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Report

Global Inventory and Analysis of Smart Grid Demonstration Projects

Arnhem, October 22, 2012

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By order of Netbeheer Nederland, project group Smart Grids

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FOREWORD

The Dutch energy network operators, united in Netbeheer Nederland, want to facilitate and where possible accelerate the energy transition. Renewed, intelligent energy networks (smart grids) are an important prerequisite to the energy transition. The network operators are already investing approximately 1.5 billion EUR per year in the replacement and expansion of their networks. In the period up to 2050 an extra investment between 20 and 70 billion EUR will have to be made to adapt the energy networks and to make them more intelligent. This is evident from the report 'Networks for the future' of Netbeheer Nederland. Because the network operators are public organizations, it is necessary that investments in the networks of the future are efficient and effective, as ultimately society bears these costs.

Before the network operators can come to well balanced decisions on such a major investment, it is important that they first experience the different aspects of a smart grid on a smaller scale. Therefore network operators participate in a number of pilot projects where these aspects are tested in practice on the technical, economic, and social feasibility. The experiences are shared with each other and with other stakeholders with the objective to make the right choices for the future on this basis. In addition, Netbeheer Nederland has set up a working agenda in their Smart Grids Roadmap to facilitate a sustainable energy supply and the changing customer demand for network and metering services. Based on current knowledge and understanding, a number of actions that are of interest to the implementation of smart grids have been formulated.

Netbeheer Nederland wants to prevent the network operators reinventing the wheel or making sub-optimal investments. Therefore, it is important to also look at what happens outside the Netherlands in the field of smart grids. DNV KEMA Energy & Sustainability has been asked to make a global inventory of the initiatives relating to smart grids. In this inventory a direct relationship is made between the action points as set out in the Smart Grids Roadmap and the 'lessons learned'. Netbeheer Netherlands wants to make use of the experiences that are abroad and still to be gained with smart grids, and to involve these learning points in the current and future smart grid projects in the Netherlands where network operators themselves fulfill an active role.

DNV KEMA gives in its final report a summary of the state of affairs and the main 'lessons learned ' until mid-2012. The report also refers per project to sources where the reader can find more background information on the project. Netbeheer Nederland sets this report available to anyone involved or interested in the developments in the field of smart grids. It is hoped that this will provide further insight to various stakeholders about smart grids and thus to contribute to the development of smart grids in Netherlands.

Laurens Knegt
Director Netbeheer Nederland

VOORWOORD

De beheerders van de Nederlandse elektriciteits- en gasnetten, verenigd in Netbeheer Nederland, willen de transitie naar een duurzame energiehuishouding graag faciliteren en waar mogelijk versnellen. Vernieuwde, intelligente energienetten (smart grids) zijn een belangrijke randvoorwaarde om de energietransitie mogelijk te maken. De netbeheerders investeren nu al circa 1,5 miljard EUR per jaar in de vervanging en uitbreiding van hun netten. In de periode tot 2050 zal er tussen de 20 en 70 miljard EUR extra geïnvesteerd moeten worden om de energienetten aan te passen en intelligenter te maken. Dit blijkt uit het rapport 'Net voor de toekomst' van Netbeheer Nederland. Omdat de netbeheerders publieke organisaties zijn, is het noodzakelijk dat de investeringen in de netten van de toekomst doelmatig en efficiënt zijn. De maatschappij draagt immers de kosten hiervoor.

Voordat de netbeheerders goed afgewogen besluiten kunnen nemen over dergelijke omvangrijke investeringen, is het van belang dat zij eerst op kleinere schaal ervaring opdoen met de verschillende aspecten van een smart grid. Daartoe participeren de netbeheerders in een aantal proeftuinen waarbij deze aspecten in de praktijk worden getoetst op de technische, economische, en maatschappelijke haalbaarheid daarvan. De ervaringen worden met elkaar en met andere stakeholders gedeeld met het doel op basis hiervan de juiste keuzes voor de toekomst te kunnen maken. Daarnaast heeft Netbeheer Nederland in haar Roadmap Smart Grids een werkagenda opgesteld om de verduurzaming van de energievoorziening en de veranderende klantvraag naar netwerk- en meetdiensten te faciliteren. Op basis van de huidige kennis en inzichten is een aantal acties geformuleerd die van belang zijn om smart grids te implementeren.

Netbeheer Nederland wil voorkomen dat de netbeheerders het wiel opnieuw uitvinden of een weinig zinvolle investering doen. Het is daarom belangrijk om ook te kijken naar wat er buiten onze landgrenzen gebeurt op het gebied van smart grids. Zij heeft aan DNV KEMA Energy & Sustainability gevraagd een wereldwijde inventarisatie te maken van de initiatieven met betrekking tot smart grids. Bij deze inventarisatie is een directe relatie gelegd tussen de actiepunten zoals geformuleerd in de Roadmap Smart Grids en de 'lessons learned'. Netbeheer Nederland wil gebruik maken van de ervaringen die in het buitenland zijn, en nog worden, opgedaan met smart grids en deze leerpunten betrekken bij de huidige en toekomstige smart grid projecten in Nederland waarbij de netbeheerders zelf een actieve rol vervullen.

DNV KEMA geeft in haar eindrapport een overzicht van de stand van zaken en de belangrijkste 'lessons learned' tot medio 2012. Daarbij wordt per project ook verwezen naar bronnen waar de lezer meer achtergrondinformatie over het betreffende project kan vinden. Netbeheer Nederland stelt dit rapport graag ter beschikking aan iedereen die betrokken of geïnteresseerd is in de ontwikkelingen op het gebied van smart grids. Zij hoopt hiermee aan diverse stakeholders meer inzicht te verschaffen over smart grids en daarmee een bijdrage te leveren aan de ontwikkeling van smart grids in Nederland.

Laurens Knegt
Directeur Netbeheer Nederland

EXECUTIVE SUMMARY

As the key enabler of a more sustainable, economical and reliable energy system, the development of smart grids has received a great deal of attention in recent times. In many countries around the world the benefits of such a system have begun to be investigated through a number of demonstration projects. With such a vast array of projects it can be difficult to keep track of changes, and to understand which best practices are currently available with regard to smart grids. This report aims to address these issues through providing a comprehensive outlook on the current status of smart grid projects worldwide.

Methodology to select relevant smart grid projects and guide through results
Netbeheer Nederland wants to learn from other smart grid projects before starting their own projects. To this end, the findings of this inventory have been categorized according to the action points listed in '*The road to a sustainable and efficient energy supply; Smart Grids Roadmap*' of Netbeheer Nederland. DNV KEMA developed a methodology through an iterative process after applying certain criteria on a first series of projects and discussing the results with Netbeheer Nederland.

The final methodology includes several filters to extract the projects from hundreds of smart grid demonstrations. The criteria applied vary from factors such as the starting date of the project, to how many technologies relevant to Netbeheer Nederland's action list are incorporated. This has resulted in 47 selected projects that have been thoroughly analyzed. The main results have been summarized per domain – i.e. technical domain, policy and regulatory domain, and social and other domain – of the aforementioned action list. In order to support readers who are interested only in information regarding specific projects or specific topics, the report contains many hyperlinks which can be used to locate relevant material in the large appendices.

Regions show different focus
This Worldwide Smart Grid Inventory has been formed from combining the work of four previous quarterly reports. The first quarterly report was an update of an existing smart grid inventory, whilst the remaining three focused on smart grids developments in a specific region, namely Asia-Pacific, Europe and the Americas. This regional focus allowed for specific trends in developments to be seen.

For example it is apparent that in America there is a strong focus on peak load reduction technology and dynamic pricing tariff pilots, whilst in Europe more emphasis is placed on improving energy efficiency and reducing emissions through the use of more decentralized means of production. In the Asia-Pacific region drivers vary country to country – from modernizing and improving grid reliability in China, to techniques for load management in Australia and New Zealand.

The inventory in both the European and the Americas region show a larger number of lessons learned compared to the Asia Pacific region. Some of these lessons are transferable to the Netherlands, while others remain specific to the country in question.

Asia Pacific region – limited lessons to be learned for the Netherlands

A common characteristic in Asia-Pacific projects is the limited amount of information that was available in the public domain. Little information about the projects is shared, even after contacting the companies personally. Projects are being promoted with brochures and websites but after the initiation of the project, hardly any information is provided about results and lessons learned.

Nevertheless the following general conclusions can be drawn from this region:

- There is a strong emphasis on incorporating demand response as a means of reducing peak load, through the use of automated devices and various feedback appliances;
- Several ongoing projects will lead to knowledge regarding the effectiveness of different pricing tariffs;
- The increase in products offered to consumers which utilize real-time metering information will result in more stakeholder agreements over the use of smart meters being required;
- In China, the preferred strategy for EV charging seems to be through swap stations (i.e. locations where batteries can be exchanged);
- Installation of smart meters forms a key component in many of the demonstration projects – with the choice of communication standards (e.g. 4G/LTE) taking into account potential privacy concerns.

Europe region – many projects share information due to governmental financing

Smart grid developments have started earlier in Europe than in e.g. Asia Pacific, resulting in more projects with conclusions and lessons learned available. Furthermore it seems that the sharing of information is more embedded in the culture in Europe and there are relatively more government-financed projects, resulting in more emphasis on information sharing. This report revealed many lessons learned in smart grid demonstration projects all over Europe. Taking these projects into account the following general conclusions can be drawn:

- Several projects are using agent based systems to connect local devices and appliances and create local market mechanisms. This development should certainly be followed up by Distribution System Operators (DSOs);
- The need for standardization is mentioned in many projects, either for enabling combinations of communication (and other) technologies, cost reduction, and/or payment schedules. In future field trials, (open) standards should be integrated in the project;
- Feedback increases awareness of consumption and often results in lower energy (mainly electricity) use;
- One can segment different types of consumers each asking for a different approach and/or business model, so a 'one type fits all' solution is not an option;

- Although the focus point of the 12 analyzed projects were different – for example one focusing on storage and one on VPPs – many projects shared the same reason for their project, namely the integration of intermittent renewables;
- New roles are arising, which may require the role of the DSO to adapt as well;
- There is lack of information available yet on how project partners have used the results from their pilot projects in commercial, 'real life' projects.

Americas region – projects have more focus on peak load reduction than in Europe

The main differences in the smart grid demonstration projects between the Americas and Europe is that, as a starting point, the grid (grid structure, grid development, grid operation, grid reliability and grid use) is different. This leads to, for example, higher (average) electricity consumption per customer, a lower reliability and a stronger focus on peak load reduction than in Europe, as an environment for the smart grid. Consequently, many of the projects in America deal with development of Advanced Metering Infrastructure and Distribution Automation.

Additionally it is important not to assume that a 'one-solution fits all approach' is always applicable as project outcomes can differ considerably. For example, several projects investigated some form of demand response and dynamic pricing tariffs – but with different results. Thus it would be necessary to validate certain findings in real-life situations within the context of the Dutch market.

Keeping this in mind, the following overall conclusions can be drawn:

- When looking at peak demand reduction, it is important to have knowledge of the overall peak demand shape to choose an appropriate 'toolkit' for shaping consumption. Often simply a high tariff is not enough to reduce capacity requirements;
- High pricing appears to be more effective than cash rebates when incentivizing reduction in loads;
- It is difficult to simultaneously manage both 'strategic' wider goals, with the general day-to-day operation issues of a smart grids project;
- All projects will carry a degree of risk, which should be managed through appropriate scaling of the project and a carefully managed implementation;
- The use of fluctuating distributed energy resources to reduce peaks in the loading of the grid is not straightforward and has its own challenges (e.g. availability issues);
- Simple systems such as smart thermostats are effective in bringing about savings;
- In-home displays improve awareness of energy usage to an extent, however a more detailed breakdown of usage (for example, by appliance) would provide even more value for consumers;
- Consumers are primarily incentivized by individual benefits – in particular reduction of their monthly bill (followed by other advantages such as improved reliability, better control of energy usage, environmental benefits). Segmentation will enable an even greater customized approach to engaging customers;

- The effect of electricity price on consumption behavior is variable. In general a smarter pricing rate does bring about savings (albeit limited in some cases), but the effectiveness may vary depending on specific consumer segments (due to different price elasticity).

Technical domain – wide variety of technologies and services demonstrated

As business drivers for smart grid differs per region, and even per country, there is a different focus on technology in the three regions covered in this report. In general smart meters and IT systems are applied in almost any demonstration project. Demand response is often applied as a smart grid service mainly to reduce peak loads rather than to 'fill' load gaps.

In order to improve the integration of many renewable energy sources and at the same time apply smart devices and EVs, many agent-based algorithms demonstrated ‘plug-and-play’ capabilities. Other purposes of these algorithms are to support utilities in congestion management, critical operations, and load shedding. The PowerMatcher concept is well known in the Netherlands although it has been applied in other countries as well in several projects subsidized by the European Commission. Other controller concepts successfully demonstrated operation of technical Virtual Power Plants (VPPs), allowing for decentralized control of technically aggregated resources in the distribution network. In many of these projects distribution network operators play a key role. Cooperation with 'aggregators' or Balance Responsible Parties is regarded vital.

As flexibility is often mentioned as a key parameter in a smart grid many demonstration projects prove the value of energy storage, next to demand response aforementioned. Amongst others several thermal storage devices have been applied offering storage capacity up to weeks.

IT is often regarded as a crucial part of a smart grid. Nevertheless, the use of IT in power systems implicitly brings about a degree of risk. The probability of communication failure between assets can be minimized – but there is still always the possibility that unwanted system errors may occur. The importance of interoperability and clear interface specifications has been shown in several projects as different project partners may use different systems and communication needs to be compatible. A suggestion made to ease this process of integration was to send out the necessary software prior to project commencement in order to identify any problem areas well in advance.

Technical issues arising from distributed energy resources have been shown as well as solutions to deal with that. Examples are smart inverters of PV panels and the use of Volt/VAr control.

There is also a lot of non-technical learning from the selected demonstration projects. One finding is to carry out a clear scoping and cost-benefit analyses prior to the project commencement to prevent large project overruns. Another one is the management of expectations, i.e. provide the benefits that you promised to energy consumers and other stakeholders (or that they perceive to get provided). Clear and transparent communication is strongly recommended.

All innovative projects carry technical (and financial) risks. Another lesson to be learned is the importance of carrying out demonstration projects on the correct scale – appropriate to the risks involved in the project. Implementation should be planned, scaled and managed carefully to avoid problems.

Policy and regulatory domain

Smart Grids require a clear distinction of roles between the key players especially as roles are likely to change over time. For example, in some of the selected projects DSOs are dealing directly with clients for demand response opportunities which might be regarded as a commercial role. Time varying electricity tariffs are often applied in demonstration projects. In most cases these are offered by retailers or other service suppliers, in some cases also grid capacity is offered in different tariffs. Here too, it should be clear who is in the lead when offering a time varying tariff to the consumer.

Another example comes from Germany where changing regulation is leading to new roles, e.g. metering point operator and the metering service provider. This might also be the case for Dutch situation as regulation will change in the Netherlands as well. Changes in regulation should also ensure the DSO is not discouraged from introducing distributed technologies to the existing network.

New contracts and pricing models are required for creating markets in flexibility. With these new contracts and pricing models protection clauses are also needed as well as changes in the regulation to allow for Balance Responsible Parties to take advantage of offering flexibility to consumers. To that end different business model offerings are required in order to provide value to consumers, depending on the consumer and circumstances.

Virtual Power Plants (VPPs) have been shown to have a high socio-economic value within the energy market. However, it is not easy to copy results from field trials in one country to another country due to different regulations, ancillary services etcetera. The grid regulation can also vary considerably per country – at least in Europe – influencing the possibilities for smart grid investments. Advantages of innovation funding therefore seem difficult to measure.

A key factor influencing consumer benefit of smart grid technology is the type of price structure used. An appropriate rate structure will increase the value proposition offered by smart grids (and may in turn for example promote the adoption of smart appliances). In specific studies it was seen that a tiered pricing rate was more effective than a time-of-use pricing (off-peak/on-peak) scheme in terms of influencing a reduction in load. The increased resolution offered by a tiered rate structure enabled the price level to more appropriately reflect system capacity. It was even recommended to introduce an extra ‘super-peak’ price level when an even greater load reduction is needed. This suggests that an increased number of dynamic price levels enabled by smart grids is beneficial, however care should be taken not to add too many price levels. Complexity will increase uncertainty, and this may then lead to resistance against changes brought about by Smart Grids.

In several pilots in the US, a ‘Critical Peak’ price aspect was incorporated into the tariffs. This was generally shown to be an effective technique in triggering load reduction (by varying amounts), either by increasing prices or rebates. The rebate option showed lower demand reduction during peak periods, suggesting that "punishments" are more effective than "rewards".

Social and other domain

In general providing feedback to consumers makes them more aware of their energy usage. Some Home Energy Management Systems offer the possibility of comparing energy usage with other consumers, e.g. neighbors. Increasing awareness in energy consumption will induce change in consumption behavior. This is a necessary step before introducing smart grid technologies and services. Various feedback applications were trialed in projects. Feedback via an application for a smart phone was generally seen to be preferable over an in-home display.

Standardization formed a key trend throughout many projects, and was seen as a pre-requisite for many changes to occur on both a micro and meso level. In order for flexibility to be introduced into the market more needs to be done with regards to standardizing control systems, as currently retro-fitting costs are higher than returns from flexibility. In general standardization will lower costs and enable the use of different technologies in the same system. In various projects open communication standards have been applied.

On a micro-level it was recommended that aspects of machine-to-machine communications are kept separate and as independent as possible from the rest of a home energy management solution. Although this will perhaps result in an increase in costs, it will ensure a future-proof solution until some kind of standardization in home communications occurs.

Another trend observed throughout the projects was the changing role of the consumer to a prosumer. However, it is essential to segment the consumer base and to create specific business models for these segments. This is also important to increase user acceptance of smart grid offerings as there is still a huge concern among consumers regarding privacy and security. A general lack of understanding of bills, a lack of trust in electricity companies and fear of discomfort all present barriers in many consumers embracing the potential benefits of smart grids and becoming prosumers.

A basic awareness amongst many consumers of what smart grids are is low. It is vital that this changes, as with increasing awareness will come increasing support for the technology. End-user acceptance will ultimately determine the success of many aspects of smart grids, and thus the need for education and communicating the smart grid message effectively is more important than ever. The language needs to be as simple and non-technical as possible, e.g. one should rather talk about ‘money saved’ instead of ‘kWh saved’. This education should begin before any deployment of smart grid technology. Overall it is important to emphasize what the benefits of the technology are, not how it works.

Recommendations – use lessons learned as input for 'do-it-yourself' approach

This report provides a comprehensive overview of the key findings from many smart grid demonstration projects globally. It has been structured based on Netbeheer Nederland's own smart grids roadmap, and the first recommendation is that a great deal of value can be obtained through navigating the appendices using the hyperlinks. It is here that full project descriptions and action point specific findings can be found, enabling a deeper understanding of the demonstration projects analyzed.

Before undertaking a demonstration project by one or several Netbeheer Nederland members, it is advised to carefully examine the findings from demonstration projects given in this report related to the relevant action points. This should provide guidance on what aspects to concentrate on, how to avoid mistakes of others, and to identify areas where there is a lack of knowledge or skills in advance.

The process of learning through implementing real demonstration projects can be sped up through participation in selective targeted collaborative efforts with other stakeholders. Uniting efforts with grid operators and market players in other (European) countries will allow different aspects of a project to be conducted in different locations in parallel, with results being shared throughout the duration of the project.

Last but not least it is recommended to keep track of the fast developments regarding smart grid demonstration projects globally. We learned that the majority of the projects in the long list have started after January 1, 2011. Many results therefore are expected to be reported in one to three years from now while many other projects are about to start this year, and more are expected in the coming years due to stimulus programs in all three regions.

Following these recommendations will ensure an iterative cycle of understanding, implementing and spreading knowledge regarding world wide smart grids demonstration and implementation projects.

CONTENTS

1 INTRODUCTION

This report represents the final installment of the work conducted for the Global Inventory and Analysis of Smart Grid Demonstration Projects. Since the third quarter of 2011, four quarterly reports have been produced detailing developments in Smart Grids demonstration projects in several regions of the world (Asia, Europe and the Americas). In this report, the findings from these four documents containing a total of 47 projects, are brought together to provide an insight into lessons learned from demonstration projects globally.

The selection and description of the demonstration projects have been tailored to focus on areas that have an added value for Netbeheer Nederland as described in their report *'The road to a sustainable and efficient energy supply; Smart Grids Roadmap*', (hereafter referred to as 'Smart Grids Roadmap') which envisions the role of smart grids in 2050. In this Smart Grids Roadmap, Netbeheer Nederland has composed various action points to enable a smart grid in the Netherlands in 2050 (see Appendix A). All information in this report has been structured around these action points, thereby providing a direct link to topics of interest for Netbeheer Nederland.

In Section 2 the applied methodology is explained, while in Section 3 a general overview of the status and developments in the area of smart grids is given for the regions Asia, Europe and the Americas. Furthermore an overview of the analyzed demonstration projects per region is given. The overall summary of the lessons learned from these demonstration projects are captured in the Sections 4 (Technical aspects), 5 (Policy & Regulatory aspects) and 6 (Social & Other aspects) of this report. These conclusions are not only divided by the domain in question but also by region. Based on these findings several recommendations for Netbeheer Nederland are given in Section 7.

For a more extensive look into the demonstration projects from which the conclusions in Sections 4, 5 and 6 are derived, it is highly recommended that the analysis of individual projects in Appendix C is studied. It is this analysis which formed the core of the work and from which real insight can be gained. In Appendix D, lessons learned from analyzed projects are aggregated by action points as defined in the Smart Grids Roadmap of Netbeheer Nederland. This is intended to provide an easy reference for findings relating to a specific issue. The accessibility has been further increased by adding hyperlinks (for example [EUR 7]) throughout the document, which lead directly to the related demonstration project in Appendix C.

2 METHODOLOGY

This chapter describes the approach taken to select smart grid demonstration projects to analyze for this report, and how this approach was altered through the course of the quarterly report write-ups.

2.1 Working Principles

In four quarterly reports the global developments in the area of smart grids demonstration projects were mapped. In the first quarterly report, an update of a previous smart grids study "*International example developments in Smart Grids – Possibilities for application in the Netherlands" (Smart Grids Inventory report)*" by order of the project group Smart Grids of Netbeheer Nederland, was performed. During the following three quarters a specific region was assessed and the preliminary results were presented. The findings from these reports have now been combined to produce this final report.

The topics mentioned in the Smart Grids Roadmap of Netbeheer Nederland formed the basis for the assessment of the demonstration projects. The division of this roadmap into three specific domains and nine aspects provided the necessary structure to frame the review of projects shown in Table 1. Each of the aspects listed contains specific action points, which were checked individually when analyzing smart grid demonstration projects. These action points are further explained in Appendix A.

Table 1: Division of focus areas on smart grid developments

Domain	Aspect
Technical	Systems
	Control
	Information
Policy & Regulation	Responsibilities & tasks
	Financial aspects & incentives
	Policy development
Social & Other	Protocols & standards
	Stakeholders & user interaction
	Other

The action points in the Roadmap are also divided on three levels: Micro (household level), Meso (local area) and Macro (national level). During the kick-off meeting with Netbeheer Nederland it was decided to focus on the electricity distribution grid. Consequently demonstration projects focused on the Macro level (mainly transmission grid issues) were not considered for analysis unless the findings influenced system services on the distribution network. A similar stance was taken for projects on gas infrastructure. Nevertheless, integration of electricity systems with gas and/or heat have been covered in some of the selected projects.

Other criteria that were applied to filter the most valuable demonstration projects from the long list to create shortlists were:

- Start of project after the 1st of January 2009;
- At least two technologies or services considered within demonstration;
- At least relevant for two domains;
- At least two stakeholders involved;
- Exclude policy projects outside EU;
- Exclude smart meter projects;
- Exclude very locally oriented projects;
- Include micro-level topics only if the project has an impact on distribution system services;
- Include transmission topics only if the project has an impact on distribution system services.

Besides filtering projects based on the criteria described above, each quarterly report aimed to focus on different domains as outlined in Table 2. This influenced the projects that were placed on the shortlist for analysis.

Table 2: Focus of consecutive quarterly reports

Quarterly report	Region	Primary focus
1	World (update of previous report)	All domains
2	Asia	Technical domain
3	Europe	Policy & Regulation and Social domains
4	Americas	Social & other domain

Whilst the filter criteria and focus domains provided a useful basis for deciding on which projects to analyze, applying these criteria too strictly would sometimes have resulted in otherwise valuable projects being excluded (for example a useful project may have only been conducted by a single stakeholder in a domain different to the intended focus of the quarterly report). Thus, in such cases the rules were relaxed to allow such projects to be included.

In order to find information regarding demonstration projects a variety of methods were utilized. The predominant method of research was conducting internet searches and desk studies. However this did not always lead to the necessary in-depth information needed to understand the project in full. Quite often individual contacts for projects were contacted personally for further information with mixed success. Additionally colleagues within the DNV KEMA global network were approached when it was deemed that they would be able to provide further guidance on particular projects (especially those outside of Europe).

For each quarterly report the selected projects were presented individually in order to provide a clear overview of the activities involved and lessons that could be learned in relation to Netbeheer Nederland’s own action points. For this final report, the 47 projects which were analyzed have been collected together in Appendix C.

In that appendix the findings of each project are presented in a table, in which the current status, the project partners and a short explanation of the project are given. Next follow the findings which are presented along the structure of the domains, aspects and action points. One star indicates that the topic of the action point is mentioned in the project and two stars indicate that the project dealt with topics that are relevant for Netbeheer Nederland and contains lessons to be learned. The number code in the description refers to an action point in the roadmap, although one number has been added in front which indicates either 1) micro or 2) meso level. Summarizing, the number code refers to (level, domain, aspect, action point). For example 1.1.2.3 refers to the micro level (1) on the technical domain (1) on control aspects (2) regarding the third action point 'Effect of the remote switching of household appliances'. As mentioned before the list of action points from the roadmap of Netbeheer Nederland can be found in Appendix A.

A summary of findings, structured by action point can be found in Appendix D.

2.2 Validation of Methodology

The first quarterly report did not require applying the complete methodology as the list of projects to be analyzed was already set (see Appendix B.1). This meant that the formation of the long list was not necessary in the first quarter. However this report did provide a useful way to test the rest of the methodology. An overview of the countries in which the project took place is given in Figure 1.

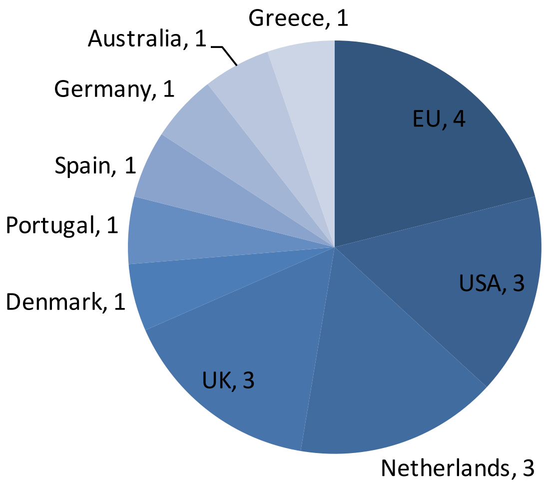

Figure 1: Overview of countries in which demonstration projects in the previous smart grid inventory study were executed.

Overall it was seen that although this first quarterly report provided a number of results for action points (see Table 3), there was a lack of real lessons that could be learned from the findings as they were in many cases quite descriptive. As the first quarterly report was an update of an older report, some projects also fell out of scope based on the criteria described in section 2.1. Lessons that could be learned from the first quarterly report have been integrated into the regional conclusions in sections 4-6.

Table 3: Indication of relevance of information in analyzed demonstration projects in previous DNV KEMA report

		Micro		Meso	
Domain	**Aspect**	★	★★	★	★★
Technical	Systems	16	3	10	4
	Control	13	3	11	1
	Information	6		6	1
Policy & Regulation	Responsibilities & tasks	5		1	
	Financial aspects & incentives	4	1	2	3
	Policy development	2	1	1	2
Social & Other	Protocols and standards	5	1	1	
	Stakeholders & user interaction	2	3		
	Other	3		n/a	n/a

Following the first and second quarterly reports, a change in the methodology was adopted. A greater emphasis was placed on focusing on projects which had already been completed and had final reports (or at least progress reports) available. This was because such reports offered more valuable conclusions based on actual results. Such an approach led to a greater number of relevant lessons learned in the Europe and Americas reports, evident in sections 4-6. Figure 2 provides an overview of the end dates of the demonstration projects on the long lists. Projects that have end dates before 2012 have proven to provide more lessons learned at the moment.

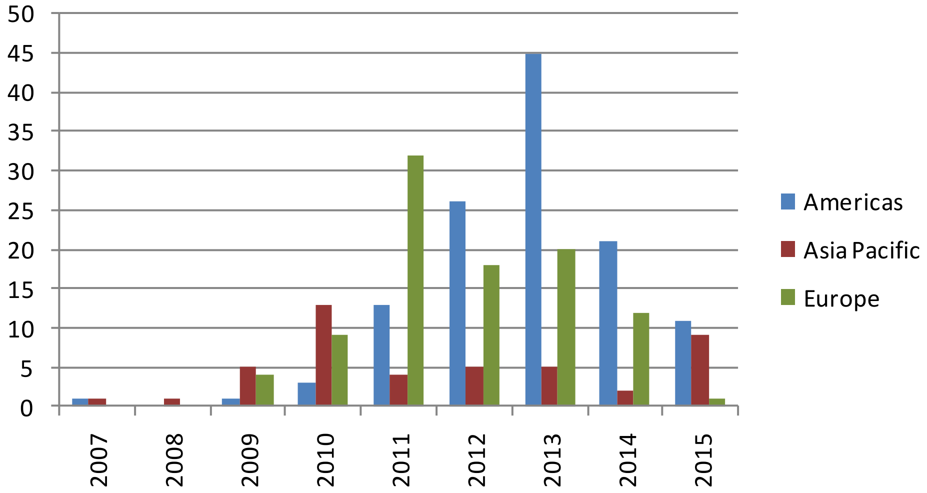

Figure 2: End dates of demonstration projects on long lists

Concluding remarks on methodology

Netbeheer Nederland wants to learn from other smart grid projects before starting their own projects. To this end, the findings of this inventory have been categorized according to the action points listed in *'The road to a sustainable and efficient energy supply; Smart Grids Roadmap*' of Netbeheer Nederland. DNV KEMA developed a methodology through an iterative process after applying certain criteria on a first series of projects and discussing the results with Netbeheer Nederland.

The final methodology includes several filters to extract the projects from hundreds of smart grid demonstrations. The criteria applied vary from factors such as the starting date of the project, to how many technologies relevant to Netbeheer Nederland's action list are incorporated. This has resulted in 47 selected projects that have been thoroughly analyzed. The main results have been summarized per domain – i.e. technical domain, policy and regulatory domain, and social and other domain – of the aforementioned action list. In order to support readers who are interested only in information regarding specific projects or specific topics, the report contains many hyperlinks which can be used to locate relevant material in the large appendices.

3 REGIONS

This chapter provides an overview of the status of smart grid developments for the three regions investigated in the quarterly reports. Tables detailing the final shortlist of projects selected for each region and the number of findings per aspect are also included.

3.1 Asia Pacific

Whilst deployment of smart grid projects in the Asia-Pacific region is not yet as widespread as in other areas of the world, recent developments suggest that large-scale implementation is not so far away.

The Asia Pacific countries' efforts to meet their Green Energy objectives have boded well for the Smart Grid market in the region. The utilities, spurred on by government funding and the cost saving benefits of the advanced technology, have started moving toward Smart Grids. Various governments in the Asia Pacific region, including Australia, New Zealand, Singapore, South Korea and Japan, have issued regulatory mandates requiring utilities to modernize their grids.

However, while the developed nations are deploying smart grids, the lack of financial means has restrained their widespread adoption in the developing countries of Malaysia, Indonesia, Thailand, and the Philippines. Once these countries learn from the experience of other nations and realize the required investments and environmental benefits of large-scale smart grid implementations, their governments are likely to increase support to utilities through funding plans.

In 2010, China surpassed the United States in total smart grid expenditures, and is anticipated to spend more than any other country on smart grid developments for several years at least. China leads in total smart grid stimulus funding with 7.3 billion USD on smart grids, compared to 7.1 billion USD in the United States. Chinese funding is primarily distributed to expand and improve transmission infrastructure. Other countries in that region with relatively large smart grids investments in 2010 are Japan (849 million USD), South Korea (824 million USD) and Australia (360 million USD)[1].

[1] http://zpryme.com/news-room/smart-grid-china-leads-top-ten-countries-in-smart-grid-federal-stimulus-investments-zpryme-reports.html, accessed February 2, 2012

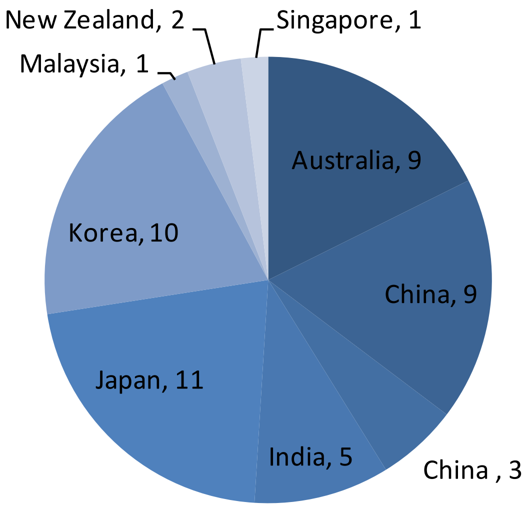

Figure 3: Overview of countries on long list of smart grid demonstration projects in Asia Pacific

Based on the long list of smart grid projects in the Asia Pacific region (Appendix B.2), the projects in Table 4 were chosen for analysis. An overview of the countries in which the projects on the long list took place is given in Figure 3. The full description of these projects can be found in Appendix C.2.

Table 4: Shortlisted Smart Grids demonstration projects Asia Pacific

#	Country	Name of project	Page
AP 1	Australia	Smart Grid, Smart City	84
AP 2	Japan	Yokohama City	88
AP 3	New Zealand	Smart Upper South Island Load Management Project	90
AP 4	Singapore	Intelligent Energy Systems	94
AP 5	China	Electric Vehicle Charging Stations	96
AP 6	China	Demand Response System Pilot	97
AP 7	China	Smart Community Demonstration Project	98
AP 8	South Korea	Consumer Portal System, Jeju island	100
AP 9	India	DRUM Program	102

From the shortlisted projects above, the total number of findings for each aspect are shown in Table 5. The focus of this quarterly report was on the Technical domain, and from the number of stars allocated in this section it can be seen that most of the findings were indeed from this domain.

Table 5: Indication of relevance of information in analyzed demonstration projects in Asia Pacific

		Micro		Meso	
Domain	**Aspect**	★	★★	★	★★
Technical	Systems	12	2	8	
	Control	12	3	5	1
	Information	5		3	
Policy & Regulation	Responsibilities & tasks	4			
	Financial aspects & incentives	3		2	
	Policy development				
Social & Other	Protocols and standards	3		1	
	Stakeholders & user interaction	4	2		
	Other	2	0	n/a	n/a

What is also clear is that most of these findings are 'one-star' findings, rather than more descriptive and valuable 'two-star' findings. A common characteristic in Asia-Pacific projects was the limited amount of information that was available in the public domain. Little information about the projects is shared, even after contacting the companies personally. Projects are being promoted with brochures and websites but after the initiation of the project, hardly any information is provided about results and lessons learned. This is in stark contrast to the European projects, where results and findings of many projects are openly shared.

Concluding remarks Asia Pacific region

A common characteristic in Asia-Pacific projects is the limited amount of information that was available in the public domain. Little information about the projects is shared, even after contacting the companies personally. Projects are being promoted with brochures and websites but after the initiation of the project, hardly any information is provided about results and lessons learned.

Nevertheless the following general conclusions can be drawn from this region:

- There is a strong emphasis on incorporating demand response as a means of reducing peak load, through the use of automated devices and various feedback appliances;
- Several ongoing projects will lead to knowledge regarding the effectiveness of different pricing tariffs;
- The increase in products offered to consumers which utilize real-time metering information will result in more stakeholder agreements over the use of smart meters being required;
- In China, the preferred strategy for EV charging seems to be through swap stations (i.e. locations where batteries can be exchanged);

Installation of smart meters forms a key component in many of the demonstration projects – with the choice of communication standards (e.g. 4G/LTE) taking into account potential privacy concerns.

3.2 Europe

Currently smart grid developments are high on the agenda of DSOs, TSOs, energy companies, service providers and research centers and public organizations in Europe. The forecasted smart grid investments until 2020 are 56.5 billion EUR, with transmission accounting for 37% of the total amount[2].

Implementation in Europe has been strongly assisted through favorable policies such as the 20-20-20 targets and the Third Energy Package. Projects within the European Commission Framework Programme for example have also led to sharing of knowledge regarding smart grid programs. This is particularly useful in Europe where such sharing is vital in order to overcome complexities in realizing Smart Grid benefits due to a deregulated and unbundled electricity supply.

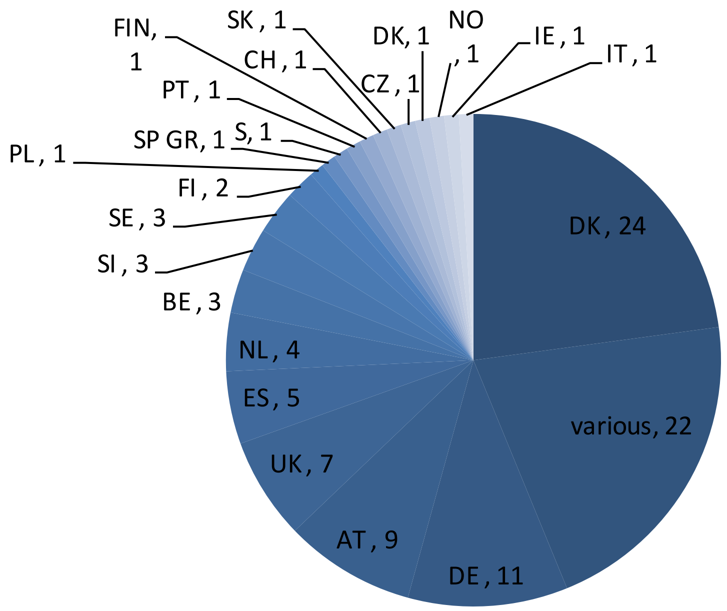

Figure 4: Overview of countries on long list of smart grid demonstration projects in Europe

In Figure 4 an overview is given of the countries in which the projects on the long list (see Appendix B.3) took place. For Europe the twelve projects in Table 6 were shortlisted from this long list and a full analysis of these demonstrations can be found in Appendix C3.

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[2] Smart Grid projects in Europe: lessons learned and current developments, JRC reference reports, 2011.

Table 6: Shortlisted Smart Grids demonstration projects Europe

#	Main country	Name of project	Page
EUR 1	EU-wide	EU DEEP	103
EUR 2	Switzerland	IMPROSUME	108
EUR 3	Germany	IRIN	113
EUR 4	Finland	Adine	118
EUR 5	Germany	ETelligence (part of E-Energy program)	121
EUR 6	EU-wide	MERGE	126
EUR 7	Germany	Model City of Mannheim (part of E-Energy program)	134
EUR 8	Germany	Smart House / Smart Grid	140
EUR 9	Germany	Regenerative region Harz (part of E-Energy program)	145
EUR 10	Spain	BeyWatch	148
EUR 11	Denmark	Cell Controller Pilot Project (CCPP)	154
EUR 12	Denmark	Twenties, VPP work package	158

From the projects above, the total number of findings for each aspect are seen in Table 7. Although the focus of the Europe quarterly report was on the Policy & Regulation and Social domains, the distribution of stars indicates a more balanced number of findings. A number of lessons learned are found within the Technical domain, which is perhaps unsurprising given the nature of many of these projects. A greater proportion of findings are ‘two-star’ than in the Asia-Pacific region, signifying the higher value embedded within these lessons learned.

Table 7: Indication of relevance of information in analyzed demonstration projects in Europe

		Micro		Meso	
Domain	Aspect	★	★★	★	★★
Technical	Systems	5	2	6	7
	Control	2	5		1
	Information	2	2	2	3
Policy & Regulation	Responsibilities & tasks	1		1	1
	Financial aspects & incentives	2	3	4	1
	Policy development	1	1	2	1
Social & Other	Protocols and standards	4	1	1	2
	Stakeholders & user interaction	7	6	2	
	Other			n/a	n/a

Concluding remarks Europe region

Smart grid developments have started earlier in Europe than in e.g. Asia Pacific, resulting in more projects with conclusions and lessons learned available. Furthermore it seems that the sharing of information is more embedded in the culture in Europe and there are relatively more government-financed projects, resulting in more emphasis on information sharing. This report revealed many lessons learned in smart grid demonstration projects all over Europe. Taking these projects into account the following general conclusions can be drawn:

- Several projects are using agent based systems to connect local devices and appliances and create local market mechanisms. This development should certainly be followed up by Distribution System Operators (DSOs);
- The need for standardization is mentioned in many projects, either for enabling combinations of communication (and other) technologies, cost reduction, and/or payment schedules. In future field trials, (open) standards should be integrated in the project;
- Feedback increases awareness of consumption and often results in lower energy (mainly electricity) use;
- One can segment different types of consumers each asking for a different approach and/or business model, so a 'one type fits all' solution is not an option;
- Although the focus point of the 12 analyzed projects were different – for example one focusing on storage and one on VPPs – many projects shared the same reason for their project, namely the integration of intermittent renewables;
- New roles are arising, which may require the role of the DSO to adapt as well;
- There is lack of information available yet on how project partners have used the results from their pilot projects in commercial, ‘real life’ projects.

3.3 Americas

A vast majority of smart grid deployment projects in America have come to fruition through stimulus funding. In particular the American Recovery and Reinvestment Act of 2009, whereby the federal government allocated $4.3 billion[3] for grid modernization initiatives has led to a number of projects mainly focused around distribution automation. Another prominent focus in projects has been on methods of peak load reduction. Other drivers for smart grids include Energy Independence and Security Act of 2007 and legislation at the state level – namely the ‘Renewable Portfolio Standard’ (RPS) which mandates a certain capacity of renewable energy sources to be installed for a designated year. It is forecast that the American Smart Grid market will grow from $5.6 billion in 2010 to $9.6 billion in 2015[4].

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[3] Sources: http://www.smartgrid.gov/recovery_act/overview/smart_grid_investment_grant_program and http://www.smartgrid.gov/recovery_act/overview/smart_grid_demonstration_program

[4] Source: http://www.greentechmedia.com/research/report/us-smart-grid-market-forecast-2010-2015/

Emphasis on many (but not all) projects still seems to be based within the context of the traditional centralized grid model, with fewer projects focused on investigating aspects of a more decentralized network topology (e.g. integration of distributed generation). In general, smart metering projects have a high profile, in both Canada and the US, with it being anticipated that by 2015 there will be a 48% deployment of smart meters in the US. Consequently many development projects also involve the deployment of Advanced Metering Infrastructure.

Progress in Smart Grid deployments in South America are predominantly being led by Brazil. The rapid economic growth of the country has resulted in the need to modernize the grid. Improved reliability will help support industries such as manufacturing which form a key part of the Brazilian economy. With an aim to incorporate more renewable into the power mix, to build upon the large amount of hydro-generation already present, a smarter grid will help this integration. A reduction in losses in some areas is also targeted with a more modernized grid. Currently relatively few pilots are underway in Brazil; however with the up-coming World Cup and Olympics in Brazil in 2014 and 2016 respectively, significant investments are expected to be focused towards smart grid development and clean technology.

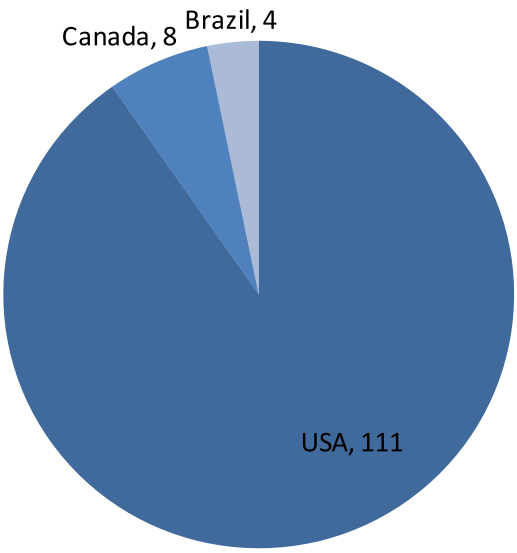

Figure 5: Overview of countries on long list of smart grid demonstration projects in the Americas

Figure 5 shows that the projects on the long list are all from the USA, Canada or Brazil, with a large majority of projects performed in the USA. For the Americas the seven projects in Table 8 were shortlisted from the long list in Appendix B.4. Ultimately all the projects in this shortlist came from America, due to the lack of projects and availability of information in countries like Canada and Brazil. It should be noted that although [AME 4] and [AME 7] are strictly speaking not demonstration projects in the sense that no smart grid infrastructure has been built, they do provide important lessons learned through the various consumer studies conducted as part of these projects. This consequently provides valuable information for Social domain aspects, which would not typically be found in more traditional Smart Grid demonstration work, hence their inclusion. A full analysis of the projects below can be found in Appendix C.4.

Table 8: Shortlisted Smart Grids demonstration projects Americas

#	Country	Name of project	Page
AME 1	USA, Oklahoma	Smart Study Together	162
AME 2	USA, Illinois	Customer Application Program Pilot	165
AME 3	USA, Colorado	Fort Collins Renewables and Distributed Systems Integration Project	168
AME 4	USA	2012 State of the Consumer Report	173
AME 5	USA, District of Colombia	PowerCentsDC Program	181
AME 6	USA, Colorado	SmartGridCity	185
AME 7	USA	EPRI Consumer Engagement Project	189

The focus of the Americas quarterly report was on the Social domain. This is evident from Table 9 where there are a significant number of findings particularly in the stakeholder and user interaction aspects. This is largely down to the consumer studies analyzed focused entirely on social aspects dealing with how to engage with customers. Within the Policy & Regulation domain, most of the findings relate to financial aspects and incentives. This is due to the prominence given to projects on dynamic pricing tariffs and demand response within the US.

Table 9: Indication of relevance of information in analyzed demonstration projects in Americas

		Micro		Meso	
Domain	Aspect	★	★★	★	★★
Technical	Systems			2	2
	Control		1		
	Information			1	1
Policy & Regulation	Responsibilities & tasks				
	Financial aspects & incentives	1	4		1
	Policy development				
Social & Other	Protocols and standards			1	
	Stakeholders & user interaction	8	10		
	Other			n/a	n/a

Concluding remarks Americas region

The main differences in the smart grid demonstration projects between the Americas and Europe is that, as a starting point, the grid (grid structure, grid development, grid operation, grid reliability and grid use) is different. This leads to, for example, higher (average) electricity consumption per customer, a lower reliability and a stronger focus on peak load reduction than in Europe, as an environment for the smart grid. Consequently, many of the projects in America deal with development of Advanced Metering Infrastructure and Distribution Automation.

Additionally it is important not to assume that a 'one-solution fits all approach' is always applicable as project outcomes can differ considerably. For example, several projects investigated some form of demand response and dynamic pricing tariffs – but with different results. Thus it would be necessary to validate certain findings in real-life situations within the context of the Dutch market.

Keeping this in mind, the following overall conclusions can be drawn:

- When looking at peak demand reduction, it is important to have knowledge of the overall peak demand shape to choose an appropriate 'toolkit' for shaping consumption. Often simply a high tariff is not enough to reduce capacity requirements;
- High pricing appears to be more effective than cash rebates when incentivizing reduction in loads;
- It is difficult to simultaneously manage both 'strategic' wider goals, with the general day-to-day operation issues of a smart grids project;
- All projects will carry a degree of risk, which should be managed through appropriate scaling of the project and a carefully managed implementation;
- The use of fluctuating distributed energy resources to reduce peaks in the loading of the grid is not straightforward and has its own challenges (e.g. availability issues);
- Simple systems such as smart thermostats are effective in bringing about savings;
- In-home displays improve awareness of energy usage to an extent, however a more detailed breakdown of usage (for example, by appliance) would provide even more value for consumers;
- Consumers are primarily incentivized by individual benefits – in particular reduction of their monthly bill (followed by other advantages such as improved reliability, better control of energy usage, environmental benefits). Segmentation will enable an even greater customized approach to engaging customers;
- The effect of electricity price on consumption behavior is variable. In general a smarter pricing rate does bring about savings (albeit limited in some cases), but the effectiveness may vary depending on specific consumer segments (due to different price elasticity).

4 TECHNICAL DOMAIN

4.1 Asia Pacific

Demonstration projects in the Asia Pacific region incorporate a multitude of technologies, although the full implementation in many cases is still to be realized. Whilst the range of smart grid topics covered is broad, some trends appear with regards to the investigation of certain topics.

A consistent technology appearing throughout projects is the use of Electric Vehicles (EVs), with charging pattern strategies and their ability to provide storage capacity in the grid forming focus points for several demonstrations [AP 1, AP 4, UPDATE 18]. In the Electric Vehicle Charging Station project [AP 5] in China, an interesting contest between 2 different charging strategies is seen – swap stations (locations where batteries can be exchanged) and traditional battery charging. Each strategy is supported by one of the two state-owned enterprises in China, the former by State Grid and the latter by Southern Grid. At this moment in time, the general trend appears to be in favor of the swap strategy, perhaps unsurprisingly the method preferred by the larger of the two stakeholders.

EVs also form part of investigations into optimizing usage on a household level. The Yokohoma City project investigates the role of 2,000 EVs in their role as part of a larger Home Energy Management System (HEMS) [AP 2]. Other energy management initiatives involve using pre-programmed automation devices and smart meter appliances to create a demand response system capable of exploiting low electricity prices during off-peak hours. The Demand Response System Pilot in China expects that through such automated demand response techniques, peak loads can be reduced by 15 to 30% [AP 6].

An effective way of reducing peak load was demonstrated in the Smart Upper South Island Load Management [AP 3]. Here the use of 'ripple' signals reduced load by around 30MW during the winter period. This ripple control is deployed for several purposes: to dynamically control appliances e.g. hot water cylinders so as to avoid peak periods, and also to supply certain appliances with electricity at fixed times (usually off-peak hours). Pricing incentives are also offered to those customers who lower the amount of electricity they consume during high-priced peak periods.

Another recurring component of smart grid demonstration projects is the smart meter, with certain installations occurring on a large scale. For example 50,000 smart meters, of which 700 have a WiMAX connection, will be installed in the Australian Smart Grid [AP 1]. With regards to security, the 4G/LTE platform is being used here as it is considered to be robust in view of potential privacy concerns.

4.2 Europe

Agent based systems to match generation and demand, such as the PowerMatcher concept, were employed in several projects throughout Europe [EUR 5, EUR 7, EUR 9, EUR 10]. Agent-based algorithms demonstrated 'plug-and-play' capabilities; new production units could be easily added or removed without having to re-calibrate the control system all over again [EUR 1]. Furthermore agents have been used for various other purposes such as congestion management, critical operations, load shedding and the integration of a new type of consumers such as EV batteries [EUR 8, EUR 6]. The DSO will have to play a critical role in this new scenario of EV batteries integration [EUR 6]. In the E-program projects [EUR 5, EUR 7, EUR 9] there is also stipulated that forecasting systems play an important role in the smart supply system.

The Cell Controller Pilot Project successfully demonstrated operation of technical VPP (allowing for decentralized control of technically aggregated resources in distribution network) [EUR 11]. With a very high penetration of renewables, such a system is important. The project allowed technical activation of resources to be carried out in parallel (without disruptions) with normal power market operation. However, despite good forecasts and influence on loads in real time, a 100-per cent spatial and temporal balance of production and consumption is not possible with current means [EUR 7].

Large scale EV deployment can be performed without major concerns if one adopts an intelligent based approach, involving full use of ICT, to manage and control the presence of EV consumers in the electrical network [EUR 6]. However, difficulties in IT system integration – with Balance Responsible Parties (complexity) as well as with DSO (security considerations, obtaining metering data) present challenges to be overcome [EUR 12]. This IT however is necessary, as a dumb charging strategy of electric vehicles will increase the daily peak demand, however those peaks will occur at a different time to that of the baseline peak demand [EUR 6].

On the generation side a sudden peak in generation by PV panels can disrupt the system as other generation units will respond simultaneously by lowering their output. Smart inverters, which require to be interconnected, are able to solve this issue, but are currently still 40% more expensive [EUR 9].

To absorb the mismatch between generation and demand, the future energy system will require additional storage capacity. A small addition to capacity can be expected in pump storage and intelligent charging management in electric mobility, but these systems will not be able to keep up with the rapidly growing balancing needs for renewable energies. One technology will not be enough as it must perform buffering functions between a few seconds and weeks [EUR 7]. Installations in companies afford great potential in general, e.g. large cold-storage depots, treatment plants or block-type thermal power stations. In the private sector, these are primarily heat pumps, refrigerators and air conditioners of a certain scale and in the future charging stations for electric vehicles. Flexibility could also increasingly come from heating grids [EUR 5, EUR 7].

4.3 Americas

The use of IT in power systems implicitly brings about a degree of risk. The probability of communication failure between assets can be minimized – but there is still always the possibility that unwanted system errors may occur. In the Fort Collins Renewables and Distributed Systems Integration project [AME 3] it was seen that limited feedback capabilities of DER assets and firewall issues led to ambiguous asset response rates.

Thus when considering technical aspects of smart grids projects, care needs to be taken in the choice of communication and control infrastructure. Different partners in the same project may use differing systems and so it is important that the chosen means of communication is compatible with existing infrastructure. Additionally the interfacing between these different IT systems must be scrutinized, and it should be ensured that all parties involved understand the interface specifications. A suggestion made to ease this process of integration was to send out the necessary software prior to project commencement in order to identify any problem areas well in advance [AME 3].

In the Fort Collins project distributed energy resources were utilized to reduce the feeder peak load. Although results were relatively successful, it was seen that the reduction was less than expected due to the unavailability of some DER assets. In the SmartGridCity project [AME 6] an alternative means of deferring capital investment in networks was pursued through the use of Volt/VAr control via distributed capacitor banks. This was expected to allow deferral in network investment for up to 2 years in feeder-specific situations where low load growth was anticipated. Peak capacity reductions through voltage reductions were also anticipated to provide benefits through deferring investment in generation capacity.

Both Fort Collins and SmartGridCity highlight the complexity of smart grids programs in general. In Fort Collins the difficulty of dealing with multiple partners was highlighted. Not only are there technical factors which limit availability of DER, but there are also individual constraints acting upon the owners of DER – related to their own business operations. Although it is important to give these partners ultimate control of their assets, this is also likely to cause an impact on expected DER availability if the constraints that affect them are not fully understood.

The SmartGridCity project also raises many lessons learned from its deemed ‘failure’. The main problems have come from overrunning the budget due to higher costs of permits, software and negotiations and the large amount of rock needed to drill through for fiber optic lines. A cost-benefit analysis was not performed before project commencement either.

On a technical level such a project raises the question of the benefits of smart metering systems, as one of the complaints against Xcel Energy (the public utility company serving customers in Boulder, Colorado), is based on the opinion that the project did not provide as many in-home benefits as expected (in-home monitoring capabilities to allow greater control of energy usage). Boulder is now pursuing other alternatives to having Xcel serve the city, such as forming a municipal utility.

Whilst a ruling on whether Xcel is fully at fault is still pending, an interesting question that is raised regards the lack of in-home benefits being less than expected and how such criteria can effectively be evaluated in the future. To what extent did Xcel fail to meet their promised vision, and to what extent were consumers perceptions of smart grid technology misguided? Whilst it is clear that Xcel certainly failed on provision of smart meters to residents (only 43% have smart meters), perhaps greater communication from the start indicating more precisely what benefits would be enabled by smart grids and meters would have prevented a fall-out with the residents of Boulder to the extent that has now occurred.

All innovative projects like SmartGridCity carry technical (and financial) risks. Another lesson to be learned is the importance of carrying out demonstration projects on the correct scale – appropriate to the risks involved in the project. Implementation should be planned, scaled and managed carefully to avoid the problems that were seen in SmartGridCity.

5 POLICY AND REGULATION DOMAIN

5.1 Asia Pacific

With the main focus of demonstrations in the Asia Pacific region being on achieving technically successful projects in the short term, very few projects touch upon aspects of the policy and regulation domain. This is perhaps not critical as policy actions for Asia are unlikely to hold too much relevance in the current Dutch context.

One of the main topics to observe from the projects in this region is the changing roles of the existing entities in the electricity supply chain in light of smart grid developments. For example in the Smart Upper South Island Load Management project, network capacity is scarce during peak times and therefore the DSO is dealing directly with clients for demand response opportunities [AP 3].

With the capability to offer time-varying electricity tariffs and value added services, suppliers will have to compete more and provide a more tailored offering to the needs of the consumer. The insights gained from the results of the pricing trials in Smart Grid, Smart City and the Intelligent Energy System will lead to valuable knowledge regarding the effectiveness of different tariffs, and provide the necessary input for the development of a new market model [AP 1, AP 4].

5.2 Europe

New contracts and pricing models are required for creating markets in flexibility. With these new contracts and pricing models protection clauses are also needed [EUR 1]. Furthermore it is recommended to change the regulation to allow for Balance Responsible Parties to take advantage of flexibility of potential of consumers on market [EUR 8]. Care should be taken in designing contracts which are not too restrictive with regards to utilizing active demand, and any potential conflicts which may occur from two separate market actors wishing to utilize the same available flexibility should be avoided (for example through more transparent procedures) [UPDATE 1].

Different business model offerings are required in order to provide value to consumers, depending on the consumer and circumstances [EUR 2]. It is important to provide an accessible and easy process for consumers to switch from their standard electricity profile regime, to a metered regime when applying flexible tariffs [EUR 8].

VPP was shown to have a high socio-economic value within the energy market [EUR 12]. However the business case for VPP must be adapted for each specific country (with different regulations, ancillary services etcetera), which makes it difficult to copy results to the Netherlands. Often there is a high cost of participation due to:

- required changes in business processes/staffing;
- cost of retro-fitting modifications to integrate local units into VPP portfolio;
- sometimes a new energy meter is required, depending on the regulations.

Greater coordination between the DSO and TSO is required regarding regulations (e.g. access to metering data) [EUR 12]. Furthermore the changing regulation in Germany is leading to new roles, e.g. metering point operator and the metering service provider, which might also be the case for Dutch situation as regulation will change in the Netherlands as well [EUR 5].

Changes in regulation should also ensure the DSO is not discouraged from introducing distributed technologies to the existing network (perhaps as a result of increased OPEX from accommodating distributed generation) [UPDATE 8]. The use of energy storage as both a production and transmission asset raises questions as to how system operators can utilize this effectively [UPDATE 11]. For example new regulation must consider whether strict unbundling regimes should be kept or whether the operators can use such storage to engage in energy trading (to cover asset depreciation, efficiency losses etc.).

Regarding smart grid investments, smart contracts between grid operator and grid consumer on a voluntary basis might be a good incentive to 'interact' with consumers regarding the required investments. The smart contracts approach is expected to be superior to local spot pricing or a locally differentiated grid pricing, as it is easier to implement [EUR 3]. Depending on the country, the grid regulation can vary considerably, influencing the possibilities for smart grid investments. Advantages of innovation funding seem difficult to measure and the implementation in the regulation varies from country to country (UK, Germany, Italy).

5.3 Americas

A key factor influencing consumer benefit of smart grid technology is the type of price structure used. An appropriate rate structure will increase the value proposition offered by smart grids (and may in turn for example promote the adoption of smart appliances). 3 of the projects analyzed in this report (OG&E Smart Study Together [AME 1], Customer Application Program Pilot [AME 2] and PowerCentsDC Program [AME 5]) investigated the impact that differing price tariffs had on energy consumption.

In the OG&E study it was seen that a tiered pricing rate was more effective than a time-of-use pricing (off-peak/on-peak) scheme in terms of influencing a reduction in load. The increased resolution offered by a tiered rate structure enabled the price level to more appropriately reflect system capacity.

It was even recommended to introduce an extra ‘super-peak’ price level when an even greater load reduction is needed. Event notification was also seen to incur a demand response effect, even when a consumer’s price rate was not affected by the event itself [AME 2].

This suggests that an increased number of dynamic price levels enabled by smart grids is beneficial, however care should be taken not to add too many price levels. Whilst the Customer Application Program Pilot showed that dynamic rates scored slightly higher on customer satisfaction than flat price rates, it was also seen that customers did not always understand all the specific aspects of the rate structure they are on. PowerCentsDC showed a simple and easy to understand tariff is also valued. It is questionable at what stage a tariff becomes too complicated. Complexity will increase uncertainty, and this may then lead to resistance against changes brought about by Smart Grids. It is thus important to come up with tariffs that find a balance between taking advantage of the rate-structure possibilities brought about by smart grid infrastructure, but also that are simple for consumers to understand.

In all of these pilots, a ‘Critical Peak’ price aspect was incorporated into the tariffs. This was generally shown to be an effective technique in triggering load reduction (by varying amounts) through increasing prices during times when demand was reaching high levels. Interestingly in PowerCentsDC it was seen that offering a rebate to consumers during such Critical Peak periods (i.e. incentivizing them to reduce consumption during critical periods through financial rewards), led to greater savings in bills than the standard Critical Peak Pricing tariff consumers. However, the rebate option showed lower demand reduction during peak periods, suggesting that "punishments" are more effective than "rewards".

In contrast to the OG&E and PowerCentsDC studies, in the Customer Application Program Pilot generally there was a considerable lack of savings that would be typically expected through the use of dynamic pricing tariffs. However within this pilot there was a small subset of customers who did respond to the price signals, and showed similar savings to other demand response studies [AME 2]. An explanation for this could be down to the fact that the design of the investigation was on an opt-out basis for participants. If true, this would imply that only after the explicit consent of consumers they would be inclined to participate in load reductions etc. The small subset could represent the customers who would have normally opted-in to such a pilot anyway. An alternative explanation for the lack of savings could also be down to the low adoption levels of in-home displays and thermostats in this project.

6 SOCIAL & OTHER DOMAIN

6.1 Asia Pacific

The increase in products offered to consumers which utilize real-time metering information will result in more stakeholder agreements and standards over the use of smart meters being required [AP 4]. In-home devices such as web portals will provide consumers with information about energy consumption, historical energy data, carbon footprint data and allow for online billing [AP 8]. The system may even include reminders for the user to avoid or reduce electricity consumption during peak hours [AP 7]. An interesting feature of the feedback devices in the Consumer Portal System project is the ability to compare energy usage data with neighbors. It remains to be seen from these projects whether this increased awareness of energy usage will induce change in consumption behavior.

From a consumer viewpoint, it is expected that green IT services should be introduced by companies as they can help reduce energy consumption and save money [AP 8]. According to the Green IT survey, 26.5% of consumers in South Korea are willing to pay for such services. The higher the income of the consumer segment, the more their willingness to pay.

Whilst the concept of a smart home or smart community is attractive, the implementation of such visions can be fraught with potential pitfalls. In the Smart Community Demo Center in China, the residents can use a variety of smart technologies to form an economical and ‘greener’ energy consumption habit [AP 7]. Through the interface of a smart device residents can even shop, make appointments with their doctors, make video telephone calls, and order food delivery without stepping out of their homes. Yet despite enthusiastic marketing from local government and the grid utilities involved, it seems that not all residents share the same enthusiasm. The projects imply higher costs than living in normal communities, and the reliability and service of post construction, equipment, interface, socket interchangeability and maintenance has not necessarily improved due to complicated system and product design.

6.2 Europe

Standardization formed a key trend throughout many projects, and was seen as a pre-requisite for many changes to occur on both micro and meso level. In order for flexibility to be introduced into the market more needs to be done with regards to standardizing control systems, as currently retro-fitting costs are higher than returns from flexibility [EUR 1]. A similar problem with high integration costs was faced by local units wishing to be included within a VPP portfolio [EUR 12]. In order for technical VPPs to interact successfully, they must also use the same open communication standards [EUR 11]. Standardization (both technical and payment) was also shown to be necessary for EVs [EUR 6]. Unless this challenge is met it is unlikely smaller scale DER services will be able to enter the market.

On a micro-level it was recommended that aspects of Machine-to-Machine communications are kept separate and independent as possible from the rest of a home energy management solution. Although this will perhaps result in an increase in costs, it will ensure a future-proof solution until some kind of standardization in home communications occurs [EUR 10]. Once open communication standards are established, decentralized Multi-Agent software solutions may be applied and implemented for in-home appliances as part of this home energy management solution [EUR 1]. This is a credible alternative to centralized DER control, as it will most likely leading to better customer acceptance as decisions are taken locally. However In-Home Technology will only find acceptance if it has been developed to an adequate standard of maturity, when it is secure and when responsibilities are clearly regulated in the case of a fault [EUR 7].

