The Impact of Electricity Markets on Consumers

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International Energy Agency Demand-Side Management Programme
Task 23: The Role of the Demand Side in Delivering Effective Smart Grids

Participants

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Swedish Energy Agency, Sweden

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Summary

This Report represents the first step towards understanding the extent to which consumers might be motivated to actively engage in Smart Grids. It underlines the importance of the electricity market structure on the role of consumers in delivering effective Smart Grids. The aspects that have a direct influence on willingness and ability to play an active part in the delivery of Smart Grids are highlighted. This report demonstrates that the impacts on consumer willingness to actively engage in activities to support Smart Grids are wide ranging and to a large extent, poorly understood.

The next step of this Task will focus more closely on consumer interaction with technology, and will consider the appropriateness of selected technologies, both from the consumer perspective and the Smart Grid industry perspective.

Glossary

AMS	Advanced Metering System
CHP	Combined Heat and Power
CPP	Critical Peak Pricing
DCC	Data Collection Company
DECC	Department of Energy and Climate Change (UK)
ENARD	IEA Implementing Agreement on Electricity Networks Analysis, Research and Development
EV	Electric Vehicle
ICT	Information and Communication Technology
IHD	In Home Display
ISGAN	The IEA Implementing Agreement for a Co-Operative Programme on Smart Grids (aka International Smart Grid Action Network)
PV	Photovoltaic
RTP	Real Time Pricing
SSEG	Small Scale Embedded Generation
ToU	Time of Use
TSO	Transmission System Operator

Currency Exchange Rates

		€
1	NOK	0.134712
1	SEK	0.117875
1	GBP	1.251384
1	KRW	0.000687

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Contents

1 Introduction

The current pace of change within the electricity supply industry worldwide is unprecedented. The wide ranging measures being implemented to reduce the emissions of greenhouse gases, particularly the wide-scale deployment of time variable renewable generation, presents a number of challenges in relation to the balance of supply and demand. No longer is it considered viable for electricity to be provided 'on demand' in response to the requirements of end-users. Rather, a co-ordinated approach is required whereby energy production and demand are integrated to ensure the use of renewables can be optimised whilst also minimising the use of fossil fuel fired generation and network infrastructure investment. Such an approach is the essence of the Smart Grid concept.

Whilst there is considerable focus on the technological aspects of delivering Smart Grids, little is understood of the extent to which consumers are willing and able to embrace new technologies and initiatives that enable their use of energy to be actively managed. There is a real risk that if consumers do not adopt new approaches to the way that they consume electricity, Smart Grids may not be able to achieve their full potential.

Therefore, this project has been established within the IEA Demand Side Management Implementing Agreement to focus on investigating the role of consumers in delivering effective Smart Grids[1]. The project is entitled Task 23 – The Role of the Demand Side in Delivering Effective Smart Grids. The aim and objectives of the project are described below.

1.1 Aim, Objectives and Scope

The overall aim of the project is to explore the potential risks and rewards associated with Smart Grids from the perspective of consumers. The project will draw together international experiences and identify best practices to ensure the demand side become an integral component of a successful Smart Grid. By identifying the potential risks and rewards the Task seeks to develop best practice guidelines in order to ensure the demand side contributes to the delivery of effective Smart Grids.

The project focuses on the interaction of policies, technologies and tools with consumers, and examines the impact of these interactions on the effectiveness of Smart Grids, as indicated below.

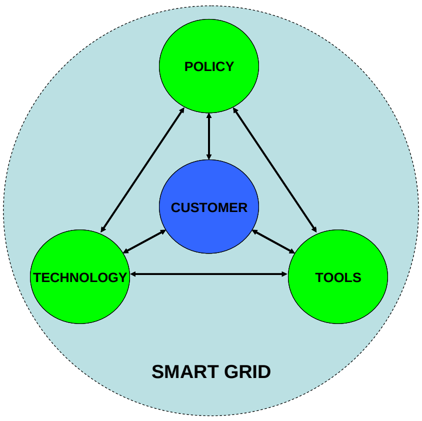

Figure 1.1 Overview of Task 23

[1] An overview of the IEA DSM Implementing Agreement can be found in Appendix 6.

There are a number of examples worldwide of Smart Grid and Smart Metering implementations. These have met with varying success and a number have experienced difficulties as a result of resistance on the part of consumers.

There are also a number of initiatives currently underway that focus on Smart Grids and Smart Metering. Examples include ISGAN[2] and other IEA activities, as well as country specific work such as US Department of Energy funded trials, and the Low Carbon Network Fund in the UK. These trials and initiatives are primarily focused on the technical aspects of Smart Grids, both in terms of the technology requirements needed for implementation as well as the policy measures required to facilitate the roll-out of Smart Metering. The present Task however specifically focusses on the customer perspective, rather than the more technological aspects.

Specific objectives of Task 23 are therefore to:

- Understand the impact of the structure of energy markets on the interactions of consumers with Smart Grids;
- Explore the impact of technologies on the ability and willingness of consumers to contribute towards the successful implementation of Smart Grids;
- Identify the risks and rewards associated with Smart Grids from the perspective of consumers;
- Understand the opportunity for stakeholders to influence these risks and rewards;
- Identify tools to minimise the risks and maximise the rewards associated with the Smart Grid from the point of view of the consumer, whilst still satisfying the needs of other stakeholders;
- Understand consumer reactions and preferences to offers and opportunities that a Smart Grid might provide (including local supply); and
- Understand regulatory options, practice and consequences.

The scope of the project is limited to those who are or are expected to be a participant of a Smart Grid initiative. Specifically, the scope of Task 23 will focus on consumers with Smart Meters or likely to have Smart Meters in the coming years, thus are expected to play an important part in the future Smart Grids as they become deployed. This therefore includes:

- Residential consumers; and
- Small commercial, business and local authority consumers, i.e. those that are treated in a similar way to residential consumers (for example have similar metering arrangements, or have similar access to the energy market).

[2] The IEA Implementing Agreement for a Co-Operative Programme on Smart Grids (ISGAN), http://www.iea-isgan.org/

1.2 Task 23 Work Plan

Task 23 comprises five Subtasks, as highlighted below. This report focusses only on Subtask 1 (ST1 in Figure 1.2 below), and considers the contextual framework within which Smart Grids exist, i.e. the electricity market as the fundamental system within which Smart Grids will have to develop.

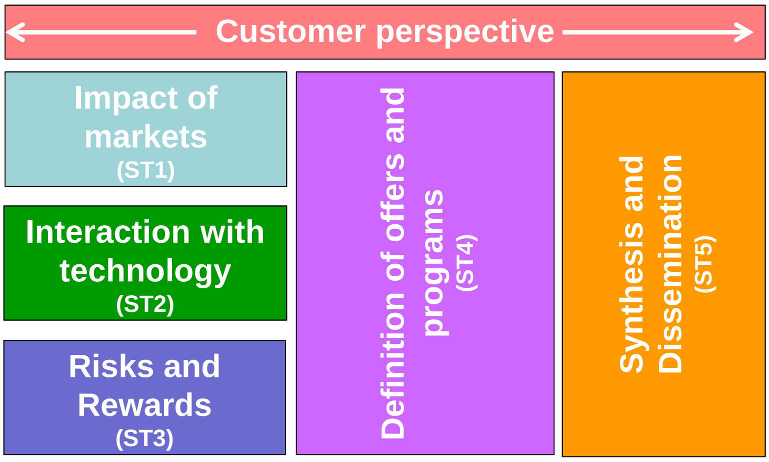

Figure 1.2 Task 23 Overall Work Programme

1.3 Report structure

This report focuses specifically on the impact of the electricity market on consumer behaviour. The term "market" is addressed as a wide concept, including not just price formation and actors, but also regulatory mechanisms and structural issues. The analysis describes *who* the market stakeholders are, *why* consumer engagement in Smart Grids is important to them, and how the electricity market impacts on *what* initiatives can be implemented. The report is structured as follows:

- Section 2 provides an introduction to understanding customer energy behaviours and introduces a 5 Ws framework (Who, Why, What, Where and When) which is used in this report to explore the contextual framework within which Smart Grids exist.
- Section 3 considers the various definitions of Smart Grids and Smart Meters which are taken into consideration for the delivery of this Task.
- Section 4 provides an overview of the main electricity market stakeholders in the participating countries. It provides a description of their roles and responsibilities, and considers how the overall structure of the market impacts on consumers.
- Section 5 compares the drivers for Smart Grids in the participating countries, whilst Section 6 considers how the approach to Smart Metering impacts on consumers.
- Section 7 discusses how tariffs can motivate consumers to change the way they consume energy, and how different approaches to tariff setting impacts on consumers. A comparison of tariffs in the participating countries is also presented.
- The way that electricity trades are treated on the wholesale market (settlement) is discussed in Section 8, whilst other issues that may be relevant are highlighted in Section 9.
- A high level summary of the issues raised throughout this report is provided in Section 10 whilst the next steps in Task 23 are outlined in Section 11.
- The Appendix contains the National Reports prepared by the Participants, which provide the background information upon which this report has been compiled.

2 Understanding consumer behaviour

The factors that impact on the way that consumers behave are wide-ranging and complex. A number of models or frameworks of understanding exist and these have been used with varying success in an array of situations. Some focus on individuals, whilst others focus on the individual in his/her social environment. Some focus only on behaviour whilst others also focus on the context impacting that behaviour. Some focus on one-off behaviours whilst others focus on habitual behaviours. Where some focus on discrete actions, others focus on a complex inter-related set of actions.

Task 24[3] of the IEA DSM Implementing Agreement is focussed on creating a better understanding of how models of understanding behavioural change can be used by policy makers and practitioners in the context of Demand Side Management. The Task is exploring how a wide range of models have been used in a number of energy related case studies in different countries. Task 24 is still in its early stages, but early conclusions suggest that there is no single model or framework that is best suited to understanding a particular facet of energy end use behaviour. Rather, there are a range of possible models and frameworks, each with their own particular strengths and weaknesses and a particular fit with certain contexts.

Whilst no single model or framework is considered to be ideal, they are considered to be necessary tools to assist decision makers implement policies and practitioners implement technologies and initiatives to help achieve an outcome that depends upon behaviour change. The Smart Grid technology achieves energy efficiency (or savings) by enabling or stimulating certain energy behaviours. It is necessary to base an analysis of behavioural aspects of Smart Grid technology on the identification of these behaviours. A definition of a behaviour can be done by considering the following elements:

- the 'actor'/decision maker who decides/acts/performs the behaviour (in this context this would be the consumer);
- a well-defined outcome or action (i.e. switching off lights, buying low energy light bulbs, reducing the indoor temperature or deciding when to use the washing machine)';
- a goal or object (within the home, the office or whilst driving);
- a point in time or a 'time period'; and
- a specific context, where relevant.

Once the behaviour is well defined, a behavioural model can be used to help explain the factors that influence the decision maker's choice over whether or not to perform the behaviour. It is always the individual who makes the decision and performs the behaviour. The fundamental academic debate – as indicated above – is whether this choice is best understood by studying characteristics of the decision maker (individualistic approach) or by studying the physical, social and political context within which the decision is made (system approach). Some energy behaviours may be best discussed within the individualistic approach, while others are best understood within the system approach. The starting point for the present Task 23 is that valuable insights can be found within both approaches, and therefore the following model is suggested as theoretical guidance for this Task[4],[5].

[3] IEA DSM Implementing Agreement, Task 24, Closing the loop - Behaviour change in DSM, from theory to policies and practice

[4] Predicting and Changing Behaviour: The Reasoned Action Approach; M. Fishbein, and I. Ajzen;: Psychology Press, New York; 2010

[5] Nothing is as practical as a good theory. Analysis of theories and a tool for developing interventions to influence energy-related behaviour; C. Egmond and R. Bruel; SenterNovem; 2007

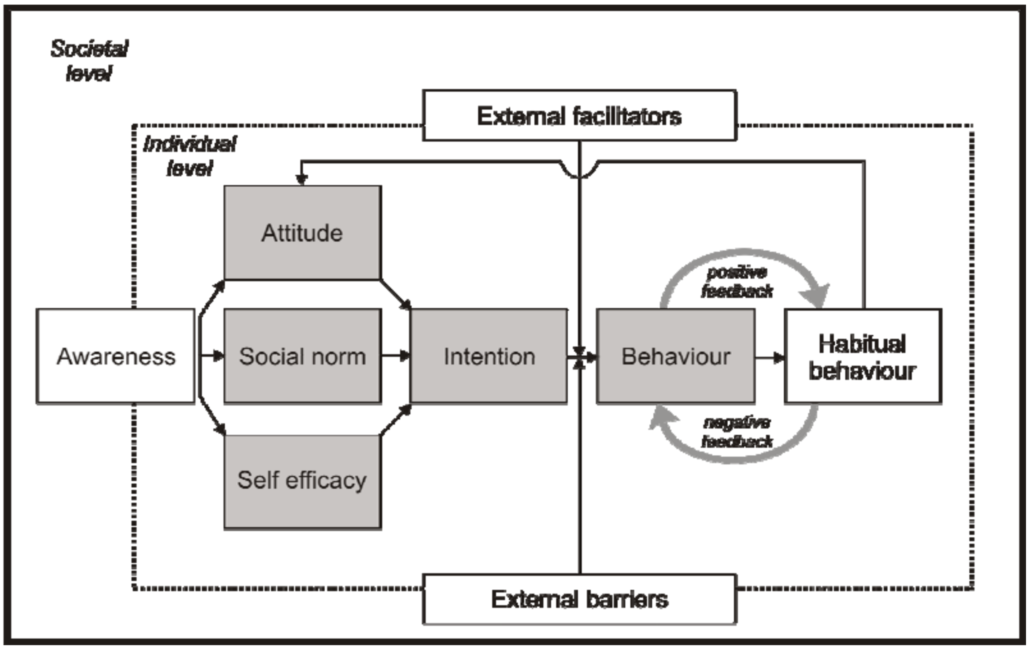

Figure 2.1 Theoretical model of energy behaviour[6]

It is acknowledged that this very brief discussion is on the border of oversimplifying a very complex issue. However, the model illustrates the central elements of "energy behaviour" and as such it is believed that will serve as useful guidance for the structuring of this Task.

This report considers the contextual framework for understanding the potential role of customers in delivering Smart Grids. This corresponds to the system (or societal) level of the model. More concretely, the analysis focuses on the electricity market as the fundamental system within which Smart Grids will have to develop. The next stage of the Task will then move to focus more on the individual level of the model.

The model specifies that there exists, in general, a societal level that must be understood in order to understand consumer energy behaviour. The model does not imply concrete hypotheses or methods in order to approach this concept. We therefore need to find a suitable methodological framework to facilitate this analysis. This framework should be useful in supporting an analysis of the impact of the roles and responsibilities of different market stakeholders and the overarching market structure on customers. It is not within the scope (nor the capabilities) of Task 23 to identify which approach would be best suited to this purpose, therefore a simple and straightforward framework has been selected. This is not because it is considered to be better than other potential frameworks or approaches, but because it is considered to be simple, and sufficiently robust for this Task.

The framework selected here is referred to as the ‘5 Ws’, i.e. Who, Why, What, When and Where, as depicted in Figure 2.2.

6 Understanding Household Energy Use Investment Decisions, Even Bjørnstad, Enova SF, Energy Efficiency and Behaviour Conference, Helsinki, 20 September 2012

Figure 2.2 The 5 Ws Framework

The 5 Ws framework provides a useful tool to do this within the context of Task 23, as outlined in Table 2.1.

This report focuses specifically on three of these dimensions; it describes **Who** the market stakeholders are and **Why** consumer engagement in Smart Grids is important to them, and how the electricity market impacts on **What** initiatives can be implemented.

The next phase of the project (Subtask 2), will consider the interaction of consumers with technologies and other Smart Grid initiatives. It is envisaged that this analysis will focus more on the behavioural choices of customers at the individual level, and for this it is envisaged that the behavioural model presented in Figure 2.1 will be useful to help explain which factors influence the consumer's choice whether or not to perform a particular energy behaviour.

Table 2.1 Description of the 5 Ws in the context of Task 23

Who	This identifies who is involved in the implementation of Smart Grids. It also defines their role and their position in the network of involved stakeholders. This includes implementers (i.e. Energy Suppliers, Network Companies, Demand Aggregators, Energy Service Companies), and the 'target' consumers either as individuals or as a group. It also includes facilitators such as Technology Developers and Appliance Manufacturers as well as other stakeholders who have a direct interest in the successful delivering of Smart Grids, such as Government.
Why	This characterises the impact of the desired outcome (the end for which the means are used) on the realisation of Smart Grids, both from the perspective of the implementer and from the perspective of the consumer. It also focuses on potential issues around benefits and costs and issues of short and long term impacts. Furthermore it focuses on the motivations for different stakeholders to react to policies/technologies and or interventions. Within the context of Task 23, desired outcomes from the implementer's perspective relate to those that are compatible with successful Smart Grids. The impact of desired outcome from the consumer outcome could vary from financial motivation, environmental motivation or social 'norms'.
What	This describes the technologies, policies and intervention(s) implemented (or being considered) in order to achieve the desired outcome. In the context of Task 23 this includes initiatives such as time of use pricing, direct and automatic load control, feedback of energy use information, advice or any combination of these interventions. This includes the actual response and or behaviour that the end-users are demonstrating in reaction to the technology, policies and interventions, i.e. so what exactly did the consumers do (adopt, reject, alter, accept etc.).
When	This includes the time related aspects of the initiative, such as: - when it is put in place and for how long ; - at what times or periods is it delivered; - the length of time before consumers deliver an outcome; and - for how long the outcome is sustained.
Where	This defines the location of the intervention, both in terms of the system as well as in terms of the location in the home (feedback can be provided in different rooms, and a virtual power plant is virtual. In the case of Distribution Network Companies the location of demand response will be very important, as it will need to be located on the constrained part of the network. This is unlikely to be the case Supplier or Transmission System Operator (TSO) led Demand Response.

3 Smart Grid and Smart Meter definitions

In order to understand the role which consumers play in developing a Smart Grid it is first necessary to develop a shared understanding of the concept of a 'Smart Grid'. It is not within the scope of this Task to develop a new definition of a Smart Grid, and the discussion which follows aims to combine existing definitions in order to meet the needs of the current Task. Similarly, the use of Smart Meters and how consumers interact with these is likely to be of importance to the Task and it is necessary to have a shared understanding of the features which constitute a 'Smart Meter'. This section therefore considers the range of Smart Grid and Smart Meter definitions that need to be accommodated within the scope of Task 23.

3.1.1 Smart Grid definitions

A large number of definitions are available from a number of organisations worldwide, and a sample of these are summarised below.

- European Technology Platform[7]: "an electricity network that can intelligently integrate the actions of all users connected to it – generators, consumers and those that do both – in order to efficiently deliver sustainable, economic and secure electricity supplies. A Smart Grid employs innovative products and services together with intelligent monitoring, control, communication, and self-healing technologies to:
  - better facilitate the connection and operation of generators of all sizes and technologies;
  - allow consumers to play a part in optimizing the operation of the system;
  - provide consumers with greater information and choice of supply;
  - significantly reduce the environmental impact of the whole electricity supply system;
  - deliver enhanced levels of reliability and security of supply.

  Smart Grids deployment must include not only technology, market and commercial considerations, environmental impact, regulatory framework, standardization usage, ICT (Information & Communication Technology) and migration strategy but also societal requirements and governmental edicts."

- US Energy Independence and Security Act (2007): "The goal is to use advanced, information based technologies to increase power grid efficiency, reliability, and flexibility and reduce the rate at which additional utility infrastructure needs to be built."
- UK Department of Energy and Climate Change (DECC): "A Smart Grid is likely to have the following characteristics[8],[9]:
  - Observable: ability to view wide range of operational indicators in real time;
  - Controllable: ability to manage and optimise the power system to a far greater extent than today;
  - Automated: ability of the network to make certain demand response decisions; and
  - Fully integrated: integrated and compatible with existing systems."

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[7] http://www.smartgrids.eu/documents/SmartGrids_SDD_FINAL_APRIL2010.pdf Accessed 28/08/0212
[8] Smarter Grids: The Opportunity, DECC, December 2009
[9] Definition also used by the UK Smart Grid Forum, established by DECC and Ofgem

- IEA Smart Grid Roadmap (2011)[10]: "A Smart Grid is an electricity network that uses digital and other advanced technologies to monitor and manage the transport of electricity from all generation sources to meet the varying electricity demands of end-users. Smart Grids co-ordinate the needs and capabilities of all generators, grid operators, end-users and electricity market stakeholders to operate all parts of the system as efficiently as possible, minimising costs and environmental impacts while maximising system reliability, resilience and stability."
- Korean Smart Grid Institute: "A Smart Grid refers to a next-generation network that integrates information technology (Smart) into the existing power grid (Grid) to optimise energy efficiency through a two-way exchange of electricity information between suppliers and consumers in real-time. Building a Smart Grid can induce reasonable energy consumption, enable the provision of high-quality energy, and provide a wide array of added services. Since Smart Grids are open systems, it is more feasible to incorporate into them clean, green technologies such as renewable energy and electric vehicles."[11]

It is not the purpose of this project to determine an appropriate 'one-size-fits-all' Smart Grid definition. Rather it is necessary to be able to ensure that the work of this project, as far as is practicable, encompasses all Smart Grid definitions. Thus, the following highlights the common elements in the various definitions which are of relevance to Task 23.

[10] http://www.iea.org/papers/2011/smartgrids_roadmap.pdf Accessed 24/08/2012
[11] Korea's Smart Grid Roadmap 2030. Korean Smart Grid Institute. Available from: http://www.smartgrid.or.kr/10eng4-3.php Accessed 28/08/2012

Table 3.1 Comparison of different Smart Grid definitions

	Element	Definitions: European Technology Platform	US Energy Independence and Security Act	UK DECC	IEA Smart Grid Roadmap	Korean Smart Grid Institute
Common Elements	Combining the actions of all users	✓	×	✓	✓	✓
Common Elements	Sustainability/ Minimising environmental impact	✓	×	×	✓	✓
Common Elements	Ability of Smart Grid to make decisions	✓	×	✓	✓	×
Common Elements	Explicit reference to consumers/ end users	✓	×	×	✓	✓
Common Elements	Increasing efficiency	✓	✓	×	✓	✓
Common Elements	Provision of information/ monitoring	✓	✓	✓	×	✓
Common Elements	Improving system reliability/ resilience	✓	✓	×	✓	×
Additional Elements:		• Facilitating the connection of generators of varying sizes • Allow consumers to play a part in the system • Provide consumers with greater information and choice • Consideration of societal impacts is required	• Reduce the rate at which additional infrastruct-ure is required	• Greater ability to manage the power system through control • Automated demand response decisions • Can be integrated with existing systems	• Monitoring and managing transport of generation to meet varying electricity demands	• Inducing “reason-able energy consump tion”

The characteristics most associated with the Smart Grid definitions highlighted above are “the combination of actions from a number of stakeholders” (although in one case without an explicit reference to consumers) and the use of the Smart Grid to increase efficiency.

The European Technology Platform and IEA Smart Grid Roadmaps include the greatest number of the common elements each (7 of 7 and 6 of 7 respectively). The European Technology Platform puts a greater importance on the inclusion of consumers and their role, which is the focus of the current task. It is therefore proposed that the European Technology Platform definition is used, with a minor addition from the Korean Smart Grid Institute definition to reflect the real-time nature of Smart Grid systems, resulting in the following:

> A Smart Grid is an electricity network that can intelligently integrate the actions of all users connected to it in real time– generators, consumers and those that do both – in order to efficiently deliver sustainable, economic and secure electricity supplies. A Smart Grid employs innovative products and services together with intelligent monitoring, control, communication, and self-healing technologies to:

- better facilitate the connection and operation of generators of all sizes and technologies;
- allow consumers to play a part in optimizing the operation of the system;
- provide consumers with greater information and choice of supply;
- significantly reduce the environmental impact of the whole electricity supply system;
- deliver enhanced levels of reliability and security of supply.

Smart Grid deployment must include not only technology, environmental impact, regulatory framework, standardization usage, ICT, migration strategy and market and commercial considerations but also societal requirements and governmental edicts."

3.1.2 Smart Metering definitions

Smart Metering is one of the key technologies to facilitate the move to Smart Grids. The way that consumers interact with Smart Meters is considered in Subtask 2. This Section therefore compares definitions for Smart Meters, of which several exist. These typically focus on the specific functionalities of the Smart Meter, many of which are not relevant for the current task. The European Smart Metering Alliance suggests that Smart Metering has the following features[12]:

- Automatic processing, transfer, management and utilisation of metering data
- Automatic management of meters;
- 2-way data communications with meters;
- Provides meaningful and timely consumption information to the relevant actors and their systems, including the energy consumer;
- Supports services that improve the energy efficiency of the energy consumption and the energy system (generation[13], transmission, distribution and especially end-use).

Definitions used within each of the Participating Countries have been provided in various formats and levels of detail within each National Expert's Subtask 1 report. The functionalities/ characteristics included within these definitions are compared in the following table.

[12] http://www.esma-home.eu/UserFiles/file/downloads/Final_reports/ESMA_WP2D3_Definition_of%20Smart_metering_and_Benefits_v1_1.pdf Accessed 07/09/2012

[13] Generation includes centralised generation based on all forms of primary energy resources, including renewables and also localised generation either located at the end-user or connected to the distribution network

Table 3.2 Comparison of different Electricity Smart Metering functionality

	Netherlands	Norway	South Korea	Sweden	UK
Measurement of energy import	✓	✓	✓	✓	✓
Measurement of energy export	✓	✓	✓	✓	✓
Ability to upload tariff information	✓	✓	✓		✓
Transmission/ recording of data in hourly (or sub-hourly) intervals)	✓ (15 minute interval)	✓ (maximum of 60 minutes, possibility of setting to 15 minutes)	✓ (15 minute interval)	✓	✓
Measure quality of supply (e.g. power factor)	✓ (to a certain extent)	✓	✓	✓	✓
Fraud detection	✓	✓	✓ (also, protection against theft and damage)	✓	✓
Remote disruption/ reconnection of supply	✓	✓	✓	✓	✓
Communication with other meters	✓	✓	✓		✓
Communication with other equipment	✓ (one way)	✓	✓ (communication via open standard)	✓	✓
Storage of data	✓	✓	✓	✓	✓
Measurement of power	✓		✓ (including peak demand)	✓	✓
Remote updating of meter (e.g. time updates)	✓		✓	✓	✓

The characteristics above represent some of the basic or 'core' functionalities of smart meters, including

- Transmission / recording of data in hourly (or sub-hourly) intervals.
- *Storage of data (allowing access by the consumer to review his/her consumption).*
- *Measurement of quality of supply;*
- *Fraud detection;*
- *Remote disruption/ reconnection of supply; and*
- *Remote updating of tariff information;*

These features are broadly similar to those set out in the European Smart Metering Alliance definition set out above.

4 Stakeholder Roles and Responsibilities

This Section describes the roles and responsibilities of the market stakeholders and their impact on consumers, i.e. it identifies **Who** is involved in the implementation of Smart Grids (see the 5 Ws framework in Section 2).

This Section 4.1 lists the stakeholders in each of the participating countries and describes their roles and responsibilities, and describes if and **Why** smart grid initiatives are relevant to them. Section 4.2 then considers the impact of the market structure (particularly in terms of unbundling and the development of competition) on consumers.

4.1 Overview of market roles and responsibilities

There is a wide range of stakeholders in the electricity market. This includes those directly involved in generation, transport, metering and electricity retail, as well as the consumers themselves. There are also myriad other organisations, including those involved in regulation / policy setting, service providers and appliance / device manufacturers.

Table 4.1 provides an overview of the main stakeholders in each of the participating countries. The information is collated from a series of National Reports provided by the National Representatives from each of the participating countries. Copies of these are found in the Appendix.

Table 4.1 Overview of electricity market stakeholders – roles and responsibilities

Activity / Area		Netherlands	Norway	South Korea	Sweden	GB
Generation	Number	There are currently 5 large generating companies, with various other small companies.	There are currently 208 licensed generating companies.	There are 6 major generation subsidiaries, all of which are owned by KEPCO. Their total installed capacity, around 68.6GW, represents around 84% of the total installed capacity.	3 companies own the majority of the generation power plants. In addition, there are a number of medium sized and smaller actors (CHP, small hydro, wind)	There are over 100 generation licensees, with six companies accounting for over 70% of the market.
	Fuel mix	Electricity generation is dominated by gas and coal, but renewable sources are becoming increasingly important.	Generation is dominated by hydropower plant, with water outflow rights typically leased from reservoirs - main responsibility is to manage water resource. Smaller hydropower plant and wind resources are beginning to enter the market.	5 of the 6 main generation companies are based on coal or natural gas. The remaining is nuclear. Most of hydro plants are owned by a nuclear generation company.	Electricity generation is dominated by nuclear and hydro plant, with renewables (e.g. wind) becoming increasingly important. Fossil fuel accounts for a very small proportion of electricity generation (less than 3%).	Electricity generation is dominated by gas (40%) and coal (30%), with nuclear also accounting for a sizeable portion (19%). Renewable sources are becoming increasingly important.
Transmission		Single entity that owns, develops and operates the single transmission network grid.	Single entity that owns, develops and operates the single transmission network grid.	Transmission division of KEPCO(*) that owns, develops the single transmission network grid. KPX, an independent power system operator manages the national power networks.	Single entity that owns, develops and operates the single transmission network grid.	Owned by three companies (one in England and Wales, and two in Scotland). The three sections of the GB Transmission network are operated as a single system by National Grid.
Distribution	Number	~ 8	220 in total, of which: - 70 are regional companies (transporting power within the different regions) - 150 local companies (transporting power to end users)	Distribution division of KEPCO, which owns transmission and distribution assets and retail business.	~ 190, where the majority are small municipally owned companies and some are larger privately owned companies	14 regional Distribution networks, operated by 7 Distribution Network Operators (DNOs).

Activity / Area		Netherlands	Norway	South Korea	Sweden	GB
Metering	Who	Distribution network company	Distribution network company	Distribution division of KEPCO	Distribution network company	Supply company
	Regulation	Regulated	Regulated	Regulated	Regulated	Competitive
Energy Retail	Regulation	Fully deregulated	Fully deregulated	Regulated	Fully deregulated	Fully deregulated
	Number	~ 35 licensed retailers	Around 200	Electricity retail is dominated by KEPCO, which has a market share of 99%. There are around 16 Community Energy Suppliers that are small vertically integrated organisation that provide electricity in a franchise area.	~175	~100, although the market is dominated by six retailers
Energy Billing		Optional (currently) - integrated bill from Retailer or two separate bills (Network Company / Energy Retailer) 2013 onwards: - integrated bill from energy supplier only	Two separate bills: - Distribution network company (for network charges) - Energy Retailer (for energy consumption)	One integrated energy bill from the vertically integrated utility, KEPCO	Two separate bills: - Distribution network company (for network charges) - Energy Retailer (for energy consumption)	One bill from the Energy Supplier

(*) Korea operates a wholesale electricity market in the generation sector in the form of compulsory pool. Although 6 major generation subsidiaries are owned by KEPCO, they are allowed a complete management independence from the government based on the “Act on the Management of Public Organization.” Therefore, KEPCO doesn’t have a generation business licence. In addition, KEPCO has separate licences for transmission, distribution, and retail by the Electricity Business Act.

4.2 Unbundling and competition: the impact on consumers

Whilst there is an increasing move towards the unbundling of monopoly network activities from the competitive activities of supply and generation, not all electricity markets are fully unbundled. For example, South Korea has a monopoly in place that has responsibility for the generation, transmission and supply of electricity to almost all consumers in South Korea. However, as stipulated by the European Union's Third Energy Package, electricity activities in Netherlands, Norway and Sweden are now fully unbundled with fully competitive retail markets.

A market that is not fully unbundled makes it difficult for new entrants to enter the market and offer innovative new products and services to consumers, thus limiting choice to consumers. Similarly, a retail monopoly may have little incentive to provide increased choices to consumers, for example due to concerns over ensuring they can maintain their allowed level of regulatory return. They may also have little or no flexibility over the way tariffs are structured, and changing tariff structures may be difficult. Such issues are pertinent in South Korea.

A market that is not fully unbundled and without effective competition does not necessarily imply there is little or no scope for consumers to actively participate in Smart Grids. There are many examples of consumers actively participating in demand side management programmes for vertically integrated monopoly utilities. One such example is the PowerSave project conducted in Anglesey, a small island off the coast of North Wales in the early 1990s. The project predated the unbundling of the electricity industry in the UK. The electricity utility at the time (Manweb) identified a need to replace a transformer at a cost of some £850k. In order to avoid this expenditure, a project was established to provide energy efficiency measures to households on the island.

The project was successful and, to the author's knowledge, the network reinforcement on the island was successfully deferred. Although not specifically a Smart Grid issue, it does highlight an example of a vertically integrated utility successfully engaging with consumers to deliver peak load reduction.

However, whilst the lack of competition is generally regarded to be a barrier to the introduction of new innovative products[14], including those relating to Demand Side Management and Integrated Resource Planning, there are specific aspects of a fully unbundled market that make it more difficult for consumers to become active participants in the implementation of Smart Grids. These are discussed below.

Broken value chain

In an unbundled electricity market, the value chain for demand side management products and services is '*broken*', i.e. the benefits of particular actions are distributed amongst a number of disparate stakeholders. For example, demand side management actions to reduce peak demand impact both on suppliers (who need to purchase less electricity at the peak) and network operators (who may be able to defer or avoid investment in network assets). The possibilities for ensuring the costs and benefits are allocated appropriately are not well defined. For example, most demand response products are generally procured using bilateral contracts between a 'buyer' and a 'seller'. There are examples where demand aggregators combine resources from a number of 'sellers', but typically there is a bilateral agreement in place between the aggregator and the 'buyer'.

[14] For example, see Sanya Carley; Historical Analysis of U.S. Electricity Markets: Reassessing Carbon Lock-In; Energy Policy; Vol. 39; No. 2, pp. 720-732, 2011

In general, the market mapping exercise conducted by each of the participating countries demonstrates unbundled electricity markets do not provide for a co-ordinated approach for the supply of and demand for demand side management services and products. This issue has been highlighted by a number of the DNOs in GB, and one submitted a proposal for funding for a £28m project to develop a market platform for the trading of DSR services[15]. The proposal was not successful, but it is understood that the UK TSO is now in dialogue with UK DNOs to further consider the opportunities. Due to the islanded nature of GB, there is a requirement for balancing services to maintain system frequency within prescribed limits that is more onerous than that for countries on mainland Europe. As a result, the TSO in GB places a very high value on resources used to maintain the quality of supply at or close to real time. Many consumers that are able and willing to provide demand response resource are already contracted to the TSO, and experience from the projects conducted under the Low Carbon Network Fund shows that it is difficult for DNOs to access this resource. In particular, there is no possibility for the TSO and a DNO to **share** a common resource. For example, a DNO's requirement is generally limited to certain times of the day or the year (e.g. early evening in the winter) or only in the event of a network fault. The resources required by a DNO are location specific which is not the case for TSO resource requirement. The TSO typically secures more resource than required, paying only where resources are utilised, i.e. resources are not fully utilised. Therefore, it is likely that the possibility exists for the TSO to select from multiple, alternative resources when a 'TSO' event occurs, allowing the DNO to access the resources it requires during agreed times. Thus, a single consumer could potentially provide resource to more than one organisation, although not simultaneously.

Consumer understanding of market stakeholder roles

There are many stakeholders in the energy market, each having specific roles and responsibilities. These differing roles and responsibilities are not necessarily well understood by consumers, and thus it may not be a straightforward process for consumers to be able to define the impact of their energy end use on the different stakeholders. For example, consumers may not understand the significance of the pattern of their electricity consumption on the local network company (or indeed have an awareness of their local network company and its responsibilities).

For example, Ofgem's Consumer Panel gauged consumer understanding and interest in the Distribution Network Operators in GB[16], and explored what, if any, information the consumers were interested in receiving on the performance of DNOs. Despite having had explanations on the existence and role of DNOs in a previous meeting, there was very low spontaneous recall from the panel members. More poignantly, there was little interest in receiving any information. This is despite the fact that network charges currently account for around 19% of the total electricity costs[17].

This could be particularly an issue where integrated bills are sent to end use consumers, as is the case in the UK, Korea and from 2013 the Netherlands. In Norway and Sweden, consumers are sent separate bills from their energy supplier and energy network operator.

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[15] The GB Flexibility Market, Low Carbon Networks Fund Screening Submission Northern Power Grid, accessible via www.ofgem.gov.uk

[16] Ofgem Consumer First Panel – 2009/2010, Findings from third workshops (held in March 2010), published May 2010, accessible via www.ofgem.gov.uk

[17] Electricity and Gas Supply Market Report Report, Ofgem, Reference 176/11, December 2011

Too much consumer choice

The increasing move towards competition in electricity supply means more choice for consumers who can (in theory at least) choose when to purchase, how much to purchase and from whom. The need for Electricity Suppliers to retain existing consumers and attract new business ensures they focus on ensuring cost effectiveness and consumer service. This leads to the introduction of innovative and new products and services. However, whilst this is important, it does not always help consumers become active participants. For example, too much choice can make it very difficult for consumers to compare offerings and select the one that is best for them.

Behavioural economic theory by Abbott et al[18] suggests that consumers who are offered an exhaustive variety of options are often paralysed by their inability to choose. This is put down to a number of reasons, including:

- Worry that they may make the wrong choice; and
- Difficulty quantifying the benefits and risks.

A retail market review conducted by GB regulator Ofgem also provides evidence to support the principle that too much choice is not good for consumers. The following is an excerpt from a Consultation Document published in December 2011:

> "At present, many consumers are disengaged from the energy retail market. Of particular concern is the growing complexity of pricing information and the high number of sticky consumers(i). Many consumers who try to switch find it difficult to make a well informed choice, which leads some to switch to more expensive tariffs. In addition, 75 per cent of consumers(ii) are on standard tariffs(iii) which lack any obvious decision or trigger points for engagement"

i Sticky consumers are those consumers that choose not to switch, cannot switch due to their circumstances, or are put off switching due to other features of the market such as tariff complexity. In the March consultation we estimated that around 40-60 per cent of consumers in the energy sector are currently sticky (although we recognise they may have switched in the past) and that vulnerable consumers are likely to be disproportionately represented in this group.

ii DECC (January 2010) „Energy Trends, p. 48 and 49. This figure is the simple average of the percentage of GB gas and electricity consumers on standard tariffs.

iii Standard (or „evergreen) products are those that have no termination date

[18] Predictably Irrational Customers, Optimizing Choices for How People Really Buy, Not How We Think They Buy, Bill Abbott, Alex Mannell, Kyle McNamar, Amaresh Tripathy

5 Drivers for Smart Grids

The drivers for Smart Grids differ from stakeholder to stakeholder, for example, Governments are interested in the successful delivery of Smart Grids as they support energy policy, particularly in terms of the move to decarbonised electricity generation, heating and transport.

Table 5.1 below lists the stakeholders involved in the implementation of Smart Grids, and describes the main drivers for the successful implementation Smart Grid initiatives from their perspective. Using the 5 Ws framework from Section 2. i.e. **Why** Smart Grids are considered a desirable outcome. Although, consumers are the focus of the overall Task, this Report focusses on the impact of the market on consumers, and therefore, consumers and not considered here.

