



Survey of existing studies of smart grids and consumers - Nordic countries

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STRATEGIC PLATFORM FOR INNOVATION AND
RESEARCH IN INTELLIGENT POWER [IPOWER]

SURVEY OF EXISTING STUDIES OF SMART GRIDS AND CONSUMERS - NORDIC COUNTRIES

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3 INTRODUCTION

3.1 OBJECTIVE AND GENERAL PERSPECTIVE

The objective of this survey is to map smart grid studies that address private consumers. The survey shall identify what knowledge there exists about consumer and user behaviour in connection to smart grids and, moreover, how consumers and users are approached in the studies made. The focus is on household consumers; not on industrial companies or other private or public organisations. The present report focuses on studies in the Nordic region, i.e., studies in Denmark, Finland, Iceland, Norway and Sweden. Initially this report was part of a dual delivery, where 1) focused on the Nordic countries; and 2) focused on selected projects in other countries. This present report is the work completed in relation to the first part.

Many smart grid projects contain abstract representations or assumptions about private consumers and their possible behaviour in connection to smart grid technology. Fewer projects actually investigate the behaviour of consumers and make analyses of consumers and their contexts. It is the insight from such studies we gather in this survey. The survey covers studies that carry out empirical investigation of consumer behaviour, consumer practices, attitudes and preferences in connection to smart grid and make claims about consumers based on the empirical investigations. In most cases, the studies also contain a vision, a hypothesis, or other kinds of assumptions and descriptions of the role of private consumers in the smart grid in the future.

Not every study that addresses energy consumption, energy savings or other aspects of energy behaviour in homes is included in our survey. We employ a relatively narrow delimitation of smart grid relevant studies and include only studies that are explicitly declared smart grid related, or include technology for external control or frequent information exchange about energy consumption forth and back between the home and an external entity. Apart from completed studies and projects that have published results about consumer aspects already, the survey includes a number of projects that have started field trials or other systematic empirical investigations of consumers in relation to smart grid. Thus there are projects included that do not directly have results yet but on the other hand have progressed further than just indicating the intention of making consumer analysis e.g. in an initial project description. If they have specified in details their methodological set up with respect to analysis of consumers, they are included in the survey.

There are both analytical and practical-pragmatic reasons for the focus and delimitation to Nordic countries. The Nordic region has relatively many smart-grid studies, also in international comparison, not least due to a high number of projects in Denmark. Neither consumers nor energy systems can be assumed to be identical across the globe. There will typically be larger or smaller differences from country to country. Therefore it is relevant to use the geographical location of the studies as a parameter in a survey analysis. The Nordic countries are, despite differences, relatively

close to each other, geographically, culturally, and with respect to socio-economic structures. It makes sense to describe them together. Another (practical) reason for this focus is our own localization as researchers in Denmark and the fact that our work is a part of the large Danish iPower project. The report is not least targeted for use in this context.

Finally, an argument for making a report focused on the Nordic region is the possibility to make a more or less complete coverage of the Nordic countries. To produce a complete international analysis of smart grid and consumer behaviour studies would be considerably more challenging, amongst other things due to language barriers. The investigations conducted prior to this report identified a number of relevant studies and projects taking place also outside the Nordic region. With a few exceptions, they are not included in the analysis below. The exceptions are a couple European projects that specifically have attention to consumer behaviour in at least one of the Nordic countries.

3.2 HOW TO USE THIS REPORT

The appendix constitutes an essential part of this working report. It is in the appendix you will find the most detailed information about the approach and knowledge build-up on smart grid and consumers in the individual projects. There is an information sheet for each project. Further information on the individual projects can be found through the references and links mentioned in the sheets. In addition to the project sheets, the appendix contains two brief overview lists of projects: One list of the projects included in our analysis. And another one on other relevant projects that for different reasons were not possible to include in our analysis. This can e.g. because the projects have just started, because the relevant information is not yet published, or because we for other reasons could not get access to the information. Many of these projects can be interesting to keep an eye on as they might produce relevant insight and results in the future.

The structure of the main report is as follows: After the report's introduction containing a description of our focus and the method approach, an initial overview of the country distribution of the projects identified is given. Thereafter, a cross-going analysis of findings is presented. The cross-going analysis sums up how consumers are addressed in the existing studies and what the main results are. Some overall classifications of consumer aspects are employed and selected aspects of consumer interaction and information exchange are compared and discussed. In addition to the individual empirical studies of consumer behaviour, the cross-going analysis also builds on insight from a few cross-going review studies that were published recently.

We use the terms 'consumers' and 'users' more or less interchangeably, when referring to a private person using energy in a household in this report. The former term typically emphasize the role as consumer and buyer of energy, while the latter often has more weight on the interaction with the energy equipment, technology and systems.

‘Residents’, ‘citizens’, ‘occupants of the house’, etc., or simply ‘persons’ or ‘families’, may also be used in some places. The term participant is used primarily when emphasising the role of the user within an experimental project.

4 IDENTIFYING SMART GRID PROJECTS IN THE NORDIC REGION

4.1 METHOD APPROACH

The process of identifying relevant smart grid studies and projects has been iterative, with the following main steps:

1. Database search and creation of an initial gross list of potentially relevant projects.
2. Initial analysis of project material – decisions on inclusion or exclusion of the individual projects.
3. Additional search of projects through e.g. consulting of selected researchers and experts, simple online Google search and search on homepages of expertise networks, public authorities, etc. (Steps 2 and 3 are repeated.)
4. Creation of final net list of projects.

A number of databases on smart grid and on energy research and development projects were employed. On European level, the database on smart grid projects established by the European Commission’s Joint Research Centre was used (see Giordano et al. 2011 and 2013 and ses.jrc.ec.europa.eu). This database is established through repeated questionnaires targeted to system operators, utilities, EU member state representatives, and European associations in the latest years. In addition, searches were made in the EU Cordis database on research projects funded through the EU R&D Framework Programmes (cordis.europa.eu). Moreover, the project catalogue established by the International Energy Agency’s smart-grid implementing agreement was searched (IEA ISGAN 2013A and 2013B).

This was combined with searches in databases in the individual Nordic countries. For Norway, the information bases on demonstration activities and research and development projects established by the national competence centre Norwegian Smart Grid Centre and the Norwegian Centres of Expertise Smart Energy Markets were used. Moreover, through the database of the Research Council of Norway projects in a number of research and development programmes like e.g. the RENERGI and ENERGIX programmes were searched. For Sweden, projects in the different research, development and innovation programmes in the energy area were searched through the web page and project database of the Swedish Energy Agency. In addition searches were made in the project database of VINNOVA (the Swedish Governmental Agency for Innovation Systems), in Elforsk’s Smart Grid Programme 2010-2014 and in SUST – Centre for Energy Efficiency in Sweden. For Denmark, the joint database of the different energy-related research, development and demonstration programmes was employed in combination with the project catalogue about the future power system published by Energinet.dk and Danish Energy Association (Energinet.dk and DE 2011). For Finland, the research and development programmes administered by TEKES (the Finnish Funding Agency for Innovation) and by Sitra (The Finnish Innovation Fund) were searched, however with relatively few results. A number

of projects were identified through personal communication with experts. For Iceland amongst other things the activities of Orkustofnun (the National Energy Agency and Energy Fund) and Rannis (the Icelandic Centre for Research) were searched, however no relevant projects were found.

All information sources were accessed in 2013 or the first quarter of 2014. In many instances, there were overlaps between the project information found in the international and the country-specific databases. With the chosen method approach, the survey can be considered to be well-covering concerning studies and projects that have received public support and funding from national and international programmes. On this point the coverage is complete or at least close to complete. Concerning studies and projects carried out within companies, there are some projects included in the survey however it is likely that there exist more projects than we have covered. In both private and public organisations there can moreover be consumer-oriented investigations hidden inside other, maybe primarily technical activities without it has been possible for us to identify them. In this connection it shall be noted, that a clear, traditional distinction between private and public organisations is not always possible and meaningful to make in the energy area. Not only do a number of formally semi-public and semi-private organisations appear in the area. In a number of cases, organisations can in practice be considered as public-private hybrids to some extent, despite their ownership structure. For example, some privately owned companies have considerable public service obligations that influence their way of acting. And there are publicly owned organisations that act on market conditions like traditional private companies in larger or smaller parts of their activities. The energy markets are moreover to a considerable degree publicly regulated, despite liberalisation and privatisation efforts.

4.2 DISTRIBUTION OF THE IDENTIFIED PROJECTS

Through the searches, a gross list of 67 projects was established. Of these 43 were from Denmark, 11 from Sweden, 7 from Norway and 6 from Finland. As mentioned, no projects were found in Iceland. The final list of projects consist of 22 projects: 12 from Denmark; 4 from Sweden; 5 from Norway; and 1 from Finland. The other projects were excluded from further analysis for different reasons, e.g. lack of reporting of results, lack of consumers involved; that the results were not meant for public use, or that the project was in a too early stage of development to have the specific study design or results ready.

Of the 22 projects, 19 projects are internal national projects and three projects are EU projects.¹ With 19 national projects, our survey covers more Nordic projects about smart grid and consumers than the European JRC database that identified 14 Nordic projects (Giordano 2013, p. 72). The European database in addition included nine

¹ In our account the EU projects are counted under the Nordic country where they have the main consumer emphasis in practice.

multinational projects (EU projects etc.) with attention to consumer aspects and with participation of Nordic countries (Sweden is the Nordic country who participates in most of the multinational projects, six out of nine). However, not all of these projects have the emphasis on consumers in the Nordic countries and they are not all included in our survey.

Figure 1 shows the number of projects on smart grid and consumers starting up in the years 2005-2012 in the Nordic countries (our survey) and in Europe (the JRC study, Giordano et al. 2013). Though the numbers for Norden and Europe are not directly comparable due to method differences in the two studies, it is clear that the Nordic activities on smart grid and consumers constitute a considerable part of the activities in Europe in general. Both studies show that the number of smart grid projects addressing consumers have increased since 2005. Especially in the period 2009- 2011 many projects commenced. This tendency to increasing attention to consumers in smart grid projects has also been pointed out by Verbong et al. (2013). The number of multinational projects also increased after 2008 and there has been a growing attention to households and the potential for energy savings in the residential sector (Giordano et al. 2013).



Figure 1: The development in the number of new projects addressing smart grid and consumers identified in our Nordic survey and in the European survey carried out by the EU Joint Research Centre (Giordano et al. 2013) (shown after year of project start). The number for Europe for 2012 is preliminary and the decrease appearing is probably at least partly due to methodological reasons.

It has not been possible in our survey to make a systematic account of the size and economic resources used in the studies of consumer and user behaviour. However, it can be illustrative to look at the numbers found in the European study on smart grid projects in general in the European countries. Figure 2 shows the capital spent on smart grid projects in the European countries in the period 2005 to 2012 and the ranking of the countries according to the spending (Giordano et al., 2013). It appears that Denmark is the fifth most spending country in Europe. Denmark

stands for around 10% of the total investments in smart grid projects. If one considers the spending relative to the population size of the countries, Denmark also stands out: It is the country investing the most per capita. With this accounting method, Sweden and Finland are also among the most spending countries in Europe.

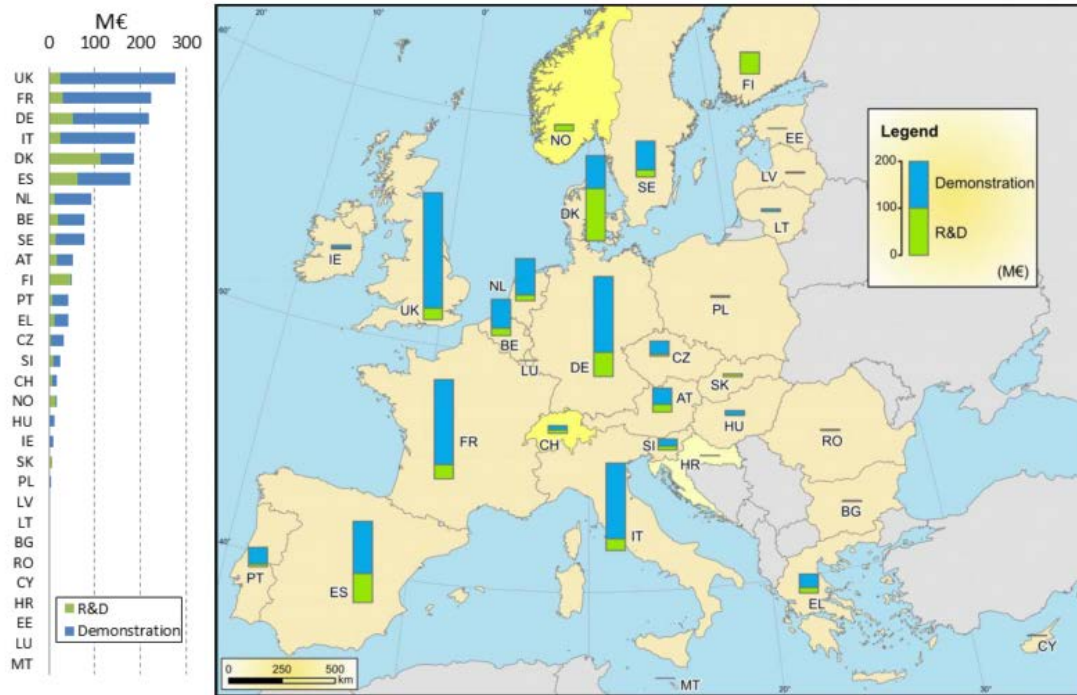


Figure 2. Investment in R&D and demonstration smart grid projects in Europe. Cumulative data from year 2005 – 2012 (Giordano et al., 2013).

Table 1 shows the number of smart grid projects in general and the capital spent on the projects in the Nordic countries in accurate numbers. It appears that also concerning the number of projects Denmark stands out. The number of projects in Denmark exceeds the other Nordic countries taken together. The column on budget per project (in average) shows that Sweden and Finland seem to invest in relatively large projects. Compared to Finland and Sweden, the projects in Denmark and Norway are in average less than half the size or even smaller. The picture in Denmark and Norway might suggest that there is an exploratory approach in these countries where the project funding is spread out over more projects, instead of focusing on few big projects. This picture seems in accordance with what is seen in other studies of energy innovation systems and innovation systems in general, with Denmark and Norway with many relatively small companies, with much cross-going interaction and (at least for Denmark) with many relatively small projects. Compared to this, Sweden and Finland have less cross-going interaction, but often relatively large companies and projects (Borup et al 2008).

	Number of projects		Budget [million euro]		
	Total	Demonstration	Total	Pr. project	Demonstration
Denmark	94	19	184.6	~ 1.7	71.39
Finland	13	3	46.99	~ 3.6	-
Sweden	18	7	77.85	~ 4.3	62.17
Norway	15	2	14.15	~ 0.9	-

Table 1: Number of projects and total budget on smart grid projects in the Nordic countries (cumulative over the years 2005 – 2012). Data from the webpage: <http://ses.jrc.ec.europa.eu/number-smart-grid-projects-country>. The data is based on the report: Smart Grid projects in Europe: Lessons learned and current developments (2012 update) (Giordano et al., 2013).

In addition to the total number of projects, Table 1 shows the number of smart grid demonstration projects. Different definitions of ‘demonstration projects’ exist and not all European countries distinguish systematically between demonstration projects and R&D projects in general. It can be assumed, however, that demonstration projects in many cases have to do with some kind of showing and testing of smart grid technology in practical use and the projects can often involve consumers. This is why the number of demonstration projects is stated here. Some of the demonstration projects might as well, however, deal primarily with other parts of the electricity systems than the consumption side and the figures cannot be taken as a direct measure of consumer-oriented studies. It appears that most of the spending in Sweden (80%) is done through demonstration projects. For Denmark around 40% of the spending is demonstration projects.

5 CONSUMERS AND SMART GRIDS - CROSS-GOING ANALYSIS

5.1 INTRODUCTION

In this chapter the findings on consumers and smart grid will be described. Concurrently with our surveying of the studies on consumers and smart grids, a number of other cross-going studies of the topic have appeared. This development is interesting to notice. It confirms the picture of an increasing attention to consumers and users in connection to smart grid developments at present. In the following we will firstly mention some of the main findings from these other cross-going studies, to the extent that they include projects in the Nordic countries. Hereafter, we turn to our own analysis of the individual projects identified in our survey.

5.1.1 FINDINGS FROM OTHER CROSS-GOING ANALYSES

The cross-European survey mentioned above finds that most of the consumer oriented projects focus on the residential sector and households, and not on industrial or public/commercial service sectors. This finding seems well in accordance with our investigation, though we have not systematically searched for projects with industrial and other professional consumers and therefore cannot state as specific distribution of projects between the two types of consumers. The cross-European survey reports two overall objectives found in the projects: 1) to gain deeper knowledge of consumer behaviour (observing and understanding the consumer); and 2) to motivate and empower consumers to become active energy customers and smart grid participants (engaging the consumer). The motivational factors addressed in the projects are often environmental concerns and reduction of/control over electricity bills. This is the case in more than 60% of the projects. A smaller share of the projects address better comfort for the consumer as a motivational factor (Giordano et al. 2013, see also Gangale et al. 2013).

Haunstrup Christensen and colleagues study Danish, Norwegian, and Spanish smart grid efforts and analyse household-oriented projects with respect to two dimensions: 1) type of smart-grid related activity (electricity saving, management of load; micro-generation; and other); and 2) specific household consumption areas/technologies addressed (e.g. heating/cooling of houses, use of white goods (laundrying, cooking, refrigerating, etc.), lighting & other electric appliances, and transportation (electric cars)) (Haunstrup Christensen et al. 2013a and 2013b). Concerning the type of smart-grid related activities, a majority of the projects address load management. Load management refers to balancing the electricity supply on the net by the means of controlling the load and not the output from the power station. For the consumer this can imply external control of household loads (electric devices). Of the Danish projects, 12 out of 18, that is 2/3, focus on load management. Around 1/3 of the projects address electricity saving. A couple of projects cover both types. The picture is similar for Norway and Spain, but the number of projects analysed is considerably smaller for these countries (respectively 3 and 7). Two projects address micro-generation (one Norwegian and one Danish). Six projects address 'other' smart-grid related activities. Of these, three

are about transportation (electric car use) in Denmark. Apart from transportation, it is the heating/cooling of houses, that is the most often addressed specific area of consumption in the households. In a number of cases this is done with special focus on heat pumps. No projects are identified with focus on laundering, cooking, refrigerating, or lighting & other electronics in Denmark and Norway. (One Spanish project focused partly on laundering and refrigerating). In general, it is concluded, that most activities so far have had a primary focus on the technical aspects of developing the future smart grid. The household consumers' contexts are usually relatively weakly integrated and only of secondary interest in the studies (Christensen, Ascarza, & Throndsen, 2013). This picture is in agreement with the findings of the European analysis mentioned above.

In Norway, Sæle et al. (2013) summarized the experiences about consumer flexibility ('demand response') in electricity consumption that were gained in connection to a row of six research projects, funded by the Norwegian research council over a period of 16 years (1996-2012). Though some of the project activities covered fall outside what we include in our analysis, e.g. by being idealized model calculations and not actually investigating consumer behaviour in practice, a number of test activities with consumer participation are included. Among the main findings are that consumers are often interested in and willing to change consumption behaviour, and that motivation and incentives are of significant importance for making it happen. A main incentive for changing the behavior is the possibility of cost reductions, however the variations in spot market prices do not make up a sufficiently big incentive. Instead, a tariff scheme with larger time variations is suggested. Another main finding is that household consumers are a more homogeneous group of consumers than industrial consumers. Efforts for flexible consumption of household consumers need not to the same extent to be individually targeted as they do for industrial consumers (Sæle, Grande, & Mørch, 2013).

5.2 METHOD APPROACHES IN THE PROJECTS

We use two overview tables to present the findings of our analysis on consumers and smart grid in the Nordic countries. The first one, here in this section, offers an overview of the projects' method approaches and analysis design in the study of the consumers (Table 2). The table indicates which types of empirical data about the consumers that are used in the projects and the extent of the empirical material. The second overview table, Table 3, shows which aspects of consumer – smart grid interaction that are addressed in the individual projects. One project, IHSMAG, was included in the review sheets, but not in the two tables due to lack of information on the categories addressed in the two tables.

	Project title	Consumption data	Qualitative data	Questionnaires	Project duration	Field test	Households
DK	Automation systems for Demand Response	x	x	-	3 years	2 years	500 ²
DK	Charge stands ³	-	x	-	n.a.	6 months	18
DK	Demand as Frequency- controlled Reserve	x	x	x	3 years	11 months	28
DK	ECOGRID-EU	x	x	x	3 years	3 years	1800
DK	EDISON	x	-	-	n.a.	3 months	13
DK	Energy Forecast	x	x	x	3 years	5 months	558 (100)
DK	From wind power to heat pumps	x	-	-	2 years	2 years	300
DK	Intelligent remote control of individual heat pumps - (IFIV)	x	-	-	2 years	2 months	4
DK	Prøv1elbil	-	x	-	3 years	3 months	80
DK	Test-en-elbil (ChooseCom)	x	-	x	n.a.	3 months	300 (>8)
DK	The e-Flex Project	x	x	-	n.a.	1 year	119
FI	Beaware	x	x	-	3 years	~3 months	20
NO	MSiSG	-	-	-	2 years	n.a.	n.a.
NO	IMPROSUME	x	x	x	3 years	6 months	17
NO	Market Based Demand Response	x	-	-	3 years	1year	37
NO	Demo Steinkjer	-	-	-	3 years	n.a.	330
NO	Smart Energy Hvaler	-	-	-	n.a.	n.a.	5000
SE	Matning 2009	-	-	-	4 years	n.a.	270.000
SE	Smart Grid Gotland	x	x	x	5 years	n.a.	11.500
SE	Stockholm Royal Seaport	-	-	-	15 years	n.a.	10.000
SE	Pilotstudie i Vallentuna	x	x	-	n.a.	5 days	30

Table 2 shows a characterisation of the projects: Columns 3, 4, 5 inform of what types of data the individual projects base their research on; columns 6, 7, 8 inform of the size of the individual projects. The fields marked with n.a. (not available) indicate that no information was available.

² Selection based on high electricity consumption. The 500 households were divided into four groups where one group was the control group

³ Subproject of 'test-en-elbil'

5.2.1 DATA TYPE USED

Three columns in Table 2 indicate the types of empirical data used in the projects; whether it is ‘consumption data’ (technical consumption data collected via smart meters or other consumption registering technologies); ‘qualitative data’ (e.g. from interviews or observation studies); and/or data from ‘questionnaires’ (survey questionnaires distributed to electricity consumers or participants in the field tests).

From the table it is clear that the majority of projects employ consumption data. Around half of the projects use qualitative data. Six projects employ questionnaire data to collect information from the consumers.

There is great variety within the category of ‘Qualitative data’. In some projects anthropological methods were applied where in other interviews were collected more randomly. This table does not include an evaluation of the methods applied in the projects but solely lists if they were occurring at all. Table 2 thus gives more a hunch of which types of data are collected and not the quality within each project. Many of the projects base their analysis on ‘consumption data’ (the majority was from electrical heating, heat pumps or charging data) and in addition utilised some kind of qualitative methods (from the categories: interviews (in person and over the phone), focus groups, questionnaires, blogs (diaries), and observations).

5.2.2 PROJECT SIZE

Table 2 moreover indicates the size of the empirical study by the three columns ‘Project duration’, ‘Field test’ and ‘Households’. The ‘Field test’ column informs of the duration of the field test, thus for how long a timespan the field experiment including consumers lasted. As the table shows, data was available of the duration of field tests from 15 out of 21 projects. There is great variety in duration of the field tests among the projects, from 5 days up to 3 years. 7 of the 15 projects had field tests which lasted between 3-6 months. 5 projects had field tests that lasted between 1-3 years. The category ‘Households’, informs of the amount of households that were included in the field tests. The amount of households included in the field tests vary from 4 to 270.000. The column, ‘Project duration’, informs of the duration of the entire project. The duration of the smart grid projects spans from 2 – 15 years, where the majority of the projects last 2 or 3 years. Singular projects lasted of 4, 5 and 15 years. All together this information gives an impression of the scale of the projects and enables a rough comparison among them, based on the included factors.

5.3 CONSUMER ASPECTS ADDRESSED IN THE PROJECTS

Table 3 shows which aspects of the interaction between the consumer and the smart grid technology that are investigated in the individual projects. Four main categories are used for this (column 3 - 6). Of these categories, the first, 'Behaviour and everyday life', is the most broad and general. It can include a number of different aspects e.g. utility, comfort, patterns of use in practice, energy saving efforts, etc. The categories 'Economic incentives', 'Automation' and 'Feedback/visualization' are more specific and relatively narrow. The last column 'Technology' shows which specific technology areas that are addressed in the individual projects. The findings are described further after the table.

	Project title	Behaviour and everyday life	Economic incentives	Auto-mation	Feedback/visualization	Technology
DK	Automation systems for Demand Response	-	x	x	x	Automation; electrical heating.
DK	Charge stands ⁴	x	x	-	-	EV's; charge stands
DK	Demand as Frequency controlled Reserve	-	-	x	-	Automation (to control individual loads)
DK	ECOGRID-EU	-	x	x	x	RT-signals; consumption visualization; automatic control
DK	EDISON	-	-	x	-	EV's and charging functionalities
DK	Energy Forecast	x	x	-	x	Energy forecast; Indication of electricity price
DK	From wind power to heat pumps	-	-	x	-	Automatic control of heat pump; data collection; measure consumption
DK	IFIV ⁵	-	x	x	-	Heat pumps; automation; sensors
DK	Prøv1elbil	x	x	-	-	EV's
DK	Test-en-elbil (ChooseCom)	x	-	-	-	Charging; EV's
DK	The e-Flex Project	x	x	x	x	Heat pumps; automation; consumption visualization
FI	Beaware	x	-	-	x	Consumption visualization; Games; Light visual
NO	MSiSG	-	-	-	-	AMI
NO	IMPROSUME	-	-	x	-	Heat pumps; RC ⁶ by utility Company
NO	Market Based Demand Response	-	x	x	x	Smart Meter and AMI; RC
NO	Demo Steinkjer	-	x	-	-	Living lab
NO	Smart Energy Hvaler	-	-	-	x	Living lab; holiday homes DER's ⁷
SE	Matning 2009	-	-	-	-	AMR; Collection of electricity, water; Hourly values
SE	Smart Grid Gotland	-	x	x	x	Personal energy advice; RC; price signal, prognosis; neighbour compare
SE	Stockholm Royal seaport	-	-	-	-	City development project
SE	Pilotstudie i Vallentuna	x	-	x	-	Heat pumps, RC

Table 3 Consumer aspects addressed in the projects. The table shows: 1) if the projects include an investigation of the everyday lives of the user in relation to the new smart grid technology (column 3). 2) The initiatives used in the projects to change the user's consumption of energy (column 4 - 6). 3) The main smart grid technologies and concepts in the projects (column 7).

⁴ Subproject of 'test-en-elbil'

⁵ Short for: Intelligent remote control of individual heat pumps.

⁶ RC = Remote Control

⁷ DER = Distributed Energy Recourses, in this case Photovoltaics (PV)

The category 'Behaviour and everyday life' covers an investigation of, if/how the projects incorporate a study of the new smart grid technology, in relation to the everyday life of the consumers. Smart grid technologies impose changes in the energy consumption in the households. Since energy consumption is related to everyday practises, an implementation of smart grid technologies in the households will have an effect upon the user's everyday lives and routines. For example, there are differences in the everyday routines when driving an electric vehicle compared to a combustion engine driven vehicle. Likewise, homes equipped with smart grid technology have an effect upon the people that occupy them.

The categories 'Economic incentives'; 'Automation'; and 'Feedback/visualization' cover the types of concepts applied in the projects to investigate or change the consumers' consumption of energy. The category 'Economic incentives' Includes different types of pricing initiatives, typically different types of dynamic pricing (price consisting of: spot-price and dynamic net tariff; or real time pricing). The category 'Automation' shows if the projects included automation of equipment in order to change the consumer's consumption. For example, in connection to use of electric vehicles, the automation category covers automatic charging of the vehicle, the relationship between the users plugging in the car when arriving at home and when the charging occurs (when circumstances are right; according to stability of the grid, price of electricity, etc.). In similar ways automation can also cover control of heat pumps and water boilers.

The category 'Feedback/visualization' shows if the projects include feedback and/or visualization to the consumers of the energy consumption; peak periods; or price signals between the energy supplier and the household consumer. The category hence covers by which methods the energy consumption; peak periods or price signals are communicated. The methods are e.g. static watch communicating peak periods; in-home display; different PC and email methods.

5.3.1 BEHAVIOUR AND EVERYDAY LIFE

Table 3 shows that 7 out of the total 21 projects included investigation of the consumer's everyday life and practices related to the new technology. Some projects had a strong focus of how new technology affected the daily lives of the consumer participants in the project. Among these were the 'eFlex-' and 'Beaware project'. The 'eFlex project' investigated the changes in the user's lives that the home automation system caused. The investigation was conducted by anthropologists. The domestication process of the new technology, i.e. how the new 'wild, unknown' technology gets 'tamed' by the families was studied in diverse families (families in different age groups, with or without children etc.) and provided with information of how the families behave differently when using the technologies. For example having a heat pump does not mean the same thing for all the families. For some of the families, having a heat pump is merely a way of heating up their homes while for others the heat pump is a hobby. When home automation equipment was installed allowing automated control of the pump, the technology hereby gets different roles depending on which families it becomes incorporated in. Among the dimensions investigated in

the 'e-flex project' are economic concerns and environmental concerns of consumers in their smart grid interaction. It was found that it made sense to distinguish between primarily economic oriented consumers and consumers that are economic as well as environmentally oriented in their praxis.

The 'Beaware project' investigated the convergence between users' perception of changed consumption habits and their actual energy consumption. More specifically, the project investigated how a persuasive technology (Energy Life that controls the consumption of the households' appliances and includes tips and games) affects the consumption of energy in the households. The Energy Life contains information and awareness tips of the electricity consumption of the household. It is tailored to address the consumption of individual devices and of the entire household. The investigation centred on how persuasive design technology changed the consumer 'electricity saving' behaviour.

Three out of the four projects including electric cars paid focus on how the new technology fit into the users' everyday lives. The project 'Charge Stands' used an analytical framework to specifically understand the change in social practices in everyday life. The project focused on how the electric cars fit into the participants' daily lives in terms of flexibility, freedom, spontaneity and confidence. The project 'Prøv1elbil' explored the attitude towards electric cars in families, and if electric cars can fit into the everyday lives of the families. In this connection the project investigated what aspects of electric cars were perceived positive or negative (compared to a combustion engine car) in the families. The project 'Test-en-elbil' is a project building on 'Prøv1elbil' and has continued investigating the everyday settings around the electric vehicles and the consumers. 'Test-en-elbil' investigated how frequent the users prefer charging stations to be available. Furthermore the project explored how safety issues in electric cars affect the users, and how the non-existence of noise in the electric cars affects the drivers' behaviour in traffic. Also the project investigated how the usage of an electric vehicle can affect the overall consideration for the environment and energy consumption.

Some projects included smaller studies of the users' everyday lives in homes with new smart grid technology. The project 'Pilotstudie i Vallentuna' investigated how comfortable the users were in relation to the new technology (automated heat pumps). The comfort was both in relation to the indoor temperature but also in relation to the managing the device. The investigation focused on the trust of the users' towards the new heat pumps. Another project that included a small study of the consumers' everyday life was the 'Energy Forecast' where it in a survey was investigated if the households included in the field test showed increased interest in demand response. Furthermore the survey investigated if the households were more interested in the electricity price after the implementation of the energy forecast service.

5.3.1.1 PROJECT CONCLUSIONS ABOUT BEHAVIOUR AND EVERYDAY LIFE

The anthropologists participating in the 'eFlex project' concluded that the users could be divided into the five following groups in relation to their interaction with the technology: The technician, the economist, the curious, the sympathetic, and the comfortable. Because of the differences between the users, the needs and wishes, in relation to the concept, design and communication, varied. The anthropologists concluded that demand response is related to lives that are being lived within private homes. Demand response thus is about getting people to change their habits and routines. Also it was concluded that electricity is used to create life in the homes. Electricity is used on necessities (cooking, heating etc.) and luxurious lifestyle (hobbies, social life) practises. The participants were mostly willing to change the consumption practises related to necessities opposed to the consumption related to social events or hobbies. In the project the families showed interest in including the children in the usage of the new technology. The project found that the new technology changed the roles within the families, and concluded that if the willingness towards such technology is to be advanced, the diversity of the consumers should be considered in the technological set-up.

The results relating to behaviour and everyday life in the 'Beaware project' showed that the involved consumers did change their consumption if they declared that they would in the beginning of the test phase. The persuasive technology EnergyLife assisted the users in the process, although the amount of time spent by specific users interacting with the system was not collated with the energy conservation of those. EnergyLife provided with energy consumption feedback of all the electric appliances, and it was the availability of specific feedback on certain devices combined with a possibility of receiving further knowledge in terms of energy savings tips that seemed to trigger the participants in the project to use less energy.

The project 'Charge Stands' concluded that electric cars are not easily integrated into the social practises of the consumer's everyday lives. Some core values within the families were not fulfilled by the new technology. Especially there were notions of flexibility, freedom, spontaneity, and confidence within the users' values that were not fulfilled. Tests from the project 'Prøv1elbil' showed that electric cars can replace a traditional car in average Danish families' everyday life; and with the exciting charging infrastructure electric cars can be included in most two-car families as car number two. This conclusion supports the conclusion from 'Charge Stands' of not fulfilling all the functions and values that the families wish for in a car. The project 'Test-en-elbil' showed that drivers of electric vehicles believe that an increase number of charging stations will affect the distances that they drive and that this distance will mostly occur in holidays. The project stated that the electric cars can easily cover the needs of the families and that the desire for more charging stations is an expression of a desire that is not founded in real needs. Furthermore the project concluded that a great deal of the participants is more focused on their energy consumption after participating in the project. A majority became more environmental considerate by participating in the project.

The project 'Pilotstudie i Vallentuna' concluded that the participants in the project did not feel comfortable with the new technology (heat pumps and remote control). The participants experienced a great level of insecurity towards the technology and did not experience a good enough level of comfort. The project 'Energy Forecast' concluded that the SEE1 (small box indicating electricity price level) combined with a spot contract resulted in an increased interest in energy consumption. The SEE1 had a strong impact on the awareness of the electricity prices in the households and resulted in a reduction of their energy consumption by moving electric loads to hours less expensive. The project caused a considerably increased knowledge about the electricity system among the participants. Although the knowledge level was increased, only the group receiving a spot-contract had an increased interest in demand response.

5.3.2 ECONOMIC INCENTIVES

Out of the total 21 projects 10 projects included different types of economic initiatives to change the consumers' consumption of energy. In relation to the pilot project 'Market Based Demand Response' the following statement was made: *'To achieve flexibility in demand it is important to make the customers more conscious of their own electricity consumption, through information and price signals'* (Sæle & Grande, 2011). The statement supports the earlier stated understanding that price signals are one important component for increasing energy awareness. Thus many projects consider the consumers as being price oriented when it comes to the subject of participating in the energy system. In the final 'eFlex project'- report from DONG Energy it was stated: *'In order to encourage load shedding in the consumer segment, price incentives become a natural choice. However, studies have revealed that a relatively large segment of customers is not sensitive to variations in electricity pricing, and other incentives may play a more influential role in customers' procurement behaviour'* (Dong Energy Eldistribution, 2012). Regardless to the sceptic formulation about price incentives, price incentives were applied in the project with the following argument: *'Despite what has been said about customers' insensitivity as regards price changes, the customers were exposed to varying price signals. Even though some customers emphasise climate, environment or have a more sophisticated approach to prices than expected from homo economicus, one or more signals will have to control interruptions of heat pumps and charging of electrical vehicles, and here the price signal is useful, as it is easy to ascribe meaning to the signal (no matter for what reason)'* (Dong Energy Eldistribution, 2012). Price signals are thus on the one hand considered an important component of increasing awareness, but on the other hand seen as inadequate as a stand-alone initiative. For the 'eFlex project' price signals subscribed meaning and value to electricity consumption and availability.

In this review several projects consider price signals as means (at least partly) to achieve change in electricity consumption. These projects have constructed economic incentives to change consumption patterns. The economic incentives were specifically found in the realisation of demand response among the private consumers through dynamic pricing. An overall description of dynamic pricing has been linked to shifting of electric loads. When electric

loads vary according to time and are shifted because of price incentives, the term is dynamic pricing. The variation in time might occur according to peak periods, time of day etc. The concept of dynamic pricing can be linked to the perception of the consumer as being 'price oriented' since it implies that the consumers need 'economic compensation' for adjusting his/her consumption. Although the 'eFlex project' argues that the price signal was intended to apply meaning to the signal, there is also argued that other economic incentives are important when discussing demand response: *'When discussing prices and economy in relation to demand response, the discussion should therefore be less focused on the design of the price signal than on the price of the technology that will automatically offer load shedding. As soon as the customers have accepted to purchase the technology, any signal would work, but for some, the promised financial benefit of purchasing and installing the technology may be a decisive factor and in this respect is a discussion of price signal design relevant'* (Dong Energy Eldistribution, 2012). Accordingly the overall saving that the private consumer may get, may be important for the consumer. Therefore the consumer is seen as price oriented and the amount of the saving that he/she might get will (partly) rely on the construction of the dynamic pricing.

Of the projects viewing the consumer as 'price oriented' most of them applied dynamic pricing to all the included households, suggesting dynamic pricing to be a generally acknowledged concept in connection to smart grid. Only one project, 'Energy Forecast', tested if the concept of dynamic pricing was beneficial at all. Here 100 (out of 558) participants were given a spot contract. All the projects that included dynamic pricing (except 'Charge stands' and 'Prøv1elbil') also included an increased visualisation of the electricity consumption within the home. The consumer should consider electricity as something with a variable price and be aware of the consumption level of the household. The price that the consumers were to consider included different price elements that independently of each other could vary during the day, week or season. The majority of the projects that included Dynamic pricing, included spot prices from the NordPool Spot market. Spot prices of electricity (wholesale price of electricity) are communicated on the Nordic electricity market, Nord Pool, where the price per hour is decided, dependent on supply and demand⁸. As previously mentioned, previous studies have shown that spot price variation is not incentive enough for the consumer to change consumption behaviour (Sæle et al., 2013). A number of the projects (four) also included dynamic net tariffs. The project 'Charge stands' (subproject of 'Dynamisk Grid tariff') included a price which was a combination of spot price and a dynamic net-tariff. The hourly price of electricity was announced to the consumer at noon the day before it occurred. The dynamic net-tariff had 4 categories (cheapest at night and most expensive at daytime) and was constant and known to the participants in advanced. In similar way the 'eFlex project' had based the price on spot price and time of day network tariff, where the 'eFlex project' had a 3-step grid tariff instead of 4 steps.

⁸ <http://www.energifyn.dk/privat/elhandel/vaerd-at-vide/nord-pool>

The two other projects containing similar pricing mechanisms are the project 'Market Based Demand Response' and 'Smart Grid Gotland'. For the participants in these projects to predict the price of the electricity, they have to consider the spot price and the net tariff. The project 'Prøv1elbil' had a simpler approach where the consumer got 1 Kroner discount per charged kWh between midnight and 6 o'clock in the morning. Most of the projects including dynamic pricing have price structures that exceed the previously flat structure in complexity.

The 'ECOGRID-EU project' was focusing on real time pricing. In the first round (beginning in May 2013) in the 'ECOGRID-EU project' the real-time prices are based on the Nordic power market (Nord Pool), balancing markets and information on available wind power. The information gained from the first trial will be used to develop the 5 minutes real-time pricing that is planned to take place in the following round. The consumers within the 'ECOGRID-EU project' will get a signal with the price of electricity 5 minutes before it occurs. Within the real time pricing projects, the consumers will not know in advanced what the price of electricity will be. In the projects that base the price partly on the NordPools spot market the consumer has the possibility to know the price the day ahead of occurrence.

5.3.2.1 PROJECT CONCLUSIONS ABOUT ECONOMIC INCENTIVES

The 'eFlex project' concluded that the consumers' participation and motivation for demand response was not connected merely to economic incentives. The participant's economical rationales were complex and diverse. The consumers had a wish to avoid waste of energy but also had a wish to behave as social norms detect (wanted to do what is perceived as normal, reasonable actions).

The project 'Charge Stands concluded that encouraging the participants to charge in off-peak periods (when the price also is cheapest) was not enough. The greatest savings were achieved in the cases where the charging was done intelligently.

5.3.3 AUTOMATION

Within the projects that included dynamic pricing there was a focus on including automation equipment. The automation equipment was in several projects set up to react on price signals and turn electric devises on/off according to the signal. Within the projects reviewed in this report 11 of the total 21 projects included automation equipment. Off the 11 projects including automation 6 projects automate on the basis of price signals. The remaining projects did not include price signals and focused on the state of power system. The participants in these projects were expected to let the automation equipment control their appliances in order to achieve a better functioning power system.

The project 'Automation systems for Demand Response' included an automation box that reacted according to the electricity price. In a quite similar manner the 'eFlex project' contained a control unit that would prevent the heat

pumps in the households from operating during peak periods. The 'ECOGRID-EU project' declares that automation together with customer choice is a key feature in the concept. The project is comparing groups of consumers with different types of load control technologies available. In the project one group (500 households) will receive price but will have to adjust their level of consumption manually. Two other groups (sum = 1300 households) will test two different types of automation equipment (IBM/GreenWave and Siemens/SyncoLiving). The IBM/GreenWave group will be controlled at an 'individual-household level'. The Siemens/SyncoLiving group will be controlled at an 'aggregator control - level'. The households in the individual level respond to price signals on an independent level. The households in the aggregator control group have heat pumps or electric heating devices that respond to aggregator control. The difference between the two groups lies in the presence of the aggregator controlling the units remotely in one group; in the other the consumers decide completely how to program the automation equipment.

Within above listed projects the consumers have the possibility to enter specific settings in to the installed automation equipment. In the following period the automation equipment would turn on/off and optimize the energy consumption according to the settings. In this case the consumers would passively get an economic benefit. The consumer would have an incentive to not be in charge of their own energy consumption but to leave out the daily practices of turning the heat on/off. If the consumer was not satisfied with the indoor temperature for example, the settings could be changed. However this did not seem to be a daily practice.

Quite similar to the above stated projects the project 'Demand as Frequency-controlled Reserve' developed and tested a smart-box to regulate the consumption of attached electrical devices according to a received signal. The signals were based on grid frequency. Another project that took departure in the electricity supply was the project 'From wind power to heat pumps'. The project constructed a site where it was possible to control heat pumps in households on the basis of local weather prognoses and according to the electricity supply. Also the 'EDISON project' focused on the needs of the power system. Apart from other activities the 'EDISON project' tested optimised charging of the vehicles according to 'the needs of the power system'. The project 'Market Based Demand Response' included remote control of water heaters. The utility company would control the water heaters from a far. In this project the consumers were tested if they could live with remotely controlled equipment. The field test investigated the tolerance level of the participants. In the 'IMPROSUME project' the initial plan was to test remote control of heat pumps where the utility company was in charge. However the activities did not go as planned. The project 'Smart Grid Gotland' plans to include direct control of the consumers' devices. The project has planned to include direct steering of water heater and electricity heating. In the group of projects, that does not include price signals, the consumers are not viewed to be dependent on economic incitements when having such equipment installed within their premises. The consumers are in these projects expected to cooperate with the energy companies. As mentioned earlier it is only within a few projects that broader aspects of consumer behaviour and everyday life are studied.

5.3.3.1 PROJECT CONCLUSIONS ABOUT AUTOMATION

The project 'Automation systems for Demand Response' which, mainly focused on the technological ability to move the consumption, concluded that information on energy prices alone did not have any effect on moving consumption, as the following quota shows: *'The study showed that the effect of information on energy prices alone did not move any consumption. The effect was not measurable on the consumers that did not have automatic technology to move the consumption. The consumers that had installed automation equipment had clearly moved consumption.'*

(Energibranchen, Danfoss, & S, 2009). The consumers that had installed automation equipment had clearly moved consumption. Furthermore the project concluded that there is potential for activating the electricity consumers in order to move their consumption by means of variable prices. The positive feedback from the participants from the field experiments and the high activity level on the participants' side in the experiment can be seen as a positive in relation to acceptance of the technology.

The 'eFlex project' reached a quite similar conclusion in relation to the consumers' willingness to let others control their heat pumps. The project concluded that given the right incentives the consumers were willing to let their heat pumps be controlled externally. The project also found that the participants reacted differently according to the technology depending different societal factors. On this basis consumer segmentation, with 5 different user groups according to their behaviour to the technology, was constructed. The project showed that flexibility could be achieved without the consumer would lose their comfort level.

In the two above projects the technologies that were automated were electrical heating and heat pumps. The project 'Market Based Demand Response' had a general focus on personal economic benefit for the consumer and thereby considered economic incentives important to the consumer as the citation suggests: *The pilot study focused on daily demand response from households, utilizing smart metering, remote load control, pricing based on the hourly spot price combined with a time of day network tariff, and a token provided to the customers indicating peak hours* (Grande, Graabak, Vognild, & Wilberg, 2007). Secondly the project had focused on reduction of electricity consumption. The results from the projects showed that the consumer was focused on comfort. Since the consumer had no loss in the comfort level in the project the participants had accepted remote load control. The study clearly focused on comfort level as being the most important aspect to maintain when implementing external control of appliances. The implementation of ToD (time of day) network tariff in the project had increased interest in energy conservation and had motivated other activities to lower the users' energy consumption.

Unlike the previously mentioned projects, which included remote control and heat pumps, 'Pilotstudie i Vallentuna' reported negative results on the acceptance of the automotive system. The project reported that there was great difference between how much an exact comfort level meant to the different house owners. Furthermore an increased

level of reinsurance in relation to the heat pumps was required by some of the participants. The participants varied in the level of insecurity towards the new technology.

5.3.4 FEEDBACK AND VISUALIZATION

8 projects included types of consumption feedback or visualisation of peak periods. Since the development of Smart Grid contains two way flow of energy and the consumers in many pilot projects are being used as reserves, the feedback type is changing. In this section the focus is thus not only on feedback of energy consumption but also on other related issues that are emerging in the area of visualization and feedback in relation to Smart grid. Two other elements that are related to the consumption of energy are 1) the price of electricity and 2) remote control of appliances. These elements were applied in many projects but only price of electricity was seen combined with feedback and visualization in the projects in this survey.

From the reviewed projects in this report several projects included **visualisation of energy consumption** where the appliances were connected to the socket via a 'smart plug' that wireless communicated the data to a 'base station'. This type of energy visualisation can give accurate feedback on consumption of home appliances.

As stated in the section before (automation) the 'eFlex project' contained automatic control of heat pumps, furthermore the participants were informed of their additional electricity consumption. The participants had a home automation portal installed on their premises. The home automation system allowed the participants to change the settings related to their heat pumps and electric vehicles. Furthermore the system allowed closely monitoring of the electric devices that were attached with smart plugs. The participants had the possibility to learn about consumption of specific appliances. In the 'eFlex project' the participants on the one hand were eliminated in relation to the direct (everyday) control of certain energy consuming devices (heat pumps and charging of electric vehicles) and on the other hand made aware of their consumption of other appliances.

In the 'Beaware project' the consumers were informed about their consumption via a profile available by mobile phone (smart phone) and a special designed lamp. The system also included smart plugs and a 'base station' connected by wireless sensors. Furthermore the project included a special lamp to visualize energy consumption. The lamp could visualize the consumption from the appliances (connected to the base station). The 'Beaware project' focused on awareness tips and consumption feedback. The consumption feedback was visualized as the distance between the current consumption and the desired goal. Along with awareness tips this should enable the participants to change their energy consumption to the desired level. The expressions of the awareness tips and consumption (savings) were inspired by games, and were expressed as scores. The saving of energy was designed as a game and there were different levels that the participant could access. Furthermore the participants were presented to quizzes to test their knowledge on energy saving.

Several of the reviewed projects in this survey included **visualization of price**. The projects contained different types of price feedback. Some projects contained static types. For instance the project 'Market Based Demand Response' included visualization in form of a watch, illustrating peak hours. The watch contained 12/24 hours. The hours 8:00-10:00 were indicated as morning peak hours and the hours between 17:00-19:00 indicated the afternoon peak hours. The marking of the peak hours was static and did not change. Furthermore the consumers received signals (how they precisely were done is not clear) of the electricity price. In this case the consumers got presented the peak hours and should by themselves react on them if they had a wish to get economic benefits. In the project 'Automation systems for Demand Response' a comparison between automatic control and price feedback was conducted. One group got feedback/messages that indicated the variation of the electricity price (spot price). The feedback was delivered by e-mail or text message. This group was compared to another group where the electrical heating was automatically controlled. This project tested if the consumer would react upon dynamic pricing. Another project tested if the visualisation of electricity prices in itself could have an effect on the consumption of energy. The project 'Energy Forecast' visualized the coming 36 hours of energy spot market prices to the participants. The energy forecast was visualised on a website, on TV and in a 100 households a box was implemented. The box indicates the relative electricity price using three different colours.


Other projects included visualization of electricity price as part of a larger project set up. For example within the 'eFlex project' PODIO (social platform) was used to inform of electricity prices along with other functions. This is also the case for the 'ECOGRID-EU project' that includes price visualization at different levels. 'ECOGRID-EU' is set up to contain 4 different field trials testing different technological set ups. In the first group the households receive only a smart meter (no consumption visualisation or electricity prices). In the three remaining groups the households receive equipment that visualises the electricity consumption and price. One group will receive simple marked price information, while the two remaining groups will receive advanced home automation and visualisation equipment. The home automation system contains a central unit with display where settings may be adjusted. These (two) groups will also receive thermostats visualising different settings in the house that can be changed according to the participant's wishes. The consumers are thus capable of interfering with the remote control of their heating devices if they are not comfortable.

5.3.4.1 PROJECT CONCLUSIONS ABOUT FEEDBACK AND VISUALIZATION

From the projects that included both 'automated control of appliances' and 'consumption visualisation', the results were that the visualisation equipment had an effect on the awareness of energy consumption. The households thus in general were more aware of how much energy they used when they were presented to their consumption on different visualization equipment. The 'Beaware project', which included consumption visualization and saving tips, found that the participants that have increased awareness because of the energyLife system did decrease their

consumption during the trial. The awareness (and increased consumption) was however not linked to the interaction with the interface. The participants that were interacting the most with the interface were not the most responsive ones.

The 'eFlex project' concluded that the home automation equipment in the project functioned as a 'mediator' between the abstract 'electrical world' and the real world. Through the equipment the consumers could learn and understand their consumption. The home automation equipment advanced the willingness towards demand response among the consumers.



6 CONCLUSION

In this survey report we have investigated the consumers' roles within smart grid projects in the Nordic countries. More specifically, we explored existing knowledge from smart grid projects that address private consumers in their analyses or project setup. The number of smart grid studies that address consumers has increased in recent years. Compared to many other countries, there appear a relatively large number of such projects in the Nordic countries. This is not least the case in Denmark. The Nordic countries are moreover leading with respect to installation of smart meters for the measuring of electricity consumption. Today major parts of the population in the Nordic countries have smart meters installed. Still the promises and benefits of smart grid have not appeared to the extent expected. There is still a long way to go and much uncertainty about how the development will be.

The survey included 22 projects in the analysis. In addition it identified 34 projects that have addressed the topic, or will address it in the future, but where sufficient material was not available for further analysis in our survey. An overview of the projects' method approaches and analysis design was presented to indicate the types of empirical data about the consumers used in the projects. The results showed that the majority of the projects employed consumption data. Around half of the projects used qualitative data. The size of the projects (project duration, duration of field test, and number of households) was indicated to give the reader the possibility to compare.

Many of the projects that included considerations concerning the consumer's behaviour and everyday life. The analysis showed that the majority of the projects investigating electric vehicles and intelligent charging included research on the behavioural patterns and everyday lives of the participants. Most projects that address consumer aspects in connection to smart grids employ a primarily technical or techno-economic approach. Often, they are focused on the performance of the technical equipment in the households. Around half of the projects address automation in this connection.

Moreover, we analysed the elements of economic incentives, automation, and feedback addressed in the projects. The results showed that around half of the projects included economic incentives in form of dynamic pricing in the project set-up (often in combination with automation aspects). Around half of the projects included automation equipment. 8 out of 21 projects included feedback in form of consumption visualisation, or price visualisation. In many projects, there is a tendency to consider the consumer as economic oriented. However also other aspects as the interaction with the technical equipment, environmental concerns and energy saving behaviour are addressed in some projects. Most of the technical and techno-economic projects use technical consumption data in the analyses. A number of the studies also use qualitative data, most often in addition to the technical consumption data.

Around half of the projects focus on a specific electricity-consuming unit at the household, e.g. heat pumps or electric cars. Instead of complete smart households or complete intelligent homes, it is most often these technological elements for future smart households that are covered.

Smart Grid projects in many cases imply the use of household appliances as reserves or for balancing the system (turn on and off according to the level of energy available). From this survey of smart grid projects in the Nordic countries it is apparent that automated or remote control of households' appliances is a dominating feature in smart grid projects. Although many projects included automated or remote control of devices along with visualisation of electricity price or energy consumption, there was no project focusing on visualisation of remote control. There seemed to be a lack of projects investigating a) how will the users be informed of when their devices are being controlled? And b) how will the users declare how much flexibility they will allow through remote control of their devices?

Furthermore there seems to be a lack of projects focusing on other incentives than the economic and environmental. For example incentives could appeal to the users' social lives and include comparing energy consumption or production to the houses in the neighbourhood. Another incentive could be related to better control of the household's energy system by the consumer. Most of the projects perceived the users as one homogeneous group. They are not exploring the opportunity of delivering targeted advises about change of energy consumption to the users.

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9 APPENDIX 1: LIST OF PROJECTS

Projects included in the review.

DK	Automation systems for Demand Response Organization: Danish Energy Industries Federation (DK) Period: 01.03.2006-01.06.2009	DK	The e-Flex Project Organization: DONG Energy Period: Summer 2011 – summer 2012
DK	Charge stands (subproject of 'Dynamisk Grid tariff' and test-en-elbil) Organization: Clever Period: 01.01.2010 – not available	FI	Beaware Organization: Helsinki University of Technology 1/1/2010 -> 1/1/2013
DK	Demand as Frequency-controlled Reserve Organization: DTU CEE Period: 2008 - 2012	NO	Demo Steinkjer Organization: NTE Period: Jan 2011-Dec 2015
DK	EcoGrid EU Organization: Energinet.dk Period: 2011-2015	NO	IMPROSUME Organization: Inkubator Halden AS, Norwegian Center of Expertise for Energy and Emission Trading Period: 2010 - 2013
DK	EDISON Organization: Danish Energy Association Period: 01.02.2009 – 01.12.2011	NO	Managing Smart in Smart Grid (MSiSG) Organization: Tieto Energy AS Period: 01.01.2010-01.01.2012
DK	Energy Forecast Organization: Rambøll Period: Feb 2007 - Mar 2010	NO	Market Based Demand Response Organization: SINTEF Energy Research Period: 2005-2008
DK	From wind power to heat pumps Organization: Energinet.dk Period: Nov 2009 - Dec 2011	NO	Smart Energy Hvaler
DK	IHSMAG Organization: - Period: January 2012 to December 2014	SE	Matning 2009 Organization: Goteborg Energy AB Mar 2006 - Jul 2010
DK	Intelligent remote control of individual heat pumps - (IFIV) Organization: Nordjysk Elhandel Period: 1. april 2010 til 1. juni 2012	SE	Pilotstudie i Vallentuna Organization: Ngenic Period: 2010 - (not certain)
DK	Prøv1elbil Organization: Teknologisk institute Period: Dec 2009 – Dec 2012	SE	Smart Grid Gotland Organization: Vattenfall AB Period: Nov 2010 - Dec 2015
DK	Test-en-elbil - (ChoosCOM - Large-scale demonstration of charging of electric vehicles) Organization: CLEVER Period: Jan 2010 -	SE	Stockholm Royal seaport Organization: Fortum Distribution AB Period: October 2010 - April 30th 2011.

Projects that might be relevant but are not included in the review.

DK	Consumer acceptance of intelligent charging Organization: Danmarks Tekniske Universitet Period: 2012/6 - 2015/12	DK	Project "The Island of Fur on the map" Period: Mar 2010 - Mar 2020
DK	ConsumerWeb Organization: Vestforsyning A/S (DSO), (DK) Period: Jan 2010 - Jan 2011	DK	SDVP2 Styrdivarmepumpe version 2 Organization: Insero Energy A/S Period: 1/2013 - 1/2015
DK	DREAM Organization: Teknologisk Institut Period: 2012/6 - 2013/11	DK	Smart City Kalundborg Organization: SEAS-NVE STRØMMEN A/S Period: 2012/12 - 2015/12
DK	eButler - effektivisering af energiforbrug Organization: SASECO ApS Period: 4/2013 - 4/2015	DK	Smart Grid i forklædning Organization: IT Energy ApS Period: 3/2014 - 2/2016
DK	Energy city Frederikshavn Organization: Frederikshavn kommune Period: 2009/1 - 2011/3	DK	TotalFlex Organization: Neogrid Technologies Period: 6/2012 - 9/2015
DK	EnergyLab Nordhavn Organization: Danmarks Tekniske Universitet Period: 1/2014 - 12/2014	FI	Smart grids and energy markets Organization: Cleen Oy, Period: Sept 2009 - Sept 2014
DK	EVERgreen - intelligent charging of electrical vehicles Organization: VIKINGEGAARDEN A/S Period: 2010/3 - 2013/3	FI	Smart Metering Organization: Fortum Period: 2010 - 2014
DK	FlexPower Organization: EA ENERGIANALYSE A/S Period: 6/2010 - 6/2013	FI	The Kalasatama new residential area in Helsinki
DK	Insero live lab Period: 2013 - Organization: Insero	NO	Electricity Demand Knowledge – EIDeK Sintef Energy AS Period: 2009 - Dec 2012
DK	INCAP Organization: Københavns Universitet Period: 2012/1 - 2016/6	NO	M-AMS: Miljøgevinst ved velfungerende AMS i full skala Period: 2009 - Dec 2012
DK	Information and education of the future power consumer Organization: Østkraft A/S Period: 2011/3 - 2015/3	SE	Charging Infrastructure Organization: Goteborg Energy AB Period: Jan 2008 - Dec 2010
DK	Intelligent Remote Control for Heat Pumps, ForskEL Organization: Nordjysk Elhandel A/S, (DK) Period: Apr 2010 - Mar 2011	SE	Customer Value Proposition Smart Grid(KEL) Organization: Goteborg Energy AB Period: Jan 2008 - Dec 2012
DK	IPOWER Organization: Danmarks Tekniske Universitet Period: 2/2011 - 7/2016	SE	Elforsk Smart grid programme Organization: Elforsk AB Period: Jan 2011 - Dec 2014
DK	Nikola - Intelligent Electric Vehicle Integration Organization: Danmarks Tekniske Universitet Period: 2/2013 - 6/2016	SE	Project AMR Organization: Vattenfall AB Period: 2006 – 2009
DK	Plug n' play-concept for intelligent indeklimatestyring Organization: Neogrid Technologies, (DK) Period: Jan 2011 - Jan 2013	SE	Storstad Smart Metering Organization: E.ON Sverige AB Period: 2006 – 2009
DK	PowerLabDK Organization: Danmarks Tekniske Universitet Period: 2010/2 - 2012/9	SE	Smarta nät för ett hållbart energisystem i Hyllie Period: 2011-2014
DK	Project "Intelligent home" Organization: SEAS-NVE, (DSO) (DK) Period: 2009-2011		

10 APPENDIX 2: REVIEW SHEETS

10.1 DENMARK

Project title	Automation systems for Demand Response
Project leading organization	Danish Energy Industries Federation (DK)
Other organizations involved	SydEnergi a.m.b.a.; SEAS/NVE a.m.b.a.; Siemens A/S; Danfoss; Ea Energianalyse A/S
Website(s)	http://www.energienet.dk
Period	01.03.2006-01.06.2009
Location, consumer studies	Denmark
Background	The project was initiated to reduce energy consumption. In order to reduce the greenhouse effect and reduce dependence on imported energy, it is necessary to save energy. This also applies to electricity. One way of controlling or changing the consumption is demand response. As the name suggests, it implies managing the power consumption in relation to changes in the price of electricity on an hourly basis. 'It is well known that industrial companies can adjust their consumption to varying electricity prices.'
Research objectives	The project investigates: 'Can households contribute with demand response? Furthermore the investigation focuses on: Can the economic savings for the customer be of such size that it is interesting?'
Methodology	<p>A demonstration project was accomplished. It contained: '500 households from the areas of SydEnergi and SEAS/NVE. Households with high electricity consumption (more than 15.000 kWh/year) were chosen.'</p> <p>The consumers paid spot price for the electricity (per hour the price that is announced on the Nordic electric stock Nord pool) There are high taxes and tariffs on electricity consumed by private consumers in Denmark. Both taxes and tariffs are paid as a fixed amount per kWh. This means that there must be added between 0.85 and 1 kr/kWh for taxes and tariffs. VAT (moms) must be added as well.</p> <p>'The households were classified into four groups: 1) A group that got automation equipment (Devi) installed. The equipment regulates automatically the electrical heating based on electricity price signals. 2) A group that received electronic equipment (Electronic House-Keeper) that shows the price signals. On that basis the consumer can regulate the electrical heating. 3) A group that daily received an e-mail or sms with indication of the variation in the electricity price. 4) A control group that did not participate in the project, nor have any knowledge of it.'</p> <p>'The final evaluation of the experiment consisted of a qualitative and quantitative analyses. The quantitative part contains processing and analysis of gathered data related to the households. The type of data was: development of the electricity prices; temperature development in the house etc. The Qualitative part of the evaluation consisted of: Telephone interviews of all the participants in the experimental project (inclusive the control group); In-depth interviews in small groups.'</p>
Results	'The Electronic housekeeper did not work as planned. It was therefore excluded in many of the results. The experimental project was completed

	<p>in the period between April 2007 and March 2009.'</p> <p>'The study showed that the effect of information on energy prices alone did not move any consumption. The effect was not measurable on the consumers that did not have automatic technology to move the consumption. The consumers that had installed automation equipment had clearly moved consumption.'</p> <p>The results gained from the in-depth interviews gave an indication of the acceptance of the project among the participants of the projects. The main conclusion from the project is that there is potential for activating the electricity consumers in order to move their consumption dependent of the variable price.</p> <p>This conclusion is based on</p> <ul style="list-style-type: none"> • positive feedback from the participants from the field experiments • High activity level on the participants side in the experiment
Additional comments	Smart meter and AMI
Sources	<p>'Prisfølsomt elforbrug i husholdninger'. Sammenfatning af resultater af forsøg med kunder med elvarme. DI – Energibranchen SydEnergi a.m.b.a. SEAS/NVE a.m.b.a. Siemens A/S Danfoss A/S Ea Energianalyse A/S. August 2009.</p> <p>Direct link: http://www.ea-energianalyse.dk/reports/602_Sammenfatning_prisfoelsomt_elforbrug.pdf (as on 29.11.2013)</p>

Project title	Charge stands (subproject of 'Dynamisk Grid tariff' and test-en-elbil)
Project leading organization	SydEnergi, (DK)
Other organizations involved	Clever
Website	https://www.clever.dk/
Period	01.01.2010 – not available
Location, consumer studies	Denmark
Background	The project investigates the interaction between smart-grid technologies and households everyday practices.
Research objectives	The project focuses on how electric vehicles and dynamic electricity prices influence the Danish households' everyday life. The project investigates how the technologies constitute and change the consumers' routines and consumption habits.
Methodology	<p>The projects had an experimental part which included 18 test families. The families delivered the cars (back to the CLEVER) in the first quarter in 2013.</p> <p>In the period from 10 May to the 5th November, there were 18 families included in the study "Dynamisk Grid tariff", where both network tariff and electricity price varied during the day. The grid tariff was known in advance, and remained flat. The price of power varied with spot prices at Nord Pool. The families were given the electric cars for 6 months in total. In the first 3-4 months they had to control when they would charge the electric car. In the last 2-3 months CLEVER controlled the charging on the basis of electricity price (to be as cheap as possible for the consumer). Each of the test families had a charging box with timer function, making it possible to charge whenever they wanted. The family was to simply plug the electric car to the charger when they arrived home, Then CLEVER would take care of the charging. However, it was possible for the families to begin charging immediately if there was a need for it. Families were assured that their electric car would be ready for the time when it should be used in the morning.</p> <p>The empirical material consists of 8 qualitative interviews with Danish families who have test driven EVs for 5 months and concurrently participated in the 'Project dynamic network tariff'. Besides interviews, there gathered knowledge through participation observation for electric car handover meetings and one mid-term meeting. The empirical material is mainly analyzed through the theory of 'social practice theory', which contributes an analytical framework for understanding changes in social practices in everyday life.</p> <p>The dynamic net tariff occurs in four fixed price categories (cheapest in night time, most expensive in daytime), and is known by the participants. The variable price of electricity was not known as far ahead as the net tariff. Since it was based on Nord Pool spot it varies per hour and the price is announced the day before at noon. To benefit the most the participants should be aware of the spot price.</p>
Results	The project showed that the electric cars were not easily integrated into the social practices of the consumer's everyday life. The new technology did in other words not fit into values and norms of the households. Some values that the tested electric cars did not live up to the

	<p>participant's notion of 'flexibility, freedom, spontaneity and confidence'.</p> <p>In the field test most of the charges were scheduled to happen outside the peak periods. Several of the test families who did not have a built-in timer installed, manually started charging after 20 o'clock, when the network tariff here was the second cheapest. 23 % of the charges were started during the period at 00-01, and this was done by using the timer function.</p> <p>Some families charged the electric car in the peak periods. After CLEVER took over the charging, the share decreased and there were few vehicles being charged in the peak periods.</p> <p>When the spot price during the period was lower than the normal fixed electricity prices, there was money to be saved for the test families even though they charged in the peak periods. The greatest savings were achieved when charging was done intelligently. It is thus possible to reduce the annual cost to transport by almost ¼ in this project (spot price was set according to the market but the net tariff was artificially determined as part of the trial).</p> <p>The test showed that if the test pilots were not informed of when it is best to charge the vehicles, 37% will charge in the period 15-20. If people are encouraged to not to charge in the peak periods the share (of the people charging) will be 34%. It is therefore not enough to 'only' encourage the people to change charging habits.</p>
Additional Comments	EV's, dynamic tariffs
Sources	<p>CLEVER A/S. "TEST-EN-ELBIL KVARTALSRAPPORT 2. KVARTAL 2013/6". KVARTALSRAPPORT FOR PERIODEN 1. APRIL – 30. JUNI 2013. Direct link: https://www.clever.dk/media/85114/kvartalsrapport_juli_2013_pdf.pdf (as on 25.10.2013)</p> <p>CLEVER A/S. "TEST EN ELBIL KVARTALSRAPPORT 3. KVARTAL 2012 ". KVARTALSRAPPORT FOR PERIODEN 1. APRIL – 30. JUNI 2012. Direct link: http://www.ens.dk/sites/ens.dk/files/klima-co2/transport/elbiler/forsoegsordning-elbiler/elbilprojekter-stoettet-forsoegsordningen/test/5_Kvartalsrapport_Juni_2012.pdf (as on 10.12.2013)</p>

Project title	Demand as Frequency-controlled Reserve
Leading organization or platform	DTU CEE
Organisation(s) involved	-
Website	-
Period	2008 - 2012
Location, consumer studies	Denmark
Background	‘The purpose of this project is to obtain practical experience with implementation of frequency controlled demand. The project will demonstrate, in real-life, the ability of frequency controlled demand to provide primary control, to improve frequency quality in systems with high share of wind power generation (normal frequency reserve), and disturbance frequency reserve to support system security in interconnected power systems.’
Research objectives	<p>The project will have as objectives to:</p> <ul style="list-style-type: none"> • Practical hardware development of the technology for frequency controlled reserve (DFR) • Validate and evaluate the technology’s field performance of reserve provision • Evaluate the technology’s actual impacts on appliance operation through large-scale demonstration of hundreds of such devices. • Test and further develop monitoring methods for DFR appliances concerning the needs of the transmission system operator (TSO). • Obtain first-hand experience and feedbacks, and evaluate customer’s acceptance of the technology. • Further develop DFR control logics to fulfill specific rules of UCTE and Nordel.’
Methodology	<p>‘The DFCR (demand as a frequency controlled reserve) system for electrical space heaters was deployed in 22 houses during January 2012. Data was collected during the period 2012/01/23 until 2012/12/14. Due to the complexity in deploying and validating the functionality of the DFCR devices, only some of these devices will be part of the analysis of this report. The DFCR systems consist of two parts: A commercially available thermostat for electrical space heater (DEVI, Danfoss), which has been modified to expose a serial port to an external controller, and an external controller (“Smartbox”) which was produced for this experiment. Since the rated power consumption of the electrical heaters varies the power consumptions has been normalised in such a way that all boxes have a normalised rated power consumption of 100 % full load. Several of the electrical heaters were used as a secondary heating source the primary being wood stoves, further electrical heating devices, or other types of heating. Due to this, the electrical heaters were off at periods independent of the system frequency thereby impacting the average power usage.’</p> <p>‘A special electronic device, referred to as the “SmartBox”, has been developed during the project. The SmartBox is a demand response (DR) device developed for use in smart grid projects with the need of being able to regulate numerous demands while measuring consumption, grid</p>

	<p>frequency and other related parameters. The box can regulate an attached appliance according to an incoming signal, either digitally or by relay (on/off). Regulating parameters can be measurements like grid frequency and voltage or signals received through the build-in modem, like control parameters, price signals etc.</p> <p>The SmartBox has the ability to control a connected load by either on/off (shutting down the mains for the appliance) or by altering the temperature set-point digitally for a thermostat. The box measure all relevant data from the attached demand and sends the data by mobile network to a central server. The SmartBox is configurable from a website where it is possible to i.e.: upload new firmware for the devices, configure of various parameters and access measurement data.</p> <p>Electronic Housekeeper, a consumer product was installed in domestic households connected to i.e. freezers, refrigerators and electrical heating. The product included all necessary hardware to control the attached appliance as function of frequency. The product was customized to deliver data for the project as well.'</p> <p>A survey was sent out to evaluate the Electronic Housekeeper</p>
Results	<p>'SmartBox: Regarding user comfort we have been in contact with all 6 participants whose SmartBoxes are included in this analysis. The feedback we received was that they did not take any notice towards the boxes being in use and no change in comfort was registered.... Also there have been no extensive survey of the user experience. Hence concluding that the user comfort is uncompromised by this kind of frequency response would not be strictly supported by the experiment.</p> <p>Electronic Housekeeper: After the pilot project testing Electronic Housekeepers, an evaluation form was sent out to the participants in order to hear their response to the experiment. 15 participants (out of 28) have responded to the questionnaire. Some did not respond as they only participated very shortly in the project. Most have responded that they found it interesting to participate in the research project – 7 people replied completely agree and 4 additional agree to this statement....Even the respondents found the research project interesting, many of them where not thrilled about the Electronic Housekeeper technology. Three of the respondents noted that the Electronic Housekeeper product appears to be outdated - both the user interface, the speed and the stability.... Four participants experienced problems with their freezer, fridge, and dryers when connected to the Electronic Housekeeper. In some cases the SK2-unit was defect and the problem was solved by changing the hardware. However, the content of more than one freezer was ruined. These start-up problems in the beginning of the pilot project led to several participants losing their faith in the Electronic Housekeeper. One participant notes in the evaluation that the EH was "an extra and unnecessary electricity consuming gadget"</p>
Additional comments	<p>The smart box is designed to optimize the on/off pattern of electrical devises according to DFR.</p> <p>Electronic housekeepers was partly included in the experimental sites. Due to mistakes in the EH units they were mostly only connected to minor units such as lamps (not freezers and pumps).</p> <p>In this project the smart box technology is applied in the user's homes without much involvement of the users. The users are not expected to change anything in their daily life. The involvement of the users is to test if the users find the technology acceptable in their everyday life. Furthermore the users shall act as support for the energy syatem,</p>

Sources	<p>Christian Bang, Ea Energianalyse, Christian Brandt Rasmussen, Jacob Østergaard, Klaus Lund Nielsen, Lars Gorzelak, Majken Rolsted Mattesen, Mikael Tøgeby, Nina Marie Holmboe, Philip James Douglas, Rune Brus. "Demand as Frequency-controlled Reserve – Implementation and practical demonstration programme". Department of Electrical Engineering, Elektrovej, Building 325, DK-2800 Kgs. Lyngby, Denmark, May 2013.</p> <p>Direct link: http://orbit.dtu.dk/fedora/objects/orbit:121896/datastreams/file_a074d05f-786e-426e-9415-08b3fcf287cf/content (as on 29.11.2013)</p>
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Project title	EcoGrid EU
Project leading organization	Energinet.dk
Other organizations involved	SINTEF; Østkraft; DTU-CET; Siemens; IBM; ECN; ELIA; Tecnalia, AIT; TNO; Eandis; EDPD; Tallinn University,TUT; Landis+Gyr
Website	www.eu-ecogrid.net/
Period	2011-2015
Location, consumer studies	Bornholm
Background	EcoGrid EU is a large international demonstration project with Bornholm as the demonstration area.
Research objectives	<p>'The objective of the EcoGrid EU project is to illustrate that modern information and communication technology (ICT) and innovative market solutions can enable the operation of a power system with more than 50% renewable energy sources (RES) such as wind, biomass and photovoltaic (PV).</p> <p>The EcoGrid EU project is a large-scale demonstration of consumer participation in the balancing of renewable electricity generation by active demand response to real-time price signals, created from the current prices in the conventional balancing market.....In the course of the next two years, the interesting question is whether and how five-minute varying real-time price signals and related forecasts can influence the demand of electricity customers...' [2]</p>
Methodology	<p>'The demonstration will take place on the Danish island Bornholm with more than 50 % electricity consumption from renewable energy production.....The participants will be equipped with residential demand response devices/appliances using gateways and "smart" controllers.... Installation of the smart solutions will allow real-time prices to be presented to consumers and allow users to pre-program their automatic demand-response preferences, e.g. through different types of electricity pipe contracts. "Automation" and customer choice is one of the key elements in the EcoGrid EU concept.' [1]</p> <p>'The project advertises for getting participants to join. More than 1800 households are included in the demonstration. The households are divided into different groups:</p> <ul style="list-style-type: none"> • 'Statistic control group' (200 households, smart meters, without information or visualization technology). 200 households with smart meters, No access to specific, information or 'smart' equipment • 'Manual control group' (500 households, smart meters, simple information electricity price, non-automatic) 400-500 household. With smart meters. Receiving simple market price information. Must move their energy consumption by themselves • 'Automatic control group' (700 households, smart meters, IBM GreenWave Reality equipment, Automatic, heat pumps or electric heating, responding autonomously to price signals) • 'Automatic control group' (500 households, smart meters, Siemens equipment, Automatic, heat pumps or electric heating, responding to

	<p>aggregator for control)</p> <p>The real-time price response can be realised in several different ways – with and without help from automatic control systems and home automation solutions. Four test groups will test different solutions to realize the demand response to real-time prices:</p> <ol style="list-style-type: none"> 1) The manual control group (500 residential consumers) 2) The automatic control group with IBM/GreenWave home automation system (700 residential consumers) 3) The automatic control group with Siemens/SyncoLiving home automation system (500 residential consumers) 4) Companies' [2] <p>'The system contains a central unit storing the data. The unit sends and saves consumption data and settings. The systems include a thermostat that visualizes the setting in the rooms in the households. The user can change the temperature'.[4]</p> <p>'The GreenWave Reality system: The consumer states a minimum temperature and the system will not optimize according to the electricity price if that limit is reached. The system includes an in-home-display and an application where the electricity consumption and electricity prices are visualized.' [5]</p> <p>It seems as interviews and surveys are part of the methods to investigate the consumers/participants. For instance the following citation indicates this: 'The first EcoGrid EU survey and interviews of electricity customers on Bornholm – in advance of the recruitment – showed that a very large group of the respondents were positive towards real-time tariffs and wanted to be flexible and use electric equipment when electricity prices were low.' [2]</p>
Results	At this moment in time the experimental projects are up and running. There are no results from the test sites and the consumers yet.
Additional comments	'The project investigates diverse demand response solutions. The project tests 'state of the art' technologies to achieving that. The energy consumption will get automated. The consumers can program the devices to behave in certain patterns' [2]
Sources	<ol style="list-style-type: none"> 1. Slideshow title: EcoGrid EU A Prototype for European Smart Grids - Guide to the large-scale project, retrieved from the official ecogrid website: www.eu-ecogrid.net. Direct link: http://www.eu-ecogrid.net/images/Documents/EcoGrid%20EU%20-%20Guide%20to%20the%20large-scale%20project.pdf (as on 14.11.2013) 2. Ecogrid EU. 'EcoGrid EU: From Design to Implementation. A large scale demonstration of a real-time marketplace for Distributed Energy Resources'. Oct 2013. Direct link: http://www.zurich.ibm.com/pdf/ecogrid/131004_%20edk%20a4_ecogrid%20eu%20project_web.pdf (as on 29.11.2013) 3. Website: http://ecogridbornholm.dk/villa-smart/ (as on 10.12.2013) 4. Product sheet for Siemens/SyncoLiving home automation system: 'FAKTABLAD OM ECOHOME-UDSTYR FRA SYNCO LIVING'. http://ecogridbornholm.dk/wp-content/uploads/2013/01/120516_SyncoLiving-elvarme-faktablad.pdf (as on 10.12.2013) 5. Description of GreenWave Reality equipment: 'Greenwave Reality. 'Varmepumpe og elopvarmning, Optimér dit elforbrug udfra prissignaler'. http://ecogridbornholm.dk/wp-content/uploads/2013/01/EcoGrid_HP_quickSetupGuide_January2013_v2.pdf (as on 10.12.2014)

Project title	EDISON
Project leading organization	Danish Energy Association
Other organizations involved	The Danish Energy Association, DTU Elektro, DTU Risø, IBM Danmark A/S, Siemens, Østkraft Net A/S, DONG Energy Power A/S, EURISCO ApS,
Website	http://www.edison-net.dk/
Period	01.02.2009 – 01.12.2011
Location, consumer studies	Denmark
Background	-
Research objectives	<p>'The main goals for the project were:</p> <ul style="list-style-type: none"> • To develop system solutions and technologies for Electric vehicles (EVs) and Plug-in hybrid vehicles (PHEVs) which enable a sustainable, economic and reliable energy system where the properties of EVs are utilised in a power system with substantial fluctuating renewable energy. • To prepare and provide a technical platform for Danish demonstrations of EVs with emphasis on the power system integration aspects. • To develop standard system solutions for EVs, which are applicable globally, by utilising the Danish leading knowledge within distributed energy resources and operation of energy systems with high wind power penetration, and thereby, release the potential for Danish export of technology, system solutions, and knowledge. <p>One of the main goals of the EDISON project has been to develop the technologies that enable electric vehicles to have their charging optimized, so that it to a greater extent matches needs of the power system. These technologies have been tested on Bornholm.'</p> <p>The test site included: test of optimized charging functionalities, public charging spots and test of electric vehicles.</p>
Methodology	<p>13 Electric vehicles were driven by users for a period between 2-6 months. A data collection box was installed in the cars. The box collected data about the length of trip and geographical position of the car and 'state of charge'. The test occurred on Bornholm. Different chargers (at home and fast chargers in the public) were tested. Remote control of the charging of the vehicles within people's homes was tested.</p> <p>'The EDISON virtual power plant aggregates the data and uses it to determine when and how quickly to charge or discharge each vehicle.'</p>
Results	<p>'The testing of optimized charging was limited due to problems with the vehicles involved in the test, still it was evident that remote control of the charging to optimize according to the power system does work. However there is still quite a piece of development needed before the technology is ready for roll-out. Especially the user interfaces needs to be better, but also potential challenges with break down in the communication between vehicle and backend system should be solved. More than once the Østkraft EV was not charged because of instability in the communication.....The public charging spots installed during the project have been an unproblematic experience though the need for public charging infrastructure is still very limited as the number of electric vehicles is low. The cost of installation was quite high and this will probably limit further roll-out until a larger number of EVs enters the market. The charging spots were even used in the interoperability test with Better Place.</p>

	<p>As part of the project five Mitsubishi iMiEVs were leased to gain more driving data for the project. The iMiEV is an EV very close to market in the sense that it to a large degree can function as a normal vehicle when looking at the ability to follow traffic, size and user experience. However the range is a limit for the test drivers at least on the mental level, as many could probably plan their driving and charging so the EV could solve their daily driving need, but also the heating system needs to be better and not drain the batteries to much before the vehicle can be a sold in a larger number. And naturally the price also needs to be lower, as the price pr. Km is still much higher than a comparable combustion engine, despite the lower operating cost because of the large energy efficiency. The thirteen test drivers have on used between 20 and 80 % of the battery every day.</p> <p>To demonstrate the possibility for EVs to participate in both power market and the market for regulating power an Edison EV Virtual Power Plant (EVPP) was developed. EVPP is the resulting server-side management system containing analytics technology and featuring standards based interfaces to DERs and grid stakeholders. The EVPP were tested successful during the project, where EVPPs take on the role of Fleet Operators (FO) for individual EVs (in Zurich, Copenhagen, Bornholm) and support also larger simulated fleets driving on Bornholm, in real-time coordinating their charging in private homes, company parking lots, and at charging stations.'</p>
Additional comments	Electric vehicles and remote control of charging
Sources	EDISON. 'REPORT: EXECUTIVE SUMMARY OF THE EDISON PROJECT'. 1 May 2013. Direct link: http://www.edison-net.dk/Project%20Details/Executive%20Summary.aspx (as on 29.11.2013)

Project title	Energy Forecast
Project leading organization	Rambøll
Other organizations involved	-
Website	-
Period	Feb 2007 - Mar 2010
Location, consumer studies	Denmark
Background	-
Research objectives	<p>The main measures tested in project:</p> <ul style="list-style-type: none"> • 'The daily display of the coming 36 hours energy spot market prices - the energy forecast. The energy forecast is shown on the website www.energiudsigten.dk. Further, the energy forecast was broadcasted in the regional television station TVSyd's news programme as part of the weather forecast for a period of 3 months. • Media campaigns using TV spots, radio spots and web banners on electronic news media • Testing of spot agreements. A group of app. 100 households among the testing group has entered a spot contract with Syd Energi in August 2009. <p>Development of SEE1 – a small box indicating the relative electricity price level of each hour using three different colours. This SEE1 has been given to a group of households with spot price agreement (NordPool day-ahead market). They received SEE1 mid November 2009.</p> <p>According to cited report: The purpose of the project "Energiudsigten" is testing the impact of different measures to influence demand response or price flexibility as regards electricity consumption in households in Denmark. The overall objective of the project is to reduce electricity costs and make way for more renewable energy through electricity demand response.</p> <p>The project is implemented in Syd Energis area, geographically covering the Southern and South Western part of Jutland. In Syd Energi's supply area intelligent" meters have been installed. The meters are remotely read and consumption is registered on an hourly basis. Thus it has been possible to track customer price response as a function of the measures, which are tested in the project.'</p>
Methodology	<p>'During the project a testing group of 558 households in Syd Energi's supply area has been identified and interviewed. Rambøll has received hourly data of electricity consumption from all consumers in the testing group. The impact on the electricity consumption has been analysed in three different ways: Comparing monthly average day and night load distribution curves for different months during the test period; comparing monthly average day and night load distribution curves between two subgroups: those with a standard agreement and those with a spot price agreement; and finally using an econometric model compensating for differences in weather conditions and others. The day and night distribution curve is made on monthly basis as an average of the hourly distribution of the electricity consumption. These day and night curves are compared between the spot group and the remaining part of the testing group in order to estimate an impact of the activities. The testing</p>

	group's attitude and level of knowledge concerning demand response has been measured in surveys as well as in focus groups. A survey has been implemented before commencement of the project activities (May 2007) as well as after (November/December 2009). During the period from the first survey to the second a number of households have moved and the testing group has been reduced to 511 households. Of this group 75% responded to the second survey.'
Results	<p>'On basis of the surveys before and after the project it can be concluded that:</p> <ul style="list-style-type: none"> • The survey population is representative for households in Syd Energi's supply area in both surveys. Thus the drop-outs are not biased. • The level of knowledge of the electricity market, electricity prices and the load of the electricity system has increased considerably during the project. • However, though the level of knowledge has increased considerably the general interest in demand response has not increased. Except among the spot-group. In this group the interest has increased. • The spot-group has slightly larger electricity consumption than the other households and has a larger share of younger families than the total testing group. The share of electricity heating is the same in the two groups. • The spot-group expect saving money through the spot contract. However, they did nothing to check the hourly electricity price before they got SEE1. • SEE 1 has a strong impact on the households awareness of the electricity price as well on their activities related to moving electricity consumption to hours with low price • App. 40% of the households has no possibility of acting flexible in relation to the electricity prices due to the nature of their appliances and heat supply.' <p>In relation to the impact that the Energy Forecast had on the electricity consumption, the study showed that consumers that had spot price agreements reduced their energy consumption.</p>
Additional comments	-
Sources	<p>EBH. "Energiudsigten, slutrapport" April 2010. Rambøll, Teknikerbyen 31, DK-2830 Virum</p> <p>Direct link: http://www.risoe.dk/rispubl/NEI/NEI-DK-5606.pdf (as on 29.11.2013)</p>

Project title	From wind power to heat pumps
Project leading organization	Energinet.dk
Other organizations involved	-
Website	Energinet.dk
Period	Nov 2009 - Dec 2011
Location, consumer studies	Denmark
Background	<p>'Energinet.dk has created a test platform for heat pumps where the heating systems of approx. 300 houses can be monitored and controlled by local forecasts for weather and electricity.</p> <p>The demonstration project is developed in relation to two ForskEL projects conducted by respectively North Elhandel and the Danish Technological Institute. The two projects have the task to clarify how heat pumps can provide demand response and balancing services to the power system.</p> <p>The two projects are:</p> <ol style="list-style-type: none"> 1) North Elhandel A / S, project 'Intelligent Remote Individual Heat'. The project aims to demonstrate the following: <ul style="list-style-type: none"> • How intelligent remote control of individual heat pumps can be constructed without the consumer's comfort declines, while the socio-economic benefits (including environmental gains) are achieved. • How individual heat pumps can be used by a balancing responsible to shift consumption and to provide ancillary services to the energy system. 2) The second project contains the actors: DTI, Varmepumpefabrikanternes Branche forening, several heat pump manufacturers, SE and SEAS/NVE. The project focuses on: <ul style="list-style-type: none"> • How much consumption is it actually possible to move to periods of low electricity prices? • How does it affect the heat pump to be switched on/off in short intervals? • What are the socio-economic and private-economic benefits of controlling heat pumps in different ways?
Research objectives	<p>To which extent is it actually possible to get consumers to shift their consumption on the basis of price signals from the power system?</p> <p>How can the price flexible control between the power system, electricity trader and heat pump be framed?</p> <p>Which business models and market design can support the development of demand response?</p> <p>To what extent will it in practice be possible to get heat pumps to support a power system with wind power?</p>
Methodology	<p>Contact to house owners is arranged via the webpage: www.styrdinvarmepumpe.dk</p> <p>DTI has made a review of 10 selected installations, and the results are incorporated into a plan for the control and monitoring of all installations.</p>

	Contacts with the homeowners were made by Aros engineering and business LIAB ApS, which has developed and supplied the remote control box. The primary task was to install the equipment and have made specific arrangements related to the installment.
Results	The project mainly has contributed with technological results. There were no results available in relation to consumer's everyday life. The households seemed to function as 'factors' that needed to be included when testing the technology. The measurements of the heat pump's efficiency, from this project have shown great variation and a generally lower efficiency than indicated in the technical declarations. The measurements are, however, subject to some uncertainty, and the owners' expectations for a particular seasonal performance cannot reasonably be compared with the technical declaration. The conclusion is in accordance with the monitoring program, which DTI has conducted for the Energistyrelsen.
Additional comments	Heat pumps
Sources	Energinet.dk. 'Fra vindkraft til varmepumper' Energinet.dk, Tonne Kjærvej 65, 7000 Fredericia, Juli 2012. Direct link: http://energinet.dk/SiteCollectionDocuments/Danske%20dokumenter/Forskning/Fra%20vindkraft%20til%20varmepumper.pdf (as on 29.11.2013)

Project title	IHSMAG
Project leading organization	-
Other organizations involved	ZIV Metering and Tecnalia (the Basque Country, Spain), Norwegian University of Science and Technology NTNU (Norway) and Danish Building Research Institute (SBI), Aalborg University (Denmark)
Website	http://sbi.dk/ihsomag
Period	January 2012 to December 2014
Location, consumer studies	Denmark, Spain, Norway
Background	<p>‘The development of a future, post-carbon electricity system – the “smart grid” – implies thorough changes of the existing electricity system affecting all parts of the system from the production side over the distribution net to the daily routines of the end-users. These changes have to be integrated in order to ensure an efficient and secure energy system. This calls for a comprehensive design approach that supports the transition of the system by drawing on the experiences from existing demonstration projects and a detailed understanding of the factors influencing electricity production and consumption. It is the aim of IHSMAG to contribute to establishing this design approach.</p> <p>Households play an important role for the transition to smart grid. First of all, households represent a substantial share of electricity consumption, and with increased use of heat pumps and electric vehicles this is expected to rise. Secondly, the highly uneven time distribution of households’ electricity consumption makes it particular important to study how households can contribute to create balance between energy consumption and a fluctuating energy production through load management and storage. Thirdly, micro-generation technologies such as PV and small wind turbines give households a new role in the future post-carbon energy system.</p> <p>Initiatives within the development of smart grid solutions tend to have a technology-centred design approach. As a result, new technical solutions are designed with primary focus on the technical needs of the future electricity system, e.g. load management, and only secondary on the needs of the end-users. These technologies are then tested through demonstration projects. The IHSMAG project builds on the understanding that the work with developing future smart grid solutions would benefit from a better understanding and integration of the users and their needs and interests in the design.’ [1]</p>
Research objectives	<p>‘The specific objectives of the project are:</p> <ul style="list-style-type: none"> • To provide a survey of country-specific factors and existing research, development and demonstration activities in relation to smart grid solutions in households in the Basque Country (Spain), Norway and Denmark. • To provide knowledge about the effects of smart grid solutions in households and how they depend on everyday practices, the regulatory framework as well as the technical characteristics of the electricity system. • To develop a set of design criteria for the development of smart grid solutions for households that takes into account the social and

	<p>technical context of households. These criteria are targeted at designers of smart grid technologies and systems.</p> <ul style="list-style-type: none"> • To develop recommendations for planners and policy makers on how to promote user-oriented solutions • To disseminate the results across Europe in cooperation between the partners of the project through publications targeted specific target audiences such as designers and planners.' [1]
Methodology	<p>The project is ongoing. Therefore there is not knowledge about all used methodology.</p> <p>Survey of existing literature on smart grid projects involving households in Spain, Norway and Denmark</p>
Results	<p>From the mentioned survey a comparative study has been made (see: 'The role of households in the smart grid: A comparative study') Some Results from the survey:</p> <ul style="list-style-type: none"> • Smart Grid projects involving households in Denmark and Spain mostly focus on Load management and not so much on Electricity saving. • Consumers are perceived as individual and economically rational agents in the national politics and R&D projects in NO, ES and DK. • The importance of a social context and the complexity of everyday practices are often neglected.
Additional comments	-
Sources	<ol style="list-style-type: none"> 1. Website: http://sbi.dk/ihsomag/about-ihsomag (12.11.2013) 2. Christensen, Toke Haunstrup; Ascarza, Ainhoa; Throndsen, William; Gram-Hanssen, Kirsten; Friis, Freja (2013): "The role of households in the smart grid: A comparative study." ECEEE 2013 Summer Study, 3–8 June 2013, Belambra Presqu'île de Giens, France.

Project title	Intelligent remote control of individual heat pumps - (IFIV)
Project leading organization	Nordjysk Elhandel
Other organizations involved	Neogrid Technologies, Aalborg Universitet, Aros Teknik and Eurisco
Website	-
Period	1. april 2010 til 1. juni 2012.
Location, consumer studies	Denmark
Background	-
Research objectives	The objectives are: Research, development and demonstration in practice of how intelligent remote control of individual heat pump systems built, designed and implemented without the consumer experiences a lack in comfort or performance. Furthermore the consumer must receive a financial gain and contribute to a 'greener environment'. The project shall demonstrate that individual heat pumps can be used by a balance responsible both to shift consumption and to provide control, balancing and ancillary services in the energy system
Methodology	A VPP server (Virtual Power Plant) was developed, where many pumps are managed as one unit, seen from the balance responsible. Algorithms, that can predict the heat demand of each house the next day, were developed. The solution has been demonstrated in four houses and there has been communication with the homeowners. Furthermore there were paid visits to the homeowners. Energinet.dk was in charge of another project in which control boxes were installed along with sensors in households. The name of the project is 'Styr din varmepumpe' (Control your heat pump). This platform was used in the IFIV project. The platform was used in the communication with the heat pumps. A house simulator calculates the expected consumption in individual houses. In the calculation the following aspects are considered: the house's thermodynamic properties (heat loss, time constant and accumulability in tank or construction); number of occupants; heat characteristics (ie . consumption habits, local weather forecasts for sun and outdoor temperature); the residents' preferred indoor temperature and the range that the temperature may fluctuate within. VPP'en calculates, based on the expected consumption and spot prices, an optimal plan for each heat pump's next day of operation. The algorithm provides an estimate of electricity every hour. The aggregator purchases electricity on Nord Pool and attempts to manage the use of electricity accordingly on the following day. The intraday electricity market is also used if the calculations and forecast did not match ie.
Results	Results and conclusions are based on a couple of month's control of 4 houses. In this project, there was shown that it is possible to develop an advanced direct control of heat pumps at draw on a model for each house, as well as forecasts of weather and electricity prices. The four users, who's heat pumps were controlled were not ordinary users. They have all been "very friendly users", ie. some that are more than average interested in energy and technical solutions in general. In addition to temperature-related adjustments of the comfort level, there have been technical challenges with the installations. Therefore,

	<p>there has been cooperation with householders in order to get the heat pumps set up correctly. In relation to the temperature, it seems that when it is very cold, users often accept only a few degrees variation in indoor temperature. That is only one degree above or below the set point, which we had assumed two degrees plus / minus. At higher temperatures, the users are more tolerant. It requires a larger statistical basis to conclude that this is a general trend.</p> <p>The setup and operation of the VPP server has been more extensive than expected. This is partly due to the heat pump owners not having access to enter their comfort levels as they wish, but instead having to go through the IFIV project.</p> <p>(Brugsvandet) The domestic water has proved to be a challenge. It has proven difficult to plan 36 hours ahead due to the difficulties in predicting the use of hot water.</p> <p>The project has also shown that there is a long way to go before the controller is ready to be implemented in large numbers of heat pumps in Denmark. Especially with the current control-interface where the heat pump is controlled via a remote computer and data downloaded from external sensors, which must be installed along with the heat pump. This is partly due to the economic potential immediately is very small. Hence, there is a need for control interface to be built into the heat pumps from the start, as this is likely to be a much cheaper option.</p>
Additional comments	<p>'Therefor it is pleasing that the project moves forward with the READY project, which will take us a long step forward towards control of a large number of heat pumps. It is expected that it is a larger step to go from four to 200 heat pumps, than to go from 200 to thousands. Control of many heat pumps provides some additional challenges. The coupling of new heat pumps in the project will ultimately have to happen automatically, ie. without time-consuming communication between aggregator and homeowner'</p>
Sources	<p>Nordjysk Elhandel, Neogrid Technologies, Aalborg Universitet, Aros Teknik and Eurisco. 'Slutrapport – ForskEL 2010 – 10469 Intelligent Fjernstyring af Individuelle Varmepumper'. 2012. Direct link: http://www.energinet.dk/SiteCollectionDocuments/Danske%20dokumenter/Forskning%20-%20PSO-projekter/10469%20Slutrapport%20revideret.pdf (as on 29.11.2013)</p>

Project title	Prøv1elbil
Project leading organization	Teknologisk institute
Other organizations involved	Teknologisk Institut, Horsens og Hedensted Kommuner, NRGi Net A/S, Insero Horsens
Website	http://insero.dk/elbilforum/prov1elbil/90-mere_fakta_om_projektet.aspx
Period	Dec 2009 – Dec 2012
Location, consumer studies	Denmark
Background	-
Research objectives	To investigate if electric cars fit the transportation needs of families
Methodology	<p>The geographical area was mostly limited to Horsens and Hedensted municipality. To be included in the project the electric car should replace a traditional car (internal combustion engine). 6 – 8 families got an electric car to use in 3 months.</p> <p>The models were Citroën C1EV and Citroën C-Zero. The attitude toward electric cars was investigated via interviews of the participants. The test drivers volunteered. Out of the volunteered 8 were selected per round. The test pilots were different (old, young, families etc.) Minimum 3 interviews per user (beginning, middle and end). Blog diary (weekly)</p>
Results	<p>Highlighted results:</p> <ul style="list-style-type: none"> • Electric cars can, with existing charging infrastructure, be included as car number two in most two-car families. • Electric vehicles are still too expensive to buy, and savings by driving on electricity is too low to compensate for the higher price. Despite the automatic compared the price of the 'small' Citroën C-Zero'er and former C1'ere with the cheap mini-cars, and the price must be somewhat below DKK 150,000 to be seen as an alternative when purchasing a new car. • Even though it is good to have the opportunity to fast-charge, the range is too short - most test users want a range of 200 km on battery, even though many did not have the need for it during the test period. • Charging the car should be done at night, but the best will clearly be a smart charging, which allow users to prioritize immediately charging. • Test-en-Elbil is a project building on Prøv1elbil • The test has shown that electric cars can replace a traditional car in average Danish families' everyday life. <p>According to the last source: When NRGi offered 1 savings pr kWh that was charged between 00 and 06 most of the participants changed behaviour.</p>
Additional comments	Electric cars
Sources	Linda Christensen "Elbil eller konventionel bil, Hvad mener testkørerne i to forsøgsprojekter?", Institut for Transport, Bygningstorvet 116B, 2800

	<p>Kgs Lyngby. August 2013</p> <p>Website: http://www.insero.dk/Nyheder/308-Proev1elbil_baner_vejen_for_flere_elbil_aktiviteter.aspx (as on 12.11.2013)</p> <p>Slideshow title: 'Brugernes oplevelser og idéer'. Assessed from the INSERO website. Direct link: http://insero.dk/Images/Dokumenter/Brugernes_erfaringer.pdf (as on 12.11.2013)</p> <p>Kjeld Nørregaard, Teknologisk Institut. Slideshow title: 'Prøv1elbil- demonstration med 13 elbiler'. Direct link: http://insero.dk/Images/Dokumenter/Prov1elbil-Der_er_penge_i_elbiler_konf_dec_2010.pdf (as on 09.12.2013)</p>
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Project title	Test-en-elbil - (ChoosCOM - Large-scale demonstration of charging of electric vehicles)
Leading organization or platform	CLEVER
Organisation(s) involved	CLEVER, Trafikstyrelsen og Energistyrelsen.
Website(s)	https://www.clever.dk/test-en-elbil
Period	Jan 2010 -
Location, consumer studies	Denmark
Background	-
Research objectives	<p>The stated goals for the project are:</p> <ul style="list-style-type: none"> • To create a knowledge base consisting of data gained from the test pilots personal experiences about driving, use patterns and charging • To gain insight in the 'driving needs' and hereby illuminate what concrete needs for transportation the electric cars can cover • To gather knowledge and experience in relation to the consequences that the electric car has on the electricity net • To understand the gains when driving electric cars in relation to pollution • To get insight in where and how charging in the public areas happens in order to ensure the charging networks quality
Methodology	<p>24 Danish municipalities, 3 hospitals in Region Hovedstaden, and a number of companies are involved in the project. The project runs approximately 2 years in each area. A subproject in 'Test-en-elbil' is the project 'ChoosCOM'. ChoosCOM investigates the charging of the electric vehicles. Specifically an intelligent charging module is installed in the cars making it possible to charge in periods where the CO2 emission is the lowest. By implementing the module it is possible to investigate when the cars are being charged and the need for energy.</p> <p>As a test pilot the family gets an electric car to use for a period of three months. The car shall in this period be the family's first car if possible. The project has included a number of 198 ev's. The number of test persons were 1518. The number of ev's that include the ChoosCOM module is 185.</p> <p>A survey among all earlier test pilots has been conducted. The response rate was 52%.</p>
Results	<p>Results from the survey (mentioned above)</p> <ul style="list-style-type: none"> • 92 % of the test pilots believe that the possibility of variable electricity prices (demand response) in very high / high level will change their consumption patterns. However, 41% indicated that the saving in power consumption should be between 750-2000kr a year before they will be willing to change their consumption. • Far the most drivers charge their ev's at home. 71% have never charged the electric outside their perimeter. • The study concludes that the charging itself is not a barrier against the dissemination of electric cars. <p>Charging:</p>

	<ul style="list-style-type: none"> • Results show that the test pilots believe that an increasing number of charging stations will affect the distances that they drive. • Results show that the test driver will drive longer when/if the infrastructure is developed. Mostly it would occur during holiday periods. • Studies show that 80% of all charges are done within a period of less than 5 hours, at home. The car batteries are thus not fully discharged. Just over half of the test pilots did not use charging infrastructure in spite of it is provided without extra expenses. • The study expects that customers mostly will charge at home, where it is cheapest, and avoid using CLEVERS charging stand network. • The project states that the electric car can easily cover the needs of families. The desire for more charging stations is an expression of a mental desire of not being limited. This may be difficult to oblige. <p>Safety:</p> <ul style="list-style-type: none"> • Among all the test pilots, 68% have indicated that silence of the electric car has no impact on their sense of security. Other studies have shown that drivers of electric vehicles pay more attention to the pedestrians etc. because of their self-awareness of driving in a silenced car. <p>Behavior:</p> <ul style="list-style-type: none"> • The participants in the study have responded that the participation in the project has affected the focus on energy consumption beyond the electric car. 41% report that they think about other household consumption much higher/higher than before. • 69% of all test pilots indicate that they consider environmental- driving at a much higher / higer level than before participating in the project. 17% stated that they drive more green in their conventional car after test trial. • 58% of all test pilots have indicated that their prejudices have been reduced in a very high / high level since participation in the project. 12% indicated that their prejudices have been reduced to a very low extent or not at all. 26% responded that their prejudices are the same as before the test period.
Additional comments	Electric cars
Sources	CLEVER A/S. TEST-EN-ELBIL, KVARTALSRAPPORT, 2. KVARTAL 2013/6. CLEVER A/S KVARTALSRAPPORT FOR PERIODEN 1. APRIL – 30. JUNI 2013. Direct link: https://www.clever.dk/media/85114/kvartalsrapport_juli_2013_pdf.pdf (as on 25.11.2013)

Project title	The eFlex Project
Project leading organization	DONG Energy
Other organizations involved	-
Website	-
Period	Summer 2011 – summer 2012
Location, consumer studies	Denmark
Background	‘Understanding the dynamics of customers’ flexibility is essential for realizing such a smart energy system in which distribution companies can rely on flexibility.’ Highlighted (from DONG report):
Research objectives	‘The purpose of the project was to investigate, what incentives could be applied to make private households participate in load shedding in the distribution grid.’
Methodology	<p>‘The project included 119 households located in the DONG Energy supply area in North Zealand and Copenhagen, Denmark. 82 of these were heat pump owners and 28 customers fell in the category ‘ordinary’ households with no heat pump or electrical vehicle. The 9 customers who owned electrical vehicles were too few and did not constitute a basis for statistical analysis or safe assessment of general behavioral change. In the eFlex project, we concluded an agreement with the consultancy company Antropologerne. com to conduct a study of customer behaviour and what changes the home automation system entailed. The study was essentially conducted by home visits and cultural probes (home exercises). In total, 48 home visits were included in the survey and each visit lasted approximately 4-5 hours.’ The home visits included semi-structured interviews and observation of the homes of the participants. Furthermore focus groups were initiated and workshops conducted.</p> <p>‘The heat pumps were interrupted according to a price control scheme. The price was a combination of a spot market price, settled on North Pool day-a-head electricity market, a 3-step grid tariff and the regular public service obligation and tax fees. The price control scheme interrupted the heat pumps during price peak periods and released them to ordinary operation when prices decreased again. The control was made possible by a home automation system with an integrated control unit. The system also gave the customers an opportunity to monitor the consumption on other appliances and program these to switch on and off according to a timer.</p> <p>The customers were provided with a home automation system with an integrated control unit to interrupt the heat pump from operating during peak periods. The home automation system in parallel offered the customers the opportunity to closely monitor the energy consumption of various appliances in the house and in addition to control them by means of an ordinary time scheme control. Furthermore, the customers were invited to share experiences and get support on a social media, Podio. The aim with the latter two features was to raise interest in energy consumption.</p> <p>In order to maintain communication with the customers, a Facebook-like platform was established based on the PODIO concept.</p>

	<p>eFlex opened and experimented with several alternative communications. The Home Automation portal (and parallel facilities on the provided iPod Touch) offered a direct insight into the online consumption of energy and divided the consumption into details on the consumption of the appliances that was connected.</p> <p>(Concerning the home automation system) Greenwave Reality (GWR) delivered standard two six-plugs power nodes and two single-plugs power nodes to each household. In addition, the owners of heat pumps and electrical vehicles were equipped with technology for measurement and control of these devices. A Gateway connected the home areas network by z-wave communication. Besides measuring energy consumption of the heat pump and charging of the electrical vehicle, the main electricity consumption of the household was measured. Furthermore, customers were equipped with an iPod Touch for control of the devices or could choose to do so in a more extended version installed in their home computer; a portal.</p> <p>Greenwave Reality supplied the communication from the gateway via the internet to the server system including monitoring and execution signals and user portal. The server system also collected elspot market prices, metrological data etc.'</p>
Results	<p>The report from DONG Energy concludes that there is a technical potential, for delivering a significant reduction in the peak load, in heat pumps. Furthermore customers were willing to let other control their heat pumps when given the proper incentives. A result from the project is a deviation of the users into 5 groups in relation to their behaviour in relation to the technology. The groups are: The Technician, The economist, The curious, The Sympathetic, and The Comfortable.</p> <p>The anthropologists found that the users' (belonging to different user profiles) participation in the project was different, just like they used the home automation equipment in different ways in their everyday life. Because of the differences between the users, the needs and wishes (in relation to the concept, design and communication) varied. Furthermore the anthropologists found that demand response is related to the lives that are being lived within private homes. Demand response is about getting people to change their habits and routines. Since habits and routines give a sense of safety and recognisability, it is important to make the integration process of equipment to be pleasant with sufficient feedback, dialog and assistance from the responsible company. Electricity is used to create life in the homes. Electricity is used on necessities (cooking, heating etc.) and luxurious lifestyle (hobbies, social life) practises. The consumers are mostly willing to change the consumption practises related to necessities. The families showed interest in including the children in the new technology. The project found that the new technology changed the roles within the families and concluded that if the willingness is to be advanced then the diversity of the consumers should be included.</p> <p>The consumers' participation and motivation for demand response was not connected to economic incentives. The participant's economical rationales were complex and diverse. The consumers had a wish to avoid waste of energy but also had a wish to behave as social norms detect (wanted to do what is perceived as the normal, reasonable actions). The consumers in the projects were motivated by other things than economic incentives. The home automation equipment in the project functioned as a 'mediator' between the abstract 'electrical world' and the real world. Through the equipment the consumers could learn and understand their consumption. The home automation equipment advanced the willingness towards demand response among the consumers.</p>

	Flexibility was achieved in the households without the participants loosing on the comfort-level. When simulation the behaviour of the participants to occur among a larger crowd, the results did not reveal a clear indication for the benefits of the set up.
Additional comments	Home automation equipment to control heat pumps. Variable tariffs (3 stages)
Sources	DONG Energy 'The eFlex Project'. DONG Energy Eldistribution A/S, Department of Grid Strategy. November 2012. Direct link: http://www.dongenergy-distribution.dk/SiteCollectionDocuments/eFlex/The%20eFlex%20Project-low.pdf (as on 29.11.2013) Koppel, N. B., Ulk, R., Demant, T., & Ammentorp, P. (2012). 'eFlex :: Fleksibelt elforbrug - En kvalitativ undersøgelse af, hvordan deltagerne i projekt eFlex oplever hverdagen med energifleksibilitet.' (p. 110).

10.2 FINLAND

Project title	Beaware
Project leading organization	Helsinki University of Technology
Other organizations involved	University of Padova - Department of General Psychology, BaseN Corporation, Engineering Ingegneria Informatica, Vattenfall Research and Development AB ENEL S.p.A. Intelligence for Environment & Security – IES Solutions Srl
Website	http://www.energyawareness.eu/beaware/
Period	1/1/2010 -> 1/1/2013
Location, consumer studies	EU – Test sites: Finland, Sweden, Italy
Background	Recruitment through advertisement. Special interests in households with medium/high income
Research objectives	‘BeAware wishes to foster the creation of new services that turn householders into active players in energy and inspire creation of new services and products for energy awareness. BeAware aims to develop services for conserving electricity within households. The goal of these services is to reduce power consumption within households by 15%’ [1]
Methodology	<p>‘The project builds a service platform that will ensure scalable, deployable innovation in the consumer power market, enabling a combined service to monitor the consumption and understand the effects of different choices. This can create opportunities for learning better practices or incentives for adopting virtuous behaviors. The Energy Life architecture consists of three different logical layers: a sensing platform, a service layer and an application layer.</p> <p>The sensing platform provides consumption measurement data from a wireless network of sensors and base stations. This data is stored in a computation grid, which offers real-time analysis and scalability.</p> <p>The service layer provides an open and distributed web service infrastructure oriented towards consumers and detailed analysis of electricity consumption in households....</p> <p>The application layer provides information to the consumer and makes them an active stakeholder into the consumer energy conservation chain.’ [1]</p> <p>‘Each household has one or more members who are the users of the BeAware System. Each user can control the real consumption of the household’s appliances. In addition, s/he can play Energy Life by reading the tips and by replying to the quizzes proposed by the BeAware’s system.’ [2]</p> <p>‘The Watt-lite Twist is an oversized torchlight projecting energy statistics in a pie- chart interface. It proposes an alternative way of</p>

	<p>understanding the relationship between electricity use and the, often considered, abstract energy unit; kilo-watt- hours (kWh).....The Watt-lite Twist builds on the idea of trying to materialize the understanding of electricity use in a more tangible way. When the user are twisting the torch, setting the amounts of kilo-watt-hours to be measured, he or she can literally feel the physical resistance from the mechanism. The Watt-Lite can visualize all the consumption of the technologies connected via wireless sensors.’ [4]</p> <p>‘As anticipated, the system developed within BeAware, and called EnergyLife, bases its persuasive potential on two pillars, awareness tips and consumption feedback. Awareness tips are meant to increase the users’ knowledge of the consequences of their electricity consumption in general and of that of specific devices; consumption feedback makes the actual energy consumption visible to the users in terms of the updated distance from the selected saving goal. The two kinds of information together would help the users to monitor the quality of their conservation practices, and would enable them to know what to change in these practices in order better to achieve their goal. Both types of information are tailored to the actual consumption of individual devices and of the whole household’.[3]</p> <p>‘Energy Life (se description above) will be set up in two different pilot sites, one Nordic field site (Sweden and Finland) and one Southern European field site (Italy). The technology will be tested in real households over a longer period to be able to show the effects of the service in a realistic situation. The research approach is highly multidisciplinary and combines a variety of approaches in the area of user studies, user centered design and evaluation. Disciplines include cognitive science, social psychology, anthropology, design. The user research approach is a combination of qualitative and quantitative field studies and trials.’ [1]</p> <p>The project included two field tests. The first test contained 8 households. The second test included 12 households (http://www.energyawareness.eu/beaware/trials/first-trial/ as on 13.12.2013) (http://www.energyawareness.eu/beaware/trials/second-trial/ as on 13.12.2013)</p>
Results	<p>‘There is an amazing convergence between users’ perception and users’ automatically collected behavior: the participants declare to have changed consumption habits and have increased their awareness because of the use of EnergyLife; indeed, their actual electricity consumption decreases during the trial. This convergence also emerges at a more detailed level, since the pc is the device where the decrease of consumption reaches statistical significance both in the users’ perception and in their behaviors.</p> <p>The persuasive efficacy of Energy Life does not seem to be directly related to the mere amount of interaction with the interface. It seems instead related to receiving feedback on single specific behaviors: users seem to reduce their electricity consumption especially with the devices that are monitored by the application and ask for more specific advice tips. Also the evaluation of wasting behaviors varies in severity from one behavior to the other, and is strongly related to the frequency at which each behavior is enacted. On the other hand, the access to the application showed a constant decrease, as so did saving. This can probably be connected to the system bugs which undermined a full exploitation (and then enjoyment) of the game experience. Similarly, the design and the various features of EnergyLife concept were generally appreciated and considered as effective apart from those that were affected by bugs. Usability was rated high (navigation, general learnability and general consistency), accompanied by some specific weaknesses that can be improved in the next prototype (access to individual advice tips; undo functions, timeliness of system response to commands; specificity of advices) as well as by some aspects of the game rationale that</p>

	can benefit from clarifications (saving calculation, difference between individual and household scores, time reference of consumption/saving calculation, meaning of “dimming” feature, of the category “other” devices, community functions).’ [2]
Additional comments	<p>Sociological and anthropological methods.</p> <p>‘Energy Life: Energy Life includes an ambient interface that makes use of the home lighting and lamps as a mean to communicate with the user.) A service platform and web approach will ensure scalable, deployable innovation in the consumer power market enabling a combined service to:</p> <ul style="list-style-type: none"> • Monitor the consumption and understand the effects of different choices. • Control with more precision power consuming appliances and systems (lights, heating, etc.) with advanced personalization. • Share consumption practices in groups and communities. This can create opportunities for learning better practices or incentives for adopting virtuous behaviors.’ [1] <p>Real time feedback to the user of the energy consumption</p> <p>Role assigned to user: Active manager of own energy consumption</p>
Sources	<ol style="list-style-type: none"> 1. Brochure “BeAware introduces Energy Life Becoming aware of our electricity consumption”: http://www.energyawareness.eu/beaware/uploads/090625_BeAware_official_brochure.pdf 2. Pasquale Andriani, Giampaolo Fiorentino (ENG), ‘Boosting Energy Awareness with Adaptive Real-time Environments.’ ENG, 14-december-2010. Direct link: http://www.energyawareness.eu/beaware/wp-content/uploads/2010/12/BeAware-D5.5-ENG-V1.0-20101214.pdf (as on 29.11.2013) 3. Jacucci G., Spagnolli A., Gamberini L., Chalambalakis A., Björksog C., Bertoincini M., Torstensson C., Monti P ‘Designing Effective Feedback of Electricity Consumption for Mobile User Interfaces’. PsychNology Journal, 7(3), 265 – 289. (2009) 4. Website: http://www.energyawareness.eu/beaware/solutions/wattlight-twist/ (20.01.2014)

10.3 NORWAY

IHSMAG project is conducted in collaboration between the countries Denmark, Norway and Spain. IHSMAG is mentioned in the Danish category. The project IMPROSUME is partly Norwegian, Danish and Switzerland. The project is mentioned in the Norwegian category

Project title	Demo Steinkjer
Project leading organization	NTE
Other organizations involved	-
Website	www.demosteinkjer.no http://smartgrids.no/demo_norge/demo-1/
Period	Jan 2011-Dec 2015
Location, consumer studies	Norway
Background	<p>Demo Steinkjer is member of the Norwegian Smartgrid centre. Demo Steinkjer is a national project initiated to test new solutions for the use and measurement of energy. The Steinkjer project shall function as a national testing ground. As mentioned earlier the Norwegian government has decided to implement AMI's in all households in Norway. The participants of Steinkjer will be the first to get the new smart meters installed. In the report fase 2, slutreport the implementation phase of the smart meters is described. The report focused on the installation process. The private consumer does not have a central part in the report.</p> <p>800 households have gotten smart metering technology installed and will serve as participants in the pilot project. Of the 800, 330 consumers have joined the project as active members of the pilot project. They will be included in the development of smart grid related technologies by testing technologies. For the remaining participants, the inclusion in the project will occur behind the household, on the system level. These consumers do therefor not have to engage but will contribute with consumption data etc.</p>
Research objectives	To create a living lab with real households testing smart grid solutions and products. The lab is open for industry. The project wishes to explore Dynamic pricing.
Methodology	-
Results	-
Additional comments	Living lab, smart grid technology. The site officers industry to conduct experiments involving private consumers. AMS (Advanced Metering System) – including private consumers
Sources	1. 'Utrulling Demo Steinkjer BYAFOSSEN', NTE NETT AS. 2012.09.10. Direct link: https://www.demosteinkjer.no/content/3/Dokumenter , last accessed, 2013.10.23

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| | 2. Slideshow: 'Demo Steinkjer –a national smartgrid livelab'. ITovation. 18. nov 2011 http://www.itovation.org/_media/demosteinkjer_-_the_national_smartgrid_livelab.pdf (as on 14.12.2013) |
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Project title	IMPROSUME
Project leading organization	Inkubator Halden AS, Norwegian Center of Expertise for Energy and Emission Trading
Other organization(s) involved	University of St. Gallen (HSG) - Good Energies Chair for Management of Renewable Energies Aarhus School of Business & Social Sciences
Website	http://www.ncesmart.com/Pages/Inprosume.aspx
Period	01.01.2010-01.01.2011 (according to http://badm.au.dk/research/research-groups/marketing-and-sustainability/projects/ongoing-projects/improsume/) the period is 2010 - 2013
Location, consumer studies	Norway, Halden
Background	The main purpose of the project is to investigate the concept of Prosumer within a smart grid energy market. Within the project there are three work packages. In this review most focus will be on the work of wp1 that was in charge of the test field including the private consumers
Research objectives	<p>The objectives of the project are:</p> <ol style="list-style-type: none"> 1. 'To define and study the role of prosumers in the future power market 2. To develop strategies for securing consumer acceptance and active participation based on solid knowledge of prosumer behavior given a set of constraints and stimuli 3. To analyze and develop possible business models for prosumers 4. To develop simulation models and analyze technical and commercial impact from prosumers, given different constraints and stimuli, business models and various combinations of distributed energy resources 5. To analyze different trading strategies covering inter- as well as intra-trading 6. To analyze the relation between the prosumers and technical and commercial aggregators 7. To analyze the value chain prosumer-VPP-market 8. To extract constraints, rules and relationships that can help design and optimize the Smart Grid of tomorrow, the definition of new market mechanisms, trading instruments and grid management facilities to achieve optimal use of resources, high regularity, acceptable price levels and stability of supply as well as sustainable growth for the European countries'. [3]
Methodology	<p>Methods used by WP1:</p> <ul style="list-style-type: none"> • 'Two different prosumer types will be studied: private households and small and medium sized companies (SMCs). The first stage of this research is to do a survey of the literature on consumer's acceptance of their role in the Smart Grid. • Next, via online questionnaire studies in three countries, i.e. Denmark, Norway and Switzerland, a general overview of the motivations and barriers for consumers to participate in the Smart Grid is studied. • Field test including private households

	<ul style="list-style-type: none"> • Study the reaction of the prosumers when having their heat pumps remotely regulated by a utility company • Data collection is done via questionnaires and in-depth interviews' <p>The field test was planned to last 6 months</p>
Results	<p>Results from the survey: The online survey gave 1165 respondents in Denmark, 1251 in Norway and 1242 in Switzerland. The data has been analyzed. As hypothesized initially the WP1 team found that the participation rate in the smart grid depends on the recruitment method and specifically what is the implicit or explicit default option. This offers significant insight to business developers and smart grid pioneers requiring the participation of prosumers. Our data confirm that, as we expected, both personal and collective benefits are important for the acceptance of Smart Grid technologies in Denmark and Switzerland. However, in Norway collective benefits seem to play a less important role, and personal benefits are more important. In Switzerland user acceptance is strongly influenced by norms, while in Norway this aspect is significantly lower. This implies that acceptance of the technology in Norway is only faintly based on moral reasoning compared to the two other countries. Overall for the two other countries acceptance is more centered on a mix of usefulness and pro-social motives. When promoting smart grid, not only the technical usefulness should be communicated, but also the usefulness for the society and the environmental benefits from use of this technology. The latter being somewhat a weaker argument in Norway. These results have profound implications for how to approach people with regard to specific technologies. This also yields valuable insight with respect to behavior modeling in simulation models and have been used in the project accordingly.[2]</p> <p>Results from the field test: The field test was meant to investigate practical actions and compare it with attitudes harvested in the survey. More precisely it was meant to identify effective approaches to recruit electricity consumers as prosumers (i.e., opt-in vs. opt-out models) and to examine consumers' experiences with also being a prosumer. The recruitment of private households was delayed, but eventually executed....However, several complications arose and only 17 became part of the actual field test. The data harvest anticipated became very lean and faulty. The primary objective for the field test could never really be achieved within the extended project period. However, valuable experiences were harvested from this type of scientific field test.... Nevertheless, the unfortunate experiences gathered from the field test were openly highlighted in the final project workshop in Aarhus in June 2013 like a "lessons learned" type of entry.[2]</p>
Additional comments	The project investigates the reaction towards home appliances being controlled from afar.
Sources	<ol style="list-style-type: none"> 1. Website describing WP1 (Acceptance of the Prosumer role): http://badm.au.dk/research/research-groups/marketing-and-sustainability/projects/ongoing-projects/improsume/ (18.11.2013) 2. Bernt A. Bremdal. 'IMPROSUME, The Impact of Prosumers in a Smart Grid based Energy Market', Final report, Version 2, August 2013. Direct link: http://www.eranet-smartgrids.eu/files/IMPROSUM_Final_Reports.pdf (11.12.2013) 3. Website: Breimdal, 2010, (http://bremdal.blogspot.dk/2010/12/improsume-impact-of-prosumers-in-smart.html) (11.12.2013)

Project title	Managing Smart in Smart Grid (MSiSG)
Project leading organization	Tieto Energy AS
Other organizations involved	Norwegian Centre of Expertise Smart Energy Markets (NCE SEM), Ostfold Research, Institute for Energy Technology (IFE), Tieto, moreCom, Ostfold University College and Statsbygg
Website	http://smart-energy.no/index.php?option=com_content&view=article&id=14&Itemid=3&lang=en
Period	01.01.2010-01.01.2012
Location, consumer studies	Norway
Background	<p>The background for the project is a need for exploring the potential for Advanced Metering infrastructure (AMI) in Norway. In Norway a regulation has been adopted according to implementation of AMI (Advanced Metering Infrastructure). In 2019 all households in Norway shall have an advanced meters and energy control systems installed. Advanced Metering Infrastructure (AMI) has been a big part of the project. The regulation proposes meters that have the ability to measure the energy consumption every hour. Furthermore the meters shall have the possibility to measure every 15 minutes. Other request to the meters is that they must have a display. The display must demonstrate the consumption in price and kWh. The consumption data will automatically be sent to the grid operator once a day. If the consumer agrees a third party (an Energy Service Company, ESCO; or Smart Energy Service Provider, SESP) will get the data as well. The energy service companies will offer services related to energy budgets and energy tariff negotiation.</p>
Research objectives	<p>Project goals:</p> <ul style="list-style-type: none"> • 'A significant reduction in energy consumption and emissions of greenhouse gases from sectors that use large amounts of electricity in Norway • Making it more profitable to invest in smart grid technologies and services and create a good tool for more efficient energy use and sustainable development • Increased competitiveness and value creation in the Norwegian energy companies in relation to the sale of sustainable energy resources offered through a smart grid technology and services • Increased wealth creation in the Norwegian supplier relating to products and services related to energy trading and smart grid services • The construction of new knowledge in the field within the industry, research and teaching environments as a basis for research-based innovation in NCE Halden.' [2] <p>The report 'MSiSG, Energy and power use and ways to reduce, has a focus on a concept 'value oriented energy use' in relation to the end-consumer and the energy management of buildings. 'Sustainable buildings require an approach and indicators for measurement beyond the traditional energy efficient focus. The approach should reflect a goal to spend energy effectively when it is needed, where it is needed.' (p5).</p>

Methodology	<p>The background for implementing smart grid in NO is described. The following areas are described:</p> <ul style="list-style-type: none"> • Statistics on energy use • Knowledge of energy sources • A description of where the energy is used, for what services and at what times of the day. • Smart Grids are especially related to electricity, but electricity as a high quality energy source can substitute other energy sources and thus there is a need to understand the coupling between energy for different applications. • A presentation of the use of various energy sources at a global and local scale (NO).
Results	<p>On the basis on the above mentioned investigation the project suggests development of a Zone-concept on the basis of the retrieved knowledge. Specifically the report argues:</p> <ul style="list-style-type: none"> • the need for designing the houses according to activities. The spaces shall have the ability to have many functions and thus have multipurpose in order to be of use in as much time as possible. • for zoning of the typical Norwegian household according to different level of complexity. The levels of complexity are: 1) Pre-programmed temperature of zones according to time; 2) Demand-response: Additional zoning pre-programmed according to variables, e.g. total effect, energy price; 3) Prosumer: Preprogramed zoning is combined with production and income potential (energy price). <p>In suggested zoning concept it is possible to have the level of complexity of 1, or 1+2, or 1+2+3 as the complexity levels build upon the previously ones in the row.</p>
Additional comments	<p>In the report: “Managing Smart in Smart Grid: Macro perspectives – Energy and power use and ways to reduce” the consumers are given several roles within future energy system. Important elements in relation to the implementation of smart meters are: 1) Enabling of new functions in relation to energy consumption. For example the consumers will now pay for the actual consumption of energy instead of an estimated consumption.</p> <p>2) The consumption might be affected by implementation of various pricing schemes. Possible tariffs are dynamic tariffs/real time tariffs, time-of-use rates or critical peak pricing. This could be implemented by direct control (remote control of devices in consumers’ homes) or indirect control (inducing consumption patterns by price information). The notion of changing the consumer’s behavior (in relation to energy consumption) according to changing prices of electricity or other signals is often referred to as demand response.</p> <p>3) A long with the Demand Response functionality the notion of Prosumer is mentioned as an entity producing and consuming energy. A prosumers is seen as more than a consumer producing energy. A prosumer is a consumer that is engaged in the energy market.</p>
Sources	<p>1. Anne Rønning, Guro Nereng, Camilla Skjerve-Nielssen, Andreas Brekke, Bernt Bremdal ‘Managing Smart in Smart Grid: Macro perspectives – Energy and power use and ways to reduce’. Østfoldforskning. Direct link: http://ostfoldforskning.no/Engelsk/publication/managing-smart-in-smart-grid-macro-perspectives-energy-and-power-use-and-ways-to-reduce-708.aspx</p>

	2. Website: http://smart-energy.no/index.php?option=com_content&view=article&id=15&Itemid=10&lang=en (as on 23.11.2013)
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Project title	Market Based Demand Response
Project leading organization	SINTEF Energy Research
Other organization(s) involved	-
Website	-
Period	2005-2008
Location, consumer studies	Norway
Background	'The pilot study was implemented at Malvik Everk, a DSO in Central-Norway.'
Research objectives	'The objective of the pilot study was to motivate the customers to change their load curve in a way that reduces the total consumption in periods of expected peak load.'
Methodology	<p>The main focus of the project was Remote control of electrical water heaters in private consumers' homes. The customers were chosen according to the geographical area they were located in, the quality of metering data and their general interest in their electricity consumption. 'The invitation to customers was presented in an article in the local newspaper and via letters sent by mail. Prior to the pilot study all the DSO's household customers had installed AMR for weekly metering of their electricity consumption. In relation to this pilot study 40 household customers were given hourly metering of their electricity consumption with use of existing AMR technology.'</p> <p>The project included 40 households and hourly metering of electricity consumption and lasted 1 year. 37 customers had energy contract with spot price on an hourly basis. The consumers got a price signal depending on: ToD network tariff and the energy contract with hourly spot price to stimulate load shift.</p> <p>Contact/evaluation of the customer satisfaction:</p> <ul style="list-style-type: none"> • Two information meetings • Web site with information about their network costs with the ToD network tariff, compared with the traditional network tariff. • Survey <p>'Each household in the pilot study was equipped with three small tokens, the "El-buttons," to be placed on dishwashers, washing machines, etc., to remind the households to avoid usage of these energy consuming appliances in the predefined peak load periods. The token represents a watch with 12/24 hours, where the leftmost sector represents the morning peak hours (08:00–10:00) and the lower sector represents the afternoon peak hours (17:00–19:00)...The duration of the pilot study was one year.'</p>
Results	According to a survey performed, the customers have a positive perception of this pilot study. The main focus was on personal economic benefit, with secondary focus on reduced electricity consumption. They accepted RLC (remote load control) performed by the DSO as long as it did not have negative consequences for the perceived comfort. The survey also showed that several of the customers performed actions to

	adapt their electricity consumption to the new ToD network tariff, mainly by investing in energy control systems, buying firewood for the winter and/or through manual efforts. Some of the customers also confirmed an increased interest in energy conservation due to more attention to their own consumption.
Additional comments	Smart Meter and AMI: The pilot study focused on daily demand response from households, utilizing smart metering, remote load control, pricing based on the hourly spot price combined with a time of day network tariff, and a token provided to the customers indicating peak hours.
Sources	Hanne Sæle and Ove S. Grande 'Demand Response From Household Customers: Experiences From a Pilot Study in Norway'. IEEE TRANSACTIONS ON SMART GRID, VOL. 2, NO. 1, MARCH 2011. Direct link: http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=05710614 (as on 29.11.2013)

Project title	Smart Energy Hvaler
Project leading organization	-
Other organizations involved	Fredrikstad Energi AS, NCE Smart Energy Markets, Hvaler kommune
Website	http://www.smartenergihvaler.no/
Period	- (present)
Location, consumer studies	Norway
Background	Fredrikstad Energi, Hvaler municipality and NCE Smart Energy Markets have joined forces to create a test site. The test site is situated in Hvaler. The first step in the program is to change the meters in the area into smart meters. The area is (partly?) dominated by holiday homes (cottages).
Research objectives	The site Hvaler will be especially interested in the possibilities for local production of electricity. The means will be solar panels and small wind generators for the holiday homes. The houses (including holiday homes) shall become electricity producing entities feeding the grid. The Advanced Metering System is seen as a central actor in fulfilling this vision. The Hvaler site will serve as an umbrella for several innovation projects on the energy area. The area has gotten eWave, (for visualization of electricity equipment installed). The eWave appears to be a profile on the internet that the consumer logs on to via PC, Ipads of smart phones.
Methodology	Living lab with holiday homes. Advanced Metering System is being implemented. Afterwards the area shall function as a test site. Some projects that will be tested are: 'Producer din egen strøm' (Solar panels and small windmills); 'Hyttflex' (to develop new methods to make the energy consumption more efficient). Also a project on dynamic tariffs is planned.
Results	Since the summer 2013 more than 5000 smart meters have been installed. The meters send the consumption per hour and the past 24 hours consumption.
Additional comments	-
Sources	<p>Slideshow: Per Gunnar Rækken. 'Bli premiært for å styre ditt strømforbruk'. Direct link: http://www.smartenergihvaler.no/wp-content/uploads/Tariffprosjekt-Vidar-Kristoffersen-presenasjon-Hvaler-4-desember-2013.pdf (as on 14.12.2013)</p> <p>Slideshow: eWave. 'Energidisplay på Hvaler'. Direct link: http://www.smartenergihvaler.no/wp-content/uploads/eWave-Hvaler-4-desember-2013.pdf (as on 14.12.2013)</p> <p>Brochure: eWave. 'BRUKERVEILEDNING'. Direct link: http://www.smartenergihvaler.no/wp-content/uploads/Bruerveiledning-for-eWave.pdf (as on 14.12.2013)</p>

10.4 SWEDEN

Project title	Matning 2009
Project leading organization	Goteborg Energy AB
Other organizations involved	-
Website	-
Period	Mar 2006 - Jul 2010
Location, consumer studies	Sweden
Background	From 2005 to 2010, the Gothenburg Energy Project Metering 2009 produced and implemented a new system for the collection of metering data from 260,000 electricity customers. The reason for initiating this project was new legal requirements on monthly reading of electricity use from July 1, 2009, which demanded remote meters and a new IT system to manage the large amount of data to be received and handled. The metering system developed in the project was more advanced than the once required by the government. The reason for this decision was to enable further development of energy services, especially to prepare for likely future requirements for hourly electricity meter readings.
Research objectives	Installation of smart meters in 260 000 households and installation of related advanced metering infrastructure (AMI)
Methodology	Installation of smart meters in 260 000 households and installation of related advanced metering infrastructure (AMI)
Results	In autumn 2009, the project focused on stabilizing the delivered solution and ensured that communication was fully operational. Preparations were also made for final testing of the solution. The project was completed in autumn 2010. Göteborg Energi has procured and implemented a system that meets regulatory requirements, both current and future add-ons, as well as providing a good potential for future development including metering-related services, and network monitoring. Work remains in connection to realize the advantages that the solution enables.
Additional comments	Installation of hourly electricity meters, Smart Meter and AMI, Installation of hourly electricity meters
Sources	Slideshow: Tomas Arnewid, 'Göteborg – The first ZigBeeCity?', Advanced Metering Infrastructure Project (AMI) http://zigbee.org/zigbee/en/events/documents/May2007_Open_House_Presentations/01_Keynote_Arnewid.pdf Anders Söderberg, Disa Hammarskjöld, Hanna Tengelin. 'Genomlysning av projekt Mätning 2009, Göteborg Energi AB', 2011-10-19. Direct link: http://www.goteborgenergi.se/files/dok/ovr/utv%C3%A4rderingsrapport_g%C3%B6teborgs%20stad_geab_m%C3%A4tning%202009_2011-10-19.pdf (as on 29.11.2013)

Project title	Pilotstudie i Vallentuna
Project leading organization	Ngenic
Other organizations involved	-
Website	-
Period	2010 - (not certain)
Location, consumer studies	Sweden
Background	-
Research objectives	A field test was established in relation to the study. During the field test the potential for moving electricity loads via heat pumps was examined.
Methodology	<p>'....in this project, a prototype system for such smart heating has been tested and the results together with simulations carried out verify the economic benefits stated above.'</p> <p>The project included smart heating (via heat pumps and sensors in each room) in private consumers' houses. The heating system optimized the use of electricity on the basis of weather forecast and price signals.</p> <p>Field study: 5 rounds with 5-6 households were included. In the tests high electricity prices were simulated.</p> <p>Focus groups were interviewed to evaluate the system. Simulations were conducted on the basis of the field study.</p>
Results	<p>Many of the involved house owners did not experience a good enough level of comfort with the new automatic system installed. The importance of the 'right' comfort level varied amongst the involved house owners.</p> <p>The focus group interviews revealed that some customers had a need for an increased level of reinsurance in relation to the heat pumps. Some of the house owners did not feel comfortable with the heat pumps. The level of insecurity towards the heat pumps varied amongst the involved house owners. The field test revealed the potential of providing energy advises to the house owners, based on analyses of the collected measurements.</p> <p>'It is today possible to implement Demand Response in a large scale in Sweden through smart services which automatically optimizes heating. For a homeowner with a ground source heat pump this implies yearly savings of 2200-2600 SEK (electric boiler 2800-4000 SEK), based on simulations of price and temperature data from the years 2010 and 2011. This is made possible through a combination of increased energy efficiency (10-15 %) due to effects such as smoother indoor temperatures, and shifting of consumption from expensive to cheaper hours (approx. 15 kWh heat per day). The reward of load shifting varies heavily between seasons, since it depends on an intricate relation between price volatility and heating needs (e.g. 1720 SEK and 590 SEK for 2010 respectively 2011, simulated on ground source heat pump). It is also clear that the effect of time dependent grid tariffs dominate the savings in times of low price volatility (e.g. of 1090 SEK "load shift savings" for an electric boiler during 2011 770 SEK was due to grid tariffs). The benefits can be reached without demanding active participation or</p>

	compromising the comfort level....The tests identified the diversity of heating systems and house types as one of the main challenges for a scaling of this kind of service. It was not possible to draw any clear conclusions regarding the effects of the self-learning mechanisms in this field study. Other challenges identified where the need for increased redundancy in the prototype system and handling of existing problems in the homeowners heating systems.'
Additional comments	Heat pumps, demand response, smart heating system (to react according to price incentives and some level of comfort for the consumer), automatic demand response. The use of automated equipment is in focus. Thus the experiment induces the development of automation control of electric devices. Supports a future where the consumer does not control the devices themselves.
Sources	Einar Persson, Björn Berg, Fredrik Fernlund, Olle Lindbom. "Pilotstudie i Vallentuna, Reflektioner rörande affärsmodeller för förbrukarflexibilitet och självlärande prognosstyrning för kundanpassad effekttreglering" Elforsk rapport 12:48. juni 2012. Direct link: http://www.elforsk.se/Documents/Market%20Design/projects/12_48_DSM.pdf (as on 29.11.2013)

Project title	Smart Grid Gotland
Project leading organization	Vattenfall AB
Other organizations involved	-
Website	-
Period	Nov 2010 - Dec 2015
Location, consumer studies	Sweden
Background	There are planned 4 different pilot tests, within the Smart Grid Gotland project, including private consumers.
Research objectives	The Smart Grid Gotland R&D demonstration project intends to develop strategies for the planning, construction and operation of a fully developed, large-scale Smart Grid, including a large share of intermittent production, primarily from wind power in the distribution network. New market models and services will be developed to pave the way for new market players. Through this development of the future smart distribution grid, consumers and producers will be fully integrated in a demonstration project that is likely to become an international model for a long-term sustainable electricity power system.
Methodology	<p>The pilot tests include different types of: Grid tariffs, Price models of electricity, and Personal energy efficiency advice. Other smart grid concepts (technologies) that will be tested differently in each pilot test are: Direct steering of water heater; Direct steering of electricity heating; Visualization on pc or display; Price signals and prognosis; Comparing with neighbours; Participate in web competitions. A total number of 11500 private households are planned to be included in total in the pilot tests.</p> <p>The Smart Grid Gotland project constitutes of:</p> <ul style="list-style-type: none"> • •Energy Storage will be one important part in a system actively balancing the local production, typically wind generation, and local loads. The so called Demand Response where active consumers respond to a situation where production is low and price increases needs systems to support this. • Introduce and test possibilities for consumers to actively participate in demand respond activities to balance the intermittency of the RES generation by utilising the flexibility of consumer consumption and demand by providing novel technology metering, energy management facilities, load control via aggregators, utilise advanced tariffs, charging of EV/PHEVs and improve in-house RES generation.

Table 3: Overview design of market tests – Private

	Direct heating		Waterborne electric heating	
	Pilot A Blåeldsvägen	Pilot B Remaining Gotland	Pilot C Slättergatan	Pilot D Remaining Gotland
Grid tariff ³	Flexible time tariff/ peak power tariff	Flexible time tariff	Flexible time tariff/ peak power tariff	Flexible time tariff
Price model electricity ⁴	Spot-prices/ reinforced price signals	Spot-prices	Spot-prices/ reinforced price signals	Spot-prices
Direct steering water heater ⁵	X	X		
Direct steering electricity heating			X	X
Visualization on pc or display	X	X	X	X
Price signals and prognosis	X	X	X	
Personal energy efficiency advice	Phone, mail and meetings	Phone and mail	Phone, mail and meetings	mail
Compare with neighbours	X		X	
Participate in web competition	X		X	

Figure 2. From cited report

The grid tariffs constructions that have been discussed within the pre-study is a more flexible time tariff, a power tariff and a tariff connected to the wind production. The experience from the Demand based tariff project in Sweden shows that it is very difficult for the customers to understand what a power tariff is. Therefore the flexible time tariff is the alternative that is selected for the main part of the tests. The flexible time tariff has also high prices during the day between 07.00 – 11.00 and 16.00 – 20.00. This tariff has also a bigger difference between high and low price compared to the current time tariff. The current time tariff is described in the appendix.

The methods to study the consumers will be both qualitative and quantitative: ‘Quantitative measurements:

- The energy saving/shifting potential is measured by adding reference groups and historical consumption baselines for comparison.
- The consumption of the customers participating in the market pilots will be compared with their earlier consumption and with consumptions in the reference groups. All values must be corrected with temperature changes between the years.

Qualitative measurements:

- Before the customer gets the invitation to participate in the pilot all offers will be tested in customer focus groups.

	<ul style="list-style-type: none"> The qualitative evaluation will consist of both deep interviews and questionnaire surveys. The first interviews will be conducted after 3 month for a selected part of the participants. That survey can indicate that the customers need more information. After 6 months all participants will have a questionnaire. At the end of the market tests there will be deep interviews, customer focus groups and a survey send out to all participants.'
Results	There are no results from the study available
Additional comments	<p>Quantitative: consumption data; Qualitative: focus groups, interviews and questionnaire surveys</p> <p>Research objectives: Grid tariffs; Price models of electricity; Personal energy efficiency advice; Direct steering of water heater; Direct steering of electricity heating; Visualization on pc or display; Price signals and prognosis; Comparing with neighbours; Participate in web competitions.</p> <p>Consumer roles: The private consumer will become a Procumer</p> <p>The Prosumer is a new role on the market. A Prosumer both produce and consume electricity from micro generation, based on one contract/meter. The Prosumer role will be enabled, if and when the proposal in the net charge directive, which was submitted by the Swedish Energy Markets inspectorate (EI) in November 2010, goes into power.</p> <p>Today, micro generators are required to have one meter/contract for feed in and one contract/meter for consumption, - in practice two different roles. New regulations facilitates for end users to feed in and consume electricity from micro generation, based on one contract/meter, although both generation and consumption is required to be registered.</p>
Sources	<p>GEAB, Vattenfall, ABB, KTH. 'Smart Grid Gotland - Pre-study' - GEAB, Vattenfall, ABB, KTH, August 26, 2011</p> <p>Direct link: http://www.smartgridgotland.se/pdf/sgg_forstudie.pdf (as on 29.11.2013)</p>

Project title	Stockholm Royal seaport
Leading organization or platform	Fortum Distribution AB
Organisation(s) involved	KTH, the City of Stockholm, Ports of Stockholm, Ericsson, Electrolux, Interactive Institute, NCC, HSB, JM, ByggVesta, the Swedish Energy Agency and Vinnova
Website(s)	http://www.stockholmroyalseaport.com/en/
Period	October 2010 - April 30th 2011.
Location, consumer studies	Sweden
Background	The smart grid concept for Stockholm Royal Seaport is developed to enable a future sustainable, robust and effective energy system. In this pre-study the potential positive impact on the targets of the future society and its inhabitants has been assessed.
Research objectives	<p>The overall objective with the project is: 'Stockholm Royal Seaport Innovation (Innovation) is an arena for innovation, learning and collaboration on the theme of sustainable urban development – an arena that brings together companies, academia and the City on various research and development projects that help Stockholm Royal Seaport to meet its ambitious environmental and sustainability targets.'' The aim of the pre study is to describe, in detail, an urban Smart Grid concept including business models, market concepts and technical solutions for a full scale R&D arena in Stockholm Royal Seaport.</p> <p>Specific objectives:</p> <ul style="list-style-type: none"> • Develop use cases, requirement and functional specifications and solutions. Specify research and test scenarios related to the Smart Grid system • Time schedule and cost estimate for the implementation phase • Partners for the implementation phase • How to engage academy and small and medium sized companies in the full scale test'
Methodology	'Stockholm Royal Seaport is a city development project with the ambition to be a world class sustainable city project with international visibility by partnering with the Clinton Climate Initiative and others global climate initiative. The project started in 2010 and will be completed in 2025. The area includes approximately 10 000 apartments and 30 000 workplaces and required infrastructure'
Results	<p>The findings are:</p> <ul style="list-style-type: none"> • 'There is a strong support in the pre-study for the creation of an Urban Smart Grid pilot in SRS focused on the proposed business and market models, technical solutions with the ambition to create a general solution that shall be easily adaptable in other areas with

	<p>similar ambitions.</p> <ul style="list-style-type: none"> • The Stockholm Royal Seaport is a strong enabler of, and catalyst for, world-class research in Smart Electricity grids and Sustainable Cities. The SRS pilot enables research by providing a forum for industry-academia-public sector collaboration in which research ideas are born and developed into scientifically viable, yet industrially relevant R&D projects. • A successful pilot with long lasting sustainable solutions will require a broad participation of major stakeholders representing different parts of the value chain..... • Thematic workshops with broad participation of external stakeholders on domain width subjects of market models and cyber security revealed a need to establish Forum to discuss and share experience with objective to establish common understanding and suggest improvement and find best practice of implementation. • The proposed concepts including supporting market framework is fully applicable to Nordic electricity market conditions and with adaptations, mainly in the supporting market models, to the broader international electricity market. • A proactive approach towards communication to and dialogue with external stakeholders and public are essential for the pilot to get maximum impact for the society. •/ <p>'The concept would integrate (the future pilot project, the output of this investigation) the output from hydro power plants as well as remote wind power plants with the demand and generation could consist of the following components:</p> <ol style="list-style-type: none"> a) Local biomass power plant b) Smart homes/buildings and demand response c) Distributed energy systems (micro PV, wind, CHP etc) d) Integration and use of electric vehicles e) Energy storage for customers and the grid (batteries and dedicated storage mediums) f) Heat pumps for district heating and district cooling g) Hydro power plants h) Wind power plants i) Ferries and cruise liners plugged in the port'
Additional comments	-
Sources	<p>Report: Stockholm Royal Seaport- Urban Smart Grid- Pre-Study, 30 april 2011</p> <p>Direct link: http://www.energimyndigheten.se/Global/Forskning/Kraft/NDS%20f%C3%B6rstudie%20ENG%20final%20_public.pdf (as on 29.11.2013)</p>