Overall it is likely that an energy management system on a home-level will lead to lower consumption and improved awareness of energy usage [EUR 8]. Intelligent facilities on a household base are required as long periods from home make it difficult to respond to tariff changes. It was seen that roughly 5 - 10% of the electricity consumption in households can be influenced over time [EUR 7]. It was seen elsewhere that the saving potential in the commercial sector was up to 20%, with the private sector having a potential of up to 10% - above all with heat pumps and air conditioners, on a smaller scale dishwashers, dryers and washing machines. However, considerable educational work is needed to raise this potential [EUR 9].

With regards to raising awareness of energy consumption, various feedback applications were trialed in projects. Feedback via an application for a smart phone was generally seen to be preferable over an in-home display [EUR 10, EUR 2]. This feedback will be important if the various pricing schemes trialed in some European projects are applied. The pilot projects were able to demonstrate the technical feasibility of innovative pricing schemes however, fixed grid charges in particular pose a constraint for setting attractive rates [EUR 7]. It was seen that a time variable rate showed particular positive results out of various rating schemes [EUR 5].

Another trend observed throughout the projects was the changing role of the consumer to a prosumer. No longer is it sensible to simply treat consumers as passive participants in the context of a smart grid. It is essential to segment the consumer base and to create specific business models for these segments. Only in this way will perceived value improve, and end user acceptance of smart metering services and other smart grid offerings increase [EUR 2]. This is particularly important as there is still a huge concern among consumers regarding privacy and security [EUR 6]. One recommendation made was that consumers could be segmented based on data from Smart Meter in order to provide more personalized energy services [EUR 10].

A general lack of understanding of bills, a lack of trust in electricity companies and fear of discomfort all present barriers in many consumers embracing the potential benefits of smart grids and becoming prosumers [UPDATE 1]. For example as seen in the EU-DEEP project more awareness is needed to alleviate their concerns with potential disruptions caused by acting as providers of flexibility [EUR 1]. Also adoption of controlled charging strategies involving the adherence of the new consumers to this concept will be fundamental to the success of EV deployment [EUR 6].

6.3 Americas

As seen in the State of the Consumer Report, even a basic awareness amongst many consumers of what smart grids are is low [AME 4]. It is vital that this changes, as with increasing awareness will come increasing support for the technology. End-user acceptance will ultimately determine the success of many aspects of smart grids, and thus the need for education and communicating the smart grid message effectively is more important than ever.

It is crucial that when educating consumers about smart grid related topics, the language used is as simple and non-technical as possible [AME 4]. It was recommended that by using analogies, or focusing on common problems of consumers that smart grids addressed, the impact of the message would be strengthened [AME 5]. Also, using metrics that are more readily comprehended will see improved consumer response – for example talking about '$ saved' instead of 'kWh saved' as seen in SmartGridCity [AME 6]. This education should begin before any deployment of smart grid/meter technology. Overall it is important to emphasize what the benefits of the technology are, not how it works.

One of the consistent themes that emerged throughout analysis is the importance that consumers place on potential cost savings brought about by smart grids. In both the State of the Consumer and Consumer Engagement reports it was seen that cost savings (through energy savings) was one of the key perceived benefits of smart grids by consumers. When talking about such potential savings in bills (or perhaps any expected increases due to the changes required) there is a need to try and be as explicit as possible as to what expected savings/expenses would look like – ideally using some kind of case studies or real-life examples. Mentioning other advantages of smart grids into consumer messages e.g. benefits to the environment or higher reliability, can also be used to bolster user acceptance. However overall it seems emphasizing individual benefits as opposed to less personal, broad benefits of smart grids is more effective in improving support.

Along with lacking awareness about smart grids, many consumers are not aware of which appliances are contributing most to their electricity usage, which consequently leads to frustration among consumers who despite their best intentions are unable to significantly alter their bill [AME 7]. To improve consumer value it is therefore important to look at not only what feedback devices consumers can use to monitor consumption, but also the level of detail at which consumption information can be provided. For example being able to provide a breakdown of energy usage by appliance would be extremely valuable for consumers [AME 5, AME 7].

With regards to receiving energy usage information, consumers should be given a choice in how they receive such information. Such actions lead to the feeling of a partnership being created between the utility and the customer [AME 6]. Easy access to usage data via websites, or in-home displays is recommended as a way to engage the consumer to participate in smart grid programs. These websites and displays are also attributed to contributing to an increase in overall consumption savings through a learning effect over time [AME 1]. 'Smart' programmable thermostats were also seen to be a preferred technology for reducing energy consumption as it allowed consumers to decide upon their own cost/comfort levels whilst typically showing good load reductions too.

Whilst the above conclusions regarding user acceptance are general enough to be valid for the vast majority of consumers, the need to segment consumers to optimize efforts and improve acceptance is vital. In the State of the Consumer Report 5 different segments were presented for the American consumer market [AME 4]. A similar segmentation is recommended for the Dutch market in order to focus communication efforts based on end-user demographics, smart grid awareness, needs and preferences.

7 RECOMMENDATIONS

Whilst the conclusions in previous chapters provide a good summary of key lessons and trends for each domain, they do not represent a fully complete collection of all findings from the work conducted for this report. This report has been structured based on Netbeheer Nederland's own smart grids roadmap, and the first recommendation is that a great deal of value can be obtained through navigating the appendices using the hyperlinks. It is here that full project descriptions and action point specific findings can be found, enabling a deeper understanding of the demonstration projects analyzed.

However it is important to recognize that learning from others still represents only a first (but necessary) step in the full smart grid development cycle. The next step is implementation. The second recommendation is that before undertaking a demonstration project by one, or several Netbeheer Nederland members, one should carefully examine the findings from demonstration projects given in this report related to the relevant action points. This should provide guidance on what aspects to concentrate on, how to avoid mistakes of others, and to identify areas where there is a lack of knowledge or skills in advance.

The third recommendation is that the process of learning through implementing real demonstration projects can be sped up through participation in selective targeted collaborative efforts with other stakeholders. Uniting efforts with grid operators and market players in other (European) countries will allow different aspects of a project to be conducted in different locations in parallel. Results on content, process, regulations and social interactions (e.g. with consumers) can be shared throughout the duration of the project. Such opportunities can be used to involve and train colleagues from multiple departments, allowing the knowledge of smart grids and its business implications to disseminate faster throughout the organization.

Last but not least, it is recommended that tracking developments in smart grids projects globally should not end with this report, but rather be a continuous monitoring process through which to learn from. Since the original '*International example developments in Smart Grids'* report was issued in 2010 for Netbeheer Nederland, a huge number of projects started and technology development is speeding up in this field that can provide an additional wealth of new information and give guidance for the future direction of smart grids in The Netherlands. Looking at the long list in Appendix, it is easy to see that there are still a huge number of projects which have only recently begun or are mid-way through implementation. Many more results can thus be expected in the next one to three years, with even more findings in the long run due to stimulus programs in countries all over the world.

Following these four recommendations will ensure an iterative cycle of understanding, implementing and spreading knowledge regarding world wide smart grids demonstration and implementation projects. This will accelerate the transition to the next generation of the power system and ensure that Netbeheer Nederland's ambitions for smart grids are achieved.

APPENDIX A ACTION POINTS IN SMART GRIDS ROADMAP BY NETBEHEER NEDERLAND

MICRO: TECHNICAL – SYSTEMS		
1.1.1.1	Smart meter and smart meter cabinet specifications	Establishing the conditions that must be met by the new generation smart meters in preparation for a future with local applications and energy management. This will include consideration of alternatives, such as splitting the integrated metering function of other (advanced) metering and possibly switching functions.
1.1.1.2	Installation of smart metering systems and/or smart meter cabinet	A smart metering device will be installed in 80% of Dutch households. In part following from the EU-directive and to implement planned legislation and regulations.
1.1.1.3	Design criteria for ICT and electronics	It will be necessary to determine what balance is desirable between flexibility of the functionality versus the lifespan of the underlying ICT and electronics. In other words: what period will the technology to be implemented (always) have to span?
1.1.1.4	Technical possibilities for electricity storage	Research into the various technical possibilities for electricity storage at the micro level, such as the use of the batteries of electric modes of transport.
1.1.1.5	Security	Research into and implementation of security of the smart meter, the smart meter cabinet and data communication against hacking.
1.1.1.6	Temperature curve for heat pumps	Research into the adjustment range of the temperature curve for heat pumps and the possible deployment strategies. The research will therefore cover the relationship between electricity demand of the residence for heating purposes and the need for warmth and warm tap water as a function of, for example, the outside temperature in a cold snap.
1.1.1.7	Power quality	Research on the effect on power quality of increasing switching of household equipment, local and/or renewable means of production and increasing power electronics (for example energy-saving lighting).
MESO: TECHNICAL - SYSTEMS		
2.1.1.1	Development of systems for load management	Development of systems and methods for load management in the distribution network. This also applies to the development of local system services that promote the use of sustainably generated electricity.
2.1.1.2	Use of local means of production and adjustable load such as VPP	Due to the coordinating use of small-scale local means of production and adjustable loads, 'Virtual Power Plants' are created. The design of such systems as well as the relationship with the network must be investigated further.
2.1.1.3	Technical possibilities for electricity storage	Research on the different technical options for electricity storage, both short term options (flywheel) as well as local options.

2.1.1.4	Development of more autonomous grids	Research on the development of a grid that can be controlled more autonomously. With a smart exchange between solar panels, storage and power electronics, intelligent adjustment can be used to maintain the voltage quality and to optimize energy management.
MACRO: TECHNICAL - SYSTEMS		
3.1.1.1	Technical possibilities for electricity storage	Research into the different technical possibilities for large scale electricity storage.
3.1.1.2	ICT security	Design of a security strategy for all ICT related to smart grids and their implementation.
3.1.1.3	Capacity expansion and installation of new types of networks	Research into the application of renewable energy and alternatives for electricity supply. All the possible renewable energy generation technologies receive ‘open source’ access to the energy infrastructure. Further not only capacity expansion and efficiency improvement of the electricity grid, but also (where desirable) the installation of district heat networks, biogas pipe networks, hydrogen tank stations, etc.
3.1.1.4	Reduction of transmission and distribution losses	Reduction of the transmission and distribution losses or making them sustainable by purchasing green electricity. Smarter network design, the use of better components and more active tracing gas leaks.
3.1.1.5	Reliability analysis of grids at sea	Reliability analysis of wind at sea in relation to various grid concepts in relation to various grid concepts and in combination with grids on the continent.

MICRO: TECHNICAL – CONTROL		
1.1.2.1	Provision of measurement data for switching	Research on the way in which signals can be delivered to the equipment of members that can serve as the basis for switching actions.
1.1.2.2	Charging strategies for electric vehicles	Research on the charging strategy for batteries (such as electrical cars) and how the stored energy that may become available for the system. Likewise, there is research on the effects of this on the network.
1.1.2.3	Effect of the remote switching of household appliances	Research on the effect of switching household appliances with the purpose of shifting peaks in electricity demand so that the available transmission capacity of the grid is not exceeded. In particular, it must be clear the degree to which the activation of different devices can lead to a shift of the transmission peak (locally and nationally) and how this can be controlled.
1.1.2.4	Price responsiveness of households	Research on the response of household consumers to price signals and the effect of this, for example on the use of micro-combined heat and power plants, heat pumps and charging electric vehicles.
1.1.2.5	Automated energy management in buildings	Implementation of automated energy management in households and in companies, making more efficient energy use possible.
1.1.2.6	Control strategy and priority strategy	Development of a strategy (algorithm) for switching loads in households (and the priority of various devices).

MESO: TECHNICAL - CONTROL		
2.1.2.1	Controlling charging of electric transport	Due to the major load on the electricity grid caused by charging of electric vehicles, system operators will take the initiative to design and standardize models to control the charging process.
2.1.2.2	Using CHPs for the operational management of grids	Development of technical and contractual solutions to facilitate local network support by CHP units ('ancillary services'). For example voltage support, congestion management or automatic backup by VPPs (virtual power plants) during (long term) failure of small HV terminals.
2.1.2.3	Safety of remote switching	Research on ensuring safety when remotely switching of household devices.
MACRO: TECHNICAL - CONTROL		
3.3.2.1	Integration of wind energy	Research into the technical consequences for systems and control for integration of wind energy and other intermittent energy sources. Wind energy (as well as solar PV) can result in major fluctuations in the national generation capacity, which can affect the stability and quality of the electricity supply. Research into the availability and controllability of sufficient adjustable power, possibilities for ancillary services and new control algorithms.
3.3.2.2	Development of optimization models	Development of optimization model to optimize and cost-efficiently operate the transmission grid at different system levels (house, street, neighborhood, city, regional, national, international).
3.3.2.3	Increasing system flexibility	Drawing up an action plan to increase system flexibility. At the same time this can include what innovative forms of flexibility are 'unveiled' by the smart grids at what time.

MICRO: TECHNICAL – INFORMATION		
1.1.3.1	Registration of user information	Research must be done on the way in which consumer usage data can best be registered, can be stored (locally) and processed into useful information. Research must be done on how this information can be secured and undesired influences can be prevented.
1.1.3.2	Development of means of communication with households	To be able to measure and control, a communication channel to households must be realized (with adequate capacity). Although the nature of the information to be sent it is still unclear (measurement data, pricing plans, etc.) and who will send the data, the communication medium must be developed. Also includes research into the robustness of the different possible means of communication.
1.1.3.3	Conversion of measurement data	Development of methods to convert the large amount of measurement data from smart meters and sensors in the grid into compact, relevant information for the operational management of the grid.
1.1.3.4	Information collection on dispersed generation	Development of a method to make message traffic possible with regard to the amount of electricity that is produced by solar panels. At the same time this method will need to be able to automatically report newly connected power to the system operator.

MESO: TECHNICAL - INFORMATION		
2.1.3.1	Information system for generators and high loads	Development of an information system for knowledge about the current use of micro-CHP, heat pumps, large air conditioners and other local means of production and (larger) electrical consuming devices, partly on the basis of municipalities and project developers.
2.1.3.2	Effect of high penetration of local generation	Research on the effect of a wide roll out of local generation, concentrated behind one medium voltage space on the distribution network. At the same time, research is done as to how consumers use these alternatives (such as supplementary heating options in the form of electrical additional heating, with biogas, extra heat buffers, etc.).
2.1.3.3	Effect of heat pumps on the electricity grid	Research on the effect of the placement of a significant number of electrical heat pumps in residential neighborhoods. In particular, the behavior of these heat pumps and their effect on the electricity grid must be accurately determined.
2.1.3.4	Determining the effect of electric vehicles on the grid	Research must be done on the effect of the large scale use of electric transportation on the required capacity of the electrical grid.
MACRO: TECHNICAL - INFORMATION		
3.1.3.1	Large-scale data-exchange in the framework of smart grids	Although different projects are conducted at a small scale, there is still little known about the possibility of using ICT to handle the large amounts of data that smart grids involve and to make them available to different stakeholders. Further research must be done for this.

MICRO: POLICY & REGULATION – RESPONSIBILITIES & TASKS		
1.2.1.1	Clarity about the role of the system operator with regard to the communication to households	The extent to which system operators will play a facilitating role must be determined with regard to the (physical) communication (ICT) to households.
1.2.1.2	Clarity about the role of the system operator in the framework of electricity storage	It must be determined which role system operators will play and are permitted to play with regard to local means of electricity storage (e.g. possibilities for activation in the framework of network safety).
MESO: POLICY & REGULATION – RESPONSIBILITIES & TASKS		
2.2.1.1	Institutional recalibration of tasks and responsibilities	Given that consumers participate more actively in the energy system, the roles (tasks and responsibilities) of different players (consumers, products, system operators, market parties) must be redefined.
2.2.1.2	Notification obligation of generators and high	Research on the effect of the implementation of a notification obligation for producers and consumers that potentially have a major need for transmission (including installation of heat pumps, for example).

	loads	
2.2.1.3	Regulation for heat pumps	Drawing up a general set of rules for situations in which heat pumps are applied on a major scale.
MACRO: POLICY & REGULATION – RESPONSIBILITIES & TASKS		
3.2.1.1	Development of preconditions of local injection of gas	In order to facilitate the injection of an increasing quantity of green gas, it is necessary to develop a standard contract for the injection of biogas into the natural gas, with which the gas quality in particular is properly arranged. Suppliers will then not need to repeatedly obtain permission from a regional system operator to be permitted to supply gas to the natural gas network. On the other hand, such a contract offers guarantees to the system operator that the gas injected is of adequate quality.
3.2.1.2	Modification of grid regulations for innovation	Research must be done on the extent to which the current legal and regulatory frameworks are adequately geared to the challenges of the energy transition. The regulatory model is currently oriented to reaching cost efficiency. In contrast, smart grids demand a lot of innovation and include potentially risky new investments.

MICRO: POLICY & REGULATION – FINANCIALS ASPECTS & INCENTIVES		
1.2.2.1	Development of possible financial stimuli for system users	Modification of the rate structure so that consumers receive financial incentives to coordinate their consumption with the system load.
1.2.2.2	Conducting market research on the wishes of consumers	Market research must be done to gain a picture of the wishes of consumers with regard to smart grids. Among other things, this will look at the environmental awareness for household energy consumption, possible stimuli to influence energy consumption, preconditions for comfort and desirability of new services such as remote switching and mutual exchange of electricity.
1.2.2.3	Review of basis for invoicing	Facilitating balance of collective generation over different connections.
MESO: POLICY & REGULATION – FINANCIALS ASPECTS & INCENTIVES		
2.2.2.1	Comparison of cost of Smart Grid and conventional grid	It is expected that the (total) network costs in the case of smart grids will be lower that the installation of conventional grids (for replacement and reinforcement). For a careful balancing (optimization), further quantification of the contribution of smart grids is necessary.
2.2.2.2	Development of new market model	Due to the increasing local production and more active role of the consumer, the need will arise for a market model in which more stimuli for efficient energy use can be given. New rules will need to be developed for this, the coordination between applications and with the grid will need to be further defined and there will need to be an adequate business case to materialize this participation.
MACRO: POLICY & REGULATION – FINANCIALS ASPECTS & INCENTIVES		
3.2.2.1	Analysis of costs and benefits of smart	Given that smart grids involve asymmetrical costs and benefits, the different stakeholders (system operators will need to invest much more, but the benefits

	grids	partially go elsewhere); this will initially have to be mapped. Subsequently, settlement mechanisms will be able to be designed to give system users and service providers the right financial incentives.
3.2.2.2	Use of the demand response	Research into regulatory and financial models to stimulate the demand response of household and small business consumers.
3.2.2.3	Business models for electricity storage	Although there is a lot of research on possible technical options for electricity storage, there is a major need for the development of business models for the integration of large scale electricity storage in the electricity system.
3.2.2.4	Development of DCO-based rate systems	The cascade model is currently used for system rates. This is illogical and untenable with a lot of DCO. New rate systems must be developed with which for example 'system' usage forms the basis of the rate.
3.2.2.5	Development of market instruments for grid flexibility	To be able to accommodate rising electricity demand and the changing usage of the grid, it may occur that the system operator must 'intervene' to prevent overloading of the grid. For this, dynamic (market-based) instruments must be developed that make it possible for the system operator to influence the production and loading among consumers.
3.2.2.6	Financing of smart grids	Given that a lot will need to be invested in the coming years in metering of the medium voltage grid and the low voltage grid as well as the high costs for consumers that can be involved in the rollout of smart grids, an adequate cost recovery model will need to be developed. The rates (and possibly the regulation methodology) must be modified to facilitate smart grids. The alternative (grid reinforcement) is after all more expensive. Solutions must also be found to cover major system innovations, pilot projects and experimental projects. This can for example be done by direct government subsidies on the basis of subscriptions and/or tendering by the (collective) system operators to achieve maximum efficiency.
3.2.2.7	Review regulatory cost recovery time	The business economic cost recovery time for smart grid investments can deviate from the usual cost recovery times in the regulatory model. Especially if the investments involve a high risk, other cost recovery models must be considered. At the same time, a method will have to be developed to handle stranded investments surrounding smart grids (for example as a result of rapidly changing ICT).

MICRO: POLICY & REGULATION – POLICY DEVELOPMENT		
1.2.3.1	Authority to affect load among consumers	In the situation that overloading of the grid is impending (e.g. due to large-scale simultaneous activation of electrical heating), the system operator must have instruments to reduce the load. For this, not only must technical control options must be developed but also a regulatory framework in which such options can be used.
1.2.3.2	Reconsideration of transmission obligation	Reconsideration of the transmission obligation in the Electricity Law, especially where the boundaries within which a system operator is obligated to supply transmission services. If the transmission obligation remains unchanged, grid

		reinforcement will be an obligation in most cases and the solution can be found with less intelligence.
MESO: POLICY & REGULATION – POLICY DEVELOPMENT		
2.2.3.1	Need for a policy framework for investments in the energy transition	Providing input for a policy framework with regard to the socially desirable investments for the energy transition.
2.2.3.2	Business models for electricity storage	Although there is a lot of research on possible technical options for electricity storage, there is a major need for the development of business models for the integration of electricity storage at the neighborhood level. The system operators are considering participating in several projects for the realization of electricity storage in a distribution substation.
MACRO: POLICY & REGULATION – POLICY DEVELOPMENT		
3.2.3.1	Development of a vision for the implementation of electricity storage	Development of a vision for the role of electricity storage in the energy system, as well as the way in which this can be invoked and/or become available in the system for the various stakeholders.
3.2.3.2	Cost causation principle	Creating an agenda for a new discussion about the cost causation principle. As a result of the energy transition, the integration will increasingly be done at the lower voltage levels. A major part of the network costs related to the energy transition related can also be related to the accommodation of this production. However, the rate system is primarily based on cost allocation to users of electricity on the basis of a cascade system. If the actual situation structurally deviates from the models underlying the rate structure, socially undesirable developments can occur, whereby some parties can profit from the shift of part of the costs to the society. The system operators propose reviewing the foundations of the rates.

MICRO: SOCIAL & OTHER – PROTOCOLS & STANDARDS		
1.3.1.1	Reference architecture	Taking initiative to develop reference architecture (ICT) and additional standardization for smart grids.
1.3.1.2	Open protocols	Taking initiative to develop open protocols for the switching of ‘smart appliances’, ‘smart heat pumps’ and to stimulate charging of electric cars.
1.3.1.3	Agreements with stakeholders about smart meters	Consulting with commercial parties and stakeholders about the division of roles surrounding the development and use of the smart meter or meter cabinet.
MESO: SOCIAL & OTHER – PROTOCOLS & STANDARDS		
2.3.1.1	Sustainable neighborhood pilot projects	Contributions to broad pilot projects for energy neutral neighborhoods with a view knowledge gathering and development of standards and protocols. Preferably projects in different provinces, with the involvement of corporations, municipalities, energy companies and system operators.

2.3.1.2	Development of local electricity markets	In collaboration with other stakeholders, developing concepts for local electricity markets for coordination between available supply and demand and facilitating its implementation.
MACRO: SOCIAL & OTHER – PROTOCOLS & STANDARDS		
n/a	n/a	n/a

MICRO: SOCIAL & OTHER – STAKEHOLDERS & USER INTERACTION		
1.3.2.1	Privacy	Addressing the privacy aspects of smart grids and anticipating possible privacy problems.
1.3.2.2	Becoming conscious about energy use	Contributing to informing household and small business consumers about innovative and sustainable energy technologies and the effects of this on the grid.
1.3.2.3	Creating incentives for household consumers	Given that the involvement of consumers forms a key factor, adequate incentives and reward mechanisms will be developed to stimulate the consumers to participate (e.g. premiums, modification of the rate structure, etc.), but the social debate but also be stimulated about the development of controlling rates for optimal grid capacity usage. This component also includes the debate about possibilities for (and acceptance of) controlling demand and local storage. When electric transport grows in importance, a situation can arise in which system operators are not able to adequately reinforce their grids in the short term. By distributing charging over time, capacity problems can be avoided. This does demand coordination that can be controlled in this way.
1.3.2.4	Modification of systems for electricity trade	There is currently a lower limit of 5 MW to participate in the trading systems. As a result of the larger potential participation of household, business and small industrial buyers in the electricity market, it is recommended to modify the technical conditions so that independent participation of these buyers becomes possible.
1.3.2.5	Dialogue about communication with households	Starting a dialogue with stakeholders about the realization of a communication channel to household and small business customers.
1.3.2.6	Support among system users	Because the rollout of smart grids will involve other possibilities for system use will make it possible to make new types of preconditions (such as differentiation of system prices depending on the system load), explanation about the importance of smart grids to consumers is necessary to create support.
MESO: SOCIAL & OTHER – STAKEHOLDERS & USER INTERACTION		
2.3.2.1	Supporting citizens' initiatives	Supporting the establishment of regional cooperation of citizens and companies to implement collective energy projects.
2.3.2.2	Discussion about installation of new gas networks	With a view to the future, the desirability of installation of new gas networks is unclear. A social discussion about this must be conducted about this.

2.3.2.3	Involvement of the system operator or the development of local grids	Technology will make independent local grids possible. The system operator intends to facilitate this discussion. The overall system integrity must be ensured in this.
2.3.2.4	Involvement in regional development	The system operators are offering to be actively involved in the schedule of newly constructed neighborhoods and large-scale renovation projects. At the same time they are available to provide a second opinion about the energy section in development plans.
MACRO: SOCIAL & OTHER – STAKEHOLDERS & USER INTERACTION		
3.3.2.1	Trends in energy use	Analyzing trends in the supply and use of electricity and the resulting load of the grid. Among other things, this concerns the development of the difference between daytime and night-time demand and the extent to which this can be influenced.
3.3.2.2	Awareness	Explaining the consequences of increasing energy demand and the need for smart grids to for example the government, municipalities and society.
3.3.2.3	Value chain optimization	Initiating social discussion to come to the broad optimization of the entire energy system.

MICRO: SOCIAL & OTHER – OTHER		
1.3.3.1	Development of 'smart homes'	Participation in partnership projects with municipalities, corporations, project developers and others to develop concepts for 'smart homes', in which technical options and social wishes are combined.
1.3.3.2	Investment Climate for market players	Emphasizing the need for a clear framework for innovation and investments in renewable energy in and around the residence, so that the developments are stimulated.
MESO: SOCIAL & OTHER – OTHER		
n/a	n/a	n/a
MACRO: SOCIAL & OTHER – OTHER		
n/a	n/a	n/a

APPENDIX B LONG LISTS

B.1 - List with case studies from previous DNV KEMA report

#	Project name	Region	Country	Start	End
UPDATE 1	ADDRESS	Europe	EU	2008	2012
UPDATE 2	AURA NMS	Europe	UK	2007	2010
UPDATE 3	Bio2Net	Europe	Netherlands	n/a	2007
UPDATE 4	DGFACTS	Europe	EU	2003	2005
UPDATE 5	Dynamic Line Rating	Europe	UK	n/a	n/a
UPDATE 6	EDISON	Europe	Denmark	2010	2012
UPDATE 7	Duke Energy Envision Center	Americas	USA	n/a	n/a
UPDATE 8	FENIX	Europe	UK, Portugal, Spain, France	2005	2009
UPDATE 9	Flywheel Energy Storage	Americas	USA	n/a	n/a
UPDATE 10	Grid Friendly Appliance Controller	Americas	USA	n/a	n/a
UPDATE 11	GROWDERS	Europe	EU	2009	2011
UPDATE 12	InovGrid	Europe	Portugal	2007	n/a
UPDATE 13	IntDS	Europe	Netherlands	n/a	2009
UPDATE 14	Integral – PowerMatching City	Europe	Netherlands	n/a	n/a
UPDATE 15	Kythnos Micro-Grid	Europe	Greece	n/a	2009
UPDATE 16	Orkney Active Distribution Management	Europe	UK	2004	n/a
UPDATE 17	Smart City Malaga	Europe	Spain	2009	2013
UPDATE 18	Smart Village Program	Asia Pacific	Australia	2010	2012
UPDATE 19	Virtual Fuel Cell Power Plant	Europe	Germany	2001	2005

B.2 - Long list with case studies from Asia Pacific

Project name	Region	Country	Start	End	Availability information	Start > 1-1-2009	≥ 2 technologies	≥ 2 domains	≥ 2 stakeholders	Exclude smart meter projects	Exclude policy outside EU	Exclude locally oriented	Only micro-level if impact on system services	Only transmission if impact on system services
Advanced Electricity Storage Technologies Program	Asia Pacific	Australia	2009	2012	+	+	+	+	-	+	+	+	+	+
Cool Change Trial	Asia Pacific	Australia	2007	2011	-	-	-	+	+	+	+	+	+	+
Green Town Project	Asia Pacific	Australia	2010	2014	-	+	+	+	-	-	+	+	-	+
IN Community - Bega Valley	Asia Pacific	Australia	2011	2012	-	+	+	+	+	+	+	+	+	+
Renewable Remote Power Generation Program	Asia Pacific	Australia	2008	2011	-	-	-	-	-	+	+	+	+	+
Smart Grid Smart City	**Asia Pacific**	**Australia**	2010	2013	+	+	+	+	+	+	+	+	+	+
Solar Cities Program	Asia Pacific	Australia	2004	2013	+	-	+	+	+	+	+	+	+	+
Townsville Commercial Demand Management Pilot	Asia Pacific	Australia	2005	n/a	-	-	+	+	+	+	+	+	+	+
Victoria Smart Meter Project	Asia Pacific	Australia	2008	2013	+	-	-	+	+	-	+	+	+	+
+/-660kV Ningdong - Shandong DC Line Project	Asia Pacific	China	2009	2010	+	+	-	-	+	+	+	+	+	-
750 kV /+/-400 kV AC and DC Grid Interconnection	Asia Pacific	China	2005	2010	+	-	-	-	+	+	+	+	+	-
800 kV UHV DC Converter Station	Asia Pacific	China	2009	2009	+	+	-	-	-	+	+	+	+	-
Demand Response Pilot Project	**Asia Pacific**	**China**	2012	n/a	+	+	+	+	+	+	+	+	+	+
Pilot Substations (74 to be set up, 20 already operating)	Asia Pacific	China	2011	2015	+	+	-	-	+	+	+	+	+	+
Power System Digital Real-Time Simulation	Asia Pacific	China	2009	2009	-	+	+	-	+	+	+	+	+	+
Smart Community Demonstration Project	**Asia Pacific**	**China**	2010	2010	+	+	+	+	+	+	+	+	+	+
Tianjun EcoCity	Asia Pacific	China	2008	2013	+	-	+	+	+	+	+	+	+	+
UHVAC Demonstration Project 1000kV Jindongnan-Nanyang-Jingmen	Asia Pacific	China	2006	2009	+	-	+	-	+	+	+	+	+	-
+/-500kV DC Power Transmission Project	Asia Pacific	China	2008	2010	+	-	-	-	+	+	+	+	+	-
Electric Vehicle Charging Stations	**Asia Pacific**	**China**	2010	n/a	+	+	+	+	+	+	+	+	+	+
Xiangjiaba-Shanghai 800 kV UHV DC Transmission Pilot	Asia Pacific	China	n/a	2010	+	-	-	-	+	+	+	+	+	-
Bangalore DRUM Project	**Asia Pacific**	**India**	2012	2015	+	+	+	+	+	+	+	+	+	+
Maharashtra Pilot Project	Asia Pacific	India	n/a	n/a	-	+	+	-	+	-	+	+	+	+

Mangalore Pilot Project	Asia Pacific	India	2012	2015	-	+	+	-	-	-	+	+	+	+
Rabirashmi Abasan Housing project	Asia Pacific	India	n/a	2008	-	-	-	-	+	+	+	+	+	+
SA Habitat and Valence Energy	Asia Pacific	India	n/a	2009	-	+	-	-	+	+	+	+	+	+
AMI introduction	Asia Pacific	Japan	2008	n/a	--	-	-	-	+	-	+	+	+	+
Kitakyushu-City	Asia Pacific	Japan	2010	2015	-	+	+	+	+	+	+	+	+	+
Kyoto Keihanna District	Asia Pacific	Japan	2010	2015	-	+	+	+	+	+	+	+	+	+
Next generation electricity grid project in isolated islands	Asia Pacific	Japan	2009	2012	-	+	+	+	+	+	+	+	+	+
Ota City Demonstration Site	Asia Pacific	Japan	2002	2007	-	-	+	+	-	+	+	+	+	+
Rokkasho village smart grid project	Asia Pacific	Japan	2010	n/a	--	+	+	+	+	+	+	+	+	+
Smart grid project in Tokyo Institute of Technology	Asia Pacific	Japan	2010	2012	--	+	+	+	+	+	+	+	+	+
Toyota City, Aichi	Asia Pacific	Japan	2010	2015	-	+	+	+	+	+	+	+	+	+
V2X, Electric Vehicle Smart grid Pilot	Asia Pacific	Japan	2011	2014	-	+	-	+	+	+	+	+	+	+
Wakkanai and Hokuto Solar demonstration sites	Asia Pacific	Japan	2006	2010	-	-	+	+	-	+	+	+	+	+
Yokohama City, Kanagawa	**Asia Pacific**	**Japan**	2010	2015	+/-	+	+	+	+	+	+	+	+	+
Consumer portal system	**Asia Pacific**	**Korea**	2005	2010	+	-	+	+	+	+	+	+	+	+
Energy management system (IT)	Asia Pacific	Korea	2005	2010	+	-	+	-	+	+	+	+	+	+
integration EMS for the micro grid	Asia Pacific	Korea	2007	2012	+/-	-	+	+	+	+	+	+	+	+
Intelligent Distribution management system	Asia Pacific	Korea	2005	2010	+	-	+	-	+	+	+	+	+	+
Intelligent Transmission network monitoring and operation system	Asia Pacific	Korea	2005	2010	+	-	-	-	+	+	+	+	+	-
IT based control system	Asia Pacific	Korea	2005	2010	+	-	-	-	+	+	+	+	+	+
PLC ubiquitous technology	Asia Pacific	Korea	2005	2010	+	-	-	-	+	+	+	+	+	+
Power equipment monitoring system	Asia Pacific	Korea	2005	2009	+	-	+	-	+	+	+	+	+	+
Power semiconductor for dispersed generation and industrial inverter application	Asia Pacific	Korea	2005	2010	+	-	-	-	+	+	+	+	+	+
Prototype advanced substation automation system	Asia Pacific	Korea	2005	2011	+	-	+	-	+	+	+	+	+	+
Smart Grid Test Systems	Asia Pacific	Malaysia	2010	2015	-	+	+	+	+	+	+	+	+	+
Upper North Island Demand Side Initiatives	Asia Pacific	New Zealand	2011	2015	-	+	+	+	+	+	+	+	+	+
Upper South Island load management trial	**Asia Pacific**	**New Zealand**	2009	2011	+	+	+	+	+	+	+	+	+	+
Intelligent Energy Systems	**Asia Pacific**	**Singapore**	2010	2013	+/-	+	+	+	+	+	+	+	+	+

B.3 - Long list with case studies from Europe

Besides a general web search and knowledge from DNV KEMA colleagues world wide, the following sources contributed considerably to the long list provide below:

- Joint Research Centre, Institute for Energy, 2011. Reference Reports: Smart Grid projects in Europe: lessons learned and current developments, JRC 65215.
- Smart Energy Collective, 2011. Overview Smart Grid projects; A global overview and comparison on innovativeness.
- U.S Energy Information Administration, 2011. Smart grid Legislative and Regulatory Policies and Case Studies.

Project name	Region	Country	Start	End	Availability information	Start > 1-1-2009	≥ 2 technologies	≥ 2 domains	≥ 2 stakeholders	Exclude smart meter projects	Exclude policy outside EU	Exclude locally oriented	Only micro-level if impact on system services	Only transmission if impact on system services
AMIS	Europe	AT	2005	2012	-	-	+	-	+	+	+	+	+	+
Building to Grid (B2G)	Europe	AT	2010	2013	-	+	+	+	+	+	+	+	+	+
DG Demonet Smart LV Grid	Europe	AT	2011	n/a	-	+	+	-	+	+	+	+	+	-
DG Demonetz Validierung	Europe	AT	2006	2013	-	+	+	+	+	+	+	+	+	+
Isolves PSSA-M	Europe	AT	2009	2012	-	+	-	-	+	+	+	+	+	+
More PV2Grid	Europe	AT	2010	2013	-	+	-	-	+	+	+	+	+	+
Smart Web Grid	Europe	AT	2011	2013	-	+	+	+	+	+	+	+	+	+
Vehicle to Grid - Interfaces	Europe	AT	2010	2011		+	-	+	+	+	+	+	+	+
Vehicle to Grid - Strategies	Europe	AT	2010	2012		+	+	-	+	-	+	+	+	+
Belgium east loop active network management	Europe	BE	2010	2011		+	-	-	+	+	+	+	+	-
Electrical vehicles impacts on the grids	Europe	BE	2010	2011		+	-	-	+	+	+	+	+	-
LINEAR	Europe	BE	2011	2014	-	+	+	+	+	+	+	+	+	+
Decentralized customer-level under frequency load shed-ding in Switzerland	Europe	CH	2010	2012		+	-	-	+	+	+	+	+	+
Smart Region	Europe	CZ	2011	2014	-	+	+	-	+	+	+	+	+	-
ADELE Project AA-CAES	Europe	DE	2009	2013		+	-	-	+	+	+	+	+	-
E-DeMa	Europe	DE	2009	2014	-	+	+	+	+	+	+	+	+	+

E-Energy Project “MeRegio”	Europe	DE	2008	2012	+	-	+	+	+	+	+	+	+	+
ETelligence	**Europe**	**DE**	**2009**	**2012**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**
IRIN	**Europe**	**DE**	**2009**	**2011**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**
Model City Manheim	**Europe**	**DE**	**2008**	**2012**	**+**	**-**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**
NET-ELAN	Europe	DE	2008	2011	-	-	+	+	+	+	+	+	+	+
Netze der Stromversorgung der Zukunft	Europe	DE	2008	2011	-	-	+	+	+	+	+	+	+	+
Regenerative Modellregion Harz	**Europe**	**DE**	**2008**	**2012**	**+**	**-**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**
Smart Watts	Europe	DE	2008	2012	-	-	+	+	+	+	+	+	+	+
Virtual Power Plant	Europe	DE	2008	2010	-	-	+	+	+	+	+	+	+	+
Web2energy	Europe	DE NL AT PL CH	2010	2012	-	+	+	+	+	+	+	+	+	+
Grid4EU	Europe	DE SE ES IT CZ FR	2011	n/a	-	+	+	+	+	+	+	+	+	+
Cell Controller Pilot Project	**Europe**	**DK**	**2005**	**2011**	**+**	**-**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**
Application of smart grid in photovoltaic power systems, ForskEL	Europe	DK	2010	2013	-	+	+	+	+	+	+	+	+	+
Automation systems for Demand Response, ForskEL	Europe	DK	2006	2009		-	+	+	+	+	+	+	+	+
Charge stands	Europe	DK	2010	n/a	-	+	-	+	+	+	+	+	+	+
Concept for Management of the Future Electricity System	Europe	DK	2009	2011		+	+	+	+	+	+	+	+	+
DataHub project	Europe	DK	2009	2012		+	-	+	+	-	+	+	+	+
Demand response medium sized industry consumers	Europe	DK	2009	2011	-	+	+	+	+	+	+	+	+	+
Development of a Secure, Economic and Environmentally friendly Modern Power System	Europe	DK	2010	2014	-	+	+	+	+	+	+	+	+	+
EcoGrid EU	Europe	DK	2011	2014	-	+	+	+	+	+	+	+	+	+
EDISON*	Europe	DK	2009	2011		+	+	+	+	+	+	+	+	+
Energy Forecast, ForskEL	Europe	DK	2007	2010	-	-	-	+	+	+	+	+	+	+
Flex power - perspectives of indirect power system control through dynamic power price	Europe	DK	2010	2013	-	+	+	+	+	+	+	+	+	+
Flexcom, ForskEL	Europe	DK	2008	2010		-	-	-	+	+	+	+	+	+

Heat Pumps as an active tool in the energy supply system, ForskEL	Europe	DK	2010	2012	-	+	-	+	+	+	+	+	+	+
Intelligent Remote Control for Heat Pumps, ForskEL	Europe	DK	2010	2011	-	+	+	+	+	+	+	+	+	+
iPower	Europe	DK	2011	2016	-	+	+	+	+	+	+	+	+	+
Large-scale demonstration of charging of electric vehicles, ForskEL	Europe	DK	2011	2013	-	+	-	+	+	+	+	+	+	+
Price elastic electricity consumption and electricity production in industry	Europe	DK	2006	2010		-	+	+	+	+	+	+	+	+
Price elastic electricity consumption as reserve power - a demonstration project in the horticultural sector	Europe	DK	2006	2010		-	+	+	+	+	+	+	+	+
Project "Intelligent home"	Europe	DK	2009	2011		+	+	+	+	+	+	+	-	+
Project "The Island of Fur on the map"	Europe	DK	2010	2020	-	+	+	+	+	+	+	+	+	+
Prøv1Elbil	Europe	DK	2009	2012	-	+	-	+	+	+	+	+	+	+
Second1 - Security concept for DER	Europe	DK	2010	2011	-	+	+	+	+	+	+	+	+	+
Smart neighboring heat supply based on ground heat pumps, ForskEL	Europe	DK	2011	2012	-	+	-	+	+	+	+	+	+	+
Trials with heat pumps on spot agreements	Europe	DK	2010	2011		+	-	-	+	+	+	+	+	+
TWENTIES	**Europe**	**DK ES FR BE**	**2010**	**2013**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**
Micro-Request-Based Aggregation, Forecasting and Scheduling of Energy Demand, Supply and Distribution (MIRACLE)	Europe	EL DE PT NL DK CH IT ES FR PL MK UK	2010	2013		+	+	+	+	-	+	+	+	+
Almacena	Europe	ES	2009	2013	-	+	+	+	+	+	+	+	+	-
DER-IREC 22@Microgrid	Europe	ES	2009	2011	-	+	+	+	+	+	+	+	+	+
GAD	Europe	ES	2007	2010		-	-	+	+	+	+	+	-	+
Hydrogen - Sotavento projects	Europe	ES	2005	2011		-	-	-	+	+	+	+	+	+
Smart City Malaga*	Europe	ES	2009	2013		+	+	+	+	+	+	+	+	+
Address*	Europe	ES FR IT CH SE NL UK F S BE D RO	2008	2012	+	-	+	+	+	+	+	+	+	+

Open Node	Europe	ES FR PT NL DE AT	2010	2012	-	+	+	+	+	+	+	+	+	+
MERGE - Mobile Energy Resources in Grids of Electricity	**Europe**	**ES IE EL DE BE NO UK PT**	**2010**	**2011**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**
G4V - Grid for Vehicles	Europe	ES PT NL FR DE SE IT UK	2010	2011	-	+	+	+	+	+	+	+	+	+
Fenix*	Europe	ES UK SI AT DE NL FR RO	n/a	n/a		+	+	+	+	+	+	+	+	+
Mirabel Project	Europe	EU	2010	n/a	-	+	+	+	+	+	+	+	+	+
More Microgrids	Europe	EU-wide	2006	2009	-	-	+	+	+	+	+	+	+	+
Smart grids and energy markets	Europe	FI	2009	2014	-	+	+	+	+	+	+	+	+	+
Sustainable urban living	Europe	FI	2009	2013		+	-	+	+	+	+	+	+	+
BeAware	Europe	FI IT SE	2010	2013	-	+	+	+	+	+	+	+	+	+
Adine	**Europe**	**FIN**	**2007**	**2010**	**+**	**-**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**
OPTIMATE	Europe	FR DE ES BE DK IT UK	2009	2012	-	+	+	+	+	+	+	+	+	+
GROWDERS, Demonstration of Grid Connected Electricity Systems*	Europe	FR DE ES NL	2009	2011		+	+	+	+	+	+	+	+	+
EU-DEEP	**Europe**	**FR EL UK DE BE ES SE PL LV AT HU IT FI CY CZ TR**	**2004**	**2009**	**+**	**-**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**
LASTBEG - Large Scale Tool for Power Balancing in Electric Grid	Europe	FR LT UK DE ES HU	2009	2009	-	+	+	+	+	+	+	+	+	+
Distributed connected wind farms	Europe	IE	2009	2012	-	+	-	-	+	+	+	+	+	+
Energy @ home	Europe	IT	2009	2011		+	+	+	+	+	+	+	+	+
ICOEUR	Europe	IT BE EE SI LV SE UK CH RU TR	2009	2011		+	+	-	+	+	+	+	+	-
REALISEGRID	Europe	IT NL AT FR RU DE UK SI BE	2008	2011		-	-	+	+	+	+	+	-	+
Demonstration project Smart Charging	Europe	NL	2010	2011	-	+	-	+	+	+	+	+	+	+
Easy Street	Europe	NL	2011	2014	-	+	+	+	+	+	+	+	-	+
Field trial Mobile Smart Grid	Europe	NL	2010	2011		+	-	-	+	+	+	+	+	+

Smart Energy Collective	Europe	NL	2010	2013	-	+	+	+	+	+	+	+	+	+
Smart House / Smart Grid	**Europe**	**NL D GR**	**2008**	**2011**	**+**	**-**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**
INTEGRAL	Europe	NL ES FR	2009	2010		+	+	+	+	+	+	+	+	+
E-price	Europe	NL IT CH	2010	2013	-	+	+	+	+	+	+	+	+	+
Optimal Power Network design and Operation	Europe	NO	2011	2014		+	+	+	+	+	+	+	+	-
IMPROSUME - The Impact of Prosumers in a Smart Grid based Energy Market	**Europe**	**NO CH DK**	**2010**	**2011**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**
AMI	Europe	PL	2010	2017	-	+	+	+	+	+	+	+	+	+
INOVGRID*	Europe	PT	2007	2011		-	+	+	+	+	+	+	+	+
Stockholm Royal Seaport	Europe	S	2012	2025	-	+	+	+	+	+	+	+	+	+
Charging Infrastructure for Electric Vehicles	Europe	SE	2008	2010		-	-	+	+	+	+	+	+	+
Elforsk Smart grid programme	Europe	SE	2011	2014	-	+	+	+	+	+	+	+	+	+
Smart Grid Gotland	Europe	SE	2010	2015	-	+	+	+	+	+	+	+	+	+
Advanced Systems of Efficient Use of Electrical Energy - SURE	Europe	SI	2011	2014	-	+	+	+	+	+	+	+	+	+
Kybernet	Europe	SI	2009	2011	-	+	-	-	+	+	+	+	+	+
Supermen	Europe	SI	2009	2011	-	+	+	+	+	+	+	+	+	+
ENERGOZ	Europe	SK	2010	2013	-	+	+	+	+	+	+	+	+	+
BeyWatch	**Europe**	**SP GR**	**2008**	**2011**	**+**	**-**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**
Active Network Management	Europe	UK	2010	2011	-	+	+	+	+	+	+	+	+	+
Central Networks Low Carbon Hub - Optimizing renewable energy resources in Lincolnshire	Europe	UK	2011	2014		+	+	+	+	+	+	+	+	+
CET2001 Customer Led Network Revolution	Europe	UK	2011	2013	-	+	+	+	+	+	+	+	+	+
Data Exchange	Europe	UK	2010	2011	-	+	+	+	+	+	+	+	+	+
Low Carbon London – A Learning Journey	Europe	UK	2011	2014	-	+	+	+	+	+	+	+	+	+
LV Network Templates for a Low-carbon Future’	Europe	UK	2011	2013	-	+	+	+	+	+	+	+	+	+
Plugged in Places	Europe	UK	2010	2013	-	+	+	+	+	+	+	+	+	+

* included in update previous Smart Grid Inventory (Appendix B.1)

B.4 - Long list with case studies from Americas

Besides a general web search and knowledge from DNV KEMA colleagues world wide, the following sources contributed considerably to the long list provide below:

- Electric Power Research Institute, Smart Grid Resource Center, www.smartgrid.epri.com.
- Smart Energy Collective, 2011. Overview Smart Grid projects; A global overview and comparison on innovativeness.
- SmartGrid.gov, www.smartgrid.gov. The gateway to information on U.S. federal initiatives that support the development of the technologies, policies and projects transforming the electric power industry.
- Smart Grid Sherpa, www.smartgridsherpa.com.
- Smart Grid Information Clearinghouse, www.sgiclearinghouse.org.
- U.S Energy Information Administration, 2011. Smart grid Legislative and Regulatory Policies and Case Studies.

Project name	Region	Country	Start	End	Availability information	Start > 1-1-2009	≥ 2 technologies	≥ 2 domains	≥ 2 stakeholders	Exclude smart meter projects	Exclude policy outside EU	Exclude locally oriented	Only micro-level if impact on system services	Only transmission if impact on system services
Cities of the Future (CEMIG)	Americas	Brazil	2009	2014	-	+	+	+	+	+	+	+	+	+
Companhia Paranaense de Energia (COPEL)	Americas	Brazil	2010	2014	-	+	+	-	+	+	+	+	+	+
Micro Grid of Sustainable Energy (CELESC)	Americas	Brazil	2011	2015	-	+	+	+	+	+	+	+	+	+
Smart Grid in Sao Paulo	Americas	Brazil	2010	2012	-	+	+	-	+	+	+	+	+	+
Distribution Automation Project	Americas	Canada	2009	2011	-	+	-	-	+	+	+	+	+	+
Energy Storage (2 x 1MW batteries)	Americas	Canada	2011	2012	-	+	-	-	+	+	+	+	+	+
GRID IQ Innovation Center	Americas	Canada	2011	2012	-	+	+	-	+	+	+	+	+	+
GridSmartCity	Americas	Canada	2010	2014	-	+	+	+	+	+	+	+	+	+
Powershift Atlantic	Americas	Canada	2010	2014	-	+	+	+	+	+	+	+	+	+
Smart Meters	Americas	Canada	2011	2013	-	+	-	-	+	-	+	+	-	+
Smart Meters FortisAlberta	Americas	Canada	2011	2013	-	+	-	-	+	-	+	+	-	+
Smart Zone	Americas	Canada	2010	2013	-	+	+	-	+	+	+	+	+	+
20 MW flywheel energy storage frequency regulation plant	Americas	USA	2010	2013	-	+	-	+	+	+	+	+	+	+
2012 State of the Consumer Report	**Americas**	**USA**	**2012**	**2012**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**

44 Tech Inc. Smart Grid Storage Demonstration Project	Americas	USA	2010		-	+	-	-	+	+	+	+	+	+
Advanced Compressed Air Energy Storage	Americas	USA	2010	2014	-	+	-	-	+	+	+	+	+	+
Advanced Implementation of Energy Storage Technologies	Americas	USA	2010	2014	-	+	-	-	+	+	+	+	+	+
Advanced Metering Infrastructure and Smart Grid Development Program	Americas	USA	2012	2012	-	+	+	+	+	+	+	+	+	+
Advanced Underground Compressed Air Energy Storage	Americas	USA	2010	2018	-	+	-	-	+	+	+	+	+	+
AEP Smart Grid Demonstration Project: Virtual Power Plant Simulator (VPPS)	Americas	USA	2009	2013	-	+	+	+	+	+	+	+	+	+
Amber Kinetics, Inc. Smart Grid Storage Demonstration Project	Americas	USA	2010	2014	-	+	-	-	+	+	+	+	+	+
Arizona Cooperative Grid Modernization Project	Americas	USA	2009	2013	-	+	+	-	+	+	+	+	+	+
Arizona Public Service (APS) Community Power Project Flagstaff Pilot	Americas	USA	2010	2015	-	+	+	+	+	+	+	+	+	+
ATK Launch Systems RDSI Demonstration Project	Americas	USA	2009	2013	-	+	+	+	+	+	+	+	+	+
Bangor Hydro Smart Grid Initiative	Americas	USA	2009	2011	-	+	+	+	+	-	+	+	-	+
BPA Pacific Northwest GridWise Demonstration Project	Americas	USA	2006	2007	+	-	+	+	+	+	+	+	+	+
Burbank Water and Power Smart Grid Project	Americas	USA	2011	2013	-	+	+	+	+	+	+	+	+	+
CCET—Technology Solutions for Wind Integration	Americas	USA	2010	2015	-	+	+	+	+	+	+	+	+	+
CERTS Microgrid Demonstration	Americas	USA	2008	2012	+	+	+	-	+	+	+	+	+	+
City of Anaheim Smart Grid Project	Americas	USA	2013	2014	-	+	+	-	+	+	+	+	+	+
City of Naperville Smart Grid Initiative	Americas	USA	2010	2013	-	+	+	+	+	+	+	+	+	+
Colorado Springs Utilities	Americas	USA	2005	2010	-	-	+	-	+	+	+	+	-	+
Connected Grid Project	Americas	USA	2010	2013	-	+	+	-	+	+	+	+	+	+
Consolidated Edison Company of New York, Inc. Smart Grid Regional Demonstration Project	Americas	USA	2010	2013	-	+	+	+	+	+	+	+	+	+
Customer application program pilot	**Americas**	**USA**	**2010**	**2011**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**
Customer Driven Design of Smart Grid Capabilities	Americas	USA	2010	2013	-	+	+	-	+	+	+	+	+	+
Detroit Edison Company Smart Grid Project: Smart Currents	Americas	USA	2009	2012	-	+	+	+	+	+	+	+	+	+
Distributed Energy Storage System	Americas	USA	2010	2013	-	+	-	-	+	+	+	+	+	+
Distribution Automation Project	Americas	USA	2010	2011	-	+	+	-	-	+	+	+	+	+
Dominion Virginia Power AMI Project	Americas	USA	2009	2010	-	+	+	-	-	-	+	+	-	+

Duke Energy Business Services, LLC Smart Grid Storage Demonstration Project	Americas	USA	2010	2013	-	+	-	-	+	+	+	+	+	+
Duke Energy Smart Grid Deployment Project	Americas	USA	2009	2013	-	+	+	+	+	+	+	+	+	+
East Oahu Switching Project	Americas	USA	2010	2012	-	+	+	-	-	+	+	+	+	+
East Penn Manufacturing Co. Smart Grid Storage Demonstration Project	Americas	USA	2010	2015	-	+	-	+	+	+	+	+	+	+
Electric Distribution System Automation Program	Americas	USA	2010	2012	-	+	+	-	-	+	+	+	+	+
Electric Power Board of Chattanooga Smart Grid Project	Americas	USA	2010	2014	-	+	+	+	+	+	+	+	+	+
Energy Smart Florida	Americas	USA	2010	2012	-	+	+	+	-	+	+	+	+	+
EPRI Consumer Engagement Project	**Americas**	**USA**	**2011**	**2011**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**
FirstEnergy Smart Grid Demonstration Project: Integrated Distributed Energy Resources (IDER) Management	Americas	USA	2008	2012	-	+	+	+	+	+	+	+	+	+
Flow Battery Solution for Smart Grid Renewable Energy Applications	Americas	USA	2010	2013	-	+	-	-	+	+	+	+	+	+
Fort Collins Renewables and Distributed Systems Integration Project	**Americas**	**USA**	**2012**	**2013**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**
Georgia Power PoweRewards	Americas	USA	2008	2009	-	-	-	+	-	+	+	+	+	+
Golden Spread Electric Cooperative, Inc. Smart Grid Project	Americas	USA	2010	2012	-	+	+	-	-	+	+	+	+	+
Green Impact Zone Smart Grid Demonstration	Americas	USA	2010	2014	-	+	+	+	+	+	+	+	+	+
Grid Self--Healing and Efficiency Expansion	Americas	USA	2010	2012	-	+	+	-	-	+	+	+	+	+
gridSMARTSM Demonstration Project	Americas	USA	2010	2013	-	+	+	+	+	+	+	+	+	+
Guam Power Authority Smart Grid Project	Americas	USA	2010	2013	-	+	+	+	-	+	+	+	+	+
Implementation of Smart Grid Technology in a Network Electric Distribution System	Americas	USA	2010	2013	-	+	+	-	-	+	+	+	+	+
IPC Smart Grid Program	Americas	USA	2009	2013	-	+	+	+	-	+	+	+	+	+
ISO-NE Demand Response Reserve Pilot	Americas	USA	2006	2010	+	-	+	+	+	+	+	+	+	+
Isothermal Compressed Air Energy Storage	Americas	USA	2010	2013	-	+	-	-	+	+	+	+	+	+
JEA Smart Grid Project	Americas	USA	2010	2012	-	+	-	+	-	-	+	+	-	+
Knoxville Utilities Board Smart Grid Project	Americas	USA	2011	2013	-	+	+	+	-	+	+	+	+	+

Lafayette Consolidated Government, LA Smart Grid Project	Americas	USA	2011	2013	-	+	+	+	-	+	+	+	+	+
Lee County Electric Cooperative Smart Grid Project	Americas	USA	2010	2013	-	+	-	-	+	-	+	+	-	+
Leesburg Smart Grid Investment Grant Project	Americas	USA	2010	2012	-	+	+	+	+	+	+	+	+	+
Long Island Power Authority Smart Grid Regional Demonstration Project	Americas	USA	2010	2015	-	+	+	+	+	+	+	+	+	+
Los Angeles Department of Water and Power Smart Grid Regional Demonstration Project	Americas	USA	2010	2015	-	+	+	+	+	+	+	+	+	+
MEAG Smart Grid Distribution Automation Project	Americas	USA	2010	2013	-	+	+	-	-	+	+	+	+	+
Modesto Irrigation District Smart Grid Project	Americas	USA	2010	2013	-	+	+	+	-	+	+	+	+	+
National Rural Electric Cooperative Association Smart Grid Regional Demonstration Project	Americas	USA	2010	2013	-	+	+	+	+	+	+	+	+	+
nDanville, a broadband infrastructure to support Danville's Smart Grid Energy Initiatives	Americas	USA	2007	2011	-	-	+	-	+	+	+	+	+	+
New Hampshire Electric Cooperative Smart Grid Project	Americas	USA	2010	2014	-	+	+	-	-	-	+	+	-	+
NSTAR Electric & Gas Corporation Smart Grid Regional Demonstration Project	Americas	USA	2010	2013	-	+	+	+	+	+	+	+	-	+
NSTAR Electric & Gas Corporation Smart Grid Regional Demonstration Project (2)	Americas	USA	2010	2014	-	+	+	-	+	+	+	+	+	+
NV Energize	Americas	USA	2010	2014	-	+	+	+	+	+	+	+	+	+
Oncor Electric Delivery Company, LLC Smart Grid Regional Demonstration Project	Americas	USA	2010	2013	-	+	-	-	+	+	+	+	+	-
Oncor Smart Texas Program	Americas	USA	2009	2012	-	+	+	-	-	-	+	+	-	+
Optimized energy value chain	Americas	USA	2010	2013	-	+	+	+	+	+	+	+	+	+
Pacific Northwest Smart Grid Regional Demonstration Project	Americas	USA	2010	2015	-	+	+	+	+	+	+	+	+	+
Pecan Street Project, Inc. Smart Grid Regional Demonstration Project	Americas	USA	2010	2015	-	+	+	+	+	+	+	+	+	+
PNM Smart Grid Demonstration Project: High-Penetration PV through Grid Automation and Demand Response	Americas	USA	2009	2013	-	+	+	+	+	+	+	+	+	+
Powder River Innovation in Energy Delivery Project	Americas	USA	2010	2011	-	+	+	-	-	+	+	+	+	+
Power Authority of the State of New York Smart Grid Regional Demonstration Project	Americas	USA	2010	2012	-	+	-	-	+	+	+	+	+	-

PowerCentsDC Program	**Americas**	**USA**	**2008**	**2011**	**+**	**-**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**
PPL Electric Utilities Corp. Smart Grid Project	Americas	USA	2010	2012	-	+	+	-	-	+	+	+	+	+
Primus Power Corporation Wind Firming Energy farm	Americas	USA	2010	2015	-	+	-	-	+	+	+	+	+	+
Public Service Company of New Mexico PV Plus Battery for Simultaneous Voltage Smoothing and Peak Shifting	Americas	USA	2010	2014	-	+	-	-	+	+	+	+	+	+
Rappahannock Electric Cooperative Smart Grid initiative	Americas	USA	2010	2013	-	+	+	-	+	+	+	+	+	+
RDSI - Allegheny Power Demonstration Project - West Virginia Super Circuit	Americas	USA	2009	2014	-	+	+	+	+	+	+	+	+	+
RDSI - Con Edison Smart Grid Demonstration Project: Interoperability of Demand Response Resources	Americas	USA	2008	2011	-	+	+	+	+	+	+	+	+	+
RDSI - Fort Collins Demonstration Project "3.5 MW Mixed Distributed Resources for Peak Load Reduction"	Americas	USA	2008	2011	+	+	+	-	-	+	+	+	+	+
RDSI - IIT Perfect Power Demonstration	Americas	USA	2008	2013	-	+	+	-	+	+	+	+	+	+
RDSI - Maui Grid Modernization	Americas	USA	2008	2011	-	+	+	+	+	+	+	+	+	+
RDSI - SDG&E Beach Cities Microgrid	Americas	USA	2009	2012	-	+	+	+	+	+	+	+	+	+
RDSI - UNLV Demonstration Project - Integrated PV, Battery, Storage, and Customer Products with Advanced Metering	Americas	USA	2008	2013	-	+	+	+	+	+	+	+	+	+
Sacramento Municipal Utility District Smart Grid Project	Americas	USA	2010	2014	-	+	+	+	+	+	+	+	+	+
Seeo Inc Solid State Batteries for Grid-Scale Energy Storage	Americas	USA	2010	2014	-	+	-	-	+	+	+	+	+	+
SGIG Distribution Automation project	Americas	USA	2010	2013	-	+	+	+	-	+	+	+	+	+
Smart Future Greater Philadelphia	Americas	USA	2011	2013	-	+	+	-	-	+	+	+	+	+
Smart Grid Deployment Project	Americas	USA	2010	2013	-	+	+	-	-	+	+	+	+	+
Smart Grid Distribution Automation	Americas	USA	2010	2013	-	+	+	-	+	+	+	+	+	+
Smart Grid Infrastructure Modernization of Electrical Distribution System	Americas	USA	2009	2013	-	+	+	-	-	+	+	+	+	+
Smart Grid Initiative	Americas	USA	2011	2012	-	+	+	-	+	+	+	+	+	+
Smart Grid Modernization Initiative	Americas	USA	2010	2014	-	+	+	-	-	+	+	+	+	+
Smart Grid Team 2020 Program	Americas	USA	2010	2012	-	+	+	+	+	+	+	+	+	+

Smart Study TOGETHER	**Americas**	**USA**	**2010**	**2012**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**
SmartGRID Project	Americas	USA	2011	2012	-	+	+	+	+	+	+	+	+	+
SmartGridCity	**Americas**	**USA**	**2008**	**2012**	**+**	**-**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**
Southern California Edison Company Smart Grid Regional Demonstration Project	Americas	USA	2010	2014	-	+	+	+	+	+	+	+	+	+
Southern Company Services, Inc. Smart Grid Project	Americas	USA	2012	2013	-	+	+	-	+	+	+	+	+	+
Spokane Smart Circuit	Americas	USA	2010	2013	-	+	+	+	-	+	+	+	+	+
SRP Smart Grid Project	Americas	USA	2003	2013	-	-	-	+	+	-	+	+	-	+
Tehachapi Wind Energy Storage Project	Americas	USA	2010	2015	-	+	-	-	+	+	+	+	+	+
The Boeing Company (Boeing Smart Grid Solution)	Americas	USA	2010	2013	-	+	+	+	+	+	+	+	+	-
Town of Danvers, MA Smart Grid Project	Americas	USA	2010	2014	-	+	+	-	+	+	+	+	+	+
Transverter "One house at a time"	Americas	USA	2010	2011	+	+	+	+	+	+	+	+	-	+
Vanadium Redox Battery Demonstration Program	Americas	USA	2010	2014	-	+	-	-	+	+	+	+	+	+
Vermont Transco, LLC Smart Grid Project	Americas	USA	2010	2013	-	+	+	-	+	+	+	+	+	+
Vineyard Energy Project	Americas	USA	2010	2011	-	+	+	+	+	+	+	+	+	+
Wabash Valley Power Smart Grid Project	Americas	USA	2010	2012	-	+	+	+	+	+	+	+	-	+
Waukesha Electric Systems Smart Grid Regional Demonstration Project	Americas	USA	2010	2015	-	+	-	-	+	+	+	+	+	+
Westar Energy, Inc. Smart Grid Project	Americas	USA	2011	2012	-	+	+	+	-	+	+	+	+	+

APPENDIX C CASE STUDIES

In this appendix the findings of each project are presented in a table, in which the current status, the project partners and a short explanation of the project are given. Next follow the findings which are presented along the structure of the domains, aspects and action points. One star indicates that the topic of the action point is mentioned in the project and two stars indicate that the project dealt with topics that are relevant for Netbeheer Nederland and contains lessons to be learned. The number code in the description refers to an action in the roadmap, although one number has been added in front which indicates either 1) micro or 2) meso level. Summarizing, the number code refers to (level, domain, aspect, action point).