Table 5.1 Overview of electricity market stakeholders and their main drivers (if any) for Smart Grids

Who		Why
Government		Supports the delivery of energy policy – in terms of support for renewable generation, decentralised generation and decarbonisation of heating and transport.
Generators	**Centralised**	Traditionally, generation has been the dominant resource used to maintain electricity supply and generation in balance at all times. As the proportion of generation met by renewable resources increases, this will become increasingly more challenging. The Smart Grid represents an alternative to relying solely on the resources of central generation to balance electricity supply and demand. Thus, centralised generation will have little reason to engage actively in Smart Grids.
	De-centralised	Local generation represents a challenge for the management of distribution networks, particularly where significant flows of locally generated electricity cause local network constraints. However, where the output can be controlled, they also represent a valuable resource to help manage local constraints.
Suppliers / Energy Retail		Electricity wholesale prices could become increasingly peaky, and effective Smart Grids provide the opportunity for demand to be optimised to make best use of the available resources, thus minimising energy costs to the Energy Supplier and reducing risk. Smart Meters also provide Energy Suppliers with the opportunity to provide energy advice and tailored solutions to customers, which could help reduce customer churn.
Distribution Network Companies		De-carbonisation of heating and transport could lead to significant increases in electricity consumption due to growth in heat pumps and electric vehicles. Energy efficiency and actively managing the pattern of demand helps to defer and/or avoid network investment. This could be particularly relevant where the network company is incentivised to reduce the costs associated with network development or faces severe financial or other constraints to network development.
Technology Developers / Appliance Manufacturers		Smart grid and smart metering represent potential new business opportunities for technology developers and appliance manufacturers.
Energy Service Companies		Smart grid and smart metering represent potential new business opportunities for energy service companies to provide who may also be able to offer services or products to help consumers better understand their consumption. Alternatively, they could offer innovate products and solutions based on a detailed understanding of consumer energy consumption.

Section 5 considers the specific drivers for Smart Grids in the countries participating in Task 23, whilst these are summarised and compared in Section 5.2.

5.1 Smart Grid drivers in the participating countries

Norway

In the Norwegian market it is natural to view the development of smart grids as a two stage process.

- A mandatory national roll out of an automatic metering infrastructure, replacing old, mechanical electricity meters with so called smart meters.
- A market based development and deployment of "smart" technologies and services, resulting in a smarter grid.

Consultation papers associated with introducing a mandatory roll out of smart meters in the regulation on electricity metering and billing (FOR-1999-03-11-301) states the main purposes as:

- More accurate billing;
- Provide necessary information to end users for management of their own electricity use; and
- Increase the possibility for network owner to improve network efficiency.

Since Smart Meters are yet not installed in general in the Norwegian market, the concept "Smart Grid" is not commonly known, nor well developed. Public discussion focuses more on Smart Meters than on the concept of Smart Grids, even though a number of local pilot areas for smart grid deployment have been developed.

Circumventing network limitations is one motivation for introducing smart meters and smart grids in Norway. One characteristic of electricity end-use in Norway is that a relatively large share is used for direct space heating in homes and other buildings. This situation has historical reasons, which are not detailed here. As a consequence, a typical Norwegian winter, with periods of cold weather and little inflow to water dams, may imply high strains on the power network. Adding to these seasonal load variations the typical within day peak demands result in peak hours where most of the capacity of the network is used. Finding ways to reduce these loads will increase the security of supply, without having to undertake large network investments, thus is an important strategic driver for smart grids in Norway.

Despite this situation, network companies can hardly be said to be a driving force in introducing a smarter grid. Steps taken by the national regulation authority, influenced by the development on a European level, has until now been the main driving force. The deployment of smart meters is mainly mandated by regulation, with network companies obeying somewhat hesitantly. This hesitancy is not hard to understand; large investments in unknown technologies are involved, technical standards are not well established, which is resulting in a risk linked to being among the "first movers".

The awareness of electricity use and electricity costs is generally low among "ordinary" electricity customers (households, small businesses). Such awareness usually rises during the occasional periods of cold weather, limited supply and high prices; however the general situation is one where the electricity price is relatively low. Some end-users and their interest organisations have shown interest in the smart meter deployment, and also in the smart grid concept, however energy consumers are not regarded a driving force behind smart grid development.

In addition to what is discussed above, the following are also considered drivers for a full-scale roll out of smart metering and development of smart grid:

- Facilitating the integration of distributed renewable energy sources and energy storage
- Improved economic efficiency
- Necessary modernisation of the energy system.

Netherlands

The current Dutch energy infrastructure can be classified as relatively reliable. A total conversion of the current infrastructure into a smarter infrastructure will require large investments in ICT technology and is considered not to be realistic, nor required in the short term. Only in specific cases, where a combination of factors are present, grids in existing neighbourhoods may reach their limits (e.g. large scale implementation of heat pumps).

It is expected that energy will become more scarce and more expensive in the future, and that the share of PV and other intermittent sources will increase, as well as the shares of Electric Vehicles (EVs), heat pumps and potentially micro CHP. However, in order to keep the future supply of energy affordable and reliable, investment choices need to be made: either in grid reinforcement and peak generation capacity, or in adding intelligence to the grid to better match demand and supply at European / national and local level.

Adding intelligence to the grid, enables DR, as well as a better integration of local generation and storage of energy, intelligence increases the flexibility, reduces or postpones infrastructural investments, while at the same time guaranteeing a reliable supply of energy. Smart Grids create new opportunities for (local) energy management. New products and services can be developed to facilitate energy management at dwelling level. Residents may turn from passive users into more 'active' users, or even into ‘prosumers’. However, acceptance will be key to realise these changing roles

The vision of the Dutch 'Taskforce Smart Grids' is that a large scale introduction of Smart Grids is not yet urgent, but cannot be avoided. Given the time horizon for grid investments, the first steps need to be made now. First steps would include small scale activities with real users, to learn, in order to be well-prepared and ready for a fundamental transition.

The Taskforce aims for 50% of the consumers being connected to a smart grid by 2025, at least if the cost benefit analysis is positive. To achieve this goal, as a first step a five year action program has been defined, focusing on the following topics:

- Smart grid pilot projects.
- Regulations
- Standards and interoperability
- Future oriented R&D agenda
- Ecosystems for smart grids
- Global and European agenda.

South Korea

Climate change, energy efficiency and new growth are the main drivers for moving towards the development of Smart Grids in South Korea. These are further discussed below:

- Climate Change: Korea needs to have a green power infrastructure in order to achieve the goal of cutting down carbon emissions by 30% by 2020 compared to the Business as Usual guidelines[19]. In a situation where Korea's greenhouse gas emissions against Gross Domestic Product (GDP) stands at approximately 1.6 times the average emissions of OECD member states, a more green and robust power grid is regarded as the first necessary step for accommodating more renewable power and electric vehicles in the near future. Only with a Smart Grid in place, is it considered that achieving the emission reduction target will be realistic and achievable.

- Energy Efficiency: With the below-cost tariffs, cross-subsidies among electric use categories, and out-dated rate-of-return regulation, waste of electricity has been widespread in South Korea since 1980s. To make matters worse, the end prices of alternative energies such as natural gas and oil are higher than that of electricity. This has devastating effects on the energy efficiency in Korea. Moreover, since the current electricity industry is organised based on the large centralized system, improving energy efficiency has had limited results due to the lack of response from the consumer side. The Smart Grid will be the basic infrastructure for enabling more sophisticated responses from the demand.

- New growth engine: The Smart Grid is the next generation energy infrastructure to connect everything using electricity that has never been linked before. This so-called “fusion industry eco-system” will include almost every key industry and their value chains; internet, telecommunication, construction, home appliance, automobile, battery, new and renewable energy, and electricity. The Smart Grid will be one of the last industries enabling large scale employment.

[19] Green Growth Committee; Nov. 2009

Sweden

The Swedish government has set up a number of goals to be achieved in the energy sector. Many of these goals originate from the EU, but there are also goals showing further ambitions in the energy field. Among the goals set by the Swedish government, the following are of interest:

The new climate and energy policy, based on the EU's 20/20/20 targets, sets a number of targets and strategies for Sweden. These include:

- Sweden's renewable energy share should be at least 50% of the total energy use by 2020. This includes a goal of 30 TWh/yr of wind power.
- The share of renewable energy must, by 2020, constitute at least 10% of the total motor fuel consumption in the transport sector. In addition to this, the long-term aim is for vehicles in Sweden to be independent of fossil fuels by 2030.
- Swedish energy policy has set an overall target of a 20% reduction in energy intensity between the years 2008 and 2020.
- Swedish greenhouse gas emissions are to be reduced by 40% by the year 2020 compared with 1990. This target encompasses activities not included in the EU Emissions Trading System.
- The vision for 2050 is that Sweden should have no net emissions of greenhouse gases into the atmosphere. (See Energy in Sweden: 2011)

The goals of vehicles in Sweden to be "**independent of fossil fuels**" and "no net greenhouse gas emissions" points in the direction of an increase in electricity demand due to the foreseen introduction of electric vehicles (EVs). This will require an increase in installed renewable energy sources in order to reach the goals. There is a large interest in building wind power in Sweden and it is foreseen that the amounts will increase significantly over the coming decades. This will lead to a need for a more flexible system.

Concerning the balance management, the integration of renewable energy sources in the Nordic system should impose fewer challenges than in many other countries and/or areas because of the significant amounts of installed hydropower in the system. The hydropower constitutes a balancing resource that can handle wind power production variations thanks to its flexibility. This means that the technical need for other balancing resources, such as demand side management (DSM), is not as crucial in Sweden or the other Scandinavian countries. However, it is also foreseen that the Nordic system and market will become more integrated with the European system and market by harmonization of market rules and investments in transmission. This will allow the Nordic hydropower to act as a balancing resource in a northern Europe perspective. This means that also in Scandinavia the price differences might increase creating economic incentives for the users to become more flexible and active.

In Sweden, price areas have recently been introduced dividing the country into four different price areas. Since the hydropower production is mainly located in the northern part of the country, and the transmission network has a limited capacity, the prices in the south of Sweden have increased during peak hours some parts of the year. This strengthens the incentives for users in these parts of the country to become active.

Swedish households and small commercial electricity users have today generally a low confidence in the power companies, i.e. power producers, suppliers, distribution companies etc. Surveys have shown that consumers feel that they don't have any possibilities to influence their electricity costs ("we need the energy and only pay the bill") and that they are in the hands of the electricity providers. The possibility to have a greater influence and control of the energy consumption can be a strong driving force for many users to take control over their electricity bills.

Sweden has a long history of electric power equipment industry and telecom industry with companies such as ABB and Ericsson. These industry branches contribute to significant export revenues and are regarded important for the national economy. The introduction of Smart Grids requires new or improved technologies, which can lead to new business opportunities for Swedish companies. Hence, there is a great interest to further explore the opportunities related to Smart Grids from the business point of view.

UK

The UK Government has set a target to reduce carbon emissions by 80% by 2050 compared to 1990 levels. The pathway to achieving these goals has not yet been determined, but decarbonisation of electricity generation is a key component for meeting the target. This will include low carbon centralised generation such as nuclear and fossil fired generation fitted with carbon capture and storage. Renewable energy, particularly wind, will become increasingly important. In addition, more power will be generated locally at a small scale, through renewable or low carbon technologies. The shift to low carbon electricity generation may also see a move towards the use of electricity for heating and transport, which could result in significant growth in demand for electricity, although the extent of this is, as yet, uncertain.

The growth in local generation, and the potential growth in demand from heat pumps and electric vehicles has a significant impact on the distribution networks. Although uncertainty exists over the extent to which low carbon technologies will evolve, the work carried out by the Ofgem's Smart Grids Forum (see below) shows that Smart Grids enable Distribution Network Operators to facilitate the transition to a low Carbon economy, i.e. it is "needs led".

Whilst it is not within the scope of this project to compare the costs and benefits of Smart Grids, it is useful to note that such analysis has been conducted in GB. A summary of this study is provided here for information.

A model has been developed in conjunction with all GB network operators under a Forum brought together by the regulator Ofgem[20]. The model compares the costs associated with three investment strategies:

- Business-As-Usual –where of only conventional solutions are deployed;
- Top-Down (Smart) – the Smart Grid case that uses a combination of conventional and smart solutions, where investment is deployed in advance of need;
- Incremental (Smart) – the smart grid case of conventional and smart solutions, where smart solutions are only deployed as and when parts of the network become overloaded.

The model considers a range of network mitigating solutions, including both conventional (i.e. solutions widely used today) and smart (new) solutions.

The results show that the Smart Grid approach represents a significant net benefit, as shown in Figure 5.1. Network investment benefits were assessed for varying penetrations of renewable energy generation and uptake of new electric loads (the scenarios). The results indicate that under all the scenarios considered, the Smart Grid approaches represented the most cost effective, with the biggest savings achieved through the 'Top Down' approach.

[20] Assessing the Impact of Low Carbon Technologies on Great Britain's Power Distribution Networks, Report prepared for Energy Networks Association on behalf of Smart Grids Forum – Work Stream 3, EA Technology, Frontier Economics, GL Noble Denton, Element Energy, Chiltern Power

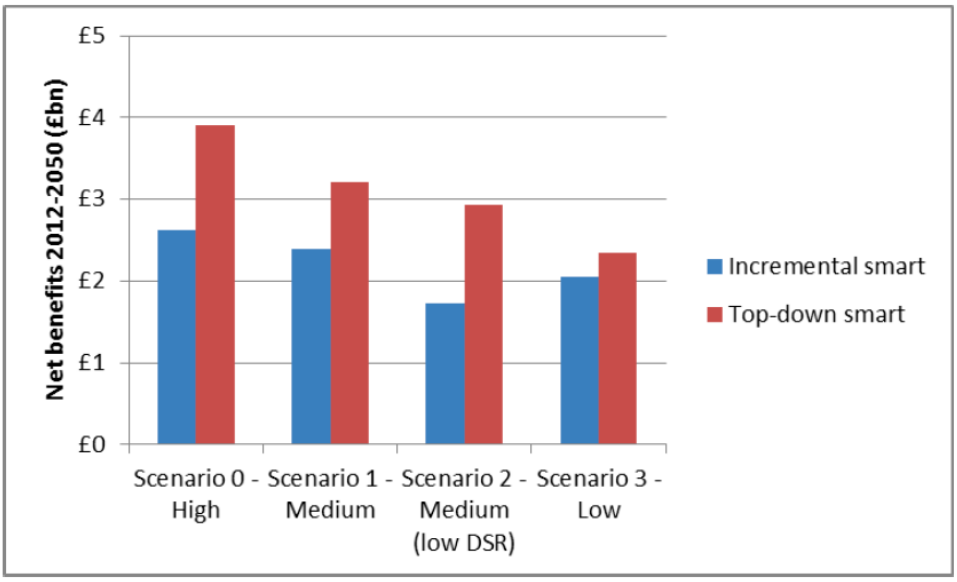


Figure 5.1 Net benefits of smart grid solutions to GB

5.2 Comparison of Smart Grid drivers

The drivers for the move to a Smart Grid (i.e. Why Smart Grids are considered a desirable outcome) presented in Section 5.1 are summarised below, together with the timescales over they occur.

Table 5.2 Comparison of country specific drivers for Smart Grids and the timescales[21]

Country	Now	Short to medium term (0 to 10years)	Medium to longer term (+10 years)
NO	• Network constraints	• Increase in distributed energy resources	
NL	• None	• New end uses for electricity – electric vehicles and heat pumps • Increase in renewable energy resources • New business opportunities for Dutch industries	
SE	• Network constraints	• New end uses for electricity – electric vehicles and heat pumps • Increase in renewable energy resources • New business opportunities for Swedish industries	
KR	• To drive through energy efficiency	• Increase in renewable energy resources • New business opportunities for South Korean industries	
UK	• Network constraints	• Increase in distributed energy resources • Increase in renewable energy resources	

Each of the countries have identified a number of drivers for Smart Grids as a method of ensuring electricity demand and supply can be balanced in a future with increasing amounts of renewable energy resource and increasing demand for electricity. However, many of these needs are expected to arise in the future, rather than now.

Immediate drivers for Smart Grid developments are also identified. In Norway, the move to a Smart Grid provides the potential to help manage network constraints resulting from the prevalence of electric heating. In South Korea, the Smart Grid is viewed as essential to counteract the devastating effects of electricity subsidies on energy efficiency. The end prices of gas and oil are higher than those of electricity; this discourages the use of these fuels for heating and cooking.

In order to handle more renewable generation there appears to be increasing recognition of the need to develop an electricity system better able to handle renewable energy production. In addition, moves to decarbonise heating and transport which result in the wide-scale adoption of heat pumps and electric vehicles, will lead to significant changes in demand for electricity (both in terms of the amount and the pattern of consumption).

[21] Based on information provided in National Reports, see Appendices for details

6 Approach to Smart Metering

Smart meters are being rolled out worldwide, and it is not the purpose of this project to consider the different approaches to Smart Metering adopted. Rather, the focus of this Section is to consider the way that Smart Meters can impact on behaviour changes.

Smart Meters (in very simple terms) provide consumers with the ability to:

- Have their meter read remotely (and thus more frequently than is the case with manual meter reading);
- Have their energy consumption measured in specific time slots (for example quarter hourly or hourly); and
- Enable end use loads to be directly controlled (either remotely by a third party or automatically, for example in response to a tariff signal).

These are regarded to be the minimum functions required to support the move to the implementation of Smart Grids. In terms of the 5 Ws framework introduced in Section 2, Smart Meters influence **Why** consumers would want to engage with Smart Grid initiatives and **What** initiatives can be offered to consumers, and by **Whom**.

The ability of the meter to perform these functions is not sufficient to ensure the success of Smart Grids – there is a need to ensure that consumers themselves are willing to actively utilise these functions (or allow third parties to do so). Smart Meters meters enable behavioral changes that can contribute to a more active role of consumers, for example they provide:

- Real time information makes consumer more aware of their electricity consumption (both in terms of the amount and pattern of consumption) in order to motivate behaviour change;
- Enable energy suppliers to offer innovative time of use tariffs to motivate consumers to change their pattern of consumption;
- Enable end use loads to be actively controlled (so that consumers are able to change their behaviour).

Key characteristics of the electricity market that impact on consumer willingness to engage with these activities are:

- The rules that stipulate what energy consumption information must be provided to consumers, and how it should be provided.
- The extent to which consumer concerns with regards to data access and privacy are addressed.

6.1 Provision of energy information

In order to drive behaviour change through the implementation of Smart Meters, it is necessary to strike a balance between motivating voluntary behaviour change and driving change through mandated rules. Behaviour change includes both day to day routine (or habitual) tasks (such as turning off lighting when leaving a room) and one off changes (such as turning down a thermostat set-point or decision making when purchasing a new appliance).

The provision of real time energy consumption data to consumers could be mandated, so that a particular solution must be deployed as a minimum. Alternatively, it could be entirely at the discretion of the electricity market.

A mandated approach has been adopted in Great Britain, which requires that all Smart Meters have an In Home Display (IHD). Although no final decision has yet been made, it is likely that a minimum functionality will be specified for the data that should be provided via the IHD. However, provision exists for suppliers to provide (or consumers to incorporate) enhanced IHDs. Research undertaken in the UK[22] has shown that 56% of consumers who have an IHD look at it at least occasionally and were generally positive about their impact in helping them understand and reduce their energy use. Of those consumers who used their IHD at least occasionally, half checked the kilo-watt measure (51%) and slightly fewer than half looked at the monetary information (46%). Only 8% checked the carbon saving measure. Findings from this research (or similar) could therefore be beneficial for the development of functional specifications for IHDs to ensure that the information which consumers find most useful is most prominently displayed, and these functions are advertised to consumers to try and encourage use of IHDs.

Alternatives to an IHD include the provision of data via the internet or via portable devices such as smart phones and tablets. Other innovative approaches have also been considered that move away from the provision of data on kWh and £ basis. Examples include the flower lamp and the Energy AWARE Clock, (see Figure 6.1), developed by the Interactive Institute in Sweden. The flower lamp provides a visual reward when household energy consumption is below a threshold, whilst the Energy Aware Clock displays energy consumption over time using a clock face format.

Source: Smart grids – design, people and behaviour, Cecilia Katzeff, Interactive Institute, presented at IEA DSM-Programme Workshop. Stockholm 2010-10-06

Figure 6.1 The flower lamp

Where IHDs are not mandated, the first step is to understand whether or not consumers are interested in receiving information on their electricity consumption. Understanding consumer preferences for how they wish to receive this data is then the next priority. The results of a review to assess factors that affect the usability of IHDs were published in 2011. The review, conducted to inform the implementation programme for Smart Meters in GB, concluded that very little work has been done in this area. However, it noted that much could be learned from comparable sectors (mobile phones and TV remote controls) to ensure that IHD could be used by as many people as possible. Suggestions for further work included:

- User trials for pre-payment and consumers with Time of Use tariffs
- The effect of real time feedback on low income and vulnerable consumers

[22] Quantitative Research into Public Awareness, Attitudes and Experience of Smart Meters. Research conducted by Ipsos MORI for DECC. August 2012. Available from: http://www.decc.gov.uk/assets/decc/11/tackling-climate-change/smart-meters/6194-quantitative-research-into-public-awareness-attit.pdf accessed 28/09/2012

Billing information provides another opportunity for providing information to consumers about their energy consumption. This could include information on annual energy consumption, a comparison with historical consumption (year on year) or peer to peer consumption. How consumers respond to such information is not within the scope of this Report.

6.2 Addressing concerns over data access and privacy

Smart Meters provide the ability to collect detailed, up to date information about the electricity consumption of individual consumers.

Better information on the energy consumption of consumers provides benefits to a range of stakeholders. This includes:

- Energy Suppliers who could reduce consumer churn, for example by providing improved service to consumers through the provision of targeted advice to individuals on how to change their energy consumption behaviours or the most appropriate tariff;
- Network Operators, who could use the information to ensure better utilisation of their network assets and detect network outages as they occur; and
- Third Party service providers, who may also be able to offer services or products to help consumers better understand their consumption. Alternatively, they could offer innovate products and solutions based on a detailed understanding of consumer energy consumption.

These benefits would ultimately be shared with consumers in the form of cost efficiency savings. However, access to up to date information on electricity consumption raises concerns over privacy and security. For example, unauthorised access could enable thieves to target unoccupied households.

There is a need to ensure that the requirement of market stakeholders (i.e. ensuring that data collated from Smart Meters can be used to provide optimum solutions) are balanced against consumer concerns over privacy and security. There are also concerns that the two-way communication facility allows energy companies to disconnect electricity supplies much more readily than is the case with standard interval meters.

There are a number of examples where consumer concerns in this area have led to high profile campaigns to 'de-rail' the Smart Meter process.

For example, it was originally intended that Smart Meters would be made compulsory in the Netherlands, with fines of up to €17,000 or six months in prison for those refusing have them installed. However, research commissioned by Consumentenbond, the Dutch Consumer Organisation, led to the Dutch First Chamber refusing to approve the Smart Metering Bill over concerns that the meters would constitute a violation of consumer's rights to privacy. There were also concerns that the data could fall into the hands of third parties.

Similarly, concerns have also been raised by PG&E consumers in California, USA over data access and privacy issues (amongst other concerns), that have also led to a change in the proposed roll-out programme.

There is unlikely to be a 'one-size-fits-all' solution with regards to addressing consumer concerns in this area, but a key element is considered to include the active involvement of consumer representatives in the development of Smart Meter implementation plans. This could be facilitated by the existence of a consumer organisation, particularly one set up via legislation and with authority to take action with regard to addressing consumer complaints and/or concerns.

The following sections highlight three differing approaches that have been deployed to address specific issues with respect to data access and data privacy.

PG&E

The Pacific Gas and Electric Company (PG&E) of California originally planned to roll-out Smart Meters to its 10 million consumers by the end of 2011. By September 2012, the meters had been rolled-out to over 9 million consumers. The roll-out has not been without its difficulties, with many high profile actions undertaken by consumers to stop the process altogether. This includes a 'National Day of Action to Stop Smart Meters' held in October 2012[23]. This is despite the fact that in December 2011, and following a series of high profile actions by consumers, PG&E sought approval from the California Public Utility commission to provide choice to consumers. The request was approved, and PG&E currently provide consumers the possibility of opting out of having a Smart Meter. However, this option required the payment of an up-front fee of US$75 and a monthly fee of US$10. This is reduced to U$10 and US$5/month for low income consumers[24].

Netherlands

Following the Dutch First Chamber's refusal to approve the Smart Metering Bill, the decision has now been made to make the installation of Smart Meters voluntary or to allow consumers the option of having the meter installed but with all the smart features turned off. As a result, consumers now have three options from which they can select after their Smart Meter is installed:

- Remote meter reading functionality is turned off. In this case, the option for supply to be remotely disconnected is also turned off.
- Meter reading takes place every second month, or when switching supplier or moving house. This is the default option.
- Quarter-hourly meter data collected on a daily basis.

In all cases, the consumer retains the ability to access accurate meter data in real time.

GB

The wide-scale roll-out of Smart Meters in GB is not due to commence until 2014, and this has permitted the learning from the experiences elsewhere to be considered in the early stages. As a result, the issue of data privacy and data access were considered at the outset. Following extensive stakeholder consultation the model depicted in Figure 6.2 has been adopted.

[23] http://actiondaytostopsmartmeters.org/ accessed 29 October 2012
[24] http://www.pge.com/myhome/consumerservice/smartmeter/optout/ accessed 24 September 2012

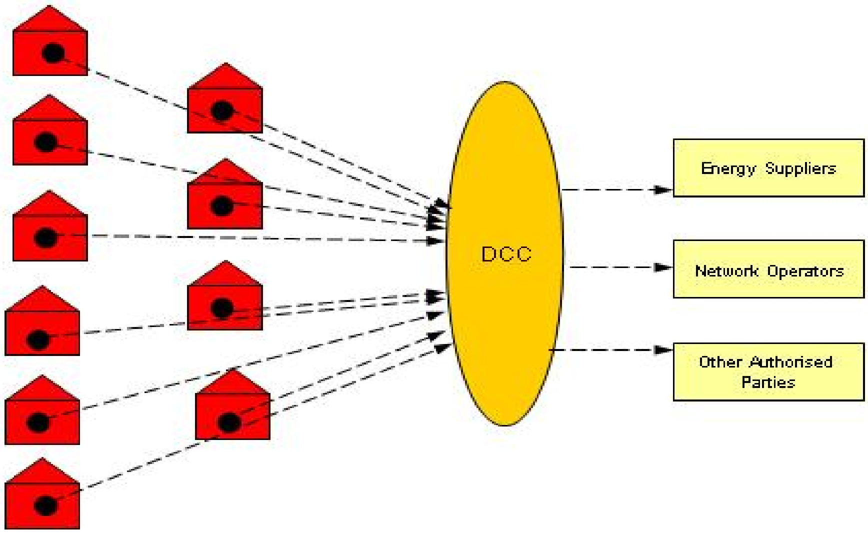


Figure 6.2 Data flow in proposed UK Smart Metering model

Data from Smart Meters will be collected via a central body referred to as the Data Collection Company (DCC). The data is then passed to the relevant stakeholders by the DCC. Only data that is required by a stakeholder to perform their regulatory duties will be passed on by the DCC. Metering in the UK is the responsibility of the Energy Suppliers, and thus data for billing will be passed to Energy Suppliers by the DCC for the purposes of billing consumers only.

Distribution Network Operators in GB (DNOs) have developed a view of the data that they require from the Smart Metering systems. To date the focus has been on ensuring that the Smart Metering systems will provide the information that the DNOs envisage will be required to design and operate 'Smart Networks'. In practice, it is likely that DNOs will have to purchase data items due to the costs associated with developing and maintaining the information systems. It is also expected that individuals may need to give permission for the data to be made available to DNOs. Thus, the DNOs are currently focussed on how they can best utilise Smart Metering data.

Consumers will be given the option of sharing their information via third parties, such as service providers. This could allow third parties to access information directly via the DCC. The Government opened a consultation[25] over the arrangements that need to be put in place to protect consumers. The proposals include provision to ensure that third parties:

- Take steps to verify that the request for third party services has come from the individual living in the premises in question;
- Properly obtain consent from consumers to access their data; and
- Provide annual reminders to consumers about the data that is being collected.

[25] Smart Metering Implementation Programme, Data access and privacy, Consultation document, April 2012

7 Tariffs

Tariffs are just one of the many potential offerings that stakeholders can provide to consumers to motivate them to engage in Smart Grids, i.e. it is one example of What can be implemented (see the 5Ws framework in Section 2). The way that consumers pay for their electricity has the potential to have a significant impact on the way that they consume electricity. Tariffs provide a form of motivation to drive consumers to change their behaviour. If consumers pay a flat rate for all electricity they consume, they have little motivation to shift electricity consumption away from peak times. Whilst there is a growing body of evidence to demonstrate the impact of time of use tariffs on energy consumption, further work is still required to understand consumer receptiveness to these tariffs.

This Section is structured as follows:

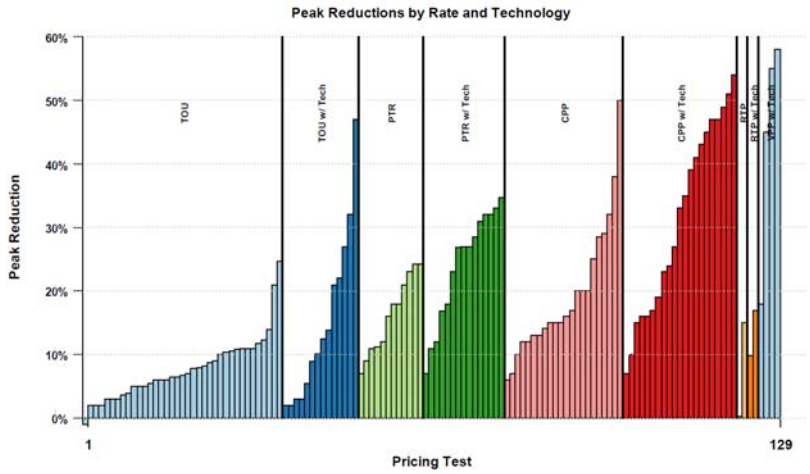
- Section 7.1 considers how Time of Use (ToU) tariffs act as a 'motivator' for energy behaviour change, and considers the extent to which ToU tariffs have led to changes in energy consumption.
- Regardless of the type of tariff in place (time of use or flat rate), if consumers do not understand the individual components of their electricity bill, they are unable to understand the implications that any changes they make will have on their overall bill. This is discussed in Section 7.2.
- Section 7.3 compares the average tariffs in each of the participating countries, and the proportion that different activities contribute to overall electricity costs.
- Section 7.4 describes different approaches to tariff setting, particularly with regards to the implementation of time of use tariffs.

7.1 A Tool to Motivate Behaviour Change

A study of the impact of some 74 Time of Use / Critical Peak Pricing trials on consumers shows wide variation in the level of responsiveness from one trial to another[26]. As shown in Figure 7.1, there is wide variation in the level of peak demand reduction delivered in each of the 129 individual pilots considered, although the level of peak load reduction is generally seen to increase if technology is used. Here, technology refers to control technology to automate the load shifting rather than relying on manual intervention by a consumer. Similarly, dynamic pricing such as CPP and RTP generally seem to deliver a greater level of peak load reduction.

The study also analysed the extent to which the ratio of the peak to off peak price influenced the level of peak load reduction. As might be expected, the analysis showed that, generally, the higher the price differential then the higher the peak load reduction. The results are shown in Figure 7.2, which shows a plot of price ratio against peak load reduction in the form of a logarithmic curve, referred to as an '*arc of price responsiveness'* by the authors.

[26] The Discovery of Price Responsivenss – A survey of experiments involving dynamic pricing of electricity, Ahmad Faruqui and Jenny Palmer, The Brattle Group, paper submitted to EDI quarterly and accessed via http://papers.ssrn.com/ 28/09/2012



Source: A Faruqui / J Palmer: The Discovery of Price Responsiveness –
A survey of experiments involving dynamic pricing of electricity

Key

TOU:	Time of Use (static)		CPP:	Critical Peak Pricing
w/Tech:	With Technology		RTP:	Real Time Pricing
PTR:	Peak Time Rebate		VPP:	Virtual Power Plant

Figure 7.1 Impact of price – by tariff type and technology

Source: A Faruqui / J Palmer: The Discovery of Price Responsiveness –
A survey of experiments involving dynamic pricing of electricity

Figure 7.2 Price Responsiveness of Dynamic Tariffs

The authors claim that about half of the variation in demand response is attributable to the variation in price ratio. The remaining variation is not explained in the paper, but could reflect differences in climate, time periods, the length of peak and the manner in which the trials were marketed to consumers. It is not known to what extent consumer willingness to participate impacts on the level of demand response – particularly at an individual household level.

7.2 A tool to improve consumer awareness

If consumers do not understand the contribution of different activities to their overall electricity costs, or the structure of their tariff (metering, network charges, energy charges, taxes etc.), they will not be able to understand the implications of any changes in their electricity consumption on their overall bill. An example of the potential implications of consumers' misunderstanding of their tariff structure can be illustrated via the well-publicised roll-out of Smart Meters by PG&E in California. The timeline of events was:

- 2001: An inverted tier rate system was introduced; whereby once consumption exceeded a baseline each unit became significantly more expensive. The aim of the tariff was to reduce consumption by the largest users.
- 2006: Smart Meters began to be rolled-out in Bakersfield, California.
- Late summer 2009: Consumer complaints began to rise as a result of large increases in bills, opposition to Smart Meters also increased due to increased bills and perceived safety and privacy issues. This resulted in a class action being filed by residents against the utility in November 2009.

An independent report was commissioned in order to understand the cause of the consumer complaints. This reported that July 2009 was much hotter than previous summers and so consumers used much more energy in a single billing period than previously due to the use of air conditioning. This increase in consumption meant that consumers were exposed to the higher rates on the inverted tariff system for the first time. Their awareness of the tariff was low and therefore their bills increased by much more than they were expecting (using both more units, and at a higher per-unit price). This example illustrates the importance of consumers being aware of their tariffs in order to understand the consequences of their actions.

Section 7.3 therefore compares electricity tariffs in the participating countries, and how different activities contribute towards overall electricity costs faced by consumers in these countries. Section 7.4 then discusses how approaches to Tariff setting and their impacts on consumers.

7.3 Comparison of tariffs components in participating countries

Table 7.1 below provides a comparison of the contribution of different activities towards the overall electricity costs faced by households. The data is based on a typical average annual consumption level, which differs from country to country. An average tariff is used as it allows the impact of different components on overall cost to be understood. For example, where a time of use tariff is applied only to one component of the overall electricity cost, the impact can be diluted once all the other components are taken into consideration. An example of such an effect is described in Section 7.4 (see approach to time of use tariffs in Italy). In order to understand the impact of changes in consumption, it is necessary also to consider the marginal cost of energy.

Table 7.1 Comparison of domestic tariff components

	GB	NL	NO	SE	KR
Average annual consumption (kWh)	3300	3450	16000	20000(*)	3822
Average tariff (€/kWh)	0.18	0.23	0.13	0.15	0.11
Of which:					
Network charges (%)	25%	23%	36%	22%	88%
Energy costs (%)	58%	51%	31%	35%	
Taxes (%)	11%	8%(**)	13%	23%	3%
VAT (%)	5%	17%(***)	20%	20%	9%
Total	100%	100%	100%	100%	100%

(*) 20,000kWh for a household with electric heating
5,000kWh for a household without electric heating
(**) taking into account the tax deduction
(***) VAT =21%

As highlighted above, the average cost per unit of electricity consumed by a householder varies significantly, from around 11 c€/kWh to 23 c€/kWh. Also, the proportion of this attributable to network charges, energy costs and taxes also varies significantly.

The extent to which different activities contribute to the overall energy costs paid by consumers has an impact on the financial motivation for consumers to participate in certain initiatives. As discussed earlier, the stronger the price signal, then the greater the level of response, as highlighted earlier in this Section. For example, where network charges account for relatively small proportion of overall costs, it becomes more difficult to financially motivate consumers to avoid network peaks, via a time of use network tariff, as the impact on their overall costs could be very small.

7.4 Impact of approaches to tariff setting

Tariffs are one of the factors that motivate consumers to change their energy consumption behaviour and thus, directly impacts on the role of consumers to participate in the delivering of successful Smart Grids. This Section therefore considers different approaches to tariff setting, and discusses how these approaches have the potential to achieve behaviour change. It also highlights some examples to demonstrate what can be learned from some of the pilots and projects that have been implemented to date.

Tariffs are regulated where a monopoly business exists in order to protect the needs of consumers. Network tariffs fall into this category. The regulation of these tariffs can take one of two basic forms:

- Incentive based regulation: Under this arrangement, the total revenue a company can collect from its consumers is regulated. The revenue is set over a number of years, typically five to eight. If the network company can achieve efficiency savings during this time and deliver its services more cheaply than expected, then it can retain some of these savings. Savings are passed onto consumers at the time of the next regulatory review. Individual tariffs are generally not approved by the regulator, rather the network company will typically need to demonstrate they have a methodology in place to ensure that costs are allocated fairly to consumers, and that the total revenue is not exceeded.
- Rate of return regulation: Under this arrangement, the total revenue a company can collect is regulated so as to ensure that a suitable rate of return is provided. Under this arrangement, which is also referred to as 'cost-plus' regulation there is no incentive for network companies to pursue cost savings other than those specifically required by the regulator. Under these arrangements, it is not untypical for individual tariffs to be approved by the regulator.

In both of these cases, it is possible that the network company retains flexibility over the way tariffs are structured, particularly in terms of any time of use pricing. The role of the regulator is then to approve the tariff. In some instances, rules or legislation is put in place to ensure that tariffs are structured in a certain way. For example, all Distribution Network Operators in GB are now required to offer time of use distribution network charges to larger consumers, based on a common charging methodology referred to as the Common Distribution Charging Methodology (CDCM). As such, the network charges for these consumers now have the following structure (although exact timings of each price band can vary by geographic region):

- Red (peak): 16:00 – 19:30 (Monday to Friday)
- Amber (shoulder): 08:00 – 16:00 and 19:30 – 22:00 (Monday to Friday)
- Green (off-peak): All other times

Thus, a time of use tariff structure is mandated for all network tariffs for consumers with maximum demands of 100kW or more in GB.

A number of pieces of research have been undertaken to understand the impact that the introduction of these charges has had on network demand, and the behaviour of individual customers. The provisional results of one of these[27] (undertaken as part of the Northern Powergrid Customer Led Network Revolution project[28]) has shown no measurable difference between demand for individual customers (from billing data) in each time band, as shown in Figure 7.3.

[27] Presentation at "Knowledge Sharing and Learning in Action" event at Durham University. 12 July 2012. Available from: http://www.networkrevolution.co.uk/industryzone/projectlibrary Accessed 13/08/2012)
[28] http://www.networkrevolution.co.uk/

Figure 7.3 below compares the percentage of each customer's total usage in each of the three time zones (red, amber, green), before and after the introduction of the ToU tariff.

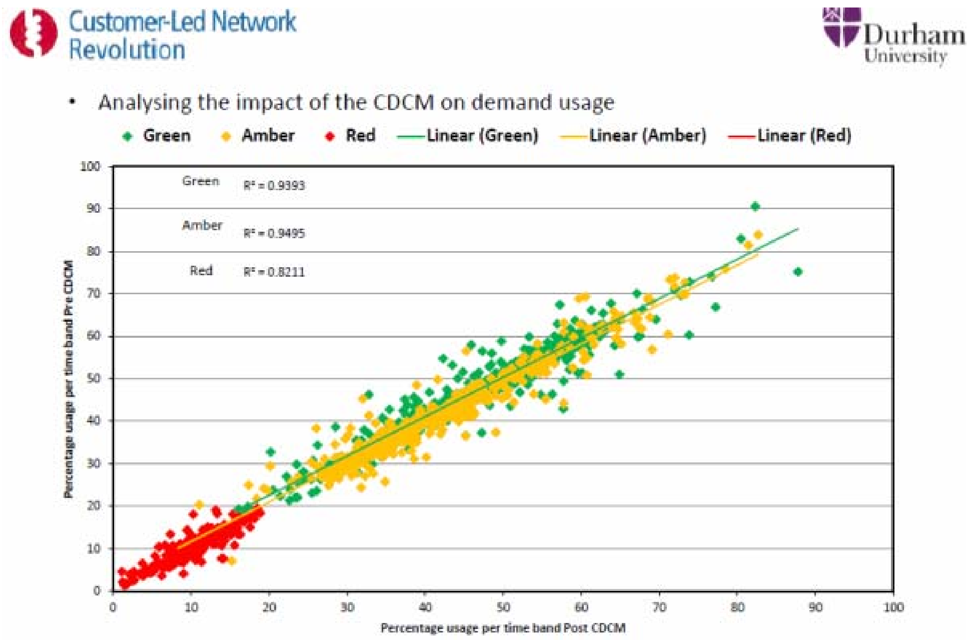


Figure 7.3 Impact of CDCM on demand usage

It is however not clear why no noticeable change in demand has been observed, potential reasons include:

- Suppliers have not fully passed on the charges and their structure to customers
- The tariff has been passed on, but customers are not aware of it
- Customers are aware of the changes but are not willing or able to change their behaviour, potentially due to the type of processes they undertake at their premises, other logistical reasons (e.g. shift patterns in manufacturing), or the financial incentive involved is not sufficient.

In a competitive electricity market, it is generally up to Energy Suppliers themselves to set electricity tariffs for consumers. In most cases, this relates both to the amount charged and the structure of the tariff (i.e. whether it includes a time of use element or not).

However, even in a fully competitive market, the possibility exists for legislation to be put in place to stipulate the type of tariff that must be offered for consumers. This, for example, could be included as a specific licence condition.

The issue of mandating a time of use tariff rather than allowing the market to select the most appropriate tariffs for its business is a complex one: it requires the need to drive behaviour change through imposing a time of use tariff to be balanced against the need to motive voluntary behaviour change and provide consumer choice.

The following provides examples of mandated and flexible approaches to time of use tariff setting.

Italy – a mandated approach

A mandatory Time of Use Tariff was introduced in Italy in July 2010[29]. This tariff is the only option for all consumers who choose to have their electricity supplied by their utility company. Under these arrangements, around 20 million households now have a Time of Use electricity tariff, whereby a higher rate is charged for all electricity consumed during the peak hours of 8am to 7pm on weekdays. As an alternative, consumers can opt to choose a supplier on the competitive retail market.

The time of use tariff applies only to the energy component of electricity charges, with the effect that the differential (as a percentage of the overall energy cost) decreases as energy consumption increases. The differential between the peak and off-peak energy cost is 10%. However, the differential between the peak and off-peak rate when all other energy components are combined is around 7% for low energy households (consuming up to 1,800 kWh/year) compared to 4% for high energy households (consuming between 2,640 and 4,444 kWh/year).

The Italian research organisation Ricerca sul Sistema Energetico (RSE SpA) is currently undertaking a research project to investigate if and how much the tariff has impacted on consumers' energy consumption. Data from a sample of some 28,000 consumers has been analysed[30]. Results indicated that over half (61.5%) of consumers shifted consumption from the peak to the off-peak, whilst the remaining consumers actually shifted consumption in the opposite direction (i.e. to the on-peak).

Although the tariff is mandated, consumers do have the option of entering the competitive supply market for an alternative tariff structure. The mandated tariff was introduced gradually, with an 18 month transition period whereby there was a limited differential between the peak and off-peak prices. The ToU tariff was introduced 5 years after the roll-out of Smart Meters had been completed in 2005.

Victoria, Australia – a mandated approach with opt-out

In 2004, the Essential Services Commission of Victoria, Australia, introduced legislation to mandate the roll-out of Smart Meters to all 2.6 million consumers in the state of Victoria.

The implementation of ToU tariffs is regarded as an important tool to ensure that the costs associated with providing the capacity needed to meet peak demands are borne by those that contribute to the peaks, rather than by all consumers regardless of whether they use their air-conditioners during peak periods.

However in 2010, the State Government called a temporary moratorium on time of use pricing because of concerns over their impact on the elderly and the poor[31, 32]. In particular, concerns were raised that those who would be worse off under time of use pricing would not be able to opt out. Therefore, a review was instigated to ensure that time of use tariffs are an 'opt-in' for those who would be adversely affected.

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[29] Definition of an instrument for the gradual application of prices differentiated by hour bands to domestic consumers in protected categories. ARG/elt 22/10, issued by The Italian Authority for Electricity and Gas (AEEG)

[30] Impact of the Enforcement of a Time of Use Tariff to Residential Customers in Italy, Michele Benini, Massimo Gallanti, Walter Grattieri, Simone Maggiore, R.S.E. (Ricerca sul Sistema Energetico S.p.A.), Power System Scenarios and Energy Efficiency Research Group, paper supplied via e-mail.

[31] Plug pulled on smart meter plan, Article by Paul Austin, March 2010, The Age, available at http://www.theage.com.au

[32] Our demand: reducing electricity use in Victoria through demand management, Sachdeva / Wallis, Report 10/4, August 2010, Monash University and Monash Sustainability Institute

The Consumer Utilities Advocacy Centre (CUAC)[33] in Victoria actively raised concerns over the implications of time of use pricing on vulnerable consumers. One particular aspect raised by the organisation is the appropriateness of introducing a time of use tariff if consumers are unwilling or unable to respond to the price signal. Three specific questions were posed to highlight their concerns:

> *" Would I like to be exposed to time of use, critical peak or dynamic electricity pricing in my home?"*
>
> *" Would my answer differ if my circumstances changed? Would I welcome such innovations if I were to have a child or lose my job?"*
>
> *" Do I think that my parents or elderly relative would welcome such product innovations? If not, why not?"*

In September 2012, the Australian Energy Market Commission published a draft paper[34] outlining is proposed approach for the roll out of time of use network tariffs. This includes provision for vulnerable consumer to 'opt-in'.

PG&E – voluntary approach

PG&E supply electricity to around 5 million consumers. They are offered a range of tariffs, including a residential critical peak pricing scheme (SmartRate™). In 2011, around 23,000 residential consumers had enrolled onto this voluntary scheme.

Results from an ex-post analysis[35] of the energy consumption patterns of these consumers showed:

- 79% of consumers with the SmartRate™ tariff saved money compared to the amount they would have paid on the 'standard' flat rate tariff.
- The vast majority of consumers stayed on the program – dropout rates were reported to be low.

Although 23,000 consumers have voluntarily taken up the tariff, the take up rate (as a percentage of the total consumers) is low at less than 0.5%. Little is known about what motivated these consumers to take up the tariff. A key factor is likely to be that they consider they are able to make the necessary behavioural changes in order to realise the potential cost savings. However, little is reported to help explain why the majority of consumers have not chosen to enrol on this type of tariff.

GB – voluntary approach (pilot)

GB is currently in the initial phases of its roll-out of Smart Meters, and as such, the potential for innovative time of use tariffs is limited to on-peak / off-peak tariffs that have been available to consumers for many years. The Consumer-Led Network Revolution (CLNR) project, funded through the Low Carbon Network Fund, is assessing the potential for new network technology and flexible consumer response to facilitate speedier and more economical take-up by consumers of low-carbon technologies and the connection to the distribution network of increasing amounts of low carbon or renewable energy generation. The project is still in its early stages, and as such focus has been on consumer recruitment. With regards to recruitment for the time of use trials, the proposition is claimed to be "very

[33] Review of the Victorian AMI Program, Response to issues paper, Customer Utilities Advocacy Centre, June 2011
[34] Draft Report Power of choice - giving consumers options in the way they use electricity, 6 September 2012
[35] 2011 Load Impact Evaluation of Pacific Gas and Electric Company's Residential Time-based Pricing Programs, Prepared for: Pacific Gas and Electric Company by Freeman, Sullivan & Co.

attractive to consumers" due to the fact that the target number of 600 participants was exceeded.

The tariff being trialled consists of three rates:

Peak rate: ~ 23 p/kWh between 16:00 and 20:00 on weekdays
Shoulder: ~ 11 p/kWh between 07:00 and 16:00 on weekdays,
Low rate: ~ 8 p/kWh at all other times

The peak rate of 23p/kWh is significantly higher (almost twice) than the typical standard flat rate charge of 12p/kWh for each unit of electricity consumed by a household.

These by no means provide an exhaustive comparison of the impact of mandated vs. flexible approaches to setting time of use tariffs, and consumer reactions to these approaches are not yet well understood. Some key learning points from the snapshots presented here include:

- Little is understood of consumer willingness to adopt time of use tariffs
- Evidence exists to suggest that some consumers will willingly adopt these types of tariffs
    - But take up rates in the selected examples are low, and it is believed that these are not untypical
- Mandating time of use tariffs in a competitive market place is not straightforward
    - In this case, it is generally the role of energy suppliers to determine prices in a competitive marketplace
- Consumer response to the mandated roll out of time of use tariffs is a significant unknown element
    - In Italy, there does not seem to be any significant concerns raised by consumers.
    - This is in contrast to the experiences in Victoria, Australia.
- Experience to demonstrate the extent to which time of use tariffs actually drives behaviour change is limited.
    - There is a risk that consumers who favour these types of tariffs are those that already have a pattern of energy consumption that is suited to the tariff. As such, they believe they save money without actually changing their pattern of consumption.

8 Settlement

In a competitive electricity market, electricity is traded in settlement intervals, which vary in length from ¼ hourly blocks to hourly blocks. The move to competitive markets pre-dated the roll-out of Smart Meters. As such, the majority of consumers, particularly smaller consumers, were metered with an accumulation meter that measures the total energy consumed. In order to ensure that these consumers could also participate in the competitive electricity market, a method of profiling was developed to allocate the overall energy consumption of a consumer to the relevant settlement intervals. This is often referred to as 'profiling'.

Under these arrangements, the pattern of consumption is as defined by the profile allocated to an individual consumer whilst the amount is determined by the periodic electricity consumption (annual or monthly consumption).

The method has advantages – it is simple to administer and it enables consumers to actively participate in the competitive electricity market. However, the major disadvantage is the inability to reflect actual patterns of consumptions for individual consumers. Therefore, there is no way for Energy Suppliers to capture the value of changes to the pattern of consumption on the wholesale market. Methods have been introduced to address this to a limited extent, for example through the use of multiple registers to allocate consumption during particular time blocks to a particular tariff rate. This allows simple time of use tariffs to be implemented, but is not well suited to more complex or variable tariff structures.

Smart Meters enable energy consumption patterns to be captured in time slots aligned to the interval settlements used for energy trading. The natural progression is therefore to ensure that this data is used for settlement purposes. Finland is believed to be the first country to introduce legislation to ensure that time of use consumption data is used for settlement purposes for all consumers with suitable meters. From the end of 2011[36], it has been mandatory that all consumers with Smart Meters are billed on the basis of their hourly consumption data, which is also used for settlement purposes in the wholesale market. In Sweden and Norway, it is now a requirement that the Distribution Company must supply the retailer with hourly metered values at no additional cost to the consumer, if the consumer requests to be billed on an hourly basis.

Thus, the approach to settlement impacts on **What** initiatives can be implemented by stakeholders (see the 5Ws framework in Section 2), as it affects the extent to which stakeholders are able to capture the true value of any initiatives they implement.

Table 8.1 provides a summary of the extent to which the participating countries have moved towards the use of Smart Meter data for settlement rather than profiling.

[36] The new AMR legislation of Finland – Energy efficiency, demand response and better services in focus, presentation by Timo Ritonummi, Ministry of Employment and the Economy, Finland at a ESMA Workshop held on 16 June 2009 in Espoo, Finland

Table 8.1 Progress made towards use of Smart Meter data for settlement

Netherlands	Common belief of market stakeholders is that synthetic profiles are not suitable to support dynamic demand response. Several market parties are studying the concept of "Smart Meter allocation", which allows Smart Meter data to be settled on a quarter-of-an-hour basis on the wholesale market. Changes to the market organization are needed to accomplish this, therefore it may take a few years to realize
Norway	Legislation specifies that customers with hourly metering shall be settled on the basis of their actual consumption. As of 2012, only a limited number of small customers in pilot areas are settled in this way.
Sweden	Consumers are currently settled according to profiles, based on the total monthly consumption readings. No commitment has been made to move to the use of actual meter data. However, since October 1st 2012, costumers requiring hourly billing must be supplied with this by the DSO without any additional charge.
Korea	Small consumers are not able to participate in the energy market. They are captive consumers of the monopoly retailer. Therefore, there is no need for profiles to settle the energy consumption of smaller consumers.

9 Other

There are a number of other factors that impact on the role of consumers in delivering effective Smart Grids. Some of these are discussed here.

9.1 Feed-In Tariff arrangements

A feed-in tariff is a mechanism that can motivate consumers to install renewable generation technologies by ensuring they are financially rewarded for doing so. The way that the Feed-In tariff (FiT) is administered has a significant impact on consumer behaviour. In particular it can increase consumer understanding of the importance of the pattern of consumption.

A number of different approaches to FiTs have been implemented to facilitate the uptake of small scale embedded generation (SSEG), as highlighted below. The extent to which it can motivate consumers to change their pattern of consumption is influenced by the approach adopted.

Feed-In Tariff paid on units generated, with additional payment for exports

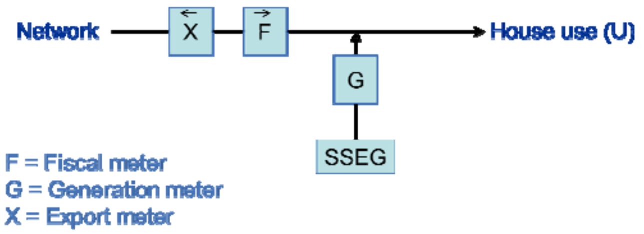

Figure 9.1: Export/Generation metering – high FiT

Under these arrangements, consumers receive a payment for all units of electricity generated, plus an additional payment for units exported. This is the arrangement currently in place in GB. For PV, the Feed-In Tariff is currently 16p/kWh, and the payment for exports is 3p/kWh. Export volume is deemed to be 50% of the electricity generated. Once Smart Metering is rolled out, it is expected that exports would be metered.

Under this arrangement, consumers are incentivised to use as much of the electricity they generate as possible as there is a significant differential between the import price paid to use electricity from the grid vs. the amount received from exports.

Feed-In Tariff paid on units exported only

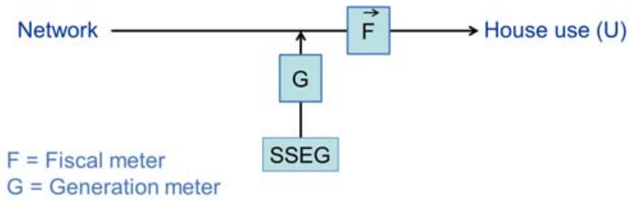

Figure 9.2: Generation metering – high FiT

If the FiT is paid for export (i.e. it is actually a "Feed-in" tariff) and the FiT payment exceeds the import tariff, then it is logical to use the metering arrangement shown in Figure 9.2. There is no incentive for own consumption of generation or, indeed, for the use of Electrical Energy storage. This was the arrangement used in Germany when FiTs were first introduced. Since then, an adjustment has been made that includes an additional payment for self-consumption.

Net metering

A simple arrangement (and one that inadvertently follows from the installation of SSEG on the house-side of an old style Ferris wheel electricity meter) is as shown in Figure 9.3. In this case consumers are billed on their net imports (F – X). Such an arrangement could provide a significant incentive for the renewable generation technology, but less incentive for the consumer to manage their pattern of consumption.

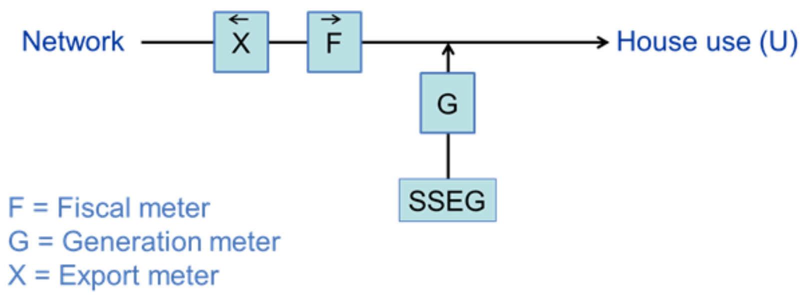

Figure 9.3: Net metering

9.2 Building regulations

Building regulations is another area that has the opportunity to impact on consumer behaviour. In addition to the direct impact on the energy consumption of a household for heating, the way that building heating systems are addressed is an important factor in motivating consumers to change their pattern of consumption.

For example, the building regulations for new dwellings in the UK[37] stipulate the energy consumption and carbon dioxide (CO_2) targets with which all new and refurbished buildings must comply with. The Standard Assessment Procedure (SAP)[38] is the UK Government's recommended method system for measuring the energy rating and CO_2 emissions rate of residential dwellings. It works by assessing how much energy a dwelling will consume and how much CO_2 will be emitted in delivering a defined level of comfort and service provision, based on standardised occupancy conditions. The current SAP methodology makes no allowance for the real time CO_2 emissions associated with electricity used for heating purposes. Thus, all electric heating systems are associated with a fixed CO_2 emissions rate. There is no benefit attached to installing a heating system that can be flexed to match the availability of off-peak generation (as with storage heating) or to match the availability of wind, or other low-carbon generation. Thus, there is no incentive for installers and house builders to provide houses to consumers with flexible electric heating systems. Such an approach is considered to be a significant barrier to the adoption of flexible electric heating systems.

[37] http://www.planningportal.gov.uk/buildingregulations/
[38] http://www.decc.gov.uk/en/content/cms/emissions/sap/sap.aspx

Another example is the energy related regulations set by the Swedish National Board of Housing, Building and Planning. The regulations are based on the Energy Performance of Buildings Directive (EPBD2) set by EU and are targeted at decreasing the energy consumption. Hence, questions related to flexibility are not covered in these regulations and no incentives exist to increase the benefit for flexible users.

9.3 Consumer perceptions and experiences

Consumer perceptions of stakeholders are also considered to play an important part in influencing their willingness to actively participate in the Smart Grid concept. This is, in part, influenced by the checks and balances that are put in place to ensure that the needs of consumers are protected. It will also be influenced by consumers' own experiences, for example in terms of the way that electricity market stakeholders keep them informed of changes. This has been acknowledged as a potentially important in helping DNOs in GB to engage with consumers to help them manage their networks more effectively. One of GB's DNOs has plans to set up a high street energy advisory centre to help it to engage with consumers as part of its New Thames Valley Vision project[39]. Such high street stores were commonplace in GB pre-privatisation of the electricity industry. However, following privatisation, these are now virtually non-existent.

There is evidence of a growing awareness of the importance of consumer service in retaining consumers[40]. This will be covered in more detail in Subtask 2 of this Task.

Lack of trust by consumers in the electricity industry could limit or restrict consumer willingness to engage in new, innovative products and solutions. There are many instances of consumers' negative views towards the electricity industry, a selection of which are listed below for illustrative purposes.

A sample of consumers from the UK were asked to comment on whether or not they thought that the energy industry was doing a good job[41]. Responses included:

> *"I don't think they do a good job"*
>
> *"When wholesale price of gas goes down they are very slow to reduce their prices"*
>
> *"I have doubts about whether they need to put prices up like they say they do"*

A survey was also carried out by a consumer group to explore consumer attitudes to energy and the energy industry in GB. The results of this survey highlighted a lack of trust and widespread negativity towards the industry. Energy suppliers were perceived as "*running a 'monopoly' to maximise profits at the expense of consumers".* Price rises in the years leading up to the survey are considered an important factor here.

[39] www.thamesvalleyvision.co.uk
[40] Institute of Customer Service, Why consumer service matters and who's leading the charge, 16th February 2012, presented at Network 2012
[41] Energy on the Street, EA Technology and Energy Networks Association (ENA) commissioned Vox Pop entitled part of the Network 2012 Conference event, accessible via http://www.youtube.com/watch?v=mOENmZC-3yo

A selection of some of the comments quoted in the report is listed here;

> “ *Now they’ve got us over a barrel and they are virtually monopolies, whatever they say. The only choice you get is cough up or freeze to death.”*

> “ *They promise you things that are not true. I think they tell you a lot of lies just to make you go with them and change who you’re with”*

> “ *They’re all in it together to make money.”*

These views are not a direct result of the structure of the electricity market *per se*, but reflect the way that industry participants engage with consumers. It does however reflect the checks and balances that are in place to protect consumers, to ensure that consumer issues and concerns are effectively handled. This could be facilitated by the existence of a consumer organisation, particularly one set up via legislation and with authority to take action with regard to addressing consumer complaints and/or concerns.

10 Concluding Remarks

Sections 4 to 9 of this report highlight that the impact of the electricity markets on consumer participation in Smart Grids is wide ranging and often poorly understood. The following Table captures, at a very high level, some of the issues and topics raised in this report. It highlights that there is rarely a ‘one-size-fits’ all solution. As indicated in the Table, most of the characteristics listed represent both an advantage and a disadvantage from the perspective of consumers.

The Table highlights the specific aspects of the 5Ws framework (**Who**, **What** or **Why**) that are affected.

Table 10.1 Overview – impact of electricity markets on consumers

	NO	NL	SE	KR	UK	Positives (from who/what/why perspective)	Negative (from a who/what/why perspective)
Fully unbundled network activities	✓	✓	✓	×	✓	**Who/What**: Potential for new entrants to enter the market, and offer innovative solutions and services	**What:** Broken value chain - benefits distributed amongst number of stakeholders. Who/What: Role of individual stakeholders may not be fully understood by consumers.
Significant competition in energy retail market	✓	✓	✓	×	✓	**Who/What**: Additional choice for consumers **Who/What**: Competition between suppliers may lead to innovation as companies try to attract and retain consumers	**Who:** Too much choice for consumers - makes it difficult for consumers to compare offerings and select the one that is best for them (purchasing paralysis). **What:** Companies may be reluctant to offer something which may 'upset' consumers as they risk their consumers switching to another supplier (loss of business)
Mandated approach to way that energy information collected by Smart Meters is presented to consumers	×	×	×	×	✓	**What**: Ensures a minimum level of information is provided as 'standard' to all consumers to increase consumer awareness. **What:** Can ensure that 'best practice' is deployed.	**What:** Limits innovation by Metering providers, who may be well placed to understand needs of specific consumer groups, e.g. elderly or low-income households. **What:** Little is currently understood about the way that consumers react to information and the extent to which it drives behaviour change.
Mechanism in place to ensure consumer concerns over data access and privacy are addressed	✓	✓	✓	×	✓	**What:** Reduces possibility of a 'consumer backlash', so that consumers are less likely to refuse to accept Smart Metering.	**Why/What:** Could restrict the use of Smart Meter data by the wider stakeholder group, which could limit innovation in products and services, which could be to the detriment of consumers in the long term.
Disaggregated tariff information provided to consumers	✓	✓	✓	×	✓	**What/Why**: Consumers better able to understand impact of changes to their energy consumption habits on total electricity costs.	**What**: Added complexity could confuse consumers.
Time of use tariffs mandated	×	×	×	×	×	**What:** Ensures that cost reflective tariffs are in place to drive behaviour change.	**What**: Limits the flexibility for Energy Suppliers to offer products and services that are most favoured by consumers. **What:** Little is understood to the way that consumers may react to these tariffs.
Smart Metering interval data for settlement	×	×	×	×	×	**Why/What**: Ensures that the value of changing patterns of demand can be captured by consumers and by Energy Suppliers.	**What**: Could increase the financial burden on consumers for little benefit, if it does not lead to behaviour change.
Statutory consumer organisation	×	✓	×	✓	✓	**What**: Has statutory authority to ensure that consumer concerns can be effectively handled. **What:** Can represent needs of consumers in industry Consultations.	-

Key:

✓	Feature present in electricity market
×	Feature not present in electricity market

11 Next Steps

This Report represents the first step towards understanding the extent to which consumers might be motivated to actively engage in Smart Grids. It underlines the importance of the electricity market structure on the role of consumers in delivering effective Smart Grids. The aspects that have a direct influence on willingness and ability to play an active part in the delivery of Smart Grids are highlighted. This report demonstrates that the impacts on consumer willingness to actively engage in activities to support Smart Grids are wide ranging and to a large extent, poorly understood.

For example, there is a growing body of evidence to show that better feedback of information to consumers will improve consumer awareness and motivation to change behaviour. However, little is understood about how best to convey this information to consumers, whether it should be mandated through a 'one-size-fits-all' approach or whether it the desired outcomes can better achieved through voluntary innovation.

Similarly, there is a growing body of evidence to demonstrate that time of use tariffs provide a strong financial motivation to consumers to change their pattern of consumption. When this is coupled with suitable technology, the response can be greater. However, little is still known about how these tariffs should be implemented – should they be mandated for all consumers or should the market decide how best to make them attractive to consumers.

The next step of this Task (Subtask 2) will focus more closely on consumer interaction with technology, and will consider the appropriateness of selected technologies, both from the consumer perspective and the Smart Grid industry perspective.

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Appendix I: Netherlands National Report

The Impact of Electricity Markets on Customers

Prepared by Yvonne Boerakker
National Expert for the Netherlands

28 August 2012

International Energy Agency Demand-Side Management Programme
Task XXIII: The Role of Customers in Delivering Effective Smart Grids

Acknowledgements

Enter any acknowledgements here if required

Glossary

If you use any acronyms – provide a summary here.

Contents

1 Smart Grid Drivers and Definitions

1.1 Description of smart grids

The Minister of Economic Affairs initiated a task force on Smart grids in October 2009. One of the tasks was to propose a widely supported vision and an action program for the realisation of smart grids in the Netherlands. In their discussion document 'Op weg naar intelligente netten in Nederland', the Task force describes smart grids as;
'innovations related to electricity grids, to keep energy supply affordable and reliable and to additionally make it more sustainable. Essential for a smart grid are the two directional electricity flows, between end users, and between end users and suppliers. By adding (information and communication) technology, energy flows can be better controlled and managed. This creates opportunities to:

- Implement demand response programs
- More efficiently integrate distributed generation and storage of energy
- Develop new products, services and markets
- Increase the flexibility of the energy system
- Reduce or postpone infrastructure investments
- Guarantee the reliability of the electricity supply.

1.2 The rational for smart grids

In the future energy will become more scarce and more expensive. The share of PV is increasing, and potentially there will be an increased share of EVs, heat pumps and micro CHP. These developments create new opportunities for (local) energy management. New products and services can be developed to facilitate energy management at dwelling level. Residents may turn from passive users into more 'active' users, or even into prosumers. Acceptance will be key to realize these changing roles. To be prepared to changing demand and supply profiles, investment choices need to be made: either in grid reinforcement and peak generation capacity, or in adding intelligence to the grid to better match demand and supply at European / national and local level.

The vision of the Taskforce is that a large scale introduction of smart grids is not yet urgent, but cannot be avoided. And given the time horizon for grid investments, the first steps need to be made now. First steps would include small scale activities with real users, to learn, in order to be well-prepared and ready for a fundamental transition.

2 Smart Metering

2.1 Smart meter rollout

The Dutch government plans to have the current energy meters of households and small commercial consumers (<3x80A (E), <170.000 m3 (G)) to be replaced by smart meters, aiming at at least 80% of the meters to be replaced by 2020 (as required by the so-called Third Energy Package of the EU). In the Netherlands, these meter replacements will be carried out in two phases. The first phase is a 2-year 'trial period' (2012-2013), in which smart meters will only be applied in specific situations. After an evaluation, smart electricity and gas meters will be introduced in virtually all households in the subsequent period (likely to be a period of six years).

The legislation regarding smart metering has been stipulated in the Dutch Electricity Act and the Gas Act, after amendment of these Acts in 2011. The original idea of a legal obligation for everyone to accept the smart meter has been revoked, after a number of problems arose around the privacy aspects on the use of the smart meter. Consumers who do not want that their meters are read remotely now have the option either to refuse the meter or accept the meter but block the remote reading facility (called 'administrative off'). With these measures a freedom of choice (opt-out) was created for the consumer, that was requested by most of the political parties in the Dutch Parliament.

The roll out of smart meters in the Netherlands started in 2012. The current rollout takes place at a limited scale: only in specific situations smart meters are offered, viz.:

- in case the current meters need to be replaced (regular replacement)
- in new buildings
- in case of large scale renovation
- in case the energy performance of buildings is improved by at least two label steps
- if a residence is renovated up to at least energy class B (of the energy label)
- on request of customers (only in this case 60 euros will be billed to the customer).

Reason to choose for a limited rollout, is to gain experience before initiating the large scale rollout. By the end of 2013 it will be decided, based upon the gained experiences until then, if and how a large scale rollout will be carried out. The aim is to offer smart meters to all households from 2014 onwards.

2.2 Smart metering functionality

Minimum functionality of the smart meters are determined at EU level. In March 2009, the European Commission issued a mandate (M/441) for the standardization of smart metering functionalities and communication for usage in Europe for electricity, gas, heat and water applications that require the standardization process to ensure interoperability of technologies and applications within a harmonised European market.

In the Netherlands the functionality of a ‘standard smart meter’ has been discussed and determined already in 2007. This has been done under the supervision of the Dutch Standardization Institute (NEN). These discussions among different parties in the energy industry have resulted in a so-called ‘Dutch Technical Agreement’ in this area (NTA 8130), which later was expanded with the 'Dutch Smart Meter Requirements' (DSMR) under the control of the Dutch Association of Grid Companies ("Netbeheer Nederland").

In the Dutch Electricity Act and the Gas Act it is determined that the requirements of meter reading installations shall be defined in an implementing regulation (Algemene Maatregel van Bestuur - AMvB). Early 2012 , the requirements for smart meters have been defined in the 'Decision on meters that enable remote reading' ('Besluit op afstand uitleesbare meetinrichtingen’). In summary, smart meters shall be able to register both electricity consumption from the grid and supply to the grid, send values with a 15 minute interval to the grid company (DNO), register the quality of the electricity supply and the metrological quality of the meter, detect fraud, and should enable remote disruption, reduction, and reconnection of the electricity supply.

Meters that are designed according the NTA 8130 and DSMR meet all the requirements of the AMvB.

2.2.1 Access to data, Summary of Smart Metering Functionality and access to, and ownership of, Smart Meter data

Dutch meters designed according the NTA8130 and DSMR will have three data ports, visualised in Figure 1. This figure shows a schematic overview of the smart metering infrastructure as provided for in the current Dutch standards. The law does not stipulate a specific communication infrastructure; although 'open' communication standards will have to be used, the grid operator is free to decide on the infrastructure, provided it complies with the privacy and security regulations.

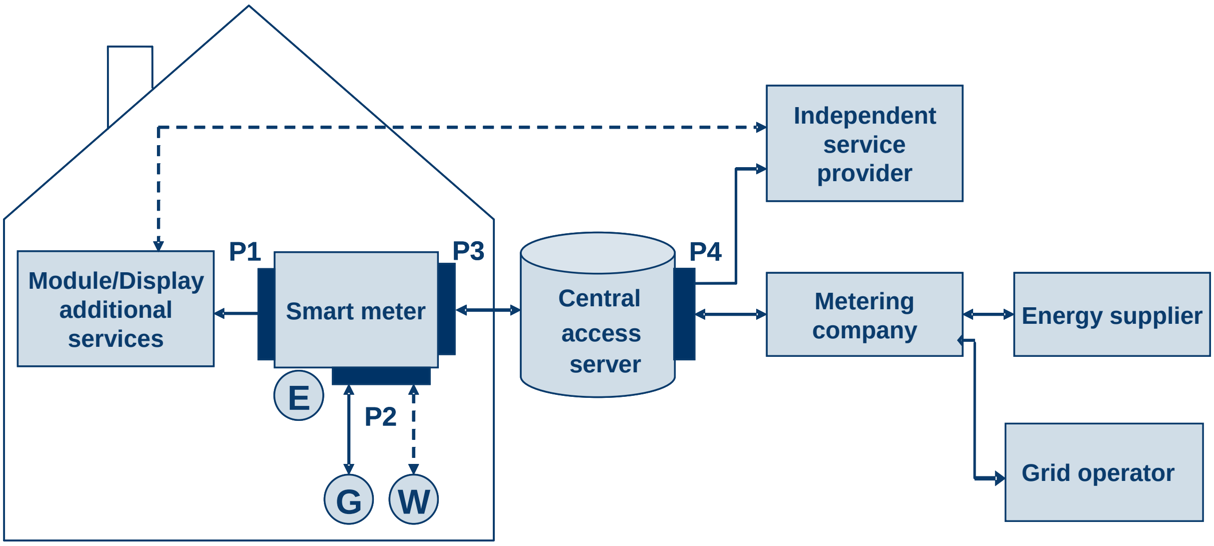


Figure 1 Intelligent metering infrastructure (based on NTA8130)[1].

The smart meter in Figure 1 is an electricity meter with modular information and communication technology. The meter can be controlled remotely by the DNO. From the P3 port data are collected in the central access server. The P3 port can also be used by the ISP and the supplier to send messages to the meter, to remotely change control software of the meter and to disrupt or recover supply of energy remotely.

Other interfaces are the P1 and P2 ports. The P2 port enables connection of other meters (e.g. for heat, gas, water, cooling). Data from these meters will be collected – via the P3 port – in the central access server. P1 is the 'consumer' port or local port, providing access to metering data at 10 seconds intervals (electricity, gas data has hourly intervals). Information from the various meters (not only the electricity meter, but meters connected via the P2 port as well) can be sent to the consumer via the P1 port. By connecting a so called in-home display to the P1-port, metering data can be visualized.

The P4 interface is a system interface, providing independent service providers access to the central access server. Independent service providers need explicit permission from the consumer to get access to the metering data.

As mentioned earlier, initially a law was proposed in the Netherlands that would oblige all consumers to accept a smart meter. Refusing a smart meter during the rollout would mean the risk of imprisonment. This proposal was not approved and in the current, new Electricity Act

[1] The figure is based on a figure published in NTA 8130, but adapted according to the latest developments related to data access

opting out is an option. Consumers that accept a smart meter, can choose between three modes (see also Table 1):

- remote data reading is 'switched off',
- metering reading takes place only every second month (and in case of moving houses or switching supplier), or
- detailed meter reading: collection of quarterly hour data on a daily basis.

The second option is the standard option.

Table 1 gives an overview of the various options and the associated functionalities. The option to have the meter turned to ‘administrative off’ should minimize the number of refusers. In the ‘administrative off’ setting the consumer port (P1) can still be used, so that the consumer himself does have access to accurate meter data. However, in this setting the consumer cannot be disconnected remotely. The option to select ‘administrative off’ will undoubtedly lower the threshold for choosing a smart meter.

Table 1: Overview of the functionalities of the smart meter in the various settings.

Functionality	conven-tional meter	smart meter		
		Administrative off	standard reading	detailed reading
remote disconnection or usage limitation	✘	✘	✓	✓
metrological control of the meter	✘	✓	✓	✓
technical control of the grid	✘	✘	✓	✓
bi-monthly reading and at the time of moving house or changing suppliers	✘	✘	✓	✓
frequent reading (e.g. 15-minute values) and tariff management	✘	✘	✘	✓
meter data locally available (P1)	✘	✓	✓	✓
connection to other meters (P2)	✘	✓	✓	✓

Functionalities that are not self-explanatory are explained briefly below:

- remote disconnection and usage limitation: the grid operator has the option to centrally control the meter so that it will allow no electricity or only a limited amount of electricity to get through (gas also has a disconnect, but no limitation)
- metrological control: control and maintenance of the meter (among others reading of the meter status (battery, alarms, error messages), firmware updates, date and time synchronization and recording changes between the various settings ‘administrative off’, ‘standard reading’ and ‘detailed reading’)

- technical control of the grid: reading the metering values and the fault register to monitor the quality of the electricity supply (power quality, short and long-term interruptions of the energy supply)
- tariff management: the possibility to (in theory) charge a variable, time-dependent tariff and to send information to the local port. More about the current tariff structure in the Netherlands can be read in Chapter 4.

2.2.2 Smart Metering and financial settlement of electricity consumption

In case of conventional meters, electricity consumption data (meter reading data) are gathered by the DNO. These data are shared with the electricity suppliers for billing purposes. Data used for billing are either coming from meter reading (often done by the customer him or herself), or from estimations (in case the customer doesn't reply to the request for metering data). Meter reading only takes place once a year. Physical meter reads by the metering company (DNO) only take place once every three years.

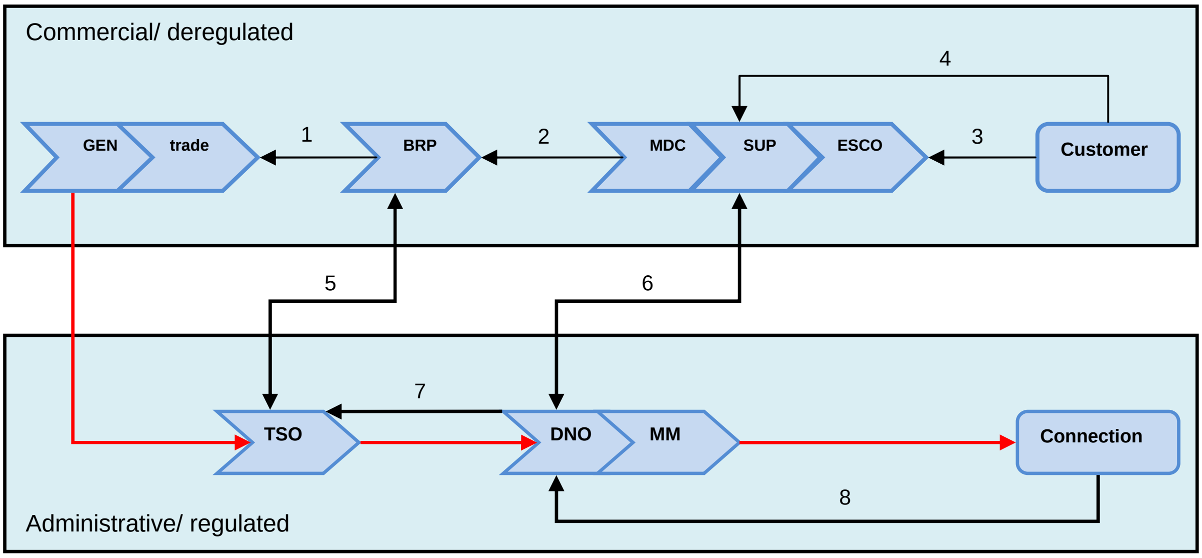
Currently (small size) consumers can opt for a separate bill from the DNO and the supplier, but in most cases an integrated bill is sent by the supplier which includes also the grid company's costs. In the near future (as from Spring 2013) an integrated bill will become the only option.

In the case of smart meters, the quality of the data used for billing will improve, as actual consumption data can be used instead of estimations. In case a smart meter is installed, and the consumer opted for ‘standard meter reading’ (see Table 1) bi-monthly consumption overviews will be sent to the customers. However, actual billing will (as currently foreseen) remain on a yearly base.

3 Electricity market structure

3.1 Stakeholders

Market roles refer to the business functional areas in the energy supply chain. Market roles own the business requirements. A description of the energy supply chain is presented in Figure 2 with an explanation of the different market roles described in Table 2. In Figure 2, a distinction between the regulated and the deregulated domains has been indicated. This distinction can be traced back to European legislation[2].



Market roles		Relationships
GEN	= generator	1= Sourcing
TRADE		2= Procurement
BRP	= balance responsible party	3= Services contact
MDC	= metering data collection	4= Supply contract
SUP	= supplier	5= Admission contract
ESCO	= energy service company	6= Admission contract
TSO	= transmission system operator	7= Cooperation contract
DNO	= distribution network operator	8= Connection contract
MM	= meter management*	

* for large consumers meter management is deregulated

Figure 2 Market roles, source: DNV KEMA 2012

[2] See for example regulation 2003/54/EC "on common rules for the internal electricity market" (which amended regulation 96/92/EC).

Table 1 Stakeholders involved in generation, distribution and supply of electricity

Role	Short Description	Current responsibilities
Generators	Generators produce electricity. Electricity is most often generated at a power station by electromechanical generators, primarily driven by heat engines. However, many other technologies exist that are currently in use to generate electricity such as combined heat-power installations, sustainable energy (from wind, sun, water and bio-mass) and geothermal power.	There are currently 5 large ones and various small ones. Generators report unit characteristics (e.g. availability, cost price, reliability, fuel type) to the Balance Responsible Party.
Energy suppliers	Suppliers are responsible for selling electricity (and often gas) to the end consumer	Suppliers are the commercial and administrative link with the customers. Suppliers make the contractual arrangements for the supply of energy products to the customers, invoices and collect the fees. Most companies supply both gas and electricity. Customers receive just one invoice for energy. The supplier invoices the cost of the use of the network. Suppliers settle accounts with the network management companies and finances in advance. Finally, suppliers may be willing to offer new services to their customers, such as TOU tariffs.
Trade	Traders purchase electricity from suppliers and sell to authorized users.	Traders are the middlemen trading power in a market with fluctuation supply, demand and pricing through time.
Transmission System Operator (TSO)	The TSO is responsible for transmission and system operations of the high voltage grid.	The TSO is responsible for maintaining and restoring the energy balance of the grid, to transport electricity, to guarantee that the transmission of electricity occurs in a safe and efficient manner, to connect large generators (and large consumers) to the grid and ensures connection with foreign networks and auctions available import capacity. It also manages international flows (imports, exports and transits) on its grid.

Distribution Network Operator (DNO)	DNOs are responsible to ensure security of supply for all connections at the lowest cost level as possible.	Regional network operators (DNOs) transport electricity to customers from the grid. Traditionally, the tasks and responsibilities of distribution network operators include the expansion and operation of the distribution network, maintenance of the network and admission of suppliers to the network. There are approx. 7 DNOs in the NLs. With more dispersed and intermittent power in the future, the role of the DNO is likely to change coming years.
Balance Responsible Party (BRP)	BRPs balance supply and demand for electricity for the following day to prevent underload or overload of the transport and distribution grid and contribute to maintaining balance in the electricity supply system. This is a consequence of legal responsibilities towards customers on the grid.	Based on the programs submitted by the BRPs daily, the TSO and DNOs can facilitate transport and distribution on the grid and are able to correct any imbalance and charge for the costs of doing so.
Measurement Responsible Party	Measure, transfer and register measurement data	The tasks and responsibilities of the MDC include: -reading and collection of consumption and production data from customers -processing the data; a.o. (technical) checks on availability -plausibility check of data -aggregation of the data -make the data available to different market parties
Meter management		The tasks and responsibilities within this role include: -installing and connecting energy meters (including communication facilities in case of 'smart meters' being installed3) -maintenance of the energy meters (and communication facilities).
ESCo	An ESCo is a professional business providing a broad range of comprehensive energy related services.	In the European directive on "energy end-use efficiency and energy services" (2006/32/EC), an ESCO has been defined as "a natural or legal person that delivers energy services and/or other energy efficiency improvement measures in a user's facility or premises, and accepts some degree of financial risk in so doing. The payment for the services delivered can be based (either wholly or in part) on the achievement of energy efficiency improvements and on the meeting of the other agreed performance criteria".

[3] Could also be put under market role 7 (MDC).

Table 2 Stakeholders involved in policy setting and regulation

Stakeholder	Short Description
Regulator (Nma Energiekamer)	Regulators supervise the operation of the energy market.
Ministry of Economic Affairs, Agriculture and Innovation	Electricity and gas law

3.2 Market Maps

3.2.1 Physical power flows

Figure 3 illustrates the potential power flows between actors at various voltage levels. At each of the levels (high voltage, middle voltage and low voltage) energy can be generated and consumed.

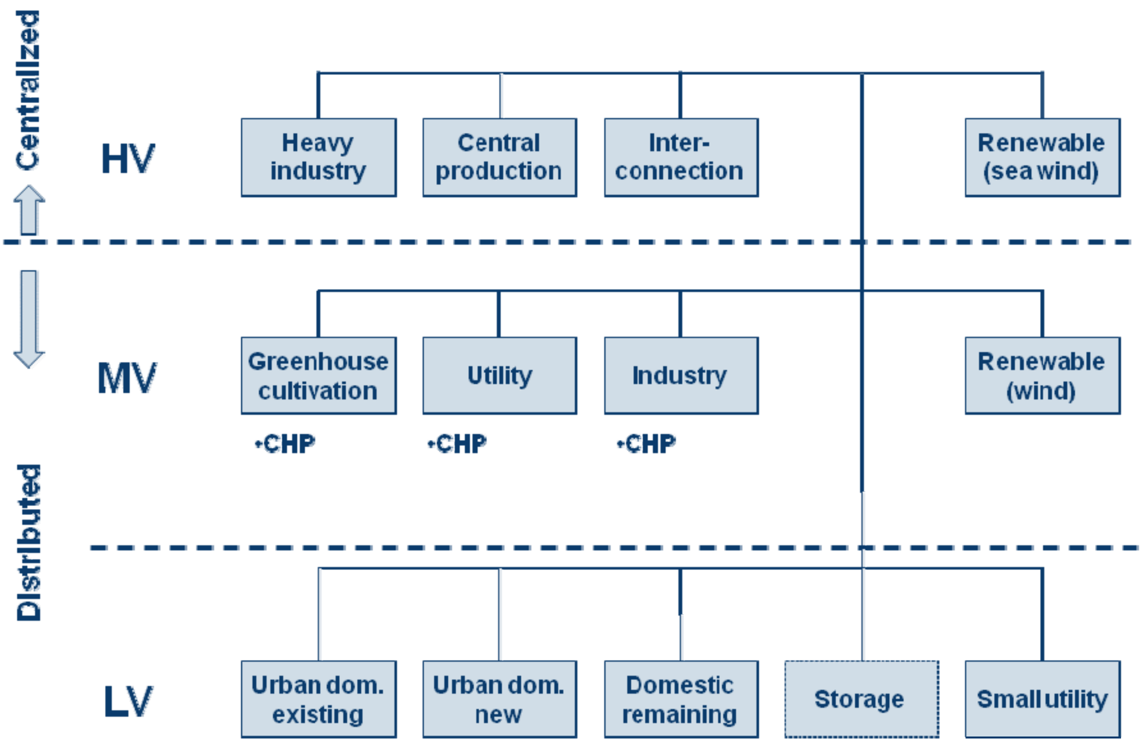


Figure 3 Grid model

3.2.2 Energy purchasing: a description of the market

Retail market
At the retail market, energy supply companies (retailers) sell energy to the small and medium size companies. To be allowed to sell energy to small and medium size customers, suppliers need to have a license.

Wholesale market
Large consumers, large generators and suppliers act at the wholesale market. In order to trade at the wholesale market actors need to be a Balance Responsible Party, or to have transferred their responsibility to a Balance Responsible Party (BRP). BRPs need to be accredited by Tennet, the TSO. An exception is made for Traders, they don't need to be (represented by) a BRP. They have no physical demand or supply to offer and their portfolio is always balanced by default (see also Figure 4).

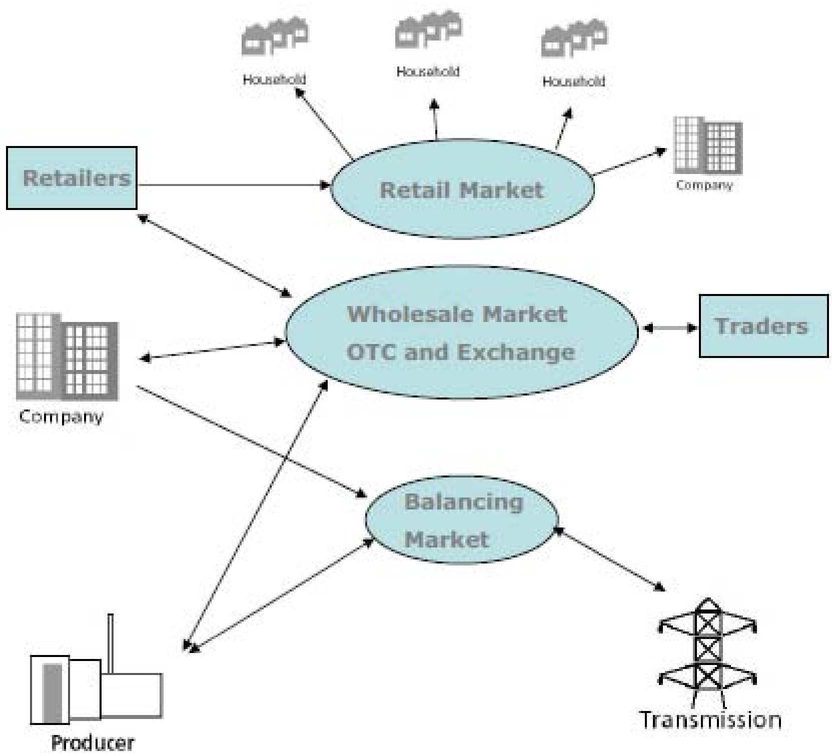


Figure 4 Financial market map(source APX-ENDEX)

BPRs and their responsibilities
BPRs can be large producers, large consumers (or combinations of them). For small consumers, the role of BPR is fulfilled by supply companies. BPRs have the responsibility to

forecast the consumption, production and transportation of electricity for the actors they represent, and to submit programs one day in advance to Tennet (TSO) (see also Figure 5). To the extent that the amount of electricity generated or required, has not be met yet by longer term contracts, it can be covered by trading at the power exchange (day ahead market, APX) or by Spot OTC contracts. At the APX day ahead market (or spot market) electricity is traded for the next day on an hourly basis, with only one price for each hour. Prices can be highly volatile. Shares of the APX spot market are owned by TenneT, while the shares of the forward markets are privately owned.

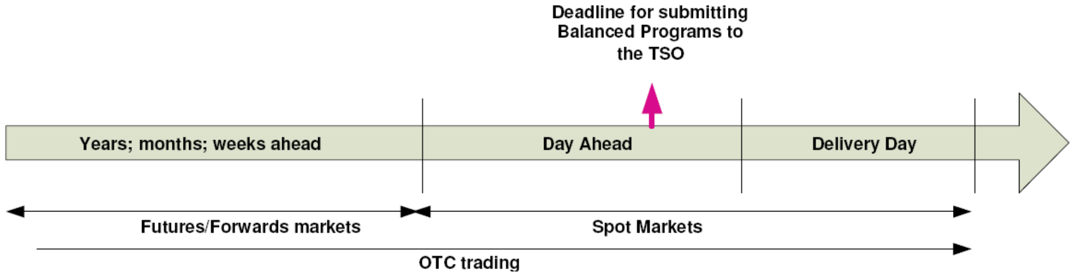


Figure 5 Overview of wholesale market (source APX-ENDEX)

Programs submitted by the BPRs can be corrected intraday, up to one hour in advance at the intraday market (see Figure 6). In case programs (forecast submitted by the BPRs) are not met, Tennet will buy flexibility at the Balancing market to keep the system technically in balance. Flexibility includes both

- additional generation capacity or switching off of large consumption units (in case demand is higher than supply) and
- reduction of generation capacity and/or switching on of consumption units (in case supply is higher than demand)

The costs related to buying these flexible generation and demand units to keep the system technically in balance, will be billed to the BRPs that caused the imbalance due to deviations from their submitted programs. However, recently it has become possible to avoid billing by the TSO due to deviations from the program, by ex-post trading (in a given period between real-time and actual billing by the TSO).

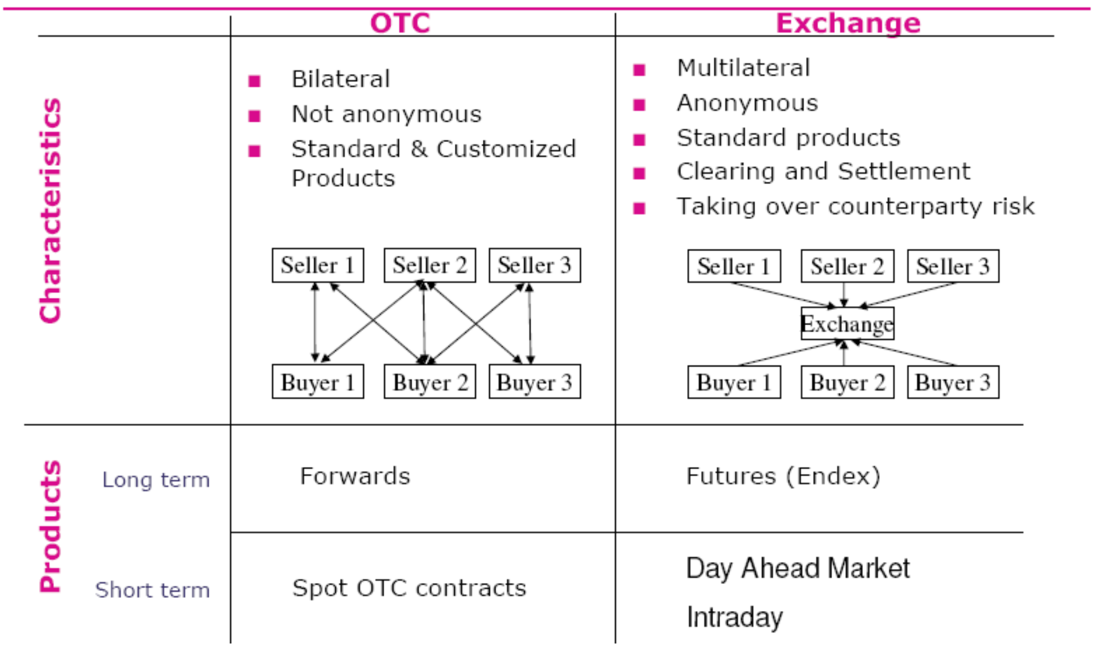


Figure 6 Wholesale market and products(source APX-ENDEX

The largest volume of electricity, about 85% in the Netherlands, is sold in the 'bilateral'market: electricity is directly sold by generating companies to their customers.

3.2.3 Network charges: a description of the market

Costs made by the network operator to transport electricity, to maintain the grid, to disconnect customers, etc are billed to the customer as ‘network charges’. These charges exist out of three components:

- connection services
    - cost for initial connection (billed only once)
    - periodic tariff for maintaining the connection
- transport services
    - transport – dependent tariff
    - transport – independent tariff
- system services
    - system services tariff

Costs related to transport service include costs of depreciation of the grid infrastructure, a ‘fair’ return on the investment of the grid infrastructure, costs for realisation and maintenance of the grid infrastructure, costs related to grid losses and maintaining the required voltage levels, cascaded costs from the grid at higher voltage levels and operational costs.

Costs for transport and system services are billed to customers based on a cascade model. This means that costs made at higher voltage levels are charged to a grid with a lower voltage level, according to its usage of energy and/or capacity of this last mentioned grid as share of the total energy and/or capacity usage at the higher level. Finally, costs are charged to the customers connected to the grid.

Grid charges for small customers (<3*80A) are based on a capacity tariff. So grid charges for small customers are not related to actual consumption, but to the capacity of their connection. In the capacity tariff no distinction is made between customers that only consume energy, and customers that both consume and produce electricity (prosumers).

4 Tariff structures

The development of total energy costs for residential customers over time and their breakdown is shown in Figure 7. As Figure 7 shows, the larger share of costs on the electricity bill are related to taxes (VAT and energy taxes) and network charges. Costs for the actual electricity supplied form about one third of the total costs charged for electricity. Not included in Figure 7, but charged separately at the electricity bill, are metering costs.

Of the total costs charged to the customer, only the delivery rates are set in a competitive market. Network charges are regulated (see paragraph on network charges). For small customers (customers with a connection capacity of maximum of 3x80 A), metering costs are regulated as well, for larger customers they are not. Energy taxes are based on a fixed amount, VAT is based on a fixed percentage of all other costs.

The electricity price in the Netherlands is dependent on the length and type of the contract. In the first quarter of 2012 the average electricity prices for residential customers, including taxes and network charges, varied between 0.260 and 0.301 Euro per kWh[4] (excluding VAT). An additional cost on the electricity bill of residential customers is '*vastrecht*'. This cost component is fixed part of the electricity supply and is charged by the electricity suppliers. Each supplier can freely set the amount of the cost . The cost varies between 20 and 60 Euro per year. Most suppliers have a *vastrecht* component of about 25 Euro, some have a higher *vastrecht* in combination with lower electricity prices.

Network charges for small connections are independent of the amount of electricity used (but may depend on the capacity of the connection) and consist of four types of charges:

- annual connection costs,
- annual transportation costs
- capacity based transportation costs and
- system service costs.

The network charges are a regulated cost, the NMa checks the method of cost allocation used by the grid companies periodically. System service cost are 0.00111 EUR/kWh. For small consumers they are based on a fixed electricity consumption. Currently the total network charges are around 230 Euro[5] per year, excluding VAT.

[4] Source: cbs.nl
[5] Source: http://www.easyswitch.nl/energie/vergelijk-energie

Metering costs are regulated costs. The NMa decides on the tariff annually. Since 2008, the metering tariff is indexed, based on inflation. There is one tariff for all small consumers. For 2012 the metering costs for residential customers are 26.38 Euro excluding VAT[6].

Energy taxes are base on a fixed amount per kWh and are depending on the amount of electricity used. For residential customers (< 10,000 kWh per year) the tax per kWh is 0.1140 Euro[7]. The Dutch government gives each residential customer a reduction on this energy tax of 379.16 Euro[8] per year. This reduction is for each connection. Finally a fixed VAT rate of 19% (21% from Oct 1 2012) needs to be paid on all components of the electricity bill.

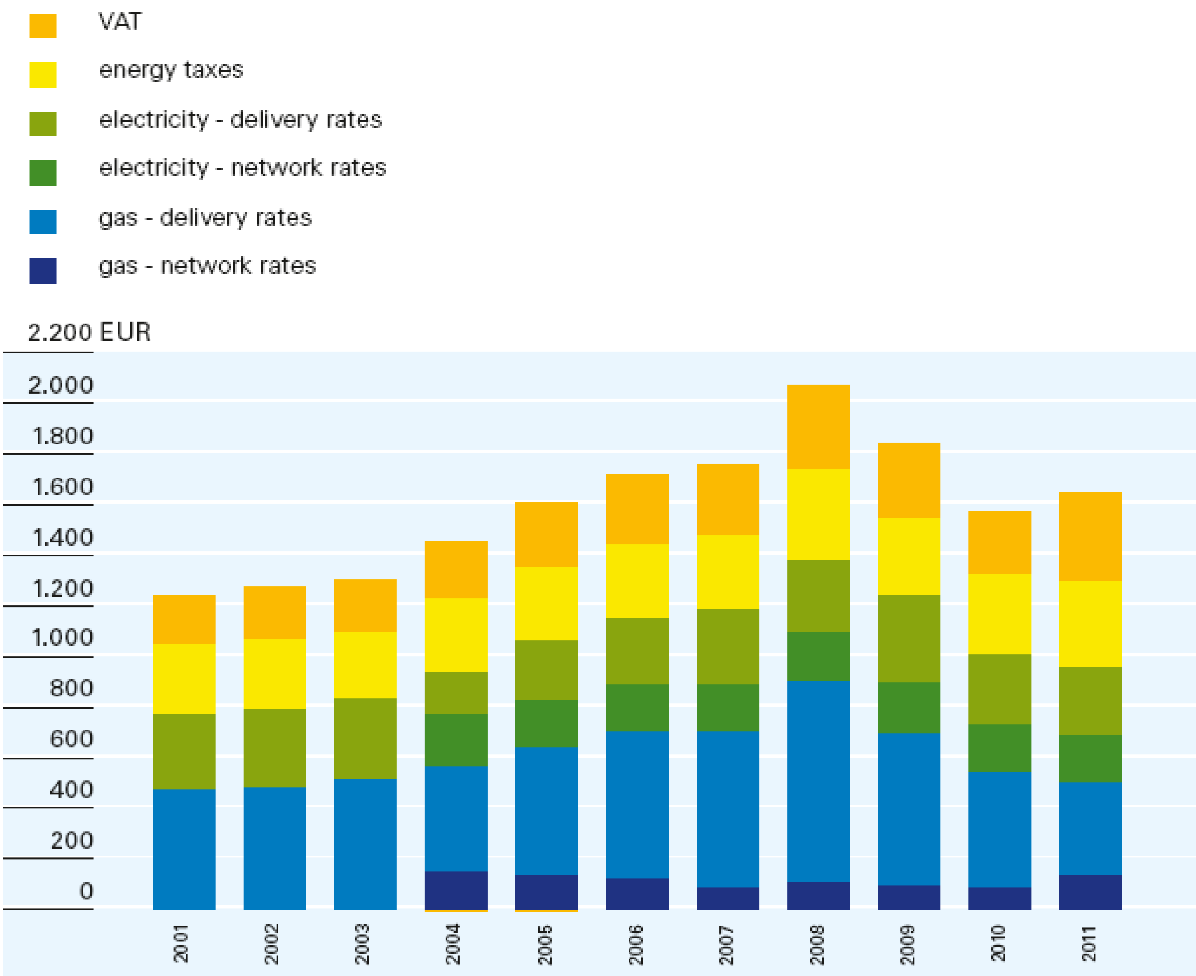


Figure 7, Components of the annual energy bill of an average household (Source:Energie in Nederland 2011)

[6] Source: Besluit tot vaststelling meettarieven elektriciteit 2012, NMa, 8-11-2011
[7] Source: http://www.energieleveranciers.nl/energie/energierekening/energiebelasting
[8] Source: http://www.energieleveranciers.nl/energie/energierekening/heffingskorting-energiebelasting

Currently (small size) consumers can opt for a separate bill from the DNO and the supplier, but in most cases an integrated bill is sent by the supplier which includes also the grid company's costs. In the near future (as from Spring 2013) an integrated bill will become the only option. Bills are sent yearly and are based on meter reading by the customer, or on an estimated consumption. Only every three year actual meter reading by the metering company (DNO) takes place. In the case of smart meters, the quality of the data used for billing will improve, as actual consumption data can be used instead of estimations. In case a smart meter is installed, and the consumer opted for 'standard meter reading' (see Table 1) bi-monthly consumption overviews will be sent to the customers. However, actual billing will remain on a yearly base.
In the energy market, electricity consumption for small customers is settled based on profiles.

The electricity consumption for small customers is settled on the wholesale market through the use of synthetic profiles. For households three profiles exists (1x single tariff, 2x double tariff with different switch times). For SME 2 different profiles exist. The profiles have been determined by measuring a set of representative customers.

Common belief is that these synthetic profiles are not suitable to support dynamic demand response, therefore several market parties are studying the concept of "smart meter allocation", which allows a set of connections with smart meters, to be settled on a quarter-of-an-hour basis on the wholesale market.   Changes to the market organization are needed to accomplish this, therefore it may take a few years to realize.

Appendix II: Norway National Report

The Impact of Electricity Markets on Customers

Prepared by Even Bjørnstad
National Expert for Norway

Nov. 2012

International Energy Agency Demand-Side Management Programme
Task XXIII: The Role of Customers in Delivering Effective Smart Grids

Acknowledgements

Contributions to this document by Emilie Nærum Everett at NVE are greatly appreciated.

Glossary

Enova: the Norwegian agency for energy efficiency and renewable energy

NVE: Norwegian Water Resources and Energy Directorate

Stortinget: the Norwegian parliament

Contents

1 Smart Grid Drivers and Definitions

Drivers

In the Norwegian market it is natural to view the development of smart grids as a two stage process.

1. A mandatory national roll out of an automatic metering infrastructure, replacing old, mechanical electricity meters with so called smart meters.
2. A market based development and deployment of "smart" technologies and services, resulting in a smarter grid.

Consultation papers associated with introducing a mandatory roll out of smart meters in the regulation on electricity metering and billing (FOR-1999-03-11-301) states the main purposes as:
- More accurate billing
- Provide necessary information to end user for management of own electricity use
- Increase the possibility for network owner to improve network efficiency

The same regulation also specifies the functional requirements of AMS (see Chapter 2)

Since smart meters are yet not installed in general in the Norwegian market (see deployment plan below), the concept "smart grid" is not commonly known, nor well developed. The public discussion still focus more on smart meters than on the concept of smart grids, even though a number of local pilot areas for smart grid deployment have been developed.

Circumventing network limitations is one motivation for introducing smart meters and smart grids in Norway. One characteristic of electricity end-use in Norway is that a relatively large share is used for direct space heating in homes and other buildings. This situation has historical reasons, which we will not detail here. As a consequence, a typical Norwegian winter, with periods of cold weather and little inflow to water dams, may imply high strains on the power network. Adding to these seasonal load variations the typical within day peaks results in peak hours where most of the capacity of the network is used. Finding ways to reduce these loads will increase the security of supply, without having to undertake large network investments, thus is an important strategic driver for smart grids in Norway.

Despite this situation, network companies can hardly be said to be a driving force in introducing a smarter grid. Steps taken by the national regulation authority, influenced by the development on a European level, has until now been the main driving force. The deployment of smart meters is mainly mandated by regulation, with network companies obeying somewhat hesitantly. This hesitancy is not hard to understand, large investments in unknown technologies are involved, technical standards are not well established, which is resulting in a risk linked to being among the "first movers".

The awareness of electricity use and electricity costs is generally low among "ordinary" electricity customers (households, small businesses). Such awareness usually rises during the occasional periods of cold weather, limited supply and high prices, however the general situation is one where the electricity price is relatively low. Some end-users and their interest organizations have shown interest in the smart meter deployment, and also in the smart grid concept, however energy consumers are not regarded a driving force behind smart grid development.

In addition to what is discussed above, the following are also considered drivers for a full-scale roll out of smart metering and development of smart grid:
- Facilitating the integration of distributed renewable energy sources and energy storage
- Improved economic efficiency
- Necessary modernisation of the energy system.

Smart Grid definition
No one formal definition of the Smart Grid concept seems to exist. The definition is more implied by the descriptions of the concept offered by different actors engaged in smart grid development.

The Norwegian Smartgrid Centre is a leading actor in the field, and at their internet site the following elements concerning Smart Grids are discussed:
- Development from the old, traditional electricity network, with a few large and centralised generation nodes and well defined end users, towards a more complex structure, with increased amounts of distributed generation, new, and often more volatile, energy sources such as wind and PV, and increased amounts of embedded generation.
- From an increased structural complexity follows a need for more advanced control systems and data management, and also an increased flexibility in the way the network is operated.
- Smart Meters automatically sends consumption data at a high time-resolution to the DSO. Meters also receive real-time price information that can aid the end-user in controlling his own consumption.
- Cutting peak loads may be facilitated by a smarter network infrastructure.
- Surveillance and remote controlling gives better information about the state of the components and facilitates maintenance and handling of network malfunctions.

(Source: http://www.smartgrids.no/content/36/Hvorfor-smartgrid)

From the Smartgrid Centre Mini ABC we read the following on smart grids:
- The electrical energy system of the future
- A quantum leap in integration of ICT at all levels in the power system
- A fusion of the power network and the internet
- A system where all appliances and end users have an IP address enabling monitoring and management via the internet
- Will affect us all.

(Source: http://www.smartgrids.no/miniabc/)

A prominent researcher in the field, Kjell Sand from the research institution SINTEF Energy, describes the smart grid as:
"An electrical power network that exploits two-way communication, distributed metering- and management systems, new sensor technologies and end user load management".
(http://www.energinorge.no/getfile.php/FILER/KALENDER/Foredrag%202011/SmartGrid/Temadag-EnergiNorge_2011_02-03.pdf

One of the Norwegian pilot projects on smart grids, “Demo Steinkjer” in North-Trøndelag county, states as the main goals in introducing smart grids to reduce:
- power peaks
- bottlenecks
- price peaks
- power outages.

And, in addition:
- balance regional congestion in the power network, and minimize bottlenecks
- automation of demand - response

- seamless integration of distributed generation
- smarter operation of the distribution network.

The different descriptions above give content to the term smart grid and are probably the closest we come a Norwegian definition.

2 Smart Metering

The Norwegian Water Resources and Energy Directorate (NVE) is the regulating authority for the Norwegian electricity market. Requirements for smart meters, collection of meter readings and access to the metering data are since June 2011 regulated by NVE in Regulation concerning Metering, Settlement and Co-ordinated Action in connection with Electricity Trading and Invoicing of Network Services (FOR 1999-03-11 nr 301)[1].

Before the new smart meter regulation came into force, all measuring points with an expected annual electricity consumption above 100 000 kWh have already installed automatic meters. In addition, 30 DSOs had already installed automatic meters in their respective concession areas. However these meters do not fulfil all the requirements specified by new smart meter regulations.

NVE's decision to impose a mandatory full-scale smart meter roll out is based on an assessment that the overall benefits outweigh the costs and inconvenience to society. In concrete terms smart metering will help achieve the main goals for the Norwegian Energy Act.

Norwegian Distribution System Operators (DSOs) have developed a plan for the rollout of smart meters. Final deadline for presenting this plan to NVE was January 1, 2012. DSOs are also required to submit annual progress reports on the rollout to NVE. The roll out plan is as following:

- By 1. January 2016 the network companies shall have installed AMS in at least 80 % of their metering points.
- By 1. January 2017 all metering points shall be equipped with smart meters.

§ 4-2 in FOR 1999-03-11 nr 301 regulates the functional requirements of the meters, and states that the smart metering system shall:

a) Store meter readings with a maximum recording interval of 60 minutes, and be adjustable to a minimum recording interval of 15 minutes
b) Provide a standardized interface that facilitates communication with external equipment based on open standards
c) Be able to connect to, and communicate with, other types of meters
d) Ensure that stored data are not lost at power outages
e) Be able to disconnect or limit power load outtake at the individual metering point, except for end uses measured at the transformer
f) Be able to send and receive information on power prices and tariffs, in addition to transmit steering signals and ground fault signals
g) Provide security against misuse of data and unwanted access to steering functions
h) Record flows of active (real) and reactive power in both directions.

The most immediate effect for end-users of a smart meter installation is that the need for manual meter readings and reporting vanishes. For the DSO, and the electricity supplier, an observed (and not estimated) time distribution of electricity consumption becomes available – down to one hour resolution. This enables more accurate power pricing and network tariff structures, better reflecting peak electricity prices and the network cost of peak loads.

[1] FOR 1999-03-11 nr 301: Forskrift om måling, avregning og samordnet opptreden ved kraftomsetning og fakturering av netttjenester

New and more flexible pricing and network tariff structures increase the opportunities for consumers of electricity to realize financial gains by demand response (or behavioural changes), but the role played by the electricity consumer (end user) also becomes potentially more complicated.

3 Electricity market structure

3.1 Stakeholders

The Norwegian electricity market is the result of the post-war industrial development in which the utilization of national waterfall resources played a central role. Until the last decade practically all electricity production in Norway was hydropower. Utilization of large remaining hydropower resources are in conflict with environmental or other social interests, thus further development along this track is limited. As a consequence, smaller scale hydropower, wind power and other alternatives are being developed.

The Norwegian power market has been formally open to competition since 1991, but real market access for all the end user groups was not established until 1995 through settlement based on the adjusted system load profile.

There are, as of today, four main functions in the electricity market:

i) Production of electricity
ii) Transmission and distribution of electricity
iii) Supplying electricity to end-users
iv) Market place for electricity trade

i) Electricity producers
These are actors who own and operate production installations (hydropower, windpower, etc.) and who deliver the power to the network. Producers may sell the power in different contractual arrangements. Bilateral contracts between seller and buyer is one arrangement, day ahead sales at the hourly spot market is another.

Electricity producers need concession from the regulatory authority. The procedural requirements of achieving such a concession depends on many factors, e.g. production volume, type of energy resource, and social, economical and environmental impacts.

Currently (2012) there are 208 registered producers of electricity.

ii) Transmission networks and system operators
There are three levels of electricity network operation in Norway: Central transmission, regional transmission and final distribution.

The role of the central transmission network is to transport power between different regions of the country, and increasingly also handle import/export of the country. The central transmission network is operated by Statnett SF, the Transmission System Operator (TSO). Statnett also owns and develops most of the central network. Smaller parts of the central network are owned by other network companies, 21 in total. Large units of power intensive industry are often connected directly to the transmission network.

The regional transmission network transports power within the different regions of the country. There are 70 network companies owning and operating the regional network. Medium size industry and large businesses are in some cases connected directly to the regional transmission network.

The final distribution network connects the central and regional network to the end users. There are 149 companies involved in the distribution network, and the operating companies are called distribution system operators (DSO). DSOs install, own and are responsible for the meters at the point of end use.

Given the monopoly nature of network services, the operation and network tariff regimes are regulated by NVE.

iii) Electricity suppliers
These are companies who buy electricity from the market place Nord Pool Spot, or directly from producers through bilateral agreements, and resell to end users. Tariff structures and "packaging" of electricity is a competitive element of these operations.

Under the old market regime (before the liberalization of the electricity market) these three actor types above were often integrated in a single company. Today these functions are usually separated. At the moment there are close to 200 companies supplying electricity to end users in Norway.

iv) Market place
The Norwegian TSO, Statnett SF, established a market place in 1993, following the 1991 deregulation. Under the name Nord Pool this market developed further as the other Scandinavian countries joined, later also followed by Baltic states. Today, named Nord Pool Spot, this market arena represents the integration of the Nordic power market. This market is a day-ahead auction of hourly electricity volumes.

For further listing of market actors, consult the table below.

Table 1 Stakeholders involved in generation, distribution and supply of electricity

Stakeholder	Short Description	Current responsibilities
Statnett SF	Transmission System Operator	Develops, operates and owns the central network. Owned by the Norwegian state.
Energy suppliers	These companies are responsible for buying electricity on the market and selling to the end consumer.	There are currently ~200 licensed suppliers in Norway. All consumers have the right to choose their supplier and to switch at their discretion.
Network (grid) owners	Licensed owners of the regional and distribution networks	Around 70 companies are responsible for the regional network, while there are close to 150 licensed distribution network owners. Responsible for the physical infrastructure that is required to bring electricity from the transmission system to the point of end consumption. These companies are also responsible for metering.
Energy producers	Power stations, connected to the transmission system. Almost only hydro power stations.	Producers often lease waterfall rights with reservoir. Main responsibility is thus to manage their water resources in an optimal way within cycles of one year. Smaller hydropower producers are entering the market, as is wind generation. 208 licensed producers.

Nord Pool Spot	Electricity market place	Manages and coordinates all supply and demand "bids" from Nordic market actors in order to find the efficient hourly spot market price for the coming day.

Table 2 Stakeholders involved in policy setting and regulation

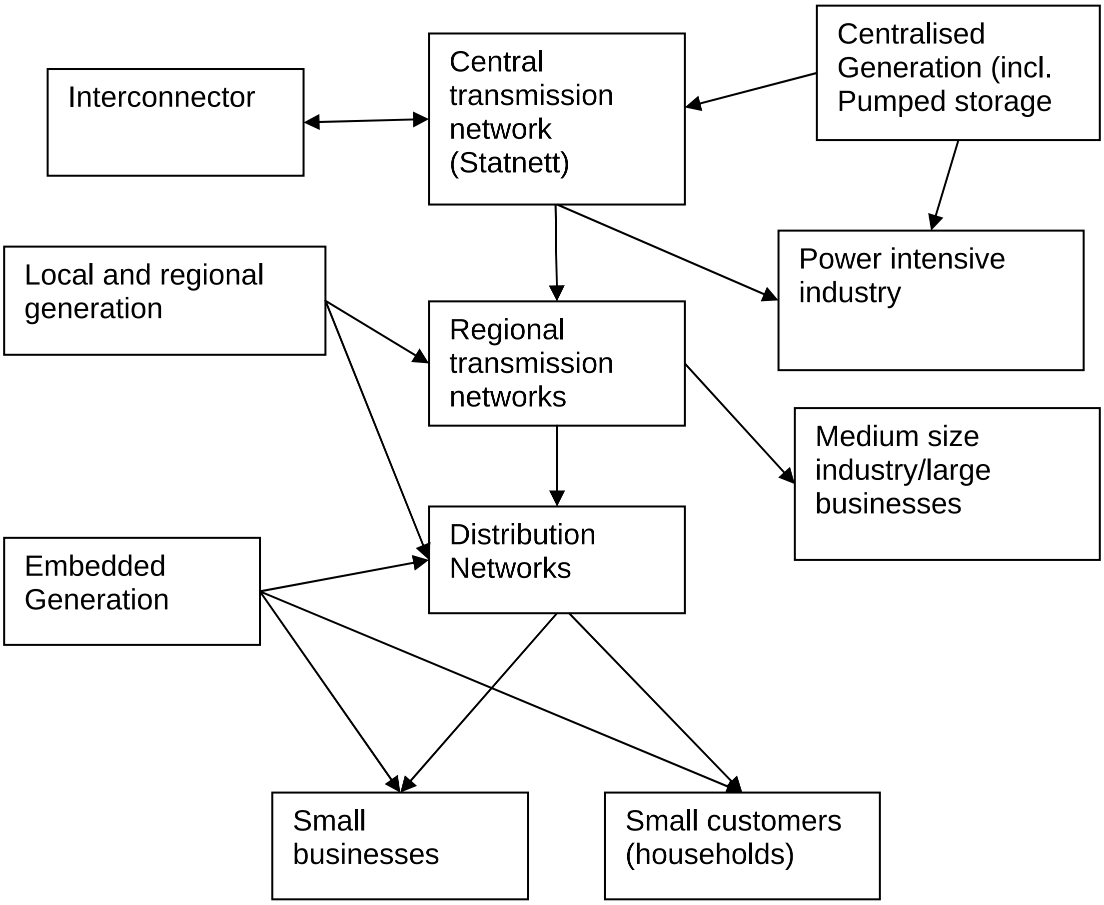
Stakeholder	Short Description
The Storting (parliament)	Sets the policy framework for national energy policies.
Ministry of Energy and Petroleum	Responsible for enacting national energy policies. Owns Statnett and Enova
Ministry of Local Government and Regional Development	Responsible for enacting national housing policies, including building regulations
NVE – Norwegian Water Resources and Energy Directorate	NVE is the regulator for the energy sector in Norway. Issues licenses to actors in the energy market. Regulates, among other issues, metering and pricing of network services.
Enova SF	National agency for energy efficiency. Responsible for designing programmes for end user energy efficiency, of which smart grids are part.

Table 3 Other Stakeholders

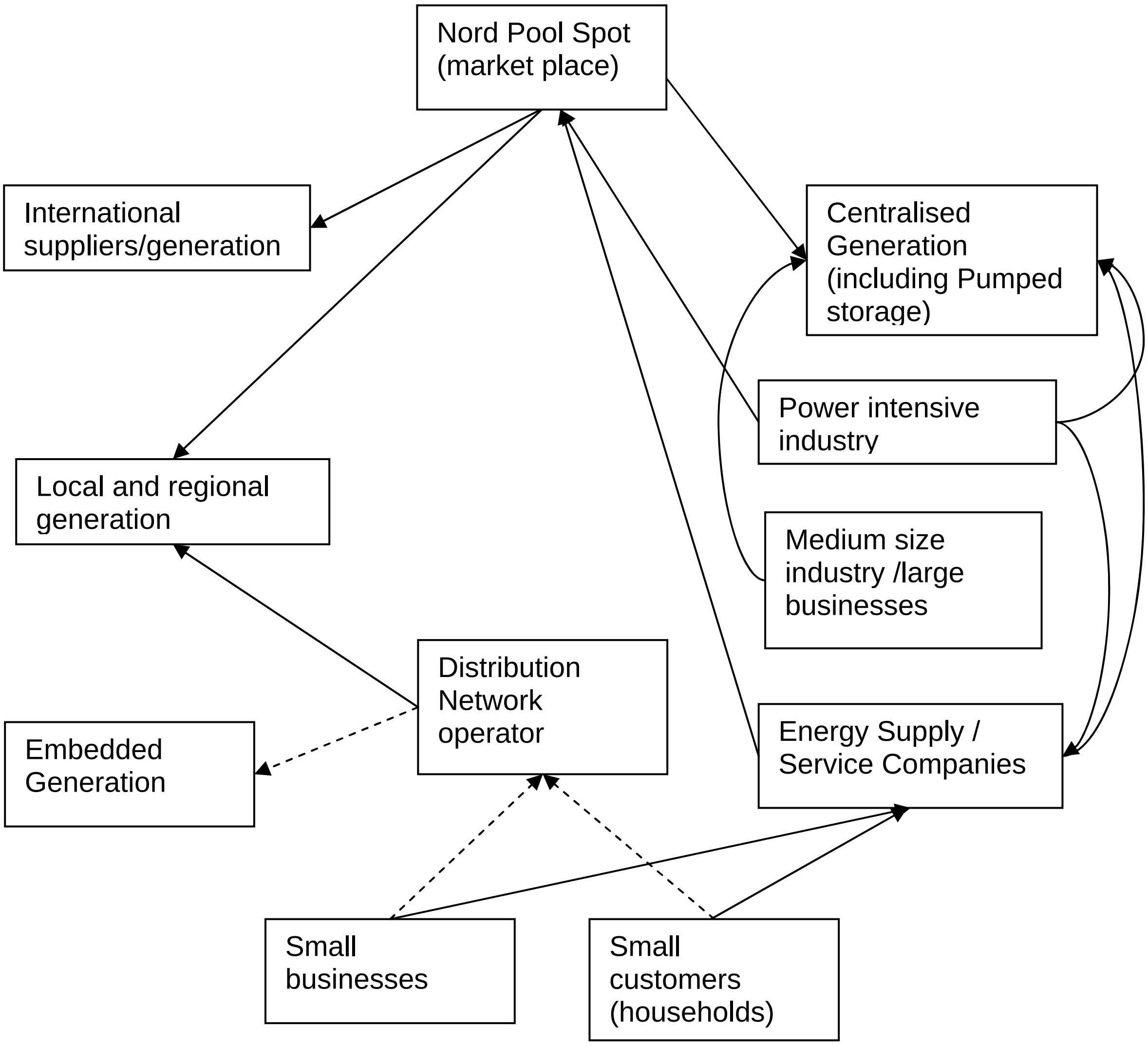
Stakeholder	Short Description / Current responsibilities
Appliance Manufacturers	Technologies for direct load control could be integrated into new appliances. This could offer manufacturers a unique selling point, enabling them to differentiate their offering from their competitors'. Some manufacturers have already announced that they are developing 'Smart Appliances' with this capability. A growing market is likely to encourage others into this space.
Appliance Suppliers	There are a wide range of organisations that supply appliances to small consumers in Norway, including department stores, large specialist retail chains, and independent retailers. Many of these will have a store, but an increasing number access the market through an online offering.
Consumer Electronics Trade Foundation	The Consumer Electronics Trade Foundation is a special interest organization for distributors and service companies in the consumer electronics industry in Norway. Around 1000 members.
Energy services companies	Third party energy services basing their products and services on the smart meter infrastructure
Norwegian Consumer Council	State financed and independent consumer protection interest organization.
Energy Norway – The Norwegian Electricity Industry Association	Energy Norway is a non-profit industry organization representing about 270 companies involved in the production, distribution and trading of electricity in Norway.
The Competition Authority	The Competition Authority's main task is to enforce competition legislation.
Elklagenemnda – The Electricity Appeal Board	The Electricity Appeal Board was established in accordance with an agreement between the Norwegian Electricity Industry Association (Energi Norge) and the Norwegian Consumer Council. The Board deals with complaints that have their origin in contract conditions between energy companies and

	consumers. Energy company here means network company and end-user company.
Back-office services	Back office services provide the support for utility companies' financial and customer relations administration. Capability to administer DSM transactions would need to be incorporated into these systems to enable the companies to manage the transactions relating to demand response programmes.
Building & Construction sector	Targets to develop 'Passive Houses', subsequently also 'Near Zero Energy' and even 'Energy plus' buildings are likely to drive this sector to investigating installation of low carbon technologies, including small scale and micro-generation, to meet required performance. DSM could allow the output from this generation to be used on-site, maximising the value to the owner/tenant and increasing the value to the developer.
Communications Infrastructure & Services	The companies provide communications services. The development of Smart/Advanced Metering will require communication functionality and it is likely to also be required for the development of DSM programmes. This sector is predominantly made up of a number of large, international players who may wish to become more active in the energy sector in light of these developments.
Consulting	There are a range of Consultants developing services in relation to the rollout of Smart Metering and DSM programmes. They are likely to look to provide additional support to existing parties, especially in areas where the utility has limited resources to assess opportunities, design programmes, etc.
IT Providers	The development of Smart Metering and Smart Grids is likely to be attractive to providers of IT solutions, particularly in relation to data management and storage.
Motor Manufacturers	Electric Vehicles are being developed by most major motor manufacturers. Vehicle to Grid technologies are being developed which could enable direct load control of EVs storage capability. Motor manufacturers may also consider installing technologies to allow charging to be controlled remotely if there is sufficient interest in such approaches.
Private Finance & Capital Markets	Parties are generally outside the energy sector but provide routes for market players to access funding for capital investment programmes. In exchange, they will be looking for a return on their capital that matches their investment objectives. The ability to access funds will be a significant factor for the investment strategies that parties within the energy sector will be able to pursue.
Property Management organisations (including Housing Associations, Social Housing Landlords & Facilities Management Companies)	Significant shares of Norwegian homes and business premises are rented. These organisations are potentially stakeholders in the development of DSM as they could act as aggregators, for example, for programmes delivered in their properties. They may also look to integrate technologies to facilitate the automation of DSM programmes during planned refits.

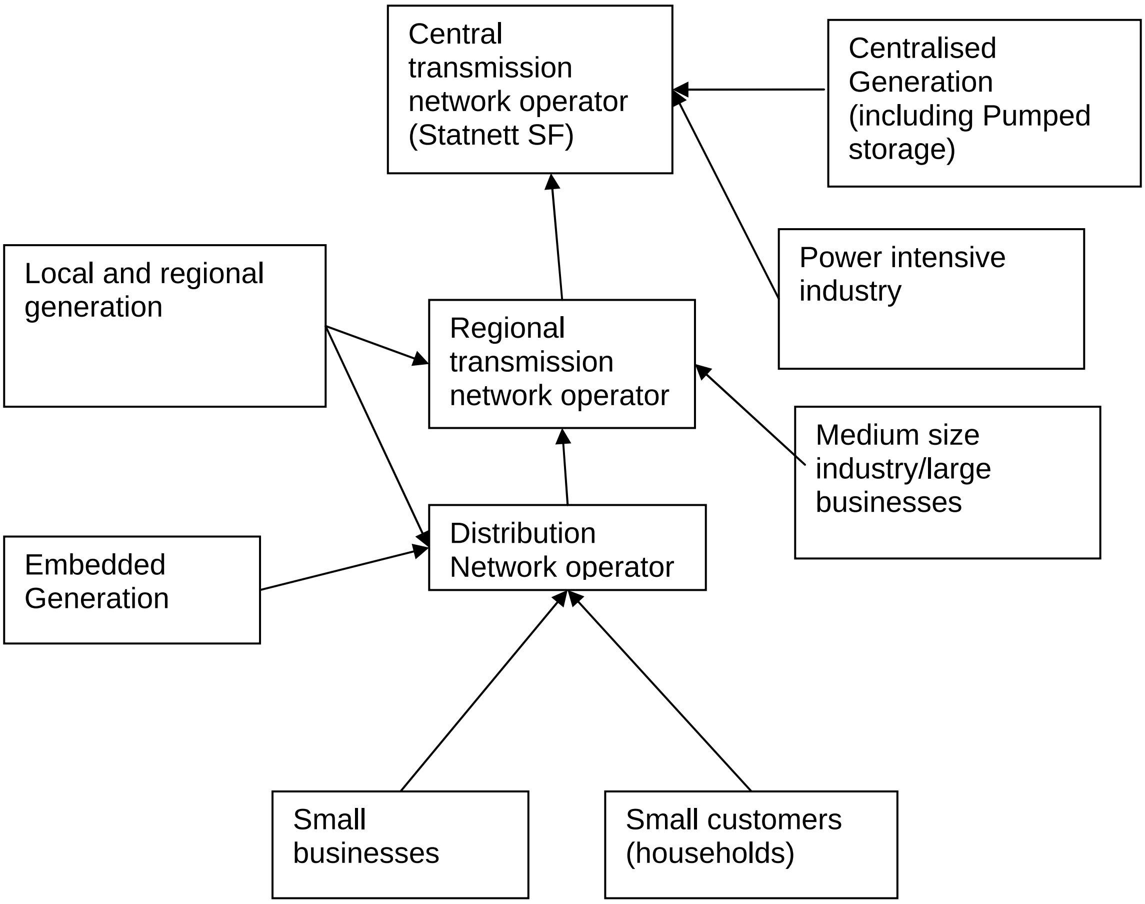
3.2 Market Maps



Physical Power Flows



Energy Purchasing (flow of money between stakeholders)



Network charges (flow of money between stakeholders)

4 Tariff structures

In 2012 the typical cost of electricity for households and small commercial customer is around NOK 1,00 per kWh. NOK = Norwegian Krone, and the exchange rate toward the Euro is typically in the area of 1 EUR = 7,5 NOK.

Elements of the total cost of electricity and network tariffs for a typical small (residential) customer may be demonstrated with a realistic example:

Total cost of electricity	
Electricity price, incl. supplier add-on (NOK/kWh)	0,3000
Electricity tax (NOK/kWh)	0,1139
Price with tax	0,4139
VAT, 25 %	0,1035
Total cost of electricity (NOK/kWh)	0,5174
Network tariff	
Variable (energy) part (NOK/kWh)	0,2000
Fixed part (NOK/Year and per kWh)	0,1500
Tax: Energy Fund	0,0100
Network tariff before VAT	0,3600
VAT, 25 %	0,0900
Network tariff with VAT (NOK/kWh)	0,4500
Electricity costs and network tariff w/VAT (NOK/kWh)	0,9674

The *electricity price* at market is determined in the Nord Pool spot market. The total cost of electricity meeting consumers depends on the type of contract one holds with the electricity supplier. There is a multitude of pricing models being offered by suppliers, and the consumer is free to choose between any electricity supplier serving in its concession area. Suppliers offer contracts with pricing schemes ranging from a pure market based spot price, with a fixed add-on, to a 2 – 3 years' fixed price. The spot price generated on Nord Pool spot typically varies in a range between NOK 0,20 and 0,50, but with extremes below NOK 0,10 and highs at NOK 1 – 2, or even higher in certain single hours.

The *electricity tax* is a fiscal tax applying to all customers, except some industry sectors. Furthermore, all customers in the northernmost parts of Norway are exempted this tax. In 2012, this tax is NOK 0,1139 per kWh. VAT applies also to the energy tax. VAT rate in Norway is 25 %. The sum of the electricity price, the electricity tax and VAT is the energy cost.

The network costs may contain three elements. A *fixed part*, an *energy part* and a *power part*. The fixed part is charged as a fixed rate (NOK) per year, usually billed evenly distributed over the year. Different customer groups (residential, agriculture, business, industry) usually are charged different fixed network elements. For a residential customer the fixed element may be NOK 2000 – 3000 per year, or NOK 0,10 – 0,20 per kWh over the year.

The *energy part* of the network tariff is a NOK/kWh charge, thus directly proportional to electricity consumption. In our price example the energy (or variable) element is NOK 0,20 per kWh.

Third, we have the "power element" which is determined by the power demand of the customer. The highest kW demand metered in the relevant time period (often month) defines this tariff element. Most small customers do not pay this element.

An "energy efficiency" tax is collected by the network company. This tax is earmarked the Energy fund, which in turn finances the programmes of Enova, the national energy agency. This tax is NOK 0,01 per kWh.

The network charges shall reflect the actual costs of operating the electricity network. Since network services are monopoly activities, the network tariff charges are regulated and monitored by NVE.

Residential customers report meter readings monthly, or every 2 or 3 months[2]. Unless there are smart meters installed, the meters are read manually by the customer and readings reported to the network company, mainly by internet or sms, but it is also possible to report by phone, mail or email. Missed readings are typically estimated by the electricity supplier or network company. Larger customers (>100 000 kWh/year) are required to have automatic meters recording consumption every hour. For smaller customers billing intervals usually follow meter reading intervals.

If the electricity supplier and the network company are different entities, they naturally bill separately. If network services and energy are supplied by one company, the customer receives a single bill. However, the energy and network charges must be specified separately.

For customers without hourly metering, the daily consumption may be determined by a so called "Adjusted Feed-in Profile". This model is used to estimate consumption of a customer for shorter time intervals than the metering interval, or in cases when the required meter reading is missing. The profiles are based on average consumption profiles for the relevant end user segment.

Demand responses (e.g. load shifting to lower-price hours) are not rewarded within this regime. The introduction of smart meters will, obviously, make the manual meter reading and reporting unnecessary. If and how the billing period or interval changes remains to be seen after the smart meter rollout.

An energy bill for households shall (§7-2 of the FOR 1999-03-11 nr 301):

- have a clear layout and be easy to understand
- contain information on the basic elements of the settlement, including prices and electricity volume, and if the latter is estimated or metered
- give a graphical representation of the consumption volume in current year's billing periods compared with similar periods the previous year
- inform of Enova's free phone service on energy efficiency advising, also inform of Enova’s phone number
- inform on what information is required to change energy supplier
- inform on where to compare energy prices at the web site of the Competition Authority
- inform on the possibility to complain on the bill to the Electricity Appeal Board

The regulation §3-1 states that "the network company is responsible for all meters and meter reading values in its network area". Thus the network company "owns" the meter data.

[2] The network company is responsible for meter readings. All meters shall be read at least once a year. Households with an annual consumption above 8000 kWh (most households with electric heating), shall perform periodical meter readings. Length of the metering periods shall be 1, 2 or 3 months.

However, the data shall be made available to the end user via internet free of charge. Third party actors, such as power suppliers or energy services providers, shall also be given access to meter data upon approval by the specific end user.

5 Other Relevant Information

In 2012 a new policy regime, a "green" electricity certificate system, was introduced jointly in Norway and Sweden with the aim of stimulating the generation of new renewable electricity into the network. The certificate costs are reflected as an increase in the market price for electricity. However, the increased supply resulting from the certificate system is expected to have an opposite effect on the price.

There are no white certificate schemes in Norway. However Enova, the national energy agency promoting energy efficiency and renewable energy, offers programs to end users that aim at reducing consumption of electric energy.

Some larger industrial companies are part of the European Emissions Trading System.

In general, the electricity price for small scale end users (households and small businesses) is lower than in neighbouring countries, hence incentives for behavioural changes to save energy also tend to be lower than in neighbouring countries. With the newly introduced electricity certificate system it is expected that the Nordic market will tend toward a surplus area for electricity, and that the price therefore will remain relatively low in coming years. The phasing in of more renewable power sources (especially wind, Solar PV) may however contribute to an increase in price volatility.

There is a collaboration between the Nordic Energy Regulators, where the main goal is to harmonise the different Nordic end-use markets.

There is work at regulatory level aimed at creating a more customer friendly billing model. It seems likely that all household consumers in the future will receive a single bill containing both network charges and electricity costs. It seems most likely that the electricity supplier will be responsible for the billing.

Appendix III: South Korea National Report

The Impact of Electricity Markets on Customers

Prepared by Yeoungjin Chae
National Expert for the Republic of Korea

Date: Sep 7, 2012

International Energy Agency Demand-Side Management Programme
Task XXIII: The Role of Customers in Delivering Effective Smart Grids

Acknowledgements

Enter any acknowledgements here if required

Glossary

If you use any acronyms – provide a summary here.

Contents

1 Smart Grid Drivers and Definitions

Summarise the main drivers for moving towards the development of Smart Grids in your country

Climate change	Korea needs to have green power infrastructure in order to achieve the goal of cutting down carbon emissions by 30% by 2020 compared to the BAU guidelines (Green Growth Committee; Nov. 2009). In a situation where Korea's greenhouse gas emissions against GDP stand at approximately 1.6 times the average emissions by OECD member states, more green and robust power grid is the first necessary step for accommodating more renewable power and electric vehicles in the near future. With the smart grid in hand, the emission reduction target will be more realistic and achievable.
Energy Efficiency	With the below-cost tariffs, cross-subsidies among electric use categories, and out-dated rate-of-return regulation, waste of electricity has been widespread in Korea since 1980s. To make matters worse, the end prices of alternative energies such as natural gas and oil are higher than that of electricity. This has devastating effects on the energy efficiency in Korea. Moreover, since the current electricity industry are organized based on the large centralized system, improving energy efficiency has had limited results due to the lack of response from the consumer side. The smart grid will be the basic infrastructure for enabling more sophisticated responses from the demand.
New growth engine	The smart grid is the next generation energy infrastructure to connect everything using electricity that has never been linked before. This so-called fusion industry eco-system will include almost every key industry and their value chains; internet, telecommunication, construction, home appliance, automobile, battery, new and renewable energy, and electricity. The smart grid will be one of the last industries enabling large scale employment.

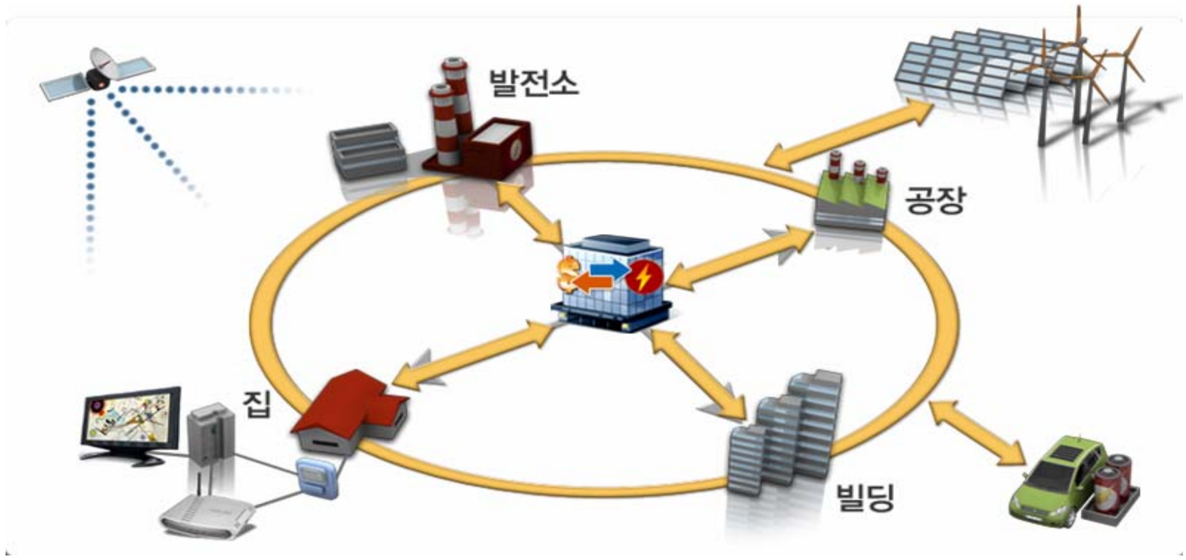
Provide a definition of a Smart Grid from the perspective of your country

i. E.g. is there a specific definition that has been developed for your country?

The national smart grid road-map (Jan 2010)	- Next-generation energy efficiency optimization enabled by incorporating ICT technology ("smart grid technology") into the current electric grid system and exchanging real-time power information between the supplier and the consumer. - Encouraging more reasonable energy consumption via two-way power information exchange; providing high-quality energy products and various related services - An open system allowing for the easy incorporation and expansion of clean ("green") technology including renewable energy and electric cars,

	capable of creating new business via inter-industry combination and convergence.
The Smart Grid Act (May 2011) - Article 2.2	The term “smart grid” means a power grid that maximizes efficiency in the use of energy by supplying electricity with information and communications technologies applied thereto, through which suppliers and users of electricity can exchange information on a real-time basis

Smart Grid Concepts(The national road-map, 2010)



power

Current Grid		ICT		Smart Grid
⦿ supplier-oriented ⦿ unilateral ⦿ closed ⦿ standardized	+	⦿ real-time information exchange	=	⦿ consumer-oriented ⦿ bilateral ⦿ open ⦿ various services

2 Smart Metering

Provide a summary/overview of Smart Meter rollout to small customers in your country

Which customers are covered

Timeline for rollout

Smart meter installation status

(The 1st national smart grid action plan, 2012-2016)

	Current status	Roll-out plan
High voltage	170,000 customers[a] (above 100kW), 100% of customers	-
Low voltage	550,000[b] customers (3.4% of the total[c])	New 9,450,000 smart meters by 2016 - please refer to the below table for more detailed plan Plans under the government review - Apartment, commercial buildings('12) - Smart grid pilot city('14) - Integrated metering('14) (electricity, heat, gas, water) - Smart meter requirements for new buildings('15)
Apartment households (8.16 million households, 2010)	None	
Community energy system	None	
Commercial complex[d]	None	
Jeju Smart Grid test-bed	2,300 two-way smart meters installed	-

[a] Industrial customers and large commercial customers. Their meters provide electricity consumption data (15 minutes interval, 4 data points) for every hour by using automated meter reading system. Seasonal/peak/off-peak tariffs are applied to these consumers.

[b] Small and medium commercial customers. Since only seasonal tariffs are applied to these consumers, the regular automated meter reading interval is monthly.

[c] The monopoly retailer(Korea Electric Power Corporation, KEPCO) has 18,500,000 customers as of 2010.

[d] Factory buildings constructed like apartment and shopping complex.

Smart meter installation plan (100% by 2020) unit: 10 thousands

Year	'10	'12	'13	'14	'15	'16	....	'20
Total customers (new)	55 (50)	105 (50)	305 (200)	530 (225)	755 (225)	1000 (245)	.....	1,800
% installed	3	6	17	29	42	55	.....	100

Summary of Smart Metering Functionality and access to, and ownership of, Smart Meter data

	Function	Type A	Type B
4.1	Metering and instrumentation		
4.1.1	Electric energy (kWh) (active power, reactive power, apparent power)	All default	Active power default
4.1.2	Electric power (kW) (active power, reactive power, apparent power)	All default	Optional
4.1.3	Power factor	Default	Optional
4.1.4	Peak demand	Default	Default
4.2	Automated meter reading and control		
4.2.1	Automated meter reading	Default	Default
4.2.2	Program upgrade	Default	Default
4.2.3	Remote setting	Default	Default
4.2.4	Time synchronization (internal clock, calendar and time check)	Default	Default

4.2.5	Load profile saving (15 minute-interval, 60 days)	Default	Default
4.2.6	Hourly metering (More than 4 seasons, more than 12 hourly intervals in a day, 4 tiers in tariff structure)	Default	Default
4.2.7	Real time price	Default	Default
4.2.8	Remote shutdown/open, limit rated current	Default	Default
4.3	Meter management		
4.3.1	Outage management (Record, setting, time recovery)	Default	Default
4.3.2	Instantaneous measurement of power quality management (voltage, current, frequency in each phase)	Default	Optional
4.3.3	Warning	Default	Default
4.3.4	Battery (Backup power for emergency)	Default	Default
4.3.5	Temper detection (protection against theft and damage)	Default	Default
4.4	Communication		
4.4.1	Two-way communication (separation between comm device and metering device)	Default	Default
4.4.2	Protocol (open standard)	Default	Default
4.4.3	Communication interface	Default	Default

How will Smart Metering affect the way electricity consumption is settled financially?

Smart metering is expected to introduce more flexibility in terms of billing/payment intervals and methods

	Current system	Smart Metering
Billing interval	Monthly, 3-month(small bills)	Monthly and/or flexible intervals reflecting consumer needs
Billing methods	Paper bill e-mail bill Text-messaging notice Cyber internet office	Paper bill e-mail bill Consumer portals Text-messaging notice Smart phone app. In-home-display TV (other smart appliances)
Payment methods	Bank transfer Credit card/debit card Cash(Bank, convenience stores) Phone-banking/internet banking	Bank transfer Credit card/debit card Cash(Bank, convenience stores) Phone-banking/internet banking Pre-payment
Payment intervals	Monthly, 3-month(small bills)	Monthly and/or flexible intervals reflecting consumer needs
Integrated billing	None	Possible
Billing agent	Only for some big apartment complex	Covering all consumer
Competitive aggregator	None	Yes

3 Electricity market structure

3.1 Stakeholders

Table 1 Stakeholders involved in generation, distribution and supply of electricity

Stakeholder	Short Description	Current responsibilities
Energy suppliers & /or Services Companies	e.g. These companies are responsible for selling electricity (and often gas) to the end consumer.	Korea has a de facto retail monopoly company, Korea Electric Power Corporation(KEPCO), which is the single transmission and distribution asset owner. The government holds 51% of KEPCO shares. 16 Community Energy Suppliers are small distribution-generation-retail companies that provide electricity for their franchise area. KEPCO's retail market share is more than 99%. With the 1st smart grid national action plan, there will be discussion for allowing new entrants in the retail market.
Distribution Network Operators	These companies are responsible for the physical infrastructure that is required to bring electricity from the transmission system to the point of end consumption.	KEPCO is the single distribution network owner and operator. Since KEPCO is also a monopoly retailer, retail department and distribution department share local branch offices. From the consumers' point of view, there is no difference between distribution and retail.
Centralized Generation	Large power stations, connected to the transmission system. Fuel mix is dominated by gas, coal and nuclear.	On the public sector, KEPCO has 6 major generation subsidiaries whose installed capacity is about 90% of the total, 80GW as of 2012. Among them, 5 generation companies are based on coal and natural gas fuel, and the last one is based on nuclear. On the private sector, there are 00 companies whose capacity is about 00% of the total. Due to recent generation capacity shortage, number of coal power plants are expected to enter into the market. There has been no changes on nuclear expansion policy after Fukushima disaster. The bi-annual 6th Basic Long-term Power Plan will decide generation expansion capacities for the next 15 years.
Transmission	The transmission system is the high voltage network, providing for bulk supply of electricity.	KEPCO is the single transmission network owner. KEPCO builds and maintain physical transmission networks. In terms of transmission planning, KEPCO prepares the draft and submits it to the Basic Long-term Power Plan.
System Operator	System operation is completely separated from transmission and generation asset owners.	Korea Power Exchange(KPX) is the sole system operator, which is responsible for maintaining the minute-by-minute balance of the electricity system in South Korea.

Market Operator	The wholesale electricity market in Korea is called Cost-Based Pool and compulsory. The hourly market price is determined based on the detailed cost data submitted by generation companies as well as load forecast.	Korea Power Exchange(KPX) is the sole market operator, which is responsible for daily wholesale electricity market operation in South Korea.
Aggregators	As a part of the government's DSM program, KPX operates demand response market. Since this demand response program is separated from the wholesale market, program participants receive incentives from the government as a reward for their load reduction. The incentives funded from the National Electricity Infrastructure Fund. Generation aggregation is not allowed under the current regulation.	There are 12 organisations providing commercial aggregation services in the Korean demand response market. These organisations currently aggregate generation from medium to large Industrial and Commercial consumers that would not meet the System Operator's requirements to tender for the provision of demand reduction services.
Metering	Metering provision is a distribution owner's monopoly activity in the Korean market.	Provision of metering to consumers is the distribution owner's responsibility, except where the construction company provides meter with their new apartment. In this case, apartment management office provide metering and billing services to the apartment residents. KEPCO, the monopoly distribution asset owner, out-sources her metering responsibility to metering service providers who bids their regional franchise contracts to KEPCO. Most metering systems for residential and small business are cumulative at present. Smart meters will be rolled out to all customers by 2020.
Virtual Power Plant (potential)		
Competitive retailer (potential)		

Electric Vehicle Service Provider (potential)		
Smart Service Provider (potential)		
Prosumer		

Table 2 Stakeholders involved in policy setting and regulation

Stakeholder	Short Description
Korea Electricity Commission(KOREC), Ministry of Knowledge Economy	Established in 2001, KOREC was the regulator for the electricity sector in South Korea. Its primary responsibilities were Policy Coordination, Power System Operation(including licensing, electricity tariff regulation), Electricity Market Operation, and Consumer Protection. In 2011, as a part of the reorganization within the Ministry of Knowledge Economy, KOREC was divided and its current responsibilities include consumer protection, reviews on electricity tariff filing, M&A, business licensing, and market surveillance.
Electricity Industry Promotion Division(EIPD), Ministry of Knowledge Economy	Established in 2011, EIPD regulates electricity market and electricity tariff. National smart grid policy is also a part of this division's responsibilities.
Electric Power Industry Division(EPID), Ministry of Knowledge Economy	Established in 2001, EPID is responsible for power system operation, national long-term power and transmission planning, national electricity infrastructure fund.
Ministry of Strategy and Finance(MOSF)	In accordance with general price stability act, MOSF operated a committee that makes a final decision on electricity rate changes.
Knowledge Economy Committee(KEC), National Assembly	KEC makes influences on policy and regulation by changing relevant Acts including the Electricity Business Act, the Smart Grid Act.
Korea Power Exchange(KPX)	As the power market and system operator, KPX operates various committees having an effect on policy and regulation in terms of marker operation, system operation, and long-term power planning.
Market Participants	Various market participants make influences on policy and regulation by participating committees operated by KPX.
Korea Smart Grid Institute(KSGI)	KSGI supports EIPD's various smart grid policy making including the 1st national smart grid action plan.
Local Government (potential)	
Non-Government Organization (potential)	

Table 3 Other Stakeholders

Stakeholder	Short Description / Current responsibilities
Appliance Manufacturers	Technologies for home energy management could be integrated into new appliances. This could offer manufacturers a unique selling point, enabling them to differentiate their offering from their competitors'. Some manufacturers have already announced that they are developing 'Smart Appliances' with this capability. A growing market is likely to encourage others into this space. In particular, Samsung and LG are active on this field in South Korea.

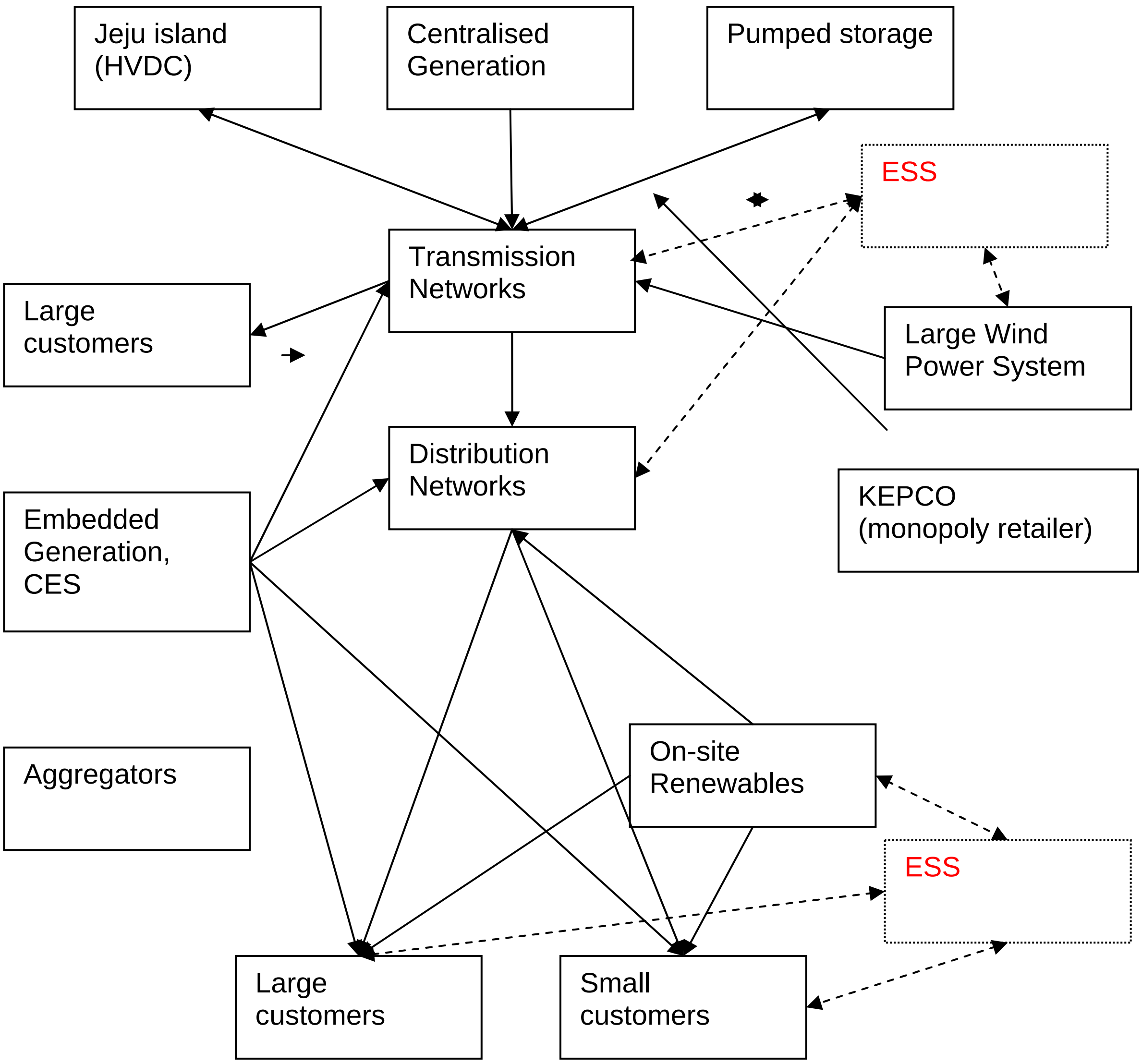
Appliance Suppliers	There are a wide range of organizations that supply appliances to small consumers in South Korea, including department stores, large specialist retail chains, and independent retailers, and internet retail portals. Among these, internet offering has shown a fast increasing market share. Until now, some retail chains has participated in the demand reduction program from DR aggregators.
Back-office services	Until now, most of the back-office functions are done within KEPCO and KPX. There is a possibility that back-office function is separated from the utility if the market is large enough.
Building & Construction sector	Targets to develop 'zero-carbon' properties such as 'Green Home', 'Korea Micro Energy Grid' are likely to drive this sector to investigating installation of low carbon technologies, including small scale and micro-generation, to meet required performance. DSM could allow the output from this generation to be used on-site, maximising the value to the owner/tenant and increasing the value to the developer. If those building can participating in the wholesale market, this also could provide another financial opportunity.
Communications Infrastructure & Services	The companies provide communications services. The development of Smart/Advanced Metering will require communication functionality and it is likely to also be required for the development of DSM programs. This sector is predominantly made up of a number of large, domestic players who may wish to become more active in the energy sector in light of these developments. In Korea, SK Telecom and Korea Telecom, and LG Telecom is active on smart grid projects. They are developing new business models based on the synergy between energy and telecommunication.
Consulting	The role of commercial consulting is limited in Korea in terms of developing services in relation to the rollout of Smart Metering and DSM programs. Rather, academics and researchers often give advices to these projects.
IT Providers	The development of Smart Metering and Smart Grids is likely to be attractive to providers of IT solutions, particularly in relation to data management and storage. All the major SI companies in South Korea are interested in the Smart Grid projects.
Motor Manufacturers	Electric Vehicles are being developed by Hyundai and Kia Motors. Some small-medium companies had entered EV market to produce small size EVs in advance, though some of them is now having financial troubles. Vehicle to Grid technologies are also being developed which could enable direct load control of EVs storage capability. However, though Hyundai and Kia produced a small number of EVs, it looks like that they are skeptical on the future of EVs including Plug-In Hybrid Electric Vehicle(PHEV). Hydro fuel cell car has been a key focus of Hyundai and Kia Motors' future vehicle projects for many years.
Energy Storage System(ESS) Manufacturers (Potential)	Energy Storage System using Lithium-ion battery is being actively developed by all major chemical companies in South Korea including LG Chem, Samsung SDI, and SK Innovations. These are top-notch ESS battery producers in the world and have global partnership with major auto companies such as GM, BMW, and Reno.

Private Finance & Capital Markets	Parties are generally outside the energy sector but provide routes for market players to access funding for capital investment programs. In exchange, they will be looking for a return on their capital that matches their investment objectives. The ability to access funds will be a significant factor for the investment strategies that parties within the energy sector will be able to pursue. Attracting private investments is one of the top priorities of the government for promoting smart grid.
Property Management organizations (including Housing Associations, Social Housing Landlords & Facilities Management Companies)	-
Korea Energy Management Corporation (KEMCO)(potential)	KEMCO is a public organization that is active in consumer education about energy savings.

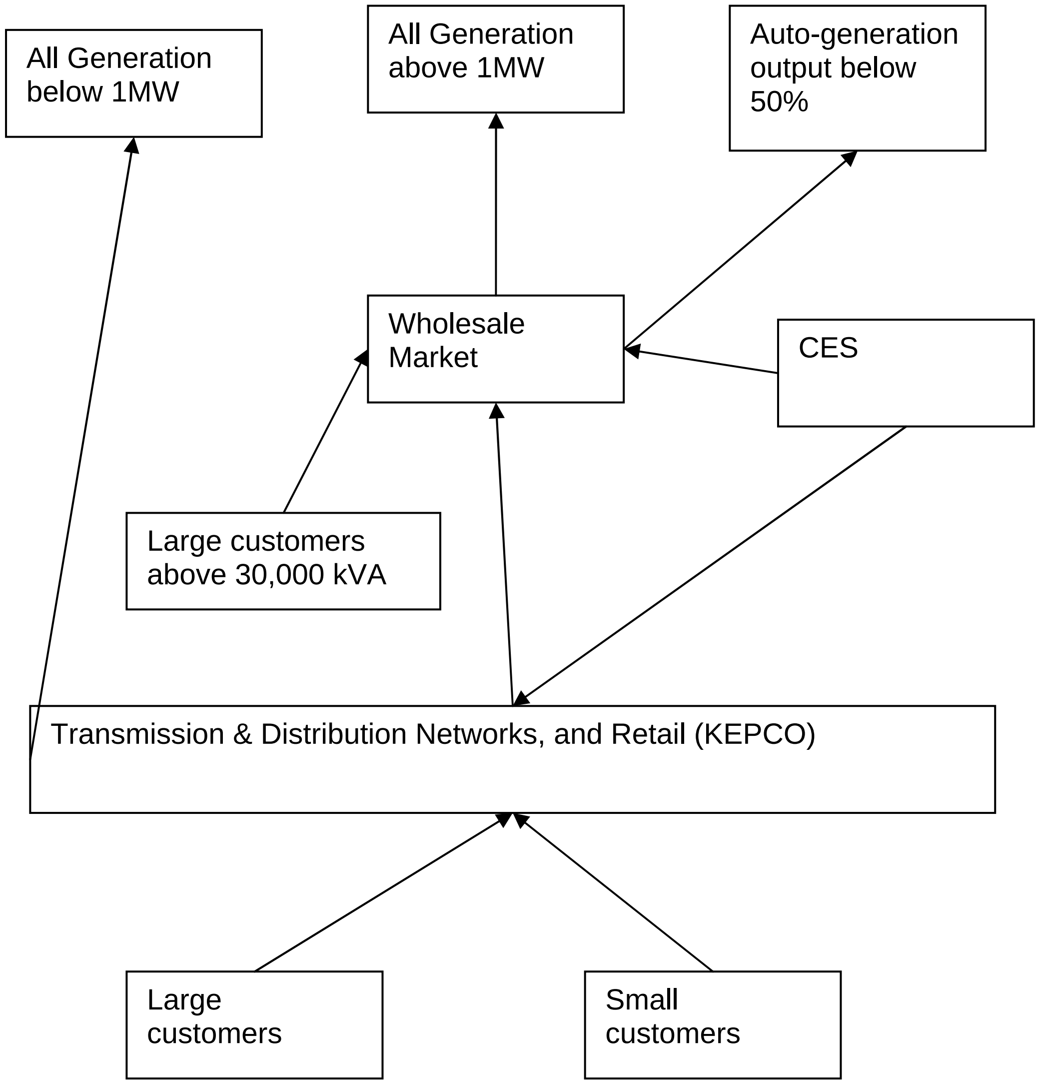
3.2 Market Maps

Complete the market maps for the following information – use a separate map for each level of information to be provided.

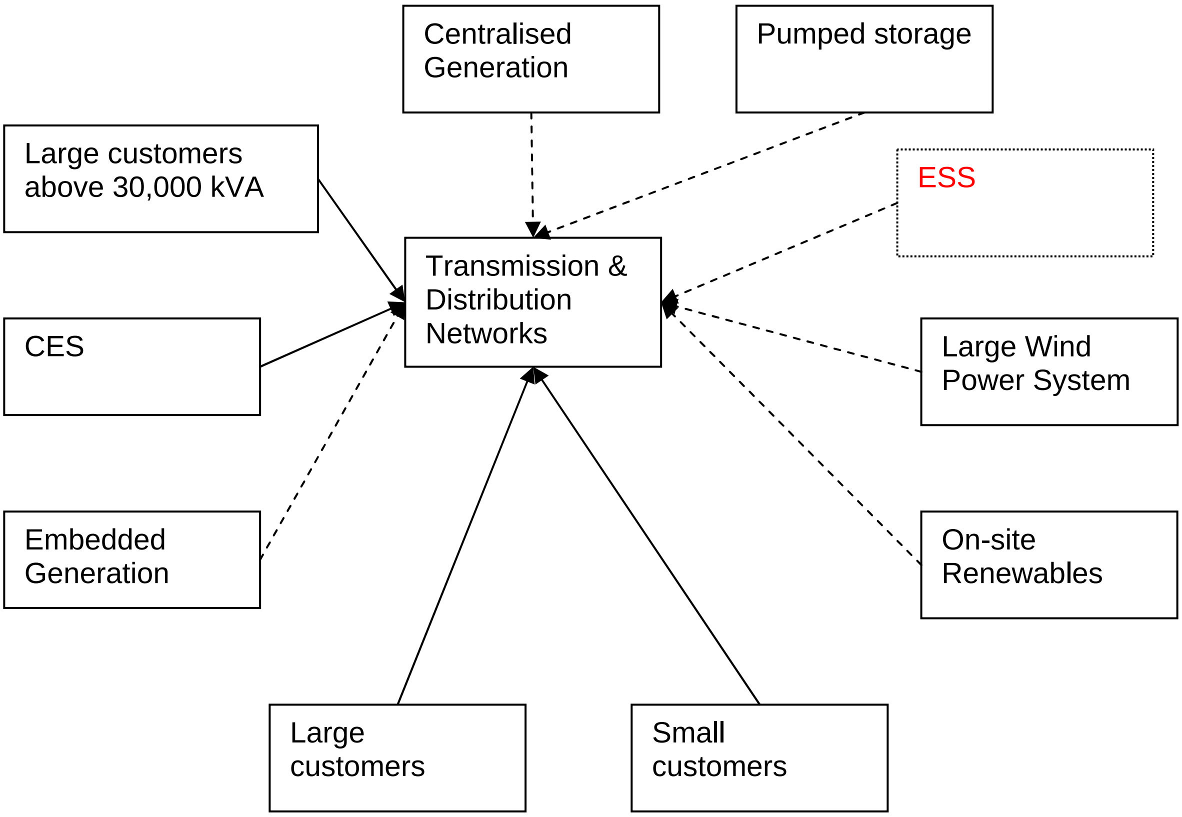
ii. Physical power flows
iii. Energy purchasing
iv. Network charges
v. Potential DSR contracting
vi. Other relevant information



Physical Power Flows

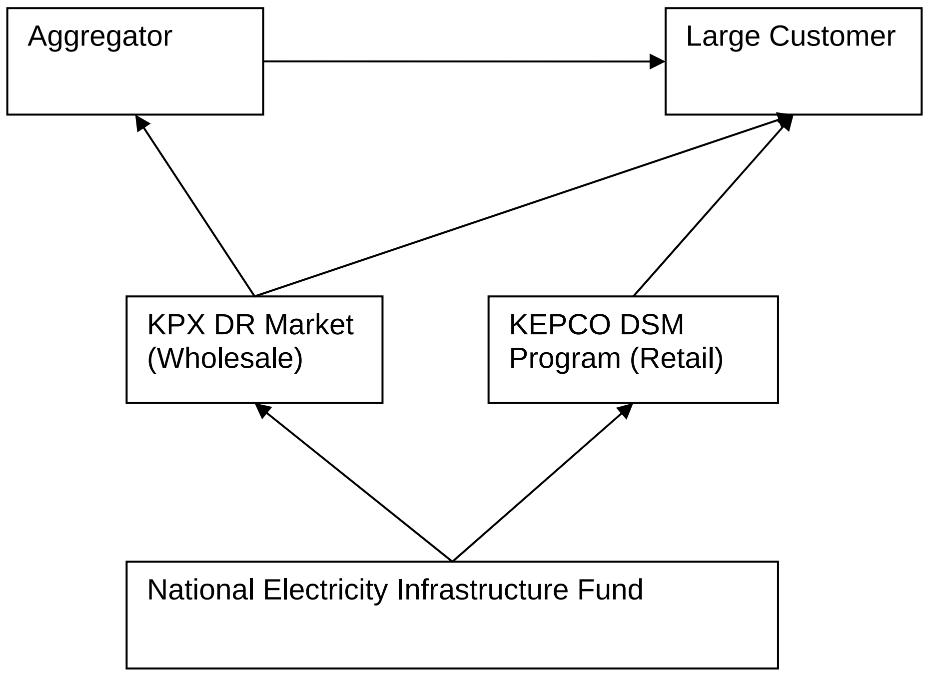


Energy Purchasing (flow of money between stakeholders)
– add in any additional stakeholders as necessary

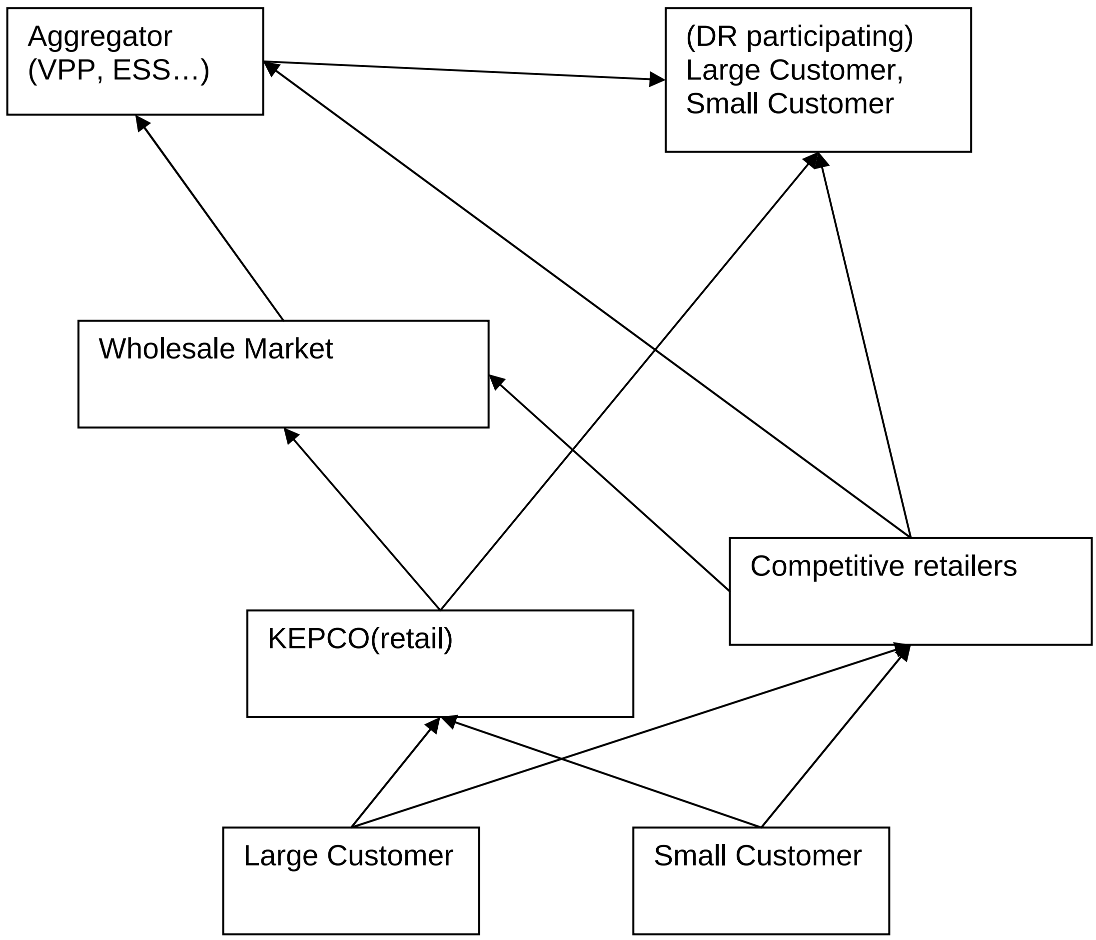


Network charges (flow of money between stakeholders)
– add in any additional stakeholders as necessary

1. Generator are currently exempted from network charges, but they paid access charges.
2. Since electricity bills don’t show any information based on functional division, portions of network charges are not clear.



Current DR Contracts(flow of money)



Potential DR Contracts(flow of money)

4 Tariff structures

Provide information on the following aspects of electricity prices in your country:

a. What is the current typical price of electricity (total price including all taxes and charges) paid by residential, small commercial, small industrial customers?

Residential Low Voltage

Fixed Charge (Korean won[a])		Energy Charge (Korean won/kWh)	
For less than 100kWh	390	For less than 100kWh	57.90
For 101kWh to 200kWh	870	For 101kWh to 200kWh	120.20
For 201kWh to 300kWh	1,530	For 201kWh to 300kWh	179.40
For 301kWh to 400kWh	3,680	For 301kWh to 400kWh	267.80
For 401kWh to 500kWh	6,970	For 401kWh to 500kWh	398.70
For more than 501kWh	12,350	For more than 501kWh	677.30

[a] USD 1.0 was approximately equal to 1,129 Korean won at the time of the survey (September 2012).

Residential High Voltage

Fixed Charge (Korean won)		Energy Charge (Korean won/kWh)	
For less than 100kWh	390	For less than 100kWh	55.00
For 101kWh to 200kWh	700	For 101kWh to 200kWh	94.40
For 201kWh to 300kWh	1,210	For 201kWh to 300kWh	140.60
For 301kWh to 400kWh	3,030	For 301kWh to 400kWh	205.80
For 401kWh to 500kWh	5,780	For 401kWh to 500kWh	310.90
For more than 501kWh	10,270	For more than 501kWh	548.50

Small Commercial under 300kW

		Fixed Charge (Korean won/kW)	Energy Charge (Korean Won/kWh)		
			Summer (Jul-Aug)	Spring, Fall (Mar-Jun) (Sep-Oct)	Winter (Nov-Feb)
Low Voltage		5,830	100.20	62.40	86.50
High Voltage A	Choice I	6,790	110.10	68.70	97.10
	Choice II	7,790	106.30	64.70	92.10

High Voltage B	Choice I	6,790	108.10	67.60	94.30
	Choice II	7,790	103.10	62.60	89.30

Small Industrial under 300kW

		Fixed Charge (Korean won/kW)	Energy Charge (Korean Won/kWh)		
			Summer (Jul-Aug)	Spring, Fall (Mar-Jun) (Sep-Oct)	Winter (Nov-Feb)
Low Voltage		5,090	74.20	55.90	71.80
High Voltage A	Choice I	5,890	80.20	60.70	79.60
	Choice II	6,780	76.00	56.40	74.00
High Voltage B	Choice I	5,450	79.20	59.60	78.30
	Choice II	6,270	75.00	55.40	72.80

b. Provide a breakdown of the total price to include: There are 4 components in the power bill.
   i. The monopoly retailer provide an inclusive bill so that it is impossible to break down the costs. This include fixed costs and energy costs. Other costs are included in the fixed and energy charges.
   ii. Value added tax is calculated by adding 10% of energy and fixed charges.
   iii. Electricity Infrastructure Fund is calculated by adding 3.7% of the sum of (energy charge + fixed charges + VAT)

c. Describe how each element of the price is determined
   i. Which elements are regulated? Fixed charge, Energy charge, National Infrastructure Fund.
   ii. Which are set in a competitive market with no regulation? All components are under the government's regulation.
   iii. Which are set as a fixed percentage? VAT and National Infrastructure Fund.
   iv. Which are set as a fixed amount? Fixed charge in a increasing block rate manner.

Billing and Settlement

a. What are the billing arrangements
   i. Who sends the bill(s) to the customer? KEPCO and/or its billing agents

ii. Do customers receive one bill for the combined energy/network charges, or do they receive separate bills. One bill
iii. What information must be provided on the bill? There is no clear legal obligation on the Electricity Business Act(Article 17). However, following information is included in a typical residential bill: Customer number, address, metering details, monthly electricity consumption amounts, past one year trend of monthly consumption.
iv. How often are bills sent? Monthly
v. Are estimated bills issued to customers, or are they based on meter readings? Meter reading
vi. Will these arrangements change once smart meters are rolled out? Not clear until now.

b. How is the electricity consumption for small customers settled in the energy market? A brief description only is required for this project.
   a. In present, small customers are not allowed in the energy market. They are captive customers of the monopoly retailer. Therefore, the hourly wholesale price is not linked with the retail rate. All bills are monthly basis under regulated tariff.

Data Ownership

d. Who owns the data collected from the meters (now) and once smart meters are deployed? Legally, all the consumption data are owned by the customer.

e. Which stakeholders have access to the data – what are the access arrangements, and what can the data be used for? In accordance with the Smart Grid Act, with the legal permission from a customer, retailer, aggregator, other 3rd party firms, and relevant organization can access the data. Detailed procedures and rules has to be made in the near future. Data can be used for energy management consultation, aggregation, power quality improvements and other marketing needs. Other possible needs might be found in the future.

f. Are there any specific issues regarding meter data ownership in your country.

   Since the government's arrangement is not decided yet, it isn't clear until now that the data sharing is well processed as expected. The monopoly retailer is expected to be highly defensive and critical on the data access by would-be future competitor.

5 Other Relevant Information

Please provide any other relevant information that impacts on the way that customers 'behave' in the electricity market.

Examples might include

a. Do you have any Feed-In Tariffs in your country?

Payment method: the government sets the basic price and supports the difference between the basic price and wholesale electricity market price.

Basic price = wholesale price(system marginal price) + FIT

FIT supports hydro, wind, photovoltaic, fuel cell, Land Fill Gas(LFG), bio-gas, bio-mass, and wastes generation technologies. Solar received the largest FIT support.

Beginning 2012, the government stops supporting new FIT capacities. Renewable Portfolio Standard (RPS) was introduced to replace FIT in order to reduce financial burden of the government and enhance competition and efficiency among the new technologies.

The accumulated FIT support

	Hydro	Wind	Solar	Fuel cell	LFG	Bio-gas	Bio-Mass	Wastes	Total
Capacity (kW)	87,396	320,205	496,624	50,500	74,868	2,711	5,500	2,247	1,010,096
Unit	63	15	1,991	20	14	3	1	1	2,108
Output (MWh)	2,179,889 (19.1%)	3,529,492 (31%)	2,266,357 (19.9%)	721,427 (6.3%)	2,591,948 (22.8%)	35,551 (0.3%)	48,753 (0.4%)	12,511 (0.1%)	11,385,928 (100%)
FIT (USD, thousands)*	24,432 (2.1%)	23,163 (2.0%)	1,013,724 (86.9%)	89,860 (7.7%)	14,563 (1.2%)	0.558 (0.0%)			1,166,302

*USD 1.0 is approximately equal to 1,229 Korean Won as of Sep. 2012

b. Emissions Trading

The Climate Change Act was enacted last June and, Presidential Decree and relevant rules regarding emission trading would be finalized within a year.

c. Renewable Portfolio Standard (RPS)

Starting in 2012, generation companies whose total capacities are above 500MW have obligation to produce designated % of renewable energy compared to their total output. In case of solar, separate targets were announced. Generators can trade their RPS certificates (REC) in the REC market operated by KEMCO.

Annual obligatory RPS targets for generation companies

Year	‘12	‘13	‘14	‘15	‘16	‘17	‘18	‘19	‘20	‘21	‘22
Obligation (%)	2.0	2.5	3.0	3.5	4.0	5.0	6.0	7.0	8.0	9.0	10.0

d. Social housing ‘approach’ – are appliances always included as part of the ‘rental’ (of either private rental homes, or social housing) and are there standards for the appliances that must be installed

In the past, appliances are not part of the rental. However, nowadays increasing number of ‘One Room(rental room for young single in city area)’ are furnished with brand new appliances.

e. Others??

Appendix IV: Sweden National Report

The Impact of Electricity Markets on Customers

Prepared by Magnus Brolin
National Expert for Sweden

September 2012

International Energy Agency Demand-Side Management Programme
Task XXIII: The Role of Customers in Delivering Effective Smart Grids

Acknowledgements

Enter any acknowledgements here if required

Glossary

EI	Energy Markets Inspectorate
EV	Electric vehicle
DSM	Demand side management
ERGEG	European Regulators Group for Electricity and Gas
DSO	Distribution system operator
SvK	Svenska Kraftnät, the Swedish transmission system operator
TSO	Transmission system operator

Contents

1 Smart Grid Drivers and Definitions

1.1 Smart grid definitions in Sweden

There is no established officially Swedish definition of smart grids. Different actors have their own definitions depending on their interests. Often these definitions are based on the definitions stated by organisations such as IEEE, European Smart Grid Technology Platform or Electric Power Research Institute (EPRI). Two major categories of definitions can be found; one focusing on the technology and one focusing on the overall problem solution. One example of the latter is the definition stated by the Swedish Energy Markets Inspectorate (EI), which in turn is based on the definition made by ERGEG:

> *"Intelligent or smart grids is the synthesis of technologies, functions, and regulatory frameworks that in a cost effective manner facilitate the introduction and use of renewable electricity generation, the reduction of overall energy consumption, the reduction of load peaks, and the creation of an environment where electricity consumers can become more active."*[1]

Even though some different definitions exist in the country, the elements mentioned are similar. The overall idea of smart grids in Sweden does not differ much from other definitions from around the world. Typical technologies includes decentralized generation resources (solar, wind), energy storage, ICT, electric vehicles (EVs), automation and monitoring systems, and technologies facilitating demand side management. The smart grid is viewed as a flexible grid, which fast can adopt to changes in available production and has the possibility of using the energy when it is available. Especially the user side is expected to play an important part in the smart grid and to be more flexible and active.

In June 2012, the government established a "coordination council/board"[2] for smart grid development in Sweden, consisting of representatives from industry, academia, institutes, and consumer organisations. One of the main tasks of this group is to produce a road map for smart grid development in Sweden. It is possible that the group will in this work also define a smart grid from the Swedish perspective. The group started its work in August 2012 and will present their final results in December 2014.

1.2 Main drivers for smart grid development

Below the main drivers for smart grid development in Sweden are described. These drivers can be associated with different levels in the system and in the decision making process; some are related to politically set goals whole other rely on actions performed by industry or users.

[1] Adapting Electricity Networks to a Sustainable Energy System – Smart metering and smart grids, EI R2011:03, November 2010, on page 92

[2] Press release: Regeringen tillsätter samordningsråd för smarta elnät, http://www.regeringen.se/sb/d/119/a/194044. In Swedish

The Swedish government has set up a number of goals to be achieved in the energy sector. Many of these goals originates from the EU, but there are also goals showing further ambitions in the energy field. Among the goals set by the Swedish government, the following are of interest:

- By 2020:
  - 50 % of the produced energy should be generated by renewable energy sources. This includes a goal of 30 TWh/yr of wind power.
  - 20 % lower energy consumption.
  - 10 % renewable energy in the transportation sector.
- Fossil fuel free vehicle fleet by 2030.
- No net emissions of greenhouse gases by 2050.

The goals of a “fossil fuel free vehicle fleet” and “no net greenhouse gas emissions” points in the direction of an increase in electricity demand due to the foreseen introduction of electric vehicles (EVs). This will require an increase in installed renewable energy sources on order to reach the goals. There is a large interest in building wind power in Sweden and it is foreseen that the amounts will increase significantly the next coming decades. This will lead to a need for a more flexible system.

Concerning the balance management, the integration of renewable energy sources in the Nordic system should impose less challenges than in many other countries and/or areas because of the significant amounts of installed hydropower in the system. The hydropower constitutes a balancing resource that can handle wind power production variations thanks to its flexibility. This means that the technical need for other balancing resources, such as demand side management (DSM), is not as crucial in the Sweden or the other Scandinavian countries. However, it is also foreseen that the Nordic system and market will become more integrated with the European system and market by harmonization of market rules and investments in transmission. This will allow the Nordic hydropower to act as a balancing resource in a northern Europe perspective. This means that also in Scandinavia the price differences might increase creating economical incentives for the users to become more flexible and active.

Swedish households and small commercial electricity users have today generally a low confidence in the power companies, i.e. power producers, suppliers, distribution companies etc. Surveys have shown that consumers feel that they don’t have any possibilities to influence their electricity costs (“we need the energy and only pay the bill”) and that they are in the hands of the electricity providers. The possibility to have a greater influence and control of the energy consumption can be a strong driving force for many users to take control over their electricity bills.

Sweden has a long history of electric power equipment industry and telecom industry with companies such as ABB and Ericsson. These industry branches contributes to significant export revenues and are regarded important for the national economy. The introduction of smart grids require new or improved technologies, which can lead to new business opportunities for Swedish companies. Hence, there is a great interest to further explore the opportunities related to smart grids from the business point of view.

2 Smart Metering

When discussing smart meter rollout, the definition of a "smart meter" must be at hand. Further, it must be settled if the discussion is about the actual meter, or the entire metering infrastructure. Often smart metering refers to the latter, including e.g. information systems and ICT.

There is no specific Swedish definition of smart meters or smart metering, but EI uses the specifications provided by European Regulators Group for Electricity and Gas (ERGEG)[3]. The main specifications from ERGEG consists of 10 items, and if including all of these as requirements, the amounts of households and/or SMI where the metering infrastructure can support these requirements, is about zero in Sweden. However, some of the specified properties are well established in the system and are "smart" in some senses. Focus in the discussions in Sweden has been on the metering interval, i.e. hourly metering.

2.1 Metering interval

Concerning electricity users having a fuse size over 63 A, these are subjected to hourly metering since 2006. Industrial users having a fuse of 200 A and above have been hourly metered since the liberalization of the Swedish electricity market in 1996.

Concerning small users up to 63 A in fuse size, the metering reform launched in 2003 stated that all consumers must have at least monthly reading from July 1, 2009. When the act was launched, this was the requirements on which some DSOs reacted. Some the DSOs starting installing meters at their customers which cannot perform hourly metering, but has the lowest metering interval of one month. More recent installed meters usually have a more advanced setup and can handle hourly metering.

A study conducted in 2007[4] concluded that about 90 % of the installed meters (up to 63 A) are capable of hourly metering. However, the study also concluded that not all of these are connected with communication systems that can handle hourly values; about 50 % has the potential to handle this.

EI performed a survey in 2010 concerning the status of meters and metering system in Sweden[5]. The survey covers consumers having fuse size up 63 A and focuses on hourly metering. Further, the survey consider not only the meters, but also the system collecting and distributing the data. The report from the Inspectorate follows this structure, having survey results about the meters, concentrators collecting the individual meter data, and central systems for data collection and storage.

[3] Status Review on Regulatory Aspects of Smart Metering (Electricity and Gas) as of May 2009. ERGEG, E09-RMF-17-03. October 2009.
[4] Badano A, P Fritz, A Göransson och M Lindén , Timmätning för alla, Elforsk rapport 07:62. 2007. In Swedish.
[5] Ökat inflytande för kunderna på elmarknaden - Timmätning för elkunder med abonnemang om högst 63 ampere. EI R2010:22. Energy Markets Inspectorate, 2010. In Swedish. The survey was sent to all network owners in Sweden, about 170, and in total 139 companies chose to answer. The total amount of consumption points in the Swedish system is about 5 300 000, and the survey covers a bit more than 5 000 000 of these. Hence, the results from the survey gives a representative picture of the situation in Sweden.

In short, the study concludes that over 90 % of the meters are technically capable of hourly metering. However, not all of these are today configured to handle this. According to Swedeenergy[6], the cost for upgrading and reconfiguration of the meters so that they are capable of hourly metering will cost between 3-5 billion SEK.

In the following section, short descriptions of the results concerning different system levels from the survey performed by EI are presented.

2.1.1 The meters

Concerning the meters, the survey concludes that in 20 % of the consumption points, hourly consumption levels are metered and collected. In 35 % of the points, daily values are collected and in 39 % monthly values are collected. In 6 % of the cases some other interval was used.

The companies not applying hourly metering were asked if it would be possible to remotely reconfigure the system to manage hourly metering. The answer showed that 53 % of the consumption points are capable to do this. Of the ones answering no to this question were asked if there exists functionality within the meter supporting hourly metering. 21 % of the total amount of consumption points answered yes to this question. These results are shown in Figure 1. As shown, the share of meters not being able to handle hourly metering at all are 6 %.

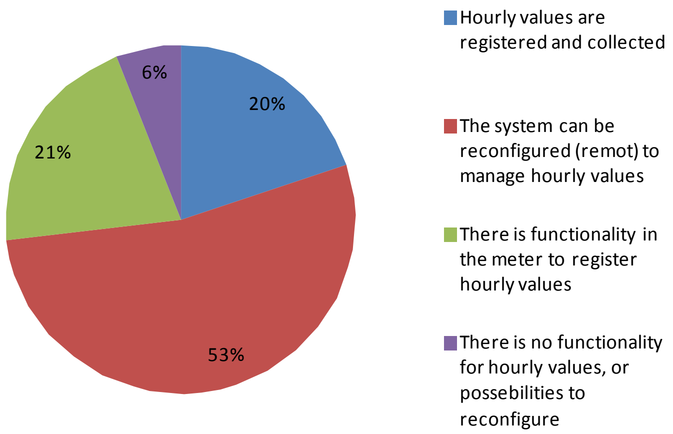


Figure 1 Status of meters in Sweden for consumers up to 63 A in fuse size.

Concerning the communication between the meters and the overlying system, different solutions are applied. The most common ones are based PLC and/or radio. Also GPRS are used for a minor part of the cases.

The frequency of collecting the measurements varies between every hour (0.3 %) up to every month (20.3 %) as shown in Figure 2.

[6] Swedenergy is the bransch organisation for companies involved in the production and distribution of electricity in Sweden.

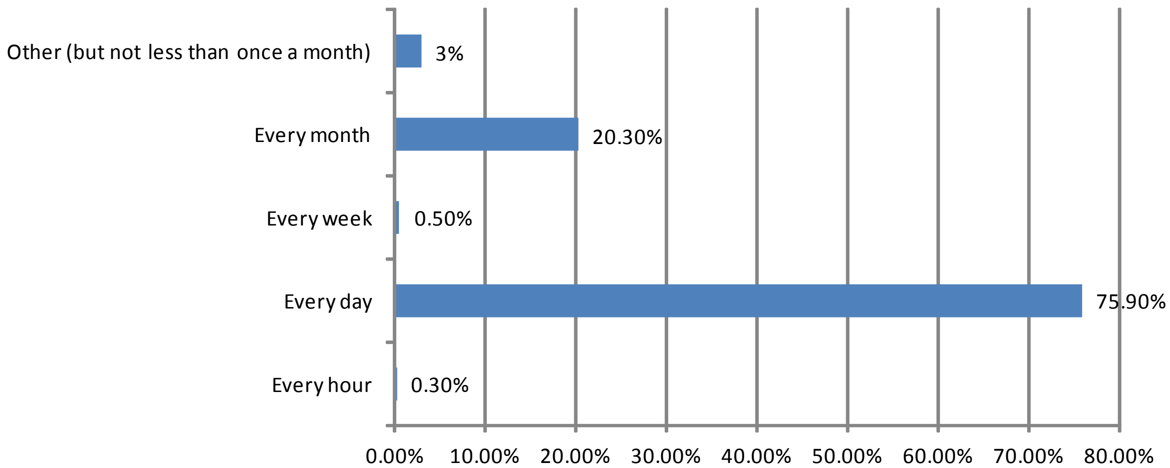


Figure 2 Frequency of collecting meter values.

2.1.2 The concentrators

Concentrators collects the data from the individual meters and sends the gathered information further up in the system to the central system. Not all consumption points are connected to a concentrator, about 10 % of the points have their data transmitted directly to the central system.

The grid owners were asked about the capacity of the concentrators to collect hourly values. In 48 % of the cases, the concentrators can collect hourly values from the meters on a daily frequency. In 20 % of the consumption points, hourly data cannot be collected on a weekly basis due to the concentrators not having capacity to handle this. The survey results are shown in Figure 3.

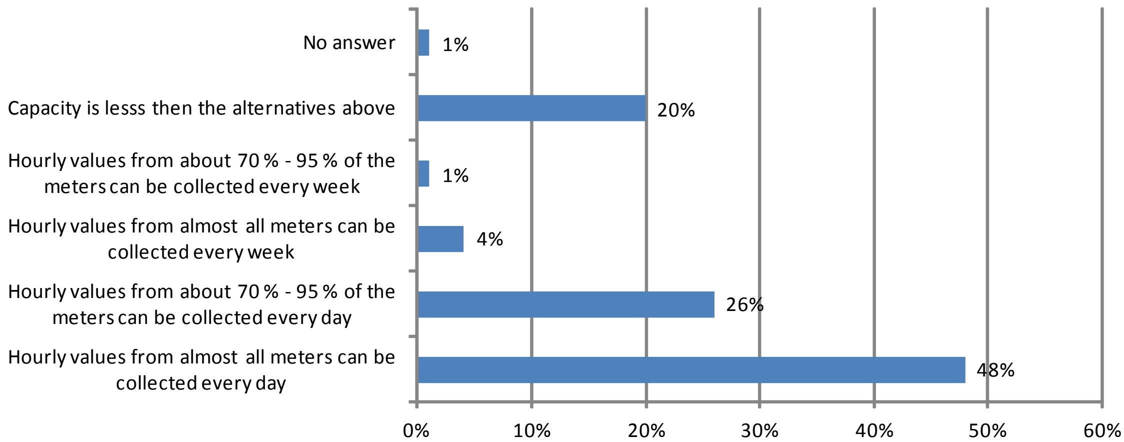


Figure 3 Capacity of the concentrators.

2.1.3 The central system

Concerning the central system, similar question as for the concentrator were asked about the capacity for collection of data. For the majority of the consumption points, hourly values can be collected for at least 70 % of the meters. The results are displayed in

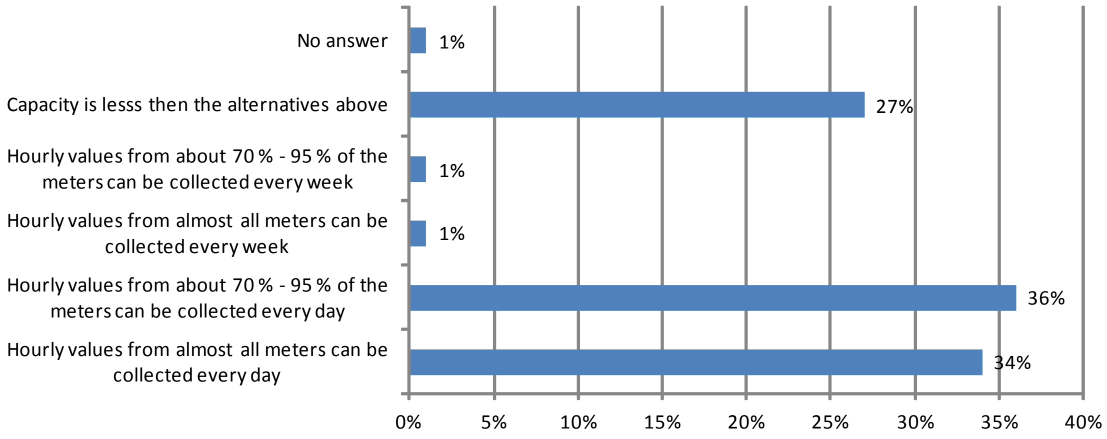


Figure 4 Capacity of the central system.

2.1.4 Making hourly statistics available for customers

In the questionnaire to the grid owners, questions were also asked about offering statistics on an hourly time resolution to customers. In 26 % of the cases, customers are today offered hourly statistics through the Internet today. In 37 % of the cases, the grid owners have prepared the systems so that this is possible.

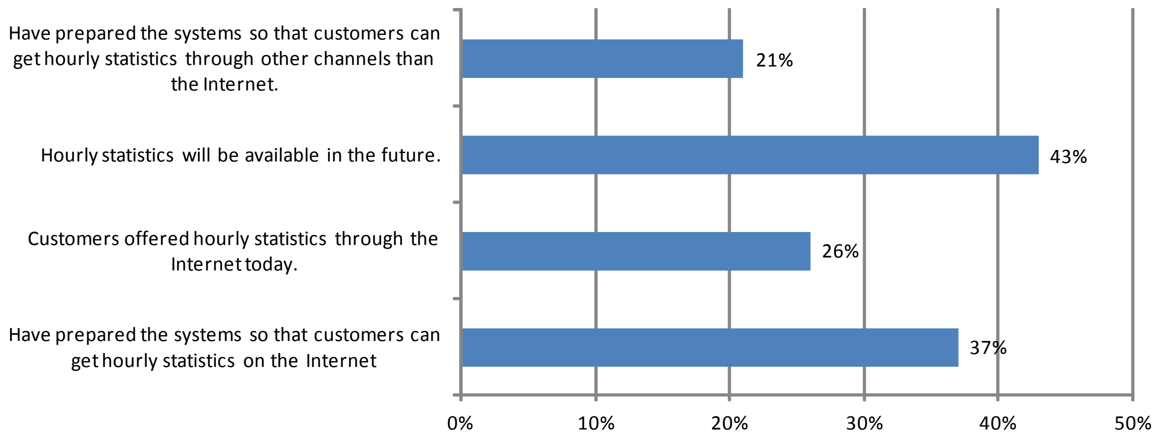


Figure 5 Hourly statistics to customers.

2.2 Remote meter reading

With the metering reform in 2003 and the introduction monthly reading in 2009, all the meters having manual reading were exchanged to new ones. Hence, all meters in Sweden are today capable of remote reading. However, not all meters have the possibility of having a more frequent reading of meter values than once a month (as described in section 2.1) , which is the requirement stipulated by the current Swedish electricity law. Similar to the situation concerning the metering time interval discussed in section **Error! Reference source not found.**, the capability of remote reading more than once a month will require some updates on site.

2.3 Measurement of net consumption

The development of energy efficient houses and the rapid development of photovoltaic panels, has created discussions in Sweden concerning the possibilities of consumers also injecting electricity of the networks. The infrastructure and market rules does not fully support this in their current forms.

The infrastructure in terms of installed meters in Sweden have different capabilities of metering consumption and local production. Some meters only measures the consumption, and any net production is not measured. Some meters measure in absolute values, thus also situations with net production will be measured as consumption. A minority of meters have the possibility today to separate the consumption from the production. According to Swedeenergy, it is unclear how large share of the installed meters that fall into these categories, and no such data is currently available.

2.4 Data access and ownership

In discussions concerning smart metering and data, the overall consensus seem to be that the consumption data are owned by the consumer. Today the metering data can only be used for billing and settlement purposes, implying that the ones having access to the data are the grid owner, the supplier, the balance responsible (if being another entity than the supplier) and the TSO. This is regulated by laws. In the future is might be possible that also other actors, such as energy service providers, to get access to the data if the consumer agrees on this. However, this is under the assumption that the data used by the energy service provider is actually distributed by the DSOs. It is however also possible that the measurements are accessed directly from the meter and the distributed to the energy service provider using other communication solutions.

2.5 Impact on settlement

Having access to more consumption data will increase the possibilities of inventing other tariff structures, which is further described in section 4.1.1. Also suppliers will the possibility of having other time dependent energy prices.

The current (September 2012) electricity law in Sweden states that customers up to 63 A will be settled on an monthly basis. Customers demanding hourly metering can get this, but has to pay for the required infrastructure and additional costs for data management. Further, the network owner is not obliged to report the actual hourly readings to the supplier, but has the possibility to report estimated values based on profiles to the supplier which will charge the customer according to the values supplied by DSO. Since the settlement is based on the monthly consumption, this is not a very crucial aspect for the average users, if their monthly consumption is well described by the profile.

In order to promote the introduction if hourly metering and settlement, a new law will come into effect on October 1, 2012. The new law states that customers having a supply contract requiring hourly values, hourly metering and settlement must be given without any additional charge from the DSO. This will open the opportunity for active users to actually get an impact of their activities on their electricity bills.

3 Electricity market structure

3.1 Stakeholders

Table 1 Stakeholders involved in generation, distribution and supply of electricity

Stakeholder	Short Description	Current responsibilities
Suppliers	Electricity suppliers sell electricity to the customers. In the country about 175 supplying companies exist. The suppliers act on a competitive market and buy the power either on the spot market or by bilateral contracts with producers or traders.	The responsibility of the supplier is manage the balance responsibility for the their customers. The supplying company can either act as balance responsible themselves or have a contract with another company which manage the balance responsibility.
Balance responsible	In Sweden 40 companies has signed a contract with the system operator Svenska Kraftnät concerning balance responsibility.	The balance responsible company is economically responsible for the hourly balance between production + purchase and consumption + sold energy. Costs for imbalances are settled after the actual hour when metering data has been reported. All producers, traders, retailers, suppliers, etc. are obliged to either be balance responsible themselves, or to have another company acting as the balance responsible on their behalf. There must be a balance responsible party for each connection point in the system where electricity is consumed. Except from large industrial consumers, the supplier acts as the balance responsible party for the customer.
Power producers	The electricity producers act on a competitive market and are free to decide whether to sell their electricity directly to large consumers, to electricity traders/suppliers or to the power exchange. Most of the generated electricity is sold to the spot market at the power exchange Nord Pool. In Sweden, three power companies owns the majority of the generation: Vattenfall, EOn and Fortum. Apart from these three, a number of medium sized and smaller actors (CHP, small hydro, wind power, etc) contribute also exist.	In the case of larger producers, these also usually act as balance responsible. It can be worth noting that it is the network owner that is obliged to measure the electricity injected into the network on an hourly basis. This will be then be used by the generating companies for billing and settlement.

Regional network operators	The regional network is the grid having voltage levels in the range 130 kV – 40 kV. The regional network is divided into about 10 different geographical areas in Sweden. The networks are owned and operated by privately held companies, such as Vattenfall, Fortum and EOn.	The main task of the regional network is to transmit power from the overlying transmission system to the local grids. Also, some generation and large loads are connected to the regional networks. The regional network operators has a concession to operate, build and maintain the grid in the same way as the DSOs. The regional network operators are also obliged to measure the flows through their networks on an hourly time scale.
Distribution system operators	The distribution system has voltage levels between 20 kV – 400 V. In Sweden, the distribution system consist of 330 areas of various sizes, operated by about 190 different DSOs. Some of the DSOs act on a very locally basis, and in many cases these are owned by the municipality. The network owners can also be privately own companies such as Vattenfall, EOn and Fortum. Note that even though these large players also act as generators, the activities are kept in separate companies in order to avoid any misuse of the monopolistic position subsidizing the generation using revenues from the distribution side.	The responsibility of the DSO is to operate and maintain the distribution system, and to calculate and collect metering data for transferred energy. The DSO has a concession to build and operate the distribution system in a certain area, and is obliged to transmit electricity. The grid owner is not permitted to trade (except for covering their losses) or to produce power. The grid tariffs are set by the DSO but are monitored by the Energy Market Inspectorate which impose limits on the revenues for the DSO. The DSOs own the metering equipement, e.g. meters in households.
Transmission System Operator	The transmission system is owned and operated by the transmission system operator Svenska Kraftnät, which is a public utility. The Swedish transmission system has voltage levels of 400 kV – 220 kV.	Svenska Kraftnät, SvK, owns, and is responsible for the physical operation of, the transmission system. They are also responsible for keeping the momentarily balance in the system. SvK does not own any generation resources but have long term contracts with generators supplying for the continuous balance management. SvK also manages an intra-hourly regulating market for the balance management, where bids can offered by producers and consumers can be accepted during the operational hour in order to compensate for deviations between planned production and actual consumption. The costs for these bids are then transferred to the balance responsible not being in balance after the operational hour in the balance settlement phase.

Market place	The dominant market place in the Nordic system is the spot market operated by Nord Pool, which is a day-ahead spot market using a trading period of one hour.	Nord Pool, which is owned by the TSOs in the Nordic system, is responsible for outgoing from the supply and demand bids calculate the hourly prices based by a procedure based on zonal pricing. Nord Pool also acts as a clearing house in the settlement process.
Metering companies	Metering is today the task of the DSOs. However, this can possibly be changed in the future and other actors can be allowed to own the meters and distribute metering data.	The DSOs are responsible for the data management and collects values from the meters in their system. The data for a specific consumer can be accessed by the supplier, the balance responsible (if not being the supplier) and the TSO.
Consumers	Consumers can be households, companies, organisations or public entities.	A consumer has a economical relationship with a supplier. Normally, the consumer does not act as a balance responsible, this is usually included in contract with the supplier. An exception can be large consumers (companies) being more active on the market and keeping the balance responsibility within their organization.
Aggregators	Companies working as aggregators do not exist in Sweden today, but are discussed as an actor that can play an important role in the future.	
Energy service providers	Services related to energy is today in a high degree provided by the established energy companies (suppliers, producers, etc), even though other independent actors exists and are growing in numbers. One example of an energy service product provided today is “indoor temperature”, where the user buys a certain indoor comfort from the energy supplier. The provider will operate the energy service system in the house in order to keep a certain temperature. For example the company Göteborg Energi sells this service to commercial customers.	The responsibilities of the energy service providers are defined by the contract between the supplier and the customer.

Table 2 Stakeholders involved in policy setting and regulation

Stakeholder	Short Description
Swedish Energy Agency	The Energy Agency is a government agency for national energy policy issues. The mission of the agency is to promote the development of Sweden's energy system so that it will become ecologically and economically sustainable.
Energy Market Inspectorate	The Swedish Energy Market Inspectorate (EI) is the regulator for the energy sector in Sweden, covering electricity, district heating and natural gas networks and markets. EI supervises the monopolistic network companies as well as the competitive energy markets. The Inspectorate works for an improvement of the functioning and efficiency of these markets.
Ministry of Enterprise, Energy and Communications.	

Table 3 Other Stakeholders

Stakeholder	Short Description / Current responsibilities
Svensk Energi (eng. Swedenergy)	Swedeenergy is a Swedish branch organization for companies involved in the supply electricity. This includes producers, traders and distributors. The organization is made up of 355 individual member companies (state-owned, municipal and private sector companies as well as associations of different types).
Appliance Manufacturers	Manufacturers of appliances for households are moving into the area of load control and smart appliances. Examples of companies acting in Sweden are Electrolux, Asko Cylinda.
Meter manufacturers	
Home automation system and heat pump manufacturers and suppliers	A large share of the Swedish houses are heated using heat pumps. The control systems includes a number of input signals such as indoor and outdoor temperatures, and in some cases also forecasts of outdoor temperatures. The heat pump industry is now also experimenting with including hourly power prices in the control systems in order to minimize the heating costs under the constraints of keeping the same comfort level in the house. Examples of actors on the Swedish market are Kabona, Nibe, xxx
Building & Construction sector	The energy performance of buildings directive drives the development of energy efficient buildings in Sweden. The building and construction companies are mainly focusing on the energy efficiency. However, the issue of flexibility is also getting more interest.

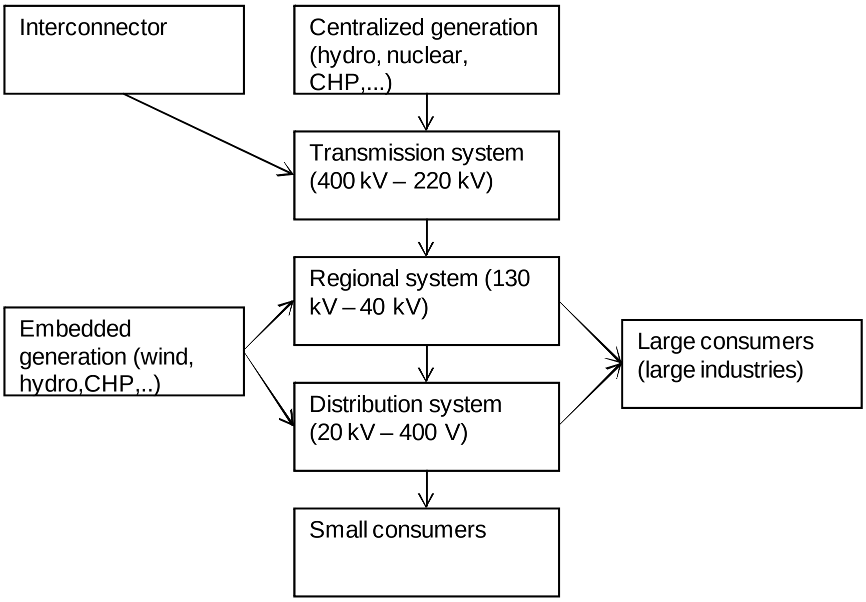
Communications Infrastructure & Services	
Consulting	
IT Providers	
Vehicle Manufacturers	
Private Finance & Capital Markets	
Real estate companies	
Equipment manufactorers	

3.2 Market Maps

Below follows market maps illustrating physical and financial flows in the Swedish electricity system and market.

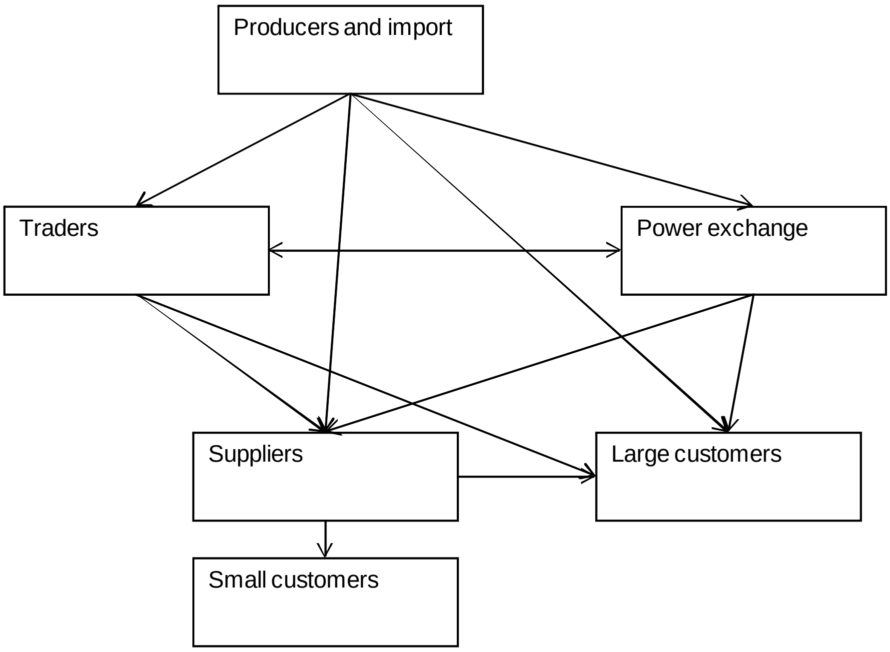
3.2.1 Physical flows

The market map of the physical flows shows the structure of the technical system and reflects the flow of the electric energy. In short the Swedish power system consists of three system levels: The transmission system, the regional system and the local system (or distribution system). The large generating units are connected to the transmission system while smaller and medium sized units are connected to the regional system. Some large industrial consumers are connected to the regional system, and on this level also the majority of embedded generation, such as wind power, injects power.



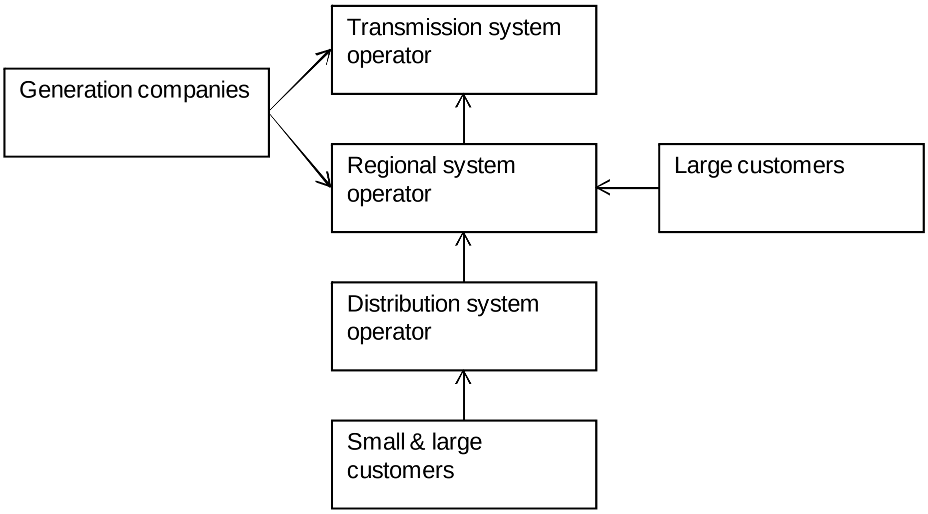
3.2.2 Energy purchasing

The market map of the energy purchase shows the financial flow in the economical system related to the trading of energy. The trading of financial contracts are not considered in the figure. Several types of actors are part in the system, including energy providers, the spot market, traders, suppliers, and consumers. Actors are free to sign bilateral contracts. Trading through the pool-based spot market Nord Pool is not mandatory in the Nordic system, but over 60 % of the electric energy is traded through Nord Pool.



3.2.3 Network charges

The market map below shows the economical flow between the actors related to network charges. The flows are in many ways a reflection of the physical flow in the network, but going in the other direction; the exception is the generating companies that also pays a fee for the grid connection.



3.2.4 Potential DSR contracting

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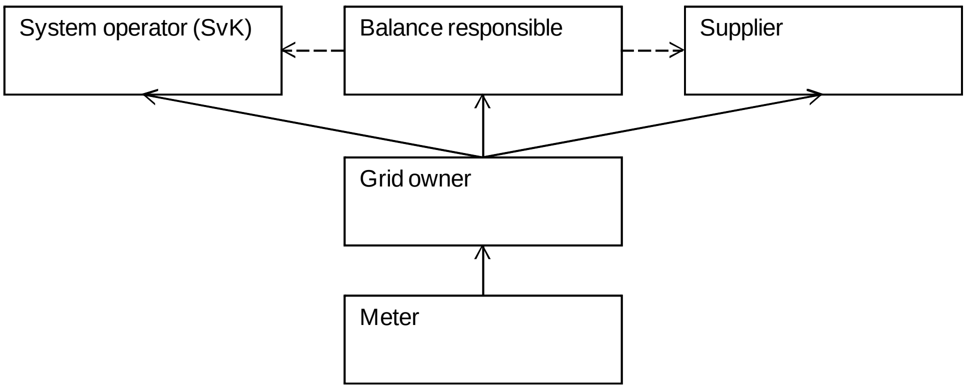
3.2.5 Metering data

The consumption data flow in the system is shown in the figure below. The grid owner is the responsible party for collecting and storing the data. Note that the grid owner in the illustration can be on the distribution or on the regional system level.



4 Tariff structures

4.1 Cost breakdown

When discussing consumer energy costs, the breakdown is usually performed in three categories:

- Network charges: Costs charged by the distribution system owner for the grid and for covering losses in the network.
- Energy costs: Costs related to the consumed energy, including green certificates.
- Taxes: Electricity tax and VAT.

The total cost of electricity for various types of consumers varies depending on the type of contract that is considered. In the table below examples of average costs for different consumer groups are listed. To illustrate the impact of the types of contracts, two different alternatives are listed: “Running”, where the customers are subjected to monthly prices, and “1 yr” which is a contract with a specified price for one year ahead. Running price is the most common type of contract and about 50 % of the Swedish consumers has this type of contract with their supplier.

Type of customer	Grid cost excl tax [öre[7]/kWh]	Energy cost excl tax [öre/kWh] Running	1 yr	Tax[8] [öre/kWh]	VAT[9]	Total cost [öre/kWh] Running	1 yr	Consumption [kWh/year]	Total cost [SEK] Running	1 yr
Flat	61.6	53.5	62.0	29	25%	180	191	2 000	3603	3815
House w/o el. heating	54.1	46.2	54.5	29	25%	162	172	5 000	8081	8600
House w. el. heating	28.6	42.5	50.9	29	25%	125	136	20 000	25025	27125
Agric. and forestry	31.7	42.1	50.7	29	0%	103	111	30 000	30840	33420
Business	21.5[10]	41.2	49.9	29	0%	92	100	100 000	91700	100400
Small industries	21.6[11]	40.9	49.4	0.5	0%	63	72	350000	220500	250250

Table 4 Electricity costs in Sweden for January 2012. Source: Statistics Sweden (SCB)[12]

The cost breakdown for the various user groups for a contract using a running price is illustrated in Figure 6, and the corresponding costs breakdown for the 1 year contract are illustrated in Figure 7. As can be seen, only minor differences can be found between the cost breakdowns.

[7] 1öre = 0.01 SEK.
[8] The electricity tax for 2012 is 29.0 öre/kWh in most parts of Sweden. Some parts have reduced electricity the tax and have a tax level of 19.2 öre/kWh. The tax levels are adjust between years. Concerning manufacturing industries, these can apply for reduced tax levels. For 2012, this level is for 2012 0.5 öre/kWh. It is only the electricity consumed in the manufactoring process, or consumption closely related to this process that can get the tax reduction
[9] VAT is 25 % and is not paid by companies.
[10] Estimated value using 4% increase in cost since January 2011.
[11] Estimated value using 4% increase in cost since January 2011.
[12] http://www.scb.se/

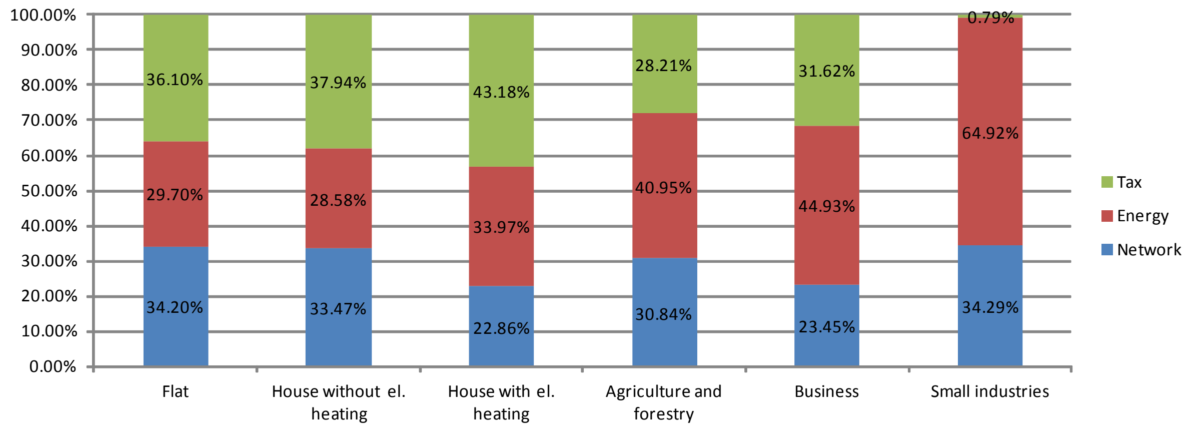


Figure 6 Percentage of the different costs for a running contract for different user groups.

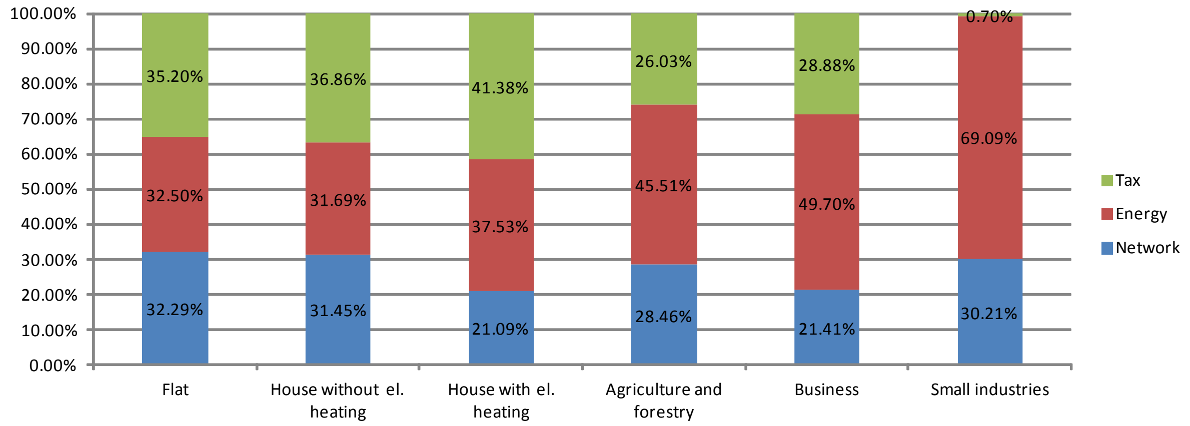


Figure 7 Percentage of the different costs for a contract with defined price for 1 year for different user groups.

The determination of the network cost, energy cost and taxes are set in fundamentally different ways. In the following sections, the grid costs, energy costs and taxes a more thoroughly described.

4.1.1 Network tariffs

The Swedish electricity laws states, in short, that the network tariffs should be objective and non-discriminatory. The economical regulation of the network companies is on their total revenues, which are reviewed ex ante by the Energy Markets Inspectorate. As long as the DSO does stay within the limit of the revenues, and fulfil the requirements on objective and non-discriminatory tariffs, the tariffs can be structured in any way the DSO wishes. Hence, there is a freedom for the DSOs to define the tariff structure.

In 2007, the Energy Market Inspectorate conducted a survey of existing tariffs[13]. Even though this was 5 year ago, the network tariff structure has not changed much since then. The survey found the following types of tariffs for households and small industries:

- Most tariffs were built upon a fixed amount plus an additional fee proportional to the energy usage. The fixed amount was usually defined by the fuse size, but in some cases it was a

[13] Utveckling av nättariffer, 1 januari 2007 – 1 januari 2008. Energimarknadsinspektionen, June 2008. In Swedish.

fixed sum for consumers up to 63 A. The additional fee can be influenced by the consumer by reducing the electricity consumption.
- One company had removed the fixed part of the fee for consumers in apartments and small houses. Only the fee proportional to the energy consumption was included.
- A few companies had only an fixed fee for households, which was based on the fuse size.
- A few network companies had introduced a tariff consisting of a fixed part (depending on fuse size) and an additional part depending on the load. The idea was to capture how much of the capacity of the network that the consumer actually used. The consumers are charged according to their highest demand during a certain time period, e.g. a month or a week. The level of the highest load is typically calculated as the average load over an hour since the meters store hourly energy values.
- Some network owners offers time-of-use tariffs. Most often these are designed using two time periods, peak and off-peak, having different fees. Peak hours are usually defined by weekdays, between 6 am – 22 pm, and are only defined for the period from November to March. This is the part of the year when the system has the highest electricity demand.

A general fee, combining the various types of tariffs mentioned above, could be expressed as the a fixed fee (SEK/year) + fee proportional to consumption (SEK/kWh) + fee for load (SEK/kW). There are no tariffs (as the author is aware of) being functions of the actual overall load in the system (dynamic tariffs). Neither are there any tariffs reflecting any momentarily surplus of local production. This is also the conclusion of EI[14].

Hence, if stating the total fee as

A + B*consumption in kWh + C*load in kW,

the parameters A, B and C are set beforehand. In a dynamic approach where the overall system load etc. affects the fee, this would not be the case.

Most network companies offer load tariffs to large industrial consumers. The tariffs that the local grids pay the overlying regional grid are also based on load tariffs.

4.1.2 Energy costs

The energy suppliers are not regulated as the network companies and the energy costs are set on the competitive electricity market. The suppliers buy electricity either on the spot market or using bilateral contracts with producers and/or traders. Over 70 % of electric energy is today traded through the spot market provided by Nord Pool[15], and the spot market prices works as a price reference also for the bilateral contracts.

The costs charged by the energy supplier onto the consumer consist of the energy cost, environmental charges and a mark-up (including expenditures, risk premium, profits etc.).

Environmental charges, such as green certificates, are included in the energy cost and are usually not specified to the customers. Other environmental charges, such as emission right, have an impact on

[14] Adapting Electricity Networks to a Sustainable Energy System – Smart metering and smart grids. Swedish Energy Markets Inspectorate. EI R2011:03. 2011.

[15] The electricity market in Sweden and the role of Svenska Kraftnät, May 2011.

the market prices when fossil fuelled production units are on the margin. However, the costs for the consumers for this are not easily assessed.

The costs for green certificates are also set on a market where certificates are being traded. The suppliers are obliged to buy certificates reflecting a certain percentage of their consumers consumption. The percentage levels are defined by the government currently exists up year 2035. The percentage for 2012 is 17.9 %.

The cost for the consumers for the certificates changes depending on the supply of certificates, i.e. production in existing units and investments in new units. Hence, the price fluctuates between years. A figure showing the development over time from 2003 – 2010 can be found below[16].

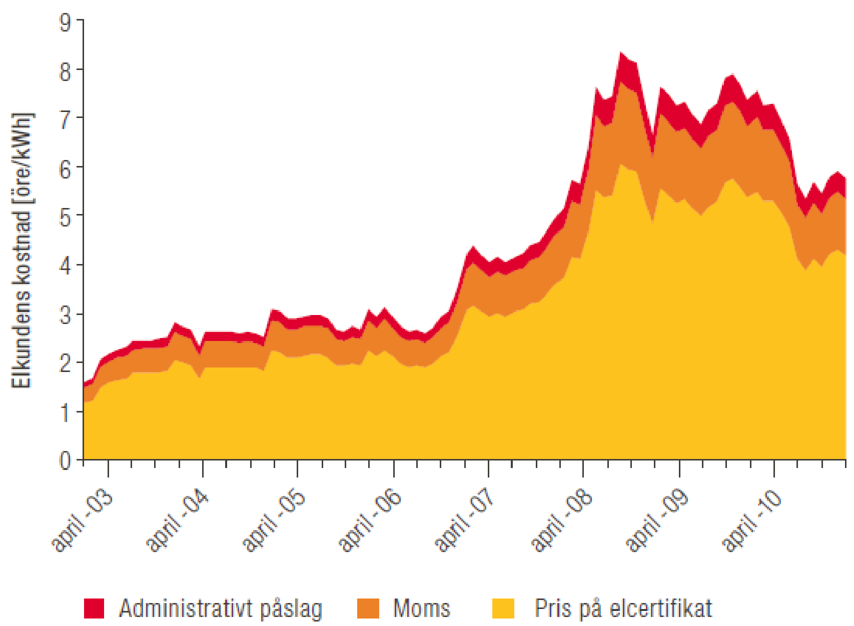


Figure 8 Prices to customers for green certificates. Translation of legend: "Administrativt påslag" = Cost for administration, "Moms" = VAT, "Pris på elcertifikat" = Certificate price. The label on the y-axis is the total consumer cost in öre/kWh.
Source: Energimyndigheten, SKM Svensk Kraftmäkling AB.

Currently (September 2012), the price on the certificate spot market is about 175 SEK/MWh, implying that the consumer cost for the certificate should be 175 * 17.9 % = 31 SEK/MWh = 3.1 öre/kWh. On top of this cost is some administrational charges added. According to Figure 8 this cost can be estimated to about 0.4 öre/kWh. This means that the total cost, VAT excluded, becomes 3.1 + 0.4 = 3.5 öre/kWh for the customers. This is a number that is often used to describe the impact of the certificate on the consumer energy cost in Sweden.

Another economical instrument is emission rights, which affects the electricity market price. According to Swedenergy, the costs for emission rights is about 9 % of the total cost (including grid charges, tax and VAT, and energy costs) for August 2012.

Calculated values reflecting the 9 % costs for emission rights and certificate cost of 3.5 öre/kWh for different user groups and running and 1 year contracts respectively, are given in Table 5, and a chart for running contracts is given in Figure 9.

[16] Elcertifikatsystemet 2011, Energimyndigheten, ET 2011:32. In Swedish

Type of customer	Energy [öre/kWh] Running	1 yr	Certificate [öre/kWh]	Emission rights [öre/kWh] Running	1 yr
Flat	33.8	41.3	3.5	16.2	17.2
House w/o el. heating	28.2	35.5	3.5	14.5	15.5
House w. el. heating	27.7	35.2	3.5	11.3	12.2
Agric. and forestry	29.3	37.2	3.5	9.3	10.0
Business	29.4	37.4	3.5	8.3	9.0
Small industries	31.7	39.5	3.5	5.7	6.4

Table 5 Breakdown of energy costs for running and 1 year contracts.

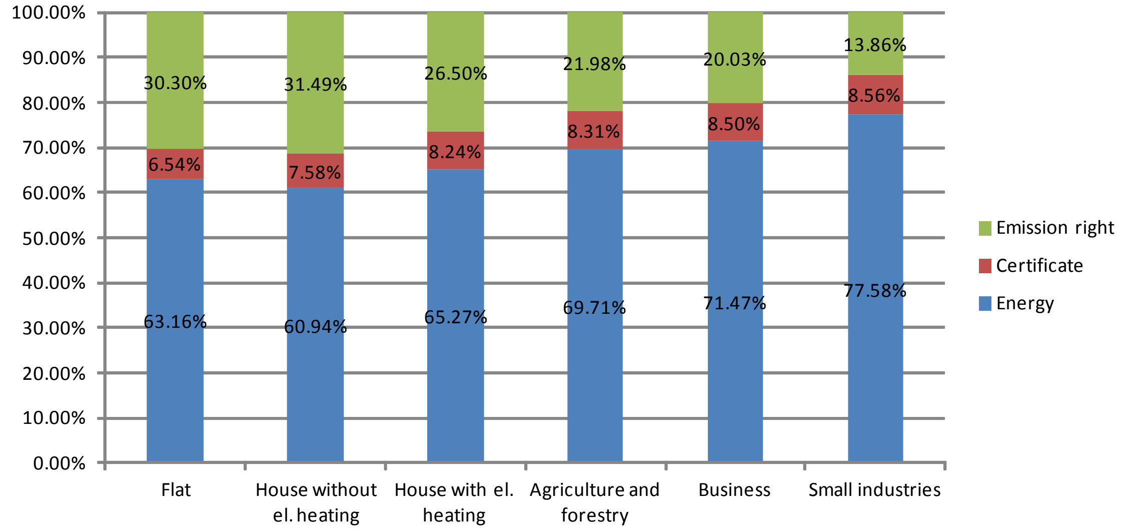


Figure 9 Cost breakdown of energy costs (excl. taxes and grid charges) for running contract for various user groups.

4.1.3 Taxes

The taxes are decided by politicians and can be adjusted between years. Including the VAT in the denomination "taxes" imply that the taxes are both absolute and relative. The electricity tax is today stated in absolute numbers, while the VAT is a percentage.

For 2012, the tax on electricity[17] is 29 öre/kWh. Exceptions from this level is made for some areas in northern Sweden having a reduced tax of 19.2 öre/kWh. Further, manufacturing industry can get a reduced tax on a level of 0.5 öre/kWh for the part of the consumption being related to the manufacturing process. The VAT is currently 25 % on energy and fuels in Sweden.

[17] The taxes on electricity and fuels can be found at the Swedish taxation authority, Skatteverket: http://www.skatteverket.se/foretagorganisationer/skatter/punktskatter/allapunktskatter/energiskatter.4.18e1b10334ebe8bc8000843.html

4.2 Billing and settlement

4.2.1 Billing

Generally, the network and energy suppliers send out bills to their customers reflecting their own costs for their products and services. The network costs are charged by the network owner, who sends the bill to the customers. The bill containing the energy charges are sent out by the electricity supplier. If the network owner and the supplier are within the same company group, only one bill is usually sent out including all costs.

The most common is that bills are being sent out each month. However, other longer time billing periods can also exist. The settlement is based on a monthly basis, which was one of aims of the metering reform, and hence, it becomes natural to also use the same periodicity to send out the bills.

The information provided on the network bill include the consumption for each month, the network tariff and VAT. If the tariff consists of different parts (fixed fee, proportional fee, etc.), these are specified on the bill. On the electricity consumption bills, the cost for energy, energy tax and VAT are included. The monthly consumption is also provided on the bill. Costs for other costs, such as green certificates, are not always defined on the electricity bill, but is included in the energy costs. The bills can also contain other information, such as statistics of the consumption levels for a number of months back.

The network and energy bills can be based on estimated consumption values, but these will be adjusted according to the metered values afterwards. The reason for the delay is not clear, but is probably a consequence of the verification process of the measurements.

The billing arrangements will probably not change much in a future with smart meters in the system. Having monthly billing is standard in Sweden and there is no need to increasing the frequency. Further, the amount of information that is meaningful to send out in the billing process concerning consumption levels etc. is limited. Customers do generally not spend too much time reading their bills and there are probably other more efficient channels to reach customers and present statistics etc concerning the energy consumption. Examples of this can be web pages or home energy displays. The influence of smart meters on the bills is probably that the actual consumption levels will be used in the cases where today estimated values are used. Thereby, no adjustments afterwards will be necessary.

4.2.2 Settlement

The Nordic market is based on hourly settlement. All trading arrangements and balance responsibilities are exercised using an hourly time resolution. The exception is the settlement to end-users up to 63 A. These users are already today settled using monthly meter readings.

To manage the hourly vs. the monthly settlement for users up to 63 A, the balance responsible use profiles to estimate the hourly consumption levels. These profiles are based on statistics and information about the consumers, which is information that the supplier usually collects. How the profiles are defined and built up is up to the involved companies and this is not available information. Some properties can however be mentioned that usually are being collected by the supplier when signing the contract:

- The home being flat or a house.
- Heating system: Electric heating, heat pump, district heating, etc.
- Fuse size.
- Number of residents.

Since the demand responds to price signals have been very low historically, and that the load profiles thereby have been repeating themselves, the forecasts of energy usage on an hourly time scale have been quite reliable. The introduction of hourly metering itself will not change the reliability of the forecasts. But having users that are more price sensitive and active on the market, will increase the uncertainties. This means that the suppliers and balance responsible companies will need to learn how the consumers will behave and act.

4.3 Data ownership

Collecting the meter values is the responsibility of the network owner, but the data is owned by the consumer. The management of hourly consumption data is discussed in Sweden, but usually the discussions are performed outgoing from that the data will be owned by the consumer. Hence, there seems to be a consensus on that data will remain owned by the consumers in the future.

The DSOs collects the data and stores the data. The DSO also has the responsibility of making the data assessable for

- suppliers for billing purposes,
- balance responsible for the balance settlement process
- the system operator.

The data is thereby protected by the law to be used for other purposes than these without agreement from the consumer.

There is today ongoing activities to evaluate how the data management should look like in the future. Since the DSOs store the data, the solutions for doing this differs between the various DSOs. There are discussions about making the data management centrally and thereby make it the task of a centralized utility to store the data. The potential benefit of this is to decrease the process time for changing supplier of energy for the consumers. Today the time before a change can be performed is three months. This benefit is being brought up to date because of the introduction of a common end-user market in the Nordic system. Having standardized solutions for changing suppliers between the various countries can possibly increase the efficiency of the market.

5 Other Relevant Information

Please provide any other relevant information that impacts on the way that customers 'behave' in the electricity market.

Examples might include

a. Do you have any Feed-In Tariffs in your country?
    i. If so, briefly describe which technologies are covered by the FiT payments, and how the payments are determined (metering of generation/exports etc)
b. White certificate schemes
    i. If so, briefly describe which the White Certificate scheme – does it relate to all customers, or only large customers
c. Emissions Trading
d. Social housing 'approach' – are appliances always included as part of the 'rental' (of either private rental homes, or social housing) and are there standards for the appliances that must be installed
e. Others??

Appendix V: UK National Report

technology

CONFIDENTIAL REPORT

International Energy Agency Demand-Side Management Programme Task XXIII: The Role of Customers in Delivering Effective Smart Grids

The UK Electricity Market

Prepared for:

IEA DSM
Task 23

Author:

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46581.1

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By
Dr Duncan Yellen

Summary

This report presents the findings of phase 1 of the five phase study underway for the IEA under Task 23. (Demand Side Mangement). The aim of Task 23 is to identify and where possible quantify the risks and rewards associated with Smart Grids and Smart Meters from the perspective of the consumer, both now and in the future. By identifying the potential risks and rewards the task would seek to develop best practice guidelines in order to ensure the demand side contributes to deliver a more effective Smart Grid. Specific objectives of Task 23 are to:-

- Understand the similarities and differences between energy markets and their interactions with the consumer in each participating country;
- Briefly review the technologies associated with the Smart Grid concept which may be relevant to the consumer;
- Identify the risks and rewards which the customer could be exposed to through the Smart Grid concept, or which they may associate with it;
- Understand the stakeholders who can influence these risks and rewards in each participating country;
- Identify tools which can minimise the risks and maximise the rewards associated with the Smart Grid from the point of view of the consumer, whilst still satisfying the needs of other stakeholders.

This report provides the background information on the current status of the Electricity market in the UK and complements similar reports produced by the other Task members, namely, South Korea, Sweden, Norway and Netherlands.

The principal deliverables associated with Task 23 are reports, addressing:-

- A clear statement of the definition of a Smart Grid used throughout the task (COMPLETE);
- Market maps for all participating countries showing the power and information flows between different stakeholders from the point of view of the consumer; (This Report)
- The risks and rewards relating to the Smart Grid concept, from the point of the view, including an understanding of the drivers of other stakeholders;
- A review of technology development, identifying both the Technology Readiness Level (TRL) and Market Readiness Level (MRL) of each relevant component of the Smart Grid concept;
- The identification of tools required to engage with the consumer to realise the greatest benefits from the Smart Grid, and how to make these tools as effective as possible.

It is anticipated that the project will be complete by December 2013

Contents

1 Smart Grid Drivers and Definitions

After a period of relative stability, the electricity supply industry worldwide is changing due to a number of relatively new drivers. The availability and acceptability of hydrocarbon based generation is beginning to diminish. The wide ranging measures being implemented to reduce the emissions of greenhouse gases, particularly the wide-scale deployment of time variable renewable generation, presents a number of challenges in relation to the balance of supply and demand. It is beginning to be questioned whether it is still viable for electricity to be provided 'on demand' in response to the requirements of end-users. Rather, a co-ordinated approach is considered whereby energy production and demand are integrated to ensure the use of renewables can be optimised whilst also minimising the use of fossil fuel fired generation and network infrastructure investment. Such an approach is the essence of the Smart Grid concept.

Whilst there is considerable focus on the technological aspects of delivering Smart Grids, little is understood of the extent to which consumers are willing and able to embrace new technologies and initiatives that enable their use of energy to be actively managed. There is a real risk that if consumers do not adopt new approaches to the way that they consume electricity, Smart Grids may not be able to achieve their full potential

The Department of Energy and Climate Change define a Smart Grid as:

"*an incremental process of applying information and communications technologies (ICTs) to the electricity system, enabling more dynamic 'real-time' flows of information on the network and more interaction between suppliers and consumers. These technologies can help deliver electricity more efficiently and reliably from a more complex network of generation sources than the system does today*[1]*.*"

The information gained from operating a smart grid would allow system operators greater visibility and flexibility of supply and demand, helping them manage the system and shift demand. Consumers would have more information about their energy use allowing them to reduce their energy costs, carbon emissions, and overall demand.

[1] *Smarter Grids: The Opportunity*, Department of Energy & Climate Change, December 2009, p1 http://www.decc.gov.uk/assets/decc/what%20we%20do/uk%20energy%20supply/futureelectricitynetworks/1_20091203163757_e_@@_smartergridsopportunity.pdf

2 Smart Metering

In the UK, the rollout of Smart Meters is to be undertaken by Energy Suppliers. The mass roll out is to begin in March 2014 and is planned to have been completed by 2019. The majority of domestic and small commercial customers should have their meter replaced. Strict obligations are being placed on the Energy Supply companies covering the installations visit to ensure that customers find it a positive, informative experience and to prevent the visit being used as an opportunity to sell products and services.

It has been decided that the data collected from domestic Smart Meters will be channelled through a central communications hub known as DataCommsCo (DCC). This hub will provide two way communications with the Smart Meter. Smart Meters should all have the functionality to be read remotely. Parties such as Energy Suppliers and Network Operators will be able to access data from Smart Meters via the DCC, as required to meet their licence obligations, or as authorized by individual customers. The data flow is represented in Figure 2.1.

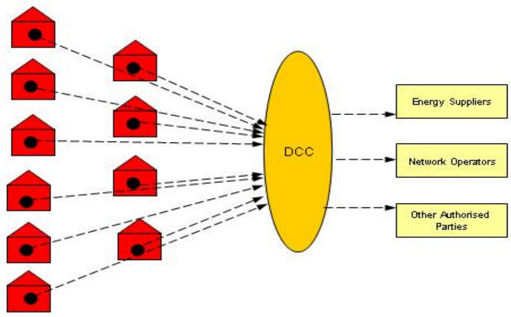
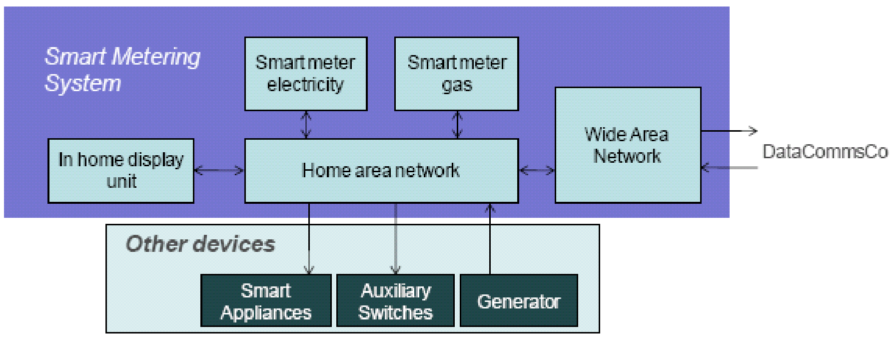


Figure 2.1 Data flow in proposed UK Smart Metering model

It is expected that licence obligations will be able to be met via access to aggregated data in most cases, negating the requirement for access to individual households energy consumption data.

In addition to accessing data, the Smart Meters will include the functionality to send pricing or other messages to the customer premises. This will be facilitated through a Home Area Network, as indicated in Figure 2.2 below. The mechanism by which network operators and other third parties implement the control of end-use loads such as Smart Appliances has yet to be defined.



Source: Smart Metering Implementation Programme: Statement of Design Requirements, 27 July 2010

Figure 2.2 Home Area Network

Thus, the Home Area Network is regarded as a crucial element in the implementation of Smart Appliances, as it enables the existing two-way communications system for the Smart Meter to be utilised to control the operation of appliances.

The profiling settlement system[2] that is currently used to allocate the total annual consumption of households and other small users[3] into half-hourly blocks means that it is difficult for energy suppliers to capture the value associated with load shifting. Under the current arrangements, the pattern of consumption of customers is determined according to a profile, and total consumption is allocated to specific half-hours according to these profiles. Customers are classified into one of eight profile classes. However, within these classes, customers with demand management are treated in the same way as customers without demand management. This is regarded as have been a major barrier to the introduction of innovative tariffs or direct load control schemes since the system was introduced in 1998.

The introduction of Smart Meters means that it will be possible for all electricity consumption to be settled according to their actual profile, rather than a 'deemed' profile. However, there is currently no requirement on Energy Suppliers to move away from the use of the existing profiling system for domestic customers and some small non-domestic customers[4], although they are able to do so if they wish.

Consumers will be given the option of sharing their information via third parties, such as service providers. This could allow third parties to access information directly via the DCC. The Government opened a consultation[5] over the arrangements that need to be put in place to protect consumers. The proposals include provision to ensure that third parties:

- Take steps to verify that the request for third party services has come from the individual living in the premises in question;
- Properly obtain consent from consumers to access their data; and
- Provide annual reminders to consumers about the data that is being collected.

[2] For a description of the load profiles and their use in electricity settlement see http://data.ukedc.rl.ac.uk/browse/edc/Electricity/LoadProfile/doc/Load_Profiles.pdf
[3] With a maximum demand less than 100kW
[4] A proposal to introduce half-hourly settlement for all customers currently in profile classes 5 to 8 is pending, but no such requirements are yet proposed for customers in profile classes 1 to 4 which includes domestic customers.
[5] Smart Metering Implementation Programme, Data access and privacy, Consultation document, April 2012

3 Electricity market structure

3.1 Stakeholders

Following privatisation in 1990 and subsequent deregulation of supply the UK electricity has evolved to become a relatively freely operating market. There are currently over 30 large electricity generators and many smaller ones. Sending electricity through one National transmission system, that then uses one of 14 distribution licence areas (operated by 6 separate businesses). Energy is supplied by either one of the big six major supply businesses or through a wide range of smaller businesses. The tables below detail the stakeholders in each stage of the electricity industry.

Table 1 Stakeholders involved in generation, distribution and supply of electricity

Stakeholder	Short Description	Current responsibilities
Energy suppliers & /or Services Companies	e.g. These companies are responsible for selling electricity (and often gas) to the end consumer.	There are currently ~70 licensed suppliers in GB[6], although half of these are only licensed to supply to non-domestic customers and a small number are constrained to a specific geographical site. All consumers have the right to choose their supplier and to switch at their discretion. A number of suppliers are developing propositions as energy services companies, providing their customers with a range of services in addition to selling energy.
Distribution Network Operators	These companies are responsible for the physical infrastructure that is required to bring electricity from the transmission system to the point of end consumption.	GB has 14 regional Distribution networks, operated by 6 Distribution Network Operators (DNOs). They have minimal contact with the end consumer, with this activity being the responsibility of the supplier. The next Price Control started in April 2010, and will cover the period 2015 to 2023 which is intended to see Distribution networks develop further to facilitate the low carbon agenda.
Centralised Generation	Large power stations, connected to the transmission system. Fuel mix is dominated by gas, coal and nuclear.	Ownership dispersed between approximately 28 companies[6] and consists of a mix of wholesale generators (generate and sell entire output to market) and integrated companies who have supply and generation licenses. Generation fleet is ageing but reliability still good. Plans for new-build being developed. Gas-fired stations likely to be quicker build and have a quicker pay-back so likely to be gas-fired in the first instance although coal and nuclear options are being developed.

[6] Based on Ofgem information on all electricity licensees, accessed via www.ofgem.gov.uk

Stakeholder	Short Description	Current responsibilities
Transmission	The transmission system is the high voltage network, providing for bulk supply of electricity. The GB system is owned and maintained by a number of companies. The onshore system is owned and maintained by three companies: National Grid Electricity Transmission owns the infrastructure in England and Wales; and the Scottish system is split into two, owned by Scottish Power Transmission and Scottish Hydro-Electric Transmission. In addition, there are six offshore transmission operator licensees who are responsible for operating the transmission assets to ensure offshore generators can connect to the onshore grid	The GB Transmission network is operated as a single system by National Grid. The Transmission System Operator(TSO) is responsible for maintaining the minute-by-minute balance of the electricity system in GB. To do this, it procures Balancing Services and operates the Balancing Mechanism. It should be noted that N.Ireland operates a separate transmission system run by Northern Ireland Electricity (NIE).
Aggregators	In order to meet the minimum volume requirements of the Balancing Services, smaller sites may be aggregated together with other sites. Aggregators provide these services, in return for either a flat fee or a proportion of the revenue received by the consumer.	The TSO currently provides contact details for 14 organisations providing commercial aggregation services in the GB market[7]. These organisations currently aggregate generation and loads from medium to large Industrial and Commercial consumers that would not meet the Transmission System Operator's requirements to tender for the provision of Balancing Services.
Metering	Metering provision is a competitive activity in the UK market, with a number of metering providers active.	Provision of metering to consumers is the supplier's responsibility, except where the consumer provides their own meter with the suppliers' agreement. Most metering systems for NHH consumers are cumulative at present. Smart meters will be rolled out to all customers by 2019.

7 Commercial Aggregation Service Providers, list accessed on 14/02/2013via http://www.nationalgrid.com/uk/Electricity/Balancing/demandside/aggregators/

Table 2 Stakeholders involved in policy setting and regulation

Stakeholder	Short Description
Ofgem (& GEMA)	Ofgem (or the Office of the Gas and Electricity Markets) is the regulator for the energy sector in GB. Its primary responsibility is to protect the interests of consumers, present and future. This is achieved by promoting competition, wherever appropriate, and regulating the monopoly companies which run the gas and electricity networks. GEMA is the Gas and Electricity Markets Authority governs Ofgem and is responsible for the strategy, policy priorities and decisions on a range of matters, including price controls and enforcement. It is provided for in statute.
Department of Energy & Climate Change (DECC)	Established in 2008, merging the departments responsible for energy and climate change (previously part of Department for Business, Enterprise, Regulatory Reform and Department for Environment, Food and Rural Affairs). The remit is to ensure that energy is secure, affordable and efficient and to bring about the transition to a low-carbon Britain.

Table 3 Other Stakeholders

Stakeholder	Short Description / Current responsibilities
Appliance Manufacturers	Technologies for direct load control could be integrated into new appliances. This could offer manufacturers a unique selling point, enabling them to differentiate their offering from their competitors'. Some manufacturers have already announced that they are developing 'Smart Appliances' with this capability. A growing market is likely to encourage others into this space.
Appliance Suppliers	There are a wide range of organisations that supply appliances to small consumers in GB, including department stores, large specialist retail chains, and independent retailers. Many of these will have a store, but an increasing number access the market through an online offering. These companies may be interested in becoming aggregators or in being able to offer these customers access to DSM programmes as a method of differentiation within the market.
Back-office services	Back office services provide the support for utility companies' financial and customer relations administration. Capability to administer DSM transactions would need to be incorporated into these systems to enable the companies to manage the transactions relating to demand response programmes.
Building & Construction sector	Targets to develop 'zero-carbon' properties are likely to drive this sector to investigating installation of low carbon technologies, including small scale and micro-generation, to meet required performance. DSM could allow the output from this generation to be used on-site, maximising the value to the owner/tenant and increasing the value to the developer.
Communications Infrastructure & Services	The companies provide communications services. The development of Smart/Advanced Metering will require communication functionality and it is likely to also be required for the development of DSM programmes. This sector is predominantly made up of a number of large, international players who may wish to become more active in the energy sector in light of these developments.

Consulting	There are a range of Consultants developing services in relation to the rollout of Smart Metering and DSM programmes. They are likely to look to provide additional support to existing parties, especially in areas where the utility has limited resources to assess opportunities, design programmes, etc.
IT Providers	The development of Smart Metering and Smart Grids is likely to be attractive to providers of ICT solutions, particularly in relation to data management and storage.
Motor Manufacturers	Electric Vehicles are being developed by most major motor manufacturers. Vehicle to Grid technologies are being developed which could enable direct load control of EVs storage capability. Motor manufacturers may also consider installing technologies to allow charging to be controlled remotely if there is sufficient interest in such approaches.
Private Finance & Capital Markets	Parties are generally outside the energy sector but provide routes for market players to access funding for capital investment programmes. In exchange, they will be looking for a return on their capital that matches their investment objectives. The ability to access funds will be a significant factor for the investment strategies that parties within the energy sector will be able to pursue.
Property Management organisations (including Housing Associations, Social Housing Landlords & Facilities Management Companies)	Approximately 32% of GB homes are rented and almost 18% are rented from Social Housing providers. A significant proportion of business premises are also leased, rather than owned, by the occupying organisation. There are therefore many parties providing rental properties and/or facilities management services for residential and business consumers. These organisations are potentially stakeholders in the development of DSM as they could act as aggregators, for example, for programmes delivered in their properties. They may also look to integrate technologies to facilitate the automation of DSM programmes during planned refits.

A full list of companies holding Electricity licences can be found in Appendix 1.

3.2 Market Maps

The diagram below shows the conventional physical flow of energy through the UK electricity network.

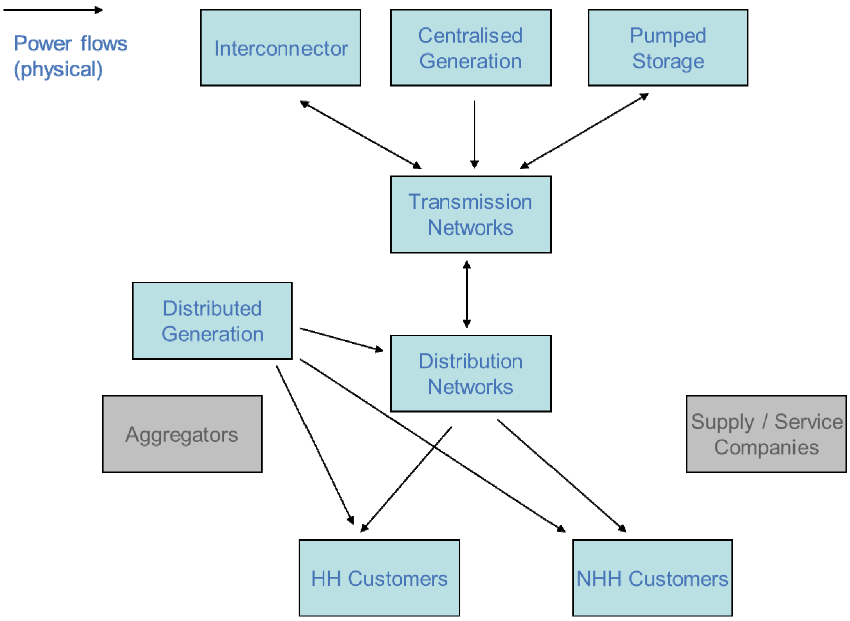


Figure 3: Physical Power Flow in the UK

The diagram below shows the mechanism for the flow of money in the UK electricity system.

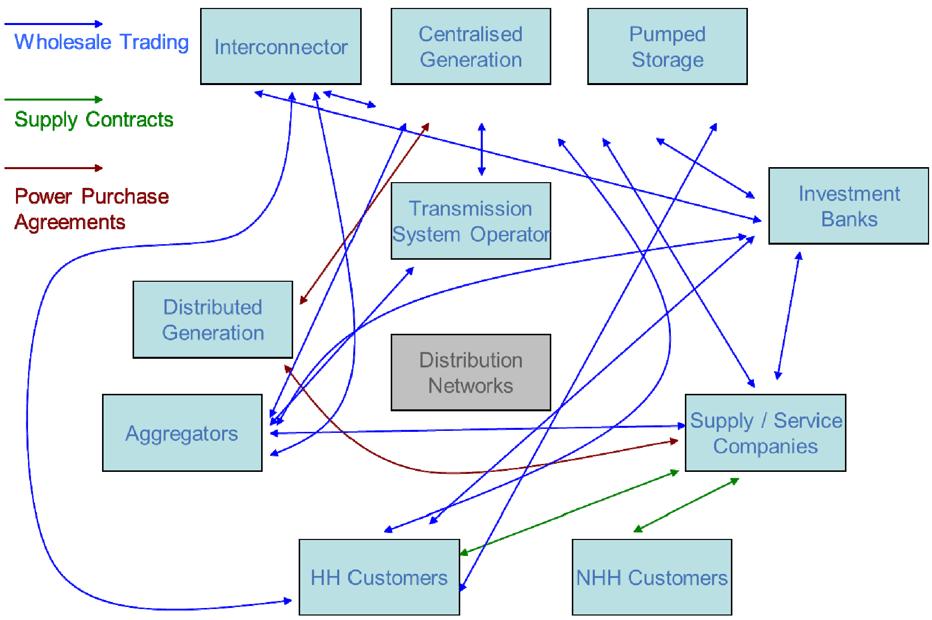


Figure 4:Energy Purchasing (flow of money between stakeholders)

The flow of charges through the UK electricity system is shown in the diagram below.

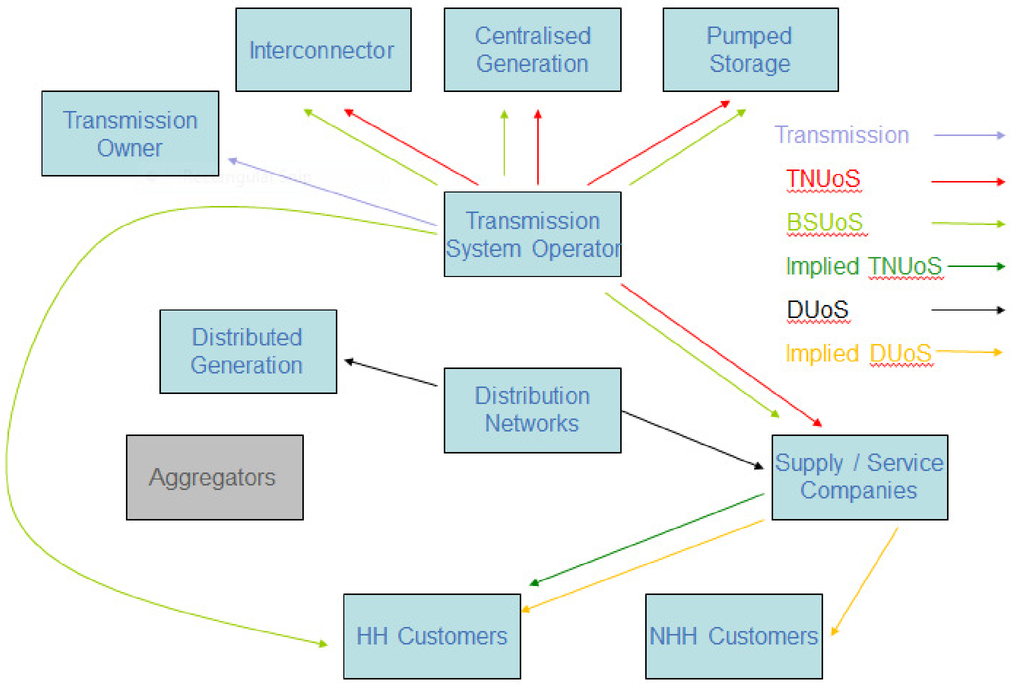


Figure 5:Network charges (flow of charges)

The Supply Company is treated as a super customer and billed for its customers share of the TNUoS (Transmission Use of System Charge) and BSUoS (Balancing Service Use of System Charge). The DUoS (Distribution Use of System Charge) is set by the Distribution License Holder according to circumstances in each of the regional 14 Distribution Licence Areas. This Use of System charge is passed on by the Energy Suppliers to the customer, itemised on their bill.

4 Tariff structures

4.1 Composition of Bill

In the UK, most residential customers are on a flat rate electricity tariffs. In 2008 20% households were on an Economy 7 style tariff which charges a cheaper rate for using electricity during the night for heating purposes (usually in conjunction with storage heaters). A small number of households are on Time of Use tariffs, usually as part of an energy trial.

The typical standard rate cost of electricity to residential non-Economy 7 customers in UK is 14.39 p/kWh[8]. The average charge for a small business is 14 p/kWh with a daily standing charge of 25p[9]. The cost of electricity to customers can be dependent on where they are based geographically because the portion of the bill that covers distribution is locality dependent.

Based on an average electricity bill (for customers without electric heating) of 3300kWh (£470) the table below breaks down the proportion of the various charges covered in a residential electricity bill (2012)[10].

Table 4: Break down of UK electricity bill

Aspect of bill	Percentage of electricity bill
Transmission charges *	5
Distribution charges *	18
Wholesale energy costs, supply costs and profit margin	55
Environmental charges **	10
Other costs (including metering, balancing and social programmes)	7
VAT **	5
Total	100

* - Regulated elements of a UK residential bill

** - Set by Government

4.2 Billing Arrangements

In the UK, billing is undertaken by the customers Energy Supplier. Households in the UK are encouraged to swap Energy Suppliers in order to achieve the best deal for their energy possible. The bill received from the Energy Supplier is for all aspects of the provision of their electricity. Billing periods are as agreed between the customer and Energy Supplier however typically most householders receive a bill quarterly, based on an estimated usage, and will pay the bill monthly by direct debit. 6.2 million households in the UK have pre-payment meters that require any electricity used to be bought in advance. This is usually done by topping-up a swipe card at one of a number of recognised outlets such as a Post Office. Households on pre-payment meters can swap Energy Suppliers if they wish.

8 http://www.energysavingtrust.org.uk/Energy-Saving-Trust/Our-calculations accessed on 16 January 2013
9 http://www.businesselectricityrates.co.uk/ accessed on 16 January 2013
10 Updated Household energy bills explained, Factsheet 81, 06.08.09, Ofgem

It is not yet known how the introduction of Smart Meters will change billing arrangements however it is anticipated that bills will be based on actual rather than estimated usage.

As well as their bill, householders receive an Annual Statement. This statement was introduced in 2010 by Ofgem to try to encourage more consumers to switch Energy Supplier. The annual Statement should detail:

- The customers tariff name,
- Quantity of electricity consumed in the last 12 months,
- Predicted cost of the next 12 months electricity consumption,
- Details on extra costs or discounts applied to the customer's account compared to the Energy Supplier's standard Direct Debit tariff,
- Principle details of the terms and conditions of the households contract,
- Reminder that the customer can switch Energy Supplier,
- Information on where impartial information can be accessed about switching Energy Supplier[11].

4.3 Profiling and Settlement System

The profiling settlement system[12] that is currently used to allocate the total annual consumption of households and other small users[13] into half-hourly blocks means that it is difficult for energy suppliers to capture the value associated with load shifting. Under the current arrangements, the pattern of consumption of customers is determined according to a profile, and total consumption is allocated to specific half-hours according to these profiles. Customers are classified into one of eight profile classes, as listed below:

1. Domestic Unrestricted Customers
2. Domestic Economy 7 Customers
3. Non-Domestic Unrestricted Customers
4. Non-Domestic Economy 7 Customers
5. Non-Domestic Maximum Demand (MD) Customers with a Peak Load Factor (LF) less than 20%
6. Non-Domestic MD Customers with a Peak LF between 20% and 30%
7. Non-Domestic MD Customers with a Peak LF between 30% and 40%
8. Non-Domestic MD Customers with a Peak LF over 40%

However, within these classes, customers with demand management are treated in the same way as customers without demand management. This is regarded to have been a major barrier to the introduction of innovative tariffs or direct load control schemes since the system was introduced in 1998.

The introduction of Smart Meters means that it will be possible for all electricity consumption to be settled according to their actual profile, rather than a 'deemed' profile. However, there is no requirement on Energy Suppliers to move away from the use of the current profiling system for domestic customers and some small non-domestic customers[14], although they are able to do so if they wish.

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11 *Missing the mark: Consumers, energy bills, annual statements and behaviour change,* Hannah Mummery and Gillian Cooper, Consumer Focus, http://www.consumerfocus.org.uk/files/2011/06/Missing-the-mark.pdf p16

12 For a description of the load profiles and their use in electricity settlement see http://data.ukedc.rl.ac.uk/browse/edc/Electricity/LoadProfile/doc/Load_Profiles.pdf

13 With a maximum demand less than 100kW

14 A proposal to introduce half-hourly settlement for all customers currently in profile classes 5 to 8 is pending, but no such requirements are yet proposed for customers in profile classes 1 to 4 which includes domestic customers.

5 Other Relevant Information

5.1 Feed-In Tariffs

Feed-in Tariffs were introduced in the UK in 2010 to encourage investment in small scale renewables and CHP. The Feed-In Tariff covers Photovoltaic(PV), Anaerobic Digestion, Hydro, Wind and Combined Heat and Power (CHP). The Tariffs currently available for domestic scale installations are detailed in the table below.

Table 5: Feed-In Tariff rates[15]

Technology	Tariff (p/kWh)
Hydro (installed capacity of 15kW or less)	21.00
Wind (installed capacity of 1.5kW or less)	21.00
CHP (installed capacity 2kW or less)	12.50
Anaerobic Digestion (installed capacity 250kW or less)	14.70
PV (total installed capacity 4kW or less, installed on or wired to a new build dwelling at the time of construction)	7.10 to 15.44*
PV (total installed capacity 4kW or less, installed on or wired to a dwelling which is already occupied)	7.10 to 15.44*
*-Rate determined by dwellings Energy Performance Certification	

A further 4.5p/kWh will be paid on half the generated electricity for those systems under 30kWp which is deemed to have been exported. Once Smart Meters are installed the amount of self-generated electricity will be measured and the export value only paid on the measured amount, rather than the deemed amount. Under this renewables incentive, consumers are incentivised to use as much of the electricity they generate as possible as there is a significant differential between the import price paid to use electricity from the grid vs. the amount received from exports.

5.2 Building Regulations

Building regulations for new dwellings in the UK[16] stipulate the energy consumption and carbon dioxide (CO_2) targets with which all new and refurbished buildings must comply. The Standard Assessment Procedure (SAP)[17] is the UK Government's recommended methodology for measuring the energy rating and CO_2 emissions rate of residential dwellings. It works by assessing how much energy a dwelling will consume and how much CO_2 will be emitted in delivering a defined level of comfort and service provision, based on standardised occupancy conditions. The current SAP methodology makes no allowance for the real time CO_2 emissions associated with electricity used for heating purposes. Thus, all electric heating systems are associated with a fixed CO_2 emissions rate. There is no benefit attached to installing a heating system that can be flexed to match the

[15] http://www.ofgem.gov.uk/Sustainability/Environment/fits/tariff-tables/Pages/index.aspx accessed 22 January 2013

[16] http://www.planningportal.gov.uk/buildingregulations/

[17] http://www.decc.gov.uk/en/content/cms/emissions/sap/sap.aspx

availability of off-peak generation (as with storage heating) or to match the availability of wind, or other low-carbon generation. Thus, there is no incentive for installers and house builders to provide houses to consumers with flexible electric heating systems. This approach is considered to be a significant barrier to the adoption of flexible electric heating systems.

5.3 Emissions Trading

The UK is a member of the EU Emissions Trading System (EU ETS). Over 1,100 energy-intensive installations (power stations, refineries, large manufacturing plants, aviation industry) in the UK are a member of the scheme, accounting for 50% of the UK's CO_2 emissions. Participants are set a cap on the amount certain greenhouse gases that they can emit. If they need to emit more that this quota they are required to buy more allowance at an allowance auction; alternatively if they do not require their full quota they can sell the remainder. Over time the quantity of emissions allowed overall is reduced. Heavy fines are imposed on any company who does not have enough allowances to cover their emissions.

6 Future Developments for DSR in the UK Electricity Market

DSR is clearly still in its infancy for small commercial (SME) and domestic customers in the UK. At present Engineering Recommendation P2/6[18] does not provide any ability for a distribution company to provide DSR at the domestic customer level. However Electricity NorthWest (one of the UK project partners) is currently consulting on" the need for an update related to recognising DSR within ER P2/6 in the interim period" – i.e in the next year. In the mean time DSR already exists in the UK for large customers through the Balancing Services offered by National Grid. In addition the energy bill published in November 2012 offers further scope for enlarging this market. These two opportunities for DSR are discussed in brief below:

6.1 Balancing Services

As the UK Transmission system operator, National Grid (NG) purchases "Balancing Services" to operate this system in an efficient, economic manner. NG publishes monthly statements and market reports on the purchasing and use of Balancing
Services on its web site (see http://www.nationalgrid.com/uk/Electricity/Balancing/)

National Grid purchases Demand Side Response from industry in the form of Short Term Operating Reserve (STOR) through a competitive tender process which is conducted three times per year. According to NGs latest monthly statement (Dec 2012) the volume that was assessed as economic and proceeded to contract was 3,530MW. The average availability payment made was £6.96/MWh for both non-working days and working days. The average contracted utilisation payment for STOR was £202/MWh. The total STOR expenditure on availability payments and utilisation payments for the month was £8.67m. The total STOR Utilisation volume for the month was 20,173MWh. **Thus as a rough rule of thumb a MWh of DSR from Industry was "worth" £430 (or 43p/kWh).**

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18 Distribution Licence : Standard Licence Condition 24.1 states "The licensee must plan and develop its Distribution System in accordance with: (a) a standard not less than that set out in Engineering Recommendation P.2/6 of the Energy Networks Association so far as that standard is applicable to it;"

6.2 The Energy Bill

The Energy Bill published in November offers two potential opportunities for DSR

Auction of DSR Response

It is proposed that energy customers could be paid a premium payment representing reduced use of electricity – this would be similar to a FiT mechanism. It would either be achieved by:

- a single payment for every kWh saved up to an agreed level
- a premium payment with a Contract for Difference.

Similarly to how the FiT CfD is intended to work, but in reverse, providers would receive a top-up payment above the electricity price for every kWh saved up to an agreed price. If the electricity price exceeds this price, a payment back to the scheme would be made. This is seen as a more stable option for investment than a single payment mechanism. The price to be received would be subject to an auction. A significant amount of further work would need to be put in to scheme design (e.g. in relation to auction design, operation of the scheme and, for a CfD based scheme, determining the electricity reference price). It is likely that customers for this market would be industrial and commercial customers (possibly through aggregators).

Inclusion of Electricity Efficiency in the Capacity Market

This option would involve electricity efficiency measures being included alongside DSR and electricity storage in the Capacity Market. Similar considerations to the premium payment would apply and, similarly, auctioning would probably be used.

The Capacity Market

While work continues on many aspects of the proposed auction-based capacity mechanism, some further detail has been published in an annex to DECC's EMR Policy Overview. The basic structure for the capacity mechanism would see publication of a forecast of peak demand made 4 years ahead of the relevant delivery year on a rolling basis (the first forecast being expected at the end of 2013). DECC plans to hold the first capacity auction in 2014 to allow for delivery of capacity in winter 2018 / 2019. National Grid (as system operator) will then operate an annual central auction to secure the net amount of required capacity. DECC has opened up the capacity mechanism widely to operators and has stated that inter alia. “Demand Side Response and storage will qualify to participate and will benefit from additional transitional provisions”

Thus it can be seen that the market for DSR is developing rapidly for large energy users and may in time become available for smaller users.

7 The Next Steps

The above report provides an overview of the UK electricity market and the intended roll out of smart metering. The principal deliverables associated with Task 23 are reports, addressing:-

- A clear statement of the definition of a Smart Grid used throughout the task (COMPLETE);
- Market maps for all participating countries showing the power and information flows between different stakeholders from the point of view of the consumer; (This Report)
- The risks and rewards relating to the Smart Grid concept, from the point of the view, including an understanding of the drivers of other stakeholders;
- A review of technology development, identifying both the Technology readiness Level (TRL) and Market Readiness Level (MRL) of each relevant component of the Smart Grid concept;
- The identification of tools required to engage with the consumer to realise the greatest benefits from the Smart Grid, and how to make these tools as effective as possible.

It is anticipated that the project will be complete by December 2013.

8 Appendix

Appendix 1 - Electricity Industry Licence Holders[19]

Electricity Distribution

Eastern Power Networks plc.
Electricity North West Limited
Energetics Electricity Limited
ESP Electricity Limited
Independent Power Networks Limited
London Power Networks plc
Northern Powergrid (Northeast) Limited
Northern Powergrid (Yorkshire) Plc
Scottish Hydro Electric Power Distribution Plc
South Eastern Power Networks plc
Southern Electric Power Distribution Plc
SP Distribution Limited
SP Manweb Plc
The Electricity Network Company Limited
UK Power Networks (IDNO) Ltd
Utility Assets Limited
Western Power Distribution (East Midlands) Plc
Western Power Distribution (South Wales) Plc
Western Power Distribution (South West) Plc
Western Power Distribution (West Midlands) Plc

Electricity Generation

2CO Power (Yorkshire) Limited
Abbey Power Generation Plc
AES Barry Limited
Baglan Operations Limited
Barking Power Limited
Beatrice Offshore Windfarm Limited
British Energy Generation (UK) Limited
Carrington Power Limited
Celtpower Limited
Centrica Barry Limited
Centrica Brigg Limited
Centrica KL Limited
Centrica KPS Limited
Centrica Langage Limited
Centrica PB Limited
Centrica RPS Limited
Centrica SHB Limited
Citigen (London) Limited
Clyde Windfarm (Scotland) Limited
Corby Power Limited
Coryton Energy Company Limited
Crystal Rig ll Limited
Deeside Power Limited
Derwent Cogeneration Limited
DONG Energy Burbo Extension (UK) Limited
DONG Energy Humber Renewables Limited
Drax Biomass (Immingham) Limited
Drax Power Limited
Dudgeon Offshore Wind Limited
E,ON Climate & Renewables UK Humber Wind Limited
E.ON Climate & Renewables UK Rampion Offshore Wind Limited
E.ON UK Plc
EDF Development Company Limited
EDF Energy (Sutton Bridge Power)
EDF Energy (West Burton Power) Limited
EDF Energy Nuclear Generation Limited
Eggborough Power Limited
Enfield Energy Centre Limited

[19] http://www.ofgem.gov.uk/Licensing/Work/Documents1/external_electricity_list.pdf accessed 22 January 2013

Enron Teeside Operations Limited
Esso Petroleum Company Limited
Fallago Rig Windfarm Limited
Fibre Power (Slough) Limited
First Hydro Company
Galloper Wind Farm Limited
GB Developers Limited
GDF Suez Marketing Limited
GDF Suez Shotton Limited
GDF Suez Teesside Limited
Grangemouth CHP Limited
Greater Gabbard Offshore Winds Limited
Green Hill Energy Ltd
Griffin Wind Farm Limited
Gwynt Y Mor Offshore Wind Farm Limited
Heartlands Power Limited
Helius Energy Gamma Limited
Horizon Nuclear Power Wylfa Limited
Immingham CHP LLP
Indian Queens Power Limited
International Power Plc
IPM Energy Trading Limited
Jade Power Generation Limited
Keadby Developments Limited
Keadby Generation Limited
Keltneyburn Hydro Limited
Knottingley Power Limited
Lincs Wind Farm Limited
London Array Limited
London Underground Limited
Marchwood Power Limited
Medway Power Limited
MGT Power Limited
MGT Teesside Limited
Morgan Credit Limited
Neart na Gaoithe Offshore Wind Limited
NNB Generation Company Limited
Nordjysk Elhandel A/S
North Blyth Energy Limited
Npower Cogen Trading Limited
Npower Direct Limited
NuGeneration Limited
Ormonde Energy Limited
Prenergy Limited
Richborough A Limited
Rocksavage Power Company Limited
Rugeley Power Generation Limited
RWE Npower Plc
RWE Npower Renewables (Stallingborough) Limited
Saltend Cogeneration Company Limited
Scira Offshore Energy Limited
Scottish Power Generation Limited
ScottishPower (DCL) Limited
ScottishPower (SCPL) Limited
ScottishPower Renewables UK Limited
Seabank Power Limited
Seagreen Alpha Wind Energy Limited
Seagreen Bravo Wind Energy Limited
Sellafield Limited
Severn Power Limited
Spalding Energy Company Limited
SPEP Limited
SSE Generation Limited
SSEPG (Operations) Limited
Thanet Offshore Wind Limited
The Green Renewable Energy Company Limited
The Nuclear Decommissioning Authority
Thor Cogeneration Limited
Thorpe Marsh Power Limited
UK Power Reserve (Trumfleet) Ltd
UK Power Reserve Limited
Uskmouth Power Company Limited
Wainstones Energy Limited
Walney (UK) Offshore Windfarms Limited
West Burton Limited

Westermost Rough Limited

Electricity Interconnector

BritNed Development Limited
Channel Cable Limited
East West Cable One Limited
EirGrid Plc
Imera Hydragrid Limited
Imera Hydragrid Limited
Moyle Interconnector Limited
National Grid Interconnectors Limited

Electricity Supply – Domestic and Non-Domestic

Better Energy Supply Limited
BizzEnergy Limited
British Gas Trading Limited
Callisto Energy Supply Limited
Candela Energy Supply Limited
Circuit Energy Supply Limited
Co-Operative Energy Limited
Coulomb Energy Supply Limited
Donnington Energy Limited
E.ON Energy Solutions Limited
Economy Energy Trading Limited
Economy Power Limited
EDF Energy Customers Plc
Electricity Plus Supply Limited
Energy 2 Sell Limited
Energy COOP Ltd
Europa Energy Supply Limited
F & S Energy Limited
Farmoor Energy Limited
First Utility Limited
FIT Energy Supply Limited
Ganymede Energy Supply Limited
Garsington Energy Limited
Good Energy Limited
Haven Power Limited
Home Counties Energy Plc
Hudson Energy Supply UK Limited
I Supply Electricity 2 Limited
I Supply Electricity 3 Limited
I Supply Electricity Limited
I Supply Energy Limited
I.C.S. 1989 Limited
Lumen Energy Supply Limited
Magnetic Energy Supply Limited
Metonomi Limited
Nationwide Electricity Limited
Npower Direct Limited
Npower Limited
Npower Northern Limited
Npower Northern Supply Limited
Npower Yorkshire Limited
Npower Yorkshire Supply Limited
Oberon Energy Supply Limited
Open4Energy Limited
Opus Energy (Corporate) Limited
Opus Energy Limited
Opus Energy Renewables Limited
OVO Electricity Limited
Pan-Utility Limited
R Electrics Limited
Reuben Power Supply Limited
Scottish Power Energy Retail Limited
SEEBOARD Energy Limited
Smart Electricity Limited
South Wales Electricity Limited
Spark Energy Supply Limited
SSE Energy Supply Limited
Supply Energy Limited
The Renewable Energy Company Limited

UK Healthcare Corporation Limited
Utilita Energy Limited

Non-Domestic

Abacus Financial Limited
AMRECS LLC
BES Commercial Electricity Limited
Better Business Energy Limited
Blizzard Utilities Limited
BP Energy Europe Limited
Brilliant Energy Limited
British Energy Direct Limited
Business Energy Solutions Limited
Dual Energy Direct Limited
E.ON UK Plc
Ecotrade Solutions Limited
Electricity Direct (UK) Limited
Eneco energy Trade BV
Energy Data Company Limited
ETUL Limited
Gazprom Marketing & Trading Retail Limited
GDF Suez Marketing Limited
Immingham CHP LLP
IPM Energy Retail Limited
Lourdes Associates Limited
MA Energy Limited
Morgan Stanley Capital Group Inc
Nordjysk Elhandel A/S
Power4All Limited
Rocpower Limited
S. C. Isramart SRL
SmartestEnergy Limited
Statkraft Markets GmbH
Team Gas and Electricity Limited
Total Gas & Power Limited
Tradelink Solutions Limited
Universal Bioenergy Limited
Utility Partnership Limited
Uttily (UK) Limited
Wilton Energy Limited
Winnington Networks Limited

Electricity Transmission

National Grid Electricity Transmission Plc
Scottish Hydro Electric Transmission Limited
SP Transmission Limited
TC Gunfleet Sands OFTO Limited
TC Ormonde OFTO Limited
Further OFTO companies exist – for more guidance on this area see http://webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk/files/file46629.pdf

Glossary

CHP	Combined Heat and Power
CO_2	Carbon Dioxide
CPP	Critical Peak Pricing
DCC	Data Collection Company
DECC	Department of Energy and Climate Change (UK)
DNO	Distribution Network Operator
DSM	Demand Side Management
EU ETS	European Union Emissions Trading System
GEMA	Gas and Electricity Markets Authority
ICT	Information and Communication Technology
kWp	Peak kW generated
NHH	Non-Half-Hourly Metered Customers (i.e. most domestic and small commercial customers)
PV	Photovoltaic
RTP	Real Time Pricing
SAP	Standard Assessment Procedure
SSEG	Small Scale Embedded Generation
ToU	Time of Use
TSO	Transmission System Operator

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Appendix VI: IEA Demand Side Management Programme

The Demand-Side Management (DSM) Programme is one of more than 40 co-operative energy technology programmes within the framework of the International Energy Agency (IEA).The Demand-Side Management (DSM) Programme, which was initiated in 1993, deals with a variety of strategies to reduce energy demand. The following 16 member countries and the European Commission have been working to identify and promote opportunities for DSM:

Austria	Netherlands
Belgium	Norway
Canada	New Zealand
Finland	Spain
France	Sweden
India	Switzerland
Italy	United Kingdom
Republic of Korea	United States
Sponsors: RAP	

Programme Vision during the period 2008 - 2012: Demand side activities should be active elements and the first choice in all energy policy decisions designed to create more reliable and more sustainable energy systems

Programme Mission: Deliver to its stakeholders, materials that are readily applicable for them in crafting and implementing policies and measures. The Programme should also deliver technology and applications that either facilitate operations of energy systems or facilitate necessary market transformations

The Programme's work is organized into two clusters:

- The load shape cluster, and
- The load level cluster.

The 'load shape" cluster will include Tasks that seek to impact the shape of the load curve over very short (minutes-hours-day) to longer (days-week-season) time periods. Work within this cluster primarily increases the reliability of systems. The "load level" will include Tasks that seek to shift the load curve to lower demand levels or shift between loads from one energy system to another. Work within this cluster primarily targets the reduction of emissions.

A total of 24 projects or "Tasks" have been initiated since the beginning of the DSM Programme. The overall program is monitored by an Executive Committee consisting of representatives from each contracting party to the Implementing Agreement. The leadership and management of the individual Tasks are the responsibility of Operating Agents. These Tasks and their respective Operating Agents are:

- Task 1 International Database on Demand-Side Management & Evaluation Guidebook on the Impact of DSM and EE for Kyoto's GHG Targets – Completed
  Harry Vreuls, NOVEM, the Netherlands

- Task 2 Communications Technologies for Demand-Side Management – Completed
  Richard Formby, EA Technology, United Kingdom

- Task 3 Cooperative Procurement of Innovative Technologies for Demand-Side Management – Completed
  Dr. Hans Westling, Promandat AB, Sweden

- Task 4 Development of Improved Methods for Integrating Demand-Side Management into Resource Planning – Completed
  Grayson Heffner, EPRI, United States

- Task 5 Techniques for Implementation of Demand-Side Management Technology in the Marketplace – Completed
  Juan Comas, FECSA, Spain

- Task 6 DSM and Energy Efficiency in Changing Electricity Business Environments – Completed
  David Crossley, Energy Futures, Australia Pty. Ltd., Australia

- Task 7 International Collaboration on Market Transformation – Completed
  Verney Ryan, BRE, United Kingdom

- Task 8 Demand-Side Bidding in a Competitive Electricity Market – Completed
  Linda Hull, EA Technology Ltd, United Kingdom

- Task 9 The Role of Municipalities in a Liberalised System – Completed
  Martin Cahn, Energie Cites, France
-
- Task 10 Performance Contracting – Completed
  Dr. Hans Westling, Promandat AB, Sweden

- Task 11 Time of Use Pricing and Energy Use for Demand Management Delivery- