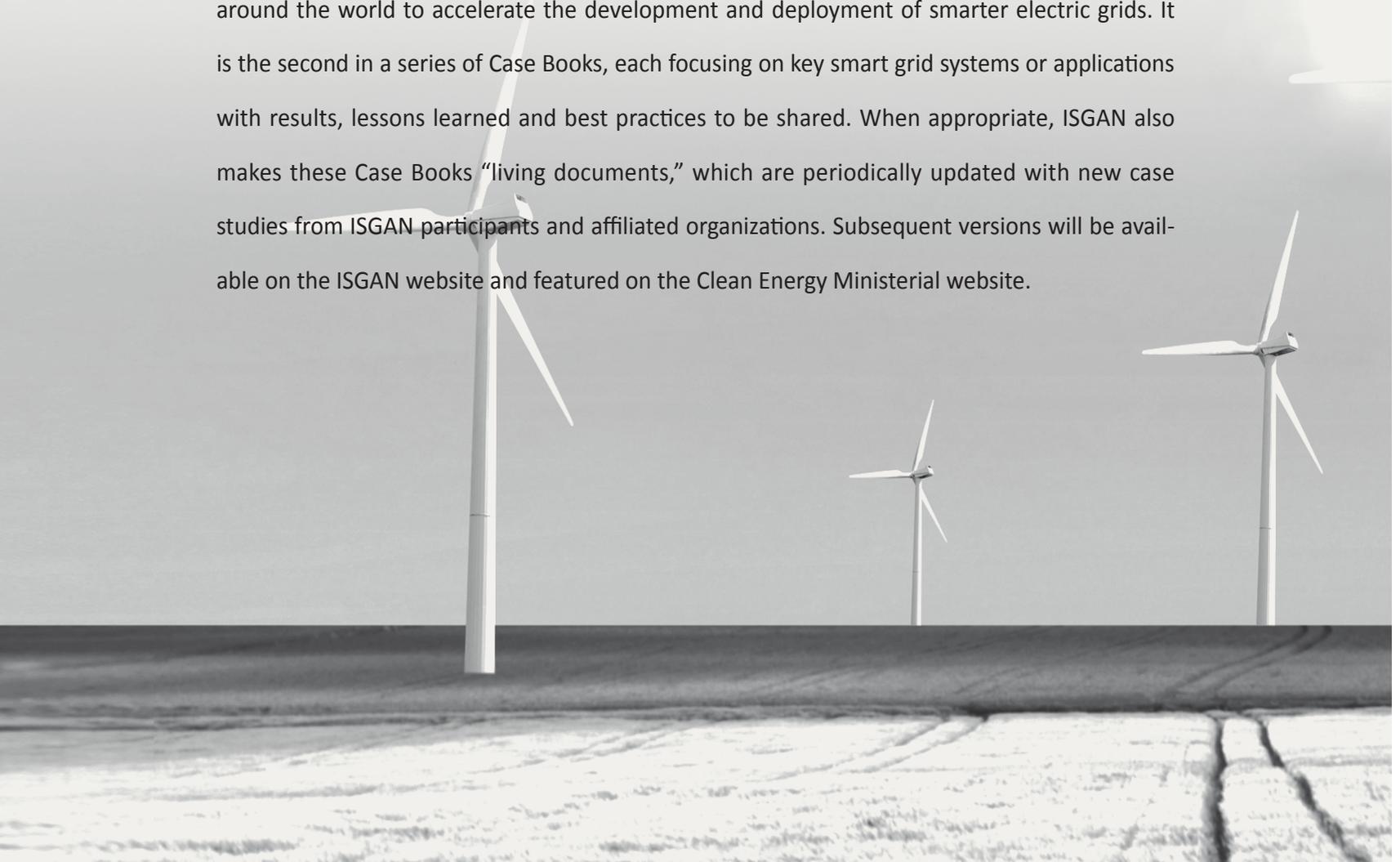


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## Preface

Case studies offer the reader points of comparison but, more importantly, tell stories in a brief and concise way that makes it easier for the reader to extract key points and gain important insights that facts and figures alone cannot convey. They point out opportunities, pitfalls, and other lessons learned in developing and deploying these technologies that can help stakeholders engaged in developing smart grids make more effective decisions and avoid costly missteps. This Case Book attempts to structure the case studies in such a way that their stories can be understood and leveraged by others. Each lists a contact person who can offer further information and details.

This Case Book reflects one way that ISGAN brings together experts and stakeholders from around the world to accelerate the development and deployment of smarter electric grids. It is the second in a series of Case Books, each focusing on key smart grid systems or applications with results, lessons learned and best practices to be shared. When appropriate, ISGAN also makes these Case Books “living documents,” which are periodically updated with new case studies from ISGAN participants and affiliated organizations. Subsequent versions will be available on the ISGAN website and featured on the Clean Energy Ministerial website.



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## >>> Acknowledgements

This case book was made possible by the following contributors to the individual cases presented. The Key Findings are based on a synthesis of the lessons learned and best practices presented in each case in the opinion of the lead author and editor and case contributors. They do not represent the official position of any of the twelve participating ISGAN countries or of ISGAN.

This case book can be downloaded from: <http://www.iea-isgan.org/>

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### **Disclaimer**

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## >>> Abbreviations

AD or ADM	Active Demand or Active Demand Management
ADSL	Asymmetric Digital Subscriber Line
AMI	Advanced Metering Infrastructure
BEMS	Building Energy Management System
CEMS	Community Energy Management System
CPP	Critical Peak Pricing
DMS	Distribution Management System
DR	Demand Response
DM or DSM	Demand Management or Demand Side Management
DP	Dynamic Pricing
DSO	Distribution System Operator
EMS	Energy Management System
ESS	Energy Storage System
HEMS	Home Energy Management System
ISO	Independent System Operator
LV / MV/ HV	Low, Medium and High Voltage (networks)
PCS	Power Conditioning System
PV	Photovoltaic
RES	Renewable Energy Supply (Sources)
SCADA	Supervisory Control and Data Acquisition system
TSO	Transmission System Operator
VPP	Virtual Power Plant

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## >>> Key Findings

*N.B: technical terms presented in the Key Findings are further detailed in the introduction section.*

### **Case book context**

The lessons learned and best practices presented in the twelve case studies included in this case book provide qualitative insights into the complexity of deploying Demand Side Management (DSM) initiatives.

These case studies are based on a diverse range of technologies and under specific market rules. They incorporate various program and policy mechanisms and include information on costs and the associated business cases for investment.

Each case presented has its own unique set of characteristics and drivers, which is indicative of the diverse range of drivers for smart grid and DSM.

The cases are at very different stages throughout the world. While some countries have completed first rounds of pilots and are building on lessons learned, the others are at earliest stage of these initiatives. The size, customer class, choice of technologies deployed, specific costs, benefits and business cases vary from case to case.

Still, there are a number of best practices and common themes emerging from these cases that are likely to be useful for any stakeholder investigating or deploying Demand Side Management. Those best practices and insights are presented here.

The key findings are a synthesis attempt of the broad range of the approaches tackled by the different smart grid demonstrators described by the 12 cases. It highlights the main lessons learned and best practices shared by the participating cases. These lessons learned mainly concerns technical approaches, customer engagement and market establishment.

### **DSM approaches in the case book**

Based on the 12 described cases, there appear to be three main approaches to Demand Side Management:

- The feedback system, which consists in informing the consumer about the system constraints. It focuses solely on providing feedback on the electricity use. This approach represents a first step towards DSM implementation.
- The price-based approach, which requires behaviour change on the customer side triggered by price signals.
- And the system capacity-based approach, which does not rely on the price sensitivity of customers but on other system forecasts. In this approach, the customers indicate their preferences to a third party player (aggregator or system operator) and consent to let this player



take the control of smart appliances. For larger customers, this can include contracts for load shedding.

The customer's consent and adhesion is a prerequisite for the success of the 3 approaches.

The 3 approaches aim to reduce the bulkiness of current solutions in terms of the business, communication and computational requirements. In some countries there is a combination of several approaches.

### **Technical approaches and challenges:**

More standardization is a condition for the development of DSM:

One of the major benefits of the conducted demonstration projects is that they offer a proper testbed for testing possible technical solutions and analyze the advantages and disadvantages of various system architectures in the ICT sector as well as in business models. In this regard, smart grid and in particular DSM technologies should address standardization and interoperability, in order to improve business cases and assure the diffusion of the implemented solutions.

### **More cooperation between DSM actors /players is required to provide the adequate services:**

Not all components of the DSM equipment are standardized products and the path towards standardization takes time. As an example, commercially available energy management systems (EMS) do not support continuous load management, and the DSM systems (DSMS) do not support ancillary services provision since the Virtual Power Plant (VPP) operates continuously in near real-time.

Therefore, continuous communication between the load and the aggregator, and between the aggregator, the VPP and the system operator is required. To demonstrate value as an ancillary service, a significant amount of load available is required to shift by the VPP via aggregators. Future developments of VPP and commercial systems include peak demand reduction as well as ancillary services based on load management and storage.

In order to make DSM sustainable, the automation of load management is an important step. However, it is absolutely necessary that customers keep the possibility to control their devices and to be able to override and intervene in automated decisions in demand response programs.

### **Customer engagement:**

Active and passive techniques of DSM:

DSM covers a large scope of techniques spreading from passive to active ones:

- From basic passive techniques where the consumer has little to no control. The utility applies the solution without informing or consulting the customer and does not allow opt-in or opt-out capability (e.g. load shedding, voltage reduction).
- To more active techniques where the consumers take a hands-on role in determining the programs that they will participate in and the extent to which they are involved. The consumer can opt-in or opt-out at any time (e.g. time-of-use rate plans and utility-controlled thermostats).
- Different combinations of techniques could be found in between

Customers accept change but do not tolerate service degradation:

Different approaches are employed to recruit customers for the demonstrators, depending on expressed customer preferences and values, as well as the current stage in the process of deploying DSM technologies. In many cases, communication with the public tends to focus on the social values and environmental aspects rather than individual financial benefits of participating in the project. These aspects are also an expectation of the participants.

However, by participating in the demonstrator, the consumers often need to be guaranteed, from the beginning, that they will neither lose money nor quality of supply. Indeed, they do not want to pay more for the electricity than they do under their normal contract. Once the participant has some experience with the new service, if the participant perceives that the service has improved, her engagement should sustain.

Best practices to appeal different groups of customers have been identified:

Recruitment techniques also vary according to customer knowledge and comfort levels with smart grid technologies. Some customers are first-movers or early adopters of new technology and smart grid solutions, while the mainstream group of customers is often not especially interested in energy issues. Sometimes these mainstream customers can be motivated to participate in test trials by receiving new smart equipment, which can allow for a critical mass of DSM participants to ensure the success of the initiative. Nevertheless, as such incentives are demonstrator dependent; it is challenging to use them at larger scales.

Managing customer expectations is paramount in a long-term research or demonstration project. Both residential and commercial customers are risk averse and require simple and understandable products and services (plug and play).

Strategies to tackle the risk aversion of customers have been developed:

Throughout customer recruitment, the utility companies have been up front with customers regarding the project duration and the fact that as a trial, the utilities do not have yet all of the answers.

To mitigate any risk associated with that, the customer support services need to be revisited and customer facing employees should be trained to be knowledgeable about the project, and about how to



communicate aspects of the project with stakeholders. The results of field trials in the cases included in this book show that the customers quickly exhibit signs of fatigue and need to be closely assisted in order to realize a sustainable load shift.

Moreover, to tackle customer fears regarding data privacy issues, clear rules on the ownership and protection of their data should be defined and shared early into their engagement with the project.

### **Market establishment**

A new market system requires the development of innovative equipments:

The operation of the electricity system changes from a high level control of a relatively small number of large power plants to an optimization of the system based on large amounts of (sustainable) generators and flexible users. This step should be possible by moving from demonstrators to large scale deployment. This makes scalability assessment not only a challenge but also an opportunity for demonstrators.

Maintaining the system's demand and supply balance will involve large numbers of small and medium-sized energy-demanding equipment.

An extension of the market set-up is expected through the introduction of an ancillary services market:

For most jurisdictions represented in this case book, the implementation of the results and findings of DSM projects across an entire energy system will require further development of market models. To make the energy transition possible, that development will need to include relevant stakeholders and decision makers to support system balance through load management. The set up of DSM ancillary services is an important step in the further development of the existing electricity wholesale markets and balancing markets that creates more favourable conditions for the integration of more renewable generation into the supply mix of energy resources. This will not necessarily require a replacement, but an extension of the current market set-up.

Remaining obstacles are still to be overcome:

Balancing markets around the world are quite diverse in market design. The two following examples illustrate these differences in market design:

- the choice of gate closure time, i.e. the moment from which the TSO doesn't allow actions by the market participants anymore, differs between countries.
- Electricity markets provide opportunities for end-use customers to realize value for reducing their demand for electricity. DR can be an integral part of markets for energy, day-ahead scheduling reserve, capacity, synchronized reserve, etc... and would compete equally with generation in these markets. End-use customers participate in DR by reducing their electricity use either during an emergency event or when locational (single) marginal prices are high in the system. However to enable this, end-use customers need to participate through acting agents and get a more in-depth understanding of the opportunities as well as determine whether they have the capability to participate.

## **Multi-national research**

To tackle the maturity differences between countries on the DSM development, there are a number of coordinated multi-national initiatives driving Demand Side Management research.

One of Europe's notable initiatives is through the EU FP7 funded project ADVANCED (Active Demand Value ANd Consumers Experiences Discovery)<sup>1</sup>, which has been launched in 2012 with the aim to better investigate behavioural barriers and fill the gap in best practices availability for Active Demand (AD) design from the customer standpoint. In particular, a framework enabling residential, commercial and also industrial consumers to participate in AD will be developed, and impacts and benefits for key stakeholders will be quantified according to different scenarios. Real data from pilot projects underway in several countries – ADDRESS pilots in Spain and France, E-DeMa in Germany and Enel Info+ in Italy, will be used together with the data collected in VaasaETT's database from more than 100 European AD projects involving around 450,000 residential consumers. The ADVANCED project involves EU energy utilities, universities, research centers and consulting firms in the energy sector, market research agency and one of the first aggregators in Europe.

Other worldwide initiatives arise through country cooperation. That includes not only cases from Europe, but also cases from other continents like America and Asia. IEA ISGAN is one example of these initiatives, where knowledge sharing is encouraged inside different annexes. Annex2 of ISGAN is a workgroup where state smart grid initiatives are shared through case descriptions. This DSM case book is a concrete illustration of this kind of cooperation.

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<sup>1</sup> [www.advancedfp7.eu](http://www.advancedfp7.eu)

A summary table of the cases included in this case book is found below:

	Pilot Deployment	Demonstration	Living Lab	Control Group	Voluntary Recruitment	Renewable Energy Drivers	System Capacity Drivers	Price responsive	Customer Behaviour Change	System control responsive	Virtual Power Plant	Built on AMI	Includes Co-Generation or CHP	Includes other commercial or industrial processes	Smart appliances or devices without heat storage capacity	Heat storage devices (water, space)	Battery Storage	Integration of electric vehicles
AUSTRIA - Smart grids Model Region Salzburg	●		●		●	●			●	●				●		●		●
CANADA - Virtual Power Plant to Balance Wind	●				●	●				●	●			●		●		
DENMARK - Ecogrid EU: Real-Time Market Demonstration		●		●	●	●		●										
FRANCE - Nice Grid: The smart Solar Energy District with Active Customer Participation		●			●	●	●	●	●	●	●	●		●	●	●	●	
GERMANY - E-DeMa: Locally Networked Energy Systems in E Market of the Future		●			●	●	●	●	●	●	●	●			●			
ITALY - ENEL's Active Customer Engagement		●		●	●	●	●		●	●		●			●		●	
JAPAN - Kitakyushu Smart Community Creation Project		●		●	●	●	●	●	●			●	●	●	●	●	●	●
KOREA - ESS as Active Demand Management for Customers		●			●			●			●				●		●	
SOUTH AFRICA - IDM Case Study		●			●			●			●				●		●	
SWEDEN: Swedish Flexible Demand Activities and Plans		●			●		●	●		●			●			●		
THE NETHERLANDS: PowerMathcingCity	●					●	●	●			●		●			●		●
USA: DM Case		●			●		●	●	●		●		●		●			

# Introduction

Demand Side Management is understood as one of the key pillars of a smart grid and one of the key differentiators between a smart grid and traditional distribution grid operation. Demand Response (DR) is a subset of the broader category of end-use customer energy solutions known as Demand-Side Management (DSM). In addition to DR, DSM includes energy efficiency (EE) programs. Active Demand (AD) is an extension of the DR capability where the response is determined by a number of customers and system and frequently driven by smart grid initiatives.

DSM embodies a number of paradigm shifts. For the system, it encompasses the shift from “supply responding to demand” to “demand and supply balancing each other”. For the customer, the system operators and the system managers, it represents a paradigm shift from consumer-oriented to producer-oriented systems. This transition requires novel solutions for energy consumption management. To sustain this transition, innovative tariff systems and new load management technologies, combined with new customer relationship models, are expected to result in viable business cases and business models to enable sustainable mechanisms for efficient energy balance. Many of those new business cases and business models are being tested in the projects around the world by ISGAN member countries.

## Case structure

This case book focuses on Demand Side Management projects. ISGAN member countries have volunteered these cases for the purposes of increasing knowledge and collaboration between stakeholders on smart grid project planning, implementation and management. Each case is about ten pages and is organized to have the following general characteristics:

- Project description
- Main objectives of the project
- Discussion of key points to the approach and lessons learned

The discussion is supported by the following quick reference tables and discussion boxes:

- Regional electricity system context table
- Project statistics table
- Discussion box on policy approach or political environment for smart grid, DR and AMI

The cases included in this book represent a broad range of economic, political, geographical, structural, cultural and market contexts. They are intended to promote more sophisticated conversation about lessons learned and best practices across stakeholders. To that end, each project has a contact person identified for further information regarding the projects.

Depending on the progress of the projects, some of the cases may only present partial results and lessons learned. Therefore, the cases may be updated as projects progress.

## Common terms and concepts

A fundamental component of the technology solutions described in each case is some sort of bi-directional communications platform which allows interaction between clients or customers and the service provider. The information exchanged, the actors involved and the roles and responsibilities of each actor vary from case to case, but a number of common terms and concepts are used to describe each project and they are briefly described here.

**Demand Side Management (DSM)** – represents a general category of all end-user energy programs that often use a set of incentives, dynamic tariffs or sustainable energy awareness strategies to reduce consumption.

**Demand Response (DR)** – is a strategy for energy consumption shaping which aims at changing end-user consumption patterns according to system capacity and or market requirements by altering the timing, the level of instantaneous demand or total electricity consumption. This form of demand side management has mainly existed for commercial and industrial customers, where they can react to tariffs or submit bids on energy markets in response to current market conditions. Demand response programs have also existed for some residential customers, but in a limited way where signals are sent to programmable thermostats, for example. In these cases the communication has been one-way and responses are to a single instruction as opposed to decision made based on a variety of customer inputs.

**Active Demand (AD)** – is an extension of the demand response capability where the response is determined by a number of customer and system, market or service provider inputs. Inputs can include a set of ‘smart’ dynamic tariffs, price and volume signals, customer comfort preferences and cost preferences and customer over-ride instructions. The result is a demand-side response to an assessment of costs and benefits, protection of consumer rights, consumers empowerment, and protection of consumer security and privacy—all at the same time. In other words, it enables the active participation of domestic and small commercial consumers in power system markets, and the provision of grid services by different power system participants, in real time.

Consumers with this capability are often referred to as ‘active customers’ and the devices or loads that are active demand enabled are called ‘active buildings’ or ‘active components’. These devices or loads are also included in the generic term distributed resources, which also includes small generation (such as solar PV) and storage (such as batteries) connected throughout the distribution network.

**Aggregator** – an aggregator is a third party service provider which allows multiple small kW loads to participate in energy markets or respond to system conditions who would otherwise be prevented from directly participating due to their small size.

**Virtual Power Plant (VPP)** - is a system user concept where the aggregated distributed resources (which include distributed generation, storage and active components) are treated as a single entity in both technical and commercial terms to the rest of the energy system and energy market. It is composed of combining various small size distributed generating units to form a “single virtual generating unit” that can act as a conventional one and capable of being visible or manageable on an individual basis as an independent trading actor at the energy market.



# AUSTRIA

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<b>Project Ownership</b>	Smart grids Model Region Salzburg is a collaboration between: AIT Austrian Institute of Technology GmbH CURE - Center for Usability Research and Engineering Siemens AG Austria Salzburg AG Salzburg AG Salzburg Netz GmbH Salzburg Wohnbau GmbH Vienna University of Technology Funded by: Climate and Energy Fund (KLIEN) Austrian Federal Ministry for Transport, Innovation and Technology (BMVIT)
<b>Electricity system in Austria</b>	Target 2020: · CO2 reduction: 16% · Share of renewable energy participating in the total energy source mix (Renewable share): 34% Total consumption: 70 TWh in 2012 Household consumption: 4,200 kWh/yr in 2012
<b>Market structure</b>	Austria with 8.4 million people has a liberalized market with independent network operators: 1 TSO (APG) and 128 DSO's
<b>Contact</b>	Sara Ghaemi, AIT Austrian Institute of Technology, sara.ghaemi@ait.ac.at

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# AUSTRIA

## Smart Grids Model Region Salzburg



Smart grids Model Region Salzburg (SGMS) is a “living lab” for Austrian smart grid experiments. In order to prove the feasibility of technical, operational and business concepts for a smart grid, it is necessary to set up a field test for demonstrating and validating the functionality of the proposed concepts. The aim of the SGMS is to aggregate different smart grid applications in an integrated system and to implement flagship projects in the real environment considering problems of daily business and addressing specific customer needs. The projects within the framework of SGMS have started since 2004 and each project delivered essential inputs to the overall goal. The holistic approach (see Fig. 1) chosen in Salzburg is noteworthy because the system integration is done at all levels. The main focus and the core of the SGMS can be classified as following:

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## Smart Grids Model Region Salzburg

- Active distribution grids
- Load and demand side management
- Integration of electric vehicles (EV)
- New technologies and intelligent strategies
- Virtual power plants

Among 23 conducted projects, about 6 are demand management oriented. Each pilot project has unique technical solutions and the suggested improvements have been applied in the technical solution of the follow up projects. In order to analyze the impact of various DSM programs, different projects have been carried out which range from analyzing the integration of renewables into distribution networks to assessing the impact of integration of EVs, residential consumers, buildings and commercial & industrial enterprises into the electricity grid. DSM has been pursued from various points and includes residential consumers, buildings and electric vehicles as active components for the future energy systems.

Consumer2Grid (C2G), Persuasive End-User Energy Management (PEEM), Building2Grid (B2G), Vehicle2Grid interfaces & strategies (V2G), load management and “Buildings as interactive smart grid participants” (HiT is the German abbreviation) are the selected projects for this case study which have been marked in (Figure 1).

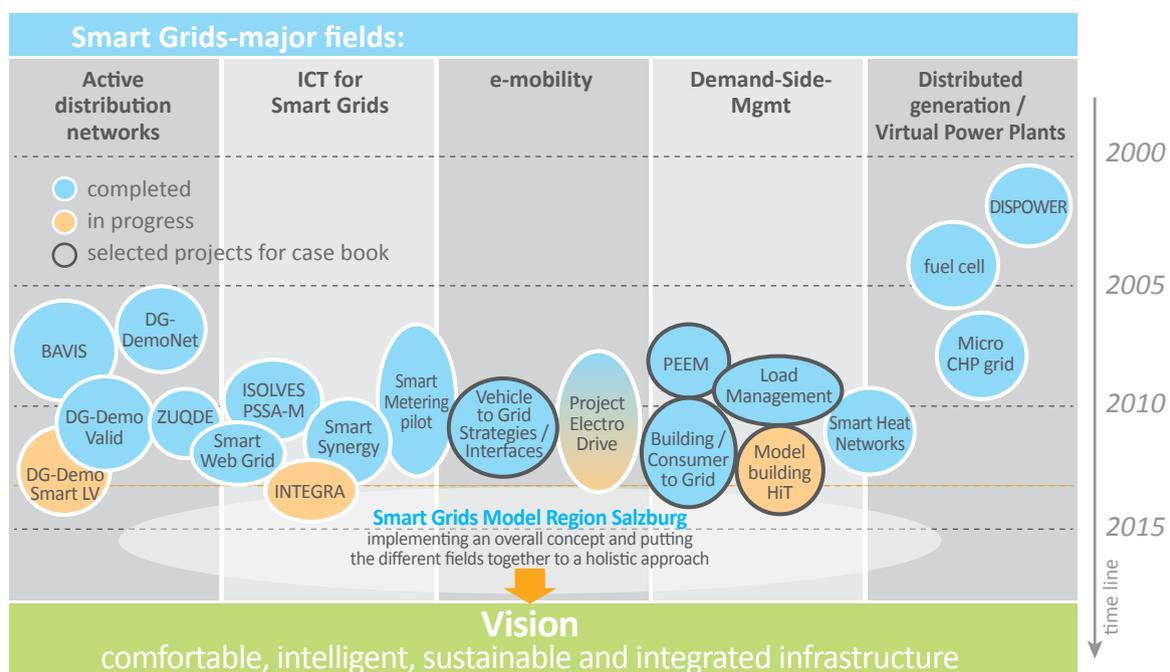


Figure 1: The big picture of Smart Grids Model Region Salzburg

## Objectives & Benefits

In the framework of the SGMS about 23 projects have been carried out which follow various objectives from Integration of renewable energy sources to electric vehicles, buildings and household consumers into the distribution grid.

The uptake integration of different active components into the grid introduces many new challenges for the existing infrastructure such as need for more flexibility on generation as well as on the demand side, new business models for the electricity market and data security & privacy of customers. The SGMS tried to find possible solutions and assess the effectiveness of approaches in different pilot projects. Since the focus of this case book is demand management, the following project objectives are highlighted here:

- Analyzing and demonstrating the impact of various feedback systems on the total energy consumption in the private sector
- Analyzing and demonstrating the potential of demand response in different energy sectors
- Analyzing and demonstrating the effect of various market and business models for the integrating of active components
- Demonstrating the application of smart metering and developing monitoring and validation concepts for the suggested approaches
- Testing the role of ICT in developing various concepts for security & privacy issues

Project summary box	
Focus of the Project	<ul style="list-style-type: none"> <li>• Integration of renewables, electric vehicles, residential consumers, residential buildings and commercial &amp; industrial enterprises into distribution networks</li> </ul>
Elements of the project	<ul style="list-style-type: none"> <li>• Renewable energy in the distribution grids of the demo regions</li> <li>• 18 small hydro power stations with ca. 24 MW, of which 4 MW involved in network control</li> <li>• 263 photovoltaic systems with ca. 3,100 kWp, thereof 41 systems with ca. 280 kWp involved in network control</li> </ul>
	<ul style="list-style-type: none"> <li>• Participants</li> <li>• 1 industrial customer</li> <li>• 30 small and medium enterprises</li> <li>• 474 residential customers, 58 buildings</li> </ul>
Project cost	<ul style="list-style-type: none"> <li>• N.A.</li> </ul>
New services	<ul style="list-style-type: none"> <li>• New feedback methods for visualizing energy consumption and reducing total demand on the customer side</li> <li>• Traffic-light model for optimized utilization of the electricity grid and available renewable resources</li> <li>• Building energy agent (BEA) to communicate between the power grid and the building automation system</li> </ul>

### Project Summary:

- Consumer2Grid (C2G): by visualizing the energy consumption using feedback systems and engaging consumers in the household sector, they reduced their total electricity consumption by about 7% per year but the response faded over time.
- PEEM -- by including external information like the availability of renewable resources or grid congestion to the feedback system, the consumer responded to the received signals continuously without losing interest. Loss of comfort and habit changes were the main obstacles for consumers to participate in this system.
- Building2Grid (B2G): by integrating the feedback system into the development of the building energy agent (BEA) system, the responses were automated and user independent therefore predictable for providing ancillary services like voltage and frequency control. By implementing the BEA in 10 selected buildings 350 kW were reduced during peak times.
- Buildings as interactive smart grid participants (HiT): is an ongoing project which pursues assessing and optimizing the potential of a smart grid-friendly buildings and expanding the interaction between buildings and their residents. The results will be published in 2015.
- Load management in commercial & industrial enterprises: the potential of demand reduction in Austria has been estimated to be around 664 MW. Cooling devices can participate in peak load reduction by 3% to 10%. Supermarket chains are one of the energy consuming sectors which can play a significant role in load management programs.
- V2G strategies & V2G interfaces: by assessing business models and analyzing technical, economic and environmental consequences of integrating EV's in low voltage networks, it was found that solely market-oriented or grid-oriented controlled charging can only partially solve congestion problems. The implementation of an adaptive controlled charging strategy is necessary to alleviate congestion problems due to charging. It may be possible to provide tertiary balancing services of about 30 MW with up to 22,000 electric vehicles in the region.

The benefits of the mentioned projects can be summarized as:

- Possibility for testing various features in the field test
- Investigation of the ability, advantages and drawbacks of centralized and decentralized feedback systems in the private sector
- Testing possible ICT solutions to transfer data locally within a building automation system and globally within the energy management system

- Understanding the required level of security and privacy in smart grid through smart metering and automated metering infrastructure AMI infrastructure in order to ensure the trust of consumers
- Determine the effective triggering signal for demand response management systems and essential data for receiving the optimal response
- Assessing the potential of flexibility in energy consumption of different sectors by implementing various concepts of energy management systems

### Current Status & Results

Most of the described projects (except the ongoing HiT) have been finalized and the results have been published on: "<http://www.smartgridssalzburg.at>"

The selected projects for this casebook have been classified into consumer-, building- and electric vehicle-integrated and introduced in brief in the following:

**Customer Integrated:** The Consumer2Grid (C2G) and PEEM projects had the main focus on the integration of residential consumers into the electric power system. These projects focused on the impact of various feedback systems on the amount and pattern of electricity use. Various feedback systems (Annual billing, monthly billing, web portal, In-home display and wattson<sup>2</sup>) have been implemented in the field test of the C2G project including 288 households and have been operated for one year (Figure 2). The average reduction in electricity consumption across all test groups was about 7% with a minimum value of 2% for monthly billing feedback system and a maximum value of 11% for web portal users. However, these results are statistically not significant. Different feedback systems offer different functionalities which can impact the awareness of people about their energy consumption. For example, consumers had the possibility to compare their daily or monthly consumption in the web portal as well as in the in-home display system with previous days and months and in addition get some saving tips from the monitoring system. Analysis of the logged data shows that the consumers were more interested in daily comparisons and used suggested tips for the energy saving in the beginning of the test period and the learning phase. Consumers were very interested in questioning their own behavior in the beginning of the project but their inclination for using the information of the feedback system decreased over the course of time. Therefore, it is important to offer additional functionalities besides electricity-use feedback to residential customers in order to maintain their interest over the long term.

In this regard the PEEM project has been carried out in which a new feedback method named "FORE-watch"<sup>3</sup> has been developed and implemented (Figure 3). This feedback method not only gives consumers information about their energy consumption, but also uses colours to inform two groups of users about the availability of renewable resources or the grid congestion in the next 12 hours. Prognosticated

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<sup>2</sup> A commercial product that delivers real-time feedback based on current-transformer measurements

<sup>3</sup> FORE stands for "Forecast Of Renewable Energy"

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## Smart Grids Model Region Salzburg



Figure 2: Energy Feedback systems, in-Home display, Webportal and Wattson, in C2G project



Figure 3: Forewatch<sup>4</sup>, developed feedback system for PEEM project

data notify the users when the “good” (green), “average” (yellow) and “bad” (red) time is for using energy. On one hand, this technology provides residential customers with the supportive information to change their consumption behaviour toward more sustainable use of electricity. On the other hand, old habits and accustomed comfort are the main barriers for consumers to alter their energy consumption pattern which could be solved by introducing automated demand response technologies in household sector.

**Building Integrated:** based on the results of the aforementioned studies, it made more sense to integrate the feedback system, which provides consumption data and time of use prices, into home automation system. This allowed the responses to be independent from user behaviour in order to optimize results without the loss of customer comfort. Automated demand management helps consumers keep the requested comfort level and optimizes the use of available renewable energy sources at the same time. In this regard, the B2G project has been conducted to analyze the effect of two approaches on the energy consumption of buildings:

**1) Direct load control:** Easily accessible flexible loads used in this project are electric heating and the hot water systems. In the direct load control approach, these units were switched on/off by the grid operator according to predefined regulated times. The calculated theoretical potential of load shedding for “Salzburg grid” is up to 50% of peak demand when all buildings are equipped with electrical heating systems. However, practically the load shedding potential is about 10% of the peak load in parts of the grid with a high density of installed electric heatings and about 1.5% of the peak load is shiftable within the existing

<sup>4</sup> FORE stands for “Forecast Of Renewable Energy”

legal framework. Since this method does not get any feedback from the indoor/hot water temperature and does not consider the comfort of the consumers in the building, it is considered as a non-flexible solution, which is also limited to predefined hours within a day.

**2) Flexible home automation system:** In B2G, it has been suggested to take this process within the building automation system in order to shift flexible loads automatically considering comfort range and external parameters like the outdoor temperature. Thus a building energy agent has been developed which acts as the communication interface between the building and the electric power system and fulfills the following tasks:

- Estimates the flexibility of these components based on outdoor temperature and optimizes the time of demand shifting according to the energy price
- Forecasts the energy consumption of the thermal components in the building
- Optimizes the utilization of on-site generated energy from e.g. photovoltaic units using flexible loads (thermal loads, electric vehicles,...)

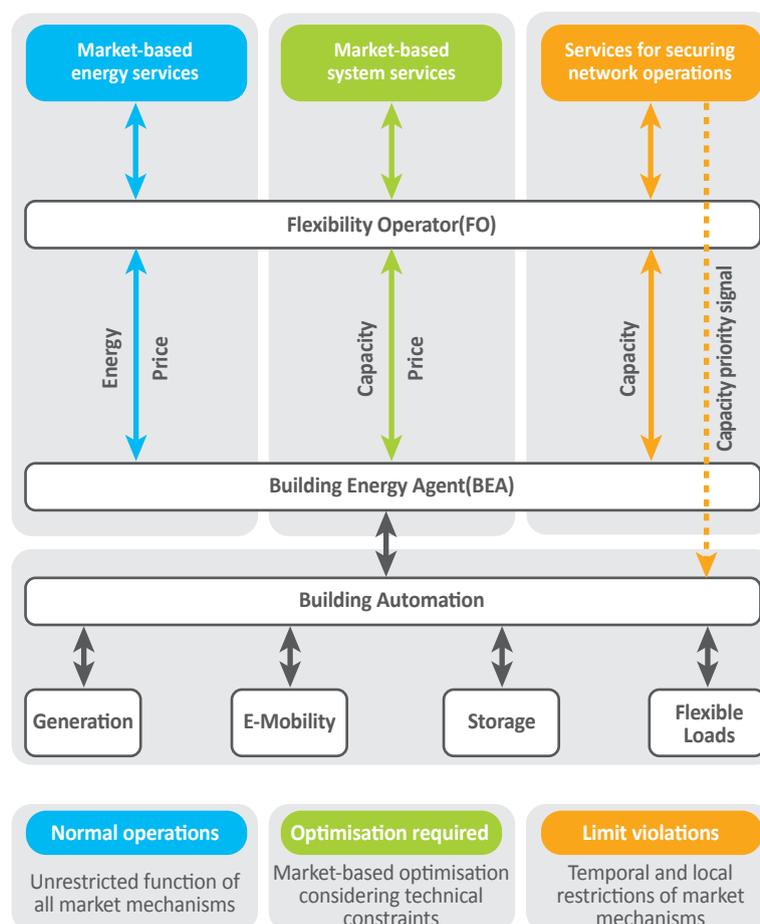


Figure 4: Approach in the Building2Grid project

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The developed building energy agent was implemented in 10 selected buildings. The maximum reduction achieved by using the building energy agent system is about 350 kW across the 10 buildings. The results have been analyzed for one of these buildings consisting of 5 residential apartments. It is technically and practically possible to achieve up to 3.7 kW of flexibility for 6 hours. In one of the field tests (St. Johann in Salzburg), the load could be shifted even for 12 hours without a perceivable impact on room temperature. However, this potential depends on the outdoor temperature. The colder the outdoor temperature is, the higher the flexibility is for load shifting. In order to optimally integrate active buildings into the smart distribution grid, not only the voltage should be kept within the regulated marginal values, available renewable resources should also be optimally exploited. In this regard, the traffic-light model has been suggested in which active buildings react to the market signal as long as critical threshold values on the power grid have not been reached (green lights). When the grid gets closer to its voltage boundaries (yellow light) the market based mechanisms is optimized considering technical constraints (see Figure 4 & Figure 5). When the voltage limits are exceeded then the grid operator can act to stabilize the grid without taking the market into account. In order to implement this proposed model a realistic market concept needs to be developed which will be done in the ongoing project HiT. To this end, necessary general conditions (“market rules”) were coordinated and the required systems and the technical solutions were designed and built. The subsequent trial operation represents a foundation for acquiring further knowledge and building more complex system and market models.

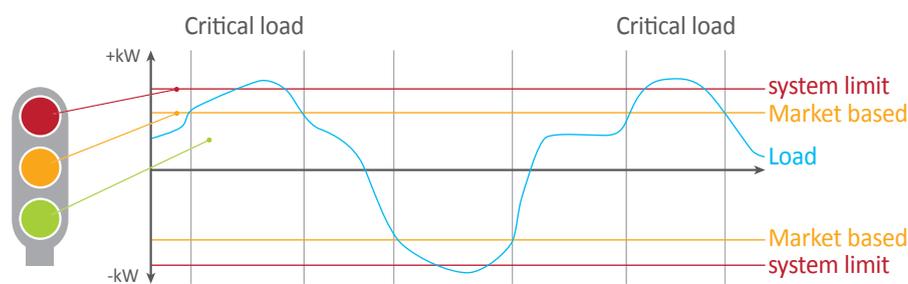


Figure 5: Traffic-light model

Since the B2G project was mainly devoted to residential and small office buildings, another study analysed the potential of load shifting for commercial and industrial buildings in Austria. In this study different sectors such as restaurants and tourism, business, healthcare, production and municipalities have been interviewed and related information has been gathered through questionnaires. According to this study, the potential of demand reduction in Austrian commercial and industrial buildings has been estimated to be around 664 MW. Cooling devices can participate in peak load reduction by 3% to 10%. Supermarket chains are one of the energy consuming sectors which can play a significant role in load management programs.

**Electric Vehicle-Integrated:** In the framework of SGMS, various concepts for the integration of electric vehicles in terms of interaction portals, interfaces and visualization were established and technological and economical effects of “grid-to-vehicle” and “vehicle-to-grid” concepts on the electricity grid were evaluated. These projects examined the effect of three charging strategies: uncontrolled, market-oriented and grid-oriented, in medium and low voltage grids.

The results of the project calculated that the effects of different charging strategies are more considerable in low voltage grids. In general, the uncontrolled charging approach is more favorable for grid operation since the market-oriented controlled charging causes a large number of vehicles to charge at the same time. However, uncontrolled charging leads to congestions at the low voltage level if the penetration rates reach 40% for electric vehicles, which may be the case in 2030 according to estimated scenarios. Grid congestion could be experienced earlier in parts of the network with higher load factors at the end of the feeders. In the case of market-based charging strategy, grid congestions can even occur with 25% penetration of electric vehicles.

In order to operate the current infrastructure of the electricity grid more efficiently, suitable measures such as slow charging and symmetrical distribution of charging points on a three-phase system should be considered. Otherwise, a large amount of available grid reserves will be dissipated. However, grid-oriented controlled charging can release the occupied capacity of the grid by 15% but it does not offer an optimal solution for the system as a whole. A further type of market-oriented controlled charging and discharging would allow electric vehicles to participate in the balancing market. In order to deliver a constant level of 30 MW as tertiary control power within a day, the number of required electric vehicles for two defined scenarios, charge and discharge “at home” (blue line) and “at home & work” (red line), has been presented in Figure 6. This corresponds to between 6% and 8% of total number of cars in the province of Salzburg.

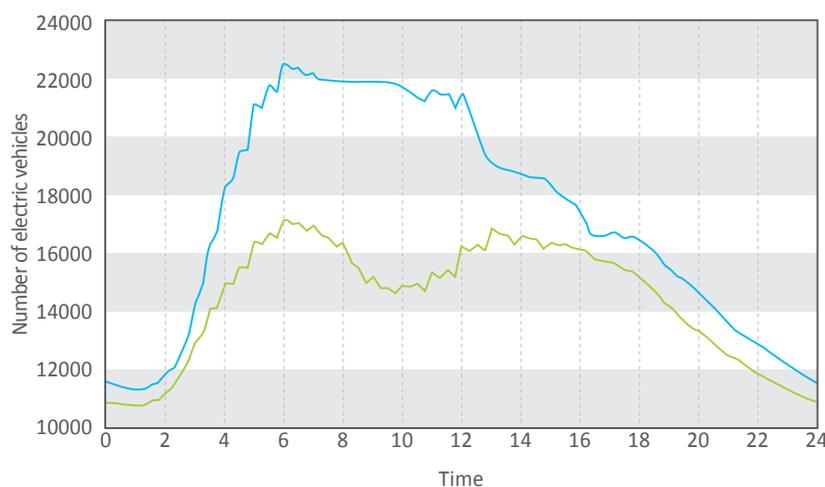


Figure 6: Number of required electric vehicles for providing 30 MW balancing services

Although controlled charging can release occupied grid reserves in the short term, it is not the optimal solution. Adaptive charging (including both market and grid oriented solutions) has been suggested in order to optimize the integration of the electric vehicles into the grid.

The demo projects made clear that the estimated theoretical potential is not viable in practice. Assumptions which are considered for simulations hardly match real conditions and in some cases they are not technically applicable. In addition, the reaction of end users to the various feedback systems could not be simulated and is not forecastable. Since the results of each project have been integrated directly into fol-

low up projects, the experiences have been used to improve the technical concept, implementation and evaluation of the results. The results and lessons learned in the field of load management were valuable inputs for the HiT project which pursues various smart grid applications in the context of buildings in an innovative housing community.

The objectives of the project are optimised planning, construction and operation of the block of flats in Rosa-Hoffmann-Straße, Salzburg Taxham, named “Rosa Zukunft”. The project started in January 2011 and will be finalized in May 2015. Currently, the construction of the buildings and the energy center are completed and the apartments have been occupied in September 2013.

The following results are expected from the project:

- Potential assessment of smart grid-friendly buildings, optimisation and development of building technologies for the residential complex
- Description of interactions between users and the building
- Evaluation of the grid-friendliness of the building
- Creation of a roadmap for the implementation of a smart grid-friendly residential complex

The final report will be available at the end of the year 2015.

### **Lessons Learned & Best Practices**

The goal of these projects is to demonstrate different aspects of the smart energy system of the future in order to figure out which of the available technologies are applicable and which new functionalities should be integrated into the system. The cooperation within the consortium made it possible to integrate different perspectives and competences. The first lesson and the motto of this flagship project is **“the whole is more than the sum of its parts”**. The following lessons have also been learned in the course of the projects:

#### **Consumer-Integrated:**

- Focusing solely on providing feedback on the electricity use is only of marginal interest. In order to achieve sustainable results it is necessary to combine information and automated services.
- Consumers are not only interested in monetary benefits which should be integrated in the feedback system as time of use (TOU) or dynamic tariffs but also on altruistic motives like contribution to save the environment.
- Visualization and feedback systems motivated users only in the beginning of the projects to reduce their consumption. Including additional information like the availability of renewables or grid congestion leads to better user response.
- Additional services, which offer further benefits to residential customers, can be developed using the available data and sources. However, mechanisms to protect privacy must be taken into account from the very beginning to design effective smart grid information and communication technologies.

- Based on the experiences from C2G, the decentralized data transfer method is suggested for the further projects because it is in accordance with the data minimisation principle of the Data Protection Act of Austria and has lower investment cost. The data minimising approach fulfills the regulations set out in the Data Protection Act because only the data used in billing or for providing legally mandated information (depending on the model, a load profile or daily usage statistics) is transferred to the grid operator.
- The integration of the feedback system into the home automation has additional potential to offer secure solutions at local level. It keeps the control over the data “closer” to the user.
- Cost synergies may also be created when the investments are spread out over different parts of the system and are therefore easier to make.
- Automation facilitates sustained changes in households. However, it is absolutely necessary that customers have the possibility to control their devices and to be able to intervene in automated decisions in demand response programs.

### **Building-Integrated:**

#### Residential:

- Thermal simulations show that even old buildings possess suitable characteristics which are qualified to shift heating loads over a period of several hours.
- Buildings can actively be integrated into the electricity system and have the potential of reducing peak loads up to 10% depending on the weather, time of the day and year considering the installed electrical heating systems in each building. In order to use the potential of buildings as a part of smart infrastructure, it is necessary to include outside information in the local optimization system in the building.
- Market models and market rules need to be established to guarantee security and stability of the grid while at the same time the best price on the electricity market is obtained by offering flexibility.
- There are still many open issues regarding technical details like standardised communication protocols, security of data transfer and privacy of collected data from buildings.

#### Commercial & Industrial:

- Load management concepts can be realised by using ICT (Information & Communication Technologies), especially in the business sector. In order to use this available potential it is necessary to adapt the legal framework.
- Technically there is considerable potential for load management in the range of Megawatts which varies according to the place, time of day and the season. This potential can only be exploited when the required bidirectional ICT infrastructure is provided. Particularly qualified

components for demand management are thermal storage components such as heating system, water boiler, etc.

- Theoretically, one third of installed capacity of electricity consuming devices have the potential to act flexibly once a day for 15 to 30 minutes. This degree of potential for the province Salzburg would provide up to 200 MW of power for flexibility services. Nevertheless, practical experiences depict that only 10% of the available potential can practically be used.

### **Electric Vehicle-Integrated:**

- In order to be able to use the existing grid as efficiently as possible, slow charging (with the capacity of 3.5 kW) is to be preferred. Symmetrical load distribution via three-phase charging should be adopted.
- Purely market-oriented controlled charging, which leads to the high number of electric vehicles charging at once, should be avoided. Market-, load-, and grid-oriented controlled charging should therefore be conducted with fewer cars charging at the same time in order to be able to apply aspects of the market and to use existing network infrastructure efficiently. In order to make the system as efficient as possible, a scheme for adaptive charging should be developed. Adaptive charging should be introduced as soon as the necessary functionality in the power grid is present or, as anticipated in the V2G Strategies project, when the level of controlled charging has reached the critical point at which the energy system can no longer adequately handle the integration of more electric vehicles.
- Vehicle-to-grid delivery of electricity is not feasible based on current market conditions, since the current costs exceed the achievable benefits by a factor of two.
- In order to implement three-phase charging at low loads, decision-making between the involved stakeholders (grid operator, electric vehicles charging station manufacturers, electric vehicles service providers) should be coordinated and appropriate technical and organisational regulations should be agreed.

One of the major benefits of the SGMS living lab is that it is a proper testbed for assessing the possible technical solutions and the advantages and disadvantages of various system architectures and associated business models. In this regard, new smart grid applications should be embedded in a reference architecture that forms the basis for developing standards. In order to benefit from the synergies discovered between smart grid applications, it is necessary to bundle the specifications of the individual technologies rather than view them separately. This will enable the creation of an efficient, generic and easy-to-extend basic infrastructure.

## Next Steps

In order to be able to implement the results and findings of these projects to the entire energy system, an overall market model including relevant decision makers which support the energy transition, should be determined. On the way to achieve applicable smart infrastructure there are four main consecutive steps to be pursued (Figure 7). Within SGMS, after developing the individual applications, their system integration was subsequently combined, merged and developed synergistically. The next step entails an examination of the potential market based on developed technologies and the further development of applications into products suited to everyday life.

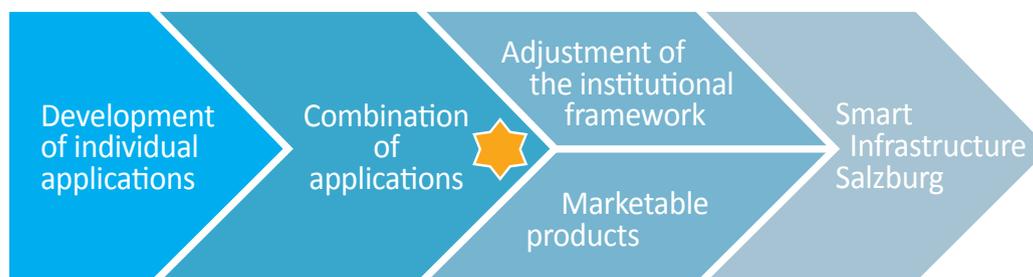


Figure 7: The steps in the way to “Smart Infrastructure” Salzburg

Focusing on demand response issues, the following subjects need to be highlighted:

- The interconnection between various development lines within the energy policy is necessary. For example political strategies for integration of PV units and incentives for the optimization of self consumption are two key leverages for supporting the development of load management.
- Currently, end users have limited choices such as selecting their energy suppliers but still have an inactive role in the energy system. Active participation of end users could support the grid operator as an alternative for grid expansion.
- One considerable obstacle to the integration of demand response is the structure of the current market model. For example, the balancing market is designed for centralized ancillary services. It is necessary to define new market players such as an aggregator or flexibility operator in order to allow the active element of the energy system participating in the energy market and support the efficient operation of the available infrastructure as much as possible.
- By defining relevant communication and security standards for the required interfaces in the smart infrastructure, not only does market entry become much easier, also investment security increases and development expenses decrease.

Based on mentioned challenges following adaptations should be considered for the integration of demand side management in the future smart grid:

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## Smart Grids Model Region Salzburg

Politics	<ul style="list-style-type: none"> <li>Defining the roles and responsibilities for “behind-the-meter” activities</li> <li>Development of smart incentive schemes to promote active participation of flexible loads</li> </ul>
Legislation	<ul style="list-style-type: none"> <li>Integration of building automation systems into the Energy Performance of Building Directive (EPBD)</li> <li>Definition of flexibility operator</li> <li>Future obligation to connect charging stations for electric vehicles to a flexibility operator in order to enable controlled and adaptive charging</li> <li>Clarification of data privacy provisions when using smart metering</li> <li>Adjustments to measurement and calibration laws relating to smart meters, e.g. in order to extend service life and thus exchange periods</li> </ul>
Regulator	<ul style="list-style-type: none"> <li>Definition of standard requirements for EV charging stations</li> <li>Type and structure of flexible tariffs</li> <li>Specification and design of flexible tariffs</li> <li>Coordination of requirements in the electricity and telecommunication market with regard to synergies during a comprehensive expansion</li> </ul>
Market model	<ul style="list-style-type: none"> <li>Creation of market-based incentives for residential and industrial customers (e.g. flexible tariff structures, power and capacity orientated grid tariffs)</li> <li>Design principles for equal treatment of consumers and prosumers during integration into the grid controller</li> </ul>
Acceptance	<p>To overcome privacy concerns:</p> <ul style="list-style-type: none"> <li>Transmission of aggregated data</li> <li>Reduction of temporal resolution</li> <li>Incentive systems for the transmission of energy data</li> <li>Allowing intervention of residential consumers in the forecasts on load shifting</li> </ul>

Table 1: Non-technical challenges regarding the integration of Demand Side Management

### Key Regulations, Legislation & Guidelines

Up to now, there is no specific regulation for the integration of demand response into the energy system in Austria. Flexible demand can participate in various markets (day ahead, intraday, balancing/capacity market,..) based on current rules for other generation units. By defining new rules for the integration of demand response, the available potential of flexible demand in a smart grid will be effectively exploited.



# CANADA

<b>Project Ownership</b>	PowerShift Atlantic is a collaboration between: New Brunswick Power Corporation (NBPC) · Saint John Energy (SJE) · Maritime Electric Company Limited (MECL) · Nova Scotia Power Incorporated (NSPI) · New Brunswick System Operator (NBSO) · University of New Brunswick (UNB) · Government of New Brunswick · Government of Prince Edward Island referred to collectively as the consortium.
<b>Number of customers</b>	Almost 1 million, across the 4 service areas GWh mix: 40% residential, 26% commercial and 31% industrial loads (balance is street lighting and other non-metered loads)
<b>Electricity delivered</b>	26,055 GWh in 2011 across the 4 service areas
<b>Information on hosting utilities and markets</b>	NBPC is owned by the province of New Brunswick. NSPI is privately owned by Emera, MECL is privately owned by Fortis and SJE is privately owned by its rate payers. All utilities are vertically-integrated, except SJE which is a local distribution company for the city of Saint John. The NBSO operates the power system in New Brunswick, in Prince Edward Island and in Northern Maine (United States). NSPI operates the network in Nova Scotia. NBSO is the reliability coordinator for New Brunswick, Prince Edward Island, Northern Maine and Nova Scotia. There is no wholesale energy market in the Maritimes.
<b>Generation mix (based on energy generation)</b>	Nuclear: NBSO (35%) NSPI (0%) Fossil fuels: NBSO (30%) NSPI (77%) Renewables: NBSO (30%) NSPI (17%) Other (imports): NBSO (5%) NSPI (6%)
<b>Contact</b>	Michel Losier, Program Director, PowerShift Atlantic, <a href="mailto:mlosier@nbpower.com">mlosier@nbpower.com</a>

# CANADA

## A Virtual Power Plant To Balance Wind Energy



PowerShift Atlantic is demonstrating one of the world's first fully grid-integrated virtual power plants designed to allow for more effective integration of wind power. The project is a collaborative demonstration led by New Brunswick Power Corporation (NBPC) in partnership with Maritime consortium members from academia, utilities and government. It is demonstrating the capability of virtual power plants to balance high penetrations of wind power on a cross-jurisdictional system. Unlike typical demand response services, the virtual power plant uses load and wind forecasting and aggregation capabilities to perform near real-time load shifting of commercial and residential loads and provide new ancillary services to the grid. This project was launched in 2010 and is scheduled for completion in the spring of 2015. It is jointly funded by Natural Resources Canada through the Clean Energy Fund and by members of the consortium.

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## A Virtual Power Plant To Balance Wind Energy

As of 2013, the Maritime region is host to one of the highest penetrations of wind energy in North America (9%). The variability of the wind generation profile coupled with the existing variable demand profiles are currently balanced with ancillary services which are provided by on-line generators (i.e. oil, gas, coal and hydro) and off-line generators which can be brought on-line as quickly as required. Load management via two virtual power plants in the PowerShift Atlantic project could reduce the requirement for ancillary services from existing assets. In this way it has the potential to reduce the costs and emissions associated with the integration of current wind energy in the Maritimes, as well as to increase the potential for future renewable development.

### Objectives & Benefits

The primary objective of this demonstration is to determine if load shifting can provide an economic and effective alternative to building new supply side ancillary services for the integration of wind with minimal or no disruption to participating utility customers. As such there are technical, business, environmental and customer benefit research objectives that this project seeks to achieve:

*Technical benefit:* Test the ability of virtual power plants managing customer loads to perform in sync with system balancing and forecasted wind profiles, and to offer a reliable alternative for balancing renewable generation.

*Business benefit:* Test the cost effectiveness of operating virtual power plants as ancillary service providers (10 minute spinning reserve and Real Time Generation Dispatch (RTGD)) and determine appropriate business models for integrating the components of a virtual power plant within a vertically-integrated utility.

*Customer benefit:* Explore new customer roles and customer relationships that support customer participation in load management, and capture value for the customer. Determine best practices for establishing relationships of trust for direct load shifting.

*Environmental benefit:* Determine the GHG reduction potential by operating a virtual power plant as opposed to operating flexible fossil fuel generation to balance variable supply and load profiles.



### Current Status & Results

To demonstrate value as an ancillary service there must be a significant amount of load available for shifting by the VPP via aggregators. Customer participation is therefore essential to the success of this project. As of Jan 31, 2014, PowerShift Atlantic has over 1,250 customers participating and 14.3 MW of connected load. As presented in Figure 1, year round management of customer loads is different from any other energy efficiency or demand side management program. A new level of trust must be established in the

relationship between the customer and the utility in order to allow the utility to shift loads. Learning how to engage customers and keep them engaged will be a key finding for utilities from the project.

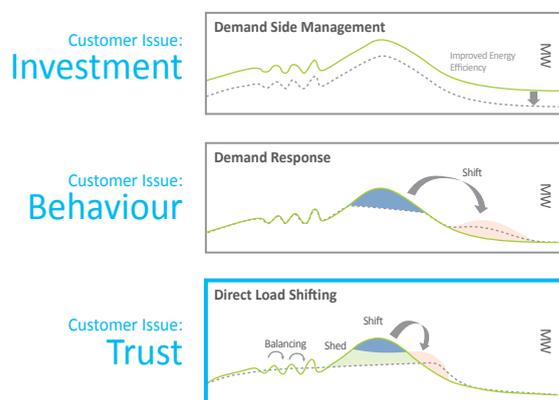


Figure 1: Relationships between the customer issues and demand-side solutions

The other key aspect of the project planning is around the technical components. The key challenge will be to ensure reliable real-time grid operation with a virtual power plant (VPP). This project includes two VPP instances (one at New Brunswick Power and one at Nova Scotia Power). New energy management systems and aggregation architecture will be developed to balance demand against the variability of wind generation, and provide the equivalent of a 10 minute spinning reserve and RTGD. Figure 2 shows the high-level system architecture for the virtual power plants. The Maritime consortium, along with Stantec, Accreon, Leidos (formerly called SAIC), and T4G companies are working on customer engagement, technology development and deployment, and VPP development. The following table gives a summary of the project (current status as of January 2014):

New Brunswick Power VPP			Nova Scotia Power VPP		
Utility	Aggregators	Customers*	Utility	Aggregators	Customers*
Maritime Electric	University of New Brunswick	134 residential 3 commercial	Nova Scotia Power	Steffes Integral Analytics, Enbala	598 residential 23 commercial
New Brunswick Power	Enbala Steffes, Integral Analytics	55 commercial 228 residential	-	-	-
Saint John Energy	University of New Brunswick	204 residential	-	-	-

Project cost : \$32M CAD

**Goal : 20 MW of up/down regulation**

Table 1: Atlantic Research and Demonstration Project Overview

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## A Virtual Power Plant To Balance Wind Energy

To date, four aggregation pilot projects are underway with 1,164 residential customers and 81 commercial sites connected, amounting to 14.27 MW of connected load with a remaining 4MW planned for installation. Each pilot project has a unique technical solution, targeted end uses and aggregator service provider. Two instances of the VPP are up and running (one for each system operator). Each aggregator has established connectivity to the VPP and is performing controlled testing of end-to-end functionality. By March 2014, the project aims to have approximately 18 MW of controllable load through a combination of commercial and residential customers. Overall customer satisfaction with the program remains high (80%) with an expressed desire for more frequent detailed program information.

As a research project focused on finding more effective ways to integrate wind energy into the electricity system, this four year demonstration project was considered an investment that would eventually lead to cost savings. The cost of this project is \$32M, where half of the funding comes from the Canadian government's Clean Energy Fund and the other half from the consortium. Now that the project is progressing through the deployment phase and the VPP functionality implemented, the project team is developing the business case by identifying and quantifying potential benefits including, but not limited to:

- Avoided cost of fuel to provide ancillary services.
- Avoided cost of maintenance associated by fossil fuel start-up or cycling.
- Avoided cost of generation, transmission and distribution network capacity.
- Avoided GHG.

While the current research is focused on integrating wind generation more effectively, the learnings will be relevant for optimizing other sources of renewable energy generation, and potentially offsetting the need for building traditional generation in the future. Future development of the VPP may also include peak demand reduction or other types of ancillary services based on load management and storage. Customer buy-in and on-going involvement will be measured as a key indicator of the potential to move beyond research and demonstration to a commercial offering.

### STATUS

- ✓ The build phase for the core functional components and primary interfaces that make up the VPP architecture is complete.
- ✓ Development and testing for all components to allow end-to-end testing is complete. Infrastructure is in place to implement aggregators, install required equipment, and perform load management and to measure results.
- ✓ All aggregators are operating end-to-end via the VPP .
- ✓ Customer installations are to be completed by March 2014.
- ✓ Periodic surveys are conducted with participating customers 2 to 3 times annually.
- ✓ One year demonstration phase officially started Oct 1, 2013 to collect data and evaluate VPP performance

## Lessons Learned & Best Practices

**Collaboration to achieve a greater scope and scale:** This project challenges the more traditional approach to managing a project of this size and complexity. For it to succeed, the project required more resources and capabilities than any one project partner could have achieved on their own. Thus, PowerShift Atlantic dictated a collaborative governance model where the congenial competitive nature of each utility could fuel progress. All consortium members are fully engaged and the project has been fully endorsed at all levels within the utility companies.

With a project of this scale and nature, the consortium is able to learn from operating a VPP with:

- A variety of residential and commercial end-uses (water heaters, water boilers, HVAC, refrigeration, electrical thermal storage).
- Two system operators, utilities with different ownership and governance, markets with different rate structures (time of day versus flat rate).
- Commercial customers with energy management systems, commercial customers with a specific device directly controlled by the aggregator.

**Project Management:** This project has rekindled a spirit of working together to find solutions. The project team continually challenges the consortium members to right-size their pilot projects with internal processes such as procurement and contract negotiation. As well, regular review and reporting of risk and issue management across all levels of governance has proven effective in managing the expectations of all stakeholders. The project is also influencing change across the broader industry, from a vendor, supplier and regulatory perspective. This has been significant in that:

- It has helped identify criteria for vendors and equipment, and to identify areas that are particularly challenging for the vendor.
- It has enabled the industry to better understand the utility's vision and some of the challenges they face with renewable services.
- Vendors are changing their products to accommodate PowerShift Atlantic requirements. This collaboration with the vendor is building strong relationships for future opportunities; pushing demand response providers to go beyond existing capabilities.
- The regulators are engaged in discussions about the project and future implications to regulation based on the results.

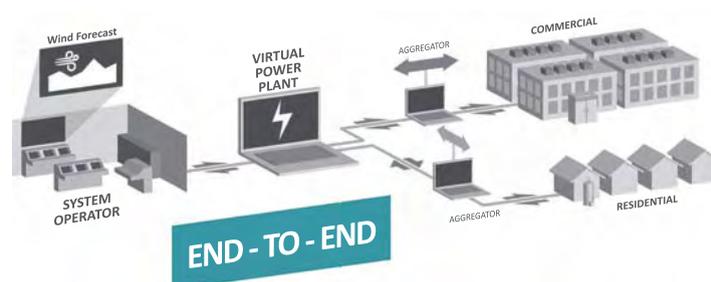


Figure 2: High-level system architecture for PowerShift Atlantic virtual power plants

# CANADA

## A Virtual Power Plant To Balance Wind Energy

**Technical Lessons:** The PowerShift Atlantic project requires the seamless integration of modern technology, connecting customer to the aggregator and system operator. At this stage of installation and operation the project team has gained insight into the current industry capabilities with respect to load shifting, load forecasting and aggregation solutions. After receiving offers for the VPP technology platform, the consortium found that commercially available energy management systems (EMS) do not support continuous load management, and that the demand response management systems (DRMS) do not support ancillary service provision satisfactorily. Consequently, the consortium decided to develop an innovative VPP solution (developed by the system integrator Stantec, Accreon and Leidos), to provide load shape management and to provide the equivalent of a 10 minute spinning reserve on demand. Also, to further reduce project costs, the consortium decided to host the VPP solution on a Bell-Alliant virtual platform versus purchasing hardware.

The VPP operates continuously in near real-time, therefore continuous communication between the load and the aggregator, and between the aggregator, VPP and the system operator, is required. On the residential aggregation side, it was demonstrated that aggregators utilizing customer broadband communications (Internet connection) were able to operate closer to real-time than those using radio frequency (RF) mesh-node networks. Most solutions involved are using broadband communications except one which uses the advanced metering infrastructure (AMI) communication network.

AMI utilizing RF mesh-nodes poses challenges for real-time management of loads. Inherent latency between issuing a load control action and confirmation of the execution of that action make it difficult to be utilized as a near real-time communications technology for load control. Data transfer through AMI is sometimes lost or delayed, challenging the load aggregation and the ability to provide reliable forecasts. Also, extracting information on the electric water heater status from the global household consumption measured by the smart meter, instead of direct measurement of the appliance, poses additional technical challenges in determining an appliance's status and forecasting its demand and load shifting capabilities.

**Customer Engagement Lessons:** To meet the project objectives, a good customer engagement strategy ensures that there is adequate controllable load to conduct the research. The project team realized that for customers to participate it must be easy, at no cost and with limited risk to their operations. The utilities invested in their customer engagement program up-front with surveys and related work to ensure that the solutions that would be developed would resonate with the customer. The up-front activities included:

- Studying best practices, conducting residential and commercial customer surveys and focus groups to better understand customer.
- Customer Engagement programs designed and being implemented.
- Ongoing participant surveys and communications.

The research indicates that Maritimers care about the environment; they care about protecting and preserving it, finding solutions to do so, and being proactive about it. It also shows that they value and appreciate when organizations (i.e. government, the region's utilities, and corporations) work together in a collaborative way to explore environmental options.



In collaboration, the utilities developed a common engagement program for customers in the project. This major achievement is the result of a strategy which incorporates the common aspects shared across utilities but also provides the flexibility to customize and meet the unique requirements of each utility and their customers. The Customer Engagement Program was designed with key customer principles agreed upon by all the utilities, as follows:

- Participation in the project is intended to be largely unnoticed by the customer, such that the customer will not notice any change in operations during load-shifting events.
- There is no cost for the customer to participate.
- There is no savings guarantee.
- There are no financial incentives provided as motivation for residential and commercial customers.

PowerShift Atlantic utility companies have found that the project has enabled them to build new types of relationships with their customers that foster new opportunities and methods for communication and involvement. Despite not having financial incentives or other guaranteed monetary benefits, customers have been keen to participate in order to contribute to finding ways to more efficiently integrate wind, as well as to capture other environmental benefits, such as reducing GHGs. Under the commercial program, customers are able to participate in a co-branding program with their utility promoting their involvement in PowerShift Atlantic. The co-branding program aligns with a commercial customer's corporate social responsibility objectives.

Managing customer expectations is paramount in a long-term research project, particularly with commercial customers since they tend to have lower tolerance for risk from interruptions compared to residential customers. Throughout customer recruitment, the utility companies have been up front with customers regarding the project duration and the fact that as a research project, the utilities do not have all of the answers. To mitigate any risk associated with that, the customer support services have been revisited and customer facing employees have been trained to be knowledgeable about the project, and about how to communicate aspects of the project with stakeholders.

**Engaging Large Customers Through Energy Management Providers:** Engaging large commercial customers through an aggregation service provided by energy management providers has proven to be a challenge. Energy management service providers controlling multiple sites through one energy management system are not abundant in the Maritimes and are not as advanced in this area as originally anticipated. While costs of installation could be avoided by leveraging the existing telemetry they have with their customers, those businesses would still need to upgrade their energy management system and capabilities to meet the aggregation service provider requirements dictated by the VPP. Their energy management platform would also have to evolve technically to provide short term load shifting forecasts for the next 36 hours to the VPP. In all cases the proposals for such upgrades received were deemed unachievable within the project budget and schedule constraints. As an alternative, NB Power and NS Power decided to move forward with the Canadian company, Enbala Power Networks. Enbala is providing the technology to integrate the building control equipment to be aggregated to participate in the program. NB Power and NS Power have also engaged Steffes Corporation to provide both electrical and thermal storage equipment and Integral Analytics for residential aggregation services.

### **Key Regulations, Legislation & Guidelines**

#### **Policy in the Maritime Region of Canada**

The provinces of New Brunswick, Nova Scotia and Prince Edward Island (PEI) each have their own policies, programs and plans which influence smart grid development in the region. New Brunswick set smart grid objectives in its New Brunswick Energy Blueprint and in 2012 announced the development of a 10 year smart grid Roadmap for the province including 40% renewable energy by 2020. Nova Scotia has a Renewable Energy Plan which led to the creation of a law dictating that 25% of Nova Scotia's electricity will be supplied by renewable energy sources by 2015. The Plan sets a further goal for 40% renewable electricity by 2020. Feed-in Tariffs and enhanced net metering programs support the integration of tidal and solar projects respectively. The Prince Edward Island Energy Strategy in 2008 doubled the government's Renewable Portfolio Standard, requiring 30% of electricity to come from renewable resources by 2013 and committed to investigate policy and financial mechanisms to integrate more distributed renewable generation

This case study was developed by CanmetENERGY, Natural Resources Canada and the PowerShift Atlantic Consortium. Further information can be found from [www.powershiftatlantic.com](http://www.powershiftatlantic.com).

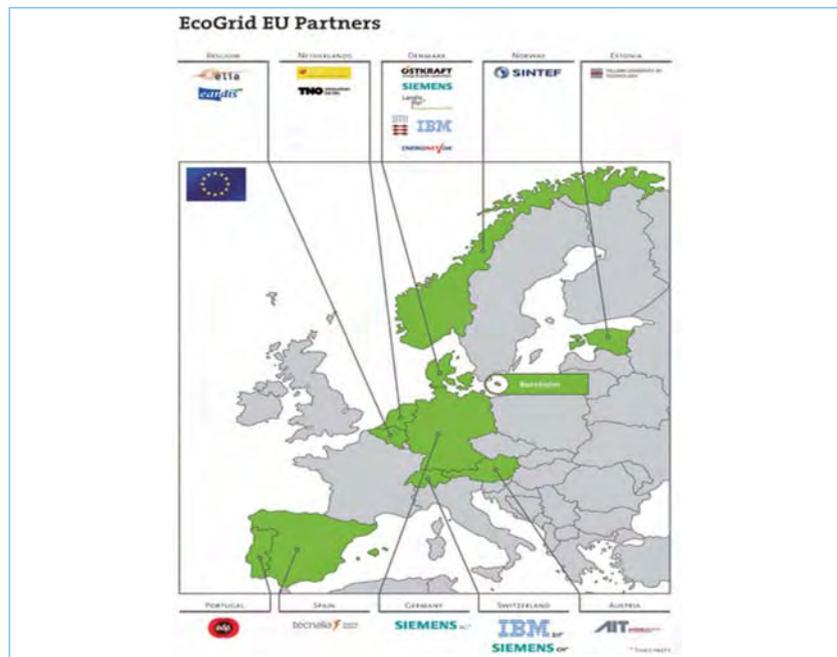


# DENMARK

<b>Market structure</b>	<p>The EcoGrid EU project will be demonstrated in full-scale demonstration in the power distribution system, operated by the local DSO Oestkraft. Oestkraft is owned by the municipality of Bornholm. A large-scale demonstration in a real power system requires active participation and full support from the DSO. Hence, Oestkraft is the key stakeholder and partner in the EcoGrid EU project. The Bornholm distribution system is part of the Nordic interconnected electricity system and fully integrated in the Danish power area DK 2.</p>
<b>Number of retail customers</b>	Approx. 28,000
<b>Electricity consumed (2012)</b>	287 GWh
<b>Peak Demand for Power (2012)</b>	55 MW
<b>Distribution Network</b>	<p>60 kV grid (131 km – Overhead lines: 73 km – Cables: 58 km) 10 kV grid (914 km – Overhead lines: 184 km – Cables: 730 km) 0.4 grid kV 1,887 km Fiber network between 60/10 kV substations.</p>
<b>Low carbon resources</b>	<p>Wind power plants: 36 MW CHP/Biomass: 16 MW PV: 5 MW Biogas plants: 2 MW</p>
<b>Number of district heating system</b>	5
<b>Contact</b>	<p>Ove.S.Grande@sintef.no www.eu-ecogrid.net For more information about the Bornholm energy system see <a href="http://www.powerlab.dk/Facilities/BornholmPowerSystem">http://www.powerlab.dk/Facilities/BornholmPowerSystem</a></p>

# DENMARK

## EcoGrid EU: Real-Time Market Demonstration



The EcoGrid EU project is a large-scale demonstration of consumer participation in the balancing of renewable electricity generation by active demand response to real-time price signals created from the present prices in the conventional balancing market. Advance meters and ICT solutions will enable small-scale customers to offer the Transmission System Operators (TSOs) additional balancing resources.

The fundamental principle of the EcoGrid EU real-time market concept is to exploit flexibility in electricity consumption. At residential level, flexibility is in this case typically associated with heat pumps and electric heating either for hot water or to keep the house warm. The consumption is flexible since the heat can be stored and there is normally a range of acceptable temperatures. There may be other significant sources of flexibility consumption in homes, eg if an electric vehicle is used.

# DENMARK

## EcoGrid EU: Real-Time Market Demonstration

The test-site is located on the Danish island Bornholm. Here wind power supply already exceeds the entire demand for electricity in many hours the course of a year. This surplus situation is likely to appear more frequently in the future – significantly increasing the need for power balancing resources. Introduction of a real-time market can provide valuable balancing resources and ancillary services and contribute to reduce the costs of these resources.

2,000 electricity customers on Bornholm will by means of flexible consumption participate in the demonstration. A majority of the test participants will be equipped with demand response devices with smart controllers and smart meters, allowing

them to respond to five minutes real-time prices based on their pre-programmed demand response preferences.

The customers’ feedback regarding the ICT technology introduced in the project and their ability and motivation to change consumption based on the real-time prices will be most valuable as source for concept adjustment in the final part of the project.

### Objectives and Benefits

The objective of the EcoGrid EU project is to illustrate that modern information and communication technology (ICT) and innovative market solutions can enable an operation of a power system with more than 50% renewable energy sources (RES) such as wind, biomass and photovoltaic (PV).

EcoGrid EU propose to extend the current wholesale electricity market to allow structure with a real-time market that will offer the Transmission System Operator additional balancing resources and ancillary services by facilitating

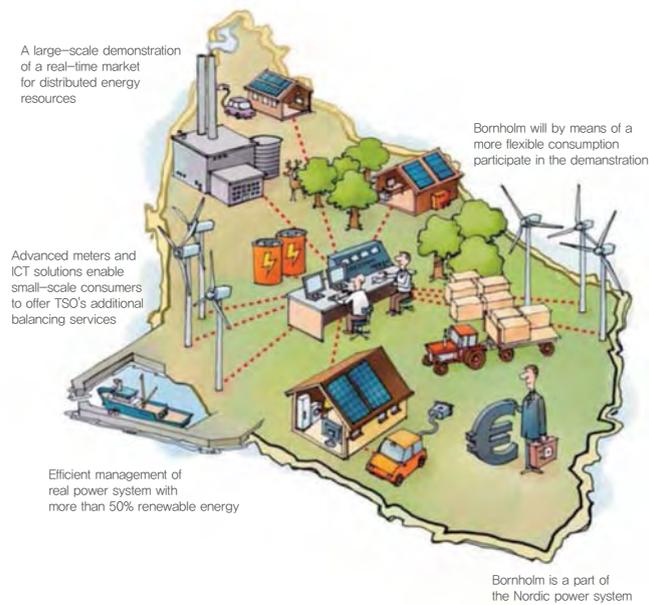


Figure 1: Systems architecture of EcoGrid EU in Bornholm

Project fact box	
Project funding and organisation	EU's 7th Framework Programme supports the EcoGrid EU project. The total budget of EcoGrid EU is € 21 million of which EU finances more than half. The 15 European EcoGrid EU partners represent global industry experience, applied research and representative geographic distribution, ie Northern Europe, Central Europe, the Iberian region and Eastern Europe. Nordic partners cover a significant share of the consortium since the demonstration is located on the Danish island Bornholm that is connected to the Nordic power system. The EcoGrid EU project started in 2011 and is scheduled to end in 2015.

Table 1: EcoGrid EU fact box

the participation of a large number of small-scale electricity customers and other distributed resources (DER). A modernisation of the existing power market design will increase the market value of eg wind power and other DER which in the long run is expected to provide the economic incentives for a higher penetration of renewables.

### The EcoGrid EU 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.

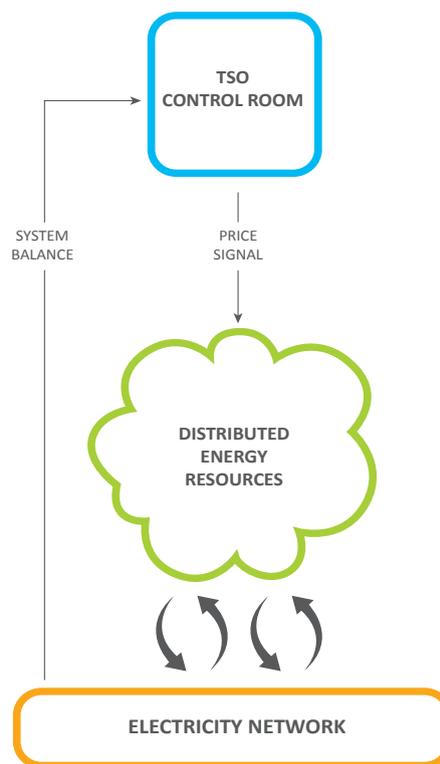


Figure 2: The basic idea of EcoGrid EU market concept

*The EcoGrid EU real-time market concept allows regulation of distributed energy resources (DER) through price signal without direct measurement of the individual DER response.*

### Extension of the current market set-up

As the wind power and other RES generation increase, so will the need for more dynamics in the power system. The introduction of real-time market is 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.

The five-minute real-time market will extend the market operation closer to real-

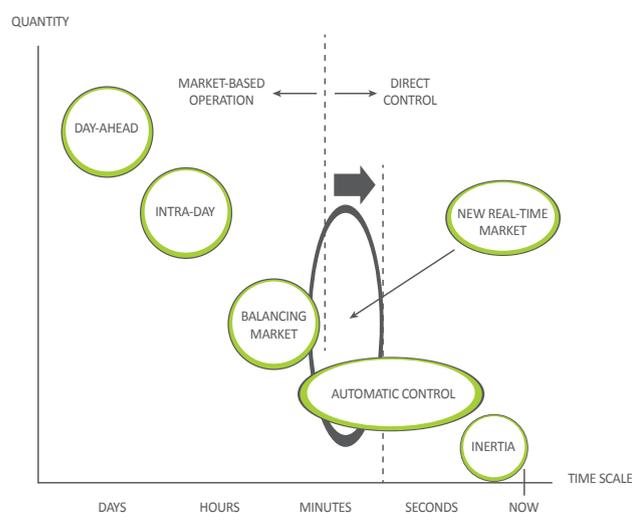


Figure 3: The new EcoGrid EU real-time market in the context of existing power balancing markets and control systems

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## EcoGrid EU: Real-Time Market Demonstration

time and potentially reduce the need for more expensive automatic control resources such as load-frequency control (LFC).

**Remove barriers for small-scale market participants:** Today and in the future most DERs under the current framework will face barriers to supply balancing resources. This means, by preventing some units for participating in the balancing (or market for ancillary services), the balancing services will be scarce and thus more costly in a terms of socioeconomic costs and not least: The end-user will probably face higher electricity bills in the future – not only because of increased cost for balancing of the power system, but also because of the need for new grid enforcement and investments.

The EcoGrid EU 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-scale generation units, because they must not create bids and schedules, but simply respond to the actual market prices.

### Project Design

**Different ways to test the real-time 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. The test households and the commercial customers are organized in groups dependent on the ‘price control system’ they belong:

- 500 households in a manual control group
- 1,200 household with automatic control group
- Up to 100 industry/commercial buildings with automatic price control.

Beside these groups a statistical control group of 200 customers represent the “business as usual” case.

The *manual control group* only has access to real-time price information, i.e. none of their electric household devices are automatically controlled. The manual control group will only receive manual response assistance, e.g. through training/energy advice and a feedback system with consumption and price information. *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 photovoltaic units. The automatic control of industry/commercial buildings include a diverse type of distributed energy resources, e.g. electric vehicles/energy storage facilities, and larger electricity appliances.

Two main approaches are used to realise the demand response of the automated test participants:

1. Automatic control of individual electric devices/resources
2. Aggregated control of a portfolio of electric devices/resources

The automatic control of individual electric devices uses IBM technology and GreenWave home automation solutions. The aggregated control groups are based on two aggregator methods developed by TNO and Siemens respectively. These houses also have two types of home automation system: One from GreenWave Reality's and one from Siemens-SyncoLiving.

Thus, the EcoGrid EU project uses different Smart home solutions and different ICT control technologies for optimization of the portfolio and demand response to direct price signals (local automation and direct demand response). It means that the systems are vendor independent, allowing for competition and freedom of choice on the hardware and software components.

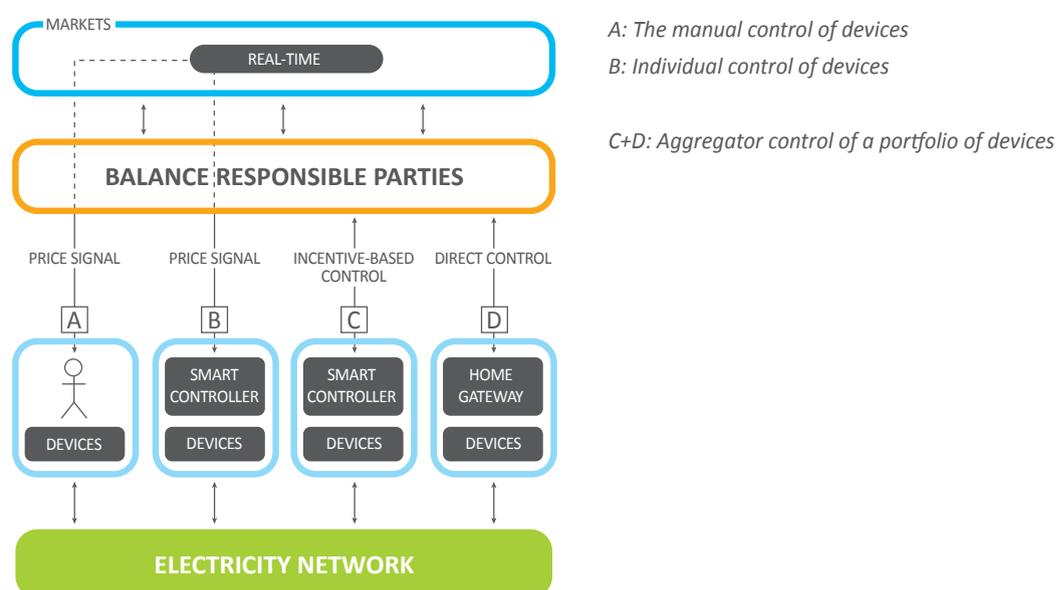


Figure 4: Implementation of real-time price responsiveness

### Current Status & Results

The design phase of the EcoGrid EU real-time market is completed and the first phase of the field test on the Danish island Bornholm started on May 2013. The theoretical concept will be materialised in real life on Bornholm in course of the next 2-3 years.

**Recruitment and Customer Participation:** In parallel to the development and design of the real time market concept an intensive effort has been done by the local grid company Oestkraft in order to recruit the 2,000 participants required in the demonstration. The recruitment process is considered a success. By August 2013 the objective of 1,900 test households on Bornholm was almost realized.

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 eg press releases and a press conference.

One month after the recruitment kick off at Oestkraft's demonstration house Villa Smart (February

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## EcoGrid EU: Real-Time Market Demonstration

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 and recruitment efforts.

The rest of the participants (approx. 900 households) signed up after an ambitious information and recruitment campaign, including direct mails to 3,000 electric heated households. On 3 February 2013, Oestkraft invited to public EcoGrid EU event on Bornholm. The visitors could enjoy free cake and coffee, EcoGrid EU exhibitions, speed talks by the Mayor on 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.

The recruitment of industry/commercial buildings is still ongoing. Oestkraft is in close dialogue with commercial customers who are positive to EcoGrid EU participation.

### 2,000 participating customers in the demonstration



#### Statistic control group

200 households with smart meters  
No access to specific information or 'smart' equipment



#### Manual control group

400-500 households with smart meters  
Receiving simple market price information  
Must move their energy consumption



#### Automatic control group

700 automated households with IBM Green Wave Reality equipment and smart meters  
All houses have heat pumps or electric heating all responding autonomously to price signals



#### Automatic control group

500 automated Siemens equipment and smart meters  
All houses have heat pumps, or electric heating all responding aggregator control



#### Industry/commercial buildings group

Up to 100 commercial with smart meters  
Include also small public customers  
Connected smart appliances responsive to control signals

Figure 5: The five groups of participating customers in EcoGrid EU

Some of the persons closest to the EcoGrid EU customers/participants are the seven electricians from Østkraft installing the EcoHome equipment in households on Bornholm. It typically takes from one to three hours to install the Smart home solutions. It is the electricians that together with the consumers define the comfort preferences and priorities. The EcoGrid industry partners provide continuous support via telephone and email to ensure that the electricians become experts in the EcoHome equipment.

### EcoGrid EU training

The training will be organized so participants in the different participant/equipment groups have training together. No more than 1,020 participants are present at the same time. The training is planned to take 1-2 hours per session. The training session will be split in different topics dependent on what is relevant for the type of group doing 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.

*On the right: Oestkraft's EcoGrid electrician team in front of Villa Smart. Oestkraft'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.*



Picture of Oestkraft's EcoGrid electrician team in front of Villa Smart

**Field-test phase I: Implementation of basis real-time prices:** The first phase of the EcoGrid EU demonstration is ongoing. In this test period 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 minutes real-time prices are based on the experience gained through the actual demand response of the test participants on Bornholm and realistic public information available about power prices.

On May 15th 2013 the demonstration and test phase 1 was officially initiated by issuing the first market based real-time price signal to a limited number of households (30 participants). These customers were also the first to have access to the online customer feed-back-system (FBS) "My EcoGrid". At "My EcoGrid" the participants can find information about the current real-time prices and prognosis for the coming hours. They can also find data from the meter installed in their homes and compare prices, consumption and cost over time. Once every month, the participants can find a report informing them about their performance during the past month, with the EcoGrid EU cost compared to the cost of a non-smart grid product. In October 2013, 95 % of the residential test participants have access to the feed-back system. The first evaluation results from the EcoGrid EU demonstration phase 1 - test of basic real-time prices are expected to be available winter 2014.

**Field-test phase II: Implementation of advanced real-time prices:** Experience gained from the test participants' reaction to basic real-time price signals (phase I) gives 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. The price calculation will utilise advanced demand response forecast models to calculate the price corrections necessary to follow the objective.

# DENMARK

## EcoGrid EU: Real-Time Market Demonstration

**Replication potential and perspectives:** 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 in the current regulation framework situations. Therefore, the implementation/replication of a real-time market concept must be considered in relation to 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 exchange of electricity.

Several parts of the EcoGrid EU market concept can be replicated within the current power market design(s) and practises across Europe, which justify and/or increase the probability of a fast track replication of the EcoGrid EU real-time market, 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.
- Likewise, the EcoGrid EU project uses different smart home solutions and different ICT control technologies for optimisation of the portfolio and demand response to direct price signals (local automation and direct demand response). It 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. It is relevant in markets where, eg 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 issue of replication and deployment of the EcoGrid EU real-time market concept is one of the key project tasks/work packages that run in parallel with the field test. One very important task will be to clarify the role of the TSO and the balance responsible parties in an EcoGrid EU real-time market setup.

### Lessons Learned & Best Practices

The education of participants takes place in the demonstration house Villa Smart and communication and technical advisors from Østkraft are giving individual advice to the participants regarding their particular role in the project and the new equipment.

The recruitment process is considered a success although various delays in the project have been a challenge. For example the recruitment of participants to the demonstration project has taken place at a faster pace than the installation of the equipment. In retrospect, it would have been wiser to start the recruitment of test participants at a later time and to have taken into account that not all components of the EcoGrid EU equipment are standardized products and that development takes time. 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.

The experience from the EcoGrid 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.



### **Strong focus on social values**

During the entire recruitment process the communication with the public was focusing 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.

In a field test that will have to involve every tenth residential household on Bornholm, it is not only to find enthusiasts, first movers or early adopters of new technology/smart grid solutions. During the last recruitment effort, much attention was given to the so-called "mainstream group" – i.e. people not especially interested in energy issues. A considerable part of this group have expressed that the motivation for participating in EcoGrid EU was the new smart equipment. For this group it is important that the equipment look "smart". They are also expected to be less tolerant for failures in their Smart home equipment installations during the test period than other groups. In the extreme case the project experienced that one of the participants signed out because he did not like the design of the 'black boxes'.

The project experience is that the great support of the EcoGrid EU project from the public on Bornholm has been an important precondition for the recruitment to the demonstration project and willingness to test the real-time market concept. The support of the project from the public on Bornholm is probably due to the fact that the population already was aware of many challenges associated with wind power and the goal of converting to a CO<sub>2</sub>- neutral electricity is deeply entrenched among the people and the Danes in general.

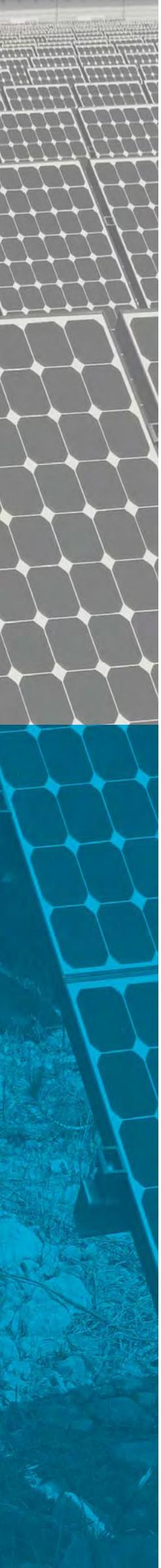
### **Strong focus on customer services and smart grid advice**

The local electricity company on Bornholm, Østkraft, expects that energy advice in terms of smart grid consultancy will be a very important part of the customer service in a smart grid deployment scenario. Lessons from e.g. large-scale smart meter roll outs in US and Europe show that it is important to have very strong focus on the concerns of customers and from the wider public right from the start. Also account for the fact that the move to smart metering and smart grid will have implications for the whole organisation. Also, the European consumer organisation (BEUC) in their analysis of 6 recent studies on use of smart meters reveals that the actual savings average 2-4 percent in the best case where consumers have clearly opted for their use.

In the next 2 years, the theoretical real-time market concept developed in the initial part of the project will be materialized in the real life on Bornholm. The first EcoGrid EU field tests started in May 2013 and the project is expected to terminate in the end of August 2015.

# FRANCE

<b>Project Ownership</b>	NICE GRID is a project managed by a consortium: Project Coordinator: ERDF Partners: Alstom, Saft, EDF SA, ARMINES, RTE, NetSeenergy, Socomec, Daikin, Watteco
<b>Location</b>	Carros, France
<b>Number of Carros customers</b>	2,500 involved customers (all will be equipped by the smart meter Linky at the end of 2014)
<b>Local Energy Supply Mix for Carros</b>	1.9 MW PV : · 330 kW from 110 PV systems of less than 3 kW · 1.5 MW from 9 PV systems of more than 10 kW
<b>Budget</b>	€ 30 million
<b>Duration</b>	4 years
<b>Contact</b>	· Christophe Arnoult (ERDF) christophe.arnoult@erdf-grdf.fr · Christophe Lebossé (ERDF) Christophe.lebosse@erdf-grdf.fr



# FRANCE

## NICE GRID: A Smart Solar Energy District With Active Customer Participation



The NICE GRID project will optimize electricity generation, consumption and storage tied in Carros municipal low-voltage (LV) grid, while accommodating a large amount of intermittent photovoltaic electricity. This optimization will make it possible to test the “islanding” of a LV grid by operating it in total autonomy for a limited period of time. The smart electricity management and control provided will be used to reduce Carros’ overall electricity consumption if upstream grids become congested.

The NICE GRID project is carried out by a consortium that consists of the Project Coordinator, distribution grid operator ERDF, and nine partners representing power systems companies, electricity suppliers, generators, a university and a provider of innovative networking solutions.

# FRANCE

## NICE GRID: A Smart Solar Energy District with Active Customer Participation

The stimulus for the NICE GRID smart solar district demonstration project was an invitation for expressions of interest issued by the French environmental and energy agency ADEME. It is funded by the French government's "Investments For The Future" program and the FP7 EU program. The NICE GRID demonstration is expected to cost approximately 30 million euros. The objective of this four-year project is to study all aspects of future electricity grid design.

NICE GRID is also part of the EU FP7 project Grid4EU coordinated by ERDF and is therefore the French demonstration project (DEMO6) within the packages. The chosen site for the project is Carros, a small town in the Nice Côte d'Azur metropolitan area near the Var River within the Eco-Valley - French "Project of National Interest". The NICE GRID project is implemented in the town itself and in its industrial zone.

Although the town's location on the margin of France's transmission grid - in the department of Alpes-Maritime - is a structural disadvantage for its electricity supply, it enjoys abundant sources of renewable energy, solar power in particular. These characteristics make Carros excellent site for this demonstration project.

### Objectives & Benefits

The four objectives of NICE GRID are:

- Optimize the operation of an electricity distribution grid accommodating a large amount of solar power and stored energy,
- Study a small autonomous LV consumption "island" that can be isolated from the main grid for a limited period of time, drawing its power from its own solar power generation and a lithium ion battery,
- Enable consumers to actively manage and balance their production and consumption,
- Test the smart grid business model.

### Project Design

To achieve these objectives ERDF and Alstom Grid have developed a "Network Energy Manager" that will optimize the balance between power consumption, solar generation and storage at the district level by:

- Forecasting the next day's consumption and solar power production,
- Installing batteries in the homes of volunteer customers, in the distribution network and at primary substations,
- Identify and locate in time and space network constraints that are likely to occur the next day
- Soliciting aggregators that can act on the active energy passing through the LV network
- Enabling participating customers to play an active role in their electricity consumption,
- Testing innovative IT and communication technologies to remotely control some energy uses.

Below are the planning and the main milestones of the project:

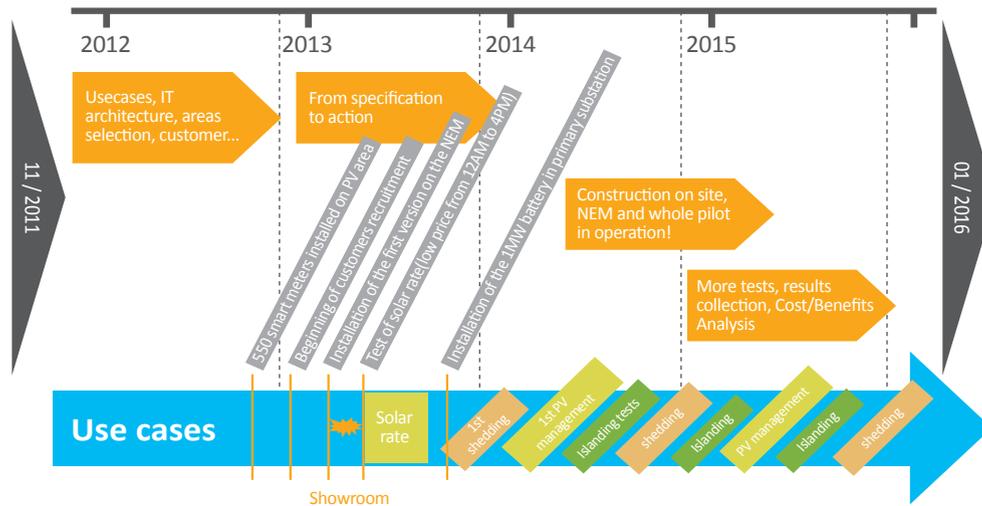


Figure 1: Planning and main milestones of NICE GRID

This project relies on AMI infrastructure and utilization of Linky smart meters, which enable more accurate consumption forecasts and allow participating grid customers or external aggregators to control and monitor devices such as Hot Water Tanks, heating systems and air-conditioners without additional internet boxes or parallel communication infrastructure. The figure below describes the overall architecture of the project:

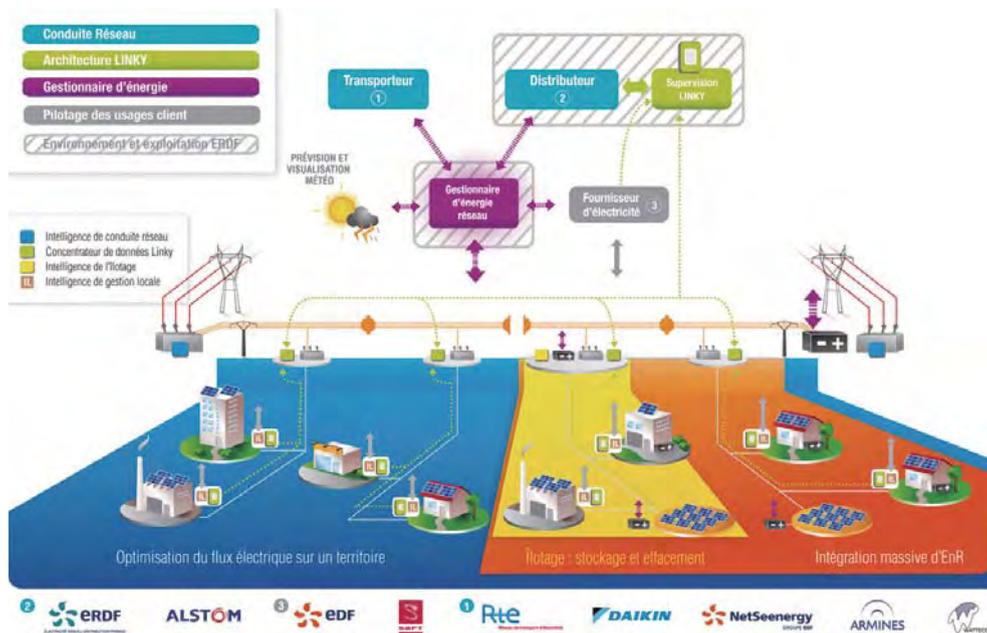


Figure 2: Overall architecture of NICE GRID

# FRANCE

## NICE GRID: A Smart Solar Energy District with Active Customer Participation

Four main use cases will be tested in NICE GRID:

**Islanding:** During approximately 4 hours, a MV/LV substation will be disconnected from the network. This type of operation will first be tested in prepared, anticipated and favorable situations. DER production and consumption will be forecasted and a battery prepared in order to achieve the system balance during islanding. Islanding must be transparent for the customer. In a second step, the islanding will be tested without preparation, recovering with a “black-start”. No Diesel generator will be used to supply the feeder, only solar panels and a 250 kW battery.

**Reduction of power demand:** The goal of this use case is to reduce the power demand in a network area. This type of operation can be used on DSO and/or a TSO request to prevent electrical constraints on the network, to help supply demand balance and to prevent customers from power outages. Different levers can be used to achieve this goal, such as flexibilities related to customer appliances or battery placed in customer premises as well as the network batteries. The aim is a 3.5 MW load reduction.

**Management of maximized PV production on LV network regarding constraints and flexibility programs:** A massive penetration of DER in the LV network may result in localized network (voltage, current) constraints. The targeted solution in this use case is to activate consumption and storage in predefined way near the constrained points, in order to prevent over-voltage and minimize PV inverter disconnections (to maximize PV production).

**Encourage consumers to adopt smarter habits in accordance with the network state:** During critical periods for the electric grid, the aim is to push consumers to try and change their electric consumption behavior by stopping, moderating or postponing some of their electrical device use. When the network state is operated under constraints, the consumer is informed about the ongoing incentive period. General suggestions and information will be sent to help them act before, during and after these periods: their consumption, PV production information (combined with weather data) and storage data will be available to improve the impact of their actions and ensure that efforts work in their favor. A key goal will be to promote their active participation, encouraging them to control their energy consumption and thus help to reduce greenhouse gas emissions.

Consumers will play this active role within the energy system by:

- Providing data on power use and consumption,
- Storing energy in hot-water heaters and/or batteries using controllable smart devices,
- Generating electricity from PV panels.

Even though the general concept of NICE GRID is based on forecasts of consumption and individual production set to Day-1, the project is also developing systems of re-forecasting constraints on an hourly basis on the event day and local intelligences responsible for correcting or adapting in real time flexibilities activation using local measurements.

**Role of the Smart Meter Linky:** The smart Linky meter is the basic building block of the NICE GRID project and plays a key role by being able to measure the consumer’s power consumption and generation. It can also send instructions for demand management. Hot water tanks will be controlled exclusively by Linky.

Heating instructions (i.e. customer number and heating start time and duration) will be preset by the platform that EDF is developing.

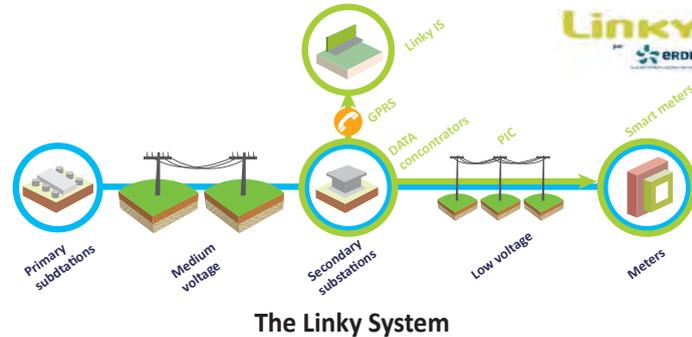
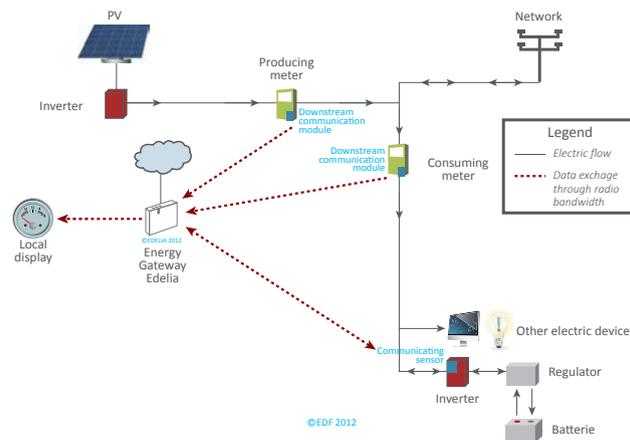


Figure 3: The Linky system, the basic building block of NICE GRID

The customer will play an active role in their home and even the neighborhood, due to their capacity to adapt their power generation (using their storage capacity) and/or consumption in accordance with network constraints. Another major focus of the NICE GRID project will have to ensure that customers are well informed of their energy use before, during and after consumption, along with its economic and environmental consequences<sup>5</sup>. These changes will encourage people to make their own energy choices and be an active part of their electricity system, whether they generate renewable energy, store energy or simply manage their own consumption.

The schema below describes the in home architecture that will be used in NICE GRID project.



### In home NICE GRID System

Figure 4: In home NICE GRID System

5 2 examples could be highlighted in France :

- «Watt et Moi» project (<https://www.watt-et-moi.fr/images/13-03-15%20DOSSIER%20DE%20PRESSE.pdf>) launched by ERDF to test the sociological impact of displaying Smart Meter information to over 1,000 consumers.
- «Edelia», which is a company of EDF (<http://www.edelia.fr/fr/Nos-solutions/Affichage-des-consommations-2-216-0-107.html>) involved in NICE GRID project that is going to reuse some of the development already done for its product

# FRANCE

## NICE GRID: A Smart Solar Energy District with Active Customer Participation

**Example of Demand Response activity within NICE GRID:** In addition to controlling voltage when a large photovoltaic power is injected into a LV grid, the NICE GRID project aims also to develop methods for assessing the behavior of “prosumers”. As known the photovoltaic power is not always generated when the consumer needs it. The diagram below shows the difference that can be noticed between the photovoltaic power generation curve and the consumer’s power consumption.

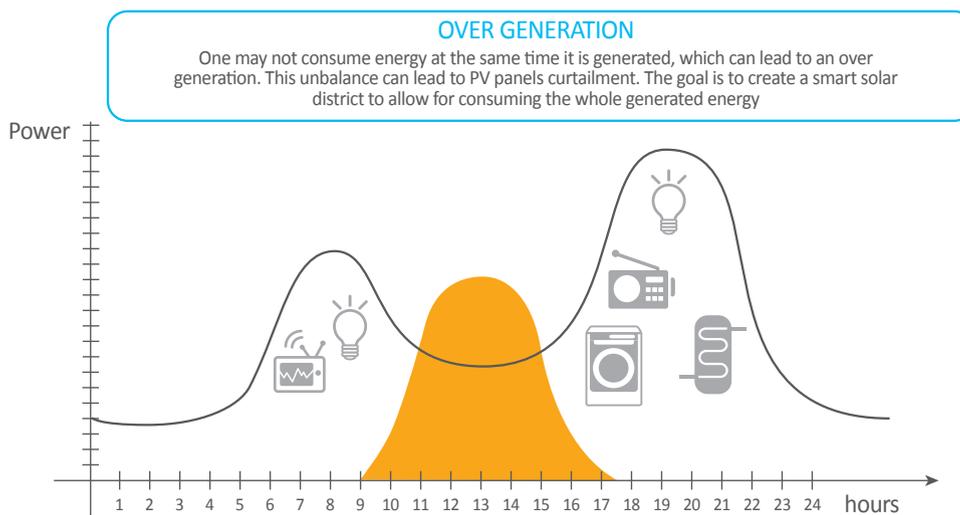


Figure 5: Illustration of the difference that can be noticed between the photovoltaic power generation curve and the consumer’s power consumption

To deal with this problem, the NICE GRID project strategy is to shift, as illustrated in the diagram below, a part of consumer’s consumption to the periods when we have a surplus photovoltaic power generated locally. For this purpose the generation and consumption forecast are key inputs to the Network Energy Manager tool (NEM).

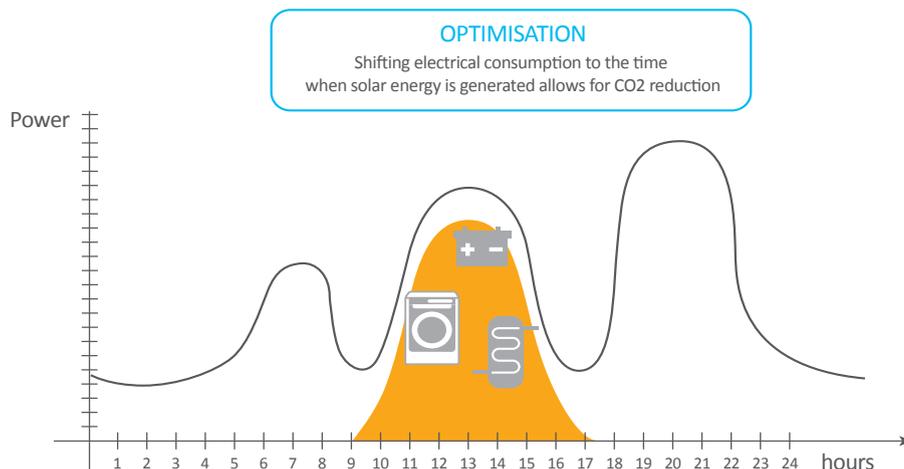


Figure 6: Illustration of the possible shift of a part of consumer’s consumption to the periods when a surplus photovoltaic power is generated locally

The means that will enable shifting of the consumption are:

- Residential batteries
- Hot water tanks
- Customer behavior (represented by the washing machine that is not monitored or controlled)

### Current Status & Results

**Customer Recruitment:** The success of the NICE GRID project depends on residential consumer’s participation and motivation. In order to encourage them to participate to this trial, EDF has developed a strategy for recruiting customers based on easy and understandable offers and raise the curiosity of the Carros’ residents. With the same goal, the solar district residents have received an active consumer guidebook and three trial offers for the photovoltaic power management.

The recruitment campaign was launched in early May 2013 with ads put up in Carros. The objective is to arouse the curiosity of the city’s residents and anchor the project in Carros. In addition to this, the solar district residents have received an active consumer guidebook and three trial offers for the PV Management use case.

**HEURES CREUSES SOLAIRES**  
FAITES L'EXPERIENCE D'UNE GESTION INTELLIGENTE DES HEURES CREUSES PENDANT L'ETE 2013 !  
L'abonnement est de 100€ à compter de mai 2013. Les heures creuses sont de 11h à 17h. Les heures pleines sont de 17h à 21h. Les heures de nuit sont de 21h à 6h.

**BALLON D'EAU CHAUDE INTELLIGENT**  
FAITES L'EXPERIENCE D'UNE GESTION INTELLIGENTE DE VOTRE BALLON D'EAU CHAUDE pendant l'été 2013 !  
L'abonnement est de 100€ à compter de mai 2013. Les heures creuses sont de 11h à 17h. Les heures pleines sont de 17h à 21h. Les heures de nuit sont de 21h à 6h.

**EQUIPEMENT SOLAIRE INTELLIGENT**  
FAITES L'EXPERIENCE D'UNE GESTION INTELLIGENTE DE VOTRE EQUIPEMENT SOLAIRE pendant l'été 2013 !  
L'abonnement est de 100€ à compter de mai 2013. Les heures creuses sont de 11h à 17h. Les heures pleines sont de 17h à 21h. Les heures de nuit sont de 21h à 6h.

**3 tests to participate in the NICE GRID project**

**EXPERIENCE 3** Subsidies to help the customers to get equipped for PV generation and battery storage

**EXPERIENCE 2** Special tariffs for hot water tank usage during solar off-peak hours

**EXPERIENCE 1** Special tariffs for all electricity usage during solar off-peak hours

Picture of example of advertisements used in the recruitment campaign of NICE GRID

# FRANCE

## NICE GRID: A Smart Solar Energy District with Active Customer Participation

Given the characteristics of the PV districts selected, residential customers who live in isolated houses were targeted. These districts have neither industrial or service sector customers nor apartment buildings, and as such these customer groups were excluded from the target participants for the PV Management use case. These offers are presented in the Solar Guidebook that was distributed to all EDF customers in the seven PV districts in May 2013.

### **Technical components:**

#### **Inverters**

Concerning the primary substation, the inverter is provided by Alstom Grid. This type of installation is unique in France, so the partners decided to do all the tests on site when the system will be in place. All the studies and administrative permits are completed. The container with the battery and container with the inverter were delivered in Carros beginning of November 2013. All the tests will end mid-February and the system will be in operation end February.

#### **Storage**

For the community storage, the inverters will be provided by the partner Socomec. All the design of the solution and the tests between the inverter and the battery are completed. The tests of the container are held in EDF R&D Concept Grid. The studies concerning the particular case of the storage also providing the islanding function leads to a 2 blocks system: a container with the battery identical to the one located in the primary substation and an inverter located inside the secondary substation with a 50 meters DC link. The system will be up and running for the PV energy storage by July 2014.

Residential storage systems will be installed in the homes of customers who participate in the project and who have already installed PV modules. Each battery will be connected to solar panel while the PV equipment will be connected directly to the grid. These storage systems will be able to accommodate the surplus power generated locally by the residential solar panels and then inject this power back when it is needed (e.g. at night). These residential batteries will be controlled by a dedicated platform and an ADSL infrastructure which will be located at the battery site. This solution is being developed by EDF.

#### **Load managing systems**

The load managing zone is the entire city of Carros. The Demo defined two types of customers: those equipped with the Linky meter - mostly the electric heating household and PV zone, and those without advanced metering infrastructure. For the former, the info will be relayed by the Linky meter to automated systems. For the latter, a program is developed to issue a signal (SMS, mail, website) to ask customers to minimize their electricity consumption. The majority of tests were conducted throughout 2013 in EDF R&D to test all the system from the IT servers to the end user systems. Two types of devices will be used, one from Watteco and one from Edelia. Already 1400 smart meters are deployed, over a 2500 target will be achieved by the end of 2014.

**Implementation and test of architecture and components of the information system needed to operate the areas:** All the system will be operated from ERDF servers. So during 2013, one of the challenges was to install on ERDF servers all the software components coming from the different partners and to

give secure access to these servers. The first test with a limited number of components was done in June and the test concerning the whole architecture in V1 was held in November 2013 to be ready to run in April 2013, beginning of the first load shedding experiments.

NICE GRID will monitor different data in order to calculate KPIs.

KPI Family	KPI Description
Load managing	<ul style="list-style-type: none"> <li>Fraction of load effectively shed out of the total reduction capacity</li> </ul>
Environmental	<ul style="list-style-type: none"> <li>Increased hosting capacity of RES integration in the local LV grid</li> </ul>
Forecasting	<ul style="list-style-type: none"> <li>Error calculations related to forecasts of solar power generation</li> </ul>
	<ul style="list-style-type: none"> <li>Error calculations related to forecasts of consumption levels</li> </ul>
Reliability	<ul style="list-style-type: none"> <li>Voltage deviation at the LV grid level</li> </ul>
	<ul style="list-style-type: none"> <li>Total Harmonic Distortion Factor</li> </ul>
Efficiency	<ul style="list-style-type: none"> <li>Energy losses and ICT energy consumption of flexibilities</li> </ul>
Societal	<ul style="list-style-type: none"> <li>Fraction of consumers opting out during load shifting</li> </ul>
Islanding	<ul style="list-style-type: none"> <li>Voltage deviation during islanding</li> </ul>

Table 1: KPIs used in NICE GRID

Some of these KPIs are common within the Grid4EU to other Demos using a common calculation methodology.

### **Information systems architecture**

The system that is used is illustrated in the figure below.

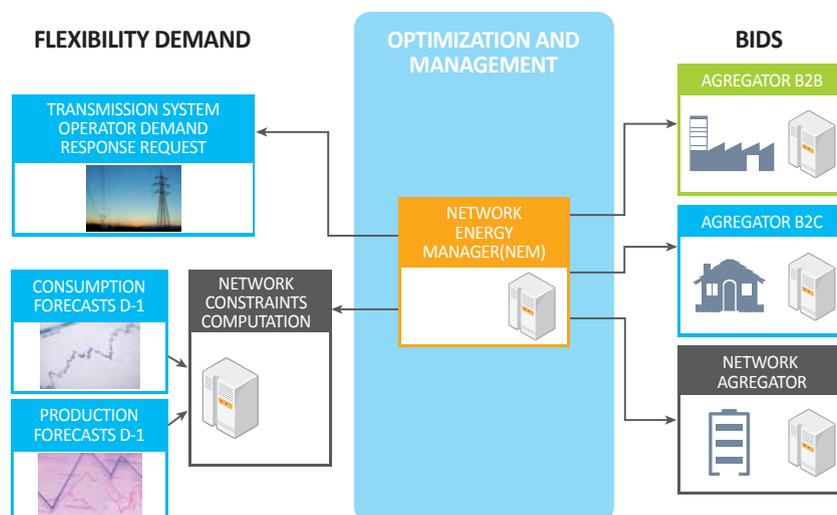


Figure 7 : Information systems architecture

### Lessons Learned & Best Practices

- **Operation of battery storage on the distribution grid**

Batteries are new technologies on the distribution grid: distribution grid is relying only on AC current, and technicians have to be used to DC current devices. Batteries have also to be monitored 24/24, and this can only be done by the DSO monitoring team, working 24/24. Operational teams and technicians have to be informed and taught some month before, especially regarding safety issues.

- **Challenge of the recruitment**

Recruitment is done using public advertising, public meetings in city, open doors day in the show room, publication in the local newspapers. Financial counterparts are very important: gift cards, investment subsidy, tariff signals...

- **Communication**

Communication and dissemination are challenging for such a technical project. NICE GRID built a dedicated show room in order to disseminate information about the project. It is located in the city of Carros and welcomes international scientists, companies, conferences and universities. Inside, each consortium partner has a dedicated space, most of the devices are exposed on a tactile wall and a large screen allows for use cases visualization.

- **Accurate use case definition in order to allocate clear tasks and actions to the different involved parties in the project**

Use cases have to be defined at early stage accurately in order to facilitate the task allocation and to ease the identification and specification of the interfaces between the partners involved in the project.



## **Key Regulations, Legislation & Guidelines**

French policy is highly influenced by European legal acts and, of course, French institutional initiatives are in line with the European guidelines. Therefore, France has put in place the liberalization and deregulation of the electricity market. This new organization has been set up gradually but today, French electricity market is mostly open, which is an important headway for the security of supply. Moreover, French authorities are acting in favor of energy efficiency improvement and renewable energies development.

Along with the future investment, the implication of regional and local authorities is evolving towards more sustainable energies.

smart grid today is benefiting from drivers at both European and French scale. It is an efficient way to decrease greenhouse gas emissions, improve energy efficiency and network security. smart grid technologies are core European and French strategic instruments for which an important investment is provided. Nevertheless, many issues remain to be solved so that a smart grid can be massively deployed in the entire electricity network.

The French Energy Regulator (CRE) is supporting the project. The results will benefit the entire smart grid community.



# GERMANY

<b>Project name</b>	E-DeMa
<b>Leading organization</b>	RWE Deutschland AG, Germany
<b>Other Participants</b>	Siemens, Miele, SWK Setec, ProSyst, TU Dortmund, RUB, University DuE, all Germany
<b>Market structure</b>	Energy Only Market
<b>Number of retail customers in Germany</b>	40 million
<b>Electricity consumption in Germany (2012)</b>	595 billion kWh
<b>Contact</b>	Prof. Michael Laskowski, RWE RWN, 0201-121228567, michael.laskowski@rwe.com

# GERMANY

## E-DeMa: Development and Demonstration of Locally Networked Energy Systems to the E-Energy Marketplace of the Future



The energy turnaround in Germany is strongly correlated to the increasing renewable energy sector and changes in the power generation system. The increasing fluctuating feed-in from renewable power plants leads consequently to generation-oriented electricity consumption. This affects the industrial, commercial and the household energy sector in Germany. The focus of E-DeMa is the electricity consumption of the household sector. E-DeMa is one of the six E-Energy projects carrying out research activities regarding the customers' acceptance of advanced smart grid technologies. E-DeMa is founded by the German Federal Ministry of Economics and Technology (BMWi) with the aim to develop and demonstrate local energy markets. The model region is located in the Western part of Germany (Rhine-Ruhr-area) and 657 customers in the household sector were provided with new electricity products and advanced inhouse communication systems.

# GERMANY

## E-DeMa: Development and Demonstration of Locally Networked Energy Systems to the E-Energy Marketplace of the Future

### Objectives & Benefits

The objective is to examine the demand side management potential of customers in a field test. The project also analyzes the influence of the E-DeMa products and incentives on the load shifting behavior of households.

In the E-DeMa field test, the participating end customers have been provided with two different types of smart grid infrastructure. The table gives an overview of the two groups of customers. Both customer groups are equipped with a Smart Metering System and an access to the E-DeMa marketplace which has been developed in the project. Customer group 1 is also equipped with a tablet computer. In addition to the Smart Metering System and the access to the marketplace, customer group 2 has been provided with automatic household devices (washing machine and laundry dryer or dish washer), an Energy Management Gateway and a Home Energy Control User Interface (HECUI).

Start date and duration of the project	Start date: 01/01/2009
Duration:	4 years
Location/s	Mülheim and Krefeld, Germany
Project summary box	
Summary of Project goals and expected benefits:	The goal of E-DeMa is to reach more energy benefits and efficiency for electricity generators, municipal utilities, device manufacturers and above all customers. E-DeMa designs solutions for an intelligent electric distribution and communication network. This project evaluates different customer engagement and behaviour change models to reduce electricity consumption.
Budget and contributing organizations (indicating share of contribution)	Budget: 21.5 million € funded by German Federal Ministry of Economics and Technology (BMWi)
List of deployed enabling assets/technologies/applications:	<ul style="list-style-type: none"> <li>• Smart Meter (two different metering systems)</li> <li>• Washing machine, dishwasher, laundry dryer, combined heat and power system</li> <li>• Application for the E-Energy-marketplace</li> <li>• Control system for the aggregator</li> <li>• Information and Communication Technology systems</li> <li>• Smart gateways</li> <li>• Inhouse-Display</li> <li>• Home Energy Control User Interface (connection to smart gateway)</li> </ul>
List of pertinent smart grid functionalities:	<ul style="list-style-type: none"> <li>• Enabling and encouraging stronger and more direct involvement of consumers in their energy usage and management. The customer should be involved through time-of-use-tariff-models and an automated demand side management.</li> <li>• Ensuring network security, system control and quality of supply. The goal of E-DeMa is to integrate renewable energy sources and its fluctuated supply and, at the same time, sustain the network security and quality.</li> <li>• Decentralized power supply should be integrated and coordinated by the power supply of renewable energy sources.</li> <li>• The smart grid has to manage the upcoming penetration of electric cars and its management requirements.</li> </ul>

Table 1: E-DeMa fact box

The inhouse infrastructure of customer group 2 in the field test is shown. The Smart Metering System in the households consists of two parts: the Smart Meter (electricity, gas or water) and the communication gateway. The communication gateway requests the data from the Smart Meters frequently over an optical interface and provides them to the E-DeMa data management system and to the Energy Management Gateway. The Energy Management gateway provides the tariff information to the customer and to the shiftable load devices (e.g. white goods), as well as to distributed energy resources (DER) via a wireless or wired Home Area Network (HAN). The gateways communicate through a secure and reliable IP based access network with the E-DeMa marketplace which is the central infrastructure entity of the E-DeMa system. The E-DeMa marketplace provides the end customer with important information regarding his individual electricity consumption. Via his personal computer, the customer is able to view his daily energy consumption. The energy consumption is shown in detail (electricity consumption of every 15 minutes) after the day of the consumption.

	Group 1	Group 2
Number of customers	550	107
Equipment	Smart Metering System	Smart Metering System
	Access to E-Energy Marketplace	Access to E-Energy Marketplace
	Tablet	Home Energy Control User Interface (HECUI)
-	-	Automatic household devices
	-	Energy Management Gateway

Table 2: Overview of the two groups of participating end customers of E-DeMa

Furthermore, the customer receives a monthly record about his energy consumption behavior at the marketplace. The access to the HECUI is provided to customer group 2 over the customer's personal computer. In contrast to the information on the marketplace, the customer is able to see his energy consumption during the current day and the daily schedule and status of his automatic household devices.

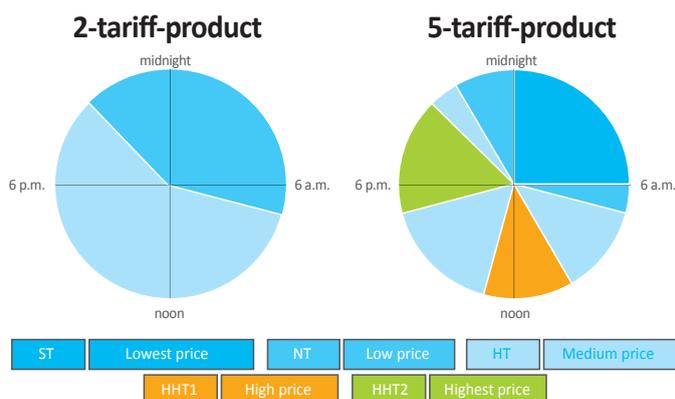


Figure 1: Two Time-of-Use products used in E-DeMa: 2-tariff-structure or 5-tariff-structure

The automatic household devices have a smart start function which allows the customer to set a desired end time when the program has to be finished at the latest. The Energy Management Gateway is connected to the automatic household devices and chooses the optimal time according to the current tariffs in the time frame between the setting and the end time. Another objective of the E-DeMa project is to promote and enable a

# GERMANY

## E-DeMa: Development and Demonstration of Locally Networked Energy Systems to the E-Energy Marketplace of the Future

faster change of the energy supplier through the customer.

In Germany the household customers are able to choose between different retailers. Today, a change of a retailer can be executed within 14 days. Using the In E-DeMa marketplace as an information hub, the E-DeMa participant is able to change his retailer within three days. The contract period with the new supplier is valid at least one month. After this month the customer can choose another product from another retailer. The faster process is verified in the field test with customer group 1. This group of households is able to choose from different products of different retailers with a minimum contract term of one month. Available for the product selection are time-of-use products and consumption-dependent-products.

The two time-of-use products either have a 2-tariff-structure or a 5-tariff-structure. The prices for the 2-tariff-structure-product change every month of the field test and the prices of the 5-tariff-structure-product can change every day. The aim of these time-of-use products is to shift the customers' load from times of high electricity consumption, e.g. in the early evening, to times with low consumption. The 2-tariff-structure-product consists of three time frames with the two tariffs: low price throughout the night (midnight – 7 a.m. and 9 p.m. – midnight) and medium price during the day (7 a.m. – 9 p.m.). The 5-tariff-structure-product is more complex than the 2-tariff-structure-product due to eight different time frames. The figures above show the tariff-structure where the high and highest prices are valid during midday (10 a.m. – 1 p.m.) and the early evening hours (5 – 9 p.m.).

Due to the provided equipment, customer group 2 cannot choose but gets their product assigned. This group cannot change between products. Two different products have been designed for this customer group in E-DeMa. Both products have the same 5-tariff-structure, which is explained above, on the demand side as well. This means that the product on the demand side of customer group 2 is the same than for the customers in group 1, who choose the 5-tariff-structure-product.

In addition to customer group 1, the customers of customer group 2 are able to use the smart start function of their automatic household devices so that the Energy Management Gateway shifts their load to times of low prices. The other product has one additional function: the possibility to market the power and energy of their automatic household appliances via the Gateway.

The aggregator is a new market role resulting from marketing flexibilities (in households) and decentralized feeds. Only the aggregation of the flexibilities offers benefits in the marketing. The added value is the refining of the flexibilities to tradable products. In general, the aggregator enables customers to offer the power and energy of their load appliances (flexibility) to other market players on the electricity market. In the E-DeMa project, the aggregator offers a product to the customer which requires the customer's provision of white goods for load shifting between 9 am and 6 pm. With an appropriate ICT-infrastructure (always under the aspect of a secure data communication), the white goods are connected to the aggregator's system so that the aggregator is able to start the appliances, e.g. when great benefit at the electricity market or the reserve power market can be realized. The remuneration for each provision by the customer is 0.35 €. If the customer achieves a total number of 40 provisions during the field test, the customer will receive an additional payment of 20 €.

Summarized, on the one hand the customers can provide their appliances to the energy management



gateway, which shifts the start of the appliances into the time frame with the lowest price. On the other hand, customer group 2 can provide the appliances between 9 am and 6 pm to the aggregator, who starts the appliances whenever he expects revenues from marketing the energy of the loads.

To evaluate the load shift of the E-DeMa households, a reference household is necessary. The reference household is created by using the standard load profile for households (so called H0-profile) from the distribution system operator in the Rhine-Ruhr-area. The average shifts in load are calculated by comparing the average of test house consumptions to a reference household consumption during the same period.

### **Current Status & Results**

The data of the end customer which has been measured during the field test is analyzed regarding the load shifting for the different products and incentives. The focus of the evaluation of each month of the field test is to get information about the time-dependent load shifting behavior and the seasonal influence. The load shift on the five characteristic days “Monday”, “Tuesday to Thursday”, “Friday”, “Saturday” and “Sunday” can reveal the behavior during the week. Tuesdays, Wednesdays and Thursdays are aggregated due to the similar life habits on these days.

On the one hand, the results are calculated separately for the two customer groups (different equipment). On the other hand, the results are shown for passive and active E-DeMa households. In a field trial with up to 700 participants, some customers relatively quickly lose the motivation to participate but do not actively unsubscribe. In order to distinguish the results of these customers from customers who respond to the incentives, the E-DeMa consortium has chosen to differentiate between active and passive customers. For this, the monetary savings of E-DeMa customers with the E-DeMa price structure was compared to the reference customer (customer with the standard load profile scaled with the same daily consumption).

To get information about the load shifting behavior over the time of the field test and the seasonal influence, the average load shift into the time frames with ST and NT resp. out of the time frames with HHT1 and HHT2 per month is summarized and divided by the total average energy consumption of each month. The load shift per characteristic day is calculated by aggregating the average load shift into the time frames with ST and NT resp. out of the time frames with HHT1 and HHT2 per characteristic day and dividing by the total average energy consumption of each characteristic day.

At the top of the figure below, the results of customer group 1 with the 5-tariff-structure are shown for both passive and active households. The results for customer group 2 (automatic household devices) are shown beneath it. Regardless of the equipment of the households, the distinction between the load shifting behavior of the passive and the active households is displayed very clearly. The load shift of the passive households has a random character without any significance structure. The results of the active households show a significant continuous load shift into the lowest and low price timeframes during the night (from 7% to 11%) and out of the expensive time frames around noon and the early evening hours (up to nearly 5%).

In comparison to customer group 1, the active customers of customer group 2 shifted more loads into the

# GERMANY

## E-DeMa: Development and Demonstration of Locally Networked Energy Systems to the E-Energy Marketplace of the Future

time frames during times frames with low prices. However, the customers showed signs of exhaustion in their consumption shift. In the first months, active customers shifted an average load of nearly 10% into the lowest or low price time frames. Then, the load shift decreases with the field trial to nearly 7% in November. The passive customers of customer group 2 showed more efficient load shift than the passive customers without automation. Yet, the load shifting behavior was not very significant in comparison to the load shift of the active households.

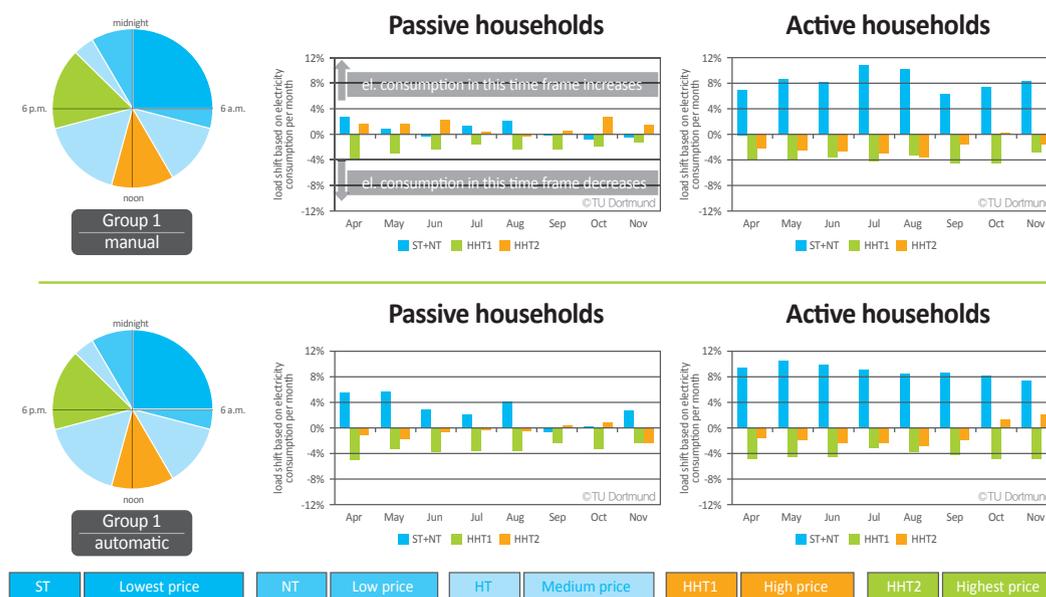


Figure 2: Results of customer groups 1 and 2 with the 5-tariff-structure for both passive and active households

The results of the investigation of the load shift on each characteristic day indicates that the active customers with automatic household devices shifted their consumption relatively evenly across all days into the lowest price and low price tariff times. Customers without automation shifted less consumption in these tariff times at the weekend. Similarly, the load shift of customer group 2 around midday (HHT1 or high price) is more constant on all days than the load shift of customer group 1 without automation. The characteristic of the load shift on Sundays does not depend on the equipment. There is always a high load shift out of the time frame around noon (HHT1 high price) and a low load shift into the early evening hours (HHT2 highest price). This indicates that the customers might be interested in load shifting, but on Sunday's life habits and privacy are more important.

The two tables summarize the product-specific load shift results for active and passive households with the 2-tariff structure and the 5 tariff-structure. Applies to both products: the active customers shift a high percentage of their consumption into the time frames with lowest and low prices (8.7% and 8.2%) and from the expensive peak hours high price (-4%) and highest price (- 2.3%). The passive customers only shift relatively small amounts of consumption.

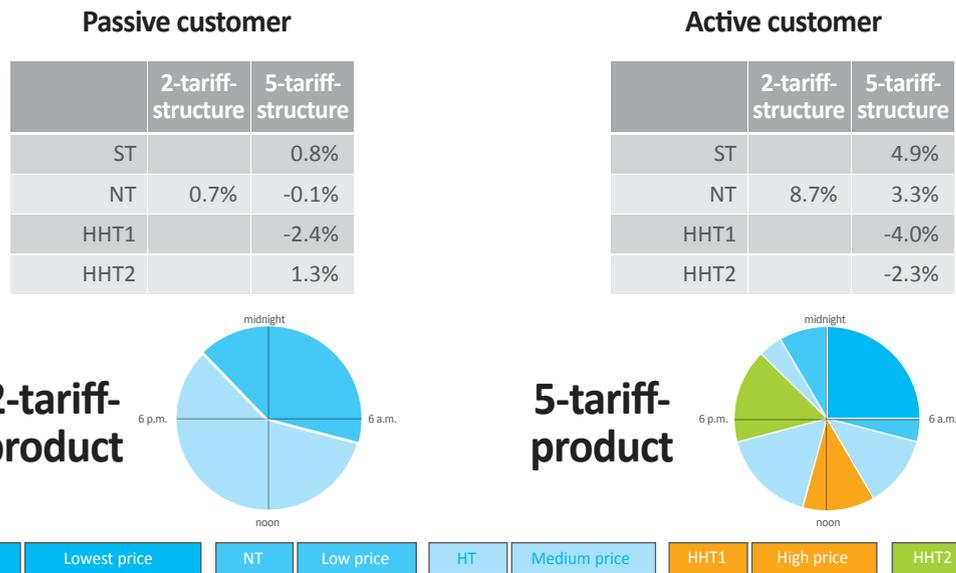


Table 3: Summary of the product-specific load shift results for active and passive households with the 2-tariff structure and the 5 tariff-structure

They shift their consumption even from the low tariff period and in the expensive highest price tariff time. It is also evident that the sum of load shift into the lowest and low price time frames of the 5-tariff-structure approximately corresponds to the load shift into the low price tariff-structure of the 2-tariff-product. This means that the differentiation of the lowest and low price time frames was not identified by customers. One reason for this is the time window from midnight to 6 a.m. in the morning. Because of their daily schedule, it is hardly possible for the customer to shift the consumption manually into these times. Secondly, the customer survey revealed that the customers' aim is to shift their consumption into green visualized time frames. Although the lowest and low price off-peak hours were visualized in two different shades of green, the households apparently did not differentiate between them.

The economic potential of the aggregator depends on the further marketing of the aggregated power and energy. In this use case, the analysis of the potential is focusing on the approximation of the minimum costs of the aggregator which arise due to ICT-Infrastructure. The costs per provision decrease with an increasing number of provisions by the households per year. This is primarily due to the relatively high ICT installation costs of the aggregator. Furthermore, the maximal power of load devices in households has to be considered. The maximum installed power of each load device used by the aggregator in E-DeMa is approx. 2 kW. Of course, this power is not available during the whole period of operation. A washing machine for example will only reach the maximal power during the heating process which endures approx. 15 minutes. Supposing that e.g. every fifth use of the participating household devices ( $\approx 3,400$ ) per year is provided to the aggregator, the resulting costs for the aggregator to be covered by a third party are about 8.30 € per provision, which means about 4.15 €/kW respectively 415 €/MW for 15 minutes. A constant providing of power for the duration of a few hours is expected being very difficult to achieve for the aggregator. For that, a high number of aggregated load devices who are set on stand-by and a more diverse portfolio (not only aggregation on white goods) are needed.

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## E-DeMa: Development and Demonstration of Locally Networked Energy Systems to the E-Energy Marketplace of the Future

Comparing the minimum costs of the aggregator e.g. to the demand rate of the tertiary reserve in the year 2011, the estimated costs to be covered by a third party for the flexibility of the aggregator are still higher today. An expected reduction of the costs for ICT infrastructure may change this situation. In future, new markets for the distribution level might realize the marketing of the flexibility in households.

### Lessons Learned & Best Practices

In general, the results of the load shift in the field trial show that the customers easily show signs of fatigue and need to be closely assisted in order to realize the load shift sustainably. The most important results are:

- The load shift into the night is independent of the complexity of the tariff structure during the day.
- High-end equipment does not necessarily lead to a higher load shift. Active customers achieved a load shift of up to 11% per month and nearly 10% per characteristic day, regardless of the customer group.
- The load shift decreases with the duration of the field test.
- The acceptance of automatic household devices requires both a certain start-up time and close customer support.

Overall, it is important to “activate” the customer. This means that customers must actively allow the automation to control their loads. Particular note is the fact that active customers without automation achieve a much more efficient load shift than passive customers with automation. The top priority must therefore be to motivate the customers not only by appropriate incentives but also by raising awareness of the impact of their consumption behavior.



## **Key Regulations, Legislation & Guidelines**

It is an issue of business models of each stakeholders to enforce demand side management in Germany.

The different objectives of the business models of the various market players for load shifting in households illustrate that the load shifting measures affect each other. An overarching concept for coordinating the interests of market players has not been developed and is found neither in the current legislation nor in discussion papers or determination of the Federal Network Agency procedure.

The electricity cost savings so far are smaller than the costs for the required smart meter and the display (e.g. tablet computer). Even if business models exist, that households do not have to pay for the smart meter infrastructure, there are still missing standardized data exchange processes. If an aggregator shifts the household's loads, standardized data exchange processes between the different market players are essential.

For example, if the aggregator uses controllable appliances to provide negative tertiary control, the system load (at a correspondingly high number of customers) and therefore the target load profile of the distribution system operator changes. Depending on the feed-in, load and system load, the objectives of the different market players can have a destructive or constructive effect and thus affect the target load profiles of individual market players.

Furthermore, today, the incentives for load shifting which households can refer to are very small.

# ITALY

<b>Market structure</b>	Liberalized demand market; all customers may choose their supplier. About 17% of household and 36% of non-residential customers have chosen free market retailers. The remaining is served by the universal supply regime. DSOs are responsible for metering activities <sup>6</sup>
<b>Number of retail customers</b>	Approx. 37 million
<b>Other Participants (Names and Countries)</b>	Siemens, Miele, SWK Setec, ProSyst, TU Dortmund, RUB, University DuE, all Germany
<b>Electricity consumed (2012)</b>	>340 TWh
<b>Peak Demand for Power (2012)</b>	>54,000 MW
<b>Net Revenue to Distribution Companies (2010)</b>	> 8 billion euro
<b>Distribution Network</b>	830,696 km of LV lines / 379,705 km of MV lines 143 DSOs operate the electricity distribution networks in Italy (54 DSOs with less than 1000 customers) 1 main distribution company: ENEL Distribuzione is the first national DSO, covering the 86%
<b>Pilot Enel Info+</b>	
<b>Project Value</b>	Consumption monitoring to raise customer awareness and enable efficient energy use
<b>Location</b>	Isernia Province (19 towns)
<b>Funding</b>	Resolution ARG/elt 39/2010 (Tariff remuneration scheme)
<b>Duration</b>	2012 - 2014 (ongoing)
<b>Targeted Customers</b>	Up to 8,000 eligible customers (residential and small commercial consumers, prosumers)
<b>Other</b>	Participation on voluntary basis, with no cost for customers involved
<b>Partners</b>	Enel Distribuzione

<sup>6</sup> AEEG 11/07, Resolution on functional unbundling <http://www.autorita.energia.it/allegati/docs/07/011-07old.pdf>

# ITALY

## ENEL's Initiatives on Customer Engagement



In the context of a smart grid playing a crucial role towards low carbon energy scenarios, consumers are in the centre of these changes. They are expected to evolve from being passive recipients of energy services into more active participants in the energy market, shifting to more efficient and sustainable energy consumption behaviours. For this to happen, solutions to empower customers with improved information exchange and to enable innovative services to the end users have been developed by Enel.

Fully leveraging on the smart metering infrastructure and expertise, Enel Distribuzione developed a local meter interface, referred as Enel's smart info®, which makes consumption and generation data available allowing the development of a platform for a bidirectional communication with the DSO's systems enabling solutions for the Active Demand (AD).

# ITALY

## ENEL's Initiatives On Customer Engagement

In particular, Enel Distribuzione has launched in 2012 the Enel Info+ project<sup>7</sup>, a large scale trial in Southern Italy (Isernia Province), where the use of the Enel smart info device is tested under real operating conditions. Both residential and small commercial customers are being provided with higher quantity and quality information on their electricity energy consumptions, addressing customer awareness and paving the way forward a more active participation to the management of the electricity energy system.



Additionally, in the context of enabling in-home energy management solutions, Enel has launched in 2012 the Energy@home<sup>8</sup> pilot project in collaboration with Telecom Italia and Indesit: a domestic platform for the provision of Value Added Services (VAS) based upon information exchange is being tested in Central Italy, having the smart info as bridge between the devices in the Home Area Network (HAN) and the DSO's systems upstream.



To develop technological and commercial solutions to enable residential Active Demand has been the aim of ADDRESS<sup>9</sup> project, a large scale FP7 research project coordinated by Enel Distribuzione. The vision is that domestic and small commercial consumers' electrical demand can be made flexible optimizing the operation of loads, embedded generation and storage system. Possible barriers against Active Demand development on the power systems and recommendations to remove these barriers have been identified. In particular, the DSO operational algorithms and prototypes developed within the project to enable and exploit Active Demand was tested in the Italian test site in Carpinone in order to validate them to ensure a reliable operation of active demand grid in presence of Active Demand (AD) and to verify if AD is exploitable for network problem solving.



FP7 funded project ADVANCED (Active Demand Value ANd Consumers Experiences Discovery)<sup>10</sup> launched in 2012 with the aim to develop actionable frameworks enabling residential, commercial and industrial consumers to participate in AD.

Furthermore, the benefits of AD for the key stakeholders and the inherent impacts on the electricity systems considering its potential contribution to system stability and efficiency are to be quantified taking different scenarios into account. This will be achieved through comparing the different AD solutions applied in Europe and enhancing them by the investigation of socio-economic and behavioral factors with direct involvement of real consumers. On this basis, key success factors of AD and recommendations for the future design of AD programmes will be derived.

<sup>7</sup> [www.enelinfopiu.it](http://www.enelinfopiu.it)

<sup>8</sup> [www.energy-home.it](http://www.energy-home.it)

<sup>9</sup> [www.addressfp7.org/](http://www.addressfp7.org/)

<sup>10</sup> [www.advancedfp7.eu](http://www.advancedfp7.eu)

## Objectives & Benefits

Potential flexibility from customers is considered one of the largest untapped energy resources, mainly because of still insufficient consumer awareness regarding energy consumptions and the potential benefits of a smart energy use in consideration of network constraints. Paving the way forward the implementation of active demand solutions, the objective of the solutions developed by Enel has primarily been to establish a direct link between the electricity energy utility and the final customers, improving their consumption awareness and enabling their active participation to the electricity market. While enabling exploitation of flexibility from customer engagement in a secure and reliable manner, the expected benefits can be summarized as follows:

- More efficient and sustainable energy use (energy consumption reduction and shifting to off-peak hours)
- New advanced in-home energy services enabled (i.e. automatic load management, coordination of consumption and generation)
- New competitive market based on distinctive services opened to several market players (e.g. service providers, retailers, aggregators, TelCos)
- Additional resources to manage the electricity energy system been enabled (e.g. better balancing of energy consumption and generation, load shedding, peak shaping, etc.)
- More efficiency and sustainability of the whole system (e.g. through energy consumption reductions, load shifting when renewable production is higher, etc.)

## Project Design

Several use cases and functionalities have been developed and implemented under the ongoing customer engagement projects and trails, ranging from customer awareness and rationalization of the energy use to the validation of the AD products from the network operating management perspective. In particular, in order to validate the technical solutions developed while getting insights into how customers can be more actively involved in the energy system management, different initiatives, exploring different levels of customer engagement, have been launched over the years in collaboration with other partners, both at the national and European level as detailed in this section. At the national level, solutions for consumption monitoring to raise customer awareness and enable efficient energy use were first developed and are currently being tested under the Enel Info+ project, launched in 2012. At the same time, a wider scope, enlarging from consumptions monitoring to in-home control, has been in the focus of the Energy@home project, where other players alongside Enel Distribuzione (such as a TelCo and a white goods manufacturer) are involved.

At European level, the investigation of a comprehensive Active Demand framework, also including the identification of possible barriers and insights for a successful AD development, had already started in 2008 within the ADDRESS project, where a full interaction between customers and energy system was envisaged as step toward in-home control.

Privacy issues, also in relation to data collection and processing, have been addressed in Enel's project terms and conditions, stating also parties' rights and liabilities, always in agreement with the customers. Moreover, customer opting out has been guaranteed and participation stated on a voluntary basis with no cost for the involved customers.

### Enel Info+

With the aim to demonstrate whether providing the end users with feedback on electricity energy consumption can address more efficient energy behaviours, a representative sample of families served by the Carpinone primary sub-station in the area of Isernia, are being equipped with an energy monitoring kit including the Enel smart info® together with dedicated interfaces. In particular, been designed as modular system, three different levels of analysis and functionalities have been implemented and solutions are Enel Distribuzione's proprietary:

- **SEE:** based on the use of the smart info's full colour and touch screen in-house display, consumers have easy and continuous access to their household energy use pattern. Smart Info Display provides near real time and historical information on energy consumption, shown in bar graphs and pie charts to highlight mean value and distribution throughout tariff bands over different time slots (i.e. day, week, month, two months, year). Consumption habits are displayed together with the measured consumption data in the graphs, helping consumers identify variations. Historical data is stored for about three years. The instantaneous power is reported together with a scatter plot of its maximum historical values for different periods of time (a single day, one week, one month), thus the consumer can check whether its supply electricity contract is consistent with its actual needs. The instantaneous power values can be refreshed automatically as well as on demand. Tariff time bands are displayed, together with the date and time of tariff time bands switching and colours settings can be modified to be consistent with the user's tariff structure. When the contractual power is exceeded an alarm is automatically generated likewise, so that load shedding is prevented. Through a dedicated wizard the customer can also measure the power used by a specific appliance. Besides pure information, additional feedback and alarms at pre-defined, modifiable thresholds (for example with reference to contractual power capacity limit), DSO's announcements and contractual data are also notified for the customers;
- **ANALYZE:** based on the smart info manager, a software application is provided to the consumers in order to assist energy consumption data analysis directly on a personal computer. For prosumers who are generating electricity themselves, their energy production is shown alongside their generation to facilitate analysis of their net energy consumption;
- **EXPLORE:** based on the smart info mobile app, consumers/prosumers can remotely access their energy data directly from their smartphone.



Figure 1: Enel smart info functionalities.

The Enel Info+ project, started in December 2012 and will finish at the end of 2014.

### Energy@home

Trial Energy@home	
Project Value	In-home energy management to enable load control and innovative smart services
Location	Mainly Fabriano and Jesi towns
Funding	Collaborative project
Duration	2012 - 2013 (ongoing)
Targeted Customers	50 (residential and prosumers)
Other	Participation on voluntary basis, with no cost for customers involved
Partners	Enel Distribuzione, Telecom Italia (TelCo operator), Indesit (white goods manufacturer)

Table 1: Trial Energy@home fact box

Within the Energy@home trail, smart customer services are enabled through the implementation of an architecture model compliant with Zigbee Home Automation, providing the end user with higher

quantity and quality of information together with tailored functionalities. An integrated management of distributed generation and customer loads is performed locally while contributing to the security and stability of the whole electricity energy system. Given the available automated metering infrastructure, the DSO provides relevant certified meter data to other market players, which can add further information such as electricity price and tariffs to provide customers with innovative services. The reference system architecture consists of the following main elements:

- The Smart Meter, responsible for providing certified metering data and allowing a bidirectional communication between the DSO's central system and the customer premises.
- The Enel's smart info<sup>®</sup>, which provides end users with certified information on electricity consumptions, through a standardized and secure bridge with the DSO's systems. Being plugged in any house socket, it communicates with the smart meter through power line communication (PLC) and makes certified metering data accessible to other market players in a nondiscriminatory way. The Enel smart info assigned to a customer provides only the data coming from the smart meter which is contractually associated unequivocally to him;
- The Smart Appliances, or white goods, are able to cooperate by adjusting their power consumption according to a pre-programmed preference or a signal from a third party. While preserving the quality of service and user experience, they are able to control their processes, offering flexibility in terms of time and energy profile;
- The Smart Plugs, implementing an on/off control on the plugged energy loads which aren't Smart Appliances;

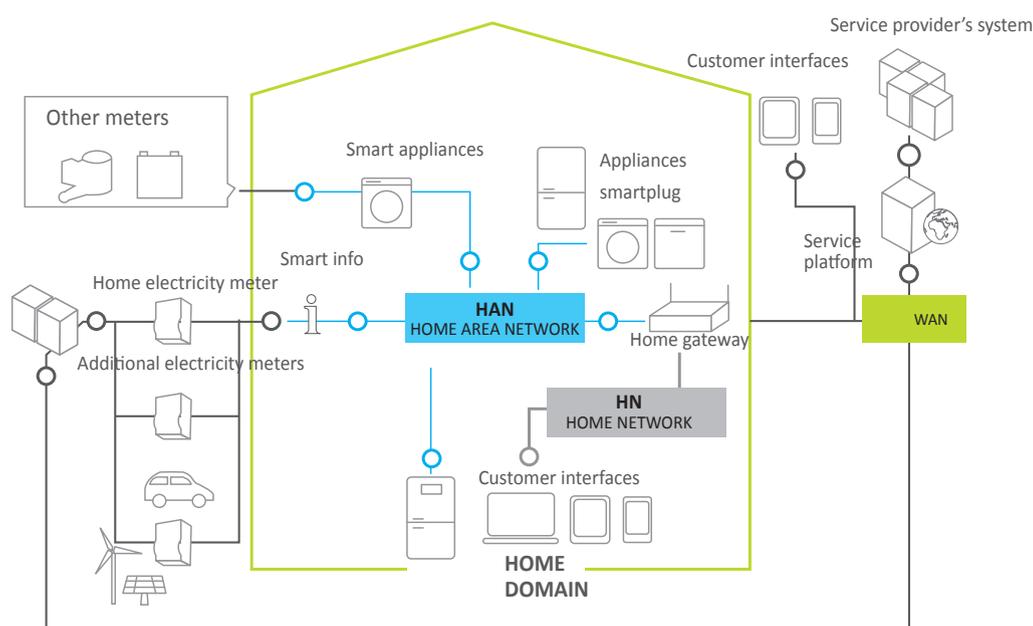


Figure 2: Energy@home architecture

- The Home Residential Gateway allows data exchange between the devices in the Home Area Network and the Internet, through a cloud-connected service platform. In addition to the Home Gateway allowing the necessary connectivity, it acts as the central home coordinator resolving between appliance capacities and system requests.
- The Customer Interfaces, which are all the devices (such as personal computers) that can be used by the customer to monitor and configure his energy preferences.

Alongside customer energy awareness and monitoring, additional use cases for automated control at customer premises have been defined and developed within the trial:

- *Load flexibility by the coordinated management of appliances*, represents the full interaction of the home appliances as a result of the information coming through the meter alongside other signals such as applied energy tariffs. Such use cases include energy consumption monitoring, coordinated appliance planning and temporary reduction of power consumption taking into account the user needs: smart appliances can start functioning at non-peak (less expensive) hours and also cooperate to avoid overloads by automatically balancing consumption without jeopardizing an appliance's designed function or performance;
- *Energy generation and consumption coordinated management*, represents the cooperation between local renewable energy generation (e.g. roof PV panels, small wind turbines) and energy consumption. Customers, or in this case prosumers, can either consume or sell energy by accounting for network needs, tariff schemes, price signals and incentives, and shift their consumption accordingly. Application software and algorithms addressing the optimal use of energy accounting for several boundary conditions and signals are currently being tested in the trial.

## ADDRESS<sup>11</sup>

As a step forward, an Aggregator that manages a portfolio of consumers is able to offer active demand services, in markets or through bilateral relationships, to the other market players. The Aggregator sends price-volume signals studied in order to be as simple as possible, and structured in a way that consumers can gain economic incentives if their load profile is within a certain band in a certain period.

However, the modification of the load profile stemming from the AD market may have a negative impact on network security and quality of supply, and contradictory actions might be performed, raising the need for coordination among the involved players. In particular, this implies that DSO plays a double key role: as validator and enabler of the AD requests and buyer of the AD products through markets or bilateral relationships. The electrical distribution network management in the presence of AD was tested

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<sup>11</sup> [www.addressfp7.org/](http://www.addressfp7.org/)

in the Italian field test. The results indicated that it was not possible to involve an adequately high number of Low Voltage (LV) consumers, AD products were provided by means of one storage system (1MW, 0.5MWh). MV producers and customers were engaged for the test of the distribution network supplied by the HV/MV transformer of the Carpinone substation, covering 340 km of network, 10 MV feeders and 157 MV/LV substations. The developed functional architecture needed by DSO's to implement those roles and responsibilities encompasses three levels: the Central Control Level, the HV/MV substation level and the MV/LV substation level, with intelligence distributed throughout. TSO validation was also included to investigate the whole chain of the Active Demand. In particular, the following steps and required systems and functionalities have been tested within the technical architecture envisaged by Enel Distribuzione:

ADDRESS PROJECT	
Project Purpose	To enable AD by developing technical solutions at the consumer premises and at the power system level, proposing recommendations and solutions to remove the possible barriers, identifying benefits for stakeholders and developing appropriate markets and contractual mechanisms
Italian test's Value	To test distribution network management in presence of Active Demand in order to verify operating conditions and enable a full exploitation of the AD products and services
Location of the Italian test	Isernia (Carpinone)
Funding	FP7 Program
Total ADDRESS Budget	16 Mln€ (9 Mln€ EC fund)
Budget Enel in the ADDRESS project	2Mln€ (1.3 Mln€ EC fund)
Duration	2008-2013 (Ended)
Project Partners	Enel Distribuzione (Project Coordinator); UK Power Networks, Iberdrola Distribución Eléctrica, Vattenfall, University of Manchester, Universidad Pontificia Comillas, Università di Siena, Università di Cassino, ENEL Ingegneria e Innovazione, VTT, VITO, Tecnalia, KEMA, Consentec, EDF-SA, ENEL Distributie Dobrogea, ABB, Landis+Gyr, ZIV, Philips, Electrolux, RLtec, Ericsson España, Alcatel, Current

Table 2: ADDRESS Project fact box

- Aggregators send intended AD-actions to DSO for validation through the Active Demand Management System (ADMS), responsible for validation management and coordination with the TSO;
- Technical Validation is performed by the DSO through the Distributed Management System (DMS), responsible for the verification of AD-products in terms of implied impacts on network management;
- Validation is then verified by TSO (through ADMS);

- Acceptance (or rejection) is sent to aggregator (through ADMS);
- DMS sends the power information to emulate the AD-action through the SCADA system, responsible for data collection and remote control of network devices;
- The SCADA system communicates the settings power to storage through a network data concentrator. The SCADA system remotely controls the power injected into and withdrawn by the network or by the storage system;
- The SCADA system and DMS work together to detect the new state of network to determine the impact of AD on the grid.

## **Current Status & Results**

### **Recruitment**

Enel Info+ pilot project was launched in 2012 and currently involves 19 towns with a high penetration of renewable generation connected at the MV level, in the Isernia Province (Southern Italy). More than 8,000 eligible LV customers were sampled, of which there are more than 100 eligible prosumers, with an average age of 45 years and a low-medium computerization level were found. About 4,000 of these LV customers have already been equipped with the Enel's smart info®.

In order to successfully activate consumers, Enel Distribuzione carried out information sessions, first involving local authorities and then customers. Meetings with mayors and a meeting with local consumers' associations have been arranged to present the Enel Info+ project, to establish a successful collaboration and to explain the potential benefits of recruitment. More focused meetings have been also arranged with participants for them to know the project details.

### **Engaging Customers**

Considering the lack of customer knowledge and awareness on electricity consumption and potential benefits from their active interaction with the energy system, a step by step customer engagement approach has been adopted. The LV customers have been initially equipped with the Smart Info Display and are therefore receiving basic feedback on their consumption. The rationale was to get customers used to a new technology, thus avoiding rejection of additional technologies and services. An upgrade is planned in the few months following installation, to progressively increase the complexity and value proposition offered. Prosumers receive an additional smart info device to manage both production and consumption metering data.

First results highlighted a remarkable use of the display, pointing out prosumers as the most active. Observed customers found it helpful to be informed of tariff bands once they had real time power monitoring. Small commercial consumers were shown to be particularly interested in these capabilities.

Flexibility enabled through customer engagement is generally a challenge to maintain in the period following initial recruitment. A web portal and a dedicated help desk have been designed and implemented to provide general information about the project and continuous technical support. Additionally, on the basis of the abovementioned investigations, participants will quarterly receive reports (e.g. evaluation of

their level of consumption, also compared with the one observed in the previous year as well as with the other participants, the neighbours having similar-sized households, etc).

In the Energy@home project, 13 initial users have been involved in the trial since 2012 in order to validate the technology and to collect the necessary information to fine tune the developed functionalities and improve the customer experience. These enhanced engagement opportunities will support plans to extend the number of customers involved by 50, and to include prosumers. Initial feedback has shown positive consumer expectations for living with the technology and enhancing their awareness of energy consumption by specific appliances. The developed solutions have generally been found to be easy to use with a remarkable frequency of use. Customers also highlighted interest in overload notification and control, together with functionalities for in-house energy generation.

### **Measuring Impact**

The customer sample living in the municipalities involved in the project have been observed by Enel Distribuzione since 2011, in order to collect pre-trial data on the energy consumption behavior. The energy consumption behaviors observed during the trial will be compared with the pre-pilot data and analyzed in relation to several factors (e.g. household size, number and type of appliances, etc.). To assure that the use of the Enel Info+ kit is actually responsible for any load curve changes, a control group of consumers, excluded from the trial participation, has also been selected and will be monitored throughout the project duration. Additional useful information will be gathered by three different sets of quantitative interviews, with the following objectives: (i) to define a representative behavioral model in terms of habits, household size, family composition, education, etc. before the massive distribution of monitoring kits; (ii) collect preliminary data on consumers' awareness, technology understanding and attitude towards energy efficient use alongside first impressions of the Enel Info+ kit, two months before the planned installation; (iii) assess of customer energy behaviors at the end of the trial, thus estimating the effect of the developed monitoring technologies and solutions. Moreover, more focused interviews on a sample of about 20 residential consumers will be carried out under the project ADVANCED, to provide with useful insights into the socio-economic drivers.

### **Enabling the full active demand chain**

Looking upstream the Active Demand chain (from AD buyers to aggregators), the DSO's algorithms and prototypes to enable and exploit AD have been developed and run in the ADDRESS Italian field test, proving that flexibility from Active Demand can be used to solve network management issues. In particular, requests by deregulated players have been simulated and the DSO received bids for 5.50 MW for the intraday and day-ahead Active Demand market to be validated through properly fine-tuned algorithms. In some cases, a product curtailment was necessary to ensure a reliable network operation.

## System operation results

Alongside the role of DSO as AD validator, the DSO as AD product buyer to resolve network problems (especially in presence of distributed energy source) has been simulated. The DSO bought Active Demand products totaling 0.3 MW to resolve expected network congestions thus avoiding MV cable overloading. No network violation was observed in the simulation. Also, the TSO's role as an Active Demand buyer to solve transmission system problems was tested with the aim to limit reverse power flow phenomena through the HV/MV substation. The TSO bought Active Demand products totaling 1.2 MW in the MV network of Carpinone.

## Lessons Learned & Best Practices

Active demand is not fully in place in Italy and a regulatory framework is still missing. As a matter of fact, pilot projects, as described above, have been launched to pave the way forward the implementation of the active demand solutions, from technological, commercial and regulatory standpoints.

According to the experience of the ADDRESS project at the European<sup>12</sup> level together with the ongoing national experiences in Italy, recommendations and lesson learned can be formulated as follows, with some insights on the necessary actions to be performed for fully enabling Active Demand in Europe:

- *Consumer engagement and involvement:* participation in active demand programs is voluntary; therefore a deep understanding of the benefits and implications from flexibility and adaptability of the consumptions (both from customer and a whole system perspective) should be addressed while maximizing the utilization of the technology. All contextual issues, as regional context, age, social conditions, are important and the full range of benefits has to be communicated to appeal to a range of customer values including not only financial benefits but also environmental benefits. Moreover, contracts and agreements with customers need to be understandable and transparent, and, as general principle, consumer privacy and data must be protected. However, alongside recruitment, a real challenge is to keep customers on-board: for this reason, the provision of technical support and frequent communication following technology installation are fundamental principles for continued involvement in managing the electricity system.
- *Coordination among the involved players and reliability of the electricity system:* as earlier mentioned, AD can be used to contribute to solve network operation problems, thus representing an additional source for electricity System Operators (SOs). However, coordination is necessary among SOs and aggregators in order to properly localize load areas and assure network security and reliability while considering local constraints. Therefore, responsibilities

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<sup>12</sup> [www.addressfp7.org/](http://www.addressfp7.org/)

have to be clearly set out and SOs' regulation updated to include fixed costs associated to the services provided to enable AD and to purchase AD products (country specific).

- *Communications infrastructures:* in order to enable an open market for services with positive business cases, standardization and interoperability of the developed solutions and devices need to be addressed. Therefore, the use of available, open and proven standards for AD related communication is recommended with no restriction to specific communication channels in order to avoid ruling out certain AD participants. Heterogeneous communication infrastructure needs to be acknowledged and interoperable standards preferred to assure a successful commercialization of smart devices.
- *Market and regulation:* as general principle, consumers must be free to opt in and out, with clear rules on the ownership and protection of data need. Moreover, rules and mechanisms for verification and measurement of AD product delivery, fair allocation of costs and benefits among all the involved players, with a fair competition have still to be established and guaranteed for Active Demand to be put in place.

Three main challenges to the massive deployment of Active Demand solutions can be identified: (i) Active Demand implies a complex, multi-stakeholder system and requires several tools/devices to work together, thus featuring really high complexity; (ii) the full AD chain is not presently existing in EU and the regulation to exploit AD is not completely in place; (iii) to be fully exploited, AD programs should be understood and largely adopted by a suitably high number of consumers (whose constant involvement is one of the greatest challenges).

Therefore, we are still on the way toward Active Consumers who fully participate in the management of the electricity system. For AD to be successful, a gradual implementation should be carried out by first adopting solutions for monitoring (to raise customer awareness and involvement), then in-home control (to get customers used to technology), and finally full interaction with the electricity system (covering the whole AD chain).

### **Regulations, Legislation & Guidelines**

*Directive 2006/32/EC on energy end-use efficiency and energy services (translated in Italy into Legislative Decree 115/08) <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:114:0064:0064:en:pdf>*

*Resolution ARG/com 56/09 on a procedure for the definition of measures on demand management and control, and efficient energy use <http://www.autorita.energia.it/it/docs/09/056-09arg.htm>*

*Resolution ARG/elt 22/10 on ToU tariff for domestic customers under the universal supply regime <http://www.autorita.energia.it/allegati/docs/10/022-10arg.pdf>*

*Consultation DCO 34/11 on criteria for distribution and measurement for the regulatory cycle 2012-15*



<http://www.autorita.energia.it/allegati/docs/dc/11/034-11dco.pdf>

*Directive 2012/27/UE of the European Parliament and of the Council on energy efficiency* <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:315:0001:0056:EN:PDF>

# JAPAN

<b>Project ownership</b>	Kitakyushu Smart Community Council
<b>Overview of Yahata Higashida district</b>	<ul style="list-style-type: none"><li>· Area: 1.2 km<sup>2</sup></li><li>· Employment: About 6,000</li><li>· Residents: About 900</li><li>· Corporations and organizations: About 210</li><li>· General households: 230</li></ul>
<b>Power supply</b>	<ul style="list-style-type: none"><li>· Supply source: Yawata Steel Works, Nippon Steel &amp; Sumitomo Metal Corporation</li><li>· Power generation facility: Natural gas engine cogeneration (33MW)</li><li>· On-premise distribution: Supplied through private line</li></ul>
<b>Objective</b>	<ul style="list-style-type: none"><li>· 50% CO<sup>2</sup> reduction (as compared with general districts in city in 2005)</li><li>· 20% energy conservation</li><li>· Peak shaving: 15%</li></ul>
<b>Project scale</b>	38 subjects, 16.3 billion yen
<b>Contact</b>	Smart Community Policy Office, Energy Conservation and Renewable Energy Department, Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry TEL:81-3-3580-2492 Smart Community Grand Design Department, Power & Social Infrastructure Business Group, Fuji Electric Co., Ltd. TEL:81-3-5435-7204

# JAPAN

## Kitakyushu Smart Community Creation Project



The Kitakyushu Smart Community Creation Project was selected by the Ministry of Economy, Trade and Industry of Japan in April 2010 as a project in one of four areas where the Next Generation Energy and Social System Demonstration Program, which aims at creating a Japanese-style smart grid and its overseas deployment, is to be implemented.

This project was launched by “Kitakyushu Smart Community Council” that comprises more than 73 firms and organizations, including City of Kitakyushu, Nippon Steel & Sumitomo Metal Corporation, IBM Japan, Ltd., YASKAWA Electric Corporation, and Fuji Electric Co., Ltd.

Master Plan (1) was formulated to cover the project scale of a total of 16.3 billion yen and 38 subjects including regional energy management and installation of solar PV equipment in five years from 2010 to promote this project.

- This year is the fourth year of the 5-year demonstration period (fiscal 2010 to 2014) in which the demonstration tests of demand response etc. are being conducted.

# JAPAN

## Kitakyushu Smart Community Creation Project

Phase	Period
Basic design, discussion on the system	May 2010 ~ October 2010
System design	October 2010 ~ March 2012
System making, test	December 2010 ~ September 2011
System design for demand response	April 2011 ~ June 2012
Installation at a local site, connection test	December 2011 ~ March 2012
Demonstration test	April 2012 ~ March 2015

Table 1: Planning of the Kitakyushu Smart Community Creation Project

Higashida cogeneration power plant of Higashida Cogeneration Corporation is wholly owned by Nippon Steel & Sumitomo Metal Corporation and is supplying power throughout Higashida district. Higashida Cogeneration possesses a power generation facility (33 MW) consisting of a natural gas engine cogeneration system in the premises of Yawata Steel Works of Nippon Steel & Sumitomo Metal Corporation, which is in charge of selling electricity. In addition, Higashida Cogeneration Corporation also has a private electric power transmission line in the Higashida district to supply power to the households, factories, offices, etc.

“Kitakyushu Hydrogen Town Project” aims at effectively using hydrogen extracted from byproduct gas generated in the course of steelmaking process at the steelworks. This hydrogen is supplied as fuel through hydrogen pipeline running through the town to pure hydrogen fuel batteries installed at hydrogen stations in Kitakyushu and the housing complexes, commercial facilities, and public facilities in the Higashida district, so that electric power and heat generated by the fuel cells can be used as energy.

### Objectives & Benefits

The objectives of this demonstration project are as follows:

- Effective use of energy (electric power, heat, hydrogen) in the entire district
- Proposal on how distributed energy system should be used
- Realization of energy conservation and peak shaving of demand for electricity

To achieve the above objectives, the following will be implemented:

Establishment of new energy system centered in a community energy conservation site and in coordination with Building Energy Management System (BEMS) and Home Energy Management System (HEMS)

- Demand side management of customer participation type such as “dynamic pricing” and “incentive program”

The effect of the above implementation, including the total effect of the measures taken so far, is expected to be “50% of reduction of CO2 from that of the ordinary blocks in Kitakyushu City”.

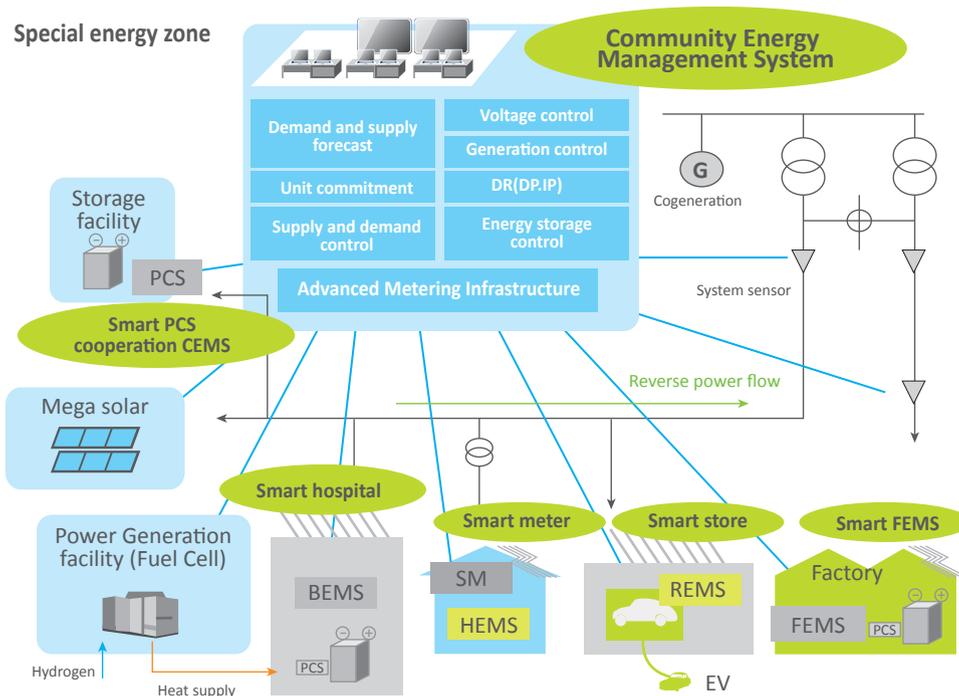


Figure 1: Field demonstration of community energy management

## Project Design

Community Energy Management System (CEMS) is the core of the field demonstration project, and is installed in the Smart Community Center. It communicates with Home Energy Management System (HEMS), Building Energy Management System (BEMS), Factory Energy Management System (FEMS) and Retail Energy Management System (REMS) via AMI (Advanced Metering Infrastructure) including smart meters. These systems and meters make it possible to implement the demand response. Furthermore, the CEMS communicates with distributed power such as solar power, wind power, and fuel cells in the area and controls charging and discharging of a Community-installed Storage Battery System according to power demand and the amount of power generation. At the same time, it induces peak shift and energy conservation by consumers with dynamic pricing that varies the electricity rate according to time of day. BEMS and HEMS control the load such as building equipment, EV charging stations and home appliances on the basis of the dynamic pricing information.

Figure 1 shows an overall configuration of the field demonstration. The field demonstration system is composed of demand side EMS (HEMS/BEMS/ FEMS/REMS), which optimally operates energy from the demand side (home, companies and factory), distributed generations and community-installed battery storage system, which supplies energy to the area, and the CEMS which optimally and comprehensively controls the demand and supply.

Furthermore, an in-home display shows energy information from the CEMS and smart meters are installed for each consumer.

# JAPAN

## Kitakyushu Smart Community Creation Project

### Community energy management system (CEMS)

Table 2 lists the functional items of a community energy management system. CEMS forecasts energy demand and supply for the entire community, formulates a plan to operate cogeneration and electricity storage systems, and delivers dynamic pricing information to smart meters and consumer energy saving systems. Picture below shows the CEMS.



Picture of CEMS

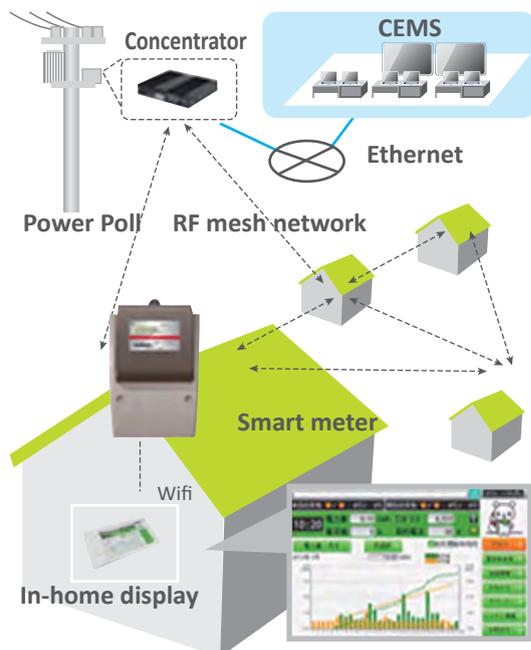


Figure 2: Smart meter system configuration

### Smart meter system

Figure 2 shows the smart meter system configuration. A smart meter bilaterally communicates with a community energy management system via a concentrator. Communication between the smart meter and the concentrator is established by a wireless mesh. Dynamic pricing information from the CEMS is displayed on an in-home display by a WiFi system through a smart meter to show the effects of energy conservation and load leveling.

Function	Control of power generation and storage based on energy supply and demand
	The stabilization by coordination of large-scale power grid
	Understanding of energy usage of each consumers
	Demand side management such as consumers' load control and dynamic pricing, etc.
	Connection with energy management systems of consumers and variety of energy equipment in standard procedures
	Creation of new services by the visualization of energy usage and the data of CO <sup>2</sup>

Table 2: Community management system functional items

### Storage batteries installed in the community

Figure 3 shows connection of a community electricity storage system. This system consists of a secondary battery and a smart power conditioning system (PCS). The electricity storage system bilaterally transfers information with the CEMS to level out the load of the community grid and to supply emergency power, maintaining the power quality of the grid with functions such as the instant frequency fluctuation control and voltage control by reactive power.

In concert with solar cells and fuel cells installed in the community, it also autonomously operates to sustain electric power supply to important loads in case of an emergency.

### BEMS

A Building Energy Management System (BEMS) is installed in the office buildings, multi-tenant buildings, commercial facilities, and the hospital. It contributes to the conservation of energy and electric power, manages the effective use of energy in the facility, stabilizes the demand and supply and the quality of electric power by using a heat storage system in a facility that demands a lot of hot water.

### FEMS

Installed in a factory and coordinating with a CEMS, a Factory Energy Management System (FEMS) contributes to conservation of energy and electric power, and effective use of energy in facilities. It stabilizes demand and supply and improves the quality of electric power, by controlling air conditioning, lighting, and batteries in accordance with the demand and supply forecast and price information sent from the CEMS. The FEMS optimizes energy use and operational costs based on the expected amount of energy that can be generated by renewable energy sources, and the fluctuation of the electric power load in the factory, which may stem from the production plan.

### HEMS

A home energy management system (HEMS) is installed in an ordinary household. Coordinating with the CEMS, it realizes the conservation of electric power and leveling out of the load by controlling the air conditioners, electric appliances, and batteries in the household, in response to the request from the CEMS.

### Demand side management (design of demand response system)

Demand response in this demonstration project is implemented by using two methods in combination: dynamic pricing (DP) and an incentive program (IP). DP is a method to get responses from consumers by changing the unit price of electric power during peak hours and thus using the unit price as a trigger. There are 3 types of DP systems, as described below:

DP for 2012 was designed based on a system called Critical Peak Pricing (CPP).

- 1) Basic pricing: This pricing system is set at the beginning of a year and feeds into a seasonal hourly unit price pattern, which serves as a basis of the year, based on the past result of demand for and supply of electric power.
- 2) Real-time pricing: This pricing system sets the unit price of electric power for the next day by multiplying the unit price of the basic pricing system by a predetermined multiplier which is derived from weather forecasting and other forecasted events such as the amount of energy that will be generated by renewable energy sources and demand and supply expected on the following day.
- 3) Critical peak pricing: This system sets the unit price based on an emergency unit price pattern that is decided in advance for a change in situation that could not be predicted on the day before (such as a significant change in the amount of electric power generated by renewable energy sources or a substantial fluctuation in demand for electric power).

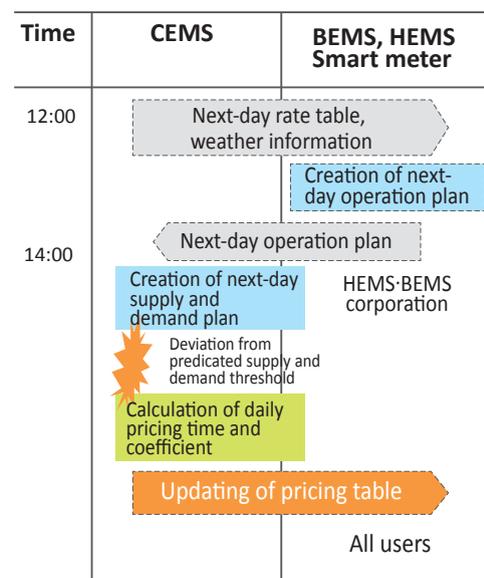


Figure 3: Example of Dynamic Pricing demonstration

A CEMS forecast of electric power demand and supply is issued a day ahead, along with a table of prices for the next day to consumers' EMS and smart meters. Based on this price table, the consumers' EMS formulates and sends an operation plan for the next day to the CEMS, which, in turn, determines the price table for the next day. Figure 4 shows an example of DP demonstration.

### Current Status & Results

The following figure shows the 5-year demonstration schedule. At the time of writing this case book, the demonstration project is in its fourth year.

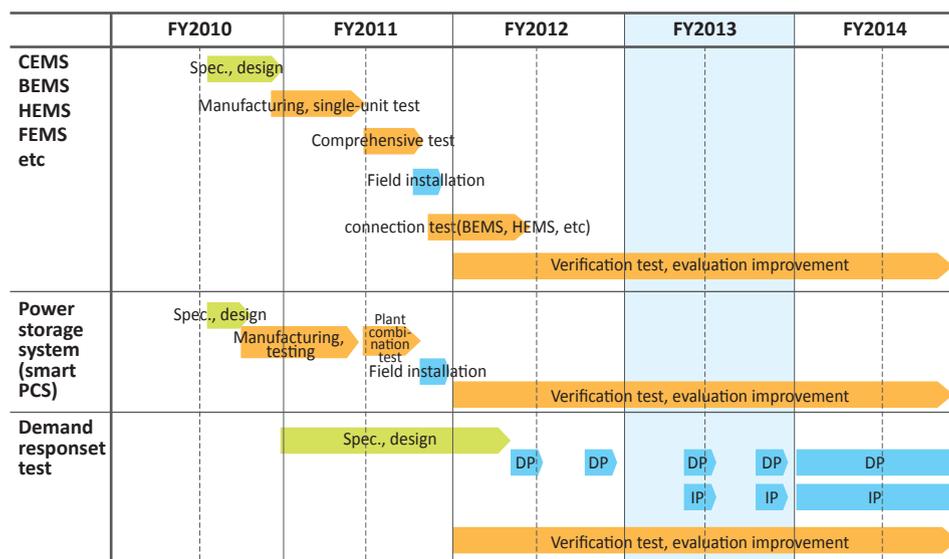


Figure 4: Overall schedule

### Design of social demonstration with the Dynamic Pricing

In the summer of 2012, a DP demonstration project was implemented for the first time in Japan. The result of the activities aimed at general consumers is described below. Social demonstration of DP was started with participants in the project divided into several groups, including a group for which the price was changed (treatment group) and a group for which the price was kept unchanged (control group), under the guidance of experts, so that the data gathered could be used for international standards development.

In the first year of the social DP demonstration project, a new, variable critical peak pricing (V-CPP) scheme that set five levels of peak price was devised. The goal was to have residents participating in the project respond to peak prices and to ascertain what price level, if any, is effective, depending on how urgent the demand-supply situation of electric power may be.

In summer, the price for 1 kWh of electricity during peak hours of 13:00 to 17:00 in June through September was set at 15 yen for level 1, 50 yen for level 2, 75 yen for level 3, 100 yen for level 4, and 150 yen for level 5. Consumers were randomly charged between levels 2 (50 yen) and 5 (150 yen) on weekdays when demand for electric power was expected to be high due to temperatures forecasted to rise above 30°C. Residents were notified a day ahead of time as to what the peak price would be.

Figure 5 shows the 5-level pricing table. Note that the basic pricing table shown in Figure 6 was the regular price applied to the control group. In designing this pricing scheme, revenue neutrality was taken into account under the guidance of experts so that the participant residents would not incur any net loss, by limiting the number of days per year when the higher price of level 2 to 5 was charged to a total of 96 days, or 24 days at each level, with the lowest level 1 being charged on the remaining 270 days.

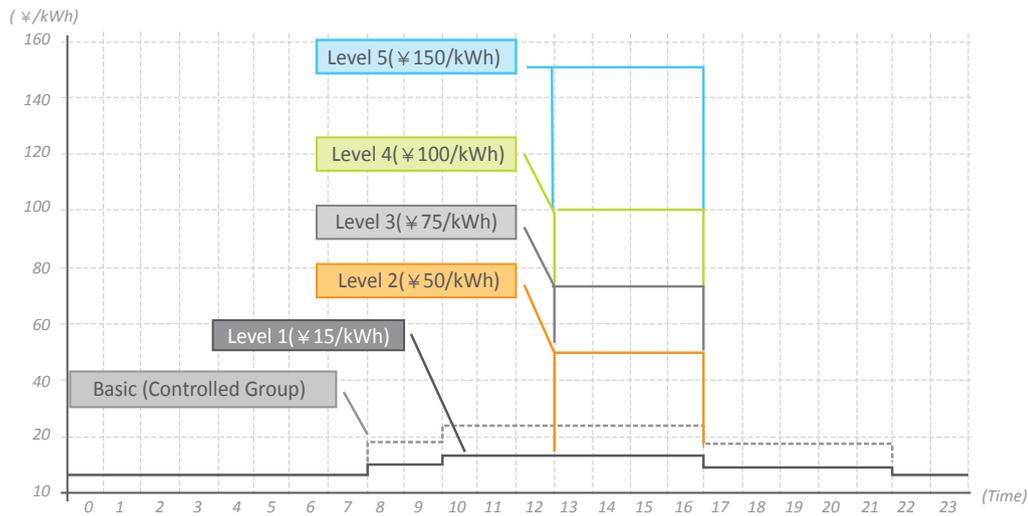


Figure 5: Fee table (summer)

### Results of social demonstration of dynamic pricing

Levels 2 to 5 were charged 10 days each, a total of 40 days, in the summer of 2012, when the highest temperature exceeded 30°C. The result was within the range of initial planning which predicted that the number of days for the levels 2 to 5 would be maximum 12 days each, totaling 48 days..

Figure 7 shows the load curves at each pricing level of the treatment and control groups. The vertical axis indicates the average electric power consumption (logarithmic value) and the horizontal axis shows the time (from 10:00 to 20:00). As is evident from Figure 7, the power consumption among the treatment group substantially declined during peak hours of 13:00 to 17:00 because level 2 to 5 was applied.

Statistically estimating the result shown in Figure 7 by using a technique of econometric analysis, the electric power consumed by the treatment group during the peak hours decreased as follows:

- About 9.0% at level 2 (50 yen)
- About 9.6% at level 3 (75 yen)
- About 12.6% at level 4 (100 yen)
- About 13.1% at level 5 (150 yen)

This is a statistically significant decrease.

The peak shaving effect of the treatment group ranged from about 9 to 13%, indicating that the higher the pricing level is, the greater the effect.

The residents who participated in this demonstration project were under TOU (time of use) rates that set a difference in price between the peak time and off-peak time. A field experiment of an hourly rate system conducted in 2011 by the Ministry of Economy, Trade and Industry (METI) of Japan resulted in peak shaving effects of 9.1%. By combining the peak shaving effect of V-CPP in this demonstration project with that of the METI field experiment, the value of the peak shaving effect could increase to about 18 to 22%.

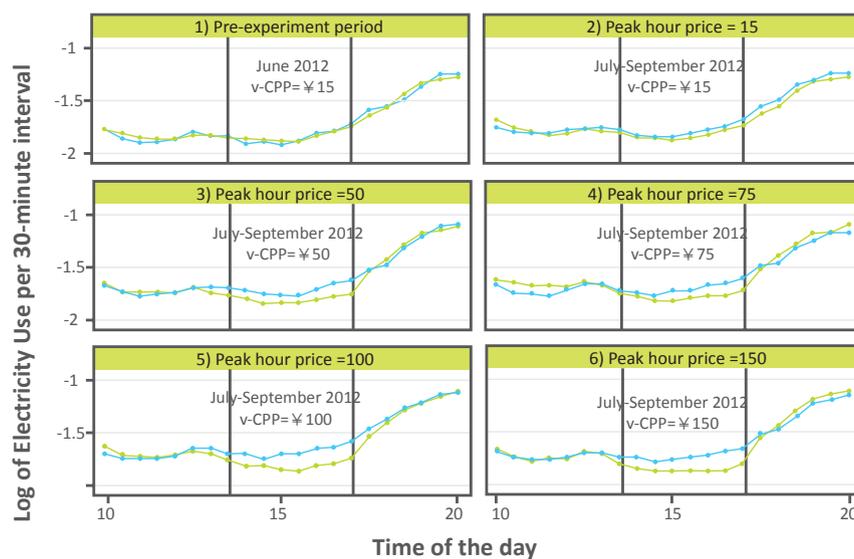


Figure 6: Dynamic pricing demonstration results (summer)

The demonstration planning and results are outlined in the following Table.

Phase	Period	Period
1	15	-
2	50	18.1
3	75	18.7
4	100	21.7
5	150	22.2

Table 3: Demonstration planning and results of Kitakyushu Smart Community Creation

DP activation condition: random activation of level 2 to 5 at the highest temperature exceeding 30°C

Operation period: June – September

Time zone to apply DP: 13:00 – 17:00

Number of DP activations: maximum 48 times

DP notification to the demand side: after 14:00 on the previous day

### Lessons Learned & Best Practices

Many residents and companies participated in this program. About 85% of 230 general households and almost 100% of the companies, or 50 companies, in the Higashida district participated in this demonstration project.

The high participation rates were attributed to multiple outreach efforts by city hall explaining the project to business owners and general residents and requesting their participation in the project. City hall efforts went so far as to visit all the offices in the district, thereby making this social system demonstration project, the Kitakyushu Smart Community Creation Project, significant. It also helped that the project was designed so that the residents and offices did not have to pay any expenses in participating the project, as all expenses were shouldered by the operators of the project (such as companies).

In these experiments, the targeted households have been randomly divided into two groups; “treatment group” (dynamic pricing is applied) and “control group” (dynamic pricing is not applied). This method, which called RCT (Randomized Control Trial), is based on the guideline of DOE (Department of Energy U. S.). Comparing these two groups, it is possible to verify the effect of the demand response with the dynamic pricing.

### **Method of DP notification**

As a demonstration, the price was randomly changed by the DP system but this pricing system needs to be reviewed to implement an actual demand-supply balancing operation for a community as a sustainable business.

In addition, the timing and frequency of price notifications and a method of distributing information, taking easiness to understand into consideration, must also be studied, aside from the review of this pricing system. For example, consumers and general households where an EMS was not installed only had an in-home display (visualization terminal) installed. The display of information such as the frequency, time band, and the method of notification was an important element for these consumers.

### **Developing the business of EMS**

For the demonstration project to grow and expand to an actual business, it is necessary to find economic advantages of the installation of an EMS and batteries, using various economic indexes and taking into account of the consumer burden of paying for the installation. To this end, various market incentives must be studied by the operators of the demonstration project and potential political assistance measures must be studied by the government. That effort will lead to the wider use of the equipment and related systems, as well as the expansion of their markets.

### **Role of CEMS and further study**

A CEMS, which can play a pivotal role in community energy supply business, is regarded as an interface between a large-scale power generation facility and consumers, playing a role of adjusting demand and supply of energy in the community. It monitors the electric power generation and transmission in the community, and consumption by consumers, and stabilizes demand and supply in the community in concert with the large-scale power generation facility.

To adjust demand and supply, the demand side should be controlled by using DR techniques such as DP and IP and, at the same time, inexpensive and stable electric power should be supplied to the community by effectively using the renewable energy source in the community and purchasing electric power from the market in negawatt transactions. In addition to controlling the demand and supply of electric power, CEMS also provides and accumulates information on the energy use by the consumers. That can create



added values for the demand side, because such information should be helpful in exploring the possibility of new business development.

Further detailed study is considered necessary, based on the result of the demonstration, to fully deploy this approach over a wide area.

### **Key Regulations, Legislation & Guidelines**

Government subsidy support: The smart community trial project was considered as one of the energy policies of the Japanese government and as such two-thirds of the expenses for the project were covered by a subsidy from the government from the Next Generation Energy and Social System Demonstration fund. In addition, the government agreed to provide assistance for up to five years.

The total subsidiary from the Ministry of Economy, Trade and Industry in 2013 for Kitakyushu and other regions was about 8.6 billion yen.

This alleviated the financial burden of businesses participating in the trial project and contributed to accelerate the smooth dissemination of these relevant technologies. In this context, this government assistance was quite useful.

For the trial project in Kitakyushu, the “Kitakyushu Smart Community Council” was established by mainly the city of Kitakyushu, which played the central role in deliberating the basic policy and the content of the project and in implementing it.

It is considered that a cooperative system was created because many companies and organizations participated in the project and because the city government played the central role, acting as a go-between for the local residents and companies.

### **Next Steps**

Expanding the result of the Kitakyushu Smart Community Project at home and abroad is being promoted. In particular, expansion to foreign countries requires establishment of close relation between the government, municipalities, and public organizations in those countries.

It is considered important to proceed with expansion in cooperation with not only Japanese companies but also the Japanese government and related organizations.

A CEMS adjusts energy supply and demand in a region and involves negawatt transaction. It is hoped that the domestic transaction market is further vitalized by an increase in the amount of electric power supplied and consumed.

It is expected that the above is supported by electricity liberalization promoted by a report of the Expert Committee on the Electricity System Reform that was commissioned by the government, advent of PPS (Power producer and supplier) operators, and increases in negawatt transactions.

# KOREA

<b>Market structure</b>	Hybrid structure of vertically integrated and single buyer utility (KEPCO). KEPCO owns, installs and maintains all meters.
<b>Number of retail customers</b>	50 million
<b>Electricity consumed (2011)</b>	443.4 TWh
<b>Peak Demand for Power (2011)</b>	73,137 MW
<b>Net Revenue to Distribution</b>	-
<b>Distribution Network</b>	Over 600V: 209,604 km Under 600V: 225,945 km
<b>Contact</b>	Dr. DJ Kang dj kang@keri.re.kr Dr. Kary Song karysong@keri.re.kr Korea Electrotechnology Research Institute (KERI)

# KOREA

## ESS as Active Demand Management for Customers



Traditional demand side management (DSM) has required the electricity load of customers to be directly interrupted or adjusted in order to reduce the consumption or to change the consumption pattern of the users. Recent technical progress, gradual changes in electric power policy and industry environments have positioned distributed energy resources as a prospective option for demand side management. Particularly, with Korea's strong promotion policy on the energy storage industry, energy

# KOREA

## ESS as Active Demand Management for Customers

storage systems (ESSs) have proven to be an important asset for demand management. Among a variety of DSM programs implemented in Korea, ESSs can be effectively utilized under the following programs.

- Time-Of-Use (TOU) electricity tariffs
- Load management programs: advance notice, designated period, emergency load reduction
- Electric power demand resource market

The Korean government has initiated various demonstration projects and deployment projects of ESSs for demand side management. This case introduces the ESS deployment project which has been promoted as a part of the “smart grid Deployment Support Project”. The purpose of the smart grid Deployment Project is to improve the power consumption profile through the deployment of ESSs and AMI (Advanced Metering Infrastructure), to overcome the limitations with the current one-way method of providing energy information and managing the electricity system.

### Objectives & Benefits

#### Objectives

- Improvement of electric power consumption patterns through ESS and AMI deployment (Deployment target: ESS 11MWh, AMI 12,000 units)

#### Benefits (expected results)

- Effective use of energy such as electricity demand reduction, peak load reduction, power quality improvement, etc. through deployment of key smart grid devices such as Advanced Metering Infrastructure (AMI) or Energy Storage System (ESS), etc
- Preparing infrastructure, accelerating revitalization of related smart grid industry and contributing to raising awareness of smart grid by building up smart grid at an early stage
- Providing various power portal services and enabling direct control of consumers load using the existing IT network
- Opening up domestic ESS markets and encouraging voluntary customer engagement
- Contributing to stabilization of power supply/demand

**Deployment target:** Deployment of ESS 11MWh and AMI 12,000 units

**Budget:** 17.8 million USD (Ministry of Trade, Industry and Energy) + 5.9 million USD (Project participants)

## DSM through ESS and AMI deployment

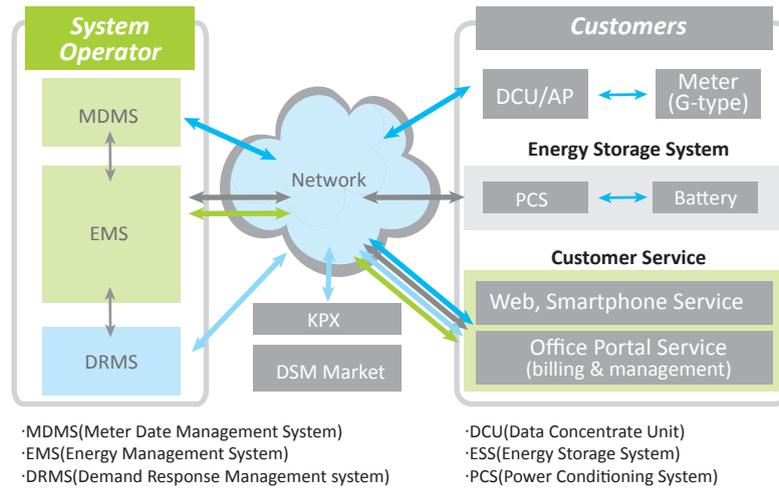


Figure 1: Demand side management through deployment of ESS and AMI

- The system operator collects system data from individual customers and provides services and controls to the customers over a wide area network.
  - Each customer measures and sends its own system data to the system operator
  - The EMS of the system operator analyzes the collected data, offers energy information services, and sends control signals to the customer EMS or connected demand response devices
  - The market operator(Korea Power Exchange, KPX) opens the DSM market and determines the DSM required and the market price for those resources
  - The customer EMS responds to the controls signals from the system operator EMS and operates either the ESS or adjusts its load

## Key smart grid devices to be deployed for DSM

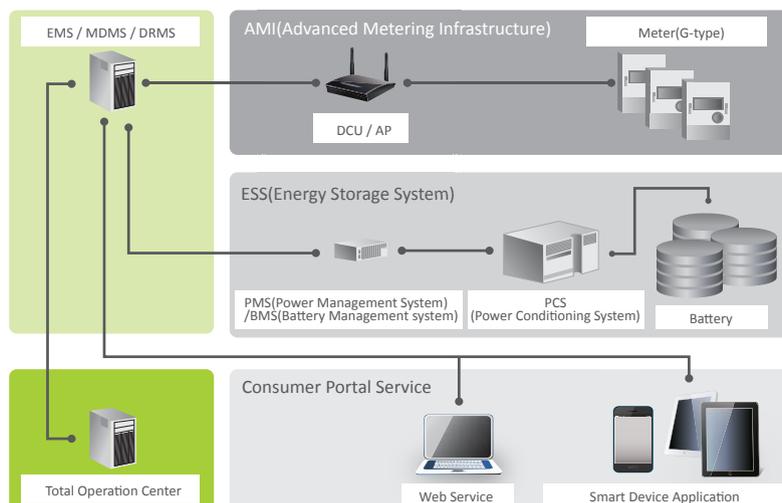


Figure 2: Key smart grid devices deployed for DSM

# KOREA

## ESS as Active Demand Management for Customers

- ESS: power conditioning system, battery, power management system, battery management system, etc.
- AMI: meter (G-Type), energy information service (Web, Smart phone application etc.), Smart Plug, data concentration unit/access point, meter data management system, etc.
- EMS: energy management system server, demand response management system, etc.

### Business options

The project explored several different business model and business case options before deciding which system architecture would be most appropriate to test.

- ESS only, AMI only and Package of ESS and AMI
- ESS only
  - installation of ESS including battery, BMS, PCS and PMS
  - charging/discharging operation for demand management of customers
  - providing operation, management and control services to the system operator and customers (e.g. manual mode, semi-auto mode, auto scheduling mode, etc.)
- AMI only
  - installation of AMI including meter (G-type), EIS, DCU/AP, MDMS
  - collecting and processing energy information of customers
  - providing operation, management and control services to the system operator and offering various energy information services to customers through web and smartphone applications
- Package of ESS and AMI:
  - Combining “ESS only” and “AMI only” options

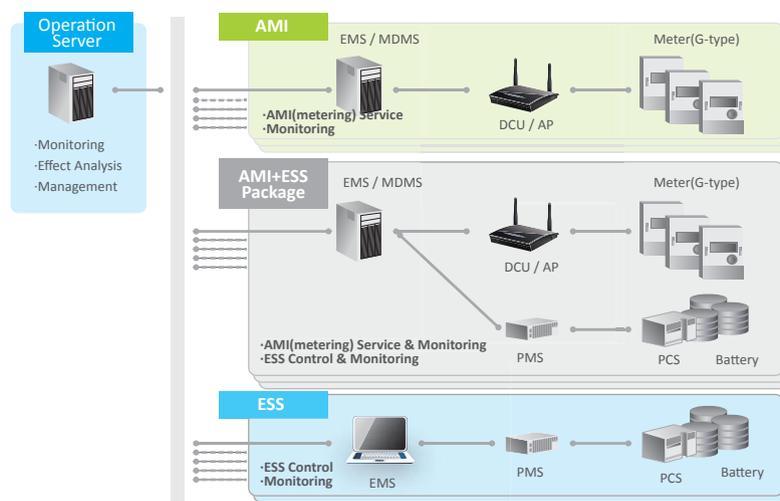


Figure 3: Business options for smartgrid deployment project

### Current Status & Results

The project deploys ESS in connection with AMI to increase the demand response capability in Korea’s power system. The pro implementation began in 2013 following the completion of the Jeju island demonstration project. The major cities on the mainland are the priority targets for the implementation projects. By 2020 the AMI deployment process is to be complete according to the national smart grid roadmap. The deployment is planned to spread to the entire country by 2030.

### Lessons Learned & Best Practices

As this project is still in the early stages of implementation at the time of writing there are a number of lessons yet to be learned and best practices yet to be established. There have been a number of lessons learned through projects leading up to this one which have been incorporated into the project design. They are described briefly here.

- Deployment should be planned in the context of current pricing, regulation and standards in place or under development.
- Pricing, regulations and incentives should be prepared to bring revenue to customers through the business models in deployment projects.
- Voluntary customer engagements are essential to deploy active DSM technologies.

### ESS Deployment Policy

The Korean government released an ESS deployment policy with targets for energy storage capacity along with the smart grid roadmap.

- Deployment target

	2013	2014	2015	2016	2017	2020
Yearly Target (MW)	100	150	250	300	300	300
Accumulated Target (MW)	100	250	500	800	1,100	2,000

- Deployment Road-map

Year	'11	'12	'13	'14	'15	'16	'17	'18	'19	'20
Customers DSM ESS	Demonstration for 100 household ESSs(3kW class)		Building ESS Demonstration (300kW class)							
	10kW up to 200kW ESS units deployment with commercial customers									
	Over 300KW ESS units deployment with commercial and industry customers									
	10Kw ESS units deployment with residential customers									

# KOREA

## ESS as Active Demand Management for Customers

### Key Regulations, Legislation & Guidelines

#### ESS Related Laws taken into account

- The Electric Utility Act requires ESS to be included with generating resources
- Mandatory installation of ESS in proportion to renewable power generation capacity
- Mandatory installation of ESS in public institutions

#### Electricity tariffs

- Extending TOU rate system into general/industrial customers of contracted capacity 100kW or more (May, 2013)
- Implementing an optional critical peak price system with general/industrial consumers (July-August, 2013)
- Considering various tariff options from which customers can select the most suitable option for their electricity usage patterns and which will also contribute to stable electric power supply and demand balance.

### Domestic incentive based DSM programs

Classification	KEPCO			KPX	
	Designated period	Advance notice	Emergency reduction	Bidding	Intelligent DR
Purpose	Reliability	Reliability	Reliability	Reliability	Reliability
Period	Summer peak (15 to 20days)	When reserve less than 4.5GW	When reserve less than 3GW	When reserve less than 4.5GW	-
Notice	2 months advance	1 to 7 days advance	1 hour advance	3 hours advance	1 hour advance
Participation	Optional	Optional	Mandatory	Optional	Mandatory
Incentive	Performance Incentive	Performance Incentive	Basic + Performance	Performance Incentive	Performance Incentive
Incentive determination	Fixed	Fixed	Fixed	Determined by bidding	Basic(bidding), Performance(fixed)
Price (krw/kWh)	108~132 krw/kWh	340~900 krw/kWh	1,000 krw/kWy (basic), 3,000 krw/kWh (performance)	760 krw/kWh (12 years average)	64,000 krw/kWy (basic) 540 krw/kWh (Performance)



# SOUTH AFRICA

<b>Market structure</b>	Eskom generates approximately 95% of the electricity used in South Africa and approximately 45% of the electricity used in Africa. Eskom generates, transmits and distributes electricity to industrial, mining, commercial, agricultural and residential customers and redistributors.
<b>Number of retail customers</b>	5.1 million customers
<b>Electricity consumed (2011)</b>	224,446 GWh
<b>Peak Demand for Power (2011)</b>	36,664 MW
<b>Net Revenue (2010)</b>	R 69.9 billion
<b>Transmission and Distribution Network</b>	354,000 km
<b>Transmission and Distribution Network</b>	n/a
<b>Contact</b>	<a href="mailto:Lawrence.padachi@eskom.co.za">Lawrence.padachi@eskom.co.za</a>

# SOUTH AFRICA

## IDM Case Study



In 2004, Eskom officially launched a national Energy Efficiency and Demand-Side Management programme under the auspices and guidelines of the National Energy Regulator of South Africa (NERSA). During the period from 2004 to 2013, the focus and scope of the programme evolved significantly in response to the changing energy landscape – as reflected in the name change to Integrated Demand Management (IDM) Programme in 2010. This case study describes the background and context of the Eskom IDM programme, funding of the programme, the programme scope and structure and the impacts and contributions achieved to date.

### **Background and context**

At the time of programme inception, South Africa had excess electricity supply capacity and very low electricity prices. Energy efficiency and de-

# SOUTH AFRICA

## IDM Case Study

mand-side management measures were introduced as a social responsibility best practice with an annual demand reduction target of 152 MW.

Since 2004, however, the pressure on energy efficiency measures to contribute to mitigating the supply challenge has steadily mounted. After the extended period of excess generation capacity, South Africa ran into electricity supply constraints in 2007 (Figure 1) when the growing need for electricity outpaced the rate at which power stations were being built. As a result the country experienced repeat power outages from late 2007, continuing into the first quarter of 2008. The ability to supply in South Africa's electricity needs has remained a challenge ever since and electricity supply is likely to remain vulnerable into the foreseeable future.



Figure 1: Percentage reserve margin % buffer between the available supply and projected demand on the electricity system

The global economic recession in 2008 slowed economic activity and electricity consumption, offering the overloaded electricity network some reprieve. Now, along with the slow economic recovery, the reserve margin is again diminishing, leaving the power system at risk.

A national capacity expansion programme is the primary intervention to supply in the country's growing electricity needs. This programme includes the development of new baseload and peaking capacity, the recommissioning of mothballed power stations, and the refurbishment of existing operating capacity, across a range of generation platforms. But, owing to long lead times for developing new baseload capacity, many of these investments will only start contributing to the national grid in the longer term.

In comparison, improving the efficiency with which consumers use available electricity resources offers an immediate opportunity to alleviate pressure on the power system.

### Funding of the IDM programme

The Eskom IDM programme is ratepayer-funded, with the costs of measured and verified<sup>13</sup> savings recovered via the electricity tariff. Through the Multi-Year Price Determination (MYPD) process, Eskom submits a multi-year revenue application supported by, amongst others, an IDM implementation plan to NERSA for review and approval. Eskom IDM initiatives and targets are therefore based on and dependent on approval of the MYPD submission.

The costs of interventions, initiatives and measures included in the approved programme and for which savings were measured and verified, can then be recovered from electricity sales.

**The role of and contribution from Integrated Demand Management** Since its inception, the focus of the IDM programme changed from a predominantly small-scale demonstration and awareness creation initiative to a concerted drive to measurably impact energy consumption in response to the projected supply shortfall while building a sustainable, energy efficient society in the longer term.

During the period from 2004 to 2013, the IDM programme established savings capacity equivalent to that of an average power station in the country and has saved energy equivalent to a full year’s electricity consumption by the country’s capital city, the City of Tswane (Figure 2).

Demand-side management interventions also successfully contributed to alleviating critical supply constraints during both 2006 and 2008.

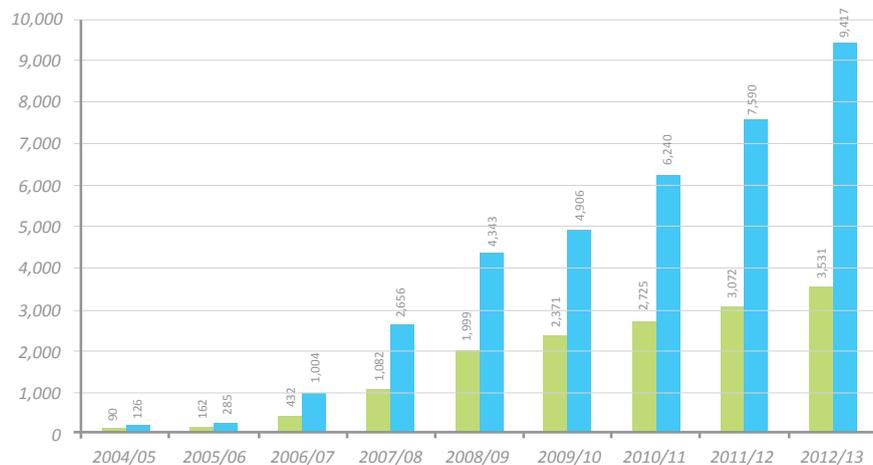


Figure 2: IDM cumulative performance over time measured and verified savings as included in the 2012/13 annual report

<sup>13</sup> <sub>1</sub> All savings are independently verified in accordance with a **Measurement and Verification** Guideline for Energy Efficiency and Demand-Side Management (EEDSM) projects, based on the International Performance Measurement and Verification Protocol (IPMVP) and SABS: SANS 50010 standard, Measurement and verification of energy savings

<sub>2</sub> Regional electricity supply constraints confined to the Western Cape province resulting from technology failure. A range of emergency IDM measures and interventions contributed over 400MW demand savings to breach the supply and demand gap.

# SOUTH AFRICA

## IDM Case Study

The IDM programme was subsequently incorporated as an essential component of the continued efforts to balance electricity supply and demand.

Acknowledging this contribution, South Africa’s Integrated Resource Plan (IRP 2010) now incorporates a significant energy efficiency and demand management contribution to meet the forecasted electricity needs over its planning horizon to 2030.

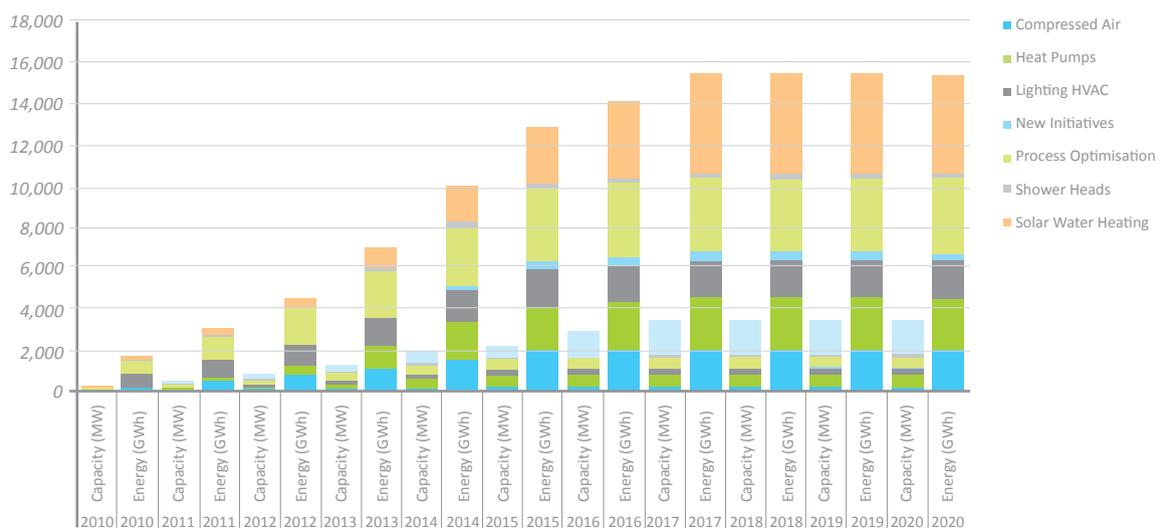


Figure 3: IDM component as included in the Integrated Resource Plan 2010. The anticipated contribution from IDM interventions to the national electricity plan

### Current status and results

#### Structure of the Integrated Demand Management Programme

A comprehensive, integrated solution was developed to deliver the targeted savings within the required timeframes. To effectively respond to the system requirements in terms of energy and capacity savings, the IDM programme utilises a combination of:

- energy efficiency measures that allow a specific function to be fulfilled as usual, while using less electricity (by installing more efficient equipment or process optimisation),
- demand management measures that shift the utilisation of electricity from a constrained period, typically out of the peak<sup>14</sup> consumption periods, to a period when electricity is more readily available, and
- demand response measures that call on consumers to rapidly reduce consumption during critical periods to avoid blackouts.

<sup>14</sup> The 16 hours between 06:00 and 22:00 presents the priority target period for energy efficiency interventions with peak consumption occurring between 07:00–10:00 and 18:00–20:00.

The programme promotes rational and efficient energy use across all sectors (most notably commercial, residential and industrial sectors, but also including public, agriculture and transport sectors) for a broad range of electricity end uses and technologies. The most common opportunities for energy efficiency improvements per sector included:

Table 1: Typical sectors and activities targeted for efficiency upgrades			
Sector	Residential	Commercial	Industrial
Technologies/ end uses	Efficient lighting Water heating Kitchen appliances Household appliances Pool pumps Power Alert ('call to action' for residential consumers)	Efficient lighting Water heating Heating, ventilation, air conditioning (HVAC) Efficient motors Building management systems Data centres	Pumping Process optimisation Compressed air Efficient motors and variable speed drives HVAC Efficient lighting Demand Response ('call to action' for large industrial customers)

IDM programme design (specific combination of technologies and sectors targeted) considers a range of solution options in terms of implementation costs, energy and demand impact, sustainability of the implemented solutions, implementation timelines or lead times and the combined impact on the system profile. The objective is to produce a balanced IDM programme portfolio that will cost-effectively and timeously respond, as best possible, to the system requirements.

The IDM programme is implemented in the South African market through a range of funding models structured to cater for a variety of project sizes, consumer types and technology interventions. For smaller projects, detailed measurement and verification and transaction costs quickly become prohibitive. The funding models have therefore been structured to accommodate small projects requiring less stringent measurements on standard technology replacements, paying a discounted incentive for deemed savings. The current portfolio of funding models includes:

- The **rebate model**, structured around paying consumers an incentive for converting their inefficient technologies to energy saving solutions, provided the suppliers are registered on the programme.
- The **Standard Product**, for customers with a potential load saving of between 10kW and 250kW.
- The **Standard Offer**, for customers with a potential load saving of between 200kW and 5MW. This model was developed to streamline the project approval process and time frame and to facilitate a quicker payment process.
- The **ESCO funding process**, for Energy Services Companies (ESCO's – specialists in energy efficiency) submitting projects with a potential load saving of 500kW or more.
- The **Performance Contract**, which aims to purchase bulk verified energy savings across multiple sites and technologies by contracting with a single Project Developer. The minimum project size will be more than 30GWh of savings over a three-year sustainability period.

# SOUTH AFRICA

## IDM Case Study

In addition to the above funding models, Eskom has also made use of extensive mass rollouts for specific technologies such as Compact Fluorescent Lamps (CFLs), Light Emitting Diode (LED) downlighters, geyser blankets, shower heads and timers, amongst others. With the Residential Mass Rollout Programme, several of these technologies are being combined under one mass rollout programme.

A summary view of the range of funding mechanisms available to customers:

Table 2: Range of IDM funding mechanisms				
Funding model (target sector)	Project size (savings capacity)	Targeted technologies	Duration of approval process	Incentive payments
Performance Contracting (industrial)	> 5MW and > 30GWh in 3 years	Custom or hybrid solutions	3–4 months	Performance payment for demonstrated savings over contract period at published R/kWh rate. First payment after commissioning.
Aggregated Standard Product	Batches of between 1 and 5 MW	Limited to specific products on a published list	2–4 weeks	Published rate per technology up to 85% of NERSA benchmark for
<b>(industrial and commercial)</b>		<b>deemed savings. Full payment on commissioning.</b>		
Residential Mass Rollout (residential)	Batches of between 1 and 5 MW	Limited to specific products on a published list	2–4 weeks	Free issue.
ESCO model (industrial and commercial)	>500 kW	Custom or hybrid solutions	6–8 months	Incentive payment based on detailed financial and technical evaluation. Progress payments with full payment on completion.
Standard Offer (industrial and commercial)	Between 200 kW and 5 MW	Limited to categories of technologies on a published list	Less than 2 months	Published R/kWh per technology category. Part payment on commissioning, part performance payments over contract period.
Standard Product (commercial)	Between 10kW and 250 kW	Limited to specific products on a published list	Less than 2 weeks	Published rate per technology up to 85% of NERSA benchmark. Full payment on commissioning.



These programmes have proven enormously successful. By May 2013, the CFL mass rollout had distributed more than 56 million energy efficient lamps with an associated demand reduction of 2,287 MW, and well over 370,000 solar water heaters had been installed through the rebate model since the inception of the rebate programme in 2008.

### **Objectives and Benefits**

The IDM contribution extends beyond the demonstrated energy and demand savings to include economic, socio-economic and environmental benefits.

Every kWh of electricity that cannot be supplied when electricity supply is constrained, results in a loss of economic activity in the country. More efficient use of the available electricity supply enables more economic activity to be supported than before. The energy savings from the IDM programme therefore presents an economic benefit to the country.

In 2008 NERSA quantified the monetary value of one kWh of unserved energy at R75. At this rate, the economic contribution of the 36,561GWh (cumulative) that the IDM programme saved during the 8 years is R2.7 trillion.

Increased economic activity also results in more employment opportunities. Economic data indicates that for every hour without electricity supply, the country risks losing 235 employment opportunities. In terms of 2012 annual consumption data, this translates to one position forfeited for every 4.3 GWh that could not be supplied. In 2012 alone, the savings from the IDM programme protected more than 40,000 jobs.

The IDM programme also contributes directly to employment creation. In 2011/12 and 2012/13, the Solar Water Heating (SWH) programme, only one component of the total IDM initiative, reported 8,063 direct employment opportunities resulting within companies registering for the IDM initiative.

The environmental benefits from energy efficiency measures are widely recognised, but are more pronounced in South Africa, where the electricity mix has a high carbon intensity. The IDM programme has saved 36 million tonnes of CO<sub>2</sub> and 49 million kilolitres of water from 2004 to March 2013. Relative to an annual water requirement for South Africa estimated in 2000 at 13.28 billion kilolitres and taking the minimum water requirement per person as 25 litres per day, the combined impact would be able to supply 15 million people with water for a year.

# SOUTH AFRICA

## IDM Case Study

### Lessons Learned & Best Practices

Successful implementation of the IDM programme has proven that energy efficiency and demand management can play an important role in providing in the energy needs of the country and can do so at a comparatively low cost. It furthermore presents an opportunity to improve the energy intensity of the country, create and protect employment and contribute to the environmental aspirations of the country.

Barriers to implementation do however remain. These include the required upfront capital investment, long payback periods, high transactional and M&V costs especially for smaller projects, low levels of awareness and low confidence in projected energy and cost savings that will be achieved.

The most critical mitigation of barriers is a policy, regulatory and funding framework that promotes and supports energy efficiency implementation and creates an appropriate and stable enabling environment.

A range of funding models, effective pricing structures and levels, channels to market and technology options assist to make energy efficiency incentives accessible to more consumers, overcome these market barriers and to accelerate the adoption of energy efficiency measures.

Effective communication is another critical aspect of successful implementation. This includes project-specific marketing and communication (i.e. details of a rollout, timing, duration, geographic location), programme communication (relating to the available incentives and how to access these) and continued, high-frequency communication for general national awareness. Communication can also be effectively employed to rapidly reduce consumption at times of severe constraint (e.g. Power Alert or Demand Response programme).

IDM initiatives are comparatively fast to implement and can be used to effectively and rapidly respond to supply constraints, provided:

- a sound, project-managed, **multi-functional implementation approach** is employed,
- **business processes, systems and controls** are optimised and automated as much as possible and
- **staff and advisors are trained** on complexities of multiple incentives.

Suitable measurement and verification of results is essential to demonstrate the achieved impacts and inform decision-making and future investments.





DW

# SWEDEN

<b>Market structure</b>	Electricity market is deregulated for production and the retail customer market including households. Network companies are monopolies.
<b>Number of retail customers</b>	5.2 million
<b>Electricity used (2011)</b>	142 TWh
<b>Electricity supplied (2012)</b>	162 TWh (including export) of which 78 TWh hydro power.
<b>Wind power supplied</b>	Approximately 10 TWh annually (increasing). Some hours wind power is 25 % of national power demand.
<b>Peak Demand for Power (2011)</b>	27,000 MW (approx.)
<b>Net Revenue to Distribution Companies (2010)</b>	41 billion SEK (4,8 billion EUR approx.) only for the network service including metering.
<b>Transmission and Distribution Network</b>	545,000 km lines of which: 329,500 km underground lines 215,500 km overhead lines Transmission lines are 15 000 km at 400 kV and 220 kV 170 network companies (various size; some public and some privately owned and mixed).
<b>Retail companies</b>	There are c. 120 electric retailers in Sweden. Vast majority of end users, including households, actively choose their retailer. Contracts may be related to spot price with a surplus, fixed price for a given period or other.
<b>Level of AMR/AMI system penetration</b>	Very close to 100 percent.
<b>Contact</b>	Magnus Olofsson / Elforsk – Swedish Electrical Utilities’ R & D Company magnus.olofsson@elforsk.se

# SWEDEN

## Swedish Flexible Demand Activities and Plans

The Swedish Government has made firm decisions related to market design regulation and support of research, innovation and demonstration of smart grid applications. Flexible demand is considered important enabling demonstration projects. The framework for the new regulation and initiatives for research, innovation and demonstration is presented here as well as two use cases: the National Power Reserve, and Elpiloten.

The first case features a larger scale procurement approach where industrial facilities and generators provide seasonal reserve services to the system through procurement by the system operator. By 2020 this method is intended to switch to a market approach where reserve power is no longer procured ahead of time, but managed completely through demand management and the capacity of interconnected markets.

The second case features a distributed demand management approach where residential loads can be aggregated to provide services to the system. These aggregated responses will respond to spot market prices.

Together these cases feature a comprehensive market approach to add short time balancing resources in addition to the large capacity of hydro power.

### **Objectives & Benefits**

Ultimately each of the projects presented here have the objective is to maintain margins in the technical power system effectively as well as to reduce the spot price volatility. Increase in wind power production in Sweden as well as in neighboring countries is increasing price volatility, and as such the system operator is looking for low-cost mechanisms to react to fluctuations in supply.

For the use cases this ultimate objective drives their project objectives. Use Case 1: National Power Reserve has the objective of providing cost effective market opportunities for industrial customers and aggregated custom-

# SWEDEN

## Swedish Flexible Demand Activities And Plans

ers. The objective of Use Case 2: Elpiloten is to save money for the customer. An important fundament for this project is a governmental bill that was passed the Swedish parliament enforcing hourly metering at no extra cost for any consumers subscribing to an hourly-based electricity supply contract in force from 1 October 2012

### Use Case Project Designs

#### Use Case # 1 – National Power Reserve with an increasing use of demand flexibility

The Swedish TSO, Transmission System Operator, Svenska Kraftnät by law annually procures a power reserve. It covers both electricity generation and consumption reduction, and can be activated by Svenska Kraftnät during extreme power situations in winter (Sweden has clearly a winter power peak). For the winter of 2014/2015 a maximum of 1,500 megawatts (MW) will be procured, of which 50 percent, if possible, should be from demand reduction capacity – i.e. industries that will be paid to reduce their use of electricity. The 2013/2014 winter procurement of power reserve totals 1,489 MW. Of this, 531 MW is from a reduction in demand. Organisations awarded participation in the demand reduction reserve are paper and pulp industries, other industries, and retailers that aggregate customer demand reduction. The rest consists of generation that can be activated on request of Svenska Kraftnät.

Procurement of demand reduction reserves for the 2013/2014 winter period is as follows:

#### Demand Reduction

Organisation	Contracted demand reduction capacity	Type of organisation
AV Reserveffekt AB	88 MW	Aggregator
Göteborg Energi DinEL AB	25 MW	Retailer doing aggregation
Vattenfall AB	56 MW	Retailer doing aggregation
Rottneros Bruk AB	27 MW	Pulp manufacturer
Stora Enso AB	240 MW	Paper and pulp manufacturer
Höganäs Sweden AB	25 MW	Metal powder manufacturer
Befesa Scandust AB	18 MW	Metals recycling company
AB Sandvik Materials Technology	22 MW	Advanced materials company
INEOS Sverige AB	30 MW	Chemical manufacturer

Table 1: Procurement of demand reduction reserves for the 2013/2014 winter period

The latest instructions to Svenska Kraftnät state (translated from Swedish): Law (2003:436) that the power reserve will expire in March 2020. The intention is a gradual transition to a market solution through a gradual tapering of the size of the power reserve, which shall fall from 2,000 MW to 750 MW before the power reserve is eliminated. During this phase-out period the percentage of the power reserve consisting of demand flexibility will increase from 25 % and over the final three years account for 100 % of the power reserve. Svenska Kraftnät shall monitor and analyze the liquidation of the power reserve in light of the situation in recent winters and of how the power reserve has been used. This analysis

should also examine further integration with other countries, increased internal transmission capacity, consumer flexibility and more volatile production in the power system to meet the needs currently met by the reserve capacity.

### Use Case # 2 - Elverket Vallentuna El AB/Elpiloten residential demand management pilot

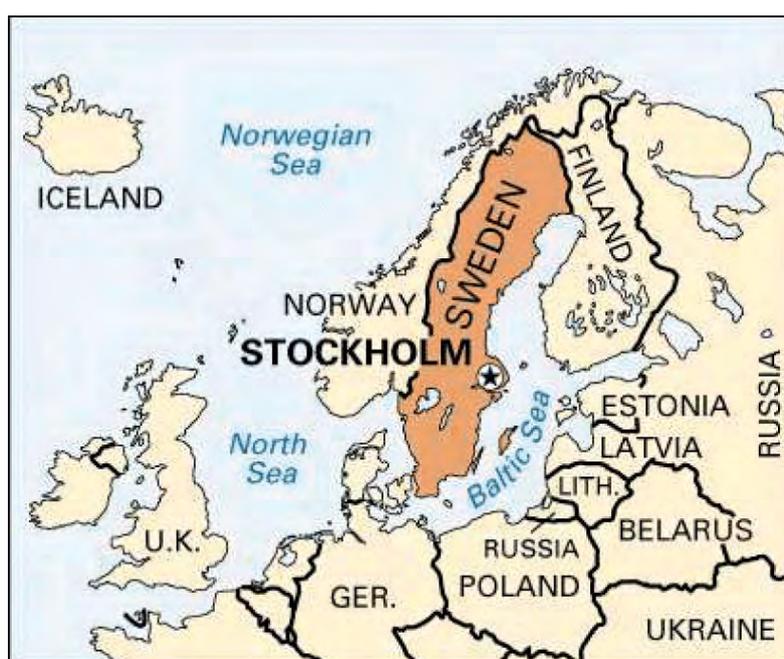


Figure 1. Location of the project: Vallentuna is in the greater Stockholm area.<sup>15</sup>

### Background

Elverket Vallentuna El AB is a utility in the greater Stockholm area, see Figure 1. In 2012 the retailer Elverket participated in a case study where new technology was used in order to implement Demand Response in households with a ground source heat pump<sup>16</sup>. The role of Elverket was to facilitate the case study by obtaining customers willing to participate in the field study and to have continuous communication throughout the project in order to collect important customer insights and comments. After the completion of the field study, Elverket arranged a dialog forum with all participants where customers discussed their views on Elpiloten, both functions and overall customer benefits.

<sup>15</sup> <http://kids.britannica.com/comptons/art-55116/Stockholm-Sweden>

<sup>16</sup> See "Pilotstudie i Vallentuna Reflektioner rörande affärsmodeller för förbrukarflexibilitet och självlärande prognosstyrning för kundanpassad effektregering. Elforsk report 12:48", with summary in English.

# SWEDEN

## Swedish Flexible Demand Activities And Plans

Conclusions from the field study were that substantial customer savings of 10-15 % were made possible through a combination of increased energy efficiency due to effects such as smoother indoor temperature variations and shifting of consumption from expensive to cheaper hours. These benefits can be achieved without requiring active participation by the customer or compromising the comfort level.

As the project was successful, Elverket is currently launching the next commercial version of the service named “Elpiloten”, or, “The Electricity Pilot”. Elpiloten is now a commercial product in the sense that the customer is paying for the hardware and the service as a subscription. The target market is households with a ground source heat pump, and households with high energy consumption generally due to hot water and heating. The customer savings outweigh the costs for Elpiloten and thus Elpiloten does not require any subsidy. It is a financially sound investment for the customer even if you don’t take into account benefits like increased comfort and monitoring of the heating system.

Elpiloten is treated as a commercial service but it also includes a hardware component.

Elpiloten is designed to meet its objective to save money for the customer while maintaining or increasing their level of comfort. Elpiloten works on two levels. First, it decreases the use of energy by using the house’s thermal inertia. Weather forecasts are used to plan the work of the heat pump and the customer has only to set desired indoor temperature. Secondly, Elpiloten also takes into account the spot market prices and plans the work of the heat pump in accordance with low spot market prices. From a system perspective a reduced demand in peak load hours is desirable and has many benefits. These benefits will be described in more detail below.



Picture of Elpiloten hardware

## Elpiloten from a Demand Management and System Perspective

Elpiloten contributes in four areas:

1. Reduced energy consumption
2. Reduced peak load
3. Creates opportunities for active consumers
4. May increase customers' awareness of their energy consumption, thus contributing to an increased use of renewable energy. Customers tend to view their use of electricity as an environmental problem. At the same time, customers don't feel that they can affect their own environmental impact. By increasing knowledge, the feeling of their own power to change their impact on the environment increases, thus giving the customer incentives to choose renewable energy.

These four areas of benefit can also be realized in various ways by the customer, the grid company, the supplier and society as a whole.

### Reduced energy consumption

- Customer benefit:
  - Reduced consumption leads to lower energy bills
- Benefit for society:
  - Decreased energy consumption with maintained level of comfort increases energy efficiency

### Reduced peak load

- Elpiloten considers the spot market prices
  - The spot market prices correlates with peak load hours
  - Reduces demand on critical peak load hours
- Customer benefit:
  - Lower energy bills
- Grid company benefit:
  - Reduced need for expanding grid capacity
  - Reduced costs by reduced power load from regional grid owner
  - Reduces risk of peak load pricing from regional grid owner
- Benefit for society:
  - Reduced demand on infrastructural development, both in grid expansion and production facilities, in order to handle peak load
  - Reduced environmental effects through reduced energy consumption on peak load hours. Peak load hours often require import of electricity with higher carbon payload
- Supplier benefit:
  - Reduced volume and hence cost for power purchase on peak load hours

# SWEDEN

## Swedish Flexible Demand Activities And Plans

### **Creates opportunities for active consumers**

- Customers
  - No need for behavioral change
  - Customers get more value without being required to engage in any new activity such as changing their supplier.
- Customer benefit:
  - Customer becomes a participant in the electricity market and contributes to increased market efficiency without personal effort
- Supplier benefit:
  - Market for new smart solutions provides opportunity for new revenue
- Benefit for society and grid company:
  - More efficient use of capacity in the grid

### **Increases energy awareness**

- Elpiloten increases customer knowledge of the energy market
- Increases the possibility for the customer to make judicious energy decisions
- Can lead to increased interest in other environmentally friendly energy solutions such as solar energy.

### **Current status & Results**

#### **Use Case 1: The National Power Reserve transition**

The National Power Reserve is gradually being phased out and according to Law (2003:436) the power reserve will expire in March 2020. At that stage spot market and other instruments shall be sufficient for a balanced system operation.

#### **Use Case 2: Elpiloten – aggregated residential demand response**

Since the field study was successfully completed Elverket and the system supplier Ngenic have continued working with commercializing the service. The first commercial units were installed in mid Spring 2013 and during this Autumn 2013 we will launch the next version of Elpiloten. Our first systems have performed well and have operating stability. We look forward to expanding Elpiloten and continue the development in close co-operation with our customers.

## **Lessons Learned & Best Practices**

### **Use Case 2: Elpiloten – aggregated residential demand response**

Main technical challenges consist of creating easy access and installation for the customer. Customers in general are not well informed about their own heating systems and this creates extra challenges in the marketing and customer communication.

#### **Implications on the market**

One interesting question arises if one considers the spot market pricing mechanisms. The spot market price is established the day before consumption. It is based on expected supply and demand for each hour. If smart solutions such as Elpiloten will be used in larger extent, these mechanisms need to be adjusted. Elpiloten will shift the energy consumption from expensive to cheap hours and thus creating difficulties to forecast the demand which is essential for the retailers being responsible for balancing. There will probably arise a need for some sort of adjustment to the different bids in the spot market due to a change in the demand side once prices have been set. In the short term this will not affect the market, but has to be considered if smart solutions gain considerable market penetration.

#### **Key Regulations, Legislation & Guidelines**

In order to enforce and facilitate the introduction of smart grid technologies in Sweden, on 30 May 2012, Swedish Government has established a Governmental organization named Swedish Smartgrid where more active customers is an important aim. The organization has a large network of participants from industry, Government, authorities and users.

Law (2003:436), link <https://lagen.nu/2003:436>.

# THE NETHERLANDS

## Project Ownership

PowerMatchingCity phase II is a collaboration between:

- DNV KEMA - Energy consulting and testing & certification company is responsible for the overall project management and design, expansion of the demonstration project and cost-benefit validation.
- Enexis - Distribution network operator explores the feasibility and economic benefits of capacity management in the distribution network.
- Essent - Energy supplier focuses on smart energy services for the end-users, including the market processes and economics plus smart charging of the electric vehicles (EVs).
- Gasunie - Gas infrastructure company that contributes to research towards an affordable sustainable energy supply, in which gas plays a role in keeping the system as a whole efficient and affordable.
- ICT Automatisering - Software company is responsible for the design, realization, management and maintenance of the ICT infrastructure.
- TNO - Knowledge institute develops and provides the PowerMatcher technology
- TU/e (Electrical faculty) - The faculty is providing the models for capacity management and the integrity of the electricity supply.
- TU Delft (Industrial design faculty) - This faculty is arranging the end-user research.
- Hanzehogeschool - is contributing to the end-user research.

## Focus of the project

A new smart coordination mechanism that moves the energy consumer to the center of the energy market.

## Physical elements of the project

- 40 households with solar pv, heat pumps/micro-chp with storage, 'smart' devices and HEM
- 10 electrical vehicles
- 2 smart distribution transformers

## New services

New tariff structures giving different kinds of added value to customers.

## Electricity system in the Netherlands

Outage: < 35 minutes/year (households)  
Consumption households: 3.500 kWh/year  
Connection on household level to both electricity and natural gas grid: 96%  
Consumption total in 2011: 120 kWh  
Production gas fired generation 2010: 63%  
Production coal fired generation 2010: 22%  
Production wind (and solar) 2011: 4%  
Target 2020 renewables: 14%  
Expected % renewable electricity 2020: > 30%

## Market structure

The Netherlands (16, 7 million people) have a liberalized market with independent network operators. One TSO, 8 DSO's.

## Contact

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# THE NETHERLANDS

## PowerMatchingCity



For the large scale implementation of a sustainable system, it is necessary to build experience in field tests. PowerMatchingCity is a living lab demonstration in the Netherlands that started as an EU-financed project. The world's first trial with a smart energy network was launched in the village of Hoogkerk in Groningen in 2009: PowerMatchingCity I, with 22 households, HRe boilers, hybrid water pumps, solar PV systems, 'smart' devices and 2 electric vehicles (EVs).

This project was completed successfully and is now getting a follow-on stimulus by the Dutch Government: PowerMatching City II, with an additional 18 households, 10 electric vehicles (EVs) and 2 smart distribution transformers. Hoogkerk is thereby gaining practical experience with new tariff structures and the feeding in of renewable energy into the network, amongst other things.

# THE NETHERLANDS

## PowerMatchingCity

PowerMatching City II is one of the twelve trials in the Netherlands aimed at accelerating the smart grid development. The main focus of these trials is gaining real world experiences with different smart grid applications and real users. New technologies, new partnerships and new forms of collaboration are used to develop new energy services which can unlock the potential of a smart grid. The results of the trials are helping to resolve important issues relating to intelligent networks, such as the needs of consumers, new business cases and new laws and regulations. These experiences must give a solid base for strategic decisions on the large scale application of a smart grid.

The powermatching concept is considered essential for the scalability of demand response applications that require large amounts of flexible distributed energy resources. Different applications of the Power-Matcher are found in the trials in the Netherlands. Also the large Ecogrid EU demonstration project on the Danish island Bornholm (included in this case book) uses the PowerMatcher concept.

DNV KEMA, the consortium leader, gives the project also a 'springboard role': companies get the opportunity to test their products and services. Next to that is TNO, together with industry partners, developing the PowerMatcher technology into a flexible power platform available for open use in smart grid projects worldwide.

### Objectives & Benefits

The objectives of the two phases of PowerMatchingCity are different. The objectives of the first phase of this demonstration project were:

- Demonstrate the feasibility of a smart grid / Smart Energy System under real living conditions.
- Demonstrate an integral optimization method based on local markets and distributed intelligence for both capacity and commodity.
- Develop an application independent solution.
- Integrate local generation and demand response.
- Integrate gas and electricity infrastructure in the most optimal way.

The main objective of the second phase (2011-2014) is to place the technically feasible solution of the first phase in the real energy world:

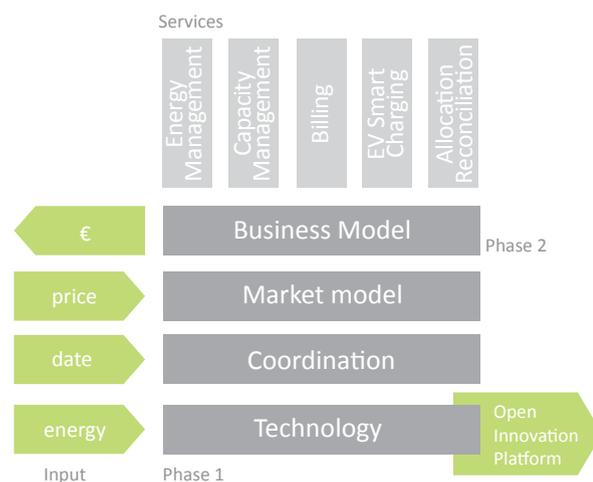


Figure 1: Overview of PowerMatchingCity

- Demonstrate new end user propositions based on real time pricing and energy management insights.
- Implement the solution into the wholesale processes (allocation, reconciliation) and billing
- Extend the role of the grid operator: validate the peak load reduction potential by extending the field trial with households behind a single transformer.

- Extend to a smart electric vehicle charging service.
- Validate the cost/benefit model with data from the field trial.

## Planning for Success

The smart energy system has numerous stakeholders. The concept of PowerMatchingCity is to find an optimization for the various goals of the stakeholders:

Consumers nowadays invest in their own power production, e.g. in PV solar installations. These so-called ‘prosumers’ are looking for the optimal economic benefits of their investments. From a household perspective the network can be regarded as a very large battery. The economic benefits for a prosumer

can be maximized by continuously seeking the highest profits for energy export towards the grid and minimizing the costs for import from the grid. This provides the flexible reactive power for a smart grid.



Figure 2: System architecture of PowerMatchingCity

Grid operators or Distributions System Operators (DSOs) are confronted with changing energy demands and load profiles. The electrification of the energy system will lead to increased network loads. Extensions of transport capacity of existing networks in especially cities are very expensive and labor intensive operations with a high impact on the built environment. Therefore the de-

velopment of advanced distribution automation is highly relevant to manage future load profiles and manage congestion and peak loads in local grids and on distribution stations. Within PowerMatchingCity the DSO can influence the load profile on the transformer by giving local price incentives. In this way it can actively limit the import or export of energy.

The interconnection of microCHPs into a Virtual Power Plant (VPP) is now a commonly known concept that can be used for the reduction of power imbalances and for the optimization of trading portfolios. Within PowerMatchingCity the whole system of households and connected devices is treated as a VPP and is directly controlled from the trading room. By continuously altering the balance between energy production and demand the resulting power production or demand of the cluster can smooth peak power demands and prevent the dispatch of costly spinning reserves.

For the demonstration of systemchanging concepts like the PowerMatcher it is essential that they can rely on solid theoretical foundation, connections with other demonstration projects, and scientific analysis of the results. In his thesis ‘The PowerMatcher: Smart coördination for the Smart Electricity Grid’ Koen Kok provides a theoretical basis for the design of the PowerMatcher and an extensive validation

# THE NETHERLANDS

## PowerMatchingCity

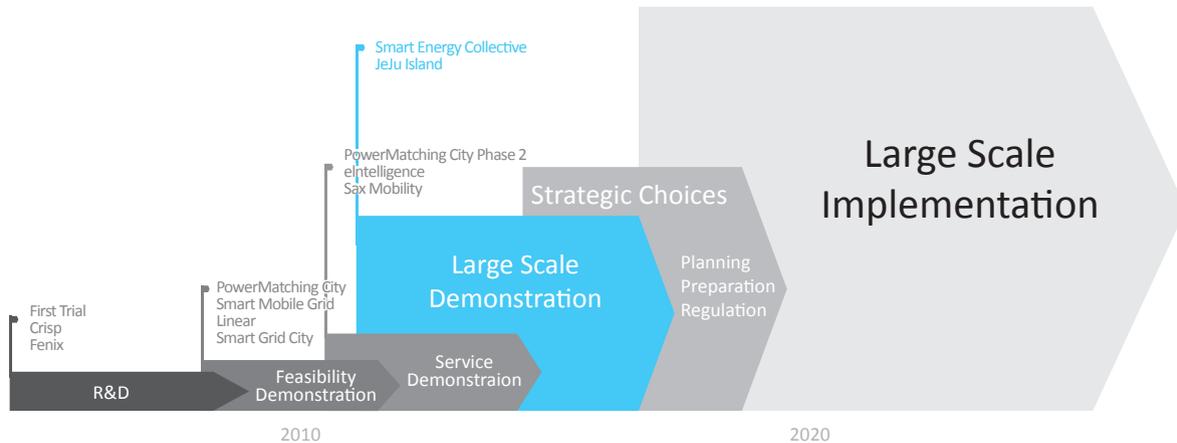


Figure 3: The PowerMatchingCity projects draw on international experience

through simulation studies and field experiments, including “PowerMatching City”<sup>17</sup>. Some key elements and conclusions in his thesis are<sup>18</sup>:

The design of the PowerMatcher is based on multi-agent systems which makes the system highly scalable and able to ensure user privacy. The theoretical work brings together elements from electrical engineering, computer science, economics and control. Further, it includes a mathematical proof of the optimal performance of the PowerMatcher. (...)

Thus the operation of the electricity system changes from central control of a relatively small number of large power plants to coordination of large amounts of (sustainable) generators and flexible users. An important requirement for this coordination system is scalability. Maintaining the system’s demand and supply balance will involve a huge number of small and medium-sized smart energy demand devices.

Controlling this from a central point will soon reach communication and computational limits. This scalability problem is even greater in the field as the distributed generators will also play a role in the coordination task. Computer science, and in particular the area of multi-agent systems, can offer a solution.

<sup>17</sup> Published by TNO, The Netherlands, SIKSDissertation Series No. 2013-17. Dissertation defended on July 4<sup>th</sup> 2013, at the VrijeUniversiteit, Amsterdam.

<sup>18</sup> See pages 273-276 (Summary).

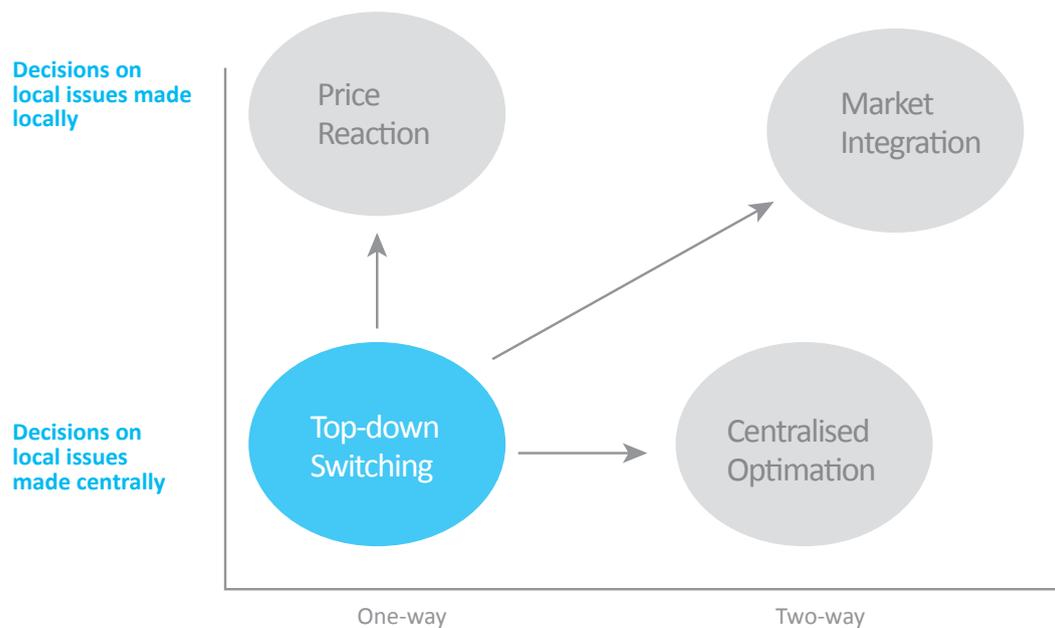


Figure 4 : Matrix of Demand Side Management approaches

A multi-agent system is a distributed software system in which so-called intelligent agents are responsible for local sub-tasks, and communicate with each other in order to achieve the higher system goals. A well-designed multi-agent system is an open, flexible and easily expandable ICT system that can properly operate in a highly complex and changing environment. As the local software agents take care of local business, it separates local (and potentially privacy-sensitive) information from the outside world by not collecting it all at a central point.

The PowerMatcher is designed and built based on this multi-agent technology. The result is a mechanism which allows for the coordination of a large number of smaller consuming and producing devices without the autonomy and privacy of the owners of these devices becoming compromised.

### Current status & Results

The field trial started in 2007 (the operational part started in 2009) and ended its first phase in 2011.

Phase 1 cost approximately 5 M€ and was partly financed by the EU (PF6).

The trial with 25 homes showed that it is possible to create a smart grid or energy network with the associated market model using existing technologies. The system enables consumers to exchange electricity freely and the level of comfort is maintained.

From 2011 to 2014 the second phase is executed. Phase 2 started at the end of 2011 and started the operational phase mid 2013. The cost of phase 2 is also approximately 5 € and is financed with 2 M€ by the Dutch Government. Phase 2 consists of the same 22 households as in phase 1, with additional 18 households, 10 EVs and 2 smart distribution transformers. The 18 new households are situated in the

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## PowerMatchingCity

same street, behind one distribution transformer. The new households are also members of the local energy cooperation that is expanding rapidly with for instance plans for collective solar panels on a local school.

By using the PowerMatcher, more renewable energy may be integrated in the electricity system. A study of the energy consumption of 3,000 households in combination with a large (off-shore) wind turbine park clearly shows this. When using the PowerMatcher, it was shown that approximately 65 to 90% of the wind power, which would normally not be used without coordination, could be locally utilised. As a result of this, the usage of power from fossil fuels is reduced by 14 to 21%.

A reaction from energy demand and distributed generators to fluctuations in the supply of renewable energy also improves the value of green power. The low day-ahead predictability of wind generation, for example, results in additional costs assigned through the electricity wholesale markets, the so-called imbalance costs. In two of the field tests performed with PowerMatcher, a wind farm was coupled to a flexible cluster in order to compensate for deviations from the wind power prediction. This reduced the imbalance caused by the wind farm 40 to 60%. This makes an interesting business case for energy suppliers.

Further, it has been shown in the field that the PowerMatcher is able to avoid overloading of electricity networks. By cleverly managing heating systems (micro-CHP and heat pumps) and/or charging electric cars, the daily peak loading could typically be reduced by 30 to 35%. In existing networks, this saves the network operator an expensive network reinforcement, while new networks can be less heavy designed. In one of the cases studied, the network capacity could be designed three times lower through application of the PowerMatcher.

### ***Results of field tests in PowerMatching City***

The results of the field test show that the market control mechanism works perfectly. The smart agents ensure that end users buy their electricity at low prices and sell at high prices (see Figure 5). The tests also show that the cluster can be operated as a virtual power plant and grid operators can send incentives to reduce the peak load in certain areas of the grid.

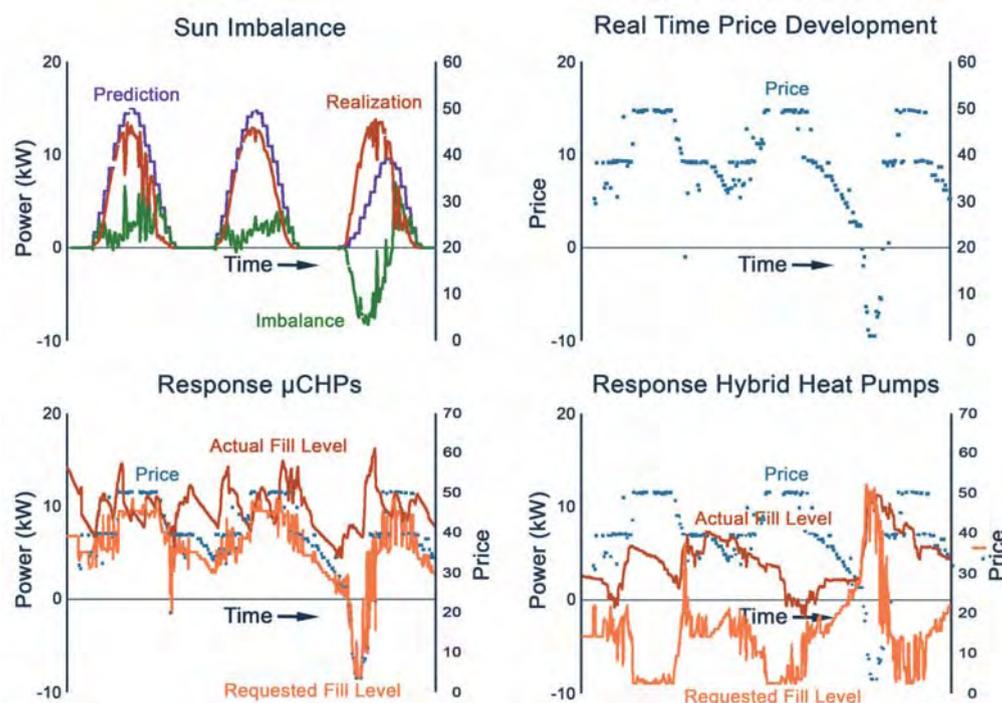


Figure 5: Example of the reduction of solar power imbalance in PowerMatching City: (top-left) a) Sun Imbalance in development: Prediction , Realization and Imbalance, (top-right) b) Real time price development, (bottom-left) c) Collective response micro cogeneration units systems, (bottom-right) d) Collective response smart hybrid heat pump systems

It is technically feasible to allow demand response to track supply rather than the other way around, as is currently the case. Measurements from the micro-CHP, the hybrid pumps and the charging of electric vehicles all indicate that the system responds quickly to fluctuating demand and maintains comfort levels for the end user over the long term. This is favorable for the smooth integration of renewable wind and solar energy.

### Lessons Learned & Best Practices

#### *A working smart grid system as starting point*

The goal of the PowerMatching City project is to demonstrate that a smart system for the future supply of energy can be built using readily available technologies. Phase 1 has succeeded in doing this. The connection of different energy flows was successful. The intelligent combination of electrical vehicles, micro-chp and heat pumps caused lower peaks in the grid and to work as a virtual power plant. The system works well, although not without applying the necessary creativity. The main lesson from the first phase is that the chosen solution is a technically feasible solution. However the results from phase 1 make it difficult to state the reduction of the energy use.

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## PowerMatchingCity

A practical trial like this turns out to be extremely well-suited for acquiring insight into what can be achieved with a smart energy system, the changes required for this purpose, as well as the hurdles still need to be overcome. One of the most important lessons to be drawn from Phase 1 is that it is only through the efforts of all parties along the entire energy chain that it becomes possible to fully exploit the opportunities inherent in a smart grid.

### **The challenge**

In the future, to ensure the security of electricity supply a new coordination mechanism is required. The reliability of our electricity supply will need special attention due to three developments:

- The rapid increase in renewable energy creates a challenge for maintaining the crucial balance of supply and demand in the network.
- The growing use of electricity, which increasingly drives aging networks towards overload.
- Part of the electricity generated is becoming distributed: large numbers of relatively small generators - solar panels, small wind turbines and micro-combined heat and power – deliver their energy close to the place of consumption. These generators operate outside the reach of the central coordination within the electricity system.

### **Smart appliances**

From actual practice it becomes evident that there is a need to design appliances, including household appliances, differently. Appliances should be allowed to decide for themselves whether to switch on or off, depending on the current electricity rate, for example, when the rate falls because the supply from renewable sources is high. This implies that the devices have knowledge on the electricity rates, communicated via the internet. In PowerMatching City we have adapted the heat pump, microCHP, EV and washing machines in such a way that they are able to communicate with the smart grid. Making these interfaces is not always trivial.

The trick is to create flexibility without adversely affecting the end user's comfort or the system's energy efficiency. A heat pump, for example, has been designed to supply heat when the consumer has a need, not when the electricity rate is favorable. To make it flexible is possible by temporarily storing the energy in a buffer tank in the form of heat. The battery in electric cars offers similar potential. By charging the battery at a time when electricity is cheapest, it is possible to drive the car at the lowest possible cost. The project demonstrates that each of the innovative technologies developed for this project provides a significant amount of flexibility and can be operated flawlessly.

### **Automation**

Households perceive a high level of comfort and don't experience any inconvenience from participating in this smart grid project since energy trading is fully automated. The acceptance level is high, and a clear change in 'energy behavior' can be observed. The effect on their direct energy consumption is limited, but the end-users show an increased willingness to invest in more energy efficient appliances once evi-



dence is provided that their investments result in the expected savings. Moreover the participants gradually transform into prosumers and more and more they want to (collectively) generate their own power.

### ***New elements in phase 2***

Three important new elements in phase 2 are new energy services, addressing the problem of network capacity management and the ‘springboard role’.

A lot of attention has been given to the end-user requirements and desires with regard to new services and the systems to deliver these services. These services and a home energy management system with a tablet have been developed with intense customer consultation. One question is how intelligent networks can be incorporated into the energy company’s processes, from reading the meter through to billing. For example, there are tariffs which can change every 5 minutes instead of a fixed tariff. That requires new sorts of bills.

Households get their bills every month, based on their actual electricity consumption. Two types of contracts have been developed, after extensive consultation with the participants:

1. Cheapest energy bill: The PowerMatcher will control the smart devices in such a way – within the comfort levels as demanded by the households – that way the energy bill will be as low as possible.
2. Sustainable local first: The Powermatcher will control the smart devices in such a way – within the comfort levels as demand by the households – that locally produced energy will be used to a maximum.

Secondly PowerMatching City II is also addressing the problem of capacity management: how can you ‘feed in’ large quantities of renewable energy into the network?

And third, the project has a ‘springboard role’: companies have the opportunity to test their products and services. Hence NXP will be building computer chips into electric scooters in order to be able to charge them smartly. iNRG will be experimenting with the communications between a HRe boiler and water heater tank, which makes it possible to break the link between the demand for heat and electricity production. These are new steps on an already working smart grid and an infrastructure.

### **Key Regulations, Legislation & Guidelines**

In the existing Dutch framework of energy laws and corresponding codes SMEs and domestic end-users are characterized by demand profiles, which are used for settlement, allocation and reconciliation. The introduction of active demand and supply within the SMEs and domestic end-users will result in shifted load profiles as a result of optimizing supply and demand of energy. These shifted load profiles will deviate from the statistically determined load profiles that are currently used to determine the average load profile of these groups of end-users. The flexibility that is created this way can have a value in the energy chain: not only by preventing congestions in the network and giving trade options on the commodity market, but also by giving balancing options. But this requires that the ‘standard load profiles’ be set

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## PowerMatchingCity

aside. Therefore the value cannot be assigned to the corresponding parties who created it in the energy system.

In PowerMatching City we explore how these wholesale processes can be adjusted such that the value created by the flexibility introduced by active demand and supply can be valorized allowing that parties responsible for balancing the system can share this value with the associated end-users.

Next to adjustment of the profile methodology the current tariff structures most likely need to be adjusted in the near future to fully unleash the potential of a smart grid and accelerate the introduction of local renewable energy production by residential end-users and SMEs.

1. Within PowerMatching City value for flexibility is created with real-time local tariffs. To valorize the flexibility the standard profiles methodology needs to be changed and dynamic tariffs both for the commodity as for the capacity are needed. Such a market model would require adjustment of the existing tariff regulations but allow for transparent cost and benefit allocation, an optimal dispatch of all assets in the system as well as freedom of dispatch, transaction and connection.
2. Currently the feed-in tariffs in The Netherlands are capped at 5,000 kWh/y. Above this threshold the benefits for feeding power in the grid reduce dramatically. When the drop in prices from renewable sources like wind and solar power continues and production volumes increase they will significantly shift the energy prices as a result, a fixed feed-in tariff, soon will no longer be socially acceptable or technically feasible.



# USA

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## Market context

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**Electricity consumed (2011)** Statewide: 59,847 GWh<sup>19</sup>  
OG&E: 29,606 GWh

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**Peak Demand for Power (2011)** Statewide: 17,200MW  
OG&E: 5,815MW<sup>20</sup>

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**Net Revenue to Distribution Companies (2011)** OG&E: US\$3.92 Billion<sup>21</sup>

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## Transmission and Distribution Network

The electric supply companies are listed in decreasing order of relative number of customers and sales: Oklahoma Gas & Electric Company and Public Service Company of Oklahoma (American Electric Power Company), Empire, Grand River Dam Authority and Western Farmers Electric Cooperative, KAMO Electric Cooperative, and the Oklahoma Municipal Power Authority.

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## Contact

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19 DOE Energy Efficiency and Renewable Energy, "Clean Energy in My State," Department of Energy, <<http://apps1.eere.energy.gov/states/>>

20 Oklahoma Corporation Commission's Public Utility Division, "The State of Oklahoma's 12<sup>th</sup> Electric System Planning Report," OCC, Oklahoma City, OK, Apr 2013 <<http://www.occeweb.com/pu/PUD%20Reports%20Page/12th%20ESPR-2013.pdf>>

21 Wikinvest, "Revenue for OGE Energy," 2011 <[http://www.wikinvest.com/stock/OGE\\_Energy\\_%28OGE%29/Data/Revenue/2011](http://www.wikinvest.com/stock/OGE_Energy_%28OGE%29/Data/Revenue/2011)>, accessed at 11 Dec 2013

# USA

## Oklahoma Gas and Electric Demand Response Programs



### Project Description

In 2010-11, Oklahoma Gas and Electric Company (OG&E) successfully piloted a new time-based rate over a two year period under a program known as Smart Study Together™, which provided about 4,670 participating customers with prices that varied daily in order to entice changes in their patterns of electricity consumption and a reduction in peak demand.

The program was deemed a success and is gradually being expanded to all customers under the program name SmartHours, with a total enrollment of approximately 81,000 customers as of December 2013. The SmartHours dynamic pricing campaign is recognized in the US electric utility as a leader in terms of scale and impact for a smart grid enabled price response program.

### Objectives & Benefits

The primary goal of OG&E's Smart Study Together™ was to assess the demand response achieved through various technologies and dynamic rate plans. The program is designed to test, and gain knowledge about customer acceptance of time-based rate designs and enabling technologies.

Two rates are offered: a Time-of-Use rate with a Critical Price component (TOU-CP) and a Variable Peak Pricing rate with a Critical Price component (VPP-CP), for both residential and small commercial customers. The four technology options include a web portal, in-home display (IHD), programmable communicating thermostat (PCT), and a combination of all three.

Based on the success of the Smart Study Together™ pilot study, OG&E expanded the dynamic pricing program as the SmartHours program by offering the most successful rate-technology combination of VPP-CP rate along with PCT to new eligible customers.

The ultimate goal of the demand response programs is to determine if the demand reductions achieved will allow OG&E to delay capital investments in incremental generation resources. With the objective of a demand reduction of 1.3 kW per customer and in anticipation of 20% residential and small commercial participation, OG&E hopes to gain roughly 210 MW of virtual generation that will contribute to this avoided generation.

By the end of 2012, the 54,000 customers participating in SmartHours reduced system demand by 67 MW, and each saved \$179 on average during the four month summer period.<sup>22</sup> Major information technology (IT) improvements have also been made in communication infrastructure, web services, system integration, and cyber security.

OG&E is one of the first distribution utilities to deploy a new Volt-Var optimization (VVO) system, which improves distribution system visibility, provides better accuracy and granularity of data, and allows for better forecasting and integration of more real-time data. VVO systems also increase power delivery efficiency by decreasing the losses through the use of capacitor banks and also enable flatter voltage profiles hence reducing peak demand. OG&E has installed VVO systems on 400 feeders, which allows them to avoid building an 80MW peaking plant.<sup>23</sup>

Some of the benefits envisioned upon full project completion in 2017 include: reducing demand by 223 MW through dynamic pricing and 75 MW through Volt-Var optimization; reducing annual meter operating costs by \$15 million; and reducing its System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI) by 30%. OG&E has a target of enrolling 160,000 customers in its "SmartHours" program (approximately 81,000 customers have enrolled through December 2013).

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<sup>22</sup> Lewis, Philip, "smart grid 2013 Global Impact Report," VaasaETT, Helsinki, Finland, 2013

<sup>23</sup> ABB in the US, OG&E Selects Volt/Var "Optimization Solution from ABB", 2010 <<http://www.abb.us/cawp/seitp202/4028068027662fa78525772000533ea6.aspx>> accessed on 29 Feb 2014

### Use Case Description

Customers were randomly assigned to either a Time-of-Use (TOU-CP) option or a Variable Peak Pricing (VPP-CP) option. Customers in the control group were left on their existing standard rates. The Critical Price component in each rate plan is to raise the price level to the critical price when a Critical Price event is issued with a minimum of two hours notice. The VPP-CP was designed by replacing the on-peak price (from 2:00 PM to 7:00 PM on weekdays) in the TOU rate with one of four variable prices shown in the chart below. Under the VPP CP, a single price will apply to the entire five-hour on-peak window each weekday. Four defined price levels – Low, Standard, High, and Critical – simplify communications of price level. The day-ahead on-peak prices for VPP-CP are communicated to the customer by 5:00 PM on the previous day via email, text message, and/or voicemail.



Figure 1 : Prices applied in the Time-of-Use option and the Virtual Peak Pricing option of OG&E’s Smart Study Together™

In conjunction with the two rates, OG&E tested the following technologies:

- **Web Portal:** an energy information website providing customers with 15 minute interval data updated every 15 minutes, neighborhood comparisons, bill estimates, environmental impacts, as well as tips and tools to manage energy consumption. The web portal is not an option for customers without internet access.
- **In-Home Display (IHD):** a countertop display providing customers with near real-time demand, estimated monthly cost and current price.
- **Programmable Communicating Thermostat (PCT):** a customer controlled device with current pricing information which allows for the automation of comfort settings based on current energy prices. The thermostat is not an option for customers without central air conditioning.



Picture of technologies used in OG&E's Smart Study Together™

OG&E collected interval data using smart meters from a sample of customers to estimate the load reduction resulting from various combinations of dynamic rates and enabling technologies. The two rates and four technology options described above result in eight combinations, with a separate sample of participating customers needed for each. In order to implement a randomized design, all eligible customers were randomly assigned to either one of the participant groups or the control group. This allows for direct and unbiased comparison of the rate-technology options.

Because the program targets system peak reduction, it is important to consider the nature of the OG&E system load. The 2011 OG&E system peak of 6,509 MW occurred at the hour ending 4:00 PM on August 3. This summer system peak is much higher than the winter peak of 4,580 MW, which occurred on February 10 at the hour ending 8:00 AM.<sup>24</sup> Reducing just the specific hour of the system peak will not significantly reduce OG&E's capacity requirements – load must be reduced in all of the peak hours. Also important is the number of hours throughout the year that the system load is at or near the system peak. The nature of the OG&E system load is such that a technology-enabled dynamic rate plan offered in this program has the potential to reduce system capacity requirements significantly, potentially enough to eliminate the need for additional peaking units.

### Current Status & Results

Load reduction is estimated by comparing the load for the customers with each rate-technology combination with the load for customers in the control group. Comparisons are made between several different day types, including average weekend days, average weekdays, event days, and average days for the various price levels for the VPP-CP rate. The demand response program results are presented below in three phases, with a brief overview of the first two phases representing the pilot study years (Smart

<sup>24</sup> Williamson C., "OG&E Smart Study Together Impact Results, Auxiliary Final Report – Summer 2011," Global Energy Partners, Walnut Creek, CA, 23 Apr 2012



Study Together™) and the third phase representing the first year of expansion beyond the pilot study (SmartHours).

### **Phase 1 – 2010**

Beginning in early 2010, OG&E recruited 3,000 customers located in Norman, Oklahoma, for the demand response study. The primary objective of the study was to determine the most effective combination of rate and technology in reducing on-peak energy consumption. OG&E hypothesized that it could achieve 1.3 kW of max reduction per customer and 20% participation by 2014.

Study results obtained from the testing period, June 1 through September 30 of 2010, show that the initial hypothesis of 1.3 kW of max demand reduction is achievable. In particular the VPP/PCT combination provided the greatest amount of demand reduction, approximately 1.96kW or 58% on average, for the VPP/PCT participants when compared to the control group.<sup>25</sup> This result is likely explained by the automated response of the thermostat, which is lacking in the web and IHD treatments.

### **Phase 2 – 2011**

The second year of this study was a continuation of Phase 1 with a few changes. OG&E engaged an additional 3,000 participants, located in Moore and south Oklahoma City. During Phase 2, OG&E was able to test responsiveness to Critical Price events, and also gain insight into commercial participation. The results from this phase confirmed the success of the VPP/PCT combination measured in 2010, with a maximum demand reduction of 1.97kW.<sup>26</sup>

Aside from the load impacts, Phase 1 and 2 analyses show there is an apparent relationship between demographic segment and demand reduction. Focusing on 2010 results (Phase 1) of the VPP/PCT treatment, high income participants exhibited the greatest average baselines than other income groups, as well as the highest average demand reduction. Additionally, low income participants exhibited the highest percentage in demand reduction (68%) during Phase 1, when compared to the other segments.

As of May 2012, 2.9% of enrollments have dropped out of the program, and 5% of enrollments have moved. During both phases, the unenrollment rates are below 5%.<sup>27</sup>

### **Phase 3 – 2012**

Based on the positive results of the two year demand response pilot, OG&E initiated the SmartHours expansion program in January 2012. This program promotes participation in the VPP rate and signing up for a thermostat. As of September 30, 2012, approximately 35,144 residential customers were participating

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25 Williamson C., Shishido J., Marrin K. "OG&E Smart Study Together Impact Results, Summer 2010 Interim Report," Global Energy Partners, Walnut Creek, CA, 28 Mar 2011

26 Williamson C., Shishido J. "OG&E Smart Study Together Impact Results, Final Report – Summer 2011," Global Energy Partners, Walnut Creek, CA, 29 Feb 2012

27 Williamson C., Shishido J. "OG&E Smart Study Together Impact Results, Final Report – Summer 2011," Global Energy Partners, Walnut Creek, CA, 29 Feb 2012

28 Williamson C., Marrin K. "2012 Evaluation of OG&E SmartHours Program," EnerNOC, Walnut Creek, CA, 20 Dec 2012

in the SmartHours pricing program, and 61.5% percent of those customers also accepted a free PCT and are referred to as SmartHours Plus participants.<sup>28</sup>

Study results show that the overall maximum impact of the program was 51.4 MW, which occurred during a Critical Price event day on the day of the system peak (August 1, 2012). The average per customer reduction at that time was 2.34 kW for SmartHours Plus participants and 0.81 kW for SmartHours VPP participants. Across the three system peak Critical Price event days held, SmartHours Plus customers averaged a reduction of 1.82 kW per customer, and SmartHours VPP customers averaged a reduction of 0.73 kW per customer.<sup>29</sup> The results of Phase 3 indicate that the program can maintain its efficacy on a significantly larger scale.

### Lessons Learned & Best Practices

The most effective rate/technology combination for residential customers is the VPP-CP with PCT. The VPP rate provided the highest load reduction on the hottest days, and also provides a full range of prices for OG&E to work with. On days when capacity is plentiful, there is no need for customers to reduce on peak energy, so the low rate can be set. When capacity is short, a High or Critical price can be set, and the Load reductions will be greater. The VPP-CP allows OG&E to tailor the price to the capacity. Combining the PCT with the rate automates the load reduction, giving the customer the ability to choose between the relative importance of cost and comfort, and to vary that choice across the different prices.

With the current rates in place, in order to maximize the load reduction on the system peak day, or on any day when capacity is constrained, it is recommended to set the VPP price as High, and then call a Critical Price event starting at 4:00 PM. This will provide more continuous load reduction across the entire on peak period, particularly at the time of the usual system peak. In the long term, OG&E could investigate adding a “super-peak” period, probably from 4:00 PM to 6:00 PM, with a higher price than the on-peak period. This would allow the automated response of the PCTs to spread the savings more evenly over the entire on-peak period without having to call events as described above.

OG&E could consider finding new ways to encourage customers without PCTs to shift load. As an example, encouraging customers to customize an “event plan,” perhaps through the web portal that outlines specific actions to be taken during an event or critical day, may increase load reduction. Similar event or action plans are often employed for demand response programs with non-automated commercial and industrial customers. While no evidence of customer fatigue was seen during the summer of 2012, it may be prudent to consider the possibility of fatigue, especially during days that are forecasted to be the system peak, and develop a protocol that ensures too many events are not called.

For planning purposes, in absence of a weather adjusted estimate, it is recommended to begin the Critical Price event period an hour prior to the expected system peak on a High priced day to maximize the impacts

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<sup>29</sup> Williamson C., Marrin K. “2012 Evaluation of OG&E SmartHours Program,” EnerNOC, Walnut Creek, CA, 20 Dec 2012

<sup>30</sup> Williamson C., Marrin K. “2012 Evaluation of OG&E SmartHours Program,” EnerNOC, Walnut Creek, CA, 20 Dec 2012



closest to the system peak. Impacts on Critical days with similar weather conditions without a Critical Price event had similar maximum impacts, but the impacts were 14% lower at hour-ending 5:00 PM.<sup>30</sup>

The following is a general overview of lessons learned and recommendations:

- Primary customer driver is savings.
- Technology and savings create sustainability, but technology only matters if it facilitates customer savings.
- Automation is key to sustainability. Thermostats were shown to be more effective in reducing demand compared to the alternatives that lack automated response capabilities (web portal, IHD).
- Pricing is critical to success. The differential between on-peak and off-peak prices must be significant enough to create demand shift.
- Members must be involved and engaged. Communicating daily prices creates awareness and focus.
- Use multiple channels including television, radio, print, earned media, website, and social media to engage and educate customers.
- Customer enrollment must be easy. Provide online enrollment and a dedicated call center.
- Effective cross-functional and supplier relationships are crucial.
- Information technology, effective processes (quality assurance, software development life cycle), and trusted partners and “Regulators” will be key essential elements.
- Statistical study is important to understand what is driving results.

### **Key Regulations, Legislation, & Guidelines**

The OG&E case study further offers the following guidelines to support successful implementation of a dynamic rate-based and technology-enabled demand response program.

1. **Stay current with industry trends, issues, and challenges.** This will help to understand how trends and issues (health issues, opt out programs, data privacy, etc.) may impact your programs and to plan accordingly.
2. **Periodic updates and reviews with regulatory stakeholders.** Keep them informed on project status/progress, issues, milestones achieved, etc.
3. **Solicit feedback and input for regulatory filings and proceedings.** Work directly with regulators on how to propose and package smart grid programs (example: alignment with other regulatory filings such as energy efficiency, peak demand reduction, customer education, etc.)



## >>> Executive Summary

This Case Book presents 12 case studies on the development and implementation of Demand Side Management (DSM) technologies and practices.

DSM represents a general category of all end-user energy programs that often use a set of incentives, dynamic tariffs or sustainable energy awareness strategies to optimize consumption of energy.

This DSM Case Book is a product of the International Smart Grid Action Network (ISGAN)<sup>31</sup> and presented as part of its deliverables to the Fifth Clean Energy Ministerial. Collectively, the case studies present findings from DSM deployment under a diverse range of policy frameworks and market conditions. Thus, the variety of cases included in this Case Book can be considered as a representative compendium of the current DSM experience as part of a global smart grid<sup>32</sup> strategy.

### **Purpose of the Case Book on Demand Side Management**

This Case Book intends to:

- Describe and discuss the application of DSM solutions based on the use of smart grid technologies in different contexts and frameworks, which is made possible by the wide variety of countries participating in ISGAN;
- Share the latest solutions and business models as illustrated by leading demonstrators in the DSM domain from around the world;
- Highlight some of the regulatory challenges impacting the wide application of smart grid technologies;
- Promote a worldwide exchange in DSM to identify best practices, share lessons learned, and streamline findings.

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<sup>31</sup> ISGAN is an initiative of the Clean Energy Ministerial and an Implementing Agreement under the International Energy Agency's Energy Technology Network. It is formally organized as the Implementing Agreement for a Co-operative Programme on Smart Grids (ISGAN). Participation is voluntary, and currently includes Australia, Austria, Belgium, Canada, China, the European Commission, Finland, France, Germany, India, Ireland, Italy, Japan, Korea, Mexico, Norway, the Netherlands, Russia, Singapore, South Africa, Spain, Sweden, Switzerland, the United Kingdom and the United States. The views, findings and publications of ISGAN do not necessarily represent the views or policies of all ISGAN participants, all CEM participants, the IEA Secretariat, or all of its individual member countries.

<sup>32</sup> A smart grid is a next-generation network that integrates digital and other advanced technologies (i.e., "Smart") into the existing power grid ("Grid") to meet the varying electricity demands of end-users. Smart grids co-ordinate the needs and capabilities of all generators, grid operators, end-users and electricity market stakeholders to operate all parts of the system as efficiently as possible, minimizing costs and environmental impacts while maximizing system reliability, resilience and stability.

## Context of the DSM Case Book

The DSM Case Book contains 12 case studies from Austria, Canada, Denmark, France, Germany, Italy, Japan, South Korea, South Africa, Sweden, The Netherlands and the United States. These case studies provide qualitative insight into the complexity of deploying DSM initiatives based on a diverse range of technologies and under specific market rules. They also incorporate various program and policy mechanisms and include information on costs and the associated business cases for investment. In doing so, each study points out opportunities, pitfalls, and best practices in developing and deploying these technologies that can help stakeholders replicate successes and avoid costly missteps.

The Case Book will exist as a “living document,” to be updated periodically with additional case studies from ISGAN participants and affiliated organizations.

The case studies included here feature unique sets of characteristics and drivers, which are indicative of the diverse range of motivations and circumstances surrounding both smart grid and DSM, such as:

- Different levels of maturity: while some countries have completed first rounds of pilots and are building on lessons learned, others are at the earliest stages of their initiatives.
- Different applied methodologies: choice of technologies deployed, benefits and business cases vary from case to case.
- Dependence on boundary-conditions: assumptions must be documented carefully, with links from the results and lessons learned back to these assumptions.
- Different scales at work: the size and the specific costs are varied among projects and can change, although most initiatives are still at a pilot stage.

Still, a number of best practices and common themes have emerged concerning the increased customer role in smart grids and business models based on creating new services and value propositions. These results are summarized in the “*Key Findings*” section<sup>33</sup> of the Case Book.

In this Executive Summary, a focus is set on three axes arising from the 12 case studies’ key findings:

- Three main approaches to DSM have been identified.
- Engaging consumers follow a “customer cycle” that should be carefully driven.
- Each stakeholder should contribute to the technical and market evolutions to make DSM possible at larger scales.

### Three main approaches to DSM have been identified

Based on the 12 described cases, there appear to be three main approaches to Demand Side Management:

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<sup>33</sup> Please refer to the “Key Findings” section (page 6) for more details

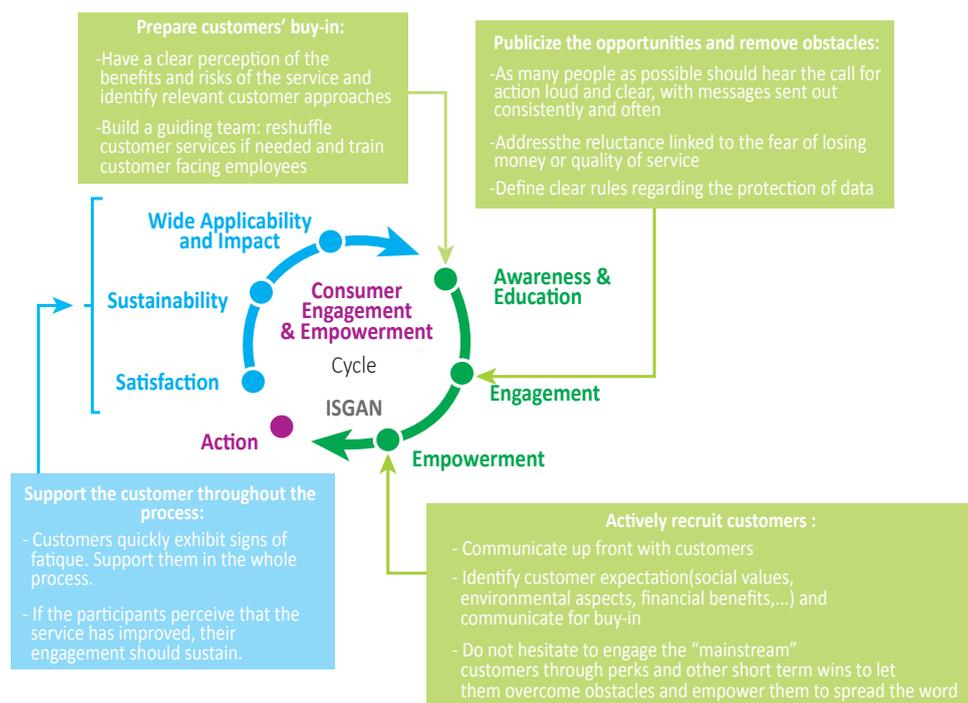
- The feedback system in which consumers are informed about the system constraints.
- The price-based approach, which encourages behavioral change on the customer-side, triggered by price signals.
- The system capacity-based approach, in which customers indicate their preferences to a third-party player (aggregator or system operator) and consent to let this player take the control of smart appliances. As such it does not rely on the price sensitivity of customers, but on system forecasts monitored by third-party players.

The customer's consent and adhesion is a prerequisite for the success of the three approaches. Different approaches are in some cases combined and, in others, independently assessed.

### Customer Engagement follows a “customer cycle” that should be carefully driven

The 12 cases of the DSM Case Book show that the involvement of customers follows a “customer cycle” that ensures a proper and smooth involvement of customers in DSM pilots. It contains several steps and milestones going from awareness and education to sustainability and wider application.

To engage and guide customers in this process, utilities should have a clear plan. The boxes around the “customer cycle” in the schema below give examples of some of the best practices developed in this DSM Case Book. This cycle goes through different steps and milestones: starting with the preparation of customer buy-in, to the removal of obstacles and the advertisement of opportunities, the active recruitment of customers and, finally, support of the customers throughout the process to minimize the dropout (or opt out) rate.



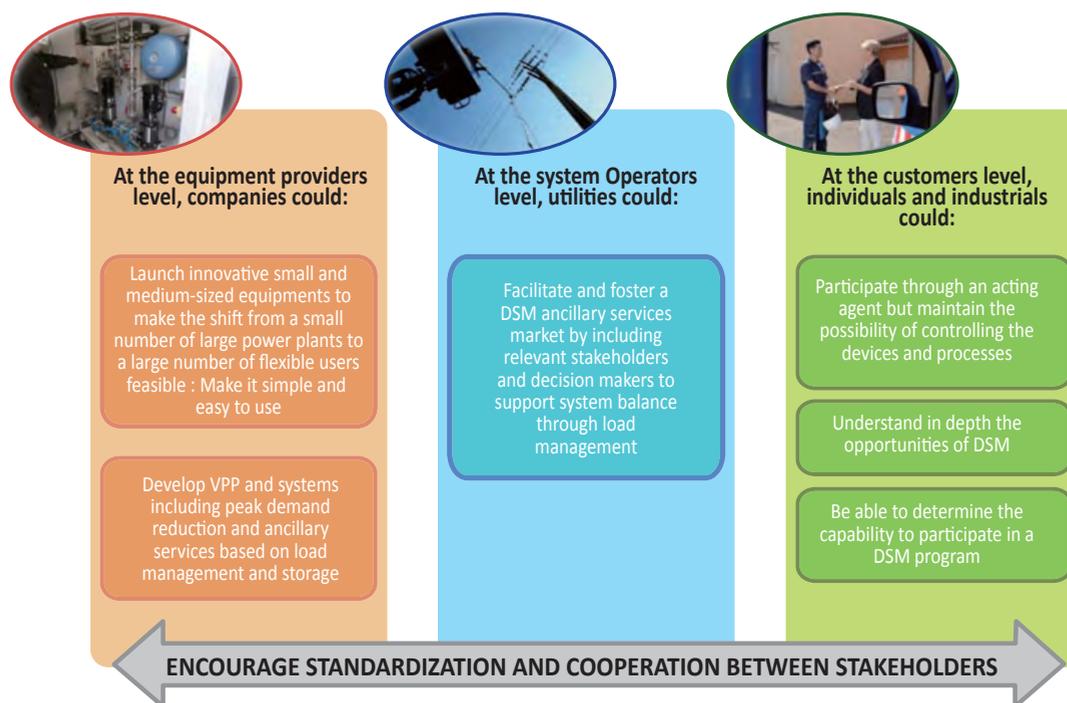
## Each stakeholder should contribute to the technical and market evolutions to make DSM possible at larger scales

Although DSM offers clear benefits to stakeholders, numerous barriers (market establishment and structure, business case, etc.) have to be overcome that are inherent in an innovative topic that deals with public acceptability.

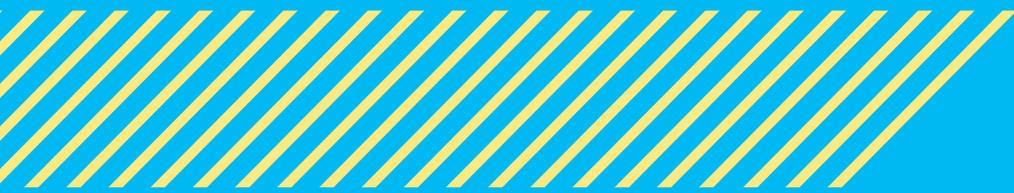
Among the several stakeholders of DSM functions and services, the 12 cases of the DSM Case Book show that customers, utilities, system operators and equipment providers should apply best practices to make DSM a reality and to ensure scalability and potential for replication.

The practice shows that DSM implementation is not just any particular party's responsibility. Rather, all actors – utilities, governments, users and other stakeholders - have an important role to play in the success of DSM programs. Each actor's effort could encourage the others' action towards efficient-energy activities.

Some examples are presented in the schema below.



Best practices around DSM and customer engagement will continue to emerge as market models, regulatory frameworks, and other aspects of smart grid evolve and benefit from innovations. This Case Book aims to provide a knowledge-sharing platform and comparative view of regional differences in the strategy and design of DSM and smart grid development.



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