C.1 - Case studies previous DNV KEMA report

UPDATE 1	Address, EU
Status	In progress
Dates	Completion in 2012
Involved	Enel Distribution, EDF, Iberdrola, Vattenfall, ABB, Landis+Gyr, ZIV, Philips, Electrolux, RLtec, Ericsson, Alcatel, Current, University of Manchester, Universidad Pontificia Comillas, Università di Siena, Università di Cassino, VTT, VITO, Labein, DNV KEMA, Consentec.

This project aims to contribute to the development of interactive distribution energy networks. It is a local energy balancing project, one of the building blocks of a Distribution System Operator. Central theme of this wide-scale project is active demand, i.e. allowing the participation of demand in power system markets and in service provision to different power system participants. This allows for increased power system efficiency and integration of renewable energy sources. There are three field test locations: in France, Spain and Italy.

Domain	Aspect	Micro	Meso	Relation to action points
Technical	Systems			
	Control	★★		1.1.2.4 - Domestic customers are not motivated by purely economic considerations. Voluntary or contractual price and/or volume signal mechanisms have to be developed in the houses or at the interface with the aggregator.
		★		1.1.2.6 - Address develops new trading mechanisms and algorithms to enable active demand in distribution networks. Software interfaces have been developed to control air conditioning and electric heating systems.
		★		1.1.2.5 - Local energy management equipment is implemented. Results are described in a confidential report.
			★	2.1.2.2 - Heat pumps are installed in a suburb and are being monitored.
	Information	★		1.1.3.2 - There is a (confidential) technical guide for building up a smart grid telecommunication infrastructure supporting active demand.

				It was recommended that although hourly metering values may be sufficient enough for monitoring consumers for the purposes of Active Demand, a higher resolution would be necessary for a more thorough analysis of consumer activity. Thus metering still poses a barrier for AD implementation.
Policy & Regulation	Tasks			
	Finance		★ ★	2.2.2.1 – The reduction of network losses and of network investments due to the implementation of Active Demand was quantified for different scenarios in Germany and Spain. It was seen that total network investments for most network components in peak reduction scenarios decreased compared to the reference scenario. Additionally monetary reductions were greater in Germany than in Spain. Reduction in network losses varied from country to country and on the scenario considered – ranging from 0.64% to 5.14%.
		★		1.2.2.2 - Benefits of Active Demand (AD) from the consumer perspective that were considered in evaluating the benefits of AD include: reduced energy costs, reduced price volatility, more consumer choice and improved quality of service.
	Policy	★ ★		1.2.3.1 - Contractual arrangements are seen to be a barrier for Active Demand (AD) if the contractor is not provided with enough flexibility to fulfill obligations. This refers to not only new contracts which may be made, but also existing agreements which may not allow the use of AD services or may be too restrictive. If the situation arises where two different actors may wish to utilize AD from consumers, this will perhaps require markets and contracts to be designed appropriately. If it is foreseen that such solutions will cause problems, then more transparency regarding the use of AD or particular processes which could remove such conflicts would be required. Clear rules and procedures for the technical validation of AD are also recommended to prevent any conflict of interest which may arise as a result of DSOs or TSOs having to validate the technical feasibility of certain AD requests, which the operators themselves may be wishing to use for their own purposes.
Social & Other	Protocols	★		1.3.1.1 - A new technical and commercial architecture for Active Distribution Networks is developed to be able to balance power generation and demand in real time.
	Stakeholders	★		1.3.2.6 - It was mentioned that although the Swedish market has been deregulated for 15 years, customers have not taken advantage of the different Time-of-Use (ToU) tariffs available (which have been in place for over 20 years). This lack of switching to ToU tariffs most likely

				results from a lack of understanding in electricity bills, lack of trust in electricity companies and fear of potential discomfort. It is these same barriers which will need to be overcome, maybe to an even greater level, for Active Demand and aggregator services.
	Other	★		1.3.2.3 - A methodology for the assessment of quantitative benefits of active demand has been described and applied in four European countries.

References

- http://www.addressfp7.org
- Contact person Jitske Burgers [DNV KEMA]
- http://www.addressfp7.org/config/files/Nordac10_ADDRESS.pdf
- http://www.addressfp7.org/config/files/Paper_ID59.pdf
- http://www.addressfp7.org/config/files/ADD-WP5-T5%201-Evaluation%20of%20AD%20benefit.pdf

UPDATE 2	AURA NMS, United Kingdom
Status	Finished
Dates	The project was active from 1 January 2007 to 30 June 2010.
Involved	Scottish Power, EDF, ABB, Imperial College and various universities

AURA NMS (Automated Regional Active Network Management System) is a multi party project addressing active network management to facilitate distributed generation connection and operation. It has a strong theme directed towards practical applications, including the 'real world' limitations imposed by the need to integrate new approaches with existing plant, equipment and controls. This project aims to produce a control structure and set of control algorithms that realize the notion of an active distribution network and enhance the service a network operator provides to load and generation customers, improving network performance (asset use, etc.).

Domain	Aspect	Micro	Meso	Relation to action points
Technical	Systems		★★	2.1.1.1 - This project has explored a means to gradually devolve control authority from the existing central control room (which is semi-automated and semi-manual) by using a peer-to-peer network of controllers/decision-makers placed in substations. The controllers can open and close remotely controlled switches to reallocate loads to different parts of the network and use local small-scale generation to help regulate the voltage magnitude. Significant progress has been made by the system design with regard to voltage control, thermal ratings and restoration algorithms based on DNO requirements. One of the lessons learned was that technical solutions for managing changing requirements only address part of the problem: DNOs also need to develop the appropriate planning and maintenance procedures and processes for the entire life cycle of active network management (ANM) schemes.
	Control		★	2.1.2.2 - In this project on load management, local small-scale generation was used to help regulate the voltage magnitude.
	Information			
Policy & Regulation	Tasks			
	Finance			
	Policy			
Social & Other	Protocols	★		1.3.1.1 - Analysis has been conducted on the communication bandwidth and protocols required to obtain feedback information and to issues control instructions. Furthermore proposals have been made on the communications to be adopted in future.
	Stakeholders			
	Other			

References

- http://www.ofgem.gov.uk/Networks/Techn/NetwrkSupp/Innovat/ifi/Documents1/Scottish%20Power%

20IFI%20Report%202007-8.pdf

- http://gow.epsrc.ac.uk/ViewGrant.aspx?GrantRef=EP/E003583/1
- http://www.aura-nms.co.uk/
- AuRA-NMS: An autonomous regional active network management system for EDF energy and SP energy networks (IEEE, 2010)
- http://www.ict4smartdg.eutc.org/system/files/pagefiles/AURA_PES_GM2010.pdf

UPDATE 3	Bio2Net, Netherlands
Status	Finished
Dates	Fully operational since 2007
Involved	BioGast, Stedin, ASN Bank, Cirmac, Hoogheemraadschap Hollands Noorderkwartier

The Bio2Net installation enables the integration of gas from biological sources into the public gas network. The installation is now commercially available. In July 2010, a European patent has been granted which is valid in 35 countries. The Bio2Net installation is produced by the company Itron.

Note: this project concerns smart grids for gas networks. This is not included in the action list of Netbeheer Nederland.

References

- http://www.biogast.nl/biogast2/index.php/nl/projectena-producten/bio2net

UPDATE 4	DGFacts, Europe
Status	Finished
Dates	Started in 2003, finished in 2005.
Involved	Labein, Iberdrola, SMA Technologie, Sintef, Electrotecnica Arteche Hermanos, Verbundplan, University of Ljubljana, University of Manchester, SEI, Osterreichisches Forschung und Prufzentrum Arsenal, University of Kassel and the Institut fur solare energieversorgungstechnik.

DGFACTS is about the improvement of the quality of supply in distributed generation networks through the integrated application of power electronic techniques. The aim of the DGFACTS project is to solve the set of quality of supply (QS) problems arising from the integration of Distributed Generation (DG) into the electric distribution networks.

Domain	Aspect	Micro	Meso	Relation to action points
Technical	Systems	★		1.1.1.7 - In this project, the effect of distributed energy sources, especially solar power, on the electricity network was analyzed. Problems regarding power quality are solved with power electronics. The project introduced the use of the FACTS (Flexible Alternating Current Transmission System) concept in distribution systems by designing a set of modular systems (DGFACTS) to optimally improve the stability and QS of each distribution network with high DG+RES penetration.
	Control			
	Information			
Policy & Regulation	Tasks	★		1.2.1.1 - This project managed the Quality of Supply responsibilities in the new situation with distributed energy sources.
	Finance			
	Policy			
Social & Other	Protocols			
	Stakeholders			
	Other			

References

- http://dgfacts.labein.es/dgfacts/index.jsp
- http://www.iset.uni-kassel.de/pls/w3isetdad/www_iset_new.main_page?p_name=7231320&p_lang=eng

UPDATE 5	Dynamic Line Rating, United Kingdom
Status	Finished
Dates	
Involved	Central Networks, AREVA, USi

This project involved the measurement and assessment of the operating conditions for a 132KV overhead line to determine its real-time maximum power carrying capacity. Real time measurements were made of ambient temperature and wind speed. This technique permits additional line loading, depending on conditions, beyond the standardized ratings typically assigned on a seasonal basis. In 2010, Areva T&D launched the Dynamic Line Rating. Areva focused on wind farms first. Areva claimed that dynamic rating allows increased energy yields by as much as 50%.

Note: this project is not included in the action list of Netbeheer Nederland as it focuses on high voltage grids.

References

- http://www.ofgem.gov.uk/Networks/Techn/NetwrkSupp/Innovat/ifi/Documents1/Central%20Networks%20IFI%20Report%202007-08.pdf

UPDATE 6	EDISON, Denmark
Status	In progress
Dates	Midterm workshop in August 2010, finished in 2012.
Involved	Danish Energy Association, Østkraft, Dong Energy, IBM, Siemens, Eurisco, DTU CET

E.D.I.S.O.N. is an abbreviation for "Electric vehicles in a Distributed and Integrated market using Sustainable energy and Open Networks". In the EDISON project Danish and international competences will be utilized to develop optimal system solutions for EV system integration, including network issues, market solutions, and optimal interaction between different energy technologies. Furthermore, the Danish electric power system provides an optimal platform for demonstration of the developed solutions. Work packages include 1. EV Technology, 2. System Architecture design for EV systems, 3. Distributed Integration Technology development, 4. Central fast-charge and battery swapping development, 5. EV communication and physical charging post, 6. Functional testing and field testing.

Domain	Aspect	Micro	Meso	Relation to action points
Technical	Systems	★★		1.1.1.7 Converters and inverters connected to the power system will emit harmonic distortion into the power system, due to the electro technical characteristics of the semi-conductor-based components used for those applications; these might exceed the limits stated in EN50160. Furthermore, switching on and off charging can lead to fast voltage changes causing flicker problems, but does not seem to have a great impact as long as EVs are not used in regulating applications. How a large number of EVs will affect the low voltage grid has been analyzed in the EDISON report “Power Quality in LV Grid”. Main findings: If the number of chargers with low charging power connected to the same interconnection point is increased, the impact on harmonic distortion is mitigated, especially when chargers of different manufacturers are used. Short-circuit level at the point of interconnection is very important for the value of harmonic distortion. A stronger MV network resp. a higher short-circuit level usually reduces the overall harmonic distortion. When connecting chargers with high power rating (e.g. fast charging stations) to the network, adequate voltage level and sufficiently high short-circuit power should be available at the interconnection point. High frequency (HF) current injections are not introduced into the MV network by converters connected to the LV level due to HF filters and the typical HF characteristics of the LV network (i.e. transformers and cables).
	Control	★★		1.1.2.2 With Time-of-Use pricing people may decide to charge quickly when electricity prices are low which can create worse peaks than with uniform prices. Need of large balancing power capacities and large variations in base generation remain. Only when charging is controlled to absorb fluctuations

				high variability is reduced, but this comes with a significant higher cost of charging and low 'green' content of energy.
			★ ★	2.1.2.1 Only externally controlled charging is considered appropriate in the future. They are working on a mixed strategy, between cost minimization, grid stabilization and other criteria. The algorithms are still being developed including driving pattern generators. The establishment of a smart-charging enabled infrastructure is a necessary fist step. Studies on the impact of fast charging on the grid and selection of locations, report delivered: *case studies of grid impacts of fast charging* and on the design on fast charging stations in *concept study on fast charging station design.*
	Information		★ ★	2.1.3.4 The impact on the medium voltage network has been analyzed in the EDISON report “Power Quality in Medium Voltage Network”. Short-circuit level at the point of interconnection is very important for the value of harmonic distortion. Sufficient short circuit-level must be available also for fast charging.
Policy & Regulation	Tasks	★		1.2.1.1 Mapping of congestions in the distribution grid, geographically differentiation of end-users, pricing through compensation mechanism, and developing new tools for including price dependent demand are obstacles to be overcome before distribution grid congestions can be handled in a new manner.
			★	2.2.1.1 New Grid Codes together with common standards should enable the use of the full potential of EVs delivering ancillary services to the overall power system, and ancillary services to the local grid. Developing grid codes for EVs could very well be based on the German experience with PV systems as the EV’s chargers approximately have the same characteristics as the PV inverters.
	Finance		★ ★	2.2.2.2 If EVs are introduced in the spot market, the market set-up is simple and possible today with an interval meter. The retailer can broadcast the electricity prices once a day and the end-user can make a charging strategy for the hours with known prices (12 to 36 hours ahead). The charging strategy can be a simple clock charging, or the cheapest hours can be selected with a local computer system (home automation system). If EVs are to participate in both the spot market and the regulating market a few more challenges have to be met. Requirements from the TSO regarding real time measurements of the individual unit and minimum bid size make it difficult for EVs to participate in the regulating power market today. Furthermore, there are some challenges with imbalances related to EVs in the regulating market, as the activation of regulating power at one hour can change the predicted charging at a later hour. Some of these challenges can be met by introducing a fleet operator to aggregate the consumption of a number of EVs and handle their interaction with the electricity market as one unit.
	Policy		★	2.2.3.2 Common for the typical chargers on the today’s market is that they

				are not supporting V2G functionality, e.g. they cannot supply power back to the grid. The V2G functionality is unlikely to be expected in the EVs on the market in the coming years.
Social & Other	Protocols	★		1.3.1.1 The necessary standards work is in fact already largely under way. EDISON is involved in developing the following International standards: • IEC TC57 WG17 (Distributed Energy Resources) • IEC TC57 WG15 (Security) • IEC TC69 WG4 (EV Power supplies and chargers) • IEC/ISO JWG (V2G Communication Interface)
	Stakeholders			
	Other			

References

- www.edison-net.dk

UPDATE 7	Duke Energy Envision Center
Status	Operational
Dates	Opened 2008
Involved	Duke Energy, KEMA, various equipment and service providers

DNV KEMA has partnered with Duke Energy in the visioning and creation of The Duke Energy Envision Center. This facility is among the first interactive exhibits that demonstrate the capabilities and functions of smart grid, renewable and energy efficient technologies. The center continues to host utility customers, key industry stakeholders, and regulatory and policy decision-makers providing them with an opportunity to experience how a modernized smart grid works and what it means for them.

This 15,000 square foot facility is located in Erlanger, Kentucky, near the Cincinnati OH airport and provides a movie-style studio with set that shows how a technology enabled "Smart Grid" benefits both customers and the utility. It shows the flow of energy from a distribution substation equipped with two-way communications networks can better help manage the reliable and effective distribution of energy. Contained within this center are intelligent networked devices including smart meters, distribution control assets (switches, capacitor control, line fault indicators, and so forth) and how these assets integrate for grid modernization. Also included in this Center is a "smart home" equipped with "grid friendly" devices such as kitchen appliances, clothes washers and dryers, water heaters and energy storage units. This home also includes an electric vehicle charging station and intelligent energy management support systems that can coordinate load management with grid demands. The display area also includes a mock-up of a multi-dwelling unit complex also provisioned with "smart meters," and a power delivery work center – monitoring conditions with real-time data. Visitors can experience a simulated power outage event to see how these technologies are used to rapidly identify problems, isolate faults, automatically operate restoration scenarios and help to effectively rectify these problems.

Interspersed throughout the Center are "viewing stations" where video segments articulate how various aspects of smart grid are able to provide consumer benefits.

DNV KEMA has also established a Smart Grid Interop Laboratory that is co-located at this facility. This 3,000 square foot operation has a number of live operating systems that are being used to test compatibility and functionality. The assets at the SGIL include, banks of smart meters, communicating appliances, multiple electric vehicle charging units and EV's; community energy storage (CES); network gateways, live feeds to university laboratories, and a fully operational medium voltage (13.5KV) feeder that is dedicated to the lab. This system is networked to other DNV KEMA laboratories and to our Testing Master that has master use cases and test scripts that can be executed and monitored over a high speed secure data network.

Note: this project is a demonstration center, enabling clients to test and experience various energy scenarios, Lessons learned differ per test and differ per client and are confidential. Therefore, they can not be included in the action list of Netbeheer Nederland.

References

- http://www.kema.com/services/ges/smart-grid/Duke-Energy-Envision-Center.aspx
- http://www.kema.com/services/consulting/moc/inc/SmartGridInterop.aspx

UPDATE 8	FENIX, USA
Status	Finished
Dates	Completion in 2009
Involved	Iberdrola, EDF, EDF Energy Networks, Areva, ECRO, ECN, Labein, Gamesa, IDEA, Imperial College London, ISET, Korona, National Grid Transco, Poyry Consulting, Red Electrica de Espana, ScalAgent, Siemens, University of Manchester, Vrije Universiteit Amsterdam, ZIV PmacC

The objective of FENIX was to boost Distributed Energy Resources (DER) by maximizing their contribution to the electric power system, through aggregation into Large Scale Virtual Power Plants and decentralized management. FENIX conceptualized, designed and demonstrated a technical architecture and commercial and regulatory framework that enabled DER units to become the solution for the future.

Domain	Aspect	Micro	Meso	Relation to action points
Technical	Systems	★		1.1.1.1 - Real-time metering of distributed generation (DG) should be mandated for DG above a certain size (a delegated dispatch is a step in this direction).
		★★		1.1.1.7 - A Distribution Management Tool called Volt Var Control (VVC) has been developed. The VVC is an Optimal Power Flow (OPF) based algorithm which helps determine what actions need to be taken to maintain the voltage levels. Power quality was improved by using inverter based grid coupling. The inverter and the doubly-fed induction generator inject reactive power and compensate harmonics and other disturbances of power quality.
			★★	2.1.1.2 - A Virtual Power Plant (VPP) concept has been developed that fits the European power system. Large-scale use of flexible operational aggregation of distributed energy resources by a virtual power plant can result in reduction of system gas consumption and therefore in CO_2 emission reductions. According to the economy-wide scenarios developed within the Fenix project, by 2020, CO_2 emissions in the electricity sector could be reduced by 7.5 kg CO_2/kW flexible DG/year in a northern European scenario and by 13 kg CO_2/kW flexible DG/year in a southern European scenario, compared to the reference case.
	Control		★	2.1.2.2 - CHP was considered as one of the DER units. The historic background anticipated that domestic small-scale generation would be common in the Distribution Network, but as it did not appeared, a municipal authority with significant CHP capacities was used, alongside simulated domestic DERs.
	Information	★		1.1.3.4 - Distributed energy resources are aggregated into large scale virtual power plants. Basically, all types of ancillary services can be provided by controllable DER units.
			★	2.1.3.1 - New hardware components and software applications were developed that realized the VPP concept.

Policy & Regulation	Tasks	★		1.2.1.2 - Carrying out technical VPP activity requires detailed local network knowledge and control capabilities, so the DSO will typically be best placed to fulfill this role.
	Finance	★		1.2.2.1 - Each commercial aggregating agent responded to incentives of both the commercial VPP it is part of, and the technical VPP that covers its grid area.
			★	2.2.2.2 - A commercial framework is developed that allows the beneficial integration of the VPP concept in the future European power system. Cost Benefit Analyses were made that quantify the economic benefits of the VPP concept.
	Policy		★ ★	2.2.3.1 - Fenix developed a regulatory framework that allows the beneficial integration of the VPP concept in the future European power system. General recommendations included ensuring that regulation allows DSOs to benefit when they use active network management to defer or avoid capital expenditure, in situations where this is socio-economically efficient. This is to avoid the DSOs being disincentivized to accommodate new DG due to increases in OPEX. DSOs should also not be required to guarantee physically firm access to all DG, and must be allowed to use lean, network design methodologies. This is to overcome the issues with current design methodology focusing on connecting and not integrating DG due to DG normally complicating the planning of networks.
Social & Other	Protocols	★		1.3.1.1 - Fenix has provided and tested in the field common information architecture to build the different forms of aggregation needed. Fenix developed an information and communication architecture that is scalable and hierarchically flexible.
	Stakeholders			
	Other			

References

- http://fenix.iwes.fraunhofer.de/home.htm
- http://fenix.iwes.fraunhofer.de/docs/documents/Project_Fenix_2009-07-06_WP3_2_5_RegulatoryFramework_FullReport_Dafydd_Elis_v1.pdf
- http://fenix.iwes.fraunhofer.de/docs/att2x/2009_Fenix_Book_FINAL_for_selfprinting.pdf

UPDATE 9	Flywheel Energy Storage, USA
Status	Finished
Dates	On 12 July 2011 the 20 MW flywheel plant in Stephentown, NY, was inaugurated.
Involved	Beacon Power, Pentadyne Power Corporation and others

This project is an example of storage technology that is now becoming commercially available at MW-scale. As with battery devices, it is modular and can therefore be scaled up to greater capacities. Unlike batteries, the device uses stored rotational energy in a fast-spinning (8,000 - 16,000 rpm) flywheel. Applications of this technology are, among others, cloud mitigation for solar PV, ramp mitigation for wind, stabilization of distributed generation peak power support and reactive power support.

Domain	Aspect	Micro	Meso	Relation to action points
Technical	Systems		★	2.1.1.3 - This project utilizes flywheel modules in a mechanical solution that provides active power (up to 20 MW) delivering an ancillary service for frequency control. The system is designed to quickly add or subtract power from the grid in a frequency regulation support mode. This technology has the potential to improving balancing responsible parties' ability to follow fast-changing loads.
			★	2.1.1.4 - The benefits of the technology to grid operators would be to improve the ability of Distributed Generation (DG) assets to operate on an islanded basis during a blackout, as well as to reduce emissions by reducing ramping needs.
	Control			
	Information			
Policy & Regulation	Tasks	★		1.2.1.2. - The project does not yet provide conclusive information as to whether fly wheel storage is more likely to become a DSO controlled asset or a producer's asset. Limited storage volumes suggest mainly frequency control purposes.
	Finance			
	Policy			
Social & Other	Protocols			
	Stakeholders			
	Other			

References

- www.beaconpower.com
- www.beaconpower.com/files/pr/20120319_Rockland_Capital_Completes_Acquisition_of_Beacon_Power.pdf

UPDATE 10	Grid Friendly Appliance Controller, USA
Status	In progress
Dates	In the first quarter of 2011, Battelle granted start-up technology firm Encryptor of Plano a non-exclusive license for the technology.
Involved	Pacific Northwest National Laboratory (PNNL)

The Grid Friendly Appliance (GFA) Controller developed at PNNL senses grid conditions by monitoring the frequency of the system and provides automatic demand response in times of disruption. The chip can be installed in household appliances and turn them off for a few minutes or a even a few seconds to allow the grid to stabilize. It is ready for licensing and installation in the next generation of appliances. PNNL is currently working with appliance manufacturers and utilities to use Grid Friendly Appliances in a variety of test-bed and demonstration projects. In the first quarter of 2011 Battelle granted start-up technology firm Encryptor of Plano a non-exclusive license for the technology.

Domain	Aspect	Micro	Meso	Relation to action points
Technical	Systems	★		1.1.1.7 - The GFA Controller has been developed to autonomously react in fractions of a second when a disturbance is detected and stabilize power grids and prevent outages.
	Control	★		1.1.2.1 - The GFA Controller is an autonomous device reacting to fluctuations on the grid. An autonomous device that reacts directly to the grid is a possible solution for automated in-home switching.
		★		1.1.2.3 - The GFA controller can be applied without affecting experienced comfort (e.g. by only switching off refrigerator compressor or central heating pump) and through automation as it does not require remote control.
	Information			
Policy & Regulation	Tasks			
	Finance			
	Policy			
Social & Other	Protocols			
	Stakeholders			
	Other			

References

- http://availabletechnologies.pnnl.gov/technology.asp?id=61
- http://www.pnl.gov/news/release.aspx?id=856

UPDATE 11	Growders, EU
Status	Finished
Dates	2009 – June 2011
Involved	DNV KEMA, Continuon, Iberdrola, MVV, EAC, CEA-INES, IPE, Exendis, SAFT, Chloride.

GROWDERS demonstrates the technical and economical possibilities of existing electricity storage technologies. Transportable storage provides a flexible asset for network management introducing possibilities for deferral of investments in expensive switchgear and creates possibilities to integrate DG and RES.

Domain	Aspect	Micro	Meso	Relation to action points
Technical	Systems	★		1.1.1.4 - The project realizes different types of transportable flexible storage systems – namely Li-ion battery and flywheel systems. The field test in Zamudio, Spain reported transportation and installation of the system was relatively easy to accomplish. The system for harmonic compensation was reported to work, but not as expected. A good set point selection was identified to be a critical step in the implementation phase of a storage system.
		★		1.1.1.7 – A flywheel that was implemented in Zutphen turned out to be very effective in dealing with PQ issues.
			★	2.1.1.1 - The importance of communication for remote control turned out to be a learning point in the first pilot projects. Subsequent pilots were installed with an improved management system.
			★	2.1.1.3 - A software tool, Platos, was developed for optimal configuration of storage systems. The software helps to select the best location, size and type of storage and provides for an optimal storage control strategy along with performance indicators.
	Control	★		1.1.2.2 - The lithium-ion based system (often used for EV) has shown to be compliant with normal grid operation.
			★	2.1.2.1 - The project shows the possibilities of transportable storages.
	Information			
Policy & Regulation	Tasks			
	Finance			
	Policy		★ ★	2.2.3.1 – The introduction of energy storage devices raises regulation issues as it can not easily be classed as simply a production or a transmission asset. It is important that system operators who invest in such technologies are not disadvantaged because of regulation which restricts innovative actions. Decisions to consider include whether TSOs/DSOs are prohibited from pursuing merchant activities or whether they are enabled to do so albeit with

				certain constraints. It could be that although merchant application of storage may be prohibited, compensation could be provided for costs of operating the storage system – via the financial benefits of trading via setting lower feed-in tariffs for TSOs and DSOs. Efficiency losses, asset depreciation and overhead costs could be compensated through selling prices being higher than buying prices. If strict unbundling of activities is maintained and the system operator cannot engage in such buying/selling activities, then regulation should ensure that the commercial firms operating the storage are capable of providing the appropriate grid support (absorbing or delivering electricity) as required. Any remaining capacity can be used for merchant activities.
Social & Other	Protocols			
	Stakeholders			
	Other			

References

- http://www.growders.eu
- http://www.growders.eu/papers/CICED%202010%20paper.pdf
- http://www.growders.eu/Documents/GROWDERS%20WP9%20Regulation%20bottleneck.pdf
- contact person: Petra de Boer [DNV KEMA]

UPDATE 12	InovGrid, Portugal
Status	In progress
Dates	The proposed implementation is as follows: start in 2007, pilot with 500 customers in 2009, installation phase 1, 50,000 customers in 2009-2010; installation phase 2, up to 600,000 customers 2010-2011 and roll-out from 2011 to 2017 for the whole of Portugal. Half way through 2011, roughly 30,000 customers have been included with an "energy box".
Involved	EDF Distribution, Insec Porto, Efacec, Logica, Janz

The project scope aims at developing a set of functionalities and new devices that can be installed on the network to facilitate a more active role for the management of the distribution system. The main objectives of the project include: i) bringing about the liberalization of electricity markets in Portugal, ii) developing a customer-focused market, iii) inducing demand modulation, iv) improving security of supply and v) promoting the renovation of grids and their operation. Expected benefits from this project are that regulators will see better implementation of conditions that support market developments, with positive implications on energy costs.

Domain	Aspect	Micro	Meso	Relation to action points
Technical	Systems	★		1.1.1.1 - One of the key components of this project are the "energy boxes", which have been developed especially for this project. Every household will require such a device to connect to the grid.
		★		1.1.1.2 - The project started of with 500 installed smart meters. Currently 30,000 energy boxes and 40,000 distribution transformer controllers have been installed.
	Control	★		1.1.2.4 - The price responsiveness of the households is one of the many subjects of this project.
	Information			
Policy & Regulation	Tasks			
	Finance	★		1.2.2.1 - The tariff structure is one of the aspects that is being evaluated in this project.
			★ ★	2.2.2.1 - During the project a special focus is on a cost-benefit analysis. Aspects that are taken into account are energy efficiency, reduction of technical and commercial losses, reduced meter reading and other operational costs, improved quality of technical and commercial service, reduced maintenance costs, and the integration of EV and micro generation to the grid. In the preliminary results the operating benefits such as reduced reading and operation costs have been confirmed. For future evaluation a crucial variable will be the energy efficiency of the consumers.
	Policy			
Social & Other	Protocols	★ ★		1.3.1.1. - The communications structure that was selected for installation in Évora was PLC DCSK. This technology has served the majority of functionalities but it has limitations to support future features, particularly in relation to demand side management, mass use of electric vehicles and

				micro generation. In a small percentage GPRS was installed and several small scale pilots were implemented to test other communications technologies, including PRIME PLC and RF mesh. This resulted in insight in limitations and costs.
	Stakeholders	★ ★		1.3.2.6 - One important lesson learned was that the involvement of the end-users is important. It is important to manage expectations, to explain clearly the benefits of the solution and to understand their needs and difficulties. Local and direct contact is very important and this was strengthened during the project.
	Other			

References

- http://www.inovcity.pt/en/Pages/inovgrid.aspx
- http://www.metering.com/node/19904
- http://ec.europa.eu/research/conferences/2009/smart_networks/pdf/messias.pdf

UPDATE 13	IntDS, Netherlands
Status	Finished
Dates	End of project in 2009.
Involved	ECN, Imtech Vonk, Eaton, Exendis, Alfen, Liander, DNV KEMA

Increased penetration of dispersed generation and developments in the power demand will steadily result in increasingly more fluctuations in the power flows of LV and MV distribution grids in the near future. To manage these fluctuations while maintaining power quality, reliability and security of supply, an intelligent 400 kVA, MV/LV-distribution station (intDS) has been designed.

Domain	Aspect	Micro	Meso	Relation to action points
Technical	Systems	★★		1.1.1.7 - The intelligent MV/LV distribution station has been designed and tested in such a way that it maintains and even improves power quality in an economic way when distributed energy resources are added to the distribution grid.
			★★	2.1.1.1 - The system has been developed to integrate dispersed generation while maintaining power quality. The simulation results show a significant reduction of harmonic voltages, resonances as well as a leak load reduction of 30%.
	Control			
	Information			
Policy & Regulation	Tasks			
	Finance			
	Policy			
Social & Other	Protocols			
	Stakeholders			
	Other			

References

- http://www.smartsubstation.eu/home
- contact person: Erik de Jong [DNV KEMA]

UPDATE 14	Power Matching City, Netherlands
Status	In progress
Dates	Phase I has ended. Phase II started February 2011.
Involved	DNV KEMA, ECN, Essent, Enexis, Humiq, TNO

An example of local matching of generation and demand. Field test covering the day-to-day market trading (Virtual Power Plant (VPP) operation), network congestion management, In-home optimization and integration of intermittent RES. Production and consumption of electricity are constantly matched by generating electricity as much as possible at high demand loads and switching on (or off) electrical devices at times of high (or low) generation.

Domain	Aspect	Micro	Meso	Relation to action points
Technical	Systems	★		1.1.1.3 - An industry-quality reference ICT-platform for distributed control in electricity grids at aggregated levels has been developed.
		★		1.1.1.4 - A generic design has been developed that allows seamless coordination of hybrid heat pumps, CHPs, electric cars and smart appliances such as freezers in a single ICT solution.
		★		1.1.1.6 - The various technologies used in this project provide flexibility without impacting the overall comfort of the end-user, and allow interoperability between components, and the ability to grow the system as organically as needed. Measurements from the micro CHP systems and the hybrid heat pumps indicate that the system responds quickly to fluctuating demands, and maintains an appropriate fill level for each household over the long term.
			★	2.1.1.1 - Renewable energy sources like solar power and wind energy were successfully integrated in the grid.
			★	2.1.1.2 - This project carried out experiments with day-to-day market trading (VPP operation).
	Control	★ ★		1.1.2.1 - Renewable energy technologies, specifically wind and solar, come with inherent intermittency challenges. Due to these fluctuations in power supply, any grid system served by renewables needs the flexibility to maintain the power balance. This project shows that smart grid technologies offer that flexibility. During the project, electrical devices of households were switched on (or off) at times of high (or low) generation.
		★		1.1.2.3 - Peaks in electricity demand were reduced by controlling electrical devices in households.
		★		1.1.2.4 - The PowerMatcher ensures that electrical devices, e.g. the heat pumps, are switched on only when sufficient electricity is available at low prices.
		★		1.1.2.5 - Local energy management equipment is implemented to match production and consumption of electricity constantly.

			★	2.1.2.2 - This project is successfully used CHP as grid support.
			★	2.1.3.3 Heat pumps are integrated in the grid and monitored.
	Information			
Policy & Regulation	Tasks			
	Finance	★		1.2.2.1 - During this project, it was shown that financial incentives worked as expected. End users buy electricity when the price is low and sell when the price is high, ensuring that comfort levels are maintained.
		★★		1.2.2.2 - Many consumers have privacy and security concerns about the type and amount of information smart devices capture. Consumers are also apprehensive about controlling their own power usage. Alleviating consumer concerns has been critical in gaining both the public approval necessary to facilitate Smart Grid transitions, and in educating consumers about the benefits they stand to reap.
	Policy	★		1.2.3.1 - In this (local) project, the network operator was able to reduce peak loads by sending incentives to the neighborhood. The producer used the decentralized energy generation units as a Virtual Power Plant.
Social & Other	Protocols	★		1.3.1.1 - An ICT infrastructure was successfully designed and implemented enabling end-users to have feed-back on the operation of their system and enabling system operators to control their cluster. A generic design has been developed that allows seamless coordination of hybrid heat pumps, -CHPs, electric cars, smart appliances such as freezers, washing machines etc. in a single ICT solution.
			★	2.3.1.1 - The flexibility provided by the various technologies applied can be generalized. This allows standardization of interfaces. An interoperable solution is provided for a heterogeneous smart grid solution that can grow organically.
	Stakeholders	★★		1.3.2.6 - Alleviating consumer concerns is critical in both gaining the public approval necessary to facilitate Smart Grid transitions, and in educating consumers about the benefits they stand to reap. End-user acceptance is guaranteed by advanced comfort control mechanisms and monitored in a participating design program. The consumer response regarding this project has been positive. Lifestyle interruptions have been minimal.
	Other	★		1.3.3.1 - Smart homes have been developed by the consortium of Essent, Humiq, TNO and DNV KEMA and in close cooperation with GasUnie, the Municipality of Groningen, the Energy Covenant Groningen.

References

- http://www.powermatchingcity.nl
- contact person: Albert van der Noort [DNV KEMA]

UPDATE 15	Kythnos Micro-Grid, Greece
Status	Finished
Dates	This project was finished in 2009.
Involved	Centre for Renewable Energy Sources and Saving (CRES), ICCS/NTUA, ANCO, ISET, SMA Regelsysteme GmbH

An interesting example of a micro-grid scheme that has been successfully deployed is in a small valley on the Greek island of Kythnos. The system is a single phase micro-grid composed of the overhead power lines and a communication cable running in parallel electrifying 12 vacation houses. This network is used to test centralized and decentralized control strategies in island mode as well as communication protocols that are a major challenge for such micro-grids. The focus in this project has been on technical feasibility rather than large scale demonstration.

Domain	Aspect	Micro	Meso	Relation to action points
Technical	Systems		★	2.1.1.3 - In this project the storage in batteries has been tested. The grid electrifying the users is powered by three Sunny-island battery inverters connected in parallel to form one strong single-phase in a master slave configuration, allowing the use of more than one battery inverter only when more power is demanded by the consumers. Each battery inverter has a maximum power output of 3.6kW. The battery inverters in the Kythnos system have the capability to operate in both isochronous or droop mode. The operation in frequency droop mode gives the possibility to pass information on to switching load controllers in case the battery state of charge is low and also to limit the power output of the PV inverters when the battery bank is full.
	Control		★	2.1.1.4 - This project incorporates solar PV generation, a diesel generator and electrical storage in a micro grid in island mode.
	Information	★		1.1.3.2 - Two implementations of the IEC 61850-7-420 standard have been applied. The first one includes several extensions to incorporate other equipment not included in the standard (namely controllable loads and measuring devices) and an alternative communication protocol (XML-RPC). The second one forces the standard data model into mapping each particular variable of one commercial PV inverter while adhering to the original MMS communication protocol.
			★	2.1.3.2 - In this micro grid several PV solar systems and a diesel generator are connected. The effect of high penetration of decentralized production capacity has certainly been tested in this set up. Integration of multiple micro grids into the operation of a decarbonized power system requires radically new control and management structures and practices to enable the interface with the upstream distribution management system and the operation of coordinated, but decentralized markets for energy and services. Specific new software tools and simulation approaches have been studied.

Policy & Regulation	Tasks	★		1.2.1.2 - One of the main components of this micro grid in island mode is the storage system that is located in the grid.
	Finance			
	Policy			
Social & Other	Protocols			
	Stakeholders	★ ★		1.3.2.6 - One of the challenges during the implementation was the fact that consumers were not adequately involved in the management of the micro grid and as such they had the tendency to overload the system. Currently there is not a viable scheme for the operation of the system by the users, which may be a key issue to address for remotely located systems.
	Other			

References

- http://www.microgrids.eu/index.php?page=kythnos&id=2
- http://www.microgrids.eu/documents/esr.pdf

UPDATE 16	Orkney Active Distribution Management, UK
Status	In progress
Dates	Initiated in 2004, operational in November 2009, further developed in 2010 and 2011.
Involved	Strathclyde University, Smarter Grid Solutions

This project is an example of an 'active network' making use of intelligent control logic and modern communications to control Distributed Generation so that available network capacity is not exceeded. It defers the need for expensive conventional reinforcement and so brings cost efficiency benefits in addition to enabling the connection of renewable generation sources. The principles have application for other constrained networks and are not limited to island situations. The techniques that have been applied include Dynamic Line Rating (DLR), Real Time Rating (RTR) and Demand Response (DR).

Domain	Aspect	Micro	Meso	Relation to action points
Technical	Systems		★	2.1.1.1 - Orkney is connected to the mainland network by two 33kV submarine cables and network simulation and analysis has shown that this active network management scheme may be capable of releasing capacity for DG connections by up to three times the firm capacity of the existing distribution network. To enable active management of the power flows on Orkney, the network has been segregated into control zones. Control logic has been designed to regulate the output or trip the New Non Firm Generation (NNFG) as required to optimize use of the available network.
			★	2.1.1.4 - Future plans are the introduction of i) state estimation, ii) voltage control, iii) energy storage. There are also plans for active network management by means of distributed automation. Currently they are applying a spreadsheet model of generation and load profiles.
	Control			
	Information		★	2.1.3.2 - The Orkney Isles are an area of abundant renewable energy resource with several wind farms and is connected to the mainland network by two 33kV submarine cables. In the Orkney project more than 15 MW of new wind capacity is added, made up of more than 13 turbines.
Policy & Regulation	Tasks			
	Finance		★	2.2.2.1 - Large investments in additional transport capacity to the mainland have been mitigated by applying demand response. It should be noted that this is a special situation as the project is located on an island, which requires high investments to connect to the mainland.
	Policy	★		1.2.3.2 - One of the principles applied in this project is the "Last in First off" principle of access. In case of contingencies the parties latest connected will be shut off first.
Social & Other	Protocols			
	Stakeholders			
	Other			

References
• http://www.ofgem.gov.uk/Networks/Techn/NetwrkSupp/Innovat/ifi/Documents1/Scottish%20and%20Southern%20Energy%20IFI%20Report%202007-08.pdf • http://www.4thintegrationconference.com/downloads/4_SG%20Post%20Workshop_SmarterGrid_Ault+Currie.pdf • http://www.cired.be/CIRED05/papers/cired2005_0520.pdf

UPDATE 17	Smart City Malaga, Spain
Status	In progress
Dates	The project was launched in July 2009 and will last for four years.
Involved	Endesa, ERDF, Enel, Acciona, IBM, Sadiel, Ormazábel, Neometrics, Isotrol, Telvent, Ingeteam, Greenpower and several universities

Smart City Malaga is a 31 million EUR project that offers a new energy management model in cities. The objective is to achieve a 20% energy saving, a reduction of 6.000 tons of CO_2 per year, and an increase of renewable energy consumption. Renewable energy sources will be linked up to the grid to more closely match generation to consumption. Furthermore there will be energy storage systems in the form of batteries. The installation of advanced telecommunication systems and remote control will operate in real time and automatically on the distribution network, enabling a new energy management and increasing the quality of service.

Domain	Aspect	Micro	Meso	Relation to action points
Technical	Systems	★		1.1.1.2 - All participating consumers will receive a smart meter. Advanced Metering Infrastructure is covered in work package (WP) 11 of the project.
		★		1.1.1.4 - The integration of several distributed energy resources for generation and storage within the low voltage network, while maintaining adequate quality of supply, is one of the objectives of this project. This topic is dealt with in WP 10.
		★		2.1.1.3 - The project integrates a small and heterogeneous set of generators and storage within the medium voltage network. The objective is an optimal integration of renewables into the grid near the consumption centers. These topics are dealt with in WP 7.
	Control	★	★	1.1.2.2 & 2.1.2.1 - A small fleet of electric vehicles is managed remotely for charging and for generation. In the proposed system, the vehicles are considered as loads that can be managed, but also as small sporadic generators, responding to the needs of network operation. This topic is handled in WP 12.
		★		1.1.2.4 - Consumption management is aimed to improve energy efficiency by influencing the information to consumers and consumer awareness. This activity includes specific areas for street lighting control, home efficiency and load management. WP 8 deals with this topic.
		★		1.1.2.5 - Network intelligence is implemented in the low voltage segment through distributed system devices which are connected in real time basis. A controller, located at the processing center, makes the control and regulation of the generation and manageable loads on the network. This is dealt with in WP 9.

	Information		★	2.1.3.1 - WP 6 implements network intelligence within the medium voltage segment. It is based on the development of a distributed system consisting of a variety of devices. A controller located in the high voltage substation feeder coordinates the functions of monitoring, protection and energy control of all the devices in the network.
			★	2.1.3.4 - A small fleet of electric vehicles is managed remotely for charging and for generation. In the proposed system, the vehicles are considered as loads that can be managed, but also as small sporadic generators, responding to the needs of network operation. Possibly also the topic of the impact on the grid will be dealt with in WP 12.
Policy & Regulation	Tasks			
	Finance			
	Policy			
Social & Other	Protocols			
	Stakeholders			
	Other			

References

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UPDATE 18	Smart Village Program, Australia
Status	In progress
Dates	Start of project in February 2010.
Involved	Energy Australia, Sydney Water, University of Newcastle, University of Sydney

The program installed 1,000 smart meters with two-way communication and 100 Home Area Networks in selected Newington properties to create state-of-the-art homes with intelligent controls, renewable energy technology and storage. The smart meters enable Ausgrid to communicate savings tips, discounts and incentives to change the way households consume energy. For some customers, they also bring new control to household energy and water consumption and allow homeowners to remotely turn off appliances through the internet. The new smart metering infrastructure installed in homes will be integrated into an intelligent electricity network, which includes remote monitoring and control.

Domain	Aspect	Micro	Meso	Relation to action points
Technical	Systems	★		1.1.1.2 - One thousand smart electricity meters, one thousand smart water meters and five hundred smart recycled water meters have been installed in this project.
		★		1.1.1.4 - Distributed energy storage options will be trialed in the Smart Home, including use of stored energy to supply electricity during peak periods and recharging during low use periods. Other stored energy options at a business or an electricity substation level may also be tested.
		★		1.1.1.7 - One of the goals of the project is to develop and test algorithms to identify individual appliances from the total energy consumption.
			★	2.1.1.3 - Storage on a meso level is possibly being evaluated as well, for example at a business or an electrical substation level.
	Control	★	★	1.1.2.2 & 2.1.2.1 - Demonstrating and testing of electric cars will also be part of this pilot project. The aim is to: measure charging patterns with typical family use of the vehicle; test the EV as another form of storage to provide peak power; trial and evaluate potential metering options for EV's to charge outside the home and still be billed.
			★	2.1.2.3 - One hundred Home Area Networks will be installed to provide real-time information on energy consumption of individual appliances and remotely monitor and control appliances online, including air conditioning, hot water systems, solar power systems, lighting, and entertainment and laundry appliances.
	Information	★		1.1.3.2 - In this project one hundred Home Area Networks will be installed to provide real-time information on energy consumption of individual appliances and remotely monitor and control appliances online, including air conditioning, hot water systems, solar power systems, lighting, and entertainment and laundry appliances, Also two 4G antennas to provide a two-way wireless communication network

				have been deployed.
			★	2.1.3.2 - The home will showcase super efficient appliances and equipment, localized electricity generation (including solar PV, gas fuel cell and electric vehicle technologies) and energy storage solutions.
Policy & Regulation	Tasks			
	Finance			
	Policy			
Social & Other	Protocol			
	Stakeholders	★		1.3.2.2 - Customers can choose to view their energy and water usage, estimated electricity costs and environmental impact through an online Home Dashboard or an in-home display. The Dashboard will also include a comparison of energy use with other Smart Village participants as well as incentives to reduce energy use.
	Other	★		1.3.3.1 - As part of the Newington Smart Village Project, a residential home has been acquired in Konrads Ave, Newington. This property will become the Newington Smart Home, a 'house of the future' showcasing and testing new technologies to reduce household energy and water use. The Smart Home will be used to educate and inspire others to adopt energy and water saving behavior.

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- http://www.smarthomefamily.com.au/

UPDATE 19	Virtual Fuel Cell Power Plant, Germany
Status	Finished
Dates	The project ended in 2005.
Involved	Initiative Brennstoffzelle (IBZ), Vaillant, Plu Power Holland, Cogen Europe, Instituti Superior Tecnico (IST), University of Essen, DLR, Sistemas de Calor, Gasunie, E.ON Ruhrgas, E.ON Energie, EWE.

The Virtual Fuel Cell Power Plant (VFCPP) is a series of decentralized residential micro-CHPs using fuel cell technology, installed in multi-family-houses, small enterprises, public facilities etc., for individual heating, cooling and electricity production. Centrally controlled and grid-connected, these elements of the virtual power plant contribute to meet peaking energy demand in the public electricity grid and act as a virtual power plant. The objective of the project was to develop, to install, to test and to demonstrate a virtual power plant consisting of 31 decentralized stand-alone residential fuel cell systems, i.e. to transform laboratory technology into an everyday technology.

Domain	Aspect	Micro	Meso	Relation to action points
Technical	Systems		★★	2.1.1.2 - One of the deliverables was a micro-CHP economic model to compare the economical performance of identical micro-CHP units in different European countries. The project identified three major hurdles to be overcome in the development of a product for the residential mass market: i) The costs must be reduced significantly to increase the technology’s economic viability; ii) The system must be simplified to improve reliability; iii) The temperature of the heat output must be increased to become compatible with existing heating systems, and to give opportunities for tri-generation (cooling, heat and power). Within the operation as a VFCPP, the capability to follow defined load profiles without relevant time delay has been successfully demonstrated. Based on the experiences gained out of this project, Vaillant and its partners are working on a High-Temperature PEM Fuel Cell system in order to overcome above mentioned hurdles.
	Control		★	2.1.2.2 - For the operation of the residential CHP-units a Central Control System (CCS) was developed. This CCS communicates with the on site Energy Manager and allows the utilities to control the micro-CHPs in the case of a power peak demand and defined load profiles. The load profiles were sent by using wireless technologies as the mobile phone standard GSM and the radio ripple control.
	Information	★		1.1.3.1 - In this project also a web-based system was installed at the central control system to give all the project partners access to the measured data from any location via the internet. The status of the system could be checked, the error message in case of a downtime and the operational mode at one glance.

		★		1.1.3.3 - For the operation of the residential CHP-units a Central Control System (CCS) was developed. This CCS communicates with the on site Energy Manager and allows the utilities to control the micro CHPs in the case of a power peak demand and defined load profiles. The load profiles were sent by using wireless technologies as the mobile phone standard GSM and the radio ripple control.
Policy & Regulation	Tasks			
	Finance			
	Policy			
Social & Other	Protocols			
	Stakeholders			
	Other			

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C.2 - Case studies Asia Pacific

AP 1	**Smart Grid, Smart City, Australia**
Status	In progress
Dates	Commenced late 2010, to be finalized end of 2013.
Involved	Ausgrid, EnergyAustralia, Landis + Gyr, GE Energy, Grid Net, IBM, CSIRO, TransGrid, Sydney Water, Hunter Water, the University of Newcastle, the University of Sydney, the City of Newcastle and Lake Macquarie City Council.

Following a competitive process, the Australian Government chose Ausgrid to lead the $100 million initiative across five sites in Newcastle, Sydney and the Upper Hunter. Smart Grid, Smart City creates a testing ground for new energy supply technologies. At least 30,000 households will participate in the project over three years. The demonstration project gathers information about the benefits and costs of different smart grid technologies in an Australian setting. Building a smart grid involves transforming the traditional electricity network by adding a chain of new, smart technology. It includes smart sensors, new back-end IT systems, smart meters and a communications network. The results of this project will be used for the government's plan for a national smart grid rollout.

Domain	**Aspects**	**Micro**	**Meso**	**Relation to action points**
Technical	Systems	★		1.1.1.1 - During the project, various smart metering solutions are being explored. Ausgrid has to date rolled in excess of 400,000 smart meters and investigated pricing options, specifically Time of Use for a large number of customers. During this project another 50,000 smart meters will be installed. Goals of the trials and pilots are to automate a range of processes through remote connection and to develop a range of new products both for network and retail businesses. Several kinds of feedback will be tested (web portal, simple IHD, Advanced IHD and customer HAN). Possible options will be: 1. Time of Use, 2. pre-payment, 3. interruptible load products, 4. dynamic peak pricing. To date 700 homes were installed with WiMAX smart meters in Newington.
		★		1.1.1.3 - An agreement has been signed between Ericsson and Ausgrid which allows Ausgrid to become the first utility to use Long Term Evolution (LTE) for its 4G communication network. A 4G machine-to-machine communications network using WiMAX and LTE standards is being built across approximately 150 sites in Sydney, the Central Coast and hunter Valley regions. One of the major benefits for choosing a 4G/LTE platform is its approach to cyber-security - a key consideration in selecting technology for the electricity industry.
		★		1.1.1.4 - This project aims to answer the following questions: Can distributed storage improve capital efficiency for networks? How could it facilitate intermittent energy sources? How can consumers benefit from it? What are the benefits or issues with the use of plug-in electric vehicles as a means of distributed storage?

		★		1.1.1.5 - In this project a 4G/LTE platform will be tested, which has many advantages in the field of cyber security.
			★	2.1.1.1 - One of the main questions regarding energy storage in the grid that the project will try to answer is how this could facilitate intermittent sources of energy.
			★	2.1.1.2 - Virtual power station trials will be performed as well. Local homes in Newcastle and Scone will be asked to participate to have new ceramic fuel cells installed at homes. A total of 25 fuel cells and five wind turbines will be installed on the grid and at homes to test distributed generation. From the available information it is not yet clear how the dispatch will be coordinated.
			★	2.1.1.3 - At several locations batteries will be installed. Depending on the location these will be put in a system with a high penetration of solar energy or wind energy and in some cases fuel cells.
	Control	★		1.1.2.2 - In this project 20 EVs, 50 standard and 6 fast charge points are included. Output of the study will be data and results on charging impacts and technology insights and explore several business models. Furthermore the possibilities and challenges of EV's as storage capacity will be researched.
		★		1.1.2.3 - The project includes a trial with demand response control in which the air conditioner and pool pump cycling at households can be switched automatically. With the consent of the households, Ausgrid will remotely put these high-energy appliances in a lower power mode at peak times.
		★		1.1.2.4 - Ausgrid and its retail partner will test new time-based pricing and incentives for households to reduce power use in peak times. These pricing trials will be voluntary.
			★	2.1.2.1 - The outcomes of this project will help to determine in which way the charging of EVs could be controlled. During the trial technical solutions such as public and private charge points are investigated. Furthermore business models will be tested that allow for the control of vehicle charging times, to avoid the peak.
			★	2.1.2.2 - A total of 25 fuel cells and five wind turbines will be installed on the grid and at homes to test distributed generation. A virtual power station trials will be performed as well, the usage of these CHP units for the operation of the grid will be analyzed as well. From the available information it is not yet clear how the dispatch will be coordinated.
			★	2.1.2.3 - In 20,000 homes, new in-home displays and products will be installed. This includes 2,000 'smart homes' where households will be able to turn appliances on and off remotely using websites and smart phones.

	Information	★		1.1.3.2 - Continuous engagement with the customer is one of the goals of the project. This will be done through a website, an energy portal, the information center, energy audits, workshops, mail outs and off course via the meter. The meter will be connected through a 4G LTE/WIMAX network.
		★		1.1.3.4 - Depending on the location of the decentralized generation, it will be supplied with a smart meter that communicates the generation and status of the installation.
			★	2.1.3.2 - The effect of an increased penetration of distributed generation devices on the grid will be tested. In this regard there are three key trial locations: Newington, Newcastle and Scone. Newington can be characterized as "suburban saturation" with a high penetration of solar PV and storage. Newcastle is simulated as the "smart future" with distributed storage, solar, fuel cells and small wind turbines. In Scone a "rural micro-grid" contains some generation plus a high level of distributed storage and a micro-grid controller to enable no-break islanding.
			★	2.1.3.4 - Electric car trials using 20 vehicles are performed. It involves 50 standard charging points and 6 fast charging points spread over the test area. Several aspects will be tested, such as the impact on the grid and the environment, when and where do drivers charge their cars, and for how long, what is the impact during peak demand and the way the community respond to EVs.
Policy & Regulation	Tasks	★		1.2.1.1 - Several options for feedback technologies will be tested in the project and depending on the possibilities, the possible role of the DSO will be influenced as well. The aim is to provide customers with additional information to allow them to manage their energy more efficiently. In the demonstration project this sharing of information with customers needs to be tested. This could be a challenging aspect, especially in areas where there is retail competition.
		★		1.2.1.2 - In the project most storage capacity is located on host customer sites (5kVA, 2 hours storage). However also some grid connected storage is anticipated in the Scone Trial Environment. The size is to be determined based on micro grid design requirements.
	Finance	★		1.2.2.1 - Ausgrid and its retail partner will test new time-based pricing and incentives for households to reduce power use in peak times. These pricing trials will be voluntary and may lead to insights which tariff structure to implement.
			★	2.2.2.2 - Ausgrid and its retail partner will test new time-based pricing and incentives for households to reduce power usage in peak times. The outcomes of these trials will provide the necessary input for the development of a new market model.
	Policy			

Social & Other	Protocols	★		1.3.1.1 - In the project a clear choice was made in favor of 4G LTE/WIMAX was made. Whether this will become a standard in Australia will depend on the results of this project.
		★		1.3.1.3 - In the pilot where several tariff structures will be tested a commercial party will be involved as well. The agreements that will be made in the pilot could give an indication of the necessary agreements.
			★	2.3.1.1 - Regarding renewable energy there are three locations of which one can be characterized as "Smart Future". This implemented in Newcastle and involves distributed storage (40 batteries located on host customer sites of 5kVA, 2hour storage), solar energy, 25 natural gas fuel cells up to 1.5kW output and 5 small wind turbines of 2.5kW. These are all connected to a single 11kV feeder. Although this is not completely sustainable, as not all electricity is generated locally from renewable sources, it will provide valuable insights.
	Stakeholders	★		1.3.2.2 - Workshops on various topics such as energy efficiency are included in the project.
	Other			

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- http://www.ret.gov.au/energy/Documents/smart-grid/smartgrid-newdirection.pdf
- Research & Markets: Australia - Smart Grid - Smart Grid-Smart City Project, Paul Budde, December 2011.

AP 2	Yokohama City, Japan
Status	In progress
Dates	2010 - 2014
Involved	NEDO, Toshiba, Panasonic, Meidensha, Nissan, Accenture, Tokyo Gas, Accenture, Meiden, DENSO, TEPCO

The demonstration project in Yokohama City, is one of the four Smart Community Projects that were initiated in 2010. The other projects are Toyota City, Kyoto Keihanna District and Kitakyushu City. Each project has a slightly different focus. The focus of this project is on existing cities where infrastructure cannot be easily reformed. The Yokohama project involves a community energy management system integrating three different areas, 4,500 smart houses, 2,000 electrical vehicles, 27 MW PV, Building and Energy Management Systems (BEMS) and Home Energy Management Systems (HEMS). The Yokohama project has a budget of 74 billion JPY (710 million EUR), the four Smart Community Projects together 127 billion JPY (1.2 billion EUR). Currently all demonstration sites are still under construction.

Domain	Aspects	Micro	Meso	Relation to action points
Technical	Systems	★		1.1.1.4 - Storage batteries will be applied as part of a system to integrate control of electricity and heat to enable high-efficiency operations and flexible supplies of electricity and heat for each household in apartment buildings.
			★	2.1.1.1 - Load control will be applied as a way of demand response (DR). Another method to absorb renewable energy that is pursued in this project is to increase battery storage in the network to absorb a surplus PV power. For this purpose also EVs will be used. To control the interactions, SCADA, HEMS, BEMS and EV data centers will be used.
			★	2.1.1.3 - Electricity storage in the grid will be used to absorb fluctuations of electricity production by PV panels. This storage capacity will exist partly of grid connected EVs.
			★	2.1.1.4 - To control the interactions between different areas and supply by PV panels and the grid and demand, SCADA, HEMS, BEMS and EV data centers will be used.
	Control	★		1.1.2.2 - One of the goals of the project is to develop an operation system for charge and discharge EV sharing by integrating PV and storage batteries. The charge and discharge capabilities of EVs will be utilized for energy management in homes. Rapid charging devices will be implemented as well.
		★		1.1.2.3 - The project will introduce systems that can balance energy supply and demand for three different areas that have diverse activities, while maintaining dependence on power grids. Furthermore demand response programs such as load control and surplus PV power absorption will be implemented to promote consumer behavior changes.

		★		1.1.2.5 - This topic is one of the key issues that this project is about. In every participating household (4,000) PV and a Home Energy Management System (HEMS) will be introduced, thereby producing energy that will be consumed locally, by controlling home electronics and devices that create and store energy. Furthermore energy management systems for entire apartment buildings (BEMS), will be included to manage demand response. Rather than optimizing each device separately, the controls will focus on entire buildings that have different types of load patterns, depending on purpose and size, while maintaining comfort levels. In practice demand response will be communicated between BEMSs, which indicate the surplus of energy per building after which DR controls will be carried out by the linked HEMS.
		★		1.1.2.6 - Their aim is to introduce renewable energy to 64% of participating households, and to manage generation and demand with HEMS in houses and BEMS in apartment buildings.
			★	2.1.2.1 - This project includes 2,000 EVs and both normal and rapid charging devices. With such a high number of EVs in this project, although not explicitly mentioned, charging strategies must be part of the project or at least result in them.
	Information		★	2.1.3.4 - With 2,000 EVs in this project, one of the aspects that will get clear is the impact of EV on the grid.
Policy & Regulation	Tasks			
	Finance			
	Policy			
Social & Other	Protocols			
	Stakeholders			
	Other	★		1.3.3.1 - During the first years of the project, 4,000 houses will be installed with Home Energy Systems (HEMS), PV panels and one on two with an EV, which will also have a charging/discharging function, once connected.

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- contact at NEDO: Shoma Yoshikawa, Smart Community Department

AP 3	**Smart Upper South Island Load Management, New Zealand**
Status	Finished
Dates	The project ran from March 2009 to April 2011. Due to its success it is still running.
Involved	DSOs: Orion, Network Tasman, Marlborough Lines, MainPower, Buller Electricity, Westpower, Electricity Ashburton, Alpine Energy and TSO Transpower.

Following an Upper South Island load management trial during winter 2008, in March 2009 Orion began a load management trial service for the region, to run for two years through to April 2011. The service is designed around real time data from Transpower and the Upper South Island electricity distributors to a centralized controller, based in Orion's control centre in Christchurch. The project had two main objectives:

1. to reduce demand during peak loading times. This reduced the need for transmission investment for growth, which puts downward pressure on costs for customers.
2. to assist Transpower (TSO) to maintain security of supply. It does this by using all available load shedding capability across the Upper South Island, to automatically reduce load if needed during grid outages.

The project is estimated to have reduced load at peak times by about 30MW during the winter period. During periods of high electricity demand, the system uses ripple signals to cooperatively control hot water cylinders throughout the region. A similar initiative with 60 MW was initiated in 2011 as part of the Upper North Island Reactive Support project (110 million NZD, 2011-2015, Transpower).

Domain	**Aspects**	**Micro**	**Meso**	**Relation to action points**
Technical	Systems		★	2.1.1.1 - Eight DSOs and the TSO have cooperatively set up this load management project. The systems operates through ripple control and is deployed for several purposes: dynamic control of supply to appliances, fixed time control, and indirectly through pricing incentives that reward retailers customers who lower the amount of electricity they consume during high priced peak period.

	Control	★ ★		1.1.2.1 - During periods of high electricity demand, the controller uses "ripple" signals to cooperatively control demand throughout the region. This technology is called "Toon Frequent Sturen" (TF) in Dutch, and was used in the Netherlands as well for boiler control however it is not used often anymore due to the intrusive character of this technique to the consumer. Orion operates two ripple coding systems in two different areas: Telenerg, based on 11kV injectors using a 175 Hz carrier frequency and Decabit, based mainly on 33 kV injectors using a 317 Hz carrier frequency. Regarding large consumers, the signal gives them the opportunity to reduce their electrical use through such means as turning off boilers, turning off freezers and running generators. This in turn reduces their following year's chargeable kVA demands and minimizes their future power bills. Many of Orion's major customers respond to their pricing signals. For example, the Chateau on the Park (a local hotel) has invested over $150,000 in an energy management system and a diesel generator. As a result of their pricing, its investment in this technology was paid back in around three years through savings in ongoing electricity purchase costs. The current ripple control channels are not suitable for use with "on demand" heaters. To avoid sudden loading changes a random delay of 0 to 7 minutes is introduced when the load is switched back on. For more technical details, please see the Ripple Signal Guide from DSO Orion: http://www.oriongroup.co.nz/downloads/ RippleSignalGuide.pdf

		★ ★		1.1.2.3 - Orion uses their ripple control system to manage load in a number of ways: 1. Directly through dynamic control of supply to appliances, mainly hot water cylinders. This "peak control" shifts the heating load to occur just after the peak. They aim to turn cylinders off for short periods only, to prevent any noticeable effects on customers' hot water supply. The cylinders are turned back on when network demand reduces. 2. Directly through fixed time control of supply to appliances, mainly hot water cylinders and night store heaters, by switching them on during off-peak night periods only. This "fixed time control" permanently shifts load away from the day time periods when peaks occur. 3. Indirectly through pricing incentives that reward retailers' customers who lower the amount of electricity they consume during our high priced peak period. This arrangement is more useful for larger business connections with special half-hour interval metering that records the reduced loading level during the peak period. Orion has made it compulsory to install controllers on all storage water heaters. For customers that want a near-continuous supply for their water heater (and do not want regular peak control or night rate options), there are emergency control channels that are only operated during an emergency that threatens supply.
	Information			
Policy & Regulation	Tasks			
	Finance	★		1.2.2.1 - Orion has specific tariffs for major customers with loading greater than 250kVA, if they participate in the load shedding program. According to Orion the potential benefit to the client can result in significant savings on their annual electricity bill. In the Upper North Island Reactive Support project, another project from the TSO, Transpower, lead to (too) high biding prices for 60 MW Demand Response. It turned out that requiring proponents to provide adequate demand response within a condensed timeframe and for a relatively short contract period only drives prices upward.
	Policy			
Social & Other	Protocols			
	Stakeholders			
	Other			

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AP 4	Intelligent Energy System, Singapore
Status	In progress
Dates	The IES pilot will be conducted in two phases. Phase 1 (2010 - 2012) focuses on the implementation of the enabling infrastructure for the IES. Phase 2 (2012-2013) will focus on the smart grid applications.
Involved	Accenture, ST Electronics (Info-Comm Systems), Singapore Power, Oracle, Hewlett-Packard, Power Automation, GreenWave Reality, Control4, Nanyang Technological University and several government agencies such as the Economic Development Board (EDB), Agency for Science, Technology and Research (A*STAR), Housing and Development Board, Infocomm Development Authority (IDA) and the National Environment Agency (NEA). In phase 2 additional partners will be involved.

In 2010 the Energy Market Authority (EMA) launched a pilot project for an “Intelligent Energy System” (IES). The project will test a range of smart grid technologies to enhance the capabilities of Singapore’s power grid infrastructure. Accenture is leading the consortium that executes the IES project of 30 million USD. Specifically, the IES pilot project seeks to develop and test the following components of a smart grid: Advanced metering and communications infrastructure, demand response management systems and management systems for distributed energy sources.

Domain	Aspects	Micro	Meso	Relation to action points
Technical	Systems	★		1.1.1.1 - In the project 4,500 smart meters will be installed in various residential, commercial and industrial locations two establish an advanced metering infrastructure (AMI). However the (requirements for) specifications of the meter are not mentioned in the available documents.
		★		1.1.1.3 - A key emphasis in the first phase of the pilot is to establish the smart metering communication protocols and standards. This will be done by leveraging on the Next Generation National Broadband Network (high speed all-fiber communication network) and other communication platforms.
	Control	★		1.1.2.2 - In the scope of the project is to facilitate the integration and testing of EV charging including vehicle-to-grid.
		★		1.1.2.4 - One of the key goals of the project is that electricity retailers will compete in the second phase to offer time-varying electricity price tariffs and value added services to consumers.
		★		1.1.2.5 - Value added services such as energy efficiency measures using Building Management Services and Home Automation Systems will be offered to consumers who are involved in this trial. Initiatives include the pre-programming of automation devices and smart meter appliances to function during off-peak hours when electricity prices are lowest.
	Information	★		1.1.3.2 - In this pilot several communication networks will be evaluated, such as fiber-optic cables, Wi-Fi or radio frequency. This will influence the related communication technologies as well.

		★		1.1.3.4 - Management systems for distributed energy sources are one of the components that are researched in this project and enable the grid to integrate the increasing number of small and variable sources of power, for example, from solar photovoltaic (PV) systems and mini co-generation plants. They also cater to the future possibility of large numbers of electric vehicles connecting to the grid, both to draw electricity from the grid and also to supply electricity to the grid during periods of peak demand.
Policy & Regulation	Tasks			
	Finance	★		1.2.2.1 - As electricity retailers will compete in the second phase to offer time-varying electricity price tariffs and value added services to consumers, this will lead to valuable insights in the success of several tariff structures.
			★	2.2.2.2 - Electricity suppliers will compete to offer electricity with time-varying electricity prices. This might result in a viable business case and the development of a new market model.
	Policy			
Social & Other	Protocols			
	Stakeholders			
	Other			

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AP 5	Electric vehicle charging station, China			
Status	In progress			
Dates	Multiple projects have been initiated, some have just been finished.			
Involved	SGCC, national energy bureau, Chinese ministry of Industry, national car standard committee			
SGCC plans to fully unfold the building of electric vehicle charging stations in 27 licensed regional and provincial companies in 2010. Seventy-five public charging stations, 6,209 AC charging spots and some battery replacement stations are projected, aiming to support the country's "Energy-efficient and New-energy Vehicle Pilot Program".				

Domain	Aspects	Micro	Meso	Relation to action points
	Control		★ ★	2.1.2.1 – State Grid has finished writing 6 industrial standards like Electric Vehicle Charging Station General Technical Requirements, Electric Vehicle Charging Station Design Guidance, Electric Vehicle Charging Station Power Supply System Standards. State Grid compiled Electric Vehicle Charging and Discharging Facilities Construction Guidance to standardize the building technology, equipment installation and intellectual supervision of the stations, basically solving issues appeared in the pilot projects, and creating a positive environment for a successful development of the charging stations. State Grid created various standards for EV charging stations from 2009 to 2011, but all of them are Chinese version. Recently 4 unified standards were released by the National Ministry of Industry and Information, they are "EV conduct charging connection device part I, II, III, communication protocol between battery management system and EV charger (not vehicle mounted), from 2010 to 2011. About 25 EV charging standards were issued by state grid and southern grid. State grid prefers swap stations to exchange EV batteries, whereas southern grid prefers battery charging. There are 2 different concepts and development directions. At this moment, the general trend is to go along the swap station direction, as State Grid is the largest stakeholder.
	Information			
Policy & Regulation	Tasks			
	Finance			
	Policy			
Social & Other	Protocols			
	Stakeholders			
	Other			

References

- http://www.sgcc.com.cn/ywlm/gsyw-e/218933.shtml
- contact person: Mike Xu [DNV KEMA China]

AP 6	Demand Response System Pilot, China
Status	Initiation
Dates	January 2012: official launch of the Demand Response System Pilot
Involved	State Grid Company China, Honeywell

This project is China's first smart grid pilot project and feasibility study to monitor and manage electricity use in commercial buildings. The project will focus on DSM, and will utilize state-of-the-art smart grid technology, including automated demand response, advanced energy management, and sub-metering. The project is part of an agreement between the U.S. Trade and Development Agency (USTDA) and the State Grid Electric Power Research Institute (SGEPRI). The project is to be developed and implemented by Honeywell.

Domain	Aspects	Micro	Meso	Relation to action points
Technical	Systems	★		1.1.1.2 - Honeywell is implementing smart meters in commercial buildings. Advanced energy management and automated demand response will be installed to enable demand side management.
	Control	★ ★		1.1.2.5 - Energy management systems are being implemented to enable efficient energy use. This equipment will help connect State Grid and its customers to manage energy supply and demand, automatically adjusting electricity consumption and reducing strain on China's utility infrastructure. Honeywell claims that deployment of automated demand response reduces peak loads by 15 to 30%.
			★	2.1.2.3 - The installed equipment manages energy supply and demand and automatically adjusts electricity consumption. Automated Demand Response puts in place an automatic system of technology checks and balances taking into account peak hours and higher electricity prices.
	Information			
Policy & Regulation	Tasks			
	Finance			
	Policy			
Social & Other	Protocols			
	Stakeholders			
	Other			

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AP 7	Smart Community Demonstration Project, China
Status	Finished
Dates	Feb 2010 - Sept 2010
Involved	North China Power grid Company of SGCC

The smart community demonstration project undertaken by North China Power Grid Company of SGCC---Xin'ao Golf Garden residential block in Langfang, Heibei province was initiated in February 2010 and completed on September 2010.

The community consists of 655 households and 11 buildings, and is the first demonstration community built by North China Power Grid as well as the first project constructed under SGCC's guideline on smart communities.

After half year's construction, the company completed nine sections of the project including the low-voltage electricity network, power usage information collection, an interactive service platform, smart household installment, electricity automobile charging facilities, distributed power generation and energy storage, automatic electricity distribution, integrated network of internet, television and telephone, as well as a showcase of the smart community technologies.

Domain	Aspects	Micro	Meso	Relation to action points
Technical	Systems	★★		1.1.1.2 - AMI meters were installed for electricity, gas and water. The community is installed with smart sockets and intellectual home appliances that automatically read the water, electricity and gas meters, record the family's power consumption habits and support remote control. The residences can find out their family's power expenses, carbon emission amount and energy consumption habits, receive suggestions on energy use, and form an economical energy consumption habit. For instance, the system would remind users to avoid or reduce using electricity during peak hours. Six charging poles for electric vehicles are stationed in its underground garage, which can adequately meet its residents' daily power needs.
		★		1.1.1.4 - The prototype room is equipped with distributed solar power generating and storage facilities at a capacity of 10 kilowatts. Six electric vehicle charging poles are stationed in its underground garage, which can adequately meet its residents' daily power needs.
		★★		1.1.1.7 - The community employs intelligent switch and automatic monitoring devices. The advanced electricity distribution system of the community can automatically detect malfunctions and reconstruct two-level network with fault self-recovery capability. It monitors the electricity transportation around the clock and tests power quality real time, which ensures 99.99% of reliable power supply.

			★	2.1.1.1 - The low-voltage optical fiber power network covers the whole community, transporting electricity to every family, at the same time, bringing broadband internet to the household, thereby integrates the telephone, television and internet.
	Control	★		1.1.2.4 - The system reminds users to avoid or reduce using electricity during peak hours but SGCC does not report any price differentiation during the day or during peak hours.
	Information	★		1.1.3.4 - Households are equipped with distributed solar power. Through the distributed solar power generating management system, the facilities offer the family the options to choose low-cost electricity, level the electricity consumption amount between peak and low hours, and reserve electricity for emergency use.
Policy & Regulation	Tasks	★		1.2.1.1 - China has a highly integrated industry on the transmission and distribution side. The State Grid Corporation of China (SGCC) controls the T&D network and coordinates smart grid developments in China.
	Finance			
	Policy			
Social & Other	Protocols	★		1.3.1.1 - The related national code for smart building design GB/T50314-"intelligent integration system" was issued in 2007.
	Stakeholders	★		1.3.2.2 - The system reminds users to avoid or reduce using electricity during peak hours.
		★ ★		1.3.2.6 - In practice, although not admitted by official governmental sources, it seems that customers are not very enthusiastic about this and similar projects although most of the projects are over-advertised by local government and related grid utility. The projects imply higher cost/price than normal community, and the reliability and service of post construction, equipment, interface, socket interchangeability and maintenance has not always improved due to the complicated system and product design.
	Other	★		1.3.3.1 - In this project, residences can find out their family's power expenses, carbon emission amount and energy consumption habits, receive suggestions on energy use, and form an economical energy consumption habit. Through the interface of the intellectual terminal, the residents can shop, make appointments with their doctors, make video telephone calls, and order food delivery without stepping out of their homes.

References

- http://www.sgcc.com.cn/ywlm/gsyw-e/234180.shtml
- for standards see: http://www.codeofchina.com/
- contact person: Mike Xu, DNV KEMA China

AP 8	Consumer portal system, South Korea
Status	Finished
Dates	October 2005 - September 2010
Involved	Kyungwon University, LS Industrial Systems, KD Power, Korea Electric Power Research Institute (KEPRI)

The Consumer Portal System is part of the smart grid test bed on Jeju Island, Korea. The test bed is touted as the world's largest Smart Grid community that allows the testing of Smart Grid technologies and R&D results, as well as the development of business models. The pilot consists of a fully integrated smart grid system for 6,000 households, wind farms and four distribution lines. Korea has announced plans to implement smart grids nationwide by 2030.

The purpose of the consumer portal system is to develop and realize a consumer portal system that will be the multi-service platform for the convergence of electric power technology and ICT. Doing so will allow large consumers to optimize the operation of electric resources and pursue diverse profitable businesses.

Domain	Aspects	Micro	Meso	Relation to action points
Technical	Systems	★		1.1.1.2 - Korea aims to encourage consumers to save energy by using real-time information and producing smart home appliances that operate in response to electric utility rates. In 2012, Korea expects to reach a smart meter penetration rate of 5.6%. Korea aims to have smart meters installed at all consumers in 2020.
	Control	★		1.1.2.4. - Within this project an array of added electricity services is delivered through the combination of electricity and ICT and to put in place real-time electricity trading system for the transactions of electricity and derivatives.
	Information			
Policy & Regulation	Tasks	★		1.2.1.1 - KEPCO is the transmission and distribution company of South Korea. KEPCO is the responsible authority for the upgrade of the transmission and distribution system and switch meters. The company plans to invest USD 7.2 billion in smart grids by 2030.
	Finance			
	Policy			
Social & Other	Protocols			
	Stakeholders	★		1.3.2.2 - The households at Jeju island feature various prototypes of smart meters and in-home displays. Energy awareness is created by providing real time information about their energy consumption. Home / Building web based portals are installed. Every portal provides the consumers information about their energy consumption, historical energy data and carbon footprint data. The portal not only enables online billing but also shows comparison of energy data with neighbors.

		★		1.3.2.5 - Households are able to monitor their energy usage through smart phones. Customers are able to obtain information about their current and accumulated electricity usage, electricity costs as well as their carbon emissions. This is done with a Service over IP terminal whereas the 'widget engine' is based on Flash Lite.
		★ ★		1.3.2.6 – A recent study shows that customers expect that green IT services can help to reduce their energy consumption and money. They also think that companies have to introduce the services that can reduce energy consumption. According to the Green IT survey, 26,5% of the customers are willing to pay for green IT services. The more they have high incomes, the more they are willing to pay.
	Other			

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- Kepco: http://www.kepco.co.kr/eng
- Korea Smart Grid Institute: http://www.smartgrid.or.kr/10eng3-1.php
- contact person KEPCO: WH Hwang (hblue@kepco.co.kr)

AP 9	USAID DRUM, India
Status	Finished
Dates	Finished in 2010
Involved	BESCOM, USAID

The electricity distribution utility BESCOM in Bangalore and the USAID DRUM program have initiated a smart grid pilot project in Doddaballapur. Doddaballapur is a rural site serving 281 villages and about 30 percent of Doddaballapur's total power load is connected to agriculture. The project focuses on the technical upgrade of the distribution system, which has improved the reliability and quality of power.

Domain	Aspects	Micro	Meso	Macro	Relation to action points
Technical	Systems	★			1.1.1.2 - BESCOM installed new static meters in the place of old mechanical meters. This has increased billing efficiency from about 60 percent to 100 percent.
		★			1.1.1.7 - Provision of a High Voltage Distribution System (HVDS) and refurbishment of feeders with transformers and meters, provision of fault passage indicators, switch capacitors and polymeric surge arresters are the technical upgrades that have improved tail-end supply and reduced interruptions in electricity supply. The technical improvements have also greatly reduced the burning out of water pumps (crucial for farmers) due to voltage fluctuations and harmonics.
				★	3.1.1.4 As a result of the improvements in technology as mentioned in 1.1.1.7, the Aggregate Technical and Commercial (AT&C) losses have been greatly reduced from 38.9 percent in 2005 to 12.8 percent by the end of 201018. Similar the transformer failure rate has reduced from 7.3 percent to 0.95 percent. Agriculture customers were given three-phase supply, which has improved reliability of electricity supply to agriculture.
	Control				
	Information				
Policy & Regulation	Tasks				
	Finance				
	Policy				
Social & Other	Protocols				
	Stakeholders				
	Other				

References

- USAID (2011) *Evaluation of DRUM and WENEXA*

C.3 - Case studies Europe

<table>
<tr><th>EUR 1</th><th colspan="2">European Distributed Energy Partnership (EU - DEEP), (FR, ES, CY, LV, BE, DE, GR, SE, HU, TR, FI, GR, UK, AT, Pl, CZ)</th></tr>
<tr><td>Status</td><td colspan="2">Completed</td></tr>
<tr><td>Dates</td><td colspan="2">2004 - 2009</td></tr>
<tr><td rowspan="5">Involved</td><td>Utilities:</td><td>GDF Suez, Iberdrola, EAC, Latvenergo, Tractebel, RWE Energy, EPA Attiki, GASAG</td></tr>
<tr><td>Research Centres:</td><td>IEA/LTH, FEEM, VEIKI, RTU Laborlec, TUBITAK, AUTh, CENTER, Enersearch, SEAES, IIE-UPV, ICCS/NTUA, VTT, Labein, STRI, KULeuven, FIT, CRES, Imperial College</td></tr>
<tr><td>Manufacturers:</td><td>Bowman, MTU, Siemens PTD, Heletel</td></tr>
<tr><td>Professionals:</td><td>Technofi, Transénergie, Axiom</td></tr>
<tr><td>Regulators:</td><td>KAPE</td></tr>
</table>

The EU-DEEP project was a comprehensive project regarding the deployment of Distributed Energy Resources (DER) in Europe, with a consortium of 42 partners from 16 countries. The project looked at how to create the necessary conditions for sustainable DER expansion. Both technical and non-technical barriers of DER for stakeholders across the energy value chain were considered, for example, issues around market integration, regulation and connection to the grid.

Five one-year field tests were carried out to validate the tools and methodologies used to feed proposed business models with real world costs and revenue data. These 5 field tests were as follows:

1. Testing the integration of a composite CHP system for market interaction, "office buildings" segment, Grenoble France;
2. Testing the integration of a composite tri-generation system for market interaction, "educational buildings" segment, Athens Greece;
3. Testing the technical feasibility of aggregating 10 kW to 1.5 MW scale DER in the UK commercial market segments;
4. Testing the technical feasibility of aggregating Micro-CHPs in the German residential sector;
5. Testing the technical feasibility of a decentralized control architecture for aggregation of load and generation (Greece).

RWE, GDF Suez and Tractebel Engineering have launched ExpandDER, an association to disseminate the EU-DEEP results and to manage the intellectual property of the project after its end. ExpandDER has taken charge of a book which synthesis the knowledge from the project.

Domain	Aspects	Micro	Meso	Relation to action points

Technical	Systems		★★	2.1.1.1 - Test 1 demonstrated use of a fully integrated system of DER components in an office building. This included a 12kW-CHP engine, UPS and control systems. A DER controller developed by Siemens PSE was used to communicate and control with the different components using the MODBUS protocol. The controller managed the CHP-engine system, switched different loads and managed decoupling protection. It also acted as the interface between the DER system and the power market. Test 2 was a more complex test of the integration capabilities of different DER components being controlled as a single unit. The installation used a gas micro-turbine of 80kWe and 135kWth, an absorption chiller to produce chilled water from the thermal load of exhaust gases, and electricity storage. Again the control technology was successfully validated. Tests 3, 4 and 5 were aggregation experiments (as opposed to the single-site experiments of Tests 1 and 2). In Test 3 the aggregated management of flexible customer loads was investigated and Tests 4 and 5 aggregated a portfolio of micro-CHP units (with use of demand flexibility in Test 5).
Technical	Systems		★	2.1.1.2 - Trial 4 successfully tested under real conditions the aggregation of 10 Micro-CHP units, with large heating water storage being used for flexibility. The performance of the units were below expectations with an electrical efficiency of 7% (instead of the anticipated 12%), and an overall efficiency of 85% (instead of 90%). The reasoning behind this was put down to the low electrical efficiency caused by self-consumption of the unit, and also the low average running times of the units per start. It is expected by optimizing the control strategy further to increase running times per start, the average usable output will increase (and hence available power for the aggregator).
Technical	Systems		★	2.1.1.4 - Test 1 successfully demonstrated the configuration of automatic-islanding reconnection with use of a DER controller. The decoupling protection checked the grid voltage and frequency and when stead-state operation was resumed, the DER controller was able to re-synchronize the CHP engine with the grid. Test 2 validated the integration capabilities of the components (time response, availability and reliability) under different grid scenarios: connected mode, islanded mode, and black start. A static switch was installed to automatically separate critical and non-critical loads, and custom-made control software was used to determine the operation of the CHP unit according to various forecasts, costs and technical factors.
Technical	Control			

	Information		★ ★	2.1.3.1 - Trial 4 validated the MAS (Multi-Agent System) software and Intelligent Load Controller (ILC) developed by NTUA, through application on the decentralized control of client load and production units. The experiments successfully showed that the agents were able to decide fairly which loads should be shed, according to the consumption of each load and the total power available. For the challenges around scalability, it was seen that many control units could be added to the control system without increasing the execution time of the MAS technology. Additionally the agent-based algorithm demonstrated 'plug-and-play' capabilities, in that new production units could be easily added or removed without having to re-calibrate the control system all over again. The report recommended the decentralized MAS solution as a credible alternative to centralized DER control, as it will most likely leading to better customer acceptance as decisions are taken locally. For this solution to become extensively used would require open communication standards and their implementation to in-house appliances.
		★		1.1.3.2 - Trial 4 showed that the Micro-CHP units could be remotely managed by an aggregator via a controller communicating through a GPRS connection. It found GPRS to be very reliable, with an availability of over 99%. Very few data points were lost during the entire operation of the 10 sites, even with data collection being conducted every minute.
			★	2.1.3.2 - Increasing DG implies a change in the operation and design for the distribution system. Although current margins in voltage, flow, fault current etc. allow some DG to be integrated, active management will allow for further increases. In order to increase 'DER hosting capacity' of the network, new design criteria may need to be developed so that curtailment can be avoided as much as possible. A 'flexible-symmetrical' design was proposed in the EU-DEEP project which allows for increased hosting capacity by sharing the voltage range between generation and consumption depending on their 'footprint'.
Policy & Regulation	Tasks		★	2.2.1.1 – It is expected that the introduction of DER and flexibility will mean customers should no longer be treated as simply consumers, but instead co-producers and even co-providers of energy services. This will in turn mean they will expect an 'equitable share' of flexibility costs and benefits between them and the energy supplier.
			★	2.2.2.2 - Trial 3 emphasized that for participation in flexibility markets to increase, new contracts and new pricing models to mitigate the risks involved in selling flexibility into the marketplace must be developed. An increase in site numbers will also make it easier to gain an accurate view of available flexibility (through a portfolio effect) – which is important to prevent overselling or underselling of flexibility.

	Finance			
	Policy	★		1.2.3.1 - In order to exploit the flexibility of customers, contractual clarification and existence of protection clauses will be required to cover areas such as: • flexibility sources and availability; • property of the equipment; • responsibilities in the case of incidents and in terms of maintenance and repair; • remuneration of the flexibility and share of the benefits penalties; • level of feedback requested by customers (reporting tools etc.); • the possibility for the customer to reserve the right of overriding.
			★	2.2.3.1 - Emphasis was placed on the need to harmonize the DG-DSO interface in order to reduce regulatory risk and promote investments in DG. It was suggested that if the regulatory regime of DSOs is based on total expenditure for a gross load output, rather than mark-ups on grid investments, then this would promote DER investments which would lead to deferred network investments. As well as acting as substitutes for network elements, DER investments can also be complementary e.g. remote controlled units which provide value added services on the network. In such a case, an ideal framework would be one that incentivizes joint investments from DER investors and networks. It was recommended that coordinated direct mechanisms would give better results in terms of investment level and benefits than traditional models using delegation or contingent investments.
Social & Other	Protocols	★ ★		1.3.1.1 - When developing the control and monitor solutions for load flexibility purposes in Test 3 it was seen that a large amount of costs and time went into creating a custom-made installation for each of the sites. The project recommended bringing in standards (and possibly even regulation) for control systems that are currently being produced, to allow for easier integration of new installations for flexibility purposes. This would be much cheaper than retro-fitting control systems which had not been designed with flexibility in mind. The overall cost of site installations was higher than could be supported by potential returns from flexibility. This was not only due to the high cost of retro-fitting the control systems, but also the costs of site surveys and electrical planning. Standardization for equipment as well as installation and interface requirements would be necessary to lower costs, and allow smaller loads to enter the flexibility market.

			★	2.3.2.3 - New design criteria for distribution networks for the purposes of integrating DER can be developed when clear exogenous objectives are defined e.g. limitation of generation power per connection, objective in terms of penetration for RES, limits set for generation control in normal and abnormal conditions. It is recommended that such objectives are defined outside of the electrical supply industry, but with its participation.
	Stakeholders	★ ★		1.3.2.4 - Trial 3 showed that the current 3MW limit (in UK) for participation in Short-term Operating Reserve could be reduced with the technology used in the experiment – allowing aggregation of a site the size of 500kW. It was also mentioned that with standardized control systems in multiple sites to lower capital expenditure, and also with triad avoidance take into account (avoiding consumption during peak periods to earn money through National Grid Transmission Network Use of System agreements), then sites as low as 100kW could be included.
		★		1.3.2.6 - When estimating the amount of load flexibility they could provide on-site, customers were apprehensive about the effects of potential interruptions – for example in the loss of air-conditioning. The tests showed that in reality many customers did not notice the effect of load reduction during regular 1-hour calls, which sometimes even occurred twice a day. Additionally it was also observed that there was poor in-site knowledge in identifying where loads could be controlled and monitored. Overcoming these issues and increasing awareness about load reduction would likely result in a greater uptake of flexibility measures.
	Other			

References

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- www.eudeep.com/index.php?id=650&no_cache=1 (Additional downloads)

EUR 2	IMPROSUME, Switzerland, Norway & Denmark
Status	In progress
Dates	2010 - September 2012
Involved	University of St.Gallen, NCE Smart Energy Markets, Aarhus School of Business

The IMPROSUME project is a research project which is investigating the impact of prosumers in a smart grid based energy market. The 'prosumer' concept in the power market applies to consumers of energy that can also be producers, and hence act as an active participant in balancing the electricity system. The motivation behind IMPROSUME is to be able to provide a business perspective on social acceptance of stakeholders and on the need for institutional changes with the introduction of smart grids, rather than simply focusing on the technical aspects.

As this is a project focused on social and policy domains, the results of the projects have often been based upon variety of customer surveys. This has provided insights on potential customer segments, preferences and identifying business models in the B2B and B2C smart grid market.

Domain	Aspects	Micro	Meso	Relation to action points
Technical	Systems			
	Control			
	Information			

<table>
<tr><td></td><td>Tasks</td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Policy & Regulation</td><td rowspan="2">Finance</td><td>★
★</td><td></td><td>1.2.2.1 & 1.3.2.3 - Based on a survey of 87 Swiss energy consumers, it was found that smart meter users could be segmented into 4 different categories and consequently be offered different incentives and reward mechanisms to create value.

'Risk averse' consumers represented the largest segment (34%). They chose the tariff model of 11Rp/kWh - 17Rp/kWh, with a flat rate of 23CHF/month. They were not willing to pay any premium for smart metering services - for example being able the ability to program and control consumption.

'Technology affine' (29%) preferred the ability to program services and had a strong interest in energy data. With regards to tariffs, this segment were willing to accept a variable tariff (11Rp/kWh - 17rp/kWh) and a base rate of 25CHF/month and seemed confident of being able to benefit from the difference in higher and lower tariffs.

'Price sensitive' consumers (20%) - preferred the tariff with the lowest off-peak price, 6Rp/kWh although it had a very high risk with an off-peak price of 50Rp/kWh. Such a segment seems ready to supervise and manage their behavior in order to reap the benefits of a low-price tariff. The flat rate for this tariff model was 25CHF/month.

Finally 'safety-oriented' consumers (17%), opted for the highest base tariff of 27CHF/month, with the off-peak - peak price from 8Rp/kWh - 30Rp/kWh. This segment placed value on monitoring and warning functions which could be included within a smart metering package.

In general customers were willing to pay a higher base fee to avoid the high tariff of 50Rp/kWh - i.e. they were willing to pay a risk premium. It was also found within the experiment customers would pay a premium of 16CHF to get their most desired smart metering product, but by the same token would require a reduction of 16CHF if the bundle did not exactly match their needs.</td></tr>
<tr><td>★
★</td><td></td><td>1.2.2.2 - A customer survey of 497 participants from Switzerland, Austria, Germany and Lichtenstein on smart grid related preferences and knowledge was used to gain customer insights as follows:
Consumers are highly interested in obtaining information on their electricity bill about individual consumption of domestic appliances.
Expected advantages of smart meters strongly outweigh concerns of most respondents.
The greatest benefits of smart metering are a reduction in costs due to</td></tr>
</table>

				increased energy efficiency, and a reduction of environmental pollution. • Willingness for consumers to adapt behavior exists: 77.7% of consumers can imagine using their washing machine at a different time of day. • 26.2% have concerns regarding security and privacy. • 24.8% are concerned they will have to pay for a smart meter, however approximately 33% were willing to pay for a smart meter. A cluster analysis was carried out based on different customer preferences regarding the following benefits and concerns of smart meters: • Benefits: improved transparency regarding consumption, reduced environmental pollution, and cost reduction. • Concerns: additional costs emerging, lack of individual benefit, and data privacy issues. Analysis revealed the following 3 customer segments: 1. 'The supporters' formed 42.3% of the total customers used in the analysis, and represented customers who expect great benefits from using smart meters, with very little concerns regarding adoption. 2. 'The ambiguous' (33.1%) represent customers who appreciate the benefits of using smart meters but also have concerns regarding issues such as data security. 3. 'The skeptics' (24.5%) represent those who had deep concerns about smart grids and only expected to receive small benefits from their use. A survey of 54 energy experts/management-level persons, working at small to medium sized commercial electricity consumers indicated preference for creating a 'green' image of their company, along with anticipation of increase in costs of energy and its procurement. 75% did not do take any action for peak load reduction. These points could be used in considering a business model for the B2B smart grid market.
			★ ★	2.2.2.2 - Based on the different customer segments identified from surveys, 4 generic smart grid business models were suggested: The 'Saver' model as the name suggests is focused on helping consumers lower energy costs through reduced energy consumption and buying at cheaper tariffs. Such a model is suitable for all customer segments identified as the principle of saving money is applicable for everyone. However it may lead to sub-optimal results due to being a low involvement product and not directly addressing the specific needs and preferences of any one segment. The 'Smart +' model suggests adding value through additional features on top of basic metering functionality. Participants suggested interested in

				functionality such related to safety and convenience such as burglary prevention devices, as well as meters enabling integration of renewable energy into the grid. Such a business model would require a medium level of involvement as customers would need to be engaged in searching for information regarding such value. The 'Smart camouflage' model targets the skeptic consumer segment especially. Through bundling home appliances, electric cars, smart phones, home-automation systems etc. with smart grid functionality, it is expected that this will create a value proposition around items other than smart meters/grid and engage the customer indirectly. The 'Trader' model is a high involvement model and allows customers the opportunity to trade different 'products'. For example the proposition of trading electricity, trading flexibility and the provision of capacity to achieve economies of scale all represent ways of engaging the consumer. Costs of acquisition are high as this model would require specific contracts for trading.
	Policy			
Social & Other	Protocols			
	Stakeholders	★		1.3.2.1 - In a customer survey of 497 participants from Switzerland, Austria, Germany and Lichtenstein, 26.2% have concerns regarding security and privacy.
		★		1.3.2.2 - A survey of 87 private Swiss energy consumers revealed that a mobile solution was deemed the preferred method of visualizing energy consumption. This was followed by preference for an in-house display, with the least preferred method being an online-based visualization tool.
		★		1.3.2.6 - The IMPROSUME report discussed that in order to fully realize the benefits of smart grids, it is important to not only analyze smart grids from a technological perspective, but also to understand the required institutional changes and social acceptance of smart grids. It is argued that at this moment the 'perceived usefulness' of smart grids has not yet reached the point to overcome company uncertainty in investing due to the high up-front costs, and that customers do not yet see enough benefits of adopting the changes brought about by smart grids/meters. Thus in order to increase the perceived value and bridge the gap between customers and technology, it is important to segment the consumer base and provide different propositions and business models based around 'prosumers'. In a survey of the B2B market, interestingly it was also found that incorporating everything that is feasible from a technical point of view, did not necessarily lead to the highest customer value.
	Other			

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EUR 3	IRIN, Germany
Status	Finished
Dates	2009 - September 2011
Involved	Bremer Energie Institute at Jacobs University (project leader), Öko-Institute Freiburg, Wissenschaftliches Institut für Infrastruktur und Kommunikationsdienste (WIK) and Ruhr-Universität Bochum: Institut für Berg- und Energierecht. The project is funded by the Federal Ministry of Economics (BMWi).

The research project IRIN - Innovative Regulation for Intelligent Networks - deals with the design of an adequate institutional framework that supports efficient and effective network development towards smart grids.

In the search for efficient and effective incentive structures for a grid on the way to becoming a smart grid, the research project "Innovative Regulation for Intelligent Networks" (IRIN) focuses on the control of investments and innovations as well as on the coordination between the net and the decentralized actors. The central question of the grid regulation concerns "efficient investments incentives": How can not absolutely necessary grid investments be avoided and at the same time necessary investments be promoted?

The research project aims to develop the institutional framework that guides efficient and effective network development towards smart grids. Central research questions are:

- How to design an incentive regulation that guarantees necessary investments while at the same time preventing inefficient investment? [literature review]
- Which network pricing system sends effective signals for efficient coordination of network, generation and load installations?
- Which advancements should be made to incentive regulation to adequately account for network innovation and transformation?
- Are changes to the current legal framework required?

Domain	Aspects	Micro	Meso	Macro	Relation to action points
Technical	Systems				
	Control				
	Information				
Policy & Regulation	Tasks			★ ★	3.2.1.2 - The question how to incentivize (CAPEX intensive asset) innovation in a smart grid context is discussed cursorily in academic literature and experiences mainly come from the telecom sector. The overall conclusion from theory is that it is challenging to anchor adequate regulatory incentives to enhance dynamic efficient investments and there is a void regarding the role of dynamically efficient investments in grid-bound energy supply. Furthermore it is concluded that incentive regulation does not sufficiently stimulate dynamic efficiency in the sense of explicit regulatory stimuli for asset innovation leading to a dynamically efficient CAPEX allocation. There are complex regulatory trade offs

between incentives focused on productive efficiency and incentives focused on dynamic efficiency; this is a regulatory dilemma.

The UK was the pioneer with RPI-X (price-cap) regulation since 1990 with a focus to increase the efficiency. On top of this price cap there is a regulatory allowance for R&D and demonstration projects. RPI-X was successful in raising the efficiency, but there are doubts whether it is "fit for purpose" in relation to the development of smart grids. The regulator in the UK (Ofgem) has introduced a new performance based model "RIIO" which is still based on RPI-X but with new regulatory features such as revenues and outputs, business plan review, extension of regulatory period, holistic and time-limited innovation stimulus and investments in a long term context. In this setting the DNO is supposed to set out an investment strategy with a well justified asset strategy, consider alternative options (OPEX/CAPEX compromise) and thorough considerations of investment implications above 8 years period. Especially the review of the business cases makes this a heavy handed approach.

In Italy there exists price cap regulation since 2000, in which the X factor only applies to the OPEX and the CAPEX is treated separately. There is an R&D component in the network tariff and an increased WACC for awarded demonstration projects. This a light-handed pragmatic approach but with a risk for demarcation problems. Overall it should be concluded that pragmatic solutions have a priority but critical and continuous reflection whether the regulatory scheme is still "fit for purpose" is required. In the longer term it is important to consider new market designs and governance options for the future energy system.

Output-oriented regulation creates indeed better incentives for effective and efficient R&D. However, the outputs of R&D measure as little, as it can be considered in the regulation. It makes sense therefore that a limited budget for innovation to get reimbursed by the operator at least a portion of R & D costs (investment budget). This raises the question whether innovation should not be addressed outside the actual incentive regulation. There is some more recently in Britain with a fund practices ("Low Carbon Network Fund" or "Network Innovation Competition"). Here, all network operators to apply for the funding of innovative projects from a fund fed by all network users. Which projects are selected, is not depending on how they contribute to the implementation of political goals. A combination of both options seems optimal: Each company receives a limited budget for network innovations that can be used for example for the continuous

					development of knowledge in R & D. Who wants to go further, for example, to test new concepts and innovative network operating in network technology pilot and demonstration stage can be used to request additional funding from the Innovation Fund. The division into innovation budget and innovation fund has the advantage of on the one hand that from the innovation budget all companies get access to R & D funds, and thus the need for innovation is indicated. On the other hand, the investment budget can have a more limited scope and particularly the innovative companies with major innovation project plans can also apply for the Innovation Fund. Because Smart Grid innovations also serve not only the efficiency of the individual company, but the development of the whole system, it should not be funded the same way as the innovation budget (through the customers of individual operators) but it should funded through the rates of all network users. This then results in the obligation for companies to publish results. In contrast to existing programs of research support the Fund could be managed by the regulatory authority, which will thereby be assigned a role in the strategic development of the electricity grid as well. This also changes the interface between regulatory and political process, because the main task consists not only of operating the existing infrastructure as efficiently as possible, but the infrastructure development is increasingly used to support policy objectives and is part of political discourse.
	Finance			★ ★	3.2.2.6 - As mentioned in 3.2.1.2 it is advisable to split the incentive regulation into an innovation budget for company related innovation, and an innovation fund for all network operators for large scale innovations with implications and results for all network operators. The division has the advantage of on the one hand that from the innovation budget all companies get access to R & D funds, and thus the need for innovation is indicated. On the other hand, the investment budget can have a more limited scope and particularly the innovative companies with major innovation project plans can also apply for the Innovation Fund.

	Policy	★★		2.2.3.1 - WP4 discusses the adaptation of the legal framework in Germany, which is mostly not relevant for the Netherlands. Besides the conclusion regarding the implementation of these incentive schemes in Germany some other remarks are made, which are also relevant for the Netherlands. Further legal considerations outside incentive regulation and tariff and electricity price formation concerned potentially contra productive influences of provisions regarding unbundling, storage and system responsibility of network operators. With regard to this, several significant deficits regarding the implementation of smart grids emerged: e.g. regarding the information flow between network operation and energy supply, regarding the far too complex regulation of the feed in management (e.g. regarding rigid "cut off hierarchies"), as well as regarding investment incentives for the expansion of the electricity storage infrastructure.
Social & Other	Protocols	★★		2.3.1.2 - In some cases network investment can be deferred by steering generation and/ or demand coordinating them with available network capacity. This coordination can be realized with institutionalized local network or energy pricing. In systems where currently uniform pricing is in use and generators do not pay use of system charges, this would require major regulatory reform. We proposed smart contracts as an alternative tool to achieve this coordination. They can send local signals in a low transaction cost and flexible way. Smart contracts are optional and voluntary agreements between the network operator and network customers that realize a trade-off between investment into the grid and changes at the demand or generation side. Network operators can flexibly design these contracts to better adapt customer behavior to network capacities when this is cheaper than network investment. Since participation in smart contracts is voluntary customers are protected against exploitation by the network monopolist in the negotiations of a smart contract. They can always fall back on a regulated default tariff. In WP2 it is concluded that an imposed "local spot pricing" is unsuitable for a distribution grid. A preferred solution would be a locally differentiated grid pricing system; however this option has a weak short-term control effectiveness. Therefore a compromise is proposed: "smart contracts" based on voluntary participation and optionality can be a low transaction cost solution to implement local signals in distribution networks and thereby avoid network investments. They are easy to implement and do not require large regulatory reform. Hence, smart contracts are an attractive solution for efficiency enhancing local pricing in smart distribution networks. Importantly, network operators need incentives to pursue smart contracts as an alternative to network expansion. This implies that they

					should be allowed part of the benefits from the avoided investment. It is the task of the regulator to a) allow network operators the flexibility to design smart contracts and b) to incentivize network operators such that they carry out efficient network investment and will offer smart contracts where investment can better be avoided. Smart contracts raise further issues with regard to governance. It is assumed that contracts can incorporate energy components. It is obvious that with unbundling this is not an easy task since network operators can only give incentives to suppliers which would than in turn design incentives for customers.
	Stakeholders				
	Other				

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- http://www.bremer-energie-institut.de/irin/en/results/public (contains among others final report with results)

EUR 4	ADINE, Finland
Status	Finished
Dates	October 2007 - 2010
Involved	Hermia Ltd (Finland), AREVA T&D Ltd (Finland), ABB Oy Distribution Automation (Finland), AREVA Energietechnik GmbH (Germany), ComPower Ab (Sweden), Tampere University of Technology, Department of Electrical Energy Engineering (Finland) and Lund University, Department of Electrical Measurements and Industrial Electrical Engineering and Automation (Sweden).

This 3.2 MEURO project develops, demonstrates and validates a new method for the active management of a distribution network and the enabling solutions to support it. The solutions operate as active components in managing the network to enable an easy interconnection of different DG units. The solutions cover the protection of the network, planning and information systems, and voltage and reactive power control. The aim of ADINE project is to develop new methods for the electric distribution network management including DG i.e. management of active distribution network to maintain networks within acceptable operating parameters. The ADINE project has demonstrated in real-life several technical solutions that make integration of DG easier.

In 2008, workshops for DSOs were arranged in Portugal, Spain and UK in order to disseminate knowledge. At the end of the project in 2010, there were results workshops in Portugal, Spain, Germany, Finland and Sweden. Focus of these workshops was on the dissemination of the results of ADINE.

Domain	Aspects	Micro	Meso	Relation to action points
Technical	Systems	★		1.1.1.7 - Short-term voltage disturbances may inflict considerable harm in the form of damaged equipment, lost production and reduced productivity. ADINE used the representative of converter based VAr compensators named STATCOM, Static synchronous compensator. STATCOM provides a solution for VAr control, voltage regulation, flicker compensation, and fault-ride through improvement. Also grid current harmonic filtering is possible if sufficiently high switching frequency can be used. Benefits of STATCOM are improved power quality and network stability, increased transmission capacity, and improved fault ride through capability and grid code compliance of renewable generation.

			★ ★	2.1.1.1 - The Active Network Management method adds value by increasing the potential for renewable energy, by improving efficient utilization of distribution network assets and by supporting distribution network by ancillary services from customer-owned resources. The distribution network management concept of ADINE project is based on existing systems like SCADA, Distribution Management System (DMS), substation and distribution automation and Advanced Metering Infrastructure (AMI). The ANM system operates on protection, decentralized control and area control levels. The existing management system includes three layers: protection system, automatic control system (decentralized) and area control level (centralized). The ADINE project deals with all layers. The goals of developed ANM method are to ensure safe network operation and to increase network reliability in networks with DG, to maximize the utilization of the existing networks with bottleneck caused by voltage issues, and to maintain the required level of power quality despite non-predictable power production or consumption. In order to achieve these goals the project has developed and demonstrated individual technical solutions (protection, voltage control and STATCOM) and validating the combination of technical solutions (developed ANM method). The developed methods together form the ANM method. Furthermore the real-time simulations demonstrate how the technical solutions interact with a power system with much DG. They also illustrate how some technical issues are closely related such as loss-of-main protection and fault ride through. Demonstrations have also shown that active network is feasible today at least in specific applications. This means that existing device, automation and IT systems are capable to provide active network features which are part of overall active network management.
	Control			
	Information		★	2.1.3.1 - Integration of new active devices into the existing distribution automation and IT systems is an important issue. It is not possible to replace the whole automation and IT system at once therefore active network and ANM requires continuous evolution instead of a revolution. The integration of active devices into automation and IT systems should be based on open interfaces and standardized protocols in order to ensure easy integration of all kind of devices and systems without replacing the core parts of automation and IT system every time a new functionality of ANM or a new active resource is connected to the automation and IT system.

Policy & Regulation	Tasks			
	Finance			
	Policy			
Social & Other	Protocols			
	Stakeholders		★	2.3.2.3 - The most important decision which DNO should make is related to distribution network planning and operation philosophy. The challenge is to decide the moment when e.g. a new DG connection is handled by ideas of active network. Investments are typically high for the first installations because new interfaces, platforms, etc. are needed.
	Other			

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EUR 5	eTelligence, Germany
Status	In progress
Dates	The project was launched in Autumn 2008; in 2010 a field test began with around 650 households and selected business enterprises.
Involved	The eTelligence consortium is comprised of partners from science and research, the energy sector and IT specialists: • EWE AG, Oldenburg, Germany (Utility, Lead Partner) • BTC AG, Oldenburg, Germany (IT Consulting and Software Development) • OFFIS e.V., Oldenburg, Germany (Research IT) • energy & meteo systems GmbH, Oldenburg, Germany (SME, Virtual Power Plant, energy meteorology) • Fraunhofer Energy Alliance, Freiburg and Ilmenau, Germany (Research CHP integration and distribution grid) • Öko-Institut (Research Evaluation)

In an extensive field test eTelligence explores and demonstrates various approaches of using modern ICT and advanced operation to improve the current energy supply system and to enable broad integration of renewable energy sources like wind, photovoltaic and biomass.

In the model region of Cuxhaven, electricity producers (wind, photovoltaics and biomass) are coupled with consumers who serve as either energy storage facilities or can flexibly adapt their electricity consumption to the generated power. Taking the example of a refrigerated warehouse: in times of wind surplus, deep-frozen fish can be cooled down to up to minus 24 degrees centigrade. In times of wind calm, cooling can be turned off until the temperature has risen to minus 18 degrees centigrade. Sewage treatment plants, swimming pools and private households are also participants in the system of intelligent integration of renewable energies into the power grid.

Domain	Aspects	Micro	Meso	Relation to action points
Technical	Systems	★		1.1.1.1 - eTelligence uses a EWE Box smart meter. Improving transparency was one of the key requirements for choosing a smart meter. The EWE Box makes electric power consumption transparent.
		★		1.1.1.2 - Six hundred fifty households have tested smart meters for everyday use. With different feedback systems (iPod app, portal, monthly printouts), the participants were able keep track of their own electricity consumption and assess the cost of electricity, CO_2 emissions and their consumption pattern.
		★		1.1.1.3 - The complexity of dynamic rates precludes a manual response to price incentives. This task is performed by energy management system. eTelligence used multi-boxes. The multi-boxes receive price signals or can request the current price before switching on an appliance via standardized interfaces.

			★ ★	2.1.1.1 - eTelligence developed and tested the implementation of load management schemes. This requires competent technical advice and the installation of automatic control systems. eTelligence proved that in enterprises and large municipal energy consumers, load management today is technically and commercially feasible. In the eTelligence project the refrigeration assemblies of large cold-storage depots adapt automatically to the wind power generated in the region. Here, the large cold storage capacities of cold-storage depots are used in a power balancing group to cope with the fluctuating off-forecast production of wind power.
			★ ★	2.1.1.2 - In the eTelligence project, Energy & meteo systems have developed a complete virtual power plant, from the technical grid connection of individual facilities via integration to providing market connections. Modules are used here to connect commercial and industrial power consumers to a virtual power station. This optimizes the supply and consumption of the connected plants and enables purchase and sale on the eTelligence market place.
			★ ★	2.1.1.3 - eTelligence was able to demonstrate that especially thermal electrical energy systems, such as cold-storage depots and block type thermal power stations can be used very effectively as energy storage facilities: When a lot of wind is available, the Cuxhaven cold-storage depot lowers its temperature and creates a cold buffer for itself. eTelligence proved that this type of energy storage is technical feasible.
	Control	★ ★		1.1.2.4 - In eTelligence dynamic pricing is applied. There are also bonus and penalty events. In certain exceptional situations, the price for defined periods is lowered or raised to an extreme. This relies on the market-conform behavior of consumers to help rectify the imbalance by shifting their consumption. When customers have detailed information about their electricity consumption, they can take specific measures to reduce it. In the large-scale eTelligence field trial, savings have even been made of as much as 10 %.
	Information			

	Tasks			
Policy & Regulation	Finance	★ ★		1.2.2.1 – eTelligence has been experimenting with various rating schemes: • time variable rate: both the intervals and the various prices charged are fixed and communicated long in advance • consumption based rate: the higher the total consumption, the more expensive is each kilowatt hour consumed in that month. • event rate: for the pre-notified time interval, extremely high or low prices per kilowatt hour are charged in response to external events. In general, consumption based rates are difficult to convey to the customer. However, the eTelligence field trials showed that these rates in particular provide an incentive for saving. eTelligence started with simple time-variable rates. In the ongoing large-scale field trial, complex dynamic rate constructions have been added. The two differ distinctly in terms of handling and their ICT requirements. eTelligence concludes for consumption rate: • Between June and October around 40 kWh or 13% reduction in consumption monthly for event rate. • Between June and October 2011 during the expensive; period around 14 kWh or 12% reduction in consumption monthly; • No statistically reliable change established during the cheaper period; • It may be the event that is influential, not the general price levels.
Policy & Regulation	Finance		★	2.2.2.1 - Considerable changes will occur in energy sector overall. In the unanimous assessment of the industry, the ICT-based smart grid and smart home applications above all will generate a gigantic market. Besides the advantages for individual actors, there is also the economic issue of the benefit for the overall system: What costs and CO_2 emissions can be saved through smart, decentralized flexibility? Model calculations in eTelligence indicate that these savings will increase substantially in future with a larger ratio of volatile renewable energies.
Policy & Regulation	Finance		★	2.2.2.2 - The pilot projects were able to demonstrate the technical feasibility of innovative pricing schemes. There are, however, still limits to the scope for setting attractive rates. eTelligence concluded that fixed grid charges in particular pose a constraint.
Policy & Regulation	Policy		★	2.2.3.2 - eTelligence demonstrated that cold-storage depots and block type thermal power stations are effective energy storage facilities.

Social & Other	Protocols	★		1.3.1.1 - The pilot projects in Germany (under the E-energy program) have taken on leading roles in developing a pan-European position for the smart grid and cooperate with other experts from all over Europe under the M/490 mandate of the EU Commission.
			★★	2.3.1.2 - During the field trial of eTelligence, the participant actors were exposed both to marketing and price risk as well as forecast risk. The market participants are two cold-storage depots, a wind park, the Cuxhaven municipal swimming pool, a treatment plant and a block-type thermal power station. These can be flexibly connected either individually or as a virtual power station and together can be managed and predicted in a similar way to a conventional power station. Here, controllable units in particular (e.g. producers with power/heat cogeneration or switchable loads) can provide power generation flexibilities for the market.
	Stakeholders	★		1.3.2.1 - Data of private persons measured by smart meters is especially sensitive. To prevent any inferences being made on personal lifestyles, data is made anonymous and aggregated, provided it is not needed for invoicing purposes with detailed itemization. No more data is collected than is actually needed for billing and for monitoring the grid state. If it must be gathered, it is not stored for longer than necessary.
		★★		1.3.2.2 - The advisory tool in eTelligence proved to be a very popular service among consumers. Based on (voluntarily) disclosed consumption data or the identification of power guzzlers in households, the advisory tool provides efficiency advice.
		★★		1.3.2.3 - eTelligence demonstrated that cold-storage depots and block type thermal power stations are effective energy storage facilities. Refrigeration systems are switched off when prices are low. Using the cold buffer previously built up, the cold-storage depot can then run for some days with much lower power demand. This substantially reduces electricity supply costs over the year. eTelligence incorporated dynamic rates for connecting retail customers with wholesale conditions. There were three different tariffs (TOU tariff combined with events, load variable tariff, tariff based on total consumption during billing period).

			★	2.3.2.3 - Due to the changed regulation in Germany, two new market roles have already emerged: the metering point operator and the metering service provider. The incorporation of renewable energies or the trade-off between market and grid interests will, however, require other (new) market functions with the business goal of optimization for the benefit of the overall system. Flexibility in scheduling consumption represents a good in itself and will increasingly come to be treated as a commodity. There may be a need for a separate function to manage and reward flexibility on the consumption side. The smart grid could also require ICT infrastructure operators.
	Other			

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- contact person: Dr. Wolfram Krause (EWE) wolfram.krause@ewe.de

<table>
<tr><th>EUR 6</th><th colspan="4">MERGE, Europe</th></tr>
<tr><td>Status</td><td colspan="4">Finished</td></tr>
<tr><td>Dates</td><td colspan="4">01-01-2010 – 31-12-2011</td></tr>
<tr><td>Involved</td><td colspan="4">16 European partners. 5 leading research institutes/universities (INESC Porto, ICCS/NTUA, TU Berlin, Cardiff and Comillas), 5 automotive connected partners (AVERE, Ricardo, IMR World, C4D and InSpire) and 6 System Operators/Regulatory Entities (PPC, REE, REN, Iberdrola, ESB and RAE).</td></tr>
<tr><td colspan="5">Merge is a EUR 4.5 million, 16-partner collaborative research project aiming to evaluate the impacts that electric vehicles will have on EU electric power systems with regard to planning, operation and market functioning. The MERGE project does this in two key ways:
1. development of a management and control concept that will facilitate the actual transition;
2. development of an evaluation suite that consists of methods and programs of modeling, analysis and optimization of electric networks into which electric vehicles and their charging infrastructure is integrated.

From the studies performed so far in the MERGE project, it is possible to conclude that large scale EV deployment can be performed without major concerns if one adopts an intelligent based approach, involving full use of ICT, to manage and control the presence of EV consumers in the electrical network.</td></tr>
<tr><th>Domain</th><th>Aspects</th><th>Micro</th><th>Meso</th><th>Relation to action points</th></tr>
<tr><td>Technical</td><td>Systems</td><td>★</td><td></td><td>1.1.1.1 - Smart meters can support the participation of EV in the complex power market through the combination of market services in different business cases. The smart meter enables the market participation of EV as individual units and aggregated sets. Smart meters provide a two way communication channel between the meter and the utility infrastructure, for automated reading and control, allowing advanced energy services to be exchanged between customers and the grid.

The MERGE project defined high level requirements that the smart meter should guarantee:
1. Interoperability and public communications standards;
2. Common communication architecture;
3. Service lifecycle management;
4. Event support and alarm handling;
5. Combination of different business and market services.</td></tr>
</table>

		★		1.1.1.5 - Communication architectures should be designed to ensure the necessary performance of data exchange in terms of availability, reliability, security and speed. Given the potentially high number of events generated in the electric grid, it is necessary to rely on an event and alarm management system that is able to provide an overview of the status of the network. Alarms generated by the smart meter can signal critical events that could adversely affect the electric system operation.
			★	2.1.1.2 - The EV stochastic behavior and duality in their operation dictate the need for a new aggregating entity that will provide market visibility and EV charging controllability. Two innovative distribution network infrastructures have been proposed to achieve efficient DER aggregation: micro grids and virtual power plants. The integration of EV in both structures requires the synergy of a technical management and market operation framework. The interaction between the VPP control centre and the VPP resources, including EV, is shown in Figure 6.
	Control	★ ★		1.1.2.2 - The MERGE project has defined different charging strategies, as showed in Figure 7. The smart meter needs to provide different functionalities to tackle both less demanding charging approaches, such as dumb charging and multiple prices approaches. And also elaborated charging schemes, like smart charging and vehicle-to-grid.

2.1.2.1 - The MERGE project concludes that large scale EV deployment requires the adoption and the development of a new set of concepts, and control / management architectures in order to minimize the need to reinforce the electrical generation, transmission and distribution infrastructure. The adoption of controlled charging strategies involving the adherence of the new consumers to this concept is fundamental for the success of EV deployment.

EV grid interfaces need to be enhanced in order to help local control of the participation of EV in delivering ancillary services to the power system. This can be performed by installing additional functionalities on board of EV or by installing these functionalities at the EV point of connection. This requires the update of the existing standards on the charging of electric vehicles.

★★ Charging power levels of the power interface need to be determined as well as the power transfer form, which can be either AC or DC. The power transfer technology which may be conductive or inductive should be decided. Furthermore, safety functions to be implemented such as ground fault interruption, proper connection interlock and immobilization of the vehicle while charging need to be specified.

There is also a need for standardizing the means of communication between the involved entities in the charging process. The payment methods for charging electric vehicles should also follow standards.

There are five main entities which, depending on the charging scenario, may need to communicate with each other. These entities are: the user, the EV, the charging point, the DSO and the supplier/aggregator. The information to be exchanged with the EV depends on a number of factors. These factors include the location of the charging point, the level of sophistication desired for charging and the business model into which the EV is to be integrated.

	Information		★ ★	2.1.3.4 - The analysis of MERGE shows that with a 10% of penetration of electric vehicles using a dumb charging strategy (with no smart control of charging) and all vehicles charging as soon as they return from their last journey of the day, the daily peak demand levels would increase by between 6% and 12% compared to the baseline peak demand and that the peaks would occur at a different time to that of the baseline peak demand. The analysis shows further that a 10% penetration of electric vehicles, with an ideal smart charging strategy with all EV charging load moved to the night-time valley periods, would cause no change to the baseline peak demand levels. In addition, the peak EV charging load is also reduced, unless the charging is already spread over a long period of the day. The daily variation from minimum to peak demand was shown to increase significantly for the dumb charging scenario and reduce significantly for the smart charging scenario.
Policy & Regulation	Tasks		★ ★	2.2.1.1 - When operating the grid in normal conditions, EV will be managed and controlled by different aggregation layers. In case of abnormal or emergency situation, the DSO takes control in order to handle violation of grid operational restrictions. A new set of agents, like the supplier / aggregator is envisaged to help manage the integration of this new type of consumers - the EV batteries. This should also be done by exploiting smart metering infrastructures that are presently being deployed. In addition, it is very important to understand that in the future, DSO's will have to play a critical role in this new scenario, by validating the EV batteries' charging profiles before the aggregators present their biddings on EV consumption needs to the market.
	Finance	★		1.2.2.3 - The MERGE project shows that there are two factors driving the decision of which payment method to use. One is the ease of implementation for the supplier or aggregator, the other is the ease of use for the user. For most of the non-domestic locations, the Pay-as-you-go is the simplest system to both install and use.
	Policy			
Social & Other	Protocols	★		1.3.1.1 - For plug-and-play charging of electric vehicles, both power stage requirements and ICT stage requirements need to be standardized.
		★		1.3.1.2 - There is a vast number of different communication methods available for use between the different elements involved in the charging process. MERGE provides an overview of those which have been identified to provide the most relevance and promise for use within the ICT stage. Furthermore, possible uses are identified for all each communication method. The evaluation identifies the best method for a specific situation (see Figure 8).

	Stakeholders	★ ★		1.3.2.1 - In order to tackle privacy and security issues, MERGE emphasizes that the following characteristic should be ensured: • Authentication: EV must register when accessing the utility energy services. The network will either authorize or refuse a determined EV connection to the grid. The electric network management will then assign unique ID to each EV user in case of successful registration. • Data encryption: The data exchanged between the EV and the aggregator must be encrypted to ensure privacy and resistance to tampering, especially in shared medium communications which are prone to eavesdropping.
		★		1.3.2.2 - The identification of traffic patterns and consumer behavior relating to the use of EV has been investigated by the MERGE project. A detailed consumer behavior questionnaire was distributed in several countries in Europe (see http://www.surveymonkey.com/s/Dutch-merge for Dutch version). Over 1600 responses were obtained. The study focuses specifically on the countries Germany, Great Britain, Spain, Greece, Portugal and Ireland. The study found that a significant majority of responders would participate in smart control of charging of tariff electricity rates were to incentivize it. See results in Figure 9 and Figure 10.
	Other			

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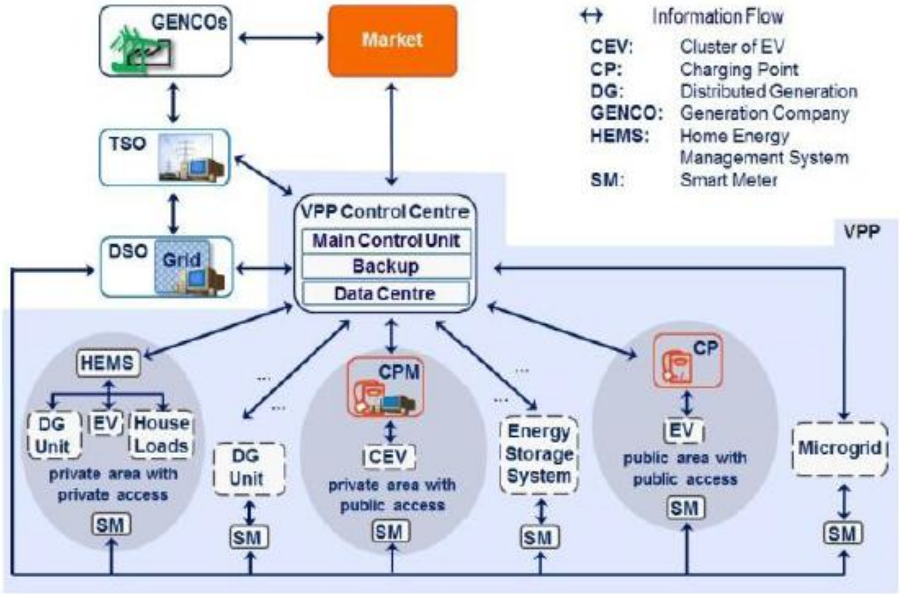

Figure 6: Interaction between the VPP control centre and the VPP resources, source: Bower et al., 2012.

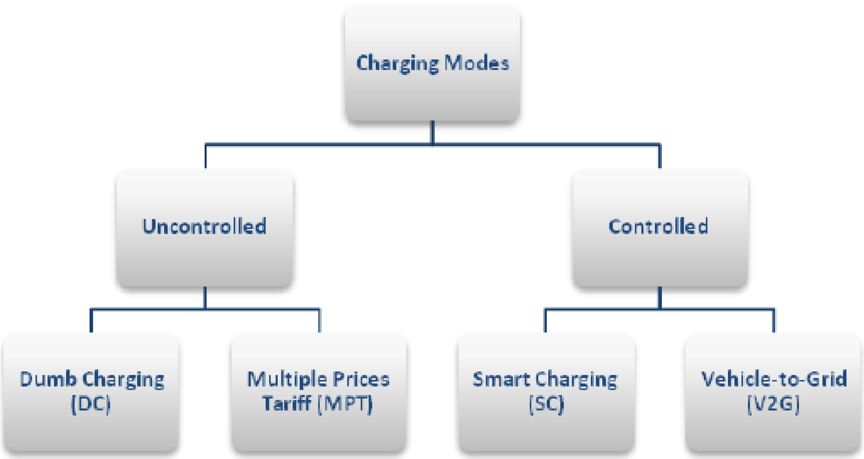

Figure 7: Charging modes for EV, source: Bower E.T. et al, 2012.

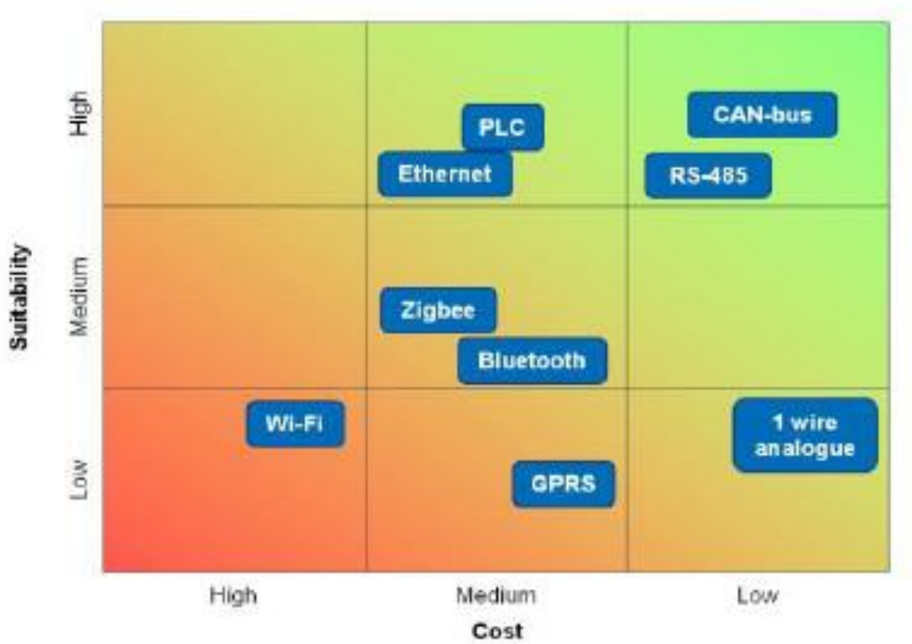

Figure 8: Evaluation matrix for communication methods, source: Bower E.T. et al, 2012.

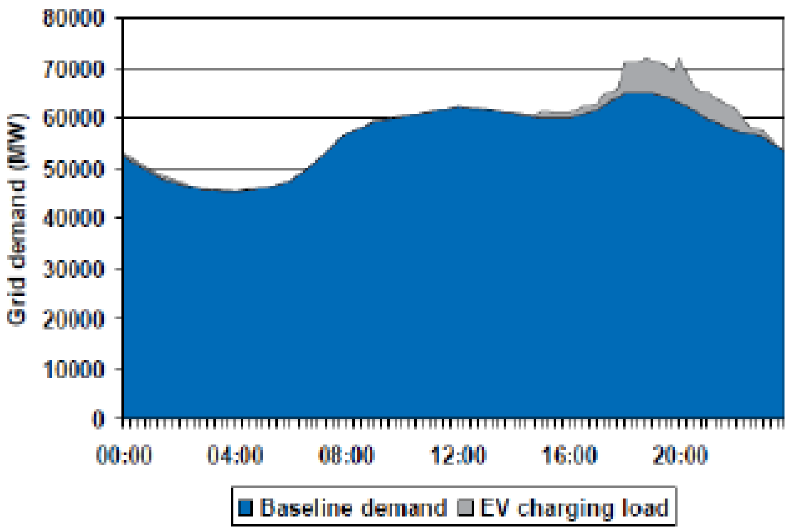

Figure 9: Example of German grid demand with a dumb charging scenario – EV charging load increases the peak load, source: Bower E.T. et al, 2012.

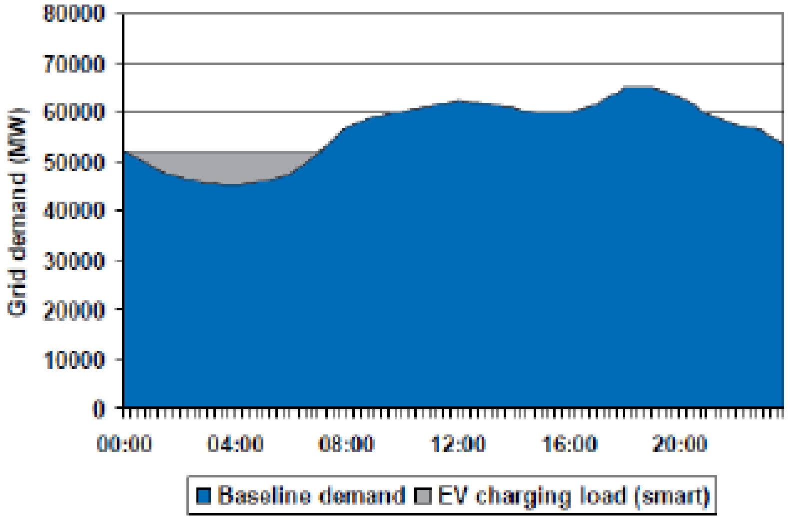

Figure 10: Example of German grid demand with a smart charging scenario – EV charging load fills the night-time 'valley', source: Bower E.T. et al, 2012.

EUR 7	**Model City of Mannheim (E-Energy program), Germany**
Status	In progress
Dates	2008 - 2013
Involved	MVV Energie AG, DREWAG - Stadtwerke Dresden GmbH, IBM Deutschland GmbH, Power PLUS, Communications AG, Papendorf Software Engineering GmbH, University of Duisburg-Essen, ISET - Verein an der Universität Kassel e.V., ifeu Heidelberg GmbH and IZES GmbH.

The Model city of Mannheim (MoMa) project concentrates on an urban conurbation with a high penetration rate in which renewable and decentralized sources of energy are used to a large extent. Within the framework of the E-Energy project, a representative large-scale trial is being conducted both in Mannheim and in Dresden to demonstrate the project can be applied and translated to other regions. The trial uses new methods to improve energy efficiency, grid quality, and the integration of renewable and decentralized sources of energy into the urban distribution network. The focus is on developing a cross-sector approach (involving electricity, heating, gas and water) to interconnect the consumption components with a broadband power line infrastructure.

Domain	**Aspects**	**Micro**	**Meso**	**Relation to action points**
Technical	Systems		★	2.1.1.1 - A complete system architecture was set up to link up households and commercial enterprises with units that use and generate power. This can provide information for the future on how far this kind of service-oriented approach is feasible in normal operation in terms of real-time capability and scalability. In particular, matching the use times of electric power in households and enterprises with electricity supply can contribute to integrating renewables into the distribution grids. The initial trials with new electronic market platforms have made promising progress. Another focus was placed on developing the system architecture for ‘security by design’. This has come up with a cellular energy system, where the outage of a cell does not necessarily impair the whole system, thus improving supply security.
			★ ★	2.1.1.3 - The tests with the cold-storage depots have led to a major finding: Despite good forecasts and influence on loads in real time, a 100-per cent spatial and temporal balance of production and consumption is not possible. The future energy system will therefore need more storage capacity than today. One technology alone will not be enough, as it must perform buffering functions between a few seconds and many days or even weeks. Even though a small addition to capacity can be expected in pump storage and also intelligent charging management in electric mobility, the expansion of these storage systems will not be able to keep up with the rapidly growing balancing needs for renewable energies. The storage technologies to be developed and particularly their costs will play a large role here. In the ICT-controlled combined energy networks, heating grids that use waste heat from power/heat cogeneration and gas grids (Power2Gas) could increasingly contribute their flexibilities in future.

	Control	★★		1.1.2.3 - As one of the projects of the E-Energy program, MoMa shows that not all appliances are equally suitable to adapt their consumption over time at all or in a cost-effective way. Installations in companies afford great potential in general, e.g. large cold-storage depots, treatment plants or block-type thermal power stations. In the private sector, these are primarily heat pumps, refrigerators and air conditioners of a certain scale and in the future charging stations for electric vehicles (and/or batteries in general) that can shift their consumption within hours or days. Figure 11 shows the shifting potential of the different technologies. Unlike with the other facilities, in home appliances and small and mini units almost the entire theoretical capacity can actually be shifted forwards or backwards. As the figure indicates, for about 30 minutes almost 20% of installed capacity can be used as positive balancing power through switch-off or delayed switch-on. Larger refrigeration plants can shift their consumption over longer periods (in this case up to 4 hours).
		★★		1.1.2.4 - The second field trial showed that the consumers on average shift the electricity consumption of appliances connected to load management to low-rate periods. Figure 12 reveals that the real consumption (red line) in high-rate periods – above all at the peak period in the early evening – keeps below forecast consumption (green line) and usually above in low-rate periods. Roughly 5 to 10 percent of the electricity consumption in households can be influenced over time. This figure may seem small, especially as the test households are predominantly interested single-family home owners and thus do not correspond to the average household. Nevertheless, this can make a major contribution to enabling distribution network operators to reduce a local critical power load.
			★★	3.1.2.1 - Of increasing importance is not just the question of the quantity but also the quality of the renewable electricity generated. In interaction with and in the transition from conventional to renewable power generation, the new energy systems must not just contribute to power supply security but also participate in the provision of so-called system services. Modern inverters permit of very diverse methods of in-feeding into the grid to accurately target the requisite phases of alternating current. They do not just generate active power but can also compensate reactive power as a major condition for stable overall operation of a supply system with a large number of highly volatile producers and consumers. The project is still looking into whether this can provide an economic solution. At present, the costs for this kind of solution are 45 % higher than the conventional method of reactive-power compensation. The picture is different, for example, if compensation is demanded exactly at the time of maximum inverter output. These modern inverters can only be used to full effect if they are interconnected and are instructed accordingly to provide power at exactly the right place and time.

				Another conclusion is that supply and demand can be balanced with more ICT at balancing group level. The transportation of high wind power surpluses remains a problem at transmission grid level. Depending on local grid state, the most cost-effective variant (smart grid ICT in the grid or at the grid margin, storage or transport) needs to be optimized.
	Information	★ ★		1.1.3.4 - To a certain extent, renewable energy systems can deliver system services (balancing power, reactive current compensation, etc.). The legal framework, however, affords little scope for efficiency. Also in 3.1.2.1 the communication with renewable intermittent energy sources is mentioned in relation to reactive current compensation.
Policy & Regulation	Tasks			
	Finance	★		1.2.2.1 - In the E-Energy program several rate scales have been tested. In the MoMa project a time-variable rate and a dynamic rate were tested. In the time-variable rate the energy price for individual rate phases is determined by day, week and month and set for a specific interval (monthly, weekly, etc.). Rate phase spreads between 10 and 60 cent/kWh. Time shift of load can result in avoidance of load peaks or consumption troughs and a possible improvement of basic load. In the dynamic rate, the energy price is based on external variables (exchange price, forecasts, residual load, grid load, etc.). Time intervals and the prices charged are set a day in advance, for example. Near-time and flexible load shifts in response to specific situations can balance production and consumption. The complexity of most dynamic rates precludes a manual response to price incentives, which is still possible in most time-variable rate cases. This task is performed by energy management systems, e.g. "energy butlers" in the MoMa project. The pilot projects were able to demonstrate the technical feasibility of innovative pricing schemes. There are, however, still limits to the scope for setting attractive rates. Fixed grid charges in particular pose a constraint.
			★	2.2.2.2 - Most of the E-Energy model regions do not expect that all consumers and producers will engage on the future electronic marketplaces themselves. Instead, a new market function will come into play with bundling and optimization tasks to be performed by different market players. These aggregators, demand-side managers or pool managers will enter into contracts with a (larger) number of small producers and flexible consumers, bundle their output and offer it as an optimum product to grid operators, electricity traders or power exchanges. These activities will need to be supported by ICT platforms to ensure that the requisite data and services are provided in secure form in keeping with market roles.
	Policy			
Social & Other	Protocols			
	Stakeholders	★		1.3.2.2 - Three feedback mechanisms were used: an online portal, hardcopy and a gateway/Energy manager display.

1.3.2.6 - For greater acceptance of smart technologies in the private domain, the following aspects are of main importance (results from E-Energy program, not all necessary from MoMa project):

- Long periods of absence from home make it difficult to make manual use of low-price times. After the novelty interest wanes, the readiness for manual switching also diminishes considerably. The installation of intelligent facilities, such as energy managers, to control the terminals autonomously based on price signals and knowledge of their operating states is indispensable.
- With progressive automatic regulation of appliances, technically less proficient consumers often fear losing control over their household. Simple and easy use is a basic prerequisite for acceptance in the broad population. Also important is retaining the option of switching the appliances on and off by hand as usual.
- Technology will only find acceptance if it has been developed to an adequate standard of maturity, when it is secure and when responsibilities are clearly regulated in the case of a fault. Here, it is up to manufacturers to develop solutions to improve security and comfort both for specific devices (protection against overheating, warning signals for faulty parts, etc.) and for system integration (smart-home approach).
- ★★ The integration of load management into rapidly developing home automation technologies affords good prospects for greater acceptance, as it will be bring benefits in efficiency and comfort as well as security, against burglary and theft, for example.
- Information from the energy industry and profit-seeking manufacturers is often seen as dubious. Customers take a skeptical view of new rates and their apparent benefits. The population should be informed about the functions and advantages of the smart grid as far as possible in collaboration with independent institutes and political agencies and consumer protection organizations. Energy saving tips and impartial consumer information build confidence and arouse interest.
- If customers have the impression that they are helping their town or their region, they are easier to motivate for the new services.
- Strategies for introducing smart technologies must take into account the various needs and attitudes of consumers. Not all customers are the same. Roughly speaking, customers seeking emancipation and self-fulfillment and who are interested in technology can be reached in an initial round. Then, those that are aware of socio-economic issues and are generally interested in change can be targeted in a second phase. Communication and marketing need to be planned to meet the expectations of these groups.

				Unlike in households where a large degree of flexibility is usually afforded by time rates, concepts are also being developed in the commercial sector for the direct control of production and consumer systems. The pilot projects have gained initial findings for raising acceptance here: • If rates scales are too complicated for the enterprises, transaction costs often become excessive and acceptance diminishes; • Interventions in functional processes are expensive and lack of personnel capacities hardly allow for managing load transfer. Competent technical support through service packages can help here; • Especially in cooling systems, control can shorten the storage life of food, give rise to complaints from employees or customers on poor air conditioning or disrupt of production in the industry. Liability issues therefore play a role both for plant operators and energy suppliers. Close cooperation among all stakeholders is essential to reduce these barriers.
	Other			

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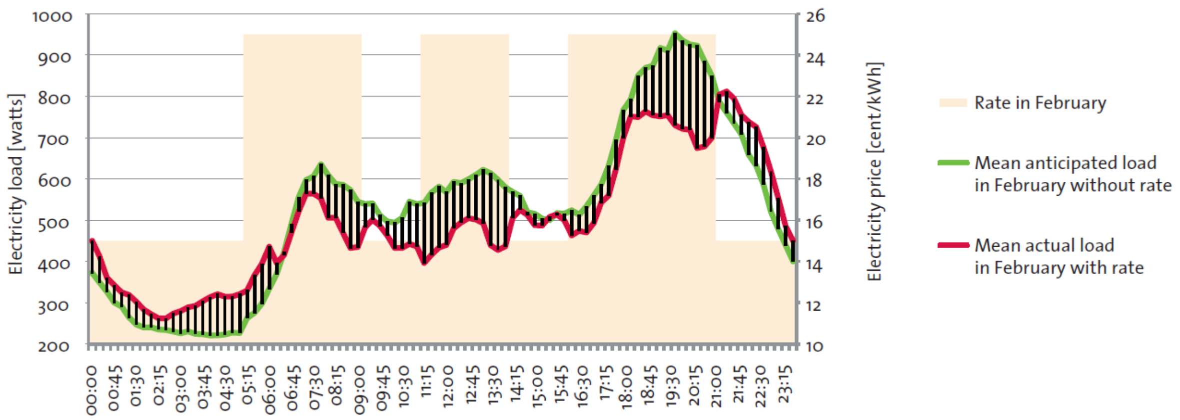

Figure 11: Load shift in the practical test (monthly average workdays), copyright IFEU 2011 (*Source: Interim results of the E-Energy pilot projects towards the Internet of Energy, February 2012***).**

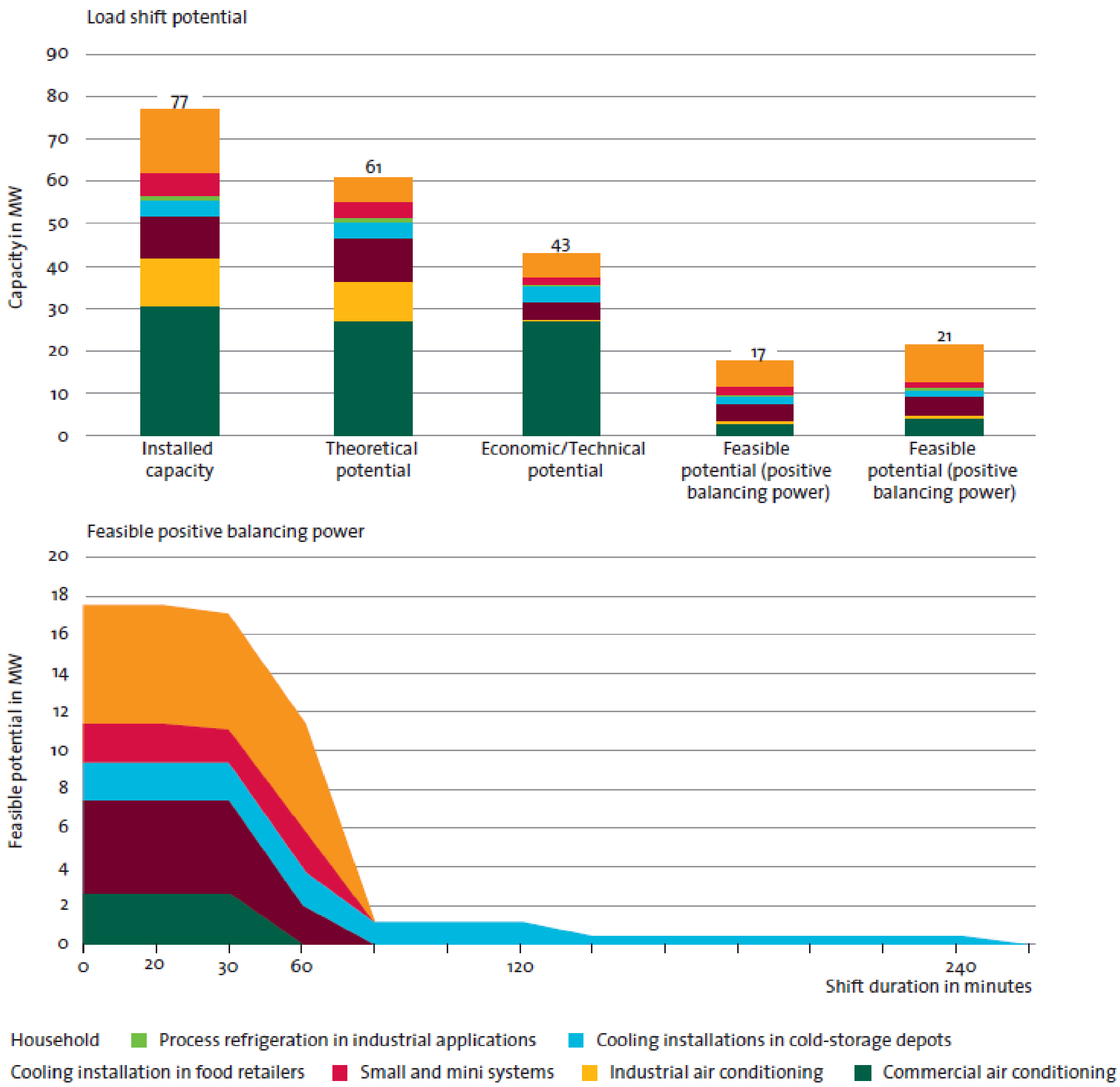

Figure 12: Refrigerators and freezer cabinets as buffers (*Source: Interim results of the E-Energy pilot projects towards the Internet of Energy, February 2012*)

EUR 8	SmartHouse/SmartGrid, Netherlands/Germany/Greece
Status	Finished
Dates	Q3 2008 - Q3 2011
Involved	SAP, IWES, MVV, TNO, ICCS-NTUA, PPC. Funding from EC 7th Framework program

The SmartHouse/SmartGrid (SHSG) project used houses as a way of creating intelligent networked collaborations alongside distributed generators for example. Intelligent agent and e-market techniques for decentralized control and optimization at network level formed a large part of the work.

TRIAL A - Hoogkerk, Netherlands: – The Hoogkerk micro grid (which includes 25 interconnected houses) was used to show that the SHSG concept was scalable, and could handle the large-scale communication between thousands of smart energy devices. PowerMatcher software developed by the ECN was used as the core intelligence for this system.

TRIAL B - Mannheim, Germany: – A small cluster of participants (100 households) was used to test the automated response of household devices, and observe consumer behavior to variable electricity prices. A Bidirectional Energy Management Interface was used to optimize local power consumption and generation automatically, using both locally available information as well as central information.

TRIAL C - Meltemi, Greece: – The purpose of this field trial was to demonstrate how a decentralized system could handle critical situations such as islanding or a black start. To test critical grid operations, a MAGIC (Multi-Agent Intelligent Control) system was used to monitor the available distributed generation and create a load shedding schedule based on forecasts and criticality of loads, as well as consumer willingness to pay for running appliances during the island mode.

Domain	Aspects	Micro	Meso	Relation to action points
Technical	Systems	★ ★		1.1.1.5 - During Trial A, it was observed that occasionally duplicate meter data readings arrived from the meters. This was because no asset management tool was available for the smart meters used in the trial. Although this did not cause a problem with the actual experiment because the data was given a timestamp when written to the database, it does highlight a potential problem that may arise if not dealt with. It shows that meter data should be checked not only on whether it conforms to the required format, but also some kind of 'logical' check should be in place to stop resubmission of measurements. If not then this will allow incorrect metering data to be 'injected' into the system to compromise the security and performance, or even to lower a monthly bill for example.

		★		1.1.2.4 - Due to severe technical problems delaying the trial and measurement of results in Trial B, there was a very limited time period for collecting data suitable for analyzing thoroughly the effects of loads shifts in response to variable tariffs being offered. This meant that seasonal effects, consumer awareness change, saturation or habitual effects that would be observable over a longer period of time could not be easily extrapolated from the data. However based on the limited data available a shift of consumption to periods of low price in the order of 6-8% was seen. On the basis of questionnaires and feedback, two-thirds indicated that they changed their electricity consumption pattern during the field test, according to the prices. They estimated they would make a saving of 5€ compared to fixed tariffs. With the limited results available, it was shown that users consumed less power and adjusted power consumption of home appliances to cheaper tariff time periods.
	Control			1.1.2.5 - For Trial B, an energy management system was developed that was able to test the automated response of household devices and also consumer behavior on variable electricity prices. The hardware aspect of this consisted of a core processor called "Energiebutler" (newly developed for this project), alongside the smart meter, data storage aggregator and some switchboxes. A web portal allowed consumers to monitor the functioning of Energiebutler. A new software platform for the energy management system was also developed – OGEMA. This allowed loads and generators of the consumer to be linked to the control stations of the smart grid, and also provided a user interface for local control capabilities. In general the design of the local controllers and home energy management systems (both hardware and Web Portal) should foster the interaction between the consumer and their awareness of cost and consumption of electricity, and hence make it more acceptable for consumers to have such technology in their home.

		★ ★		1.1.2.6 - Trial C tested congestion management as well as support for islanding/black starts was tested with the use of the MAGIC (Multi-Agent Intelligent Control) – JAVA based software which implements intelligent agents. For congestion management purposes, the intelligent agents monitored the system and provided other agents and the aggregator with data regarding the system such as consumption and production levels, voltage levels etc. The system also provides a list of loads that can be shed. The operation of the algorithm on the MAGIC system showed that the system was able to predict a disturbance such as an overload before it occurred and take action (unlike a simple algorithm which would only react when the overload is actually detected). A warning time of 15 minutes was enough for the system to respond and prevent any disturbance. For the purposes of islanding, a load shedding schedule is created based on criticality of consumption loads and also consumer willingness to pay for operating an appliance during island mode. It was seen that with a smart energy management system such as MAGIC, extensive load shedding of one or more houses did not need to take place (unlike a simple algorithm in a centralized system which can only monitor total consumption and only has the ability to carry out a generalized outage of house/houses). Through the use of forecast modules for PV and data regarding appliance consumption, then even in islanding scenarios a certain level of comfort was possible for home owners.
	Information	★		1.1.3.1 - It was seen from Trial A that a lot of time was lost on the request processing time of each meter reading, inside the application server. This suggested that the application server load should be balanced over multiple nodes. Further efficiency enhancements suggested include using a meter data concentrator to collect meter readings and submit them in bulk, or the usage of in-memory databases.

		★ ★		1.1.3.3 - One of the goals of Trial A was to show that the automated control of one million households was possible, and so allow a balance responsible party (BRP) to control demand and supply of household appliances to optimize overall balance within a settlement period. In order to take in the huge amount of measured data, two levels of Concentrators were used to take information from the Smart House Gateway Level to the Enterprise System which acted as the central optimization unit. Whilst some of the smart house gateway outlets came from the existing test field in Hoogkerk, and another concentrator took information from 100 real smart meters, the remaining concentrators took information from agents mimicking households in a virtual PC environment. In one of the experiments, each concentrator was receiving meter readings at a rate of 60readings/second. In line with current smart grid industry practices, each meter under a concentrator sends its current reading every 15 minutes. Hence this would allow for 54000 meters to be connected to each concentrator. The Metering Data System performance peaks at 66 concentrators, and therefore with a meter reading interval of 15 minutes, 3.6million meters can be used in such a configuration. Of course if the interval resolution was reduced to 1 minute, then only 240,000 meters could be connected.
Policy & Regulation	Tasks			
	Finance		★	2.2.2.2 - As all of the field trials in this project utilized flexible tariffs and the ability of the aggregator/ESCo to make arrangements, the report strongly recommended the need for an accessible and easy process for consumers to switch from their standard electricity profile regime, to a metered regime. It is only with such a scenario that a Balance Responsible Party can take advantage of the flexibility potential of consumers, for operations on wholesale markets.
	Policy			
Social & Other	Protocols	★ ★		1.3.1.1 - The OGEMA (Open Gateway for Energy Management and Alliance) standard was used in SH/SG for in-house services. This is an open software framework driven by Fraunhofer IWES which is designed to be run on a central building gateway which serves as the interface between the smart house and grid. It allows applications from different manufacturers to run in parallel, and has a flexible and modularized architecture. The aim of this initiative is to develop an open, manufacturer-independent standard. The OGEMA standard and reference implementation has also been adopted by projects such as RegModHarz and REV2020.
	Stakeholders			
	Other			

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EUR 9	RegModHarz (E-Energy program), Germany
Status	In progress
Dates	Nov 2008 - Oct 2012
Involved	RegenerativKraftwerk Harz GmbH & Co KG, E.ON Avacon Netz GmbH, Siemens AG, in.power GmbH, ISET e.V., Vattenfall Europe Transmission GmbH.

The model Harz region is mainly concerned with the joint marketing of regionally available renewable producers and flexibilities grouped into a virtual power station on different markets. For this, the IEC-61850 standard was extended to enable the simple and secure connection of systems to a joint control station. This newly developed generic data model enables the automated assimilation of systems in energy management.

With the innovative ‘regional renewable energy rate’ created as part of the project and now being tested in the field trial, consumers in the Harz region can obtain regional electricity from renewable energy sources, such as wind, sun or biogas. The rate is geared to minimize the residual load within the region so that the customers can make an active contribution to balancing out production and consumption. It is processed in part automatically through an energy management system and smart household applications.

The project demonstrated that the storage requirements for energy could be reduced through short-term wind forecasts. Load shifts on the consumer side help to improve voltage regulation in the distribution grid and compensate for forecast errors. The newly developed pool coordinator to bundle and market the decentrally generated electricity will play a central role on the new markets.

Domain	Aspects	Micro	Meso	Relation to action points
Technical	Systems	★★		1.1.1.7 - A specific challenge in some places already today are the photovoltaic modules connected to the low-voltage grid. If the sun emerges from behind the clouds, many systems start to feed into the grid at high output at the same time. This raises the frequency and in response to pre-settings some generation systems connected to the low-voltage grid would have to switch off automatically when they reach a frequency of 50.2 Hz. As many installations register this and switch off simultaneously, they can seriously disrupt system stability. The necessary smart inverters to solve these issues have already been developed. They now need to be connected with the other participants in the overall system and the corresponding control systems through appropriate communication modules. Of great importance also is the ability of decentralized producers, such as micro block-type thermal power stations, to switch in at the right time. If they are connected with the whole system via communication units, they can, for example, be switched on, if the sun disappears again behind the clouds. The preliminary findings show that ICT control of flexible generation plants (controllable inverters, current-regulated use of cogeneration stations) and localized purchase of reactive power can support grid stabilization.

			★ ★	2.1.1.1 - Savings potential is available in the commercial sector of up to 20 %, in the private sector, of 5 % to max. 10 %. Regarding the load shifting, a potential of up to 10 % is available in the private sector (above all with heat pumps and air conditioners, on a smaller scale dishwashers, dryers and washing machines). However, considerable educational work is needed to raise this potential. The load shifting potential is very high in the commercial sector and in part already economically attractive today. Due to the necessary adjustments in the production process, it can, however, frequently only be raised with intensive advisory services.
			★	2.1.1.2 - By pooling different power producers, storers and flexible consumers in virtual power systems, some model regions have effectively reduced the so-called residual load, that is, the remaining energy demand beyond the power generated by renewables. The simulations have shown that this is possible above all, if controllable renewable energies, such as biogas facilities, feed in as needed. Supply must, however, be secured at all times, which poses new challenges for the balancing energy system with a growing number of small producers and incalculable consumers (such as charging stations for electric vehicles).
			★	2.1.1.4 - The more is known about when and how much electricity is generated from renewable sources, the better it can be integrated into the grid. This is why forecasting systems play an important role in the smart supply system. They enable the timely provision of generating capacities (e. g. biogas facilities) or the early initiation of consumption adjustment (e. g. more cooling on reserve). With a suitable mix and use of all technologies already available today both on the production and the consumption side and in terms of hardware and software, short-term adjustment would seem feasible, at least within a region. This would relieve the distribution grids, reduce expansion needs and increase regional value added. This calls for considerable efforts in energy technology and above all in information and communications technology, but as the results of the simulations indicate, the effort will be worthwhile. In many cases, using electricity near where it is produced can raise the efficiency of the whole system. The ICT solutions developed in E-Energy can help to ensure that decentrally produced power is also increasingly consumed locally, which will ease the burden on the grid.
	Control			
	Information			
Policy & Regulation	Tasks	★		1.2.1.2 - The intelligent use of conventional storage devices (pump storage, batteries) affords scope for short-term load balancing in a balancing pool. For long-term buffering, other storage technologies need to be used (e. g. production of hydrogen or methane and storage in the gas grid).
	Finance			

	Policy	★★		1.2.3.1 - New business models will require more flexible grid charges, either in the form of variable or separate charges, the latter being favored by the Federal Network Agency. One obstacle could prove to be the scheduling requirements for the regulatory system. The volatility of renewable energies must either be forecast very precisely, which is only possible on a limited scale, or producers and consumers must be controlled with high spatial and temporal resolution. As far as possible, this will be done via market signals, which must, however, be transmitted to all possible suppliers of suitable balancing options because of the non-discrimination requirement. The ensuing negotiations could take too long even on electronic marketplaces to take timely countermeasures against grid instability.
Social & Other	Protocols	★		1.3.1.2 - The Open Gateway Energy Management Alliance (OGEMA) is developing an open software platform, sometimes called an operating system for energy management. OGEMA enables the integration of the most diverse communication systems (e.g. the EEBus for communication with household appliances). The OGEMA framework was developed by the Fraunhofer Institute IWES in Kassel. It is applied in the MoMa energy butler as well as in the BEMI of RegModHarz project, where it has already laid the foundation now and in future to develop numerous applications for optimizing power and heat supply.
			★	2.3.1.2 - The incorporation of renewable energies or the trade-off between market and grid interests will probably require (new) market functions with the business goal of optimization for the benefit of the overall system. The electronic marketplaces will not just trade electricity. Flexibility in scheduling consumption represents a good in itself and will increasingly come to be treated as a commodity. There may be a need for a separate function to manage and reward flexibility on the consumption side.
	Stakeholders			
	Other			

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EUR 10	Beywatch, Spain & Greece
Status	Finished
Dates	Dec 2008 - June 2011
Involved	EDF, Sigma Orionis, GL, Gorenje, Telefonica, Fagor, Universita degli studi di Palermo, Synlexis

Beywatch was a project focused on ICT tools for environmental management and energy efficiency. The aim of the project was to design, develop and evaluate an energy-aware and user-centric solution, capable of providing interactive energy monitoring, intelligent control and power demand balancing on a home and neighborhood level.

The Beywatch system implemented for this project consisted of several subsystems:

- Beywatch Agent – this software was hosted on a Residential Gateway and comprised of:
  - the Agent Scheduler & Controller;
  - the Home Energy Framework which provide services to the scheduler;
  - the Machine to Machine (M2M) communications interface.
- Supervisor – software for energy control and load balancing on a neighborhood level, and also to preserve customer contract agreements;
- Custom energy-aware, remote-controlled white goods - a washing machine and dishwasher were equipped with Zigbee interfaces and a refrigerator with a Wifi interface was used in this project;
- Metering Modules – which includes smart meters and also 'watchers' (i.e. smart plugs). This subsystem excludes the metering embedded inside the white goods;
- Combined Photovoltaic Solar (CPS) system, producing both electric and thermal energy (the thermal energy is used to supply hot water);
- Business Support Software – web-based software providing energy consumption information and also capable of initiating a social network group on energy consumption, and also 'eco-games' between energy prosumers in the same area.

Both global system tests and standalone device tests were carried out to validate the system developed as a whole.

Domain	Aspects	Micro	Meso	Relation to action points
Technical	Systems	★		1.1.1.1 - The smart meters deployed in homes for this project was the same as the meters currently deployed in France. A line interface allows metering and tariff information to be delivered to any device connected to it. A ZigBee module (CC2530 chipset) developed by EDF is able to provide metering data onto the home Zigbee sub network. A hardware platform developed allowed wireless serial point-to-point (smart meter – Agent) communication. The meter was then able to permanently broadcast information contained in its internal memory through this interface. Thus real time knowledge on consumption in the home can be provided which is necessary in order to be able segment consumers and provide personalized energy services for them.

	Control	★ ★		1.1.2.5 - One of the major achievements in the project was the design and implementation of the Agent Scheduler & Controller software. The scheduling algorithm behind this system can only optimize consumption if it has exact knowledge of the behavior of the devices it is connected to, or at the least the energy load curve related to the behavior. However because no common standard has been adopted in white goods behavior, each appliance had to be configured independently making installation a difficult process. The complexity involved in optimizing home energy was also found to be very tricky due to the large number of factors involved in the behavior of connected devices: different modes of operation, different consumptions per mode, different times and constraints in each state. This is an even more complex problem when the various energy tariffs, different generation forecasts, different energy forms (electricity and hot water) and human behavior are taken into account. Because currently white good manufacturers are not willing to provide full remote control functionality of their appliances (as pausing/delaying operations may influence quality of the provided service and hence their product quality and reputation), it was recommended that to begin with remote control scheduling functions are limited only to program start activity. In doing so only the starting time and mode of operation is chosen by the scheduler with actual operation of the device and performance left to the manufacturer. Although this is not optimal, it is at least an intermediate step towards adoption of home energy optimization. The report also suggested the improvement of forecasting programs to improve accuracy and usability within the optimization algorithm. Even with these improved forecasts another problematic area is the unpredictability of the end-user, who may easily disrupt any forecasted schedule – meaning it has to be recomputed every time a major change occurs. It was suggested that in order to take into account such potential disturbances to the schedule, schedules which are slightly less optimal could be chosen which need very little modification and so are more stable. This is likely to lead to greater end-user acceptability. Whilst the home energy management system developed in this project was trialed with success, it should still be considered a prototype. There are still issues such as self-healing functions (being able to detect malfunctions and automatically run correction procedures) and self-configuration capabilities (ability to add new devices to the system easily without complication) which need to be addressed in future developments.

		★ ★		1.1.2.6 - The BeyWatch Supervisor (operating on a neighborhood level) was an independent application which remotely interacted with a large number of Agents (home level). The feature set of the Supervisor and the Supervisor/Agent interface was informed by a conceptual model of a Monitoring and Control System which was then implemented and successfully integrated with the rest of the BeyWatch system. There were two key concepts in this monitoring and control system: 1. Hierarchical Propagation - incentives/counterincentives for the purposes of Demand Side Management were propagated hierarchically according to spatial scope i.e. from regional level, to neighborhood level, to homes and then finally to appliance level. 2. Semantic translation - the incentives/counterincentives being propagated needed to be 'translated' so as to be consistent with the scope of the hierarchical level. For example: a. A request to lower demand in a geographical region is translated to... b. ...multiple requests to lower demand in various cities/neighborhoods which are further broken down to... c. a set of incentives/counterincentives which are unique for each home and influence the scheduling algorithm which is... d. affected by scheduling of household appliances and modification of their operation. A contract-meta model was also implemented to place constraints on the variation of critical contract parameters, thus enabling demand-side management measures within the limits specified by a contract. The Supervisor is consequently able to send various waveforms to the Agent specifying contract parameters such as the price or power ceiling constraints over time and thus able to influence the scheduling carried out by the Agent for DSM measures. It should be noted that the trial of this system was in a controlled environment and so a real trial would require the active participation of consumers with a national grid administrator. Also security/privacy issues would need to be addressed through additional enhancements.
	Information			
Policy & Regulation	Tasks			
	Finance			
	Policy			

Social & Other	Protocols	★★		1.3.1.2 - Machine to Machine (M2M) communication was a key area of analysis in this project. The Zigbee interface (used for the smart Dishwasher and Washing Machine) allowed devices to send and receive information with an external management system. However this interface was found to be prone to interference and unreliable, especially when other interference sources were allowed to operate (e.g. a microwave near to the Washing Machine). Another disadvantage was the short coverage range of Zigbee. For longer distance communication in the home e.g. between basement and kitchen, the mesh networking functions of Zigbee is required implying an increase in complexity, maintenance and cost. Additionally it was found that there was functionality required which was not supported by the Zigbee standard. It was recommended that using WiFi (as with the Freezer in the project) would provide a better coverage range, and a more robust communication option. It is less affected by interference - dynamically launched channels from external WiFi (802.11) sources can provide better overall robustness to the system. Newer standards such as 802.15.7 could also be even more immune to interference. WiFi as a very mature standard also has a high degree of physical compatibility. However the same problem exists as with Zigbee that the openness of both solutions leads to proprietary and not standardized solutions. Manufacturers can create their own extensions to protocols, and this makes it very hard to achieve compatibility on an application level. Another advantage of using WiFi is that as most houses have broadband/ADSL internet access, they will by default already have a WiFi bridge/residential gateway (which can host the BeyWatch Agent) meaning no extra communication hardware would be needed. However the cost of using WiFi is higher than ZigBee meaning that if the price of white goods using WiFi is too high, the product may not be a success. The energy consumption of WiFi technology is also higher, meaning that it is still not clear which means of communications and which protocol (if any) will come to dominate the market. The project recommends to keep the aspects of M2M communications as separate and independent as possible from the rest of a home energy management solution. Although this will perhaps result in an increase in costs, it will ensure a future-proof solution until some kind of standardization in home communications occurs.

	Stakeholders	★		1.3.2.2 – The Business Support Services (BSS) web portal prototype developed provided the end user with real time energy information, reports, and comparisons on energy consumption in the past, with options to personalize and compare consumption with the similar users in the community. Through questionnaires, the feedback showed that the majority of users thought the service was interesting and understandable, but only 55% would be willing to subscribe for certain at a reasonable price. The main reasons for not wishing to subscribe were actual need and price uncertainty. It is important for this reason that there should be certainty that the system will save more money than the service costs itself. It is recommended that allowing users to experiment with sensors in the house to see how electricity is consumed by different appliances will increase awareness of consumption and also the perceived value of such a service. It was also found whilst the web user interface was useful, an application for a smartphone would be even better as this would always allow the user to see consumption data wherever they are. Being able to compare consumption patterns with those of homes around them, will also incentivize user awareness and most likely change usage patterns of consumers.
		★ ★		1.3.2.6 - The project recommended that the importance of control should be emphasized in order to increase adoption of home energy management systems. Although users thought monitoring of appliances was a good thing, they did not feel this would justify the cost. However when the control element is introduced, the user feels more empowered. There are appliances such as air conditioning which the user always wants to control manually (as temperature perception is relative), and so the user should always be able to control and override any automated decisions. However in general users do not wish to be worrying about complex decisions on how to use home appliances, so they accept the concept of an intelligent agent controlling non-critical appliances for them.

	Other	★		1.3.3.1 – The BeyWatch project used smart white goods, combine PV & solar generation, energy consumption monitoring, low-cost home networking and load/energy management to validate the concept of a smart home which is able to use ICT to improve energy efficiency. The system developed was shown to be able to avoid times of peak demand (through postponing operation of activities) and reduce energy consumption. Through a number of different scenario simulations (different houses, different consumption models, with/without CPS, different lighting, different white/brown appliances, different seasons and times) the system was shown to reduce annual energy consumption. With an adoption rate of 20% it was estimated that a town's annual energy consumption would reduce by 2.6%. A 100% adoption rate would reduce energy consumption by 14.3%.

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EUR 11	Cell Controller Pilot Project, Denmark
Status	Finished
Dates	2005 - Oct 2011
Involved	**Main Partners**: Energinet.dk, SE Syd Energi Net, Energynautics GmbH, Spirae Inc (USA) **Other Partners**: Billund Varmeværk, Bramming Fjernvarme, Hejnsvig Varmeværk, Holsted Fjernvarme, 47 private wind turbine owners, Tjæreborg Industri, Pon Power, Rolls-Royce Marine, Siemens Denmark

The Cell Controller Pilot Project (CCPP) has shown the development, deployment and successful demonstration of the so-called Cell Controller. To date it is the biggest complete prototype of an advanced control, regulation and monitoring system for the smart grid.

The 'Cell' is defined as the 60kV distribution grid below each 150/60kV transformer. It is an autonomous region fully automated by the cell controller which is able to communicate with decentralized CHP plants, wind turbines, transformers and load feeders. The amount of DG installed is such that local generation meets or exceeds local loading comfortably.

One of the main objectives of this project was to use the system developed to coordinate distributed energy resources – in particular distributed generation (which is in abundance in the Danish distribution grid) for grid reliability and power-flow applications. Additionally by using CHP plants, wind turbines and load control, VPP functionality was envisaged to provide ancillary services such as power balancing, import/export of active and reactive power, and voltage control. The final objective was to provide fast islanding capabilities of the Cell, with grid operation continuing using local resources.

The project took place over 7 years, with each new capability of the cell being tested first via simulations and laboratories, and then with a field test. The field test was carried out over a 1,000 km^2 area in cooperation with a distribution company, using 28,000 households, business and institutions, 5 CHP units, 47 large wind turbines and 12 substations (60/10kV).

Domain	Aspects	Micro	Meso	Relation to action points
Technical	Systems		★	2.1.1.2 - In this project, a technical VPP was developed which takes into account the technical aspects of the local distribution network and coordinates control using the Cell Controller. This is in contrast to a commercial/market VPP whereby Balance Responsible Parties aggregate minor units for the regulation of the power market. Each Cell can act as a virtual generator with same or better controllability than a power station of the same size. This allows increased services for the distribution network such as voltage control, and reactive power import/export to the transmission system.

			★ ★	2.1.1.4 - The ultimate objective of the CCPP was to facilitate the transition to a more autonomous grid. In the case of reaching an emergency situation, the cell is expected to be able to disconnect from the HV grid and switch to island operation. After a total system collapse the Cell should be able to black-start itself to a state of controlled island operation. To complete such ambitions the cell must be able to carry out a number of functions. A brief list of the functionality achieved by the Cell Controller is listed below (as taken from the report): • Monitoring total load and production within the cell; • Active power control of synchronous generators; • Active power control of wind farms and large wind turbines; • Reactive power control by utilizing capacitor banks of wind turbines and grid; • Voltage control by activating Automatic Voltage Regulators on synchronous generators; • Frequency control by activating Speed Governing Systems on synchronous generators; • Capability of operating 60kV breaker on 150/60kV transformer; • Capability of operating breakers of wind turbines and load feeders; • Automatic fast islanding of entire 60kV Cell in case of severe grid fault; • Automatic fast generator or load shedding in case of power imbalance; • Voltage, frequency and power control of islanded Cell; • Synchronizing cell back to parallel operation with the transmission grid; • Black-starting support to transmission grid in case of black-out.
	Control		★	2.1.2.2 - One of the major components within each cell in the field tests were the CHP units which were gas engine or gas turbine driven synchronous generators. These were used in conjunction with an exhaust boiler for district heating purposes. The synchronous generators were all equipped with Speed Governing Systems (SGS) and Automatic Voltage Regulators (AVR). A SCADA system using the Omron specific protocol is used to communicate with the Cell Controller. Using this it is possible to enter external signals into both the SGS and AVR to allow the set voltage and frequency settings to be dynamically changed. During islanding operation, generally the 1 MW Secondary Load Controller (SLC) within the substation was used to absorb active power transients of magnitude 400kW. However when these transients could not be filtered by the SLC, then the online CHPs could be used to absorb this excess.

	Information		★ ★	2.1.3.1 - The cell controller has been designed such that each cell can be combined with other cells to comprise the grid area covered by DNOs (and even TSOs). For each individual cell a layered control hierarchy is used, with the utilization of distributed agent technology and a high speed network (see Figure 13 for the hierarchy structure). Each agent is either an industry central processing unit (CPU) a high-end remote terminal unit (RTU) or an intelligent meter depending on the level at which the agent is found. The agent is an independent unit authorized to control a group of sub-units. It can act independently, according to rules or according to orders received from superior agents. As it is necessary to maintain continuous communication with substations and assets for monitoring the system and issuing commands, a communications method compatible with the DNOs existing communication system must be implemented. In this project a wide area communication systems consisting of DSL, GPRS and fiber communications was used, with CHP and wind turbine sites being retrofitted with communications capabilities.
			★ ★	2.1.3.2 - The high amount of DG in the Western Danish Power System has caused security problems (with regards to maintaining n-1 security), and this would be likely to occur for power systems in other countries such as Netherlands if local generation begins to exceed local demand, and the separation of generation and consumption is insufficient. With high DG penetration security analysis becomes less accurate due to lack of information about local generation and unpredictable wind power. Additionally traditional under-frequency load shedding schemes will disconnect both load and generation, and restoration after faults will become more time consuming. It is envisaged that as the amount of DG on the network increases, there will be an increase in opportunities to define Cells to which coordinated control can be deployed. Using the Cell Controller in areas with high DG will lead to many benefits for stakeholders at all levels. For the DNO it will allow an increased ability to maintain control of the network (in terms of voltage control, load restoration etc.) with a large amount of DER. One aspect which was not developed through this project was load-shedding functionality which would be important to consider for the purposes of an even more robust islanding-capable system.

Policy & Regulation	Tasks			
	Finance		★ ★	2.2.2.1 - Although no detailed costs were provided regarding this project, it is important to note that the solution was designed and developed so that it could be scaled and replicated on a large scale to other areas in Denmark in a cost-effective way. For this purpose, the design of the cell controller was such that it utilized existing assets wherever possible. The communications infrastructure was also designed to utilize easily available technologies. This minimization of costs was advantageous as it represents the most likely situation which will face any future deployment of this technology on a large scale. Importantly any new functionality to be added to the Cell Controller in the future is expected to be implementable as a pure software development task.
	Policy			
Social & Other	Protocols			
	Stakeholders			
	Other			

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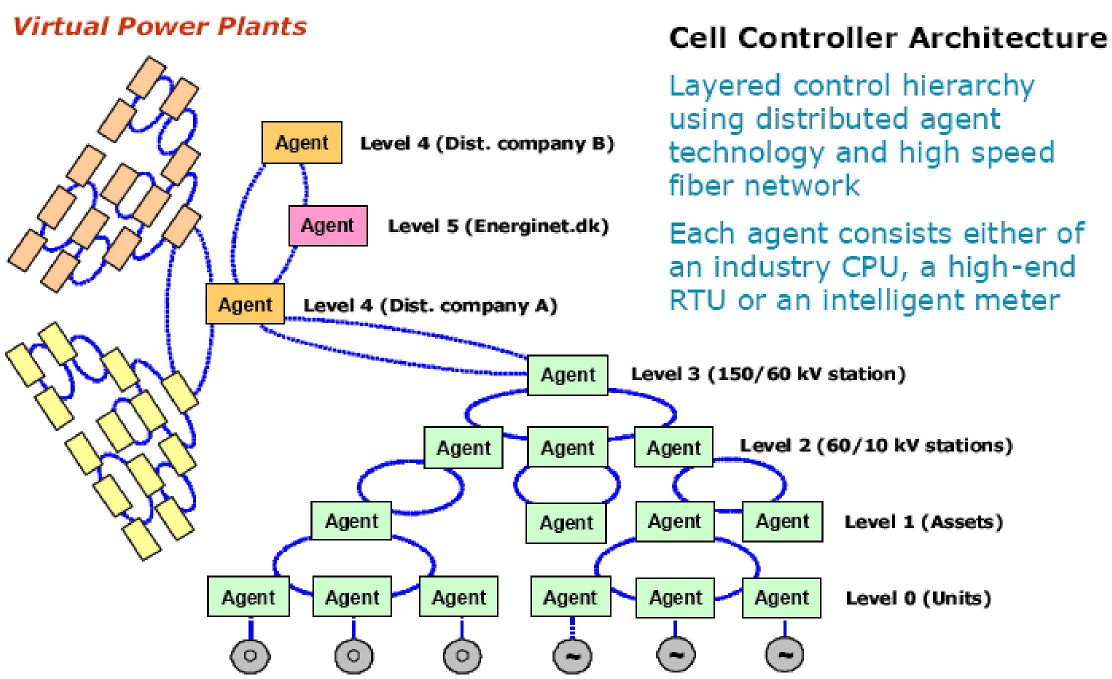

Figure 13: Diagram of Cell Controller Diagram (*Source:Cell Controller Pilot Project 2011 Public Report)*

EUR 12	Twenties (VPP work package), DE, NO, UK, IE, ES, IT, BE, DE, NL, FR
Status	In progress
Dates	2010 - 2014
Involved	DONG ENERGY, Energinet, DTU Energy, TenneT, Fraunhofer IWES, 50 HzT, SIEMENS Wind Power, ELIA, EWEA, CORESO, University Liege, University Leuven, Universite Libre Bruxells, RSE, Red Electrica De Espana, Iberdrola, ITT Comillas, Gamesa, ABB S.A., Inesc-Porto, UCD, Alstom Grid, University of Strathclyde

The TWENTIES project consortium aims to conduct large scale demonstrations (6 in total) for the purposes of showing the benefits and impacts of technologies needed to improve the pan-European transmission network, allowing Europe to integrate a higher capacity of renewables whilst keeping current reliability levels. Although much of the work is focused on the transmission level, of particular interest for this report is the Large Scale VPP Integration work package being conducted by Dong Energy. The VPP demonstration in Denmark aims to show how through distributed generation and through aggregated load units at low voltage levels, ancillary services can be provided for the purposes of flexibility and balancing intermittent renewable energy.

Domain	Aspects	Micro	Meso	Relation to action points
Technical	Systems		★ ★	2.1.1.2 - The VPP in this project aims at providing energy services to both the Nordic energy exchange, and Energinet.dk's markets for ancillary services. It was shown that from the perspective of volume contracted and competitiveness, the VPP had a high degree of competitiveness and a high socio-economic value (through the replacement of more costly thermal power units for example). One of the difficulties encountered was the complexity of the IT systems of Balance Responsible Parties (BRPs). For fast market integration it is necessary to have a means of portfolio optimization to create a value proposition for LU asset owners. Markedskraft was used as an external balance responsible party instead of DONG Energy Power. Despite the optimization capabilities being less than DONG, Markedskraft provided an easier interface with the markets, as their system ensured a one-to-one relationship between the market offer of the individual asset and the market contract of that asset. This is in contrast to DONG Energy which optimizes portfolios on an aggregated level, and separates the link been a units market offer and the activation of that unit.
	Control			

	Information		★	2.1.3.1 - The initial development of the VPP architecture was custom-made to match the functionality of the IT systems it would be interfaced with. The workflows (e.g. a workflow for converting consumption flexibility into bids for price-independent base load) were developed to comply with external systems. These external interfaces were time-consuming to integrate with due to strict IT security regulations. Highly specialized systems at Balance Responsible Parties were also difficult to integrate with. It should also be noted that the VPP was made according to agile development principles and the need for portability (to other market structures outside Denmark). Using lessons learnt from the first VPP system, the next iteration of the architecture is intended to be a much more flexible and robust solution. It is expected the future architecture will be more modular (enabling increased flexibility and updates without affecting the rest of the system). Low coupling is expected between modules with interfaces between modules being built on standardized communication protocols. This will allow easier third party module integration. In terms of scalability issues, it was seen that the Triangle Microworks SCADA Data Gateway presented a barrier for implementation as each server running the software can only accommodate 60 Local Units. The suggested solution was to implement more servers in a cluster environment.
Policy & Regulation	Tasks		★	2.2.1.1 - All units participating in the ancillary services market in Denmark are required to have an on-line measurement of current production or consumption. The DSO is responsible for providing and operating the on-line measurements. The problem that must be overcome is that only a few DSOs have standardized solutions for these measurements, which leads to longer lead times and higher costs for the VPP project. To overcome this, the project worked with the DSO (DONG Energy Distribution) to allow the VPP to act as the meter operator for on-line measurements. It would be necessary to extend such an agreement to other DSOs as well in the future. Current regulations for participating in the Danish ancillary services market require that each local unit must be tested on minimum power, linearity, response times and durability criteria. This will become impractical if more and more units participate, and also redundant if the units are aggregated together with other units. The report suggested setting up methods of verification and proof for ensuring the aggregated capacity can be offered can be delivered at all times, and also that the flexibility of non-compliant or partly-compliant local units are put to full use.

		★ ★		1.2.2.2 - Customers (owners and operators of local units, and aggregators) participating with Local Units (LU) are essential for the existence of VPPs. Based on interviews and meetings with more than 100 LU owners in approximately 10 industries, it was found that the most important value propositions for VPP offerings were: • OPEX – i.e. was participating economically beneficial? • Image – Did outside perception of the company being 'green' improve? Other value drivers included productivity, effectiveness, efficiency, quality, compliance and CAPEX. Barriers against adoption included the fact that although the VPP utilized a standardized interface and control signal concept, the control technology of the Local Unit was not standardized. Thus expensive modifications in order to integrate local units into the VPP portfolio were required in some cases (e.g. 100,000 Euros for the integration of a gas turbine). This economic barrier meant that some customers were not willing to invest such an amount given the long payback time. Another barrier to overcome was the lack of flexibility in business processes, with customer participation in VPPs being conditional on changes in operational process and staffing. Again this would cost money. It was suggested that to overcome this difficulty, and to overcome the long time needed for analyzing different processes and possibilities for integrating units, a downstream partnering approach should be used. This approach concentrates on building in-depth knowledge of specific business domains e.g. greenhouses, wind and gas turbines, cold store facilities. In doing so the optimal value proposition and business case can be put forward to the customer, and the long time needed for integrating units can be reduced. Even with such a 'best practices' method for different types of units it is likely there would still be some complications with each individual integration case. In cases where the controllable load did not represent a major share of total customer load, a new energy meter was required to be installed by the DSO. This is because the Danish TSO requires a separate plan for controllable load, and if the portfolio was relatively small – there would be increased prognosis errors (with the existing meter). For the customer this represents extra installation costs, increased annual fees and a longer implementation time. This is another barrier against fast VPP expansion.

			★ ★	2.2.2.2 - As production units involved in the VPP knew the structure of the energy market well, direct transparency between payments for services and the price at the time of service delivery was made clear to the production owners. However it was recommended that for consumption unit owners who do not know the structure of power and energy markets so well, financial predictability would be valued higher than market transparency. Hence for these customers it was decided to limit the transparency of the VPP offering, in terms of providing information about what ancillary services their Local Unit provided. Thus the VPP bought flexibility at a fixed monthly rate from the owner (the VPP project therefore took on the financial risk of not being able to create enough value). It was believed that this would allow the VPP offering to be kept as simple and clear to owners as possible (however the sales force was able to disclose details about individual LU usage to owners if required). This simple approach also allowed contracts to be closed quickly. The fixed monthly rate to pay the owner was determined based on an estimation of: • How fast consumption could be regulated; • How long consumption regulation could be maintained; • Size of the Local Unit.
	Finance			
	Policy			
Social & Other	Protocols			
	Stakeholders			
	Other			

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C.4 - Case studies Americas

AME 1	Smart Study Together, Oklahoma - USA
Status	Finished
Dates	2010 - July 2011
Involved	Oklahoma Gas & Electric (OG&E)

The Smart Study TOGETHER project investigated the potential for demand response to reduce system peak load (in order to defer investment in new generation). For this purpose different technology options and price rates were utilized and their impact on demand reduction was analyzed.

For the study, a sample group of approximately 3,100 customers (2,412 residential, 712 small commercial) was used. The four technology options tested were: (1) a programmable communicating thermostat (PCT), (2) a web portal, (3) an in-home display, or (4) a combination of all 3 technologies.

These options were combined with either the Variable Peak Pricing (VPP) rate or Time-of-Use rate (see Table 10 and Table 11), to create a total of 8 rate-technology groups. For both of these tariffs a Critical Price (CP) component was incorporated - which was issued during critical peak periods. A control group was used to eliminate effects of weather, economic conditions, fuel prices etc.

Customers were allowed to choose their own balance of cost versus comfort, and no direct control was taken of any appliances. Participation in the study was voluntary.

Domain	Aspects	Micro	Meso	Relation to action points
Technical	Systems			
	Control	★ ★		1.1.2.4 - The most effective rate/technology combination was the Variable Peak Pricing – Critical Price (VPP-CP) rate combined with the Programmable Communicating Thermostat (PCT). This option had the largest reduction in load during hot days. Also the increased resolutions for pricing (compared to TOU pricing) enabled the price to be tailored to available capacity. So for example, the low rate could be set when there is excess capacity in the system meaning customers do not need to reduce their on-peak energy consumption. Additionally, in times when capacity is low, the high/critical price level could be set leading to large load reductions. Using the PCT allows for the customer to decide upon their own cost/comfort balance and combined with the price rates, enables automated load reduction. Regardless of technology used, with an increase in temperature – energy savings during peak times was observed in almost all cases.
	Information			

Policy & Regulation	Tasks			
	Finance	★		1.2.2.1 - On a summer peak day, it was observed that the system load shape was relatively flat around the peak period (4pm) – see Figure 14. This implied that simply reducing the system load at the peak hour alone would not greatly reduce capacity requirements – and that it is necessary to reduce load at all of the hours around the peak too. It was suggested that with the current price rates that are in place, the optimum procedure on a system peak day would be to set the VPP price as High, and at 16.00 call a Critical Price event. This would lead to a more continuous load reduction across the on-peak period. For the long term, it was recommended that an additional price level should be added to the VPP price structure – a 'super-peak' price period. This would lead to the PCTs carrying out an automated response to spread savings more evenly over the on-peak period.
	Policy			
Social & Other	Protocols			
	Stakeholders	★		1.3.2.2 - It was observed that generally customers using the Programmable Communicating Thermostat showed higher load reduction than the groups using only a web portal or in-home display. Although overall load reduction through the web portal or in-home display was lower, these groups typically maintained a more constant reduction of load during peak periods than those using the PCT or all 3 technologies. The 'All 3' and PCT technologies group typically showed a large spike in load reduction at the start of peak periods, and then a reduction in savings after some time in the peak period. This could perhaps be attributed to the automated operation of the PCT, unlike the web portal or IHD which are feedback mechanisms monitored manually by users who then adjust consumption accordingly. Residential customers who participated in Phase I of the trial showed slightly higher savings for certain rate-technology groups than those in Phase II (these customers were recruited into the trial approximately a year later). A possible explanation for this was given to be that there may be some kind of learning effect where customers respond more effectively to changes in price and events, however this could also have been down to some random variation in the sample groups. The web-portal and in-home-display both showed some kind of learning effect, but not the PCT technology which perhaps did not require such a long time to use effectively to have an impact on the overall savings.
	Other			

References

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Table 10: Time-Of-Use Critical Peak Prices *(Source: OG&E Smart Study Together Final Report)*

Price Level	Residential TOU-CP Price	Commercial TOU-CP Price	Number of days in summer 2011 at each price level
Off-peak	4.2¢ per kWh	4.7¢ per kWh	36
On-Peak (weekdays)	23¢ per kWh	30¢ per kWh	86
Critical Events	46.0¢ per kWh	60.0¢ per kWh	7 (also included in the 86 weekdays)

Table 11: Variable Peak Pricing - Critical Peak Prices *(Source: OG&E Smart Study Together Final Report)*

Price Level	Residential VPP-CP Price	Commercial VPP-CP Price	Number of days in summer 2011 at each price level
Low and off-peak	4.5¢ per kWh	5.0¢ per kWh	63
Standard	11.3¢ per kWh	10.0¢ per kWh	25
High	23.0¢ per kWh	30.0¢ per kWh	28
Critical	46.0¢ per kWh	60.0¢ per kWh	6
Critical Event	46.0¢ per kWh	60.0¢ per kWh	7 (included in the above)

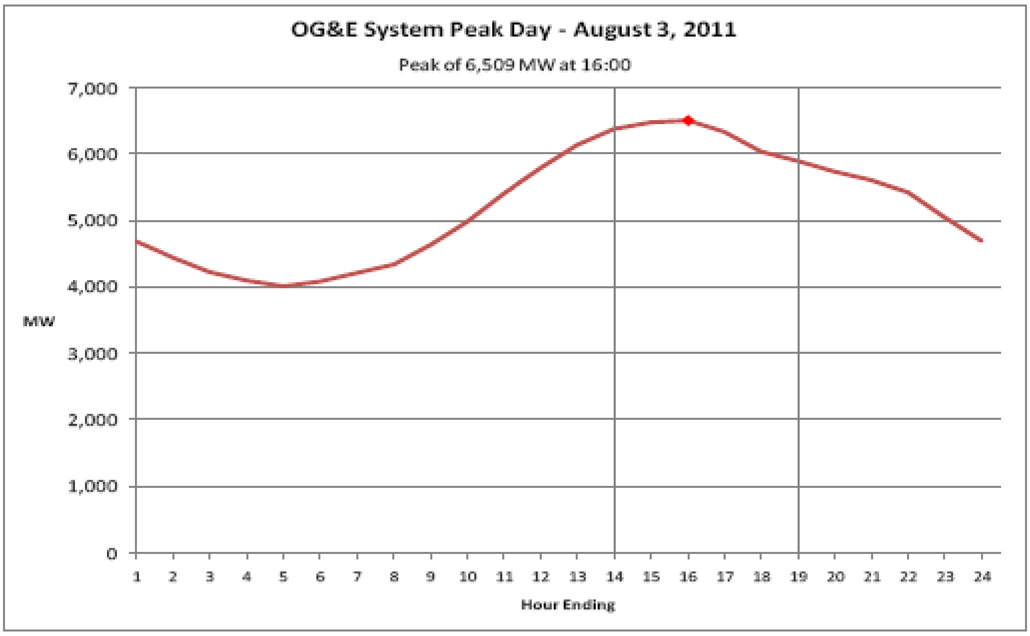

Figure 14: System load on Summer Peak Day *(Source: OG&E Smart Study Together Final Report)*

AME 2	Customer Application Program Pilot, Illinois - USA
Status	Finished
Dates	2010 - 2011
Involved	Commonwealth Edison

The Commonwealth Edison Customer Application Program (CAP) investigated the way in which AMI-enabled price structures and technology could alter energy consumption. Approximately 8,000 customers were randomly selected to participate in the trial (out of a possible 130,000) with an option to opt-out if the customer wished. Participants were randomly categorized into different treatment groups involving different combinations of dynamic price rates, and enabling technologies. A control group which remained on their existing standard (flat) rate was also used.

The five price treatment rates were as follows:

- Day-Ahead Real-Time Pricing (DA-RTP) whereby a day-ahead hourly price schedule was issued each day on an hourly basis;
- Critical-Peak Pricing (CPP) of an extra $1.74/kWh – which was added additional to the DA-RTP price, depending on the occurrence of 'events';
- Peak-time rebate (PTR) of $1.74/kWh – where a customer was paid this amount for reducing load during an event;
- Time-of-use (TOU) schedule – where prices differed between peak and off-peak demand periods on weekdays;
- Inclining Block Rate (IBR) – where prices increased in a stepwise fashion as consumption increased.

The technology utilized in certain treatment groups was typically an in-home display or a programmable thermostat. Participants were also able to sign up voluntarily to an online service which provided detailed information about their billing data. A full year's worth of data on electricity usage and prices, and data collected as part of a participant survey was used to test hypotheses and come up with conclusions.

Domain	Aspects	Micro	Meso	Relation to action points
Technical	Systems			
	Control			
	Information			
Policy & Regulation	Tasks			
	Finance			
	Policy			
Social & Other	Protocols			
	Stakeholders	★ ★		1.3.2.2 - Generally it was seen that none of the treatment groups showed any significant change in average customer energy usage, even when they had to pay an additional $1.74/kWh for electricity (this is quite high when compared to a more typical price of around $0.11/kWh). Across the whole year, there was no group which showed major differences in energy usage compared to the control group.

However a subset of approximately 10% of dynamic-rate customers (DA-RTP, CPP and PTR) responded to elevated event-day prices by reducing their usage. The most consistent responses were seen of CPP customers. During event-periods, 11.6% of CPP participants reduced their load by an average of 21.8% - which amounted to 2.2% of the usage of all enrolled CPP participants. An average load reduction of 14% was seen by the ‘event-responders’ in the PTR and DA-RTP categories.

Interestingly, even the customers using price rates which were not affected by events (IBR, TOU and flat rate) showed a small reduction in energy consumption (5.6% for IBR). This leads to the suggestion that the actual notification of an event itself could be a cause of demand response of consumers. This hypothesis that event notification could be used to play a role in demand management was deemed to require further investigation as the findings were not seen in all treatments.

It was also suggested that the energy reduction seen in customers who had no financial advantage of doing so, could have resulted as a consequence of ComEd’s educating CAP participants about the supply costs on certain days of the year.

Overall the project results did not exhibit the same kind of savings usually associated with dynamic pricing regimes seen in other pilots. The reasoning behind this was the large sample of customers in treatment groups who showed no response to price changes. The explanation behind this was put down to the fact that the CAP pilot utilized an opt-out enrolment method, whereby customers were included without their prior consent. Although it was hypothesized that an opt-out design would increase the percentage of price-responsive customers, this was not the case.

		★		1.3.2.6 - 2,423 responses were received by ComEd for a survey regarding various elements of the program. The customer satisfaction level for the IBR and DA-RTP plan were ranked the highest, with an average score of 5.9 out of 10. The flat rate received the lowest score of 5.1. This does not appear to be a statistically significant difference. Perhaps, the lowest score of 5.1 indicates that simple rates do not necessarily lead to good customer satisfaction. The survey also tested the understanding of the customers on their particular rate types. In general responses demonstrated a good level of understanding of the features of the customers own personal rate. However it was seen that only 43% of customers who were able to earn a rebate through reducing usage were aware of this feature in their rate plan. 21% of non-PTR customers thought they were able to earn a rebate on certain times, which was not the case.
	Other			

References

- Phase 1 Report: http://www.sgiclearinghouse.org/LessonsLearned?q=node/3273&lb=1
- Phase 2 Report: http://www.sgiclearinghouse.org/Technologies?q=node/4816&lb=1

AME 3	Fort Collins Renewables and Distributed Systems Integration Project, Colorado
Status	Finished
Dates	2009 - 2012
Involved	Fort Collins Utilities (Project Management, Technology and R&D) Site Partners: City of Fort Collins Operation Services, CSU Department of Facilities Management, Larimer County Facilities Department and New Belgium Brewing Company. R&D/Technology partners: CSU EECL and InterGrid Laboratory, CSU Engineering Department, Brengle Group Inc., Spirae Inc., Woodward Inc., Advanced Energy Industries Inc. and Eaton Corporation.

The Ft. Collins project was undertaken in response to a Department of Energy funding opportunity announcement by a diverse group of local government, higher education and business organizations.

The primary objective of the project was to develop and demonstrate a way of reducing the peak load on 2 distribution feeders by 20%, through the coordinated use of Distributed Energy Resources (DER). The DER consisted of generation such as PV, steam turbine generators, biogas gensets and diesel gensets. Options for load shedding including Heating, Ventilation and Air Conditioning (HVAC), thermal storage and a small percentage from Plug-in Hybrid Electric Vehicles (PHEV).

Nine months of load data was collected to provide a baseline for calculating peak load (14.35MW on the 2 feeders) prior to the demonstration phase. Approximately 5MW of DER was established to provide the 20% reduction envisaged (although 3MW was required, extra resources were included to provide buffer capacity). Ultimately the peak load reduction during the testing phase reached a high of 14.2%.

The infrastructure deployment and asset integration established in this project serves as a jump start for the FortZED project which aims to create the largest active net zero energy district in the world, offsetting energy from a 50MW peak demand. It also advanced the City of Fort Collins' local renewable and energy conservation efforts through the development of a Smart Grid-enabled distribution system.

Domain	Aspects	Micro	Meso	Relation to action points
Technical	Systems		★	2.1.1.1 - A custom control algorithm was written for the purposes of the 'Peak Load Management' software used in this project. This operated in conjunction with the Bluefin enterprise backend server and utilized the Bluefin platform to observe the total load on the feeders. If the load on the feeders exceeded a pre-assigned set point, then a calculation would be made as to how much load needed to be offset to bring the system below the set point. The software used a prioritization scheme which called upon DER-assets based on their availability, emission characteristics, and also on the basis of fairly distributing operation of assets (i.e. the same asset would not be chosen first every day).

			★	2.1.1.2 - In some cases, groups of load shedding assets were grouped together in order to act as a single asset to the BlueFin platform. This is because whilst an individual load asset such as a fan cannot contribute to extended peak reduction contributions, an aggregation of them could be put together and their utilization could be rotated within the group, allowing for this group of assets to be used in operation for a longer period of time. One of the big advantages of these load shedding assets (apart from the obvious avoidance in grid power consumption) was that they were cheaper to install and integrate than the generation assets, and had faster response characteristics.
			★ ★	2.1.1.4 - Overall the project successfully demonstrated a way of reducing feeder peak load through coordinated control of DER, although the intention to achieve a 20% reduction on both project feeders was not met (the highest reduction achieved was 14.2%). This was put down to two reasons. Firstly, the total feeder demand was higher than expected demand. Secondly, the available DER capacity was around 35% less than expected. Regarding the first reason, the peak demand values from 2010 were assumed to hold true for 2011. However in 2011 peak demand reached 17MW (peak demand in 2010 was 15MW). This meant that the amount of available DER that had been assigned to reduce feeder load by 20% was not enough at certain times. To worsen this issue, the total available generation capacity turned out to be 1.8MW less than anticipated due to partners and assets dropping out before project commencement. Additionally some generator sets delivered less power than their nameplate rating. Asset response rate was also particularly problematic. Overall on average the generation units in the project had a response rate of around 95%, whilst load shedding units had a response rate of approximately 79%. The main reasons for unresponsiveness were put down to communication failures, especially IT firewall issues with regards to the load shedding unit partner sites. The limited feedback capabilities of the load shedding assets also meant sometimes it was difficult to determine whether the unit should actually be classed as unresponsive or not. For example if a request was made to a HVAC compressor to shed load, even if the compressor was not running (and hence had no load to shed), the asset would be listed as unresponsive. Thus better feedback capabilities would have allowed the overall responsiveness rate to be higher. In order to achieve the feeder peak load reductions, the duration of availability and the capacity for reduction were the most crucial

				characteristics in a participating DER resource. A large capacity helped minimize the installed cost per kW and simplified management of the asset. A long duration of availability was also important because there was not always a distinct peaking period of the load curve of the feeder, meaning to achieve a 20% reduction could potentially require 8 hours of continuous operation. In the project although target reductions could be achieved for short periods of time, they were not always sustainable for the entire peak period. It was seen that for this purpose, conventional generator assets were the most useful. The lesson learned here is that when utilizing DER involving multiple asset owners, it is vital that the operating constraints of the owner and their resource are understood. Constraints for generation assets could include: air permission permits limiting hours of operation, noise impacts on surrounding area, increased maintenance costs, overheating during extended operation etc. For load assets typical constraints include: duration of operation that can be maintained, amount of capacity that can be reduced during certain points in the day and maintaining indoor air quality and building occupant satisfaction.
	Control			

	Information		★ ★	2.1.3.1 - In order to coordinate the DER in this project, the 'Bluefin platform' was developed by one of the project partners which acted as a Network Operating System for the DER. This privately-owned operating platform allowed the necessary communication and control infrastructure to interface with existing Building Automation Systems (BAS) and SCADA systems already being used by the utility and site partners. Each site partner was equipped with a Gateway (Bluefin embedded) PC that acted as a communication and control portal to the existing management infrastructure. The Bluefin platform was implemented in such a way that each of the participating partner sites retained ultimate control of their DER asset. The partners were able to set the availability of their assets so as to decide whether to take part in any peak reduction events that could occur in a given day. In this project, introducing a communications method which was separate from that of the utility and of the site partners systems added an extra layer of complexity. One of the lessons learned through the implementation of the IT systems in this project was that the long term objectives of an interfacing and communication system should be aligned with aim of the project and that this should be clearly defined and communicated to all participants. For example, interfacing specifications are critical to effective operation of the overall system and must be clearly understood by all participants. Additionally, it is important that DER-site partners have confidence in the demonstrated capability of the control software. This is because they likely have other operational responsibilities, and want to have a seamless integration with this software without any disruption to normal operations. For this it was recommended that a prototype of the control software is made available for partner review in early stages in order to identify any potential problems which need to be rectified for successful integration.
Policy & Regulation	Tasks			
	Finance			
	Policy			

Social & Other	Protocols		★	2.3.1.1 - The work carried out in this project, provides a platform for which the FortZED initiative can proceed in creating a zero energy district through conservation, efficiency, renewable sources and smart technologies. Such a project will require harmonizing the different expectations, assumptions and goals of all parties involved. During the Fort Collins project, conflicting requirements of partners was a key challenge to be overcome. It was seen that it was difficult to maintain integrated organizational engagement of the partners, as most partners were not capable of managing both the 'on-the-ground' operational impacts of the work as well as the more strategic, broader study aspects of the project. It was recommended that a clearer definition and understanding of the full scope of work needed in this project would have enabled the partners to adopt their processes in order to reduce implementation challenges.
		★		1.3.2.6 - The use of diesel-fuelled generation in the DER mix of this project led to some skepticism and negative reactions from the public. It was recommended in many cases public outreach and education would be key to projects like Fort Collins that needs to be supported locally.
	Stakeholders			
	Other			

References

- Final Report (draft) - contact Dennis Sumner - Dsumner@fcgov.com
- http://www.smartgrid.epri.com/doc/Ft%20%20Collins%20RDSI%20Final.pdf

<table>
<tr><th>AME 4</th><th colspan="4">2012 State of the Consumer Report, USA</th></tr>
<tr><td>Status</td><td colspan="4">Finished</td></tr>
<tr><td>Dates</td><td colspan="4">2011 – 2012</td></tr>
<tr><td>Involved</td><td colspan="4">Smart Grid Consumer Collaborative (represents over 70 commercial, utility and advocacy organizations)</td></tr>
<tr><td colspan="5">The ‘2012 State of the Consumer Report’ consolidates findings from three studies conducted by the Smart Grid Consumer Collaborative. These research studies are as follows:
1) Consumer Pulse Tracking Study – a nationally representative telephone survey (of 1200 consumers) was carried out to establish how aware consumers were of smart grids, and their interest and support in them. The survey also aimed to identify what benefits consumers wanted from smart grids. The study was conducted in 2 phases – one in September and one in November, allowing any changes in metrics over time to be observed as utilities changed their business models to be more consumer-focused.
2) Consumer Segmentation Study – As part of the Pulse Tracking study, a segmentation analysis of consumers was performed using the data collected.
3) Excellence in Consumer Engagement Study - A qualitative analysis of real-world customer engagement strategies of 21 organizations (20 U.S. utilities and 1 non-profit organization) was performed to determine drivers of smart grid awareness, understanding, acceptance and behavioral change. Over 40 interviews with key individuals in these engagement strategies were conducted, and resulted in a set of best practices for successful consumer engagement with regards to electric utilities.</td></tr>
<tr><th>Domain</th><th>Aspects</th><th>Micro</th><th>Meso</th><th>Relation to action points</th></tr>
<tr><td rowspan="3">Technical</td><td>Systems</td><td></td><td></td><td></td></tr>
<tr><td>Control</td><td></td><td></td><td></td></tr>
<tr><td>Information</td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Policy & Regulation</td><td>Tasks</td><td></td><td></td><td></td></tr>
<tr><td>Finance</td><td>★
★</td><td></td><td>1.2.2.2 - The Excellence in Customer Engagement study observed that only a few utilities segmented their customer base when it came to messaging information about their smart grid programs. Of those that did, segmentation occurred predominantly on aspects such as the square footage of the home, credit history and average monthly bill amount. It was recommended that taking into account factors such as customer attitudes, values, behaviors, motivations, technology adoption and communication preferences would yield better results.

The segmentation study of residential US customers performed led to 5 distinct segments emerging: Concerned Greens (31%), Young America (23%), Easy Street (20%), DIY & Save (16%) and Traditionals (11%).
• Concerned Greens – are concerned and active regarding environmental issues and are knowledgeable and in support of smart grids. They are likely to be early adopters and typically like new technology. This is the most likely segment to participate in energy efficiency and smart grid programs.</td></tr>
</table>

				• Young America – is a segment concerned about environmental issues, and think energy efficiency is important but has a low likelihood in participating in smart grid programs (although they are interested in using information from a smart meter for energy management purposes). Educating this segment about smart grid products and programs should be considered as the primary purpose of communication. This can be considered as a long term development opportunity, as they are likely to become homeowners later on. • Easy Street – have the highest income of any segment, but are unlikely to exhibit interest in energy management or change in behavior. Simplicity and ease-of-use are important to acceptance. Additionally communication should emphasize environmental benefits and stewardship for future generations. • DIY & Save – this segment wants to save energy, largely due to the money-saving benefits. There is a low level of interest in environmental benefits. Smart grid program communication should emphasize saving money and opportunities to leverage DIY interest and experience (84% of homeowners like 'to do it themselves' to save money). • Traditionals – are predominantly an older segment of the population and are the least favorable towards smart grid programs, and have a low interest in environmental or energy management issues. This segment is not likely to be a high priority for initial smart grid programs. Any messaging is recommended to focus on privacy issues and smart meter accuracy to offset any concerns with the technology.
	Policy			

Social & Other	Protocols			
	Stakeholders	★ ★		1.3.2.2 - It was recommended that providing detailed feedback and consumption information would encourage behavioral change of consumers. Behavioral triggers included energy savings competitions, home energy reports and comparative energy reports. Examples included Duke Energy providing such comparative energy reports leading to 84% of participants changing thermostat settings and 51% pursuing other energy-saving measures. Wright-Hennepin with The Climate & Energy Project used competitions to get consumers to reduce energy usage – and this led to participants reducing consumption by up to 58%. Another lesson learned was that free and timely access to energy usage data improves participation in smart grid programs. Access should be through channels which are easy for engagement e.g. an in-home device, or a website. It was seen that if an in-home device was provided free, then this would be preferred to a website (59% in favor of the in-home device). However if the device costs 100 USD then this preference would drop to 33%. Customers should be given a choice in how they receive their usage information also. Research revealed that the majority of smart meter owners preferred receiving energy management information through mail (with email and bill inserts also being a preferred channel of communication). For day-to-day communication about electricity usage - email, automated phone calls and online websites were preferred channels.
		★		1.3.2.3 - Providing incentives and behavioral triggers were recommended as an effective method of getting consumers to be more engaged in smart meter/grid programs. Several utilities suggested the use of time-sensitive offers to get customers to sign up to programs. Examples included Conexus offering 10 USD gift cards for a limited time to promote its Direct Load Control Program. A raffle of 1,000 in-home displays in low-income households was conducted by Reliant to engage consumers.
		★ ★		1.3.2.5 - The consumer pulse tracking study showed that only approximately 30% of consumers had a basic or complete idea of what smart meters or smart grids were (see Figure 15). When asked about what improvements or problems smart meters and smart grids would bring, again approximately 30% answered ''Don't know' or 'Need more information/education' (see Figure 16 and Figure 17). To increase awareness it was recommended that education regarding smart grids and meters should begin before any deployment occurs. A staged messaging strategy was recommended as a best practice based on findings from interviews. 60-90 days before installation local leaders, politicians and media should be used to build awareness, in combination with

				educational forums and community events. Approximately 7-21 days before installation, direct mail notices and automated calls can be used to notify customers. Through providing the appropriate information at the appropriate time, customer expectations can be effectively managed. Other examples of using education to improve customer service included creating an 'employee ambassador' (carried out by CenterPoint) to act as Smart Grid advocates within the community. A specialist customer service team was appointed by San Diego Gas & Electric to resolve complaints one-on-one. Community-based organizations which already have good relationships with customers could be partnered with to educate the community about smart grids and meters – especially as they may be better equipped at educating hard to reach consumer segments. Portland General Electric created such partnerships to reach out to non-English speakers, low-income customers and multi-dwelling building residents. Another recommendation was that relevant benefits should be communicated using simple language (as opposed to something too technical). Emphasis should be placed on how the smart meter-enabled programs satisfy consumer needs. A best practice example provided was that of SCE who broke down their smart grids/meters message into 1) a two-second tagline, 2) a brief 'elevator pitch' and 3) a detailed fact sheet. This led to 50,000 customers signing up to their program in the first 6 months. Existing points of contact with customers can also be used to promote smart grids. For example when customers call a utility regarding high bills, customer service can use this as an opportunity for program enrolment. APS and SRP utilized such a technique and this resulted in program participation rates of 50% and 22%, respectively.

		★ ★		1.3.2.6 - A key finding was that smart grid and smart meter awareness increases favorability. Consumers who have basic or full knowledge of smart meters were more likely to have higher support. Lower support was seen to be a function of lower awareness. Using a favorability index metric was suggested as a way to see how support amongst consumers was growing or lowering. To increase public support, the wide range of benefits enabled by smart grids and meters should be promoted. The two key reasons provided by consumers (without using any external sources of information to remind them of any benefits) for implementation of smart technology was 'Saving money' and 'Saving energy'. Additionally when asked which messages (from a list) increased smart grid and meter support, messages promoting higher reliability, faster power restoration and avoiding energy waste were seen to be effective as messages which promoted money savings (80% agreed these messages would slightly or strongly increase support) – see Figure 18. Further research was carried out whereby consumers were asked to rate some statements regarding benefits of smart grids and meters, based on whether they would be willing to pay an extra 3-4 USD/month (see Figure 19). Although many statements were seen to be important, generally they did not provide enough incentive for paying more. The most important statements were seen to be eliminating the need for meter readings and also delivering higher power quality. However the willingness to pay extra for this was low. This led to the conclusion that it is not essential to focus only on the 'saving money' benefit of smart grids, but in fact it is better to intertwine many benefits together to increase user acceptance. The statement which had the highest willingness to pay more for was 'reducing greenhouse gas emissions by making it easier to connect RES to the electricity grid'. It was suggested that whilst such a statement may be appealing overall, it may be more important for certain specific consumer segments (see action item 1.2.2.2).
	Other			

References

- http://smartgridcc.org/sgccs-2012-state-of-the-consumer-report
- http://smartgridcc.org/research/sgcc-research

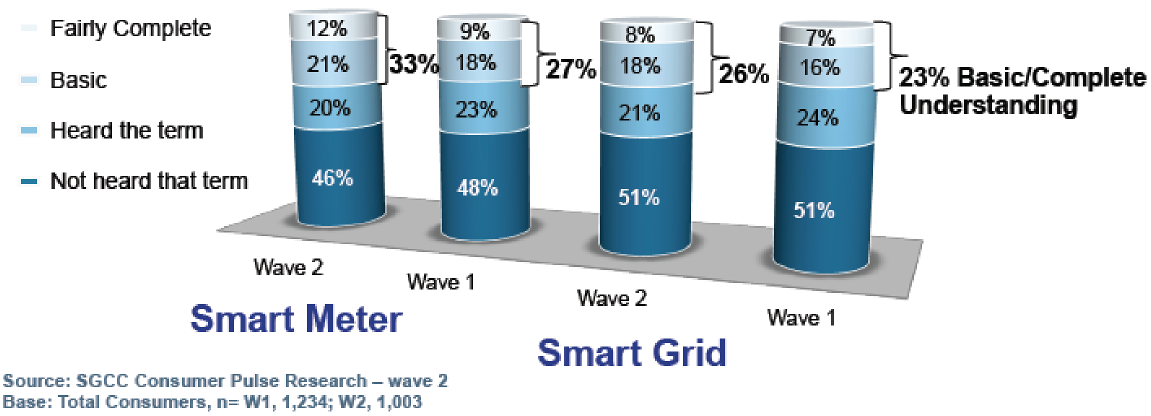

Figure 15: Current level of consumer Smart Grid and Smart Meter awareness *(Source: State of Consumer Report 2012)*

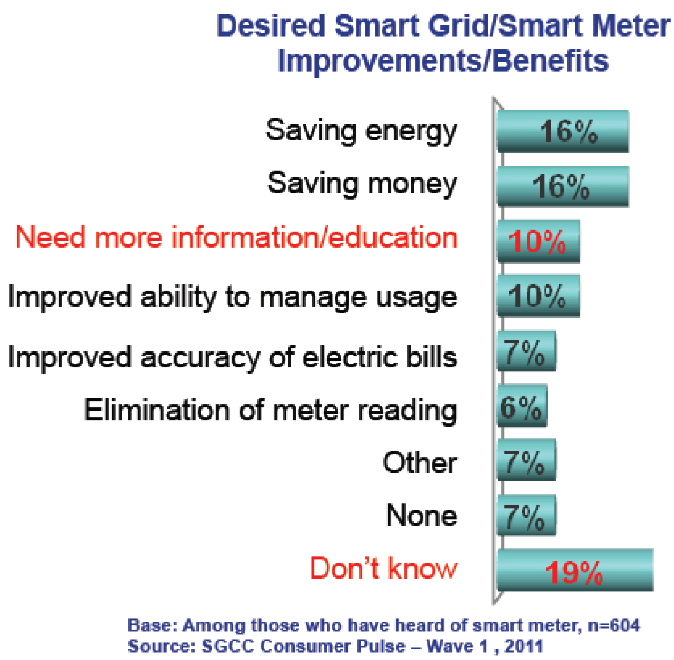

Figure 16: Desired Smart Grid/Smart Meter Improvements/Benefits *(Source: State of Consumer Report 2012)*

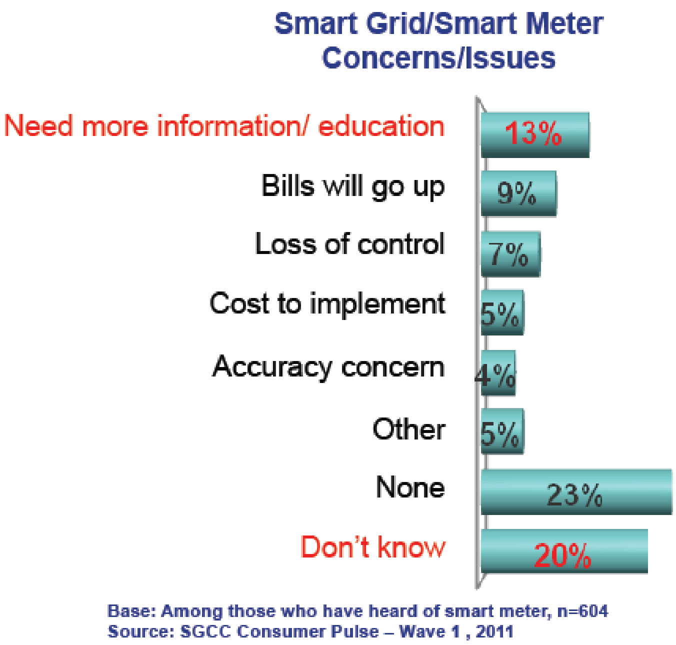

Figure 17: Desired Smart Grid/Smart Meter Improvements/Benefits *(Source: State of Consumer Report 2012)*

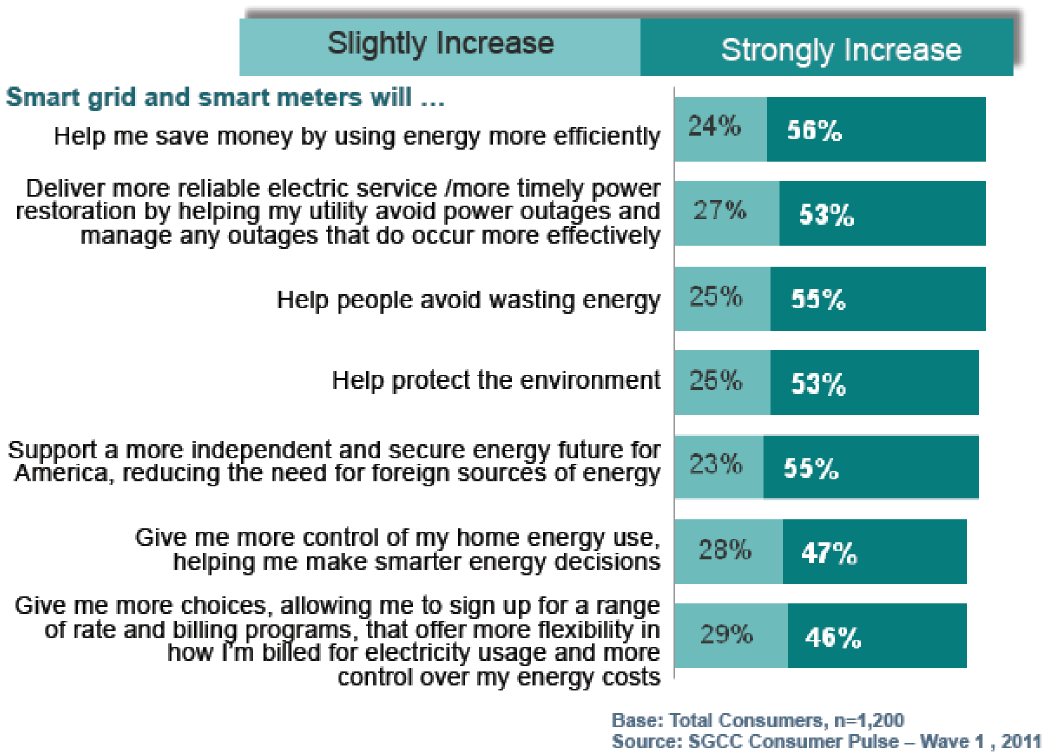

Figure 18: Messaging for Smart Grid and Smart Meter Support *(Source: State of Consumer Report 2012)*

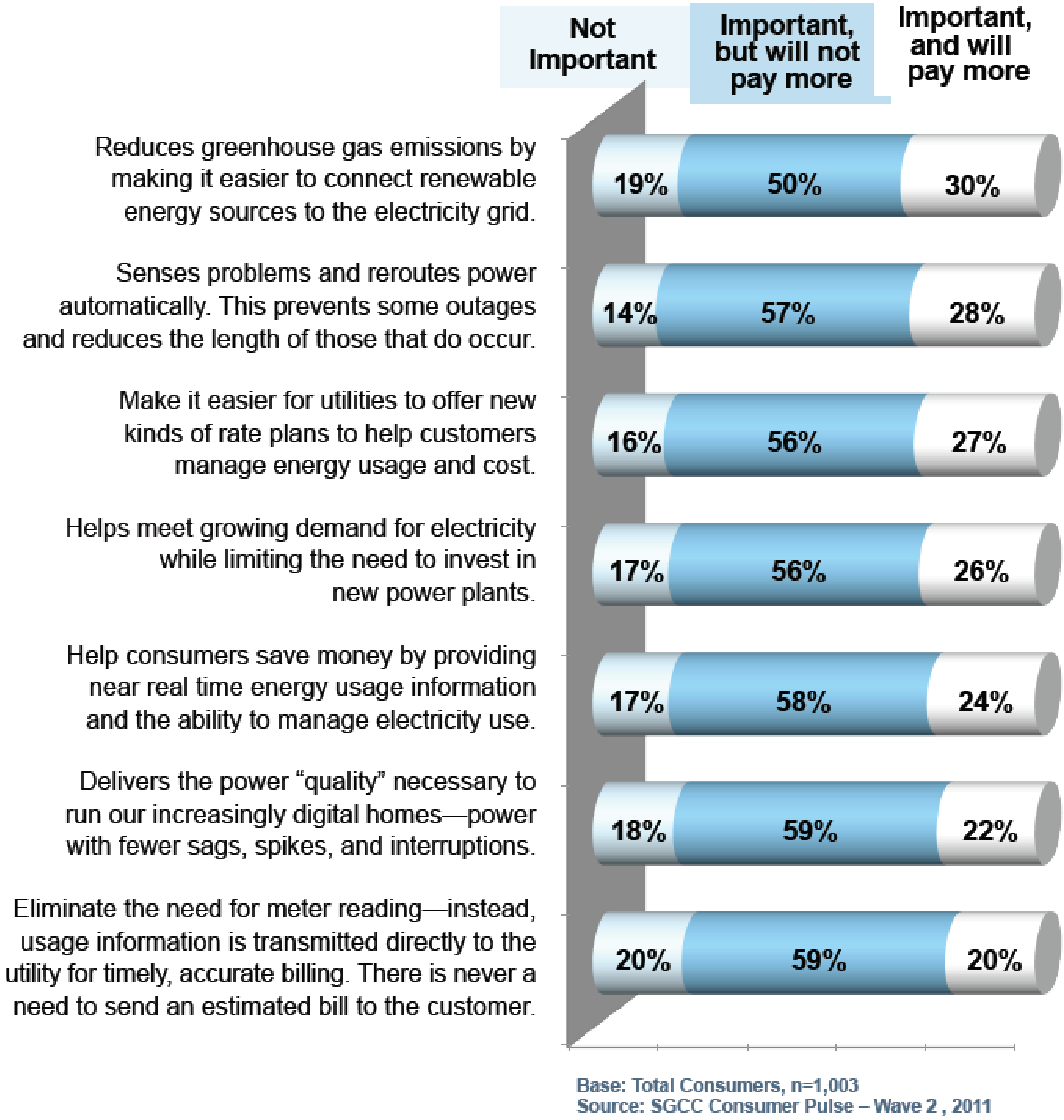

Figure 19: Smart Grid/Smart Meter Benefits *(Source: State of Consumer Report 2012)*

AME 5	PowerCentsDC Program, District of Columbia, USA
Status	Finished
Dates	2007-2010
Involved	Smart Meter Pilot Program, Inc. (SMPPI), Pepco

The PowerCentsDC Program investigated the impacts of introducing smart meters, smart pricing and smart thermostats on consumers. 900 residential customers in the District of Columbia volunteered to take part, and were assigned to one of the following three pricing plans (see Table 12):

- Critical Peak Pricing (CPP) – whereby a higher price (approx. 0.75 USD) is applied during critical peak hours. Typical price of electricity is 11¢;
- Critical Peak Rebate (CPR) – where a rebate (approx. 0.75 USD) can be gained through reducing consumption during critical peak times. Typical price of electricity is 0.11 USD;
- Hourly Pricing (HP) – prices follow wholesale prices.

Participants were billed at these price tariffs from July 2008 to October 2009. Limited-income consumers were also targeted to be recruited in this study to observe their reaction to dynamic pricing. Smart meters which measured power usage on an hourly basis were installed in all participating homes, and a smart thermostat was also offered to homes with central air conditioning. 400 meters were installed on randomly selected non-participants to provide a control group for the study. Only results with a confidence level of greater than 90% were included as key findings.

Domain	Aspects	Micro	Meso	Relation to action points
Technical	Systems			
	Control			
	Information			

	Tasks			
Policy & Regulation	Finance	★★		1.2.2.1 - It was seen that consumers demand at peak periods was consistently reduced when a price signal was provided. Those on the CPP plan showed a reduction of 34% in Summer and 13% in Winter. For CPR the figures were 13% in Summer and 5% in Winter. HP customers showed a much lower reduction of 4% in Summer and 2% in Winter. The likely reason for this was because the high prices for HP were not as expensive as the high prices of CPP and CPR. Additionally due to the 2008 economic downturn, HP customers had a declining average electricity price over time. It was also observed that customers on a low-income (who were only allowed to participate in the CPR plan) showed similar peak demand reduction when compared to 'regular income customers' on the CPR plan (13% and 11% respectively). The effect of temperature increasing (from 85°F to 97°F), led to an increase in peak demand reduction. CPP consumers reduced demand from 26% to 43%, and CPR consumers from 8% to 20%. HP consumers showed no demand reduction. The pricing structure used in the project was designed to be revenue neutral – meaning that, on average, customers who did not alter their energy usage behavior would pay the same as they would have done under the old tariff. In other words, any bill savings should be as a result of load shifting. It was seen that on average, percentage bill savings of the CPP group was 2%, and the CPR group was 5%. Interestingly the savings of the HP group was 39%. This was due to the wholesale price decreasing during the 2008 recession (HP participants took the risk of paying the hourly pricing set in wholesale markets). See Table 13.

				1.2.2.2 - A focus group was conducted to observe consumer preferences before they were recruited on to the program. It was seen that the most popular price tariff was the CPR option due to its simplicity and no-risk aspects. After the collection of all billing data from the project had been completed, participants were surveyed about the program. Overall 93% of participants preferred the pricing regime in PowerCentsDC as opposed to the default Standard Offer Service pricing normally offered by Pepco. The main motivations of consumers for participating was put down to be saving money (73%), reducing emissions (34%), exploring Smart Grids (33%) and assisting policymakers (32%). The main actions consumers undertook to reduce demand in peak periods was avoiding the use of certain appliances (60%) and reducing the use of air conditioning (59%).
	Policy			
Social & Other	Protocols			
	Stakeholders	★		1.3.2.2 - With regards to the specific type of information consumers were interested in being knowledgeable about – 81% of consumers surveyed showed interest in wanting to know more about 'Energy usage by appliance'. Only 56% of consumers wished to know about hourly usage. Between 70-76% had interest in receiving data about daily cost, daily usage, energy comparisons, weekly emails and energy alerts.
		★		1.3.2.3 - A payment of 100 USD was offered to CPP and HP participants who agreed to enroll in the program. This incentive was not considered to influence any savings or losses based of the pricing regimes. The payment was a fixed externality and participants were just as motivated to reduce peak demand after receiving the payment as they would have been if they had not received it. The average response rate was 6.6%, with 900 residential customers taking part.
		★		1.3.2.5 - Based on a survey of program participants, it was seen that 52% of consumers preferred receiving information (about energy usage, cost and emissions information) with their bill. 20% preferred receiving information in the form of mailed reports, 14% preferred emails and the last 14% preferred visiting the utility website.
	Other			

References

- http://www.powercentsdc.org/ESC%2010-09-08%20PCDC%20Final%20Report%20-%20FINAL.pdf
- http://www.powercentsdc.org/ESC%2009-11-02%20PCDC%20Interim%20Report%20FINAL.pdf
- http://www.powercentsdc.org/

Table 12: Description of price plans *(Source: PowerCentsDC Program Final Report 2010)*

Price Plan	Description	Example Prices per kWh	High Price/Rebate Event Hours
CPP	Slight discount during 8700 hours per year; much higher price during critical peaks (60 hours per year)	Critical peak: about 75¢; most times: 10.9¢	2 pm-6 pm summer weekdays (12 events per summer); 6 am-8 am and 6 pm-8 pm winter weekdays (3 events per winter)
CPR	Rebates earned for reduction below baseline during critical peaks	Rebate: about -75¢; most times: 11¢	Same as for CPP
HP	Prices change hourly, following wholesale prices	Range from 1¢ to 37¢	High prices typically occur on summer weekday afternoons and winter mornings/evenings

Table 13: Savings overview of participants (*Source: PowerCentsDC Program Final Report 2010)*

Price Group	Average Bill SOS	Average Bill PowerCentsDC	Dollar Savings	Percent Savings
CPP	$101.26	$99.70	$1.56	2%
CPR	$99.66	$95.07	$4.59	5%
HP	$110.44	$77.42	$43.02	39%

AME 6	SmartGridCity, Colorado - USA
Status	Finished
Dates	2008 - 2011
Involved	Xcel Energy and the following partners: Accenture, Current Group, GridPoint Inc., OSIsoft, Schweitzer Engineering Laboratories, SmartSynch Inc. and Ventyx.

The SmartGridCity project was designed with the intention of knowing the best way to modernize the existing electricity grid. The demonstration tested various capabilities in order to know which investments were feasible and how they helped in aspects such as reliability, sustainability, efficiency etc. Customers residing within the SmartGridCity were also expected to see the benefits of this project through increased service options, service level improvements, rate options and energy use reductions.

The costs of the SmartGridCity project were mostly expected to be covered by the partners involved, however these were higher than expected (the total cost of this over-budget project is now over $100 million). Since then Boulder city officials have been in dispute with Xcel Energy on the premise that the project has not delivered the value to consumers (e.g. not enough control over home power use). Xcel is currently in the process of trying to recoup losses.

Whilst the project provides useful lessons learned, the SmartGridCity project itself is an interesting example of a Smart Grid project which has not gone to plan. Although the bulk of the Smart Grid infrastructure has now been built, it has not yet been fully paid due to not meeting an apparent standard of consumer engagement. The final ruling on this remains to be decided.

Domain	Aspects	Micro	Meso	Relation to action points

Technical	Systems		★ ★	2.1.1.4 - Within the SmartGridCity integrated Volt/VAr control was carried out on 2 feeders. 10-12 sensors per feeder were used and these were located at strategic points where customer voltage was expected to vary most from feeder voltage. The voltage was regulated up or down automatically in real-time based on voltage measurements through the system. It was seen that the benefits of peak capacity reductions through voltage reductions on feeders was high – a 5% reduction in voltage during critical peak periods was estimated to provide a prospective benefit of $14m in deferred generation capacity if deployed on 40% of the substations in the region. Benefits were also seen in energy consumption levels, which dropped 2.7% (207 kWh per residential customer annually) on average if the average voltage was reduced from 121V to 116V on the feeder. A CO_2 emissions reduction of approximately 3.1% was also estimated for each of the feeders through T&D loss reduction. The impact of distributed automation on reliability benefits is high. Eight sectionalizing devices have been installed on four feeders to create two loops that are currently active. It is estimated that a reduction of 28,125 customer minutes outage per year per feeder will occur in the SmartGridCity environment. It was seen that data accuracy was essential to the functionality of the system. Alerts to the Distribution Control Centre were recommended as it would allow the staff member to determine whether the lack of response from an asset was down to hardware, software or communication problems. It was also concluded that deployment of Distributed Automation would create more value per dollar if invested in less accessible areas or geographies with low reliability. Line loss optimization through remote switching was also investigated. The capability to switch loads remotely required expensive remote operation switches. It was concluded that the investments in the large number of switches did not justify the fuel savings made (2,700 USD per feeder), although the value proposition could be re-evaluated in the event of switching equipment technology developments.
	Control			
	Information		★	2.1.3.2 - As the network is designed for peak load and capacity requirements (per current requirements) the use of Distributed Energy Resources and Plug-in Hybrid Electric Vehicles (PHEV) storage offers no capacity deferral as intermittency leads to unreliable power generation during times of peak load. However it was concluded that the situation may change if there is an increase in PV solar and distributed storage. Another danger seen was that the Distributed Generation could 'mask' true system demands, and at high DG penetration levels decisions of the Distribution Control Centre would be further complicated. This could affect reliability levels.

Policy & Regulation	Tasks			
	Finance		★ ★	2.2.2.1 - Capital deferment through integrating Volt/VAr control on two feeders was investigated through the coordinated control of distributed capacitor banks. It was found that the capital benefits of VAr reduction are likely, but the value is low. A deferral in investment of up to 2 years can be achieved in ideal feeder-specific situations, typically where there is low load growth. Demand response at the customer level was primarily carried out through the control of air conditioning loads during hot days (communication was only one-directional). At high customer penetration rates, 32.75 USD per DR participant was calculated to be the expected saving. Although generation capacity deferral benefits were seen to be likely, implications for distribution capacity expansion were uncertain (a DR penetration of over 1MW per feeder was the value suggested to realistically defer distribution expansion). Pilot pricing programs evaluating behavior in response to various tariffs showed that customer adoption rates would need to be high and/or the behavioral change significant for the implementation to be cost-effective. However a cost reduction of 33.62 USD in generation, transmission and distribution capacity is expected if high adoption rates occur.
	Policy			
Social & Other	Protocols			
	Stakeholders	★ ★		1.3.2.2 - In the SmartGridCity, customers were able to view their 15-minute interval via a website (with a one-day delay). The value of this is questionable if such a delay occurs. An online green energy community was also added as a tool to support customers in sharing best practices and providing advice to each other. However, a customer survey showed that only 17% would currently utilize this online energy community service. With regards to reduction in energy use through this data access –benefits were plausible. It was seen that customers responded better when metrics which they could comprehend were used e.g. using 'miles driven per year' instead of 'tons of CO_2-e', and using '$ saved' instead of 'kWh saved'. Pre-paid programs which allowed the consumer to pay for their energy consumption in advance via pay stations or using internet software were trialed to enable more awareness of energy usage and better management of bills. Customers who used the prepaid programs were extremely satisfied with their participation, with one of the key factors for success being the ease of access to the forms of payment. High visibility of usage meant that customers did not fall behind in payment of electricity bills and were motivated to save energy (up to 12% in energy savings in the first year of such a program was estimated).

		★		1.3.2.6 - A survey of customers indicated that the capability to manage personal energy use (and cost), ranked as the most important capability value by customers (out of 11 other possible benefits of the SmartGridCity). However it was recommended that to encourage greater awareness and involvement in smart grid programs, marketing would be needed to implement additional communication efforts about the role of the customer themselves and the utility in empowering the customer. It is anticipated that as the customers electricity management options evolve, their perception of the utility's business model will become increasingly important. Testing this kind of perception (for example whether they feel a sense of increased partnership) will require looking at a large enough number of customers, over a long enough time. At the time of writing, the customer experience with smart grid capabilities was not over the duration needed to verify whether a sense of partnership was perceived by customers. Within the SmartGridCity, through communication with the smart meter – the Customer Contact Centre or Distribution Control Centre was able to determine whether or not a customer service issue was the responsibility of the service company or that of the customer. This benefit of 'knowing the responsible party to fix an outage' scored 2nd highest of the 11 benefits measured.
	Other			

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AME 7	Consumer Engagement Project, USA
Status	Finished
Dates	2011
Involved	Electric Power Research Institute (EPRI), Smith-Dahmer Associates

The Consumer Engagement project aimed to address the motivational factors behind the adoption of smart grid technologies by consumers. It also investigated what kind of issues smart grid technology could address for consumers, and the best techniques to engage with these consumers.

In order to understand such issues, a consumer interaction study was undertaken. This consisted of two in-depth online bulletin board discussions (lasting 5 days), with the first discussion being that of a smart grid 'aware group' (17 participants) and the second discussion by an 'un-aware group' who did not have prior knowledge of the smart grid (15 participants). The demographics of the participants were representative of various backgrounds, ages, household types and locations. Two discussion questions were left each day on the online board allowing participants to provide input at their convenience. This allowed qualitative discussions to develop with great depth (in contrast to the traditional way of obtaining consumer insight through surveys/questionnaires).

The key findings from this interaction study were then used to create follow-up questions for a group of 1,000 respondents, allowing lessons learned from the interaction study to be validated in a more quantitative form.

Domain	Aspects	Micro	Meso	Relation to action points
Technical	Systems			
	Control			
	Information			

Policy & Regulation	Tasks			
	Finance	★ ★		1.2.2.2 - Participants were asked to rank a list of smart grid benefits in order of perceived value. The results were as follows (with 1 being the most important, and 8 the least): 1) saving money on your electric bill; 2) reliability of electricity services to your home; 3) increased information to control your energy use; 4) environmentally friendly energy options; 5) knowing when my home systems are functioning properly; 6) home security – remote knowledge of what's going on in your home; 7) reduce need to put up new power plants; 8) reduce need to build new power plants. In order to communicate benefits that resonate strongly with consumers, it was recommended that benefits should be focused on the individual first, and then to the environment and wider community. To further validate such findings, in the quantitative study 1,000 respondents were asked to decide on specific benefits of smart grid technology, and rank the benefit as 'extremely useful', 'very useful', 'moderately useful', 'somewhat useful' or 'not very useful'. It was seen that 64% of respondents thought that knowing 'how much electricity you use, when you use it and how much it costs before receiving your monthly bill', was at least very useful. 58% of respondents though that 'owning intelligent, energy-saving or energy-producing devices that share energy and information with the grid', was at least very useful.
	Policy			

Social & Other	Protocols			
	Stakeholders	★ ★		1.3.2.1 - In general, participants wanted assurance that the data collected regarding their electricity use would not be used for marketing or profiling. There was also concern from some about the potential for hackers to know when the homeowners are away from home. In the quantitative study, the 1,000 respondents were asked to rank their top 3 privacy concerns from a list containing choices such as banking, personal information, credit cards, social network sites etc. The results can be seen in Figure 20. Relative to other privacy concerns, smart meter data privacy is a very low issue, with only 4% of participants choosing this within their top 3 concerns. It was suggested that invoking this kind of comparison in the consumers mind may help to alleviate concerns over data privacy, through putting the issue into a broader perspective. Overall it is vital to provide information about the intent behind smart grid technology and to reiterate messages of reassurance that data will not be used against consumers, and that security will prevent any hacking of data.
		★ ★		1.3.2.2 - Most consumers regarded themselves as conscientious with respect to their energy consumption. For the majority of participants the main reason to reduce consumption was to save money, with environmental benefits being a bonus. For a minority, concern for the environment was the primary reason to conserve energy. It was seen that consumers felt a strong degree of frustration when they attempted to reduce consumption, but made ineffective changes which did not ultimately impact their bill. For example some consumers assumed energy use would be significantly reduced through unplugging stand-by power (although when such a change aggregated can impact the grid, on an individual level it is unlikely to change a monthly bill). Others thought reducing microwave use would lead to significant bill reductions. Even if the monthly bill turns out to be less, the reasons behind this are most likely different to the factors the customer will attribute the reduction to. As a consequence of such misunderstandings and ineffective changes, consumers can become discouraged in altering behavior to any type of energy pricing program. For this reason one of the conclusions drawn from the study is that consumers would highly value energy consumption and cost information broken down for each appliance within the home. This also leads to the suggestion that simply providing an in-home display which only provides consumption and cost information on a household level (rather than appliance-level) will not necessarily provide actionable information for consumers.

		★		1.3.2.3 - Both groups were shown the following definition of smart grid technology "*The "Smart Grid" is a vision for an updated electric utility equipped with modern communications and computer technology to create a more reliable and efficient electric grid. The smart grid will be more robust, secure, efficient, affordable and environmentally friendly. Consumers will be able to know how much electricity they use, when they use it, and how much it costs before receiving their monthly bill. In addition to managing energy costs, consumers will have the option to own intelligent, energy-saving, or energy-producing devices that can share both energy and information with the utility grid.*" asked to comment on the clarity of information. Overall it was felt that the statement was clear and concise. The most compelling aspect was the statement *'Consumers will be able to know how much electricity they use, when they use it, and how much it costs before receiving their monthly bill'*. It was recommended that this information emphasizes the benefit of smart grids to the individual – which is in contrast to much of the information obtained through research which consists mainly of information regarding benefits to the environment or community overall.
		★ ★		1.3.2.5 - It was observed that for the smart grid 'aware-group' the most common sources of information included broadcast media, newspapers/magazines, the internet and word of mouth. The smart-grid 'un-aware' group who did not understand smart grid technology was asked to research smart grids so that their understanding could then be tested. Wikipedia was commonly used alongside websites such as that of General Electric, Siemens and IBM which were perceived as easy to understand and containing helpful visuals. Other sources used included friends, newspapers and TV. As there is a heavy reliance of information from the internet, it is recommended to influence content that appears on websites such as Wikipedia (and other websites that come out at the top of search engines). In order to make consumers who are not actively seeking smart grid information aware of this technology, credible TV and print news content can be useful. Also consumers expect to hear about this technology from their utility company in inserts, newsletters and special notices. In order to communicate the implications of smart grid technology, several statements were drafted in a language consumers could readily understand (using analogies for example), and which conveyed the benefits that smart grids brought about. This is because such statements can be understood better than technical ideas. The two most compelling statements for consumers were judged to be the following: • 'Taking the Guesswork Out of Managing Energy Use' • 'A Helper for My Best Intentions'

				Both statements were accompanied by a short piece of text explaining the statement further. The first statement addressed the frustration issue which consumers experienced due to ineffective attempts to reduce energy consumption (see 1.3.2.2). The second was related to the problem of not being good at managing the use of electricity within the household despite an effort to do so. By focusing on common and relatable circumstances that cause consumer problems, these kinds of statements had an increased impact with consumers. Generally, statements which emphasized smart grids being beneficial for the common good (e.g. ‘by working together we’re having a bigger impact – like reducing the need to build power plants and put up new power lines’) did not provide the same incentives as statements which emphasized individual or tangible benefits (e.g. saving money, more control).
		★ ★		1.3.2.6 - Cost was found to be a major barrier to smart grid technology acceptance for the participants in this study. In particular participants expressed uncertainty regarding set-up costs, costs of energy-saving and energy-producing devices and who would pay for this. Even after conducting research many participants did not find information regarding to what extent smart grid technology would save them money or how much it would cost. It was recommended that more tangible examples/case studies would be useful in overcoming this concern. For example creating scenarios which detail upfront investment costs, and cost savings in the short and long term would help in this matter. It is important to be as specific as possible with regards to these costs, as this would allow consumers to understand benefits to their family etc.
	Other			

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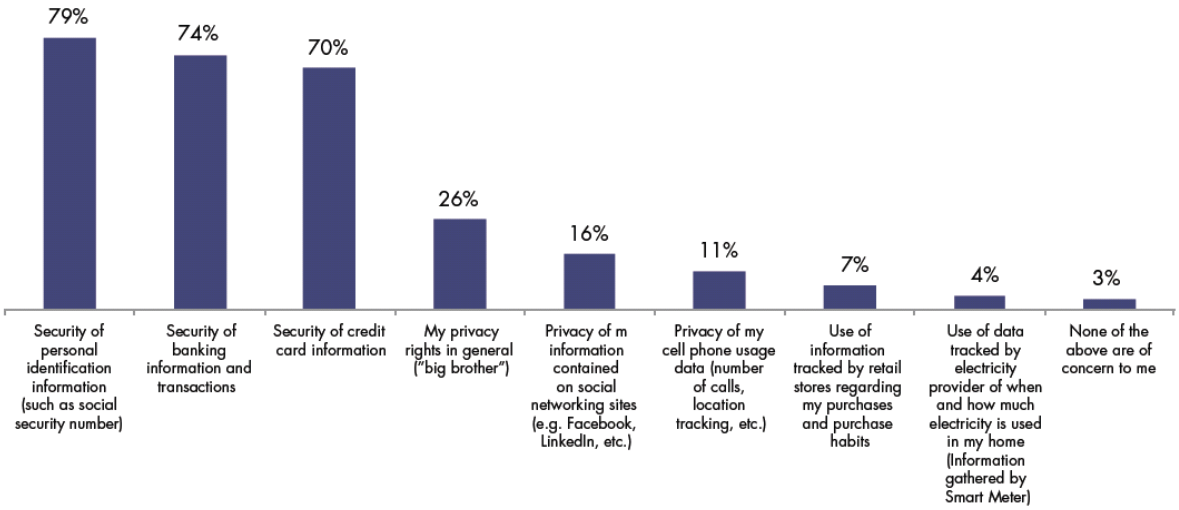

Figure 20: Comparison of consumer data privacy concerns *(Source: EPRI Consumer Engagement Report 2011)*

APPENDIX D INFORMATION PER ACTION POINT NETBEHEER NEDERLAND

In order to provide a means of reading all findings regarding a specific action point, the lessons learned from all projects have been compiled together in this appendix. Each project that is related to an action point is referenced to the code in the upper left corner of each analyzed project in Appendix C. For example [UPDATE 1] references to the Address project. The code [UPDATE] references to the projects in the first report that was an update of previously selected projects. [AP] references to the projects in the Asia Pacific region, [EUR] to the European projects and [AME] to the projects in the Americas.

D.1 - Technical

D.1.1 - Systems

Micro level

1.1.1.1 Smart meter and smart meter cabinet specifications

[UPDATE 8] Real-time metering of distributed generation (DG) should be mandated for DG above a certain size (a delegated dispatch is a step in this direction).

[UPDATE 12] One of the key components of this project are the "energy boxes", which have been developed especially for this project. Every household will require such a device to connect to the grid.

[EUR 5] eTelligence uses a EWE Box smart meter. Improving transparency was one of the key requirements for choosing a smart meter. The EWE Box makes electric power consumption transparent.

[AP 1] During the project, various smart metering solutions are being explored. Ausgrid has to date rolled in excess of 400,000 smart meters and investigated pricing options, specifically Time of Use for a large number of customers. During this project another 50,000 smart meters will be installed. Goals of the trials and pilots are to automate a range of processes through remote connection and to develop a range of new products both for network and retail businesses. Several kinds of feedback will be tested (web portal, simple IHD, Advanced IHD and customer HAN). Possible options will be: 1. Time of Use, 2. pre-payment, 3. interruptible load products, 4. dynamic peak pricing. To date 700 homes were installed with WiMAX smart meters in Newington.

[AP 4] In the project 4,500 smart meters will be installed in various residential, commercial and industrial locations two establish an advanced metering infrastructure (AMI). However the (requirements for) specifications of the meter are not mentioned in the available documents.

[EUR 6] Smart meters can support the participation of EV in the complex power market through the combination of market services in different business cases. The smart meter enables the market participation of EV as individual units and aggregated sets. Smart meters provide a two way communication channel between the meter and the utility infrastructure, for automated reading and control, allowing advanced energy services to be exchanged between customers and the grid.

The MERGE project defined high level requirements that the smart meter should guarantee:

1. Interoperability and public communications standards;
2. Common communication architecture;
3. Service lifecycle management;
4. Event support and alarm handling;
5. Combination of different business and market services.

[EUR 10] The smart meters deployed in homes for this project was the same as the meters currently deployed in France. A line interface allows metering and tariff information to be delivered to any device connected to it. A ZigBee module (CC2530 chipset) developed by EDF is able to provide metering data onto the home Zigbee sub network.

A hardware platform developed allowed wireless serial point-to-point (smart meter – Agent) communication. The meter was then able to permanently broadcast information contained in its internal memory through this interface. Thus real time knowledge on consumption in the home can be provided which is necessary in order to be able segment consumers and provide personalized energy services for them.

1.1.1.2 Installation of smart metering systems and/or smart meter cabinet

[UPDATE 12] The project started of with 500 installed smart meters. Currently 30,000 energy boxes and 40,000 distribution transformer controllers have been installed.

[UPDATE 17] All participating consumers will receive a smart meter. Advanced Metering Infrastructure is covered in work package (WP) 11 of the project.

[UPDATE 18] One thousand smart electricity meters, one thousand smart water meters and five hundred smart recycled water meters have been installed in this project.

[AP 6] Honeywell is implementing smart meters in commercial buildings. Advanced energy management and automated demand response will be installed to enable demand side management.

[AP 7] AMI meters were installed for electricity, gas and water. The community is installed with smart sockets and intellectual home appliances that automatically read the water, electricity and gas meters, record the family's power consumption habits and support remote control. The residences can find out their family's power expenses, carbon emission amount and energy consumption habits, receive suggestions on energy use, and form an economical energy consumption habit. For instance, the system would remind users to avoid or reduce using electricity during peak hours. Six charging poles for electric vehicles are stationed in its underground garage, which can adequately meet its residents' daily power needs.

[AP 8] Korea aims to encourage consumers to save energy by using real-time information and producing smart home appliances that operate in response to electric utility rates. In 2012, Korea expects to reach a smart meter penetration rate of 5.6%. Korea aims to have smart meters installed at all consumers in 2020.

[AP 9] BESCOM installed new static meters in the place of old mechanical meters. This has increased billing efficiency from about 60 percent to 100 percent.

[EUR 5] Six hundred fifty households have tested smart meters for everyday use. With different feedback systems (iPod app, portal, monthly printouts), the participants were able keep track of their own electricity consumption and assess the cost of electricity, CO_2 emissions and their consumption pattern.

1.1.1.3 Design criteria for ICT and electronics

[UPDATE 14] An industry-quality reference ICT-platform for distributed control in electricity grids at aggregated levels has been developed.

[AP 1] An agreement has been signed between Ericsson and Ausgrid which allows Ausgrid to become the first utility to use Long Term Evolution (LTE) for its 4G communication network. A 4G machine-to-machine communications network using WiMAX and LTE standards is being built across approximately 150 sites in Sydney, the Central Coast and hunter Valley regions. One of the major benefits for choosing a 4G/LTE platform is its approach to cyber-security - a key consideration in selecting technology for the electricity industry.

[AP 4] A key emphasis in the first phase of the pilot is to establish the smart metering communication protocols and standards. This will be done by leveraging on the Next Generation National Broadband Network (high speed all-fiber communication network) and other communication platforms.

[EUR 5] The complexity of dynamic rates precludes a manual response to price incentives. This task is performed by energy management system. eTelligence used multi-boxes. The multi-boxes receive price signals or can request the current price before switching on an appliance via standardized interfaces.

1.1.1.4 Technical possibilities for electricity storage

[UPDATE 11] The project realizes different types of transportable flexible storage systems – namely Li-ion battery and flywheel systems. The field test in Zamudio, Spain reported transportation and installation of the system was relatively easy to accomplish. The system for harmonic compensation was reported to work, but not as expected. A good set point selection was identified to be a critical step in the implementation phase of a storage system.

[UPDATE 14] A generic design has been developed that allows seamless coordination of hybrid heat pumps, CHPs, electric cars and smart appliances such as freezers in a single ICT solution.

[UPDATE 17] The integration of several distributed energy resources for generation and storage within the low voltage network, while maintaining adequate quality of supply, is one of the objectives of this project. This topic is dealt with in WP 10.

[UPDATE 18] Distributed energy storage options will be trialed in the Smart Home, including use of stored energy to supply electricity during peak periods and recharging during low use periods. Other stored energy options at a business or an electricity substation level may also be tested.

[AP 1] This project aims to answer the following questions: Can distributed storage improve capital efficiency for networks? How could it facilitate intermittent energy sources? How can consumers benefit from it? What are the benefits or issues with the use of plug-in electric vehicles as a means of distributed storage?

[AP 2] Storage batteries will be applied as part of a system to integrate control of electricity and heat to enable high-efficiency operations and flexible supplies of electricity and heat for each household in apartment buildings.

[AP 7] The prototype room is equipped with distributed solar power generating and storage facilities at a capacity of 10 kilowatts. Six electric vehicle charging poles are stationed in its underground garage, which can adequately meet its residents' daily power needs.

1.1.1.5 Security

[AP 1] In this project a 4G/LTE platform will be tested, which has many advantages in the field of cyber security.

[EUR 6] Communication architectures should be designed to ensure the necessary performance of data exchange in terms of availability, reliability, security and speed. Given the potentially high number of events generated in the electric grid, it is necessary to rely on an event and alarm management system that is able to provide an overview of the status of the network. Alarms generated by the smart meter can signal critical events that could adversely affect the electric system operation.

[EUR 8] During Trial A, it was observed that occasionally duplicate meter data readings arrived from the meters. This was because no asset management tool was available for the smart meters used in the trial. Although this did not cause a problem with the actual experiment because the data was given a timestamp when written to the database, it does highlight a potential problem that may arise if not dealt with.

It shows that meter data should be checked not only on whether it conforms to the required format, but also some kind of 'logical' check should be in place to stop resubmission of measurements. If not then this will allow incorrect metering data to be 'injected' into the system to compromise the security and performance, or even to lower a monthly bill for example.

1.1.1.6 Temperature curve for heat pumps

[UPDATE 14] The various technologies used in this project provide flexibility without impacting the overall comfort of the end-user, and allow interoperability between components, and the ability to grow the system as organically as needed. Measurements from the micro CHP systems and the hybrid heat pumps indicate that the system responds quickly to fluctuating demands, and maintains an appropriate fill level for each household over the long term.

1.1.1.7 Power quality

[UPDATE 4] In this project, the effect of distributed energy sources, especially solar power, on the electricity network was analyzed. Problems regarding power quality are solved with power electronics. The project introduced the use of the FACTS (Flexible Alternating Current Transmission System) concept in distribution systems by designing a set of modular systems (DGFACTS) to optimally improve the stability and QS of each distribution network with high DG+RES penetration.

[UPDATE 6] Converters and inverters connected to the power system will emit harmonic distortion into the power system, due to the electro technical characteristics of the semi-conductor-based components used for those applications; these might exceed the limits stated in EN50160. Furthermore, switching on and off charging of EVs can lead to fast voltage changes causing flicker problems, but does not seem to have a great impact as long as EVs are not used in regulating applications. How a large number of EVs will affect the low voltage grid has been analyzed in the EDISON report "Power Quality in LV Grid". Main findings:

- If the number of chargers with low charging power connected to the same interconnection point is increased, the impact on harmonic distortion is mitigated, especially when chargers of different manufacturers are used.
- Short-circuit level at the point of interconnection is very important for the value of harmonic distortion. A stronger MV network resp. a higher short-circuit level usually reduces the overall harmonic distortion.

- When connecting chargers with high power rating (e.g. fast charging stations) to the network, adequate voltage level and sufficiently high short-circuit power should be available at the interconnection point.
- High frequency (HF) current injections are not introduced into the MV network by converters connected to the LV level due to HF filters and the typical HF characteristics of the LV network (i.e. transformers and cables).

[UPDATE 8] A Distribution Management Tool called Volt Var Control (VVC) has been developed. The VVC is an Optimal Power Flow (OPF) based algorithm which helps determine what actions need to be taken to maintain the voltage levels. Power quality was improved by using inverter based grid coupling. The inverter and the doubly-fed induction generator inject reactive power and compensate harmonics and other disturbances of power quality.

[UPDATE 10] The GFA Controller has been developed to autonomously react in fractions of a second when a disturbance is detected and stabilize power grids and prevent outages.

[UPDATE 11] A flywheel that was implemented in Zutphen turned out to be very effective in dealing with PQ issues.

[UPDATE 13] The intelligent MV/LV distribution station has been designed and tested in such a way that it maintains and even improves power quality in an economic way when distributed energy resources are added to the distribution grid.

[UPDATE 18] One of the goals of the project is to develop and test algorithms to identify individual appliances from the total energy consumption.

[AP 7] The community employs intelligent switch and automatic monitoring devices. The advanced electricity distribution system of the community can automatically detect malfunctions and reconstruct two-level network with fault self-recovery capability. It monitors the electricity transportation around the clock and tests power quality real time, which ensures 99.99% of reliable power supply.

[AP 9] Provision of a High Voltage Distribution System (HVDS) and refurbishment of feeders with transformers and meters, provision of fault passage indicators, switch capacitors and polymeric surge arresters are the technical upgrades that have improved tail-end supply and reduced interruptions in electricity supply. The technical improvements have also greatly reduced the burning out of water pumps (crucial for farmers) due to voltage fluctuations and harmonics.

[EUR 4] Short-term voltage disturbances may inflict considerable harm in the form of damaged equipment, lost production and reduced productivity. ADINE used the representative of converter based VAr compensators named STATCOM, Static synchronous compensator. STATCOM provides a solution for VAr control, voltage regulation, flicker compensation, and fault-ride through improvement. Also grid current harmonic filtering is possible if sufficiently high switching frequency can be used.

Benefits of STATCOM are improved power quality and network stability, increased transmission capacity, and improved fault ride through capability and grid code compliance of renewable generation.

[EUR 9] A specific challenge in some places already today are the photovoltaic modules connected to the low-voltage grid. If the sun emerges from behind the clouds, many systems start to feed into the grid at high output at the same time. This raises the frequency and in response to pre-settings some generation systems connected to the low-voltage grid would have to switch off automatically when they reach a frequency of 50.2 Hz. As many installations register this and switch off simultaneously, they can seriously disrupt system stability.

The necessary smart inverters to solve these issues have already been developed. They now need to be connected with the other participants in the overall system and the corresponding control systems through appropriate communication modules. Of great importance also is the ability of decentralized producers, such as micro block-type thermal power stations, to switch in at the right time. If they are connected with the whole system via communication units, they can, for example, be switched on, if the sun disappears again behind the clouds. The preliminary findings show that ICT control of flexible generation plants (controllable inverters, current-regulated use of cogeneration stations) and localized purchase of reactive power can support grid stabilization.

Meso level

2.1.1.1 Development of systems for load management

[UPDATE 2] This project has explored a means to gradually devolve control authority from the existing central control room (which is semi-automated and semi-manual) by using a peer-to-peer network of controllers/decision-makers placed in substations. The controllers can open and close remotely controlled switches to reallocate loads to different parts of the network and use local small-scale generation to help regulate the voltage magnitude. Significant progress has been made by the system design with regard to voltage control, thermal ratings and restoration algorithms based on DNO requirements. One of the lessons learned was that technical solutions for managing changing requirements only address part of the problem: DNOs also need to develop the appropriate planning and maintenance procedures and processes for the entire life cycle of active network management (ANM) schemes.

[UPDATE 11] The importance of communication for remote control turned out to be a learning point in the first pilot projects. Subsequent pilots were installed with an improved management system.

[UPDATE 13] The system has been developed to integrate dispersed generation while maintaining power quality. The simulation results show a significant reduction of harmonic voltages, resonances as well as a leak load reduction of 30%.

[UPDATE 14**]** Renewable energy sources like solar power and wind energy were successfully integrated in the grid.

[UPDATE 16**]** Orkney is connected to the mainland network by two 33kV submarine cables and network simulation and analysis has shown that this active network management scheme may be capable of releasing capacity for DG connections by up to three times the firm capacity of the existing distribution network. To enable active management of the power flows on Orkney, the network has been segregated into control zones. Control logic has been designed to regulate the output or trip the New Non Firm Generation (NNFG) as required to optimize use of the available network.

[AP 1**]** One of the main questions regarding energy storage in the grid that the project will try to answer is how this could facilitate intermittent sources of energy.

[AP 2**]** Load control will be applied as a way of demand response (DR). Another method to absorb renewable energy that is pursued in this project is to increase battery storage in the network to absorb a surplus PV power. For this purpose also EVs will be used. To control the interactions, SCADA, HEMS, BEMS and EV data centers will be used.

[AP 3**]** Eight DSOs and the TSO have cooperatively set up this load management project. The systems operates through ripple control and is deployed for several purposes: dynamic control of supply to appliances, fixed time control, and indirectly through pricing incentives that reward retailers customers who lower the amount of electricity they consume during high priced peak period.

[AP 7**]** The low-voltage optical fiber power network covers the whole community, transporting electricity to every family, at the same time, bringing broadband internet to the household, thereby integrates the telephone, television and internet.

[EUR 1**]** Test 1 demonstrated use of a fully integrated system of DER components in an office building. This included a 12kW-CHP engine, UPS and control systems. A DER controller developed by Siemens PSE was used to communicate and control with the different components using the MODBUS protocol. The controller managed the CHP-engine system, switched different loads and managed decoupling protection. It also acted as the interface between the DER system and the power market. Test 2 was a more complex test of the integration capabilities of different DER components being controlled as a single unit. The installation used a gas micro-turbine of 80kWe and 135kWth, an absorption chiller to produce chilled water from the thermal load of exhaust gases, and electricity storage. Again the control technology was successfully validated. Tests 3, 4 and 5 were aggregation experiments (as opposed to the single-site experiments of Tests 1 and 2). In Test 3 the aggregated management of flexible customer loads was investigated and Tests 4 and 5 aggregated a portfolio of micro-CHP units (with use of demand flexibility in Test 5).

[EUR 4] The Active Network Management method adds value by increasing the potential for renewable energy, by improving efficient utilization of distribution network assets and by supporting distribution network by ancillary services from customer-owned resources. The distribution network management concept of ADINE project is based on existing systems like SCADA, Distribution Management System (DMS), substation and distribution automation and Advanced Metering Infrastructure (AMI). The ANM system operates on protection, decentralized control and area control levels. The existing management system includes three layers: protection system, automatic control system (decentralized) and area control level (centralized). The ADINE project deals with all layers.

The goals of developed ANM method are to ensure safe network operation and to increase network reliability in networks with DG, to maximize the utilization of the existing networks with bottleneck caused by voltage issues, and to maintain the required level of power quality despite non-predictable power production or consumption. In order to achieve these goals the project has developed and demonstrated individual technical solutions (protection, voltage control and STATCOM) and validating the combination of technical solutions (developed ANM method). The developed methods together form the ANM method.

Furthermore the real-time simulations demonstrate how the technical solutions interact with a power system with much DG. They also illustrate how some technical issues are closely related such as loss-of-main protection and fault ride through. Demonstrations have also shown that active network is feasible today at least in specific applications. This means that existing device, automation and IT systems are capable to provide active network features which are part of overall active network management.

[EUR 5] eTelligence developed and tested the implementation of load management schemes. This requires competent technical advice and the installation of automatic control systems. eTelligence proved that in enterprises and large municipal energy consumers, load management today is technically and commercially feasible. In the eTelligence project the refrigeration assemblies of large cold-storage depots adapt automatically to the wind power generated in the region. Here, the large cold storage capacities of cold-storage depots are used in a power balancing group to cope with the fluctuating off-forecast production of wind power.

[EUR 7] A complete system architecture was set up to link up households and commercial enterprises with units that use and generate power. This can provide information for the future on how far this kind of service-oriented approach is feasible in normal operation in terms of real-time capability and scalability. In particular, matching the use times of electric power in households and enterprises with electricity supply can contribute to integrating renewables into the distribution grids. The initial trials with new electronic market platforms have made promising progress. Another focus was placed on developing the system architecture for 'security by design'. This has come up with a cellular energy system, where the outage of a cell does not necessarily impair the whole system, thus improving supply security.

[EUR 9] Savings potential is available in the commercial sector of up to 20 %, in the private sector, of 5 % to max. 10 %. Regarding the load shifting, a potential of up to 10 % is available in the private sector (above all with heat pumps and air conditioners, on a smaller scale dishwashers, dryers and washing machines). However, considerable educational work is needed to raise this potential. The load shifting potential is very high in the commercial sector and in part already economically attractive today. Due to the necessary adjustments in the production process, it can, however, frequently only be raised with intensive advisory services.

[AME 3**]** A custom control algorithm was written for the purposes of the 'Peak Load Management' software used in this project. This operated in conjunction with the Bluefin enterprise backend server and utilized the Bluefin platform to observe the total load on the feeders. If the load on the feeders exceeded a pre-assigned set point, then a calculation would be made as to how much load needed to be offset to bring the system below the set point. The software used a prioritization scheme which called upon DER-assets based on their availability, emission characteristics, and also on the basis of fairly distributing operation of assets (i.e. the same asset would not be chosen first every day).

2.1.1.2 Use of local means of production and adjustable load such as VPP

[UPDATE 8**]** A Virtual Power Plant (VPP) concept has been developed that fits the European power system. Large-scale use of flexible operational aggregation of distributed energy resources by a virtual power plant can result in reduction of system gas consumption and therefore in CO_2 emission reductions. According to the economy-wide scenarios developed within the Fenix project, by 2020, CO_2 emissions in the electricity sector could be reduced by 7.5 kg CO_2/kW flexible DG/year in a northern European scenario and by 13 kg CO_2/kW flexible DG/year in a southern European scenario, compared to the reference case.

[UPDATE 14**]** This project carried out experiments with day-to-day market trading (VPP operation).

[UPDATE 19**]** One of the deliverables was a micro-CHP economic model to compare the economical performance of identical micro-CHP units in different European countries. The project identified three major hurdles to be overcome in the development of a product for the residential mass market: i) The costs must be reduced significantly to increase the technology's economic viability; ii) The system must be simplified to improve reliability; iii) The temperature of the heat output must be increased to become compatible with existing heating systems, and to give opportunities for tri-generation (cooling, heat and power).

Within the operation as a VFCPP, the capability to follow defined load profiles without relevant time delay has been successfully demonstrated. Based on the experiences gained out of this project, Vaillant and its partners are working on a High-Temperature PEM Fuel Cell system in order to overcome above mentioned hurdles.

[AP 1**]** Virtual power station trials will be performed as well. Local homes in Newcastle and Scone will be asked to participate to have new ceramic fuel cells installed at homes. A total of 25 fuel cells and five wind turbines will be installed on the grid and at homes to test distributed generation. From the available information it is not yet clear how the dispatch will be coordinated.

[EUR 1] Trial 4 successfully tested under real conditions the aggregation of 10 Micro-CHP units, with large heating water storage being used for flexibility. The performance of the units were below expectations with an electrical efficiency of 7% (instead of the anticipated 12%), and an overall efficiency of 85% (instead of 90%). The reasoning behind this was put down to the low electrical efficiency caused by self-consumption of the unit, and also the low average running times of the units per start. It is expected by optimizing the control strategy further to increase running times per start, the average usable output will increase (and hence available power for the aggregator).

[EUR 5**]** In the eTelligence project, Energy & meteo systems have developed a complete virtual power plant, from the technical grid connection of individual facilities via integration to providing market connections. Modules are used here to connect commercial and industrial power consumers to a virtual power station. This optimizes the supply and consumption of the connected plants and enables purchase and sale on the eTelligence market place.

[EUR 6**]** The EV stochastic behavior and duality in their operation dictate the need for a new aggregating entity that will provide market visibility and EV charging controllability. Two innovative distribution network infrastructures have been proposed to achieve efficient DER aggregation: micro grids and virtual power plants. The integration of EV in both structures requires the synergy of a technical management and market operation framework. The interaction between the VPP control centre and the VPP resources, including EV, is shown in Figure 6.

[EUR 9**]** By pooling different power producers, storers and flexible consumers in virtual power systems, some model regions have effectively reduced the so-called residual load, that is, the remaining energy demand beyond the power generated by renewables. The simulations have shown that this is possible above all, if controllable renewable energies, such as biogas facilities, feed in as needed. Supply must, however, be secured at all times, which poses new challenges for the balancing energy system with a growing number of small producers and incalculable consumers (such as charging stations for electric vehicles).

[EUR 11**]** In this project, a technical VPP was developed which takes into account the technical aspects of the local distribution network and coordinates control using the Cell Controller. This is in contrast to a commercial/market VPP whereby Balance Responsible Parties aggregate minor units for the regulation of the power market. Each Cell can act as a virtual generator with same or better controllability than a power station of the same size. This allows increased services for the distribution network such as voltage control, and reactive power import/export to the transmission system.

[EUR 12**]** The VPP in this project aims at providing energy services to both the Nordic energy exchange, and Energinet.dk’s markets for ancillary services. It was shown that from the perspective of volume contracted and competitiveness, the VPP had a high degree of competitiveness and a high socio-economic value (through the replacement of more costly thermal power units for example).

One of the difficulties encountered was the complexity of the IT systems of Balance Responsible Parties (BRPs). For fast market integration it is necessary to have a means of portfolio optimization to create a value proposition for LU asset owners. Markedskraft was used as an external balance responsible party instead of DONG Energy Power. Despite the optimization capabilities being less than DONG, Markedskraft provided an easier interface with the markets, as their system ensured a one-to-one relationship between the market offer of the individual asset and the market contract of that asset. This is in contrast to DONG Energy which optimizes portfolios on an aggregated level, and separates the link been a units market offer and the activation of that unit.

[AME 3] In some cases, groups of load shedding assets were grouped together in order to act as a single asset to the BlueFin platform. This is because whilst an individual load asset such as a fan cannot contribute to extended peak reduction contributions, an aggregation of them could be put together and their utilization could be rotated within the group, allowing for this group of assets to be used in operation for a longer period of time. One of the big advantages of these load shedding assets (apart from the obvious avoidance in grid power consumption) was that they were cheaper to install and integrate than the generation assets, and had faster response characteristics.

2.1.1.3 Technical possibilities for electricity storage

[UPDATE 9] This project utilizes flywheel modules in a mechanical solution that provides active power (up to 20 MW) delivering an ancillary service for frequency control. The system is designed to quickly add or subtract power from the grid in a frequency regulation support mode. This technology has the potential to improving balancing responsible parties' ability to follow fast-changing loads.

[UPDATE 11] A software tool, Platos, was developed for optimal configuration of storage systems. The software helps to select the best location, size and type of storage and provides for an optimal storage control strategy along with performance indicators.

[UPDATE 15] In this project the storage in batteries has been tested. The grid electrifying the users is powered by three Sunny-island battery inverters connected in parallel to form one strong single-phase in a master slave configuration, allowing the use of more than one battery inverter only when more power is demanded by the consumers. Each battery inverter has a maximum power output of 3.6kW.

The battery inverters in the Kythnos system have the capability to operate in both isochronous or droop mode. The operation in frequency droop mode gives the possibility to pass information on to switching load controllers in case the battery state of charge is low and also to limit the power output of the PV inverters when the battery bank is full.

[UPDATE 17] The project integrates a small and heterogeneous set of generators and storage within the medium voltage network. The objective is an optimal integration of renewables into the grid near the consumption centers. These topics are dealt with in WP 7.

[UPDATE 18] Storage on a meso level is possibly being evaluated as well, for example at a business or an electrical substation level.

[AP 1] At several locations batteries will be installed. Depending on the location these will be put in a system with a high penetration of solar energy or wind energy and in some cases fuel cells.

[AP 2] Electricity storage in the grid will be used to absorb fluctuations of electricity production by PV panels. This storage capacity will exist partly of grid connected EVs.

[EUR 5] eTelligence was able to demonstrate that especially thermal electrical energy systems, such as cold-storage depots and block type thermal power stations can be used very effectively as energy storage facilities: When a lot of wind is available, the Cuxhaven cold-storage depot lowers its temperature and creates a cold buffer for itself. eTelligence proved that this type of energy storage is technical feasible.

[EUR 7] The tests with the cold-storage depots have led to a major finding: Despite good forecasts and influence on loads in real time, a 100-per cent spatial and temporal balance of production and consumption is not possible. The future energy system will therefore need more storage capacity than today. One technology alone will not be enough, as it must perform buffering functions between a few seconds and many days or even weeks. Even though a small addition to capacity can be expected in pump storage and also intelligent charging management in electric mobility, the expansion of these storage systems will not be able to keep up with the rapidly growing balancing needs for renewable energies. The storage technologies to be developed and particularly their costs will play a large role here. In the ICT-controlled combined energy networks, heating grids that use waste heat from power/heat cogeneration and gas grids (Power2Gas) could increasingly contribute their flexibilities in future.

2.1.1.4 Development of more autonomous grids

[UPDATE 9**]** The benefits of the technology to grid operators would be to improve the ability of Distributed Generation (DG) assets to operate on an islanded basis during a blackout, as well as to reduce emissions by reducing ramping needs.

[UPDATE 15**]** This project incorporates solar PV generation, a diesel generator and electrical storage in a micro grid in island mode.

[UPDATE 16**]** Future plans are the introduction of i) state estimation, ii) voltage control, iii) energy storage. There are also plans for active network management by means of distributed automation. Currently they are applying a spreadsheet model of generation and load profiles.

[AP 2**]** To control the interactions between different areas and supply by PV panels and the grid and demand, SCADA, HEMS, BEMS and EV data centers will be used.

[EUR 1**]** Test 1 successfully demonstrated the configuration of automatic-islanding reconnection with use of a DER controller. The decoupling protection checked the grid voltage and frequency and when stead-state operation was resumed, the DER controller was able to re-synchronize the CHP engine with the grid. Test 2 validated the integration capabilities of the components (time response, availability and reliability) under different grid scenarios: connected mode, islanded mode, and black start. A static switch was installed to automatically separate critical and non-critical loads, and custom-made control software was used to determine the operation of the CHP unit according to various forecasts, costs and technical factors.

[EUR 9**]** The more is known about when and how much electricity is generated from renewable sources, the better it can be integrated into the grid. This is why forecasting systems play an important role in the smart supply system. They enable the timely provision of generating capacities (e. g. biogas facilities) or the early initiation of consumption adjustment (e. g. more cooling on reserve). With a suitable mix and use of all technologies already available today both on the production and the consumption side and in terms of hardware and software, short-term adjustment would seem feasible, at least within a region. This would relieve the distribution grids, reduce expansion needs and increase regional value added. This calls for considerable efforts in energy technology and above all in information and communications technology, but as the results of the simulations indicate, the effort will be worthwhile. In many cases, using electricity near where it is produced can raise the efficiency of the whole system. The ICT solutions developed in E-Energy can help to ensure that decentrally produced power is also increasingly consumed locally, which will ease the burden on the grid.

[EUR 11**]** The ultimate objective of the CCPP was to facilitate the transition to a more autonomous grid. In the case of reaching an emergency situation, the cell is expected to be able to disconnect from the HV grid and switch to island operation. After a total system collapse the Cell should be able to black-start itself to a state of controlled island operation.

To complete such ambitions the cell must be able to carry out a number of functions. A brief list of the functionality achieved by the Cell Controller is listed below (as taken from the report):

- Monitoring total load and production within the cell;

- Active power control of synchronous generators;
- Active power control of wind farms and large wind turbines;
- Reactive power control by utilizing capacitor banks of wind turbines and grid;
- Voltage control by activating Automatic Voltage Regulators on synchronous generators;
- Frequency control by activating Speed Governing Systems on synchronous generators;
- Capability of operating 60kV breaker on 150/60kV transformer;
- Capability of operating breakers of wind turbines and load feeders;
- Automatic fast islanding of entire 60kV Cell in case of severe grid fault;
- Automatic fast generator or load shedding in case of power imbalance;
- Voltage, frequency and power control of islanded Cell;
- Synchronizing cell back to parallel operation with the transmission grid;
- Black-starting support to transmission grid in case of black-out.

[AME 3] Overall the project successfully demonstrated a way of reducing feeder peak load through coordinated control of DER, although the intention to achieve a 20% reduction on both project feeders was not met (the highest reduction achieved was 14.2%). This was put down to two reasons. Firstly, the total feeder demand was higher than expected demand. Secondly, the available DER capacity was around 35% less than expected.

Regarding the first reason, the peak demand values from 2010 were assumed to hold true for 2011. However in 2011 peak demand reached 17MW (peak demand in 2010 was 15MW). This meant that the amount of available DER that had been assigned to reduce feeder load by 20% was not enough at certain times. To worsen this issue, the total available generation capacity turned out to be 1.8MW less than anticipated due to partners and assets dropping out before project commencement. Additionally some generator sets delivered less power than their nameplate rating.

Asset response rate was also particularly problematic. Overall on average the generation units in the project had a response rate of around 95%, whilst load shedding units had a response rate of approximately 79%. The main reasons for unresponsiveness were put down to communication failures, especially IT firewall issues with regards to the load shedding unit partner sites.

The limited feedback capabilities of the load shedding assets also meant sometimes it was difficult to determine whether the unit should actually be classed as unresponsive or not. For example if a request was made to a HVAC compressor to shed load, even if the compressor was not running (and hence had no load to shed), the asset would be listed as unresponsive. Thus better feedback capabilities would have allowed the overall responsiveness rate to be higher.

In order to achieve the feeder peak load reductions, the duration of availability and the capacity for reduction were the most crucial characteristics in a participating DER resource. A large capacity helped minimize the installed cost per kW and simplified management of the asset. A long duration of availability was also important because there was not always a distinct peaking period of the load curve of the feeder, meaning to achieve a 20% reduction could potentially require 8 hours of continuous operation. In the project although target reductions could be achieved for short periods of time, they were not always sustainable for the entire peak period. It was seen that for this purpose, conventional generator assets were the most useful.

The lesson learned here is that when utilizing DER involving multiple asset owners, it is vital that the operating constraints of the owner and their resource are understood. Constraints for generation assets could include: air permission permits limiting hours of operation, noise impacts on surrounding area, increased maintenance costs, overheating during extended operation etc. For load assets typical constraints include: duration of operation that can be maintained, amount of capacity that can be reduced during certain points in the day and maintaining indoor air quality and building occupant satisfaction.

[AME 6] Within the SmartGridCity integrated Volt/VAr control was carried out on 2 feeders. 10-12 sensors per feeder were used and these were located at strategic points where customer voltage was expected to vary most from feeder voltage. The voltage was regulated up or down automatically in real-time based on voltage measurements through the system. It was seen that the benefits of peak capacity reductions through voltage reductions on feeders was high – a 5% reduction in voltage during critical peak periods was estimated to provide a prospective benefit of $14m in deferred generation capacity if deployed on 40% of the substations in the region. Benefits were also seen in energy consumption levels, which dropped 2.7% (207 kWh per residential customer annually) on average if the average voltage was reduced from 121V to 116V on the feeder. A CO_2 emissions reduction of approximately 3.1% was also estimated for each of the feeders through T&D loss reduction.

The impact of distributed automation on reliability benefits is high. Eight sectionalizing devices have been installed on four feeders to create two loops that are currently active. It is estimated that a reduction of 28,125 customer minutes outage per year per feeder will occur in the SmartGridCity environment. It was seen that data accuracy was essential to the functionality of the system. Alerts to the Distribution Control Centre were recommended as it would allow the staff member to determine whether the lack of response from an asset was down to hardware, software or communication problems. It was also recommended that deployment of Distributed Automation would create more value per dollar if invested in less accessible areas or geographies with low reliability.

Line loss optimization through remote switching was also investigated. The capability to switch loads remotely required expensive remote operation switches. It was concluded that the investments in the large number of switches did not justify the fuel savings made ($2,700 per feeder), although the value proposition could be re-evaluated in the event of switching equipment technology developments.

D.1.2 - Control

Micro level

1.1.2.1 Provision of measurement data for switching

[UPDATE 10] The GFA Controller is an autonomous device reacting to fluctuations on the grid. An autonomous device that reacts directly to the grid is a possible solution for automated in-home switching.

[UPDATE 14] Renewable energy technologies, specifically wind and solar, come with inherent intermittency challenges. Due to these fluctuations in power supply, any grid system served by renewables needs the flexibility to maintain the power balance. This project shows that smart grid technologies offer that flexibility. During the project, electrical devices of households were switched on (or off) at times of high (or low) generation.

[AP 3] During periods of high electricity demand, the controller uses "ripple" signals to cooperatively control demand throughout the region. This technology is called "Toon Frequent Sturen" (TF) in Dutch, and was used in the Netherlands as well for boiler control however it is not used often anymore due to the intrusive character of this technique to the consumer. Orion operates two ripple coding systems in two different areas: Telenerg, based on 11kV injectors using a 175 Hz carrier frequency and Decabit, based mainly on 33 kV injectors using a 317 Hz carrier frequency.

Regarding large consumers, the signal gives them the opportunity to reduce their electrical use through such means as turning off boilers, turning off freezers and running generators. This in turn reduces their following year's chargeable kVA demands and minimizes their future power bills. Many of Orion's major customers respond to their pricing signals. For example, the Chateau on the Park (a local hotel) has invested over $150,000 in an energy management system and a diesel generator. As a result of their pricing, its investment in this technology was paid back in around three years through savings in ongoing electricity purchase costs.

The current ripple control channels are not suitable for use with "on demand" heaters. To avoid sudden loading changes a random delay of 0 to 7 minutes is introduced when the load is switched back on. For more technical details, please see the Ripple Signal Guide from DSO Orion: http://www.oriongroup.co.nz/downloads/ RippleSignalGuide.pdf

1.1.2.2 Charging strategies for electric vehicles

[UPDATE 6] With Time-of-Use pricing people may decide to charge quickly when electricity prices are low which can create worse peaks than with uniform prices. Need of large balancing power capacities and large variations in base generation remain. Only when charging is controlled to absorb fluctuations high variability is reduced, but this comes with a significant higher cost of charging and low 'green' content of energy.

[UPDATE 11] The lithium-ion based system (often used for EV) has shown to be compliant with normal grid operation.

[UPDATE 17] A small fleet of electric vehicles is managed remotely for charging and for generation. In the proposed system, the vehicles are considered as loads that can be managed, but also as small sporadic generators, responding to the needs of network operation. This topic is handled in WP 12.

[UPDATE 18] Demonstrating and testing of electric cars will also be part of this pilot project. The aim is to: measure charging patterns with typical family use of the vehicle; test the EV as another form of storage to provide peak power; trial and evaluate potential metering options for EV's to charge outside the home and still be billed.

[AP 1] In this project 20 EV's, 50 standard and 6 fast charge points are included. Output of the study will be data and results on charging impacts and technology insights and explore several business models. Furthermore the possibilities and challenges of EV's as storage capacity will be researched.

[AP 2] One of the goals of the project is to develop an operation system for charge and discharge EV sharing by integrating PV and storage batteries. The charge and discharge capabilities of EVs will be utilized for energy management in homes. Rapid charging devices will be implemented as well.

[AP 4] In the scope of the project is to facilitate the integration and testing of EV charging including vehicle-to-grid.

[EUR 6] The MERGE project has defined different charging strategies, as showed in Figure 7. The smart meter needs to provide different functionalities to tackle both less demanding charging approaches, such as dumb charging and multiple prices approaches. And also elaborated charging schemes, like smart charging and vehicle-to-grid.

1.1.2.3 Effect of the remote switching of household appliances

[UPDATE 10] The GFA controller can be applied without affecting experienced comfort (e.g. by only switching off refrigerator compressor or central heating pump) and through automation as it does not require remote control.

[UPDATE 14] Peaks in electricity demand were reduced by controlling electrical devices in households.

[AP 1] The project includes a trial with demand response control in which the air conditioner and pool pump cycling at households can be switched automatically. With the consent of the households, Ausgrid will remotely put these high-energy appliances in a lower power mode at peak times.

[AP 2] The project will introduce systems that can balance energy supply and demand for three different areas that have diverse activities, while maintaining dependence on power grids. Furthermore demand response programs such as load control and surplus PV power absorption will be implemented to promote consumer behavior changes.

[AP 3] Orion uses their ripple control system to manage load in a number of ways:

1. Directly through dynamic control of supply to appliances, mainly hot water cylinders. This “peak control” shifts the heating load to occur just after the peak. They aim to turn cylinders off for short periods only, to prevent any noticeable effects on customers' hot water supply. The cylinders are turned back on when network demand reduces.
2. Directly through fixed time control of supply to appliances, mainly hot water cylinders and night store heaters, by switching them on during off-peak night periods only. This “fixed time control” permanently shifts load away from the day time periods when peaks occur.
3. Indirectly through pricing incentives that reward retailers' customers who lower the amount of electricity they consume during our high priced peak period. This arrangement is more useful for larger business connections with special half-hour interval metering that records the reduced loading level during the peak period.

Orion has made it compulsory to install controllers on all storage water heaters. For customers that want a near-continuous supply for their water heater (and do not want regular peak control or night rate options), there are emergency control channels that are only operated during an emergency that threatens supply.

[EUR 7] As one of the projects of the E-Energy program, MoMa shows that not all appliances are equally suitable to adapt their consumption over time at all or in a cost-effective way. Installations in companies afford great potential in general, e.g. large cold-storage depots, treatment plants or block-type thermal power stations. In the private sector, these are primarily heat pumps, refrigerators and air conditioners of a certain scale and in the future charging stations for electric vehicles (and/or batteries in general) that can shift their consumption within hours or days. Figure 11 shows the shifting potential of the different technologies. Unlike with the other facilities, in home appliances and small and mini units almost the entire theoretical capacity can actually be shifted forwards or backwards. As the figure indicates, for about 30 minutes almost 20% of installed capacity can be used as positive balancing power through switch-off or delayed switch-on. Larger refrigeration plants can shift their consumption over longer periods (in this case up to 4 hours).

1.1.2.4 Price responsiveness of households

[UPDATE 1] Domestic customers are not motivated by purely economic considerations. Voluntary or contractual price and/or volume signal mechanisms have to be developed in the houses or at the interface with the aggregator.

[UPDATE 12**]** The price responsiveness of the households is one of the many subjects of this project.

[UPDATE 14**]** The PowerMatcher ensures that electrical devices, e.g. the heat pumps, are switched on only when sufficient electricity is available at low prices.

[UPDATE 17] Consumption management is aimed to improve energy efficiency by influencing the information to consumers and consumer awareness. This activity includes specific areas for street lighting control, home efficiency and load management. WP 8 deals with this topic.

[AP 1**]** Ausgrid and its retail partner will test new time-based pricing and incentives for households to reduce power use in peak times. These pricing trials will be voluntary.

[AP 4**]** One of the key goals of the project is that electricity retailers will compete in the second phase to offer time-varying electricity price tariffs and value added services to consumers.

[AP 7] The system reminds users to avoid or reduce using electricity during peak hours but SGCC does not report any price differentiation during the day or during peak hours.

[AP 8**]** Within this project an array of added electricity services is delivered through the combination of electricity and ICT and to put in place real-time electricity trading system for the transactions of electricity and derivatives.

[EUR 5**]** In eTelligence dynamic pricing is applied. There are also bonus and penalty events. In certain exceptional situations, the price for defined periods is lowered or raised to an extreme. This relies on the market-conform behavior of consumers to help rectify the imbalance by shifting their consumption. When customers have detailed information about their electricity consumption, they can take specific measures to reduce it. In the large-scale eTelligence field trial, savings have even been made of as much as 10 %.

[EUR 7**]** The second field trial showed that the consumers on average shift the electricity consumption of appliances connected to load management to low-rate periods. Figure 12 reveals that the real consumption (red line) in high-rate periods – above all at the peak period in the early evening – keeps below forecast consumption (green line) and usually above in low-rate periods. Roughly 5 to 10 percent of the electricity consumption in households can be influenced over time. This figure may seem small, especially as the test households are predominantly interested single-family home owners and thus do not correspond to the average household. Nevertheless, this can make a major contribution to enabling distribution network operators to reduce a local critical power load.

[EUR 8**]** Due to severe technical problems delaying the trial and measurement of results in Trial B, there was a very limited time period for collecting data suitable for analyzing thoroughly the effects of loads shifts in response to variable tariffs being offered. This meant that seasonal effects, consumer awareness change, saturation or habitual effects that would be observable over a longer period of time could not be easily extrapolated from the data. However based on the limited data available a shift of consumption to periods of low price in the order of 6-8% was seen.

On the basis of questionnaires and feedback, two-thirds indicated that they changed their electricity consumption pattern during the field test, according to the prices. They estimated they would make a saving of 5.- EUR compared to fixed tariffs. With the limited results available, it was shown that users consumed less power and adjusted power consumption of home appliances to cheaper tariff time periods.

[AME 1] The most effective rate/technology combination was the Variable Peak Pricing – Critical Price (VPP-CP) rate combined with the Programmable Communicating Thermostat (PCT). This option had the largest reduction in load during hot days. Also the increased resolutions for pricing (compared to TOU pricing) enabled the price to be tailored to available capacity. So for example, the low rate could be set when there is excess capacity in the system meaning customers do not need to reduce their on-peak energy consumption. Additionally, in times when capacity is low, the high/critical price level could be set leading to large load reductions.

Using the PCT allows for the customer to decide upon their own cost/comfort balance and combined with the price rates, enables automated load reduction. Regardless of technology used, with an increase in temperature – energy savings during peak times was observed in almost all cases.

1.1.2.5 Automated energy management in buildings

[UPDATE 1] Local energy management equipment is implemented. Results are described in a confidential report.

[UPDATE 14] Local energy management equipment is implemented to match production and consumption of electricity constantly.

[UPDATE 17] Network intelligence is implemented in the low voltage segment through distributed system devices which are connected in real time basis. A controller, located at the processing center, makes the control and regulation of the generation and manageable loads on the network. This is dealt with in WP 9.

[AP 2] This topic is one of the key issues that this project is about. In every participating household (4,000) PV and a Home Energy Management System (HEMS) will be introduced, thereby producing energy that will be consumed locally, by controlling home electronics and devices that create and store energy. Furthermore energy management systems for entire apartment buildings (BEMS), will be included to manage demand response. Rather than optimizing each device separately, the controls will focus on entire buildings that have different types of load patterns, depending on purpose and size, while maintaining comfort levels. In practice demand response will be communicated between BEMSs, which indicate the surplus of energy per building after which DR controls will be carried out by the linked HEMS.

[AP 4] Value added services such as energy efficiency measures using Building Management Services and Home Automation Systems will be offered to consumers who are involved in this trial. Initiatives include the pre-programming of automation devices and smart meter appliances to function during off-peak hours when electricity prices are lowest.

[AP 6] Energy management systems are being implemented to enable efficient energy use. This equipment will help connect State Grid and its customers to manage energy supply and demand, automatically adjusting electricity consumption and reducing strain on China's utility infrastructure. Honeywell claims that deployment of automated demand response reduces peak loads by 15 to 30%.

[EUR 8] For Trial B, an energy management system was developed that was able to test the automated response of household devices and also consumer behavior on variable electricity prices. The hardware aspect of this consisted of a core processor called "Energiebutler" (newly developed for this project), alongside the smart meter, data storage aggregator and some switchboxes. A web portal allowed consumers to monitor the functioning of Energiebutler.
A new software platform for the energy management system was also developed – OGEMA. This allowed loads and generators of the consumer to be linked to the control stations of the smart grid, and also provided a user interface for local control capabilities.
In general the design of the local controllers and home energy management systems (both hardware and Web Portal) should foster the interaction between the consumer and their awareness of cost and consumption of electricity, and hence make it more acceptable for consumers to have such technology in their home.

[EUR 10] One of the major achievements in the project was the design and implementation of the Agent Scheduler & Controller software. The scheduling algorithm behind this system can only optimize consumption if it has exact knowledge of the behavior of the devices it is connected to, or at the least the energy load curve related to the behavior. However because no common standard has been adopted in white goods behavior, each appliance had to be configured independently making installation a difficult process.

The complexity involved in optimizing home energy was also found to be very tricky due to the large number of factors involved in the behavior of connected devices: different modes of operation, different consumptions per mode, different times and constraints in each state. This is an even more complex problem when the various energy tariffs, different generation forecasts, different energy forms (electricity and hot water) and human behavior are taken into account.

Because currently white good manufacturers are not willing to provide full remote control functionality of their appliances (as pausing/delaying operations may influence quality of the provided service and hence their product quality and reputation), it was recommended that to begin with remote control scheduling functions are limited only to program start activity. In doing so only the starting time and mode of operation is chosen by the scheduler with actual operation of the device and performance left to the manufacturer. Although this is not optimal, it is at least an intermediate step towards adoption of home energy optimization.

The report also suggested the improvement of forecasting programs to improve accuracy and usability within the optimization algorithm. Even with these improved forecasts another problematic area is the unpredictability of the end-user, who may easily disrupt any forecasted schedule – meaning it has to be recomputed every time a major change occurs. It was suggested that in order to take into account such potential disturbances to the schedule, schedules which are slightly less optimal could be chosen which need very little modification and so are more stable. This is likely to lead to greater end-user acceptability.

Whilst the home energy management system developed in this project was trialed with success, it should still be considered a prototype. There are still issues such as self-healing functions (being able to detect malfunctions and automatically run correction procedures) and self-configuration capabilities (ability to add new devices to the system easily without complication) which need to be addressed in future developments.

1.1.2.6 Control strategy and priority strategy

[UPDATE 1] Address develops new trading mechanisms and algorithms to enable active demand in distribution networks. Software interfaces have been developed to control air conditioning and electric heating systems.

[AP 2] Their aim is to introduce renewable energy to 64% of participating households, and to manage generation and demand with HEMS in houses and BEMS in apartment buildings.

[EUR 8] Trial C tested congestion management as well as support for islanding/black starts was tested with the use of the MAGIC (Multi-Agent Intelligent Control) – JAVA based software which implements intelligent agents.

For congestion management purposes, the intelligent agents monitored the system and provided other agents and the aggregator with data regarding the system such as consumption and production levels, voltage levels etc. The system also provides a list of loads that can be shed. The operation of the algorithm on the MAGIC system showed that the system was able to predict a disturbance such as an overload before it occurred and take action (unlike a simple algorithm which would only react when the overload is actually detected). A warning time of 15 minutes was enough for the system to respond and prevent any disturbance.

For the purposes of islanding, a load shedding schedule is created based on criticality of consumption loads and also consumer willingness to pay for operating an appliance during island mode. It was seen that with a smart energy management system such as MAGIC, extensive load shedding of one or more houses did not need to take place (unlike a simple algorithm in a centralized system which can only monitor total consumption and only has the ability to carry out a generalized outage of house/houses). Through the use of forecast modules for PV and data regarding appliance consumption, then even in islanding scenarios a certain level of comfort was possible for home owners.

[EUR 10] The BeyWatch Supervisor (operating on a neighborhood level) was an independent application which remotely interacted with a large number of Agents (home level). The feature set of the Supervisor and the Supervisor/Agent interface was informed by a conceptual model of a Monitoring and Control System which was then implemented and successfully integrated with the rest of the BeyWatch system.

There were two key concepts in this monitoring and control system:

1. Hierarchical Propagation - incentives/counterincentives for the purposes of Demand Side Management were propagated hierarchically according to spatial scope i.e. from regional level, to neighborhood level, to homes and then finally to appliance level.
2. Semantic translation - the incentives/counterincentives being propagated needed to be ‘translated’ so as to be consistent with the scope of the hierarchical level. For example:
   a. A request to lower demand in a geographical region is translated to...
   b. ...multiple requests to lower demand in various cities/neighborhoods which are further broken down to...
   c. a set of incentives/counterincentives which are unique for each home and influence the scheduling algorithm which is...
   d. affected by scheduling of household appliances and modification of their operation.

A contract-meta model was also implemented to place constraints on the variation of critical contract parameters, thus enabling demand-side management measures within the limits specified by a contract. The Supervisor is consequently able to send various waveforms to the Agent specifying contract parameters such as the price or power ceiling constraints over time and thus able to influence the scheduling carried out by the Agent for DSM measures.

It should be noted that the trial of this system was in a controlled environment and so a real trial would require the active participation of consumers with a national grid administrator. Also security/privacy issues would need to be addressed through additional enhancements.

Meso level

2.1.2.1 Controlling charging of electric transport

[UPDATE 6] Only externally controlled charging is considered appropriate in the future. They are working on a mixed strategy, between cost minimization, grid stabilization and other criteria. The algorithms are still being developed including driving pattern generators. The establishment of a smart-charging enabled infrastructure is a necessary fist step. Studies on the impact of fast charging on the grid and selection of locations, report delivered: *case studies of grid impacts of fast charging* and on the design on fast charging stations in *concept study on fast charging station design.*

[UPDATE 11] The project shows the possibilities of transportable storages.

[UPDATE 17] A small fleet of electric vehicles is managed remotely for charging and for generation. In the proposed system, the vehicles are considered as loads that can be managed, but also as small sporadic generators, responding to the needs of network operation. This topic is handled in WP 12.

[UPDATE 18] Demonstrating and testing of electric cars will also be part of this pilot project. The aim is to: measure charging patterns with typical family use of the vehicle; test the EV as another form of storage to provide peak power; trial and evaluate potential metering options for EV's to charge outside the home and still be billed.

[AP 1] The outcomes of this project will help to determine in which way the charging of EV's could be controlled. During the trial technical solutions such as public and private charge points are investigated. Furthermore business models will be tested that allow for the control of vehicle charging times, to avoid the peak.

[AP 2] This project includes 2,000 EVs and both normal and rapid charging devices. With such a high number of EVs in this project, although not explicitly mentioned, charging strategies must be part of the project or at least result in them.

[AP 5] State Grid has finished writing 6 industrial standards like Electric Vehicle Charging Station General Technical Requirements, Electric Vehicle Charging Station Design Guidance, Electric Vehicle Charging Station Power Supply System Standards. State Grid compiled Electric Vehicle Charging and Discharging Facilities Construction Guidance to standardize the building technology, equipment installation and intellectual supervision of the stations, basically solving issues appeared in the pilot projects, and creating a positive environment for a successful development of the charging stations.

State Grid created various standards for EV charging stations from 2009 to 2011, but all of them are Chinese version. Recently 4 unified standards were released by the National Ministry of Industry and Information, they are "EV conduct charging connection device part I, II, III, communication protocol between battery management system and EV charger (not vehicle mounted), from 2010 to

2011. About 25 EV charging standards were issued by state grid and southern grid. State grid prefers swap stations to exchange EV batteries, whereas southern grid prefers battery charging. There are 2 different concepts and development directions. At this moment, the general trend is to go along the swap station direction, as State Grid is the largest stakeholder.

[EUR 6] The MERGE project concludes that large scale EV deployment requires the adoption and the development of a new set of concepts, and control / management architectures in order to minimize the need to reinforce the electrical generation, transmission and distribution infrastructure. The adoption of controlled charging strategies involving the adherence of the new consumers to this concept is fundamental for the success of EV deployment.

EV grid interfaces need to be enhanced in order to help local control of the participation of EV in delivering ancillary services to the power system. This can be performed by installing additional functionalities on board of EV or by installing these functionalities at the EV point of connection. This requires the update of the existing standards on the charging of electric vehicles.

Charging power levels of the power interface need to be determined as well as the power transfer form, which can be either AC or DC. The power transfer technology which may be conductive or inductive should be decided. Furthermore, safety functions to be implemented such as ground fault interruption, proper connection interlock and immobilization of the vehicle while charging need to be specified.

There is also a need for standardizing the means of communication between the involved entities in the charging process. The payment methods for charging electric vehicles should follow standards.

There are five main entities which, depending on the charging scenario, may need to communicate with each other. These entities are: the user, the EV, the charging point, the DSO and the supplier/aggregator. The information to be exchanged with the EV depends on a number of factors. These factors include the location of the charging point, the level of sophistication desired for charging and the business model into which the EV is to be integrated.

2.1.2.2 Using CHPs for the operational management of grids

[UPDATE 1] Heat pumps are installed in a suburb and are being monitored.

[UPDATE 2] In this project on load management, local small-scale generation was used to help regulate the voltage magnitude.

[UPDATE 8] CHP was considered as one of the DER units. The historic background anticipated that domestic small-scale generation would be common in the Distribution Network, but as it did not appeared, a municipal authority with significant CHP capacities was used, alongside simulated domestic DERs.

[UPDATE 14] This project is successfully used CHP as grid support.

[UPDATE 19] For the operation of the residential CHP-units a Central Control System (CCS) was developed. This CCS communicates with the on site Energy Manager and allows the utilities to control the micro-CHPs in the case of a power peak demand and defined load profiles. The load profiles were sent by using wireless technologies as the mobile phone standard GSM and the radio ripple control.

[AP 1] A total of 25 fuel cells and five wind turbines will be installed on the grid and at homes to test distributed generation. A virtual power station trials will be performed as well, the usage of these CHP units for the operation of the grid will be analyzed as well. From the available information it is not yet clear how the dispatch will be coordinated.

[EUR 11] One of the major components within each cell in the field tests were the CHP units which were gas engine or gas turbine driven synchronous generators. These were used in conjunction with an exhaust boiler for district heating purposes. The synchronous generators were all equipped with Speed Governing Systems (SGS) and Automatic Voltage Regulators (AVR). A SCADA system using the Omron specific protocol is used to communicate with the Cell Controller. Using this it is possible to enter external signals into both the SGS and AVR to allow the set voltage and frequency settings to be dynamically changed.

During islanding operation, generally the 1 MW Secondary Load Controller (SLC) within the substation was used to absorb active power transients of magnitude 400kW. However when these transients could not be filtered by the SLC, then the online CHPs could be used to absorb this excess.

2.1.2.3 Safety of remote switching

[UPDATE 18] One hundred Home Area Networks will be installed to provide real-time information on energy consumption of individual appliances and remotely monitor and control appliances online, including air conditioning, hot water systems, solar power systems, lighting, and entertainment and laundry appliances.

[AP 1] In 20,000 homes, new in-home displays and products will be installed. This includes 2,000 'smart homes' where households will be able to turn appliances on and off remotely using websites and smart phones.

[AP 6] The installed equipment manages energy supply and demand and automatically adjusts electricity consumption. Automated Demand Response puts in place an automatic system of technology checks and balances taking into account peak hours and higher electricity prices.

Macro

3.1.2.1 Integration of wind energy

[EUR 7] Of increasing importance is not just the question of the quantity but also the quality of the renewable electricity generated. In interaction with and in the transition from conventional to renewable power generation, the new energy systems must not just contribute to power supply security but also participate in the provision of so-called system services. Modern inverters permit of very diverse methods of in-feeding into the grid to accurately target the requisite phases of alternating current. They do not just generate active power but can also compensate reactive power as a major condition for stable overall operation of a supply system with a large number of highly volatile producers and consumers. The project is still looking into whether this can provide an economic solution. At present, the costs for this kind of solution are 45 % higher than the conventional method of reactive-power compensation. The picture is different, for example, if compensation is demanded exactly at the time of maximum inverter output. These modern inverters can only be used to full effect if they are interconnected and are instructed accordingly to provide power at exactly the right place and time.

Another conclusion is that supply and demand can be balanced with more ICT at balancing group level. The transportation of high wind power surpluses remains a problem at transmission grid level. Depending on local grid state, the most cost-effective variant (smart grid ICT in the grid or at the grid margin, storage or transport) needs to be optimized.

D.1.3 - Information

Micro level

1.1.3.1 Registration of user information

[UPDATE 19] In this project also a web-based system was installed at the central control system to give all the project partners access to the measured data from any location via the internet. The status of the system could be checked, the error message in case of a downtime and the operational mode at one glance.

[EUR 8] It was seen from Trial A that a lot of time was lost on the request processing time of each meter reading, inside the application server. This suggested that the application server load should be balanced over multiple nodes. Further efficiency enhancements suggested include using a meter data concentrator to collect meter readings and submit them in bulk, or the usage of in-memory databases.

1.1.3.2 Development of means of communication with households

[UPDATE 1] There is a (confidential) technical guide for building up a smart grid telecommunication infrastructure supporting active demand.

It was recommended that although hourly metering values may be sufficient enough for monitoring consumers for the purposes of Active Demand, a higher resolution would be necessary for a more thorough analysis of consumer activity. Thus metering still poses a barrier for AD implementation.

[UPDATE 15] Two implementations of the IEC 61850-7-420 standard have been applied. The first one includes several extensions to incorporate other equipment not included in the standard (namely controllable loads and measuring devices) and an alternative communication protocol (XML-RPC). The second one forces the standard data model into mapping each particular variable of one commercial PV inverter while adhering to the original MMS communication protocol.

[UPDATE 18] In this project one hundred Home Area Networks will be installed to provide real-time information on energy consumption of individual appliances and remotely monitor and control appliances online, including air conditioning, hot water systems, solar power systems, lighting, and entertainment and laundry appliances, Also two 4G antennas to provide a two-way wireless communication network have been deployed.

[AP 1] Continuous engagement with the customer is one of the goals of the project. This will be done through a website, an energy portal, the information center, energy audits, workshops, mail outs and off course via the meter. The meter will be connected through a 4G LTE/WIMAX network.

[AP 4] In this pilot several communication networks will be evaluated, such as fiber-optic cables, Wi-Fi or radio frequency. This will influence the related communication technologies as well.

[EUR 1] Trial 4 showed that the Micro-CHP units could be remotely managed by an aggregator via a controller communicating through a GPRS connection. It found GPRS to be very reliable, with an availability of over 99%. Very few data points were lost during the entire operation of the 10 sites, even with data collection being conducted every minute.

1.1.3.3 Conversion of measurement data

[UPDATE 19] For the operation of the residential CHP-units a Central Control System (CCS) was developed. This CCS communicates with the on site Energy Manager and allows the utilities to control the micro CHPs in the case of a power peak demand and defined load profiles. The load profiles were sent by using wireless technologies as the mobile phone standard GSM and the radio ripple control.

[EUR 8] One of the goals of Trial A was to show that the automated control of one million households was possible, and so allow a balance responsible party (BRP) to control demand and supply of household appliances to optimize overall balance within a settlement period.

In order to take in the huge amount of measured data, two levels of Concentrators were used to take information from the Smart House Gateway Level to the Enterprise System which acted as the central optimization unit. Whilst some of the smart house gateway outlets came from the existing test field in Hoogkerk, and another concentrator took information from 100 real smart meters, the remaining concentrators took information from agents mimicking households in a virtual PC environment.

In one of the experiments, each concentrator was receiving meter readings at a rate of 60 readings/second. In line with current smart grid industry practices, each meter under a concentrator sends its current reading every 15 minutes. Hence this would allow for 54,000 meters to be connected to each concentrator. The Metering Data System performance peaks at 66 concentrators, and therefore with a meter reading interval of 15 minutes, 3.6 million meters can be used in such a configuration. Of course if the interval resolution was reduced to 1 minute, then only 240,000 meters could be connected.

1.1.3.4 Information collection on dispersed generation

[UPDATE 8] Distributed energy resources are aggregated into large scale virtual power plants. Basically, all types of ancillary services can be provided by controllable DER units.

[AP 1] Depending on the location of the decentralized generation, it will be supplied with a smart meter that communicates the generation and status of the installation.

[AP 4] Management systems for distributed energy sources are one of the components that are researched in this project and enable the grid to integrate the increasing number of small and variable sources of power, for example, from solar photovoltaic (PV) systems and mini co-generation plants. They also cater to the future possibility of large numbers of electric vehicles connecting to the grid, both to draw electricity from the grid and also to supply electricity to the grid during periods of peak demand.

[AP 7] Households are equipped with distributed solar power. Through the distributed solar power generating management system, the facilities offer the family the options to choose low-cost electricity, level the electricity consumption amount between peak and low hours, and reserve electricity for emergency use.

[EUR 7] To a certain extent, renewable energy systems can deliver system services (balancing power, reactive current compensation, etc.). The legal framework, however, affords little scope for efficiency. Also in 3.1.2.1 the communication with renewable intermittent energy sources is mentioned in relation to reactive current compensation.

Meso level

2.1.3.1 Information system for generators and high loads

[UPDATE 8**]** New hardware components and software applications were developed that realized the VPP concept.

[UPDATE 17**]** WP 6 implements network intelligence within the medium voltage segment. It is based on the development of a distributed system consisting of a variety of devices. A controller located in the high voltage substation feeder coordinates the functions of monitoring, protection and energy control of all the devices in the network.

[EUR 4**]** Integration of new active devices into the existing distribution automation and IT systems is an important issue. It is not possible to replace the whole automation and IT system at once therefore active network and ANM requires continuous evolution instead of a revolution. The integration of active devices into automation and IT systems should be based on open interfaces and standardized protocols in order to ensure easy integration of all kind of devices and systems without replacing the core parts of automation and IT system every time a new functionality of ANM or a new active resource is connected to the automation and IT system.

[EUR 11**]** The cell controller has been designed such that each cell can be combined with other cells to comprise the grid area covered by DNOs (and even TSOs). For each individual cell a layered control hierarchy is used, with the utilization of distributed agent technology and a high speed network (see Figure 13 for the hierarchy structure).

Each agent is either an industry central processing unit (CPU) a high-end remote terminal unit (RTU) or an intelligent meter depending on the level at which the agent is found. The agent is an independent unit authorized to control a group of sub-units. It can act independently, according to rules or according to orders received from superior agents.

As it is necessary to maintain continuous communication with substations and assets for monitoring the system and issuing commands, a communications method compatible with the DNOs existing communication system must be implemented. In this project a wide area communication systems consisting of DSL, GPRS and fiber communications was used, with CHP and wind turbine sites being retrofitted with communications capabilities.

[EUR 12**]** The initial development of the VPP architecture was custom-made to match the functionality of the IT systems it would be interfaced with. The workflows (e.g. a workflow for converting consumption flexibility into bids for price-independent base load) were developed to comply with external systems. These external interfaces were time-consuming to integrate with due to strict IT security regulations. Highly specialized systems at Balance Responsible Parties were also difficult to integrate with. It should also be noted that the VPP was made according to agile development principles and the need for portability (to other market structures outside Denmark).

Using lessons learnt from the first VPP system, the next iteration of the architecture is intended to be a much more flexible and robust solution. It is expected the future architecture will be more modular (enabling increased flexibility and updates without affecting the rest of the system). Low coupling is expected between modules with interfaces between modules being built on standardized communication protocols. This will allow easier third party module integration.

In terms of scalability issues, it was seen that the Triangle Microworks SCADA Data Gateway presented a barrier for implementation as each server running the software can only accommodate 60 Local Units. The suggested solution was to implement more servers in a cluster environment.

[AME 3] In order to coordinate the DER in this project, the 'Bluefin platform' was developed by one of the project partners which acted as a Network Operating System for the DER. This privately-owned operating platform allowed the necessary communication and control infrastructure to interface with existing Building Automation Systems (BAS) and SCADA systems already being used by the utility and site partners. Each site partner was equipped with a Gateway (Bluefin embedded) PC that acted as a communication and control portal to the existing management infrastructure.

The Bluefin platform was implemented in such a way that each of the participating partner sites retained ultimate control of their DER asset. The partners were able to set the availability of their assets so as to decide whether to take part in any peak reduction events that could occur in a given day.

In this project, introducing a communications method which was separate from that of the utility and of the site partners systems added an extra layer of complexity. One of the lessons learned through the implementation of the IT systems in this project was that the long term objectives of an interfacing and communication system should be aligned with aim of the project and that this should be clearly defined and communicated to all participants. For example, interfacing specifications are critical to effective operation of the overall system and must be clearly understood by all participants.

Additionally, it is important that DER-site partners have confidence in the demonstrated capability of the control software. This is because they likely have other operational responsibilities, and want to have a seamless integration with this software without any disruption to normal operations. For this it was recommended that a prototype of the control software is made available for partner review in early stages in order to identify any potential problems which need to be rectified for successful integration.

2.1.3.2 Effect of high penetration of local generation

[UPDATE 15] In this micro grid several PV solar systems and a diesel generator are connected. The effect of high penetration of decentralized production capacity has certainly been tested in this set up. Integration of multiple micro grids into the operation of a decarbonized power system requires radically new control and management structures and practices to enable the interface with the upstream distribution management system and the operation of coordinated, but decentralized markets for energy and services. Specific new software tools and simulation approaches have been studied.

[UPDATE 16] The Orkney Isles are an area of abundant renewable energy resource with several wind farms and is connected to the mainland network by two 33kV submarine cables. In the Orkney project more than 15 MW of new wind capacity is added, made up of more than 13 turbines.

[UPDATE 18] The home will showcase super efficient appliances and equipment, localized electricity generation (including solar PV, gas fuel cell and electric vehicle technologies) and energy storage solutions.

[AP 1] The effect of an increased penetration of distributed generation devices on the grid will be tested. In this regard there are three key trial locations: Newington, Newcastle and Scone. Newington can be characterized as "suburban saturation" with a high penetration of solar PV and storage. Newcastle is simulated as the "smart future" with distributed storage, solar, fuel cells and small wind turbines. In Scone a "rural micro-grid" contains some generation plus a high level of distributed storage and a micro-grid controller to enable no-break islanding.

[EUR 1] Increasing DG implies a change in the operation and design for the distribution system. Although current margins in voltage, flow, fault current etc. allow some DG to be integrated, active management will allow for further increases. In order to increase 'DER hosting capacity' of the network, new design criteria may need to be developed so that curtailment can be avoided as much as possible. A 'flexible-symmetrical' design was proposed in the EU-DEEP project which allows for increased hosting capacity by sharing the voltage range between generation and consumption depending on their 'footprint'.

[EUR 11] The high amount of DG in the Western Danish Power System has caused security problems (with regards to maintaining n-1 security), and this would be likely to occur for power systems in other countries such as Netherlands if local generation begins to exceed local demand, and the separation of generation and consumption is insufficient. With high DG penetration security analysis becomes less accurate due to lack of information about local generation and unpredictable wind power. Additionally traditional under-frequency load shedding schemes will disconnect both load and generation, and restoration after faults will become more time consuming.

It is envisaged that as the amount of DG on the network increases, there will be an increase in opportunities to define Cells to which coordinated control can be deployed. Using the Cell Controller in areas with high DG will lead to many benefits for stakeholders at all levels. For the DNO it will allow an increased ability to maintain control of the network (in terms of voltage control, load restoration etc.) with a large amount of DER.

One aspect which was not developed through this project was load-shedding functionality which would be important to consider for the purposes of an even more robust islanding-capable system.

[AME 6] As the network is designed for peak load and capacity requirements (per current requirements) the use of Distributed Energy Resources and Plug-in Hybrid Electric Vehicles (PHEV) storage offers no capacity deferral as intermittency leads to unreliable power generation during times of peak load. However it was concluded that the situation may change if there is an increase in PV solar and distributed storage. Another danger seen was that the Distributed Generation could ‘mask’ true system demands, and at high DG penetration levels decisions of the Distribution Control Centre would be further complicated. This could affect reliability levels.

2.1.3.3 Effect of heat pumps on the electricity grid

[UPDATE 14] Heat pumps are integrated in the grid and monitored.

2.1.3.4 Determining the effect of electric vehicles on the grid

[UPDATE 6] The impact on the medium voltage network has been analyzed in the EDISON report “Power Quality in Medium Voltage Network”. Short-circuit level at the point of interconnection is very important for the value of harmonic distortion. Sufficient short circuit-level must be available also for fast charging.

[UPDATE 17] A small fleet of electric vehicles is managed remotely for charging and for generation. In the proposed system, the vehicles are considered as loads that can be managed, but also as small sporadic generators, responding to the needs of network operation. Possibly also the topic of the impact on the grid will be dealt with in WP 12.

[AP 1] Electric car trials using 20 vehicles are performed. It involves 50 standard charging points and 6 fast charging points spread over the test area. Several aspects will be tested, such as the impact on the grid and the environment, when and where do drivers charge their cars, and for how long, what is the impact during peak demand and the way the community respond to EV's.

[AP 2] With 2,000 EVs in this project, one of the aspects that will get clear is the impact of EV on the grid.

[EUR 6] The analysis of MERGE shows that with a 10% of penetration of electric vehicles using a dumb charging strategy (with no smart control of charging) and all vehicles charging as soon as they return from their last journey of the day, the daily peak demand levels would increase by between 6% and 12% compared to the baseline peak demand and that the peaks would occur at a different time to that of the baseline peak demand. The analysis shows further that a 10% penetration of electric vehicles, with an ideal smart charging strategy with all EV charging load moved to the night-time valley periods, would cause no change to the baseline peak demand levels. In addition, the peak EV charging load is also reduced, unless the charging is already spread over a long period of the day. The daily variation from minimum to peak demand was shown to increase significantly for the dumb charging scenario and reduce significantly for the smart charging scenario.

D.2 - Policy & regulation

D.2.1 - Responsibilities & tasks

Micro level

1.2.1.1 Clarity about the role of the system operator with regard to the communication to households

[UPDATE 4] This project managed the Quality of Supply responsibilities in the new situation with distributed energy sources.

[UPDATE 6] Mapping of congestions in the distribution grid, geographically differentiation of end-users, pricing through compensation mechanism, and developing new tools for including price dependent demand are obstacles to be overcome before distribution grid congestions can be handled in a new manner.

[AP 1] Several potions for feedback technologies will be tested in the project and depending on the possibilities, the possible role of the DSO will be influenced as well. The aim is to provide customers with additional information to allow them to manage their energy more efficiently. In the demonstration project this sharing of information with customers needs to be tested. This could be a challenging aspect, especially in areas where there is retail competition.

[AP 7] China has a highly integrated industry on the transmission and distribution side. The State Grid Corporation of China (SGCC) controls the T&D network and coordinates smart grid developments in China.

[AP 8] KEPCO is the transmission and distribution company of South Korea. KEPCO is the responsible authority for the upgrade of the transmission and distribution system and switch meters. The company plans to invest USD 7.2 billion in smart grids by 2030.

1.2.1.2 Clarity about the role of the system operator in the framework of electricity storage

[UPDATE 8] Carrying out technical VPP activity requires detailed local network knowledge and control capabilities, so the DSO will typically be best placed to fulfill this role.

[UPDATE 9] The project does not yet provide conclusive information as to whether fly wheel storage is more likely to become a DSO controlled asset or a producer's asset. Limited storage volumes suggest mainly frequency control purposes.

[UPDATE 15] One of the main components of this micro grid in island mode is the storage system that is located in the grid.

[AP 1] In the project most storage capacity is located on host customer sites (5kVA, 2 hours storage). However also some grid connected storage is anticipated in the Scone Trial Environment. The size is to be determined based on micro grid design requirements.

[EUR 9] The intelligent use of conventional storage devices (pump storage, batteries) affords scope for short-term load balancing in a balancing pool. For long-term buffering, other storage technologies need to be used (e. g. production of hydrogen or methane and storage in the gas grid).

Meso level

2.2.1.1 Institutional recalibration of tasks and responsibilities

[UPDATE 6] New Grid Codes together with common standards should enable the use of the full potential of EVs delivering ancillary services to the overall power system, and ancillary services to the local grid. Developing grid codes for EVs could very well be based on the German experience with PV systems as the EV's chargers approximately have the same characteristics as the PV inverters.

[EUR 1] It is expected that the introduction of DER and flexibility will mean customers should no longer be treated as simply consumers, but instead co-producers and even co-providers of energy services. This will in turn mean they will expect an 'equitable share' of flexibility costs and benefits between them and the energy supplier.

[EUR 6] When operating the grid in normal conditions, EV will be managed and controlled by different aggregation layers. In case of abnormal or emergency situation, the DSO takes control in order to handle violation of grid operational restrictions.

A new set of agents, like the supplier / aggregator is envisaged to help manage the integration of this new type of consumers - the EV batteries. This should also be done by exploiting smart metering infrastructures that are presently being deployed. In addition, it is very important to understand that in the future, DSO's will have to play a critical role in this new scenario, by validating the EV batteries' charging profiles before the aggregators present their biddings on EV consumption needs to the market.

[EUR 12] All units participating in the ancillary services market in Denmark are required to have an on-line measurement of current production or consumption. The DSO is responsible for providing and operating the on-line measurements. The problem that must be overcome is that only a few DSOs have standardized solutions for these measurements, which leads to longer lead times and higher costs for the VPP project. To overcome this, the project worked with the DSO (DONG Energy Distribution) to allow the VPP to act as the meter operator for on-line measurements. It would be necessary to extend such an agreement to other DSOs as well in the future.

Current regulations for participating in the Danish ancillary services market require that each local unit must be tested on minimum power, linearity, response times and durability criteria. This will become impractical if more and more units participate, and also redundant if the units are aggregated together with other units. The report suggested setting up methods of verification and proof for ensuring the aggregated capacity can be offered can be delivered at all times, and also that the flexibility of non-compliant or partly-compliant local units are put to full use.

2.2.1.2 Notification obligation of generators and high loads

n/a

2.2.1.3 Regulation for heat pumps

n/a

Macro level

3.2.1.2 Modification of grid regulations for innovation

[EUR 3] The question how to incentivize (CAPEX intensive asset) innovation in a smart grid context is discussed cursorily in academic literature and experiences mainly come from the telecom sector. The overall conclusion from theory is that it is challenging to anchor adequate regulatory incentives to enhance dynamic efficient investments and there is a void regarding the role of dynamically efficient investments in grid-bound energy supply.

Furthermore it is concluded that incentive regulation does not sufficiently stimulate dynamic efficiency in the sense of explicit regulatory stimuli for asset innovation leading to a dynamically efficient CAPEX allocation. There are complex regulatory trade offs between incentives focused on productive efficiency and incentives focused on dynamic efficiency; this is a regulatory dilemma.

The UK was the pioneer with RPI-X (price-cap) regulation since 1990 with a focus to increase the efficiency. On top of this price cap there is a regulatory allowance for R&D and demonstration projects. RPI-X was successful in raising the efficiency, but there are doubts whether it is "fit for purpose" in relation to the development of smart grids. The regulator in the UK (Ofgem) has introduced a new performance based model "RIIO" which is still based on RPI-X but with new regulatory features such as revenues and outputs, business plan review, extension of regulatory period, holistic and time-limited innovation stimulus and investments in a long term context. In this setting the DNO is supposed to set out an investment strategy with a well justified asset strategy, consider alternative options (OPEX/CAPEX compromise) and thorough considerations of investment implications above 8 years period. Especially the review of the business cases makes this a heavy handed approach.

In Italy there exists price cap regulation since 2000, in which the X factor only applies to the OPEX and the CAPEX is treated separately. There is an R&D component in the network tariff and an increased WACC for awarded demonstration projects. This a light-handed pragmatic approach but with a risk for demarcation problems. Overall it should be concluded that pragmatic solutions have a priority but critical and continuous reflection whether the regulatory scheme is still "fit for purpose" is required. In the longer term it is important to consider new market designs and governance options for the future energy system.

Output-oriented regulation creates indeed better incentives for effective and efficient R&D. However, the outputs of R&D measure as little, as it can be considered in the regulation. It makes sense therefore that a limited budget for innovation to get reimbursed by the operator at least a portion of R&D costs (investment budget). This raises the question whether innovation should not be addressed outside the actual incentive regulation. There is some more recently in Britain with a fund practices ("Low Carbon Network Fund" or "Network Innovation Competition"). Here, all network operators to apply for the funding of innovative projects from a fund fed by all network users. Which projects are selected, is not depending on how they contribute to the implementation of political goals. A combination of both options seems optimal: Each company receives a limited budget for network innovations that can be used for example for the continuous development of knowledge in R&D. Who wants to go further, for example, to test new concepts and innovative network operating in network technology pilot and demonstration stage can be used to request additional funding from the Innovation Fund.

The division into innovation budget and innovation fund has the advantage of on the one hand that from the innovation budget all companies get access to R & D funds, and thus the need for innovation is indicated. On the other hand, the investment budget can have a more limited scope and particularly the innovative companies with major innovation project plans can also apply for the Innovation Fund.

Because Smart Grid innovations also serve not only the efficiency of the individual company, but the development of the whole system, it should not be funded the same way as the innovation budget (through the customers of individual operators) but it should funded through the rates of all network users. This then results in the obligation for companies to publish results. In contrast to existing programs of research support the Fund could be managed by the regulatory authority, which will thereby be assigned a role in the strategic development of the electricity grid as well. This also changes the interface between regulatory and political process, because the main task consists not only of operating the existing infrastructure as efficiently as possible, but the infrastructure development is increasingly used to support policy objectives and is part of political discourse.

D.2.2 - Financial aspects & incentives

Micro level

1.2.2.1 Development of possible financial stimuli for system users

[UPDATE 8**]** Each commercial aggregating agent responded to incentives of both the commercial VPP it is part of, and the technical VPP that covers its grid area.

[UPDATE 12**]** The tariff structure is one of the aspects that is being evaluated in this project.

[UPDATE 14**]** During this project, it was showed that financial incentives worked as expected. End users buy electricity when the price is low and sell when the price is high, ensuring that comfort levels are maintained.

[AP 1**]** Ausgrid and its retail partner will test new time-based pricing and incentives for households to reduce power use in peak times. These pricing trials will be voluntary and may lead to insights which tariff structure to implement.

[AP 3**]** Orion has specific tariffs for major customers with loading greater than 250kVA, if they participate in the load shedding program. According to Orion the potential benefit to the client can result in significant savings on their annual electricity bill.

In the Upper North Island Reactive Support project, another project from the TSO, Transpower, lead to (too) high biding prices for 60 MW Demand Response. It turned out that requiring proponents to provide adequate demand response within a condensed timeframe and for a relatively short contract period only drives prices upward.

[AP 4**]** As electricity retailers will compete in the second phase to offer time-varying electricity price tariffs and value added services to consumers, this will lead to valuable insights in the success of several tariff structures.

[EUR 2**]** Based on a survey of 87 Swiss energy consumers, it was found that smart meter users could be segmented into four different categories and consequently be offered different incentives and reward mechanisms to create value.

- 'Risk averse' consumers represented the largest segment (34%). They chose the tariff model of 11Rp/kWh - 17Rp/kWh, with a flat rate of 23CHF/month. They were not willing to pay any premium for smart metering services - for example being able the ability to program and control consumption.
- 'Technology affine' (29%) preferred the ability to program services and had a strong interest in energy data. With regards to tariffs, this segment were willing to accept a variable tariff

(11Rp/kWh - 17rp/kWh) and a base rate of 25CHF/month and seemed confident of being able to benefit from the difference in higher and lower tariffs.

- 'Price sensitive' consumers (20%) - preferred the tariff with the lowest off-peak price, 6Rp/kWh although it had a very high risk with an off-peak price of 50Rp/kWh. Such a segment seems ready to supervise and manage their behavior in order to reap the benefits of a low-price tariff. The flat rate for this tariff model was 25CHF/month.
- Finally 'safety-oriented' consumers (17%), opted for the highest base tariff of 27CHF/month, with the off-peak - peak price from 8Rp/kWh - 30Rp/kWh. This segment placed value on monitoring and warning functions which could be included within a smart metering package.

In general customers were willing to pay a higher base fee to avoid the high tariff of 50Rp/kWh - i.e. they were willing to pay a risk premium. It was also found within the experiment customers would pay a premium of 16CHF to get their most desired smart metering product, but by the same token would require a reduction of 16CHF if the bundle did not exactly match their needs.

[EUR 5**]** eTelligence has been experimenting with various rating schemes:

- time variable rate: both the intervals and the various prices charged are fixed and communicated long in advance;
- consumption based rate: the higher the total consumption, the more expensive is each kilowatt hour consumed in that month;
- event rate: for the pre-notified time interval, extremely high or low prices per kilowatt hour are charged in response to external events.

In general, consumption based rates are difficult to convey to the customer. However, the eTelligence field trials showed that these rates in particular provide an incentive for saving. eTelligence started with simple time-variable rates. In the ongoing large-scale field trial, complex dynamic rate constructions have been added. The two differ distinctly in terms of handling and their ICT requirements. eTelligence concludes for consumption rate:

- Between June and October around 40 kWh or 13% reduction in consumption monthly for event rate.
- Between June and October 2011 during the expensive; period around 14 kWh or 12% reduction in consumption monthly;
- No statistically reliable change established during the cheaper period;
- It may be the event that is influential, not the general price levels.

[EUR 7**]** In the E-Energy program several rate scales have been tested. In the MoMa project a time-variable rate and a dynamic rate were tested. In the time-variable rate the energy price for individual rate phases is determined by day, week and month and set for a specific interval (monthly, weekly, etc.). Rate phase spreads between 10 and 60 cent/kWh. Time shift of load can result in avoidance of load peaks or consumption troughs and a possible improvement of basic load. In the dynamic rate, the energy price is based on external variables (exchange price, forecasts, residual load, grid load, etc.).

Time intervals and the prices charged are set a day in advance, for example. Near-time and flexible load shifts in response to specific situations can balance production and consumption.

The complexity of most dynamic rates precludes a manual response to price incentives, which is still possible in most time-variable rate cases. This task is performed by energy management systems, e.g. "energy butlers" in the MoMa project. The pilot projects were able to demonstrate the technical feasibility of innovative pricing schemes. There are, however, still limits to the scope for setting attractive rates. Fixed grid charges in particular pose a constraint.

[AME 1] On a summer peak day, it was observed that the system load shape was relatively flat around the peak period (4pm) – see Figure 14. This implied that simply reducing the system load at the peak hour alone would not greatly reduce capacity requirements – and that it is necessary to reduce load at all of the hours around the peak too.

It was suggested that with the current price rates that are in place, the optimum procedure on a system peak day would be to set the VPP price as High, and at 4pm call a Critical Price event. This would lead to a more continuous load reduction across the on-peak period. For the long term, it was recommended that an additional price level should be added to the VPP price structure – a ‘super-peak’ price period. This would lead to the PCTs carrying out an automated response to spread savings more evenly over the on-peak period.

[AME 5] It was seen that consumers demand at peak periods was consistently reduced when a price signal was provided. Those on the CPP plan showed a reduction of 34% in Summer and 13% in Winter. For CPR the figures were 13% in Summer and 5% in Winter.

HP customers showed a much lower reduction of 4% in Summer and 2% in Winter. The likely reason for this was because the high prices for HP were not as expensive as the high prices of CPP and CPR. Additionally due to the 2008 economic downturn, HP customers had a declining average electricity price over time.

It was also observed that customers on a low-income (who were only allowed to participate in the CPR plan) showed similar peak demand reduction when compared to ‘regular income customers’ on the CPR plan (13% and 11% respectively).

The effect of temperature increasing (from 85°F to 97°F), led to an increase in peak demand reduction. CPP consumers reduced demand from 26% to 43%, and CPR consumers from 8% to 20%. HP consumers showed no demand reduction.

The pricing structure used in the project was designed to be revenue neutral – meaning that, on average, customers who did not alter their energy usage behavior would pay the same as they would have done under the old tariff. In other words, any bill savings should be as a result of load shifting.

It was seen that on average, percentage bill savings of the CPP group was 2%, and the CPR group was 5%. Interestingly the savings of the HP group was 39%. This was due to the wholesale price decreasing during the 2008 recession (HP participants took the risk of paying the hourly pricing set in wholesale markets). See Table 13.

1.2.2.2 Conducting market research on the wishes of consumers

[UPDATE 1**]** Benefits of Active Demand (AD) from the consumer perspective that were considered in evaluating the benefits of AD include: reduced energy costs, reduced price volatility, more consumer choice and improved quality of service.

[UPDATE 14**]** Many consumers have privacy and security concerns about the type and amount of information smart devices capture. Consumers are also apprehensive about controlling their own power usage. Alleviating consumer concerns has been critical in gaining both the public approval necessary to facilitate Smart Grid transitions, and in educating consumers about the benefits they stand to reap.

[EUR 2**]** A customer survey of 497 participants from Switzerland, Austria, Germany and Lichtenstein on smart grid related preferences and knowledge was used to gain customer insights as follows:

- Consumers are highly interested in obtaining information on their electricity bill about individual consumption of domestic appliances.
- Expected advantages of smart meters strongly outweigh concerns of most respondents.
- The greatest benefits of smart metering are a reduction in costs due to increased energy efficiency, and a reduction of environmental pollution.
- Willingness for consumers to adapt behavior exists: 77.7% of consumers can imagine using their washing machine at a different time of day.
- 26.2% have concerns regarding security and privacy.
- 24.8% are concerned they will have to pay for a smart meter, however approximately 33% were willing to pay for a smart meter.

A cluster analysis was carried out based on different customer preferences regarding the following benefits and concerns of smart meters:

Benefits: improved transparency regarding consumption, reduced environmental pollution, and cost reduction.

Concerns: additional costs emerging, lack of individual benefit, and data privacy issues.

Analysis revealed the following 3 customer segments:

1. 'The supporters' formed 42.3% of the total customers used in the analysis, and represented customers who expect great benefits from using smart meters, with very little concerns regarding adoption.
2. 'The ambiguous' (33.1%) represent customers who appreciate the benefits of using smart meters but also have concerns regarding issues such as data security.
3. 'The skeptics' (24.5%) represent those who had deep concerns about smart grids and only expected to receive small benefits from their use.

A survey of 54 energy experts/management-level persons, working at small to medium sized commercial electricity consumers indicated preference for creating a 'green' image of their company, along with anticipation of increase in costs of energy and its procurement. 75% did not do take any action for peak load reduction. These points could be used in considering a business model for the B2B smart grid market.

[EUR 12**]** Customers (owners and operators of local units, and aggregators) participating with Local Units (LU) are essential for the existence of VPPs. Based on interviews and meetings with more than 100 LU owners in approximately 10 industries, it was found that the most important value propositions for VPP offerings were:

- OPEX – i.e. was participating economically beneficial?
- Image – Did outside perception of the company being 'green' improve?

Other value drivers included productivity, effectiveness, efficiency, quality, compliance and CAPEX.

Barriers against adoption included the fact that although the VPP utilized a standardized interface and control signal concept, the control technology of the Local Unit was not standardized. Thus expensive modifications in order to integrate local units into the VPP portfolio were required in some cases (e.g. 100,000 Euros for the integration of a gas turbine). This economic barrier meant that some customers were not willing to invest such an amount given the long payback time.

Another barrier to overcome was the lack of flexibility in business processes, with customer participation in VPPs being conditional on changes in operational process and staffing. Again this would cost money.

It was suggested that to overcome this difficulty, and to overcome the long time needed for analyzing different processes and possibilities for integrating units, a downstream partnering approach should be used. This approach concentrates on building in-depth knowledge of specific business domains e.g. greenhouses, wind and gas turbines, cold store facilities. In doing so the optimal value proposition and business case can be put forward to the customer, and the long time needed for integrating units can be reduced. Even with such a 'best practices' method for different types of units it is likely there would still be some complications with each individual integration case.

In cases where the controllable load did not represent a major share of total customer load, a new energy meter was required to be installed by the DSO. This is because the Danish TSO requires a separate plan for controllable load, and if the portfolio was relatively small – there would be increased prognosis errors (with the existing meter). For the customer this represents extra installation costs, increased annual fees and a longer implementation time. This is another barrier against fast VPP expansion.

[AME 4] The Excellence in Customer Engagement study observed that only a few utilities segmented their customer base when it came to messaging information about their smart grid programs. Of those that did, segmentation occurred predominantly on aspects such as the square footage of the home, credit history and average monthly bill amount. It was recommended that taking into account factors such as customer attitudes, values, behaviors, motivations, technology adoption and communication preferences would yield better results.

The segmentation study of residential US customers performed led to 5 distinct segments emerging: Concerned Greens (31%), Young America (23%), Easy Street (20%), DIY & Save (16%) and Traditionals (11%).

- Concerned Greens – are concerned and active regarding environmental issues and are knowledgeable and in support of smart grids. They are likely to be early adopters and typically like new technology. This is the most likely segment to participate in energy efficiency and smart grid programs.
- Young America – is a segment concerned about environmental issues, and think energy efficiency is important but has a low likelihood in participating in smart grid programs (although they are interested in using information from a smart meter for energy management purposes). Educating this segment about smart grid products and programs should be considered as the primary purpose of communication. This can be considered as a long term development opportunity, as they are likely to become homeowners later on.
- Easy Street – have the highest income of any segment, but are unlikely to exhibit interest in energy management or change in behavior. Simplicity and ease-of-use are important to acceptance. Additionally communication should emphasize environmental benefits and stewardship for future generations.
- DIY & Save – this segment wants to save energy, largely due to the money-saving benefits. There is a low level of interest in environmental benefits. Smart grid program communication should emphasize saving money and opportunities to leverage DIY interest and experience (84% of homeowners like ‘to do it themselves’ to save money).
- Traditionals – are predominantly an older segment of the population and are the least favorable towards smart grid programs, and have a low interest in environmental or energy management issues. This segment is not likely to be a high priority for initial smart grid programs. Any messaging is recommended to focus on privacy issues and smart meter accuracy to offset any concerns with the technology.

[AME 5] A focus group was conducted to observe consumer preferences before they were recruited on to the program. It was seen that the most popular price tariff was the CPR option due to its simplicity and no-risk aspects.

After the collection of all billing data from the project had been completed, participants were surveyed about the program. Overall 93% of participants preferred the pricing regime in PowerCentsDC as opposed to the default Standard Offer Service pricing normally offered by Pepco.

[AME 7] Participants were asked to rank a list of smart grid benefits in order of perceived value. The results were as follows (with 1 being the most important and 8 the least):
1) saving money on your electric bill;
2) reliability of electricity services to your home;
3) increased information to control your energy use;
4) environmentally friendly energy options;
5) knowing when my home systems are functioning properly;
6) home security – remote knowledge of what's going on in your home;
7) reduce need to put up new power plants;
8) reduce need to build new power plants.

In order to communicate benefits that resonate strongly with consumers, it was recommended that benefits should be focused on the individual first, and then to the environment and wider community.

To further validate such findings, in the quantitative study 1,000 respondents were asked to decide on specific benefits of smart grid technology, and rank the benefit as 'extremely useful', 'very useful', 'moderately useful', 'somewhat useful' or 'not very useful'.

It was seen that 64% of respondents thought that knowing 'how much electricity you use, when you use it and how much it costs before receiving your monthly bill', was at least very useful. 58% of respondents though that 'owning intelligent, energy-saving or energy-producing devices that share energy and information with the grid', was at least very useful.
The main motivations of consumers for participating was put down to be saving money (73%), reducing emissions (34%), exploring Smart Grids (33%) and assisting policymakers (32%).

The main actions consumers undertook to reduce demand in peak periods was avoiding the use of certain appliances (60%) and reducing the use of air conditioning (59%).

1.2.2.3 Review of basis for invoicing

[EUR 6] The MERGE project shows that there are two factors driving the decision of which payment method to use. One is the ease of implementation for the supplier or aggregator, the other is the ease of use for the user. For most of the non-domestic locations, the Pay-as-you-go is the simplest system to both install and use.

Meso level

2.2.2.1 Comparison of cost of Smart Grid and conventional grid

[UPDATE 1] The reduction of network losses and of network investments due to the implementation of Active Demand was quantified for different scenarios in Germany and Spain. It was seen that total network investments for most network components in peak reduction scenarios decreased compared to the reference scenario. Additionally monetary reductions were greater in Germany than in Spain. Reduction in network losses varied from country to country and on the scenario considered – ranging from 0.64% to 5.14%.

[UPDATE 12**]** During the project a special focus is on a cost-benefit analysis. Aspects that are taken into account are energy efficiency, reduction of technical and commercial losses, reduced meter reading and other operational costs, improved quality of technical and commercial service, reduced maintenance costs, and the integration of EV and micro generation to the grid. In the preliminary results the operating benefits such as reduced reading and operation costs have been confirmed. For future evaluation a crucial variable will be the energy efficiency of the consumers.

[UPDATE 16**]** Large investments in additional transport capacity to the mainland have been mitigated by applying demand response. It should be noted that this is a special situation as the project is located on an island, which requires high investments to connect to the mainland.

[EUR 5**]** Considerable changes will occur in energy sector overall. In the unanimous assessment of the industry, the ICT-based smart grid and smart home applications above all will generate a gigantic market. Besides the advantages for individual actors, there is also the economic issue of the benefit for the overall system: What costs and CO_2 emissions can be saved through smart, decentralized flexibility? Model calculations in eTelligence indicate that these savings will increase substantially in future with a larger ratio of volatile renewable energies.

[EUR 11**]** Although no detailed costs were provided regarding this project, it is important to note that the solution was designed and developed so that it could be scaled and replicated on a large scale to other areas in Denmark in a cost-effective way. For this purpose, the design of the cell controller was such that it utilized existing assets wherever possible. The communications infrastructure was also designed to utilize easily available technologies. This minimization of costs was advantageous as it represents the most likely situation which will face any future deployment of this technology on a large scale.

Importantly any new functionality to be added to the Cell Controller in the future is expected to be implementable as a pure software development task.

[AME 6] Capital deferment through integrating Volt/VAr control on two feeders was investigated through the coordinated control of distributed capacitor banks. It was found that the capital benefits of VAr reduction are likely, but the value is low. A deferral in investment of up to 2 years can be achieved in ideal feeder-specific situations, typically where there is low load growth.

Demand response at the customer level was primarily carried out through the control of air conditioning loads during hot days (communication was only one-directional). At high customer penetration rates, $32.75 per DR participant was calculated to be the expected saving. Although generation capacity deferral benefits were seen to be likely, implications for distribution capacity expansion were uncertain (a DR penetration of over 1MW per feeder was the value suggested to realistically defer distribution expansion).

Pilot pricing programs evaluating behavior in response to various tariffs showed that customer adoption rates would need to be high and/or the behavioral change significant for the implementation to be cost-effective. However a cost reduction of $33.62 in generation, transmission and distribution capacity is expected if high adoption rates occur.

2.2.2.2 Development of new market model

[UPDATE 6] If EVs are introduced in the spot market, the market set-up is simple and possible today with an interval meter. The retailer can broadcast the electricity prices once a day and the end-user can make a charging strategy for the hours with known prices (12 to 36 hours ahead). The charging strategy can be a simple clock charging, or the cheapest hours can be selected with a local computer system (home automation system). If EVs are to participate in both the spot market and the regulating market a few more challenges have to be met. Requirements from the TSO regarding real time measurements of the individual unit and minimum bid size make it difficult for EVs to participate in the regulating power market today. Furthermore, there are some challenges with imbalances related to EVs in the regulating market, as the activation of regulating power at one hour can change the predicted charging at a later hour. Some of these challenges can be met by introducing a fleet operator to aggregate the consumption of a number of EVs and handle their interaction with the electricity market as one unit.

[UPDATE 8] A commercial framework is developed that allows the beneficial integration of the VPP concept in the future European power system. Cost Benefit Analyses were made that quantify the economic benefits of the VPP concept.

[AP 1] Ausgrid and its retail partner will test new time-based pricing and incentives for households to reduce power usage in peak times. The outcomes of these trials will provide the necessary input for the development of a new market model.

[AP 4] Electricity suppliers will compete to offer electricity with time-varying electricity prices. This might result in a viable business case and the development of a new market model.

[EUR 1] Trial 3 emphasized that for participation in flexibility markets to increase, new contracts and new pricing models to mitigate the risks involved in selling flexibility into the marketplace must be developed. An increase in site numbers will also make it easier to gain an accurate view of available flexibility (through a portfolio effect) – which is important to prevent overselling or underselling of flexibility.

[EUR 2] Based on the different customer segments identified from surveys, 4 generic smart grid business models were suggested:

1. The 'Saver' model as the name suggests is focused on helping consumers lower energy costs through reduced energy consumption and buying at cheaper tariffs. Such a model is suitable for all customer segments identified as the principle of saving money is applicable for everyone. However it may lead to sub-optimal results due to being a low involvement product and not directly addressing the specific needs and preferences of any one segment.
2. The 'Smart +' model suggests adding value through additional features on top of basic metering functionality. Participants suggested interested in functionality such related to safety and convenience such as burglary prevention devices, as well as meters enabling integration of renewable energy into the grid. Such a business model would require a medium level of involvement as customers would need to be engaged in searching for information regarding such value.
3. The 'Smart camouflage' model targets the skeptic consumer segment especially. Through bundling home appliances, electric cars, smart phones, home-automation systems etc. with smart grid functionality, it is expected that this will create a value proposition around items other than smart meters/grid and engage the customer indirectly.
4. The 'Trader' model is a high involvement model and allows customers the opportunity to trade different 'products'. For example the proposition of trading electricity, trading flexibility and the provision of capacity to achieve economies of scale all represent ways of engaging the consumer. Costs of acquisition are high as this model would require specific contracts for trading.

[EUR 5] The pilot projects were able to demonstrate the technical feasibility of innovative pricing schemes. There are, however, still limits to the scope for setting attractive rates. eTelligence concluded that fixed grid charges in particular pose a constraint.

[EUR 7] Most of the E-Energy model regions do not expect that all consumers and producers will engage on the future electronic marketplaces themselves. Instead, a new market function will come into play with bundling and optimization tasks to be performed by different market players. These aggregators, demand-side managers or pool managers will enter into contracts with a (larger) number of small producers and flexible consumers, bundle their output and offer it as an optimum product to grid operators, electricity traders or power exchanges. These activities will need to be supported by ICT platforms to ensure that the requisite data and services are provided in secure form in keeping with market roles.

[EUR 8] As all of the field trials in this project utilized flexible tariffs and the ability of the aggregator/ESCo to make arrangements, the report strongly recommended the need for an accessible and easy process for consumers to switch from their standard electricity profile regime, to a metered regime. It is only with such a scenario that a Balance Responsible Party can take advantage of the flexibility potential of consumers, for operations on wholesale markets.

[EUR 12] As production units involved in the VPP knew the structure of the energy market well, direct transparency between payments for services and the price at the time of service delivery was made clear to the production owners.

However it was recommended that for consumption unit owners who do not know the structure of power and energy markets so well, financial predictability would be valued higher than market transparency. Hence for these customers it was decided to limit the transparency of the VPP offering, in terms of providing information about what ancillary services their Local Unit provided. Thus the VPP bought flexibility at a fixed monthly rate from the owner (the VPP project therefore took on the financial risk of not being able to create enough value).

It was believed that this would allow the VPP offering to be kept as simple and clear to owners as possible (however the sales force was able to disclose details about individual LU usage to owners if required). This simple approach also allowed contracts to be closed quickly.

The fixed monthly rate to pay the owner was determined based on an estimation of:

- How fast consumption could be regulated;
- How long consumption regulation could be maintained;
- Size of the Local Unit.

Macro level

3.2.2.6 Financing of smart grids

[EUR 3] As mentioned in 3.2.1.2 it is advisable to split the incentive regulation into an innovation budget for company related innovation, and an innovation fund for all network operators for large scale innovations with implications and results for all network operators. The division has the advantage of on the one hand that from the innovation budget all companies get access to R & D funds, and thus the need for innovation is indicated. On the other hand, the investment budget can have a more limited scope and particularly the innovative companies with major innovation project plans can also apply for the Innovation Fund.

D.2.3 - Policy development

Micro level

1.2.3.1 Authority to affect load among consumers

[UPDATE 1] Contractual arrangements are seen to be a barrier for Active Demand (AD) if the contractor is not provided with enough flexibility to fulfill obligations. This refers to not only new contracts which may be made, but also existing agreements which may not allow the use of AD services or may be too restrictive.

If the situation arises where two different actors may wish to utilize AD from consumers, this will perhaps require markets and contracts to be designed appropriately. If it is foreseen that such solutions will cause problems, then more transparency regarding the use of AD or particular processes which could remove such conflicts would be required.

Clear rules and procedures for the technical validation of AD are also recommended to prevent any conflict of interest which may arise as a result of DSOs or TSOs having to validate the technical feasibility of certain AD requests, which the operators themselves may be wishing to use for their own purposes.

[UPDATE 14] In this (local) project, the network operator was able to reduce peak loads by sending incentives to the neighborhood. The producer used the decentralized energy generation units as a Virtual Power Plant.

[EUR 1] In order to exploit the flexibility of customers, contractual clarification and existence of protection clauses will be required to cover areas such as:

- flexibility sources and availability;
- property of the equipment;
- responsibilities in the case of incidents and in terms of maintenance and repair;
- remuneration of the flexibility and share of the benefits penalties;
- level of feedback requested by customers (reporting tools etc.);
- the possibility for the customer to reserve the right of overriding.

[EUR 9] New business models will require more flexible grid charges, either in the form of variable or separate charges, the latter being favored by the Federal Network Agency. One obstacle could prove to be the scheduling requirements for the regulatory system. The volatility of renewable energies must either be forecast very precisely, which is only possible on a limited scale, or producers and consumers must be controlled with high spatial and temporal resolution. As far as possible, this will be done via market signals, which must, however, be transmitted to all possible suppliers of suitable balancing options because of the non-discrimination requirement. The ensuing negotiations could take too long even on electronic marketplaces to take timely countermeasures against grid instability.

1.2.3.2 Reconsideration of transmission obligation

[UPDATE 16] One of the principles applied in this project is the "Last in First off" principle of access. In case of contingencies the parties latest connected will be shut off first.

Meso level

2.2.3.1 Need for a policy framework for investments in the energy transition

[UPDATE 8] Fenix developed a regulatory framework that allows the beneficial integration of the VPP concept in the future European power system.

General recommendations included ensuring that regulation allows DSOs to benefit when they use active network management to defer or avoid capital expenditure, in situations where this is socio-economically efficient. This is to avoid the DSOs being disincentivized to accommodate new DG due to increases in OPEX.

DSOs should also not be required to guarantee physically firm access to all DG, and must be allowed to use lean, network design methodologies. This is to overcome the issues with current design methodology focusing on connecting and not integrating DG due to DG normally complicating the planning of networks.

[UPDATE 11] The introduction of energy storage devices raises regulation issues as it can not easily be classed as simply a production or a transmission asset. It is important that system operators who invest in such technologies are not disadvantaged because of regulation which restricts innovative actions.

Decisions to consider include whether TSOs/DSOs are prohibited from pursuing merchant activities or whether they are enabled to do so albeit with certain constraints. It could be that although merchant application of storage may be prohibited, compensation could be provided for costs of operating the storage system – via the financial benefits of trading through setting lower feed-in tariffs for TSOs and DSOs. Efficiency losses, asset depreciation and overhead costs could be compensated through selling prices being higher than buying prices.

If strict unbundling of activities is maintained and the system operator cannot engage in such buying/selling activities, then regulation should ensure that the commercial firms operating the storage are capable of providing the appropriate grid support (absorbing or delivering electricity) as required. Any remaining capacity can be used for merchant activities.

[EUR 1] Emphasis was placed on the need to harmonize the DG-DSO interface in order to reduce regulatory risk and promote investments in DG. It was suggested that if the regulatory regime of DSOs is based on total expenditure for a gross load output, rather than mark-ups on grid investments, then this would promote DER investments which would lead to deferred network investments.

As well as acting as substitutes for network elements, DER investments can also be complementary e.g. remote controlled units which provide value added services on the network. In such a case, an ideal framework would be one that incentivizes joint investments from DER investors and networks. It was recommended that coordinated direct mechanisms would give better results in terms of investment level and benefits than traditional models using delegation or contingent investments.

[EUR 3] WP4 discusses the adaptation of the legal framework in Germany, which is mostly not relevant for the Netherlands. Besides the conclusion regarding the implementation of these incentive schemes in Germany some other remarks are made, which are also relevant for the Netherlands. Further legal considerations outside incentive regulation and tariff and electricity price formation concerned potentially contra productive influences of provisions regarding unbundling, storage and system responsibility of network operators. With regard to this, several significant deficits regarding the implementation of smart grids emerged: e.g. regarding the information flow between network operation and energy supply, regarding the far too complex regulation of the feed in management (e.g. regarding rigid "cut off hierarchies"), as well as regarding investment incentives for the expansion of the electricity storage infrastructure.

2.2.3.2 Business models for electricity storage

[UPDATE 6] Common for the typical chargers on the today’s market is that they are not supporting V2G functionality, e.g. they cannot supply power back to the grid. The V2G functionality is unlikely to be expected in the EVs on the market in the coming years.

[EUR 5] eTelligence demonstrated that cold-storage depots and block type thermal power stations are effective energy storage facilities.

2.2.3.3 Supply chain analysis for regional development

n/a

D.3 - Social & other

D.3.1 - Protocols & standards

Micro level

1.3.1.1 Reference architecture

[UPDATE 1] A new technical and commercial architecture for Active Distribution Networks is developed to be able to balance power generation and demand in real time.

[UPDATE 2] Analysis has been conducted on the communication bandwidth and protocols required to obtain feedback information and to issues control instructions. Furthermore proposals have been made on the communications to be adopted in future.

[UPDATE 6] The necessary standards work is in fact already largely under way. EDISON is involved in developing the following International standards:

• IEC TC57 WG17 (Distributed Energy Resources);
• IEC TC57 WG15 (Security);
• IEC TC69 WG4 (EV Power supplies and chargers);
• IEC/ISO JWG (V2G Communication Interface).

[UPDATE 8] Fenix has provided and tested in the field a common information architecture to build the different forms of aggregation needed. Fenix developed an information and communication architecture that is scalable and hierarchically flexible.

[UPDATE 12] The communications structure that was selected for installation in Évora was PLC DCSK. This technology has served the majority of functionalities but it has limitations to support future features, particularly in relation to demand side management, mass use of electric vehicles and micro generation. In a small percentage GPRS was installed and several small scale pilots were implemented to test other communications technologies, including PRIME PLC and RF mesh. This resulted in insight in limitations and costs.

[UPDATE 14] An ICT infrastructure was successfully designed and implemented enabling end-users to have feed-back on the operation of their system and enabling system operators to control their cluster. A generic design has been developed that allows seamless coordination of hybrid heat pumps, -CHPs, electric cars, smart appliances such as freezers, washing machines etc. in a single ICT solution.

[AP 1] In the project a clear choice was made in favor of 4G LTE/WIMAX was made. Whether this will become a standard in Australia will depend on the results of this project.

[AP 7] The related national code for smart building design GB/T50314-"intelligent integration system" was issued in 2007.

[EUR 1] When developing the control and monitor solutions for load flexibility purposes in Test 3 it was seen that a large amount of costs and time went into creating a custom-made installation for each of the sites. The project recommended bringing in standards (and possibly even regulation) for control systems that are currently being produced, to allow for easier integration of new installations for flexibility purposes. This would be much cheaper than retro-fitting control systems which had not been designed with flexibility in mind.

The overall cost of site installations was higher than could be supported by potential returns from flexibility. This was not only due to the high cost of retro-fitting the control systems, but also the costs of site surveys and electrical planning. Standardization for equipment as well as installation and interface requirements would be necessary to lower costs, and allow smaller loads to enter the flexibility market.

[EUR 5] The pilot projects in Germany (under the E-energy program) have taken on leading roles in developing a pan-European position for the smart grid and cooperate with other experts from all over Europe under the M/490 mandate of the EU Commission.

[EUR 6] For plug-and-play charging of electric vehicles, both power stage requirements and ICT stage requirements need to be standardized.

[EUR 8] The OGEMA (Open Gateway for Energy Management and Alliance) standard was used in SH/SG for in-house services. This is an open software framework driven by Fraunhöfer IWES which is designed to be run on a central building gateway which serves as the interface between the smart house and grid. It allows applications from different manufacturers to run in parallel, and has a flexible and modularized architecture. The aim of this initiative is to develop an open, manufacturer-independent standard. The OGEMA standard and reference implementation has also been adopted by projects such as RegModHarz and REV2020.

1.3.1.2 Open protocols

[EUR 6] There is a vast number of different communication methods available for use between the different elements involved in the charging process. MERGE provides an overview of those which have been identified to provide the most relevance and promise for use within the ICT stage. Furthermore, possible uses are identified for all each communication method. The evaluation identifies the best method for a specific situation (see Figure 8).

[EUR 9] The Open Gateway Energy Management Alliance (OGEMA) is developing an open software platform, sometimes called an operating system for energy management. OGEMA enables the integration of the most diverse communication systems (e.g. the EEBus for communication with household appliances). The OGEMA framework was developed by the Fraunhofer Institute IWES in Kassel. It is applied in the MoMa energy butler as well as in the BEMI of RegModHarz project, where it has already laid the foundation now and in future to develop numerous applications for optimizing power and heat supply.

[EUR 10] Machine to Machine (M2M) communication was a key area of analysis in this project. The Zigbee interface (used for the smart Dishwasher and Washing Machine) allowed devices to send and receive information with an external management system. However this interface was found to be prone to interference and unreliable, especially when other interference sources were allowed to operate (e.g. a microwave near to the Washing Machine).

Another disadvantage was the short coverage range of Zigbee. For longer distance communication in the home e.g. between basement and kitchen, the mesh networking functions of Zigbee is required implying an increase in complexity, maintenance and cost. Additionally it was found that there was functionality required which was not supported by the Zigbee standard.

It was recommended that using WiFi (as with the Freezer in the project) would provide a better coverage range, and a more robust communication option. It is less affected by interference - dynamically launched channels from external WiFi (802.11) sources can provide better overall robustness to the system. Newer standards such as 802.15.7 could also be even more immune to interference. WiFi as a very mature standard also has a high degree of physical compatibility.

However the same problem exists as with Zigbee that the openness of both solutions leads to proprietary and not standardized solutions. Manufacturers can create their own extensions to protocols, and this makes it very hard to achieve compatibility on an application level.

Another advantage of using WiFi is that as most houses have broadband/ADSL internet access, they will by default already have a WiFi bridge/residential gateway (which can host the BeyWatch Agent) meaning no extra communication hardware would be needed. However the cost of using WiFi is higher than ZigBee meaning that if the price of white goods using WiFi is too high, the product may not be a success. The energy consumption of WiFi technology is also higher, meaning that it is still not clear which means of communications and which protocol (if any) will come to dominate the market.

The project recommends to keep the aspects of M2M communications as separate and independent as possible from the rest of a home energy management solution. Although this will perhaps result in an increase in costs, it will ensure a future-proof solution until some kind of standardization in home communications occurs.

1.3.1.3 Agreements with stakeholders about smart meters

[AP 1] In the pilot where several tariff structures will be tested a commercial party will be involved as well. The agreements that will be made in the pilot could give an indication of the necessary agreements.

Meso level

2.3.1.1 Sustainable neighborhood pilot projects

[UPDATE 14**]** The flexibility provided by the various technologies applied can be generalized. This allows standardization of interfaces. An interoperable solution is provided for a heterogeneous smart grid solution that can grow organically.

[AP 1**]** Regarding renewable energy there are three locations of which one can be characterized as "Smart Future". This implemented in Newcastle and involves distributed storage (40 batteries located on host customer sites of 5kVA, 2hour storage), solar energy, 25 natural gas fuel cells up to 1.5kW output and 5 small wind turbines of 2.5kW. These are all connected to a single 11kV feeder. Although this is not completely sustainable, as not all electricity is generated locally from renewable sources, it will provide valuable insights.

[AME 3**]** The work carried out in this project, provides a platform for which the FortZED initiative can proceed in creating a zero energy district through conservation, efficiency, renewable sources and smart technologies. Such a project will require harmonizing the different expectations, assumptions and goals of all parties involved. During the Fort Collins project, conflicting requirements of partners was a key challenge to be overcome.

It was seen that it was difficult to maintain integrated organizational engagement of the partners, as most partners were not capable of managing both the ‘on-the-ground’ operational impacts of the work as well as the more strategic, broader study aspects of the project. It was recommended that a clearer definition and understanding of the full scope of work needed in this project would have enabled the partners to adopt their processes in order to reduce implementation challenges.

2.3.1.2 Development of local electricity markets

[EUR 3] In some cases network investment can be deferred by steering generation and/ or demand coordinating them with available network capacity. This coordination can be realized with institutionalized local network or energy pricing. In systems where currently uniform pricing is in use and generators do not pay use of system charges, this would require major regulatory reform. We proposed smart contracts as an alternative tool to achieve this coordination. They can send local signals in a low transaction cost and flexible way. Smart contracts are optional and voluntary agreements between the network operator and network customers that realize a trade-off between investment into the grid and changes at the demand or generation side. Network operators can flexibly design these contracts to better adapt customer behavior to network capacities when this is cheaper than network investment. Since participation in smart contracts is voluntary customers are protected against exploitation by the network monopolist in the negotiations of a smart contract. They can always fall back on a regulated default tariff.

In WP2 it is concluded that an imposed "local spot pricing" is unsuitable for a distribution grid. A preferred solution would be a locally differentiated grid pricing system; however this option has a weak short-term control effectiveness. Therefore a compromise is proposed: "smart contracts" based on voluntary participation and optionality can be a low transaction cost solution to implement local signals in distribution networks and thereby avoid network investments. They are easy to implement and do not require large regulatory reform. Hence, smart contracts are an attractive solution for efficiency enhancing local pricing in smart distribution networks.

Importantly, network operators need incentives to pursue smart contracts as an alternative to network expansion. This implies that they should be allowed part of the benefits from the avoided investment. It is the task of the regulator to a) allow network operators the flexibility to design smart contracts and b) to incentivize network operators such that they carry out efficient network investment and will offer smart contracts where investment can better be avoided. Smart contracts raise further issues with regard to governance. It is assumed that contracts can incorporate energy components. It is obvious that with unbundling this is not an easy task since network operators can only give incentives to suppliers which would than in turn design incentives for customers.

[EUR 5] During the field trial of eTelligence, the participant actors were exposed both to marketing and price risk as well as forecast risk. The market participants are two cold-storage depots, a wind park, the Cuxhaven municipal swimming pool, a treatment plant and a block-type thermal power station. These can be flexibly connected either individually or as a virtual power station and together can be managed and predicted in a similar way to a conventional power station. Here, controllable units in particular (e.g. producers with power/heat cogeneration or switchable loads) can provide power generation flexibilities for the market.

[EUR 9] The incorporation of renewable energies or the trade-off between market and grid interests will probably require (new) market functions with the business goal of optimization for the benefit of the overall system. The electronic marketplaces will not just trade electricity. Flexibility in scheduling consumption represents a good in itself and will increasingly come to be treated as a commodity. There may be a need for a separate function to manage and reward flexibility on the consumption side.

D.3.2 - Stakeholders & user interaction

Micro level

1.3.2.1 Privacy

[EUR 2**]** In a customer survey of 497 participants from Switzerland, Austria, Germany and Lichtenstein, 26.2% have concerns regarding security and privacy.

[EUR 5**]** Data of private persons measured by smart meters is especially sensitive. To prevent any inferences being made on personal lifestyles, data is made anonymous and aggregated, provided it is not needed for invoicing purposes with detailed itemization. No more data is collected than is actually needed for billing and for monitoring the grid state. If it must be gathered, it is not stored for longer than necessary.

[EUR 6**]** In order to tackle privacy and security issues, MERGE emphasizes that the following characteristic should be ensured:

- Authentication: EV must register when accessing the utility energy services. The network will either authorize or refuse a determined EV connection to the grid. The electric network management will then assign unique ID to each EV user in case of successful registration.
- Data encryption: The data exchanged between the EV and the aggregator must be encrypted to ensure privacy and resistance to tampering, especially in shared medium communications which are prone to eavesdropping.

[AME 7] In general, participants wanted assurance that the data collected regarding their electricity use would not be used for marketing or profiling. There was also concern from some about the potential for hackers to know when the homeowners are away from home. In the quantitative study, the 1,000 respondents were asked to rank their top 3 privacy concerns from a list containing choices such as banking, personal information, credit cards, social network sites etc. The results can be seen in Figure 20. Relative to other privacy concerns, smart meter data privacy is a very low issue, with only 4% of participants choosing this within their top 3 concerns.

It was suggested that invoking this kind of comparison in the consumers mind may help to alleviate concerns over data privacy, through putting the issue into a broader perspective. Overall it is vital to provide information about the intent behind smart grid technology and to reiterate messages of reassurance that data will not be used against consumers, and that security will prevent any hacking of data.

1.3.2.2 Becoming conscious about energy use

[UPDATE 18] Customers can choose to view their energy and water usage, estimated electricity costs and environmental impact through an online Home Dashboard or an in-home display. The Dashboard will also include a comparison of energy use with other Smart Village participants as well as incentives to reduce energy use.

[AP 1] Workshops on various topics such as energy efficiency are included in the project.

[AP 7] The system reminds users to avoid or reduce using electricity during peak hours.

[AP 8] The households at Jeju island feature various prototypes of smart meters and in-home displays. Energy awareness is created by providing real time information about their energy consumption. Home / Building web based portals are installed. Every portal provides the consumers information about their energy consumption, historical energy data and carbon footprint data. The portal not only enables online billing but also shows comparison of energy data with neighbors.

[EUR 2] A survey of 87 private Swiss energy consumers revealed that a mobile solution was deemed the preferred method of visualizing energy consumption. This was followed by preference for an in-house display, with the least preferred method being an online-based visualization tool.

[EUR 5] The advisory tool in eTelligence proved to be a very popular service among consumers. Based on (voluntarily) disclosed consumption data or the identification of power guzzlers in households, the advisory tool provides efficiency advice.

[EUR 6] The identification of traffic patterns and consumer behavior relating to the use of EV has been investigated by the MERGE project. A detailed consumer behavior questionnaire was distributed in several countries in Europe (see http://www.surveymonkey.com/s/Dutch-merge for Dutch version). Over 1600 responses were obtained. The study focuses specifically on the countries Germany, Great Britain, Spain, Greece, Portugal and Ireland. The study found that a significant majority of responders would participate in smart control of charging of tariff electricity rates were to incentivize it. See results in Figure 9 and Figure 10.

[EUR 7] Three feedback mechanisms were used: an online portal, hardcopy and a gateway/'Energy manager display'.

[EUR 10] The Business Support Services (BSS) web portal prototype developed provided the end user with real time energy information, reports, and comparisons on energy consumption in the past, with options to personalize and compare consumption with the similar users in the community. Through questionnaires, the feedback showed that the majority of users thought the service was interesting and understandable, but only 55% would be willing to subscribe for certain at a reasonable price. The main reasons for not wishing to subscribe were actual need and price uncertainty. It is important for this reason that there should be certainty that the system will save more money than the service costs itself.

It is recommended that allowing users to experiment with sensors in the house to see how electricity is consumed by different appliances will increase awareness of consumption and also the perceived value of such a service. It was also found whilst the web user interface was useful, an application for a smart phone would be even better as this would always allow the user to see consumption data wherever they are.

Being able to compare consumption patterns with those of homes around them, will also incentivize user awareness and most likely change usage patterns of consumers.

[AME 1] It was observed that generally customers using the Programmable Communicating Thermostat showed higher load reduction than the groups using only a web portal or in-home display.

Although overall load reduction through the web portal or in-home display was lower, these groups typically maintained a more constant reduction of load during peak periods than those using the PCT or all 3 technologies. The 'All 3' and PCT technologies group typically showed a large spike in load reduction at the start of peak periods, and then a reduction in savings after some time in the peak period. This could perhaps be attributed to the automated operation of the PCT, unlike the web portal or IHD which are feedback mechanisms monitored manually by users who then adjust consumption accordingly.

Residential customers who participated in Phase I of the trial showed slightly higher savings for certain rate-technology groups than those in Phase II (these customers were recruited into the trial approximately a year later). A possible explanation for this was given to be that there may be some kind of learning effect where customers respond more effectively to changes in price and events, however this could also have been down to some random variation in the sample groups.

The web-portal and in-home-display both showed some kind of learning effect, but not the PCT technology which perhaps did not require such a long time to use effectively to have an impact on the overall savings.

[AME 2] Generally it was seen that none of the treatment groups showed any significant change in average customer energy usage, even when they had to pay an additional $1.74/kWh for electricity (this is quite high when compared to a more typical price of around $0.11/kWh). Across the whole year, there was no group which showed major differences in energy usage compared to the control group.

However a subset of approximately 10% of dynamic-rate customers (DA-RTP, CPP and PTR) responded to elevated event-day prices by reducing their usage. The most consistent responses were seen of CPP customers. During event-periods, 11.6% of CPP participants reduced their load by an average of 21.8% - which amounted to 2.2% of the usage of all enrolled CPP participants. An average load reduction of 14% was seen by the 'event-responders' in the PTR and DA-RTP categories.

Interestingly, even the customers using price rates which were not affected by events (IBR, TOU and flat rate) showed a small reduction in energy consumption (5.6% for IBR). This leads to the suggestion that the actual notification of an event itself could be a cause of demand response of consumers. This hypothesis that event notification could be used to play a role in demand management was deemed to require further investigation as the findings were not seen in all treatments.

It was also suggested that the energy reduction seen in customers who had no financial advantage of doing so, could have resulted as a consequence of ComEd's educating CAP participants about the supply costs on certain days of the year.

Overall the project results did not exhibit the same kind of savings usually associated with dynamic pricing regimes seen in other pilots. The reasoning behind this was the large sample of customers in treatment groups who showed no response to price changes. The explanation behind this was put down to the fact that the CAP pilot utilized an opt-out enrolment method, whereby customers were included without their prior consent. Although it was hypothesized that an opt-out design would increase the percentage of price-responsive customers, this was not the case.

[AME 4**]** It was recommended that providing detailed feedback and consumption information would encourage behavioral change of consumers. Behavioral triggers included energy savings competitions, home energy reports and comparative energy reports. Examples included Duke Energy providing such comparative energy reports leading to 84% of participants changing thermostat settings and 51% pursuing other energy-saving measures. Wright-Hennepin with The Climate & Energy Project used competitions to get consumers to reduce energy usage – and this led to participants reducing consumption by up to 58%.

Another lesson learned was that free and timely access to energy usage data improves participation in smart grid programs. Access should be through channels which are easy for engagement e.g. an in-home device, or a website. It was seen that if an in-home device was provided free, then this would be preferred to a website (59% in favor of the in-home device). However if the device costs $100 then this preference would drop to 33%.

Customers should be given a choice in how they receive their usage information also. Research revealed that the majority of smart meter owners preferred receiving energy management information through mail (with email and bill inserts also being a preferred channel of communication). For day-to-day communication about electricity usage - email, automated phone calls and online websites were preferred channels.

[AME 5] With regards to the specific type of information consumers were interested in being knowledgeable about – 81% of consumers surveyed showed interest in wanting to know more about ‘Energy usage by appliance’. Only 56% of consumers wished to know about hourly usage. Between 70-76% had interest in receiving data about daily cost, daily usage, energy comparisons, weekly emails and energy alerts.

[AME 6] In the SmartGridCity, customers were able to view their 15-minute interval via a website (with a one-day delay). The value of this is questionable if such a delay occurs. An online green energy community was also added as a tool to support customers in sharing best practices and providing advice to each other. However, a customer survey showed that only 17% would currently utilize this online energy community service. With regards to reduction in energy use through this data access –benefits were plausible. It was seen that customers responded better when metrics which they could comprehend were used e.g. using ‘miles driven per year’ instead of ‘tons of CO_2-e’, and using ‘$ saved’ instead of ‘kWh saved’.

Pre-paid programs which allowed the consumer to pay for their energy consumption in advance via pay stations or using internet software were trialed to enable more awareness of energy usage and better management of bills. Customers who used the prepaid programs were extremely satisfied with their participation, with one of the key factors for success being the ease of access to the forms of payment. High visibility of usage meant that customers did not fall behind in payment of electricity bills and were motivated to save energy (up to 12% in energy savings in the first year of such a program was estimated).

[AME 7] Most consumers regarded themselves as conscientious with respect to their energy consumption. For the majority of participants the main reason to reduce consumption was to save money, with environmental benefits being a bonus. For a minority, concern for the environment was the primary reason to conserve energy.

It was seen that consumers felt a strong degree of frustration when they attempted to reduce consumption, but made ineffective changes which did not ultimately impact their bill. For example some consumers assumed energy use would be significantly reduced through unplugging stand-by power (although when such a change aggregated can impact the grid, on an individual level it is unlikely to change a monthly bill). Others thought reducing microwave use would lead to significant bill reductions. Even if the monthly bill turns out to be less, the reasons behind this are most likely different to the factors the customer will attribute the reduction to. As a consequence of such misunderstandings and ineffective changes, consumers can become discouraged in altering behavior to any type of energy pricing program.

For this reason one of the conclusions drawn from the study is that consumers would highly value energy consumption and cost information broken down for each appliance within the home. This also leads to the suggestion that simply providing an in-home display which only provides consumption and cost information on a household level (rather than appliance-level) will not necessarily provide actionable information for consumers.

1.3.2.3 Creating incentives for household consumers

[UPDATE 1**]** A methodology for the assessment of quantitative benefits of active demand has been described and applied in four European countries.

[EUR 2**]** Based on a survey of 87 Swiss energy consumers, it was found that smart meter users could be segmented into four different categories and consequently be offered different incentives and reward mechanisms to create value.

- 'Risk averse' consumers represented the largest segment (34%). They chose the tariff model of 11Rp/kWh - 17Rp/kWh, with a flat rate of 23CHF/month. They were not willing to pay any premium for smart metering services - for example being able the ability to program and control consumption.

- 'Technology affine' (29%) preferred the ability to program services and had a strong interest in energy data. With regards to tariffs, this segment were willing to accept a variable tariff (11Rp/kWh - 17rp/kWh) and a base rate of 25CHF/month and seemed confident of being able to benefit from the difference in higher and lower tariffs.
- 'Price sensitive' consumers (20%) - preferred the tariff with the lowest off-peak price, 6Rp/kWh although it had a very high risk with an off-peak price of 50Rp/kWh. Such a segment seems ready to supervise and manage their behavior in order to reap the benefits of a low-price tariff. The flat rate for this tariff model was 25CHF/month.
- Finally 'safety-oriented' consumers (17%), opted for the highest base tariff of 27CHF/month, with the off-peak - peak price from 8Rp/kWh - 30Rp/kWh. This segment placed value on monitoring and warning functions which could be included within a smart metering package.

In general customers were willing to pay a higher base fee to avoid the high tariff of 50Rp/kWh **-** i.e. they were willing to pay a risk premium. It was also found within the experiment customers would pay a premium of 16CHF to get their most desired smart metering product, but by the same token would require a reduction of 16CHF if the bundle did not exactly match their needs.

[EUR 5**]** eTelligence demonstrated that cold-storage depots and block type thermal power stations are effective energy storage facilities. Refrigeration systems are switched off when prices are low. Using the cold buffer previously built up, the cold-storage depot can then run for some days with much lower power demand. This substantially reduces electricity supply costs over the year. eTelligence incorporated dynamic rates for connecting retail customers with wholesale conditions. There were three different tariffs (TOU tariff combined with events, load variable tariff, tariff based on total consumption during billing period).

[AME 4] Providing incentives and behavioral triggers were recommended as an effective method of getting consumers to be more engaged in smart meter/grid programs.

Several utilities suggested the use of time-sensitive offers to get customers to sign up to programs. Examples included Conexus offering $10 gift cards for a limited time to promote its Direct Load Control Program. A raffle of 1000 in-home displays in low-income households was conducted by Reliant to engage consumers.

[AME 5] A payment of $100 was offered to CPP and HP participants who agreed to enroll in the program. This incentive was not considered to influence any savings or losses based of the pricing regimes. The payment was a fixed externality and participants were just as motivated to reduce peak demand after receiving the payment as they would have been if they had not received it. The average response rate was 6.6%, with 900 residential customers taking part.

[AME 7] Both groups were shown the following definition of smart grid technology: "*The "Smart Grid" is a vision for an updated electric utility equipped with modern communications and computer technology to create a more reliable and efficient electric grid. The smart grid will be more robust, secure, efficient, affordable and environmentally friendly. Consumers will be able to know how much electricity they use, when they use it, and how much it costs before receiving their monthly bill. In addition to managing energy costs, consumers will have the option to own intelligent, energy-saving, or energy-producing devices that can share both energy and information with the utility grid.*" asked to comment on the clarity of information. Overall it was felt that the statement was clear and concise. The most compelling aspect was the statement *'Consumers will be able to know how much electricity they use, when they use it, and how much it costs before receiving their monthly bill'*. It was recommended that this information emphasizes the benefit of smart grids to the individual – which is in contrast to much of the information obtained through research which consists mainly of information regarding benefits to the environment or community overall.

1.3.2.4 Modification of systems for electricity trade

[EUR 1] Trial 3 showed that the current 3MW limit (in UK) for participation in Short-term Operating Reserve could be reduced with the technology used in the experiment – allowing aggregation of a site the size of 500kW. It was also mentioned that with standardized control systems in multiple sites to lower capital expenditure, and also with triad avoidance take into account (avoiding consumption during peak periods to earn money through National Grid Transmission Network Use of System agreements), then sites as low as 100kW could be included.

1.3.2.5 Dialogue about communication with households

[AP 8] Households are able to monitor their energy usage through smart phones. Customers are able to obtain information about their current and accumulated electricity usage, electricity costs as well as their carbon emissions. This is done with a Service over IP terminal whereas the 'widget engine' is based on Flash Lite.

[AME 4] The consumer pulse tracking study showed that only approximately 30% of consumers had a basic or complete idea of what smart meters or smart grids were (see Figure 15). When asked about what improvements or problems smart meters and smart grids would bring, again approximately 30% answered ''Don't know' or 'Need more information/education' (see Figure 16 and Figure 17).

To increase awareness it was recommended that education regarding smart grids and meters should begin before any deployment occurs. A staged messaging strategy was recommended as a best practice based on findings from interviews. 60-90 days before installation local leaders, politicians and media should be used to build awareness, in combination with educational forums and community events. Approximately 7-21 days before installation, direct mail notices and automated calls can be used to notify customers. Through providing the appropriate information at the appropriate time, customer expectations can be effectively managed.

Other examples of using education to improve customer service included creating an 'employee ambassador' (carried out by CenterPoint) to act as Smart Grid advocates within the community. A specialist customer service team was appointed by San Diego Gas & Electric to resolve complaints one-on-one.

Community-based organizations which already have good relationships with customers could be partnered with to educate the community about smart grids and meters – especially as they may be better equipped at educating hard to reach consumer segments. Portland General Electric created such partnerships to reach out to non-English speakers, low-income customers and multi-dwelling building residents.

Another recommendation was that relevant benefits should be communicated using simple language (as opposed to something too technical). Emphasis should be placed on how the smart meter-enabled programs satisfy consumer needs. A best practice example provided was that of SCE who broke down their smart grids/meters message into 1) a two-second tagline, 2) a brief 'elevator pitch' and 3) a detailed fact sheet. This led to 50,000 customers signing up to their program in the first 6 months.

Existing points of contact with customers can also be used to promote smart grids. For example when customers call a utility regarding high bills, customer service can use this as an opportunity for program enrolment. APS and SRP utilized such a technique and this resulted in program participation rates of 50% and 22%, respectively.

[AME 5] Based on a survey of program participants, it was seen that 52% of consumers preferred receiving information (about energy usage, cost and emissions information) with their bill. 20% preferred receiving information in the form of mailed reports, 14% preferred emails and the last 14% preferred visiting the utility website.

[AME 7] It was observed that for the smart grid 'aware-group' the most common sources of information included broadcast media, newspapers/magazines, the internet and word of mouth. The smart-grid 'un-aware' group who did not understand smart grid technology was asked to research smart grids so that their understanding could then be tested. Wikipedia was commonly used alongside websites such as that of General Electric, Siemens and IBM which were perceived as easy to understand and containing helpful visuals. Other sources used included friends, newspapers and TV.

As there is a heavy reliance of information from the internet, it is recommended to influence content that appears on websites such as Wikipedia (and other websites that come out at the top of search engines). In order to make consumers who are not actively seeking smart grid information aware of this technology, credible TV and print news content can be useful. Also consumers expect to hear about this technology from their utility company in inserts, newsletters and special notices.

In order to communicate the implications of smart grid technology, several statements were drafted in a language consumers could readily understand (using analogies for example), and which conveyed the benefits that smart grids brought about. This is because such statements can be understood better than technical ideas. The two most compelling statements for consumers were judged to be the following:

- 'Taking the Guesswork Out of Managing Energy Use'
- 'A Helper for My Best Intentions'

Both statements were accompanied by a short piece of text explaining the statement further. The first statement addressed the frustration issue which consumers experienced due to ineffective attempts to reduce energy consumption (see action item 1.3.2.2). The second was related to the problem of not being good at managing the use of electricity within the household despite an effort to do so. By focusing on common and relatable circumstances that cause consumer problems, these kinds of statements had an increased impact with consumers.

Generally, statements which emphasized smart grids being beneficial for the common good (e.g. 'by working together we're having a bigger impact – like reducing the need to build power plants and put up new power lines') did not provide the same incentives as statements which emphasized individual or tangible benefits (e.g. saving money, more control).

1.3.2.6 Support among system users

[UPDATE 1] It was mentioned that although the Swedish market has been deregulated for 15 years, customers have not taken advantage of the different Time-of-Use tariffs available (which have been in place for over 20 years). This lack of switching to ToU tariffs most likely results from a lack of understanding in electricity bills, lack of trust in electricity companies and fear of potential discomfort. It is these same barriers which will need to be overcome, maybe to an even greater level, for Active Demand and aggregator services.

[UPDATE 12**]** One important lesson learned was that the involvement of the end-users is important. It is important to manage expectations, to explain clearly the benefits of the solution and to understand their needs and difficulties. Local and direct contact is very important and this was strengthened during the project.

[UPDATE 14] Alleviating consumer concerns is critical in both gaining the public approval necessary to facilitate Smart Grid transitions, and in educating consumers about the benefits they stand to reap. End-user acceptance is guaranteed by advanced comfort control mechanisms and monitored in a participating design program. The consumer response regarding this project has been positive. Lifestyle interruptions have been minimal.

[UPDATE 15**]** One of the challenges during the implementation was the fact that consumers were not adequately involved in the management of the micro grid and as such they had the tendency to overload the system. Currently there is not a viable scheme for the operation of the system by the users, which may be a key issue to address for remotely located systems.

[AP 7**]** In practice, although not admitted by official governmental sources, it seems that customers are not very enthusiastic about this and similar projects although most of the projects are over-advertised by local government and related grid utility. The projects imply higher cost/price than normal community, and the reliability and service of post construction, equipment, interface, socket interchangeability and maintenance has not always improved due to the complicated system and product design.

[AP 8**]** A recent study shows that customers expect that green IT services can help to reduce their energy consumption and money. They also think that companies have to introduce the services that can reduce energy consumption. According to the Green IT survey, 26,5% of the customers are willing to pay for green IT services. The more they have high incomes, the more they are willing to pay.

[EUR 1**]** When estimating the amount of load flexibility they could provide on-site, customers were apprehensive about the effects of potential interruptions – for example in the loss of air-conditioning. The tests showed that in reality many customers did not notice the effect of load reduction during regular 1-hour calls, which sometimes even occurred twice a day. Additionally it was also observed that there was poor in-site knowledge in identifying where loads could be controlled and monitored. Overcoming these issues and increasing awareness about load reduction would likely result in a greater uptake of flexibility measures.

[EUR 2**]** The IMPROSUME report discussed that in order to fully realize the benefits of smart grids, it is important to not only analyze smart grids from a technological perspective, but also to understand the required institutional changes and social acceptance of smart grids. It is argued that at this moment the 'perceived usefulness' of smart grids has not yet reached the point to overcome company uncertainty in investing due to the high up-front costs, and that customers do not yet see enough benefits of adopting the changes brought about by smart grids/meters. Thus in order to increase the perceived value and bridge the gap between customers and technology, it is important to segment the consumer base and provide different propositions and business models based around 'prosumers'. In a survey of the B2B market, interestingly it was also found that incorporating everything that is feasible from a technical point of view, did not necessarily lead to the highest customer value.

[EUR 7**]** For greater acceptance of smart technologies in the private domain, the following aspects are of main importance (results from E-Energy program, not all necessary from the MoMa project):

- Long periods of absence from home make it difficult to make manual use of low-price times. After the novelty interest wanes, the readiness for manual switching also diminishes considerably. The installation of intelligent facilities, such as energy managers, to control the terminals autonomously based on price signals and knowledge of their operating states is indispensable.

- With progressive automatic regulation of appliances, technically less proficient consumers often fear losing control over their household. Simple and easy use is a basic prerequisite for acceptance in the broad population. Also important is retaining the option of switching the appliances on and off by hand as usual.
- Technology will only find acceptance if it has been developed to an adequate standard of maturity, when it is secure and when responsibilities are clearly regulated in the case of a fault. Here, it is up to manufacturers to develop solutions to improve security and comfort both for specific devices (protection against overheating, warning signals for faulty parts, etc.) and for system integration (smart-home approach).
- The integration of load management into rapidly developing home automation technologies affords good prospects for greater acceptance, as it will be bring benefits in efficiency and comfort as well as security, against burglary and theft, for example.
- Information from the energy industry and profit-seeking manufacturers is often seen as dubious. Customers take a skeptical view of new rates and their apparent benefits. The population should be informed about the functions and advantages of the smart grid as far as possible in collaboration with independent institutes and political agencies and consumer protection organizations. Energy saving tips and impartial consumer information build confidence and arouse interest.
- If customers have the impression that they are helping their town or their region, they are easier to motivate for the new services.
- Strategies for introducing smart technologies must take into account the various needs and attitudes of consumers. Not all customers are the same. Roughly speaking, customers seeking emancipation and self-fulfillment and who are interested in technology can be reached in an initial round. Then, those that are aware of socio-economic issues and are generally interested in change can be targeted in a second phase. Communication and marketing need to be planned to meet the expectations of these groups.

Unlike in households where a large degree of flexibility is usually afforded by time rates, concepts are also being developed in the commercial sector for the direct control of production and consumer systems. The pilot projects have gained initial findings for raising acceptance here:

- If rates scales are too complicated for the enterprises, transaction costs often become excessive and acceptance diminishes;
- Interventions in functional processes are expensive and lack of personnel capacities hardly allow for managing load transfer. Competent technical support through service packages can help here;

Especially in cooling systems, control can shorten the storage life of food, give rise to complaints from employees or customers on poor air conditioning or disrupt of production in the industry. Liability issues therefore play a role both for plant operators and energy suppliers. Close cooperation among all stakeholders is essential to reduce these barriers.

[EUR 10**]** The project recommended that the importance of control should be emphasized in order to increase adoption of home energy management systems. Although users thought monitoring of appliances was a good thing, they did not feel this would justify the cost. However when the control element is introduced, the user feels more empowered. There are appliances such as air conditioning which the user always wants to control manually (as temperature perception is relative), and so the user should always be able to control and override any automated decisions. However in general users do not wish to be worrying about complex decisions on how to use home appliances, so they accept the concept of an intelligent agent controlling non-critical appliances for them.

[AME 2] 2,423 responses were received by ComEd for a survey regarding various elements of the program. The customer satisfaction level for the IBR and DA-RTP plan were ranked the highest, with an average score of 5.9 out of 10. The flat rate received the lowest score of 5.1. This does not appear to be a statistically significant difference. Perhaps, the lowest score of 5.1 indicates that simple rates do not necessarily lead to good customer satisfaction.

The survey also tested the understanding of the customers on their particular rate types. In general responses demonstrated a good level of understanding of the features of the customers own personal rate. However it was seen that only 43% of customers who were able to earn a rebate through reducing usage were aware of this feature in their rate plan. 21% of non-PTR customers thought they were able to earn a rebate on certain times, which was not the case.

[AME 3] The use of diesel-fuelled generation in the DER mix of this project led to some skepticism and negative reactions from the public. It was recommended in many cases public outreach and education would be key to projects like Fort Collins that needs to be supported locally.

[AME 4] A key finding was that smart grid and smart meter awareness increases favorability. Consumers who have basic or full knowledge of smart meters were more likely to have higher support. Lower support was seen to be a function of lower awareness. Using a favorability index metric was suggested as a way to see how support amongst consumers was growing or lowering.

To increase public support, the wide range of benefits enabled by smart grids and meters should be promoted. The two key reasons provided by consumers (without using any external sources of information to remind them of any benefits) for implementation of smart technology was ‘Saving money’ and ‘Saving energy’.

Additionally when asked which messages (from a list) increased smart grid and meter support, messages promoting higher reliability, faster power restoration and avoiding energy waste were seen to be effective as messages which promoted money savings (80% agreed these messages would slightly or strongly increase support) – see Figure 18.

Further research was carried out whereby consumers were asked to rate some statements regarding benefits of smart grids and meters, based on whether they would be willing to pay an extra $3-4/month (see Figure 19). Although many statements were seen to be important, generally they did not provide enough incentive for paying more. The most important statements were seen to be eliminating the need for meter readings and also delivering higher power quality. However the willingness to pay extra for this was low. This led to the conclusion that it is not essential to focus only on the 'saving money' benefit of smart grids, but in fact it is better to intertwine many benefits together to increase user acceptance.

The statement which had the highest willingness to pay more for was 'reducing greenhouse gas emissions by making it easier to connect RES to the electricity grid'. It was suggested that whilst such a statement may be appealing overall, it may be more important for certain specific consumer segments (see action item 1.2.2.2).

[AME 6] A survey of customers indicated that the capability to manage personal energy use (and cost), ranked as the most important capability value by customers (out of 11 other possible benefits of the SmartGridCity). However it was recommended that to encourage greater awareness and involvement in smart grid programs, marketing would be needed to implement additional communication efforts about the role of the customer themselves and the utility in empowering the customer. It is anticipated that as the customers electricity management options evolve, their perception of the utility's business model will become increasingly important. Testing this kind of perception (for example whether they feel a sense of increased partnership) will require looking at a large enough number of customers, over a long enough time. At the time of writing, the customer experience with smart grid capabilities was not over the duration needed to verify whether a sense of partnership was perceived by customers.

Within the SmartGridCity, through communication with the smart meter – the Customer Contact Centre or Distribution Control Centre was able to determine whether or not a customer service issue was the responsibility of the service company or that of the customer. This benefit of 'knowing the responsible party to fix an outage' scored 2nd highest of the 11 benefits measured.

[AME 7] Cost was found to be a major barrier to smart grid technology acceptance for the participants in this study. In particular participants expressed uncertainty regarding set-up costs, costs of energy-saving and energy-producing devices and who would pay for this.

Even after conducting research many participants did not find information regarding to what extent smart grid technology would save them money or how much it would cost.

It was recommended that more tangible examples/case studies would be useful in overcoming this concern. For example creating scenarios which detail upfront investment costs, and cost savings in the short and long term would help in this matter. It is important to be as specific as possible with regards to these costs, as this would allow consumers to understand benefits to their family etc.

Meso level

2.3.2.1 Supporting citizens' initiatives

n/a

2.3.2.2 Discussion about installation of new gas networks

n/a

2.3.2.3 Involvement of the system operator or the development of local grids

[EUR 1] New design criteria for distribution networks for the purposes of integrating DER can be developed when clear exogenous objectives are defined e.g. limitation of generation power per connection, objective in terms of penetration for RES, limits set for generation control in normal and abnormal conditions. It is recommended that such objectives are defined outside of the electrical supply industry, but with its participation.

[EUR 4] The most important decision which DNO should make is related to distribution network planning and operation philosophy. The challenge is to decide the moment when e.g. a new DG connection is handled by ideas of active network. Investments are typically high for the first installations because new interfaces, platforms, etc. are needed.

[EUR 5] Due to the changed regulation in Germany, two new market roles have already emerged: the metering point operator and the metering service provider. The incorporation of renewable energies or the trade-off between market and grid interests will, however, require other (new) market functions with the business goal of optimization for the benefit of the overall system. Flexibility in scheduling consumption represents a good in itself and will increasingly come to be treated as a commodity. There may be a need for a separate function to manage and reward flexibility on the consumption side. The smart grid could also require ICT infrastructure operators.

2.3.2.4 Involvement in regional development

n/a

D.3.3 - Other

Micro level

1.3.3.1 Development of 'smart homes'

[UPDATE 14] Smart homes have been developed by the consortium of Essent, Humiq, TNO and DNV KEMA and in close cooperation with GasUnie, the Municipality of Groningen, the Energy Covenant Groningen.

[UPDATE 18] As part of the Newington Smart Village Project, a residential home has been acquired in Konrads Ave, Newington. This property will become the Newington Smart Home, a 'house of the future' showcasing and testing new technologies to reduce household energy and water use. The Smart Home will be used to educate and inspire others to adopt energy and water saving behavior.

[AP 2] During the first years of the project, 4,000 houses will be installed with Home Energy Systems (HEMS), PV panels and one on two with an EV, which will also have a charging/discharging function, once connected.

[AP 7] In this project, residences can find out their family's power expenses, carbon emission amount and energy consumption habits, receive suggestions on energy use, and form an economical energy consumption habit. Through the interface of the intellectual terminal, the residents can shop, make appointments with their doctors, make video telephone calls, and order food delivery without stepping out of their homes.

[EUR 10] The BeyWatch project used smart white goods, combine PV & solar generation, energy consumption monitoring, low-cost home networking and load/energy management to validate the concept of a smart home which is able to use ICT to improve energy efficiency.

The system developed was shown to be able to avoid times of peak demand (through postponing operation of activities) and reduce energy consumption. Through a number of different scenario simulations (different houses, different consumption models, with/without CPS, different lighting, different white/brown appliances, different seasons and times) the system was shown to reduce annual energy consumption. With an adoption rate of 20% it was estimated that a town's annual energy consumption would reduce by 2.6%. A 100% adoption rate would reduce energy consumption by 14.3%.

1.3.3.2 Investment Climate for market players

n/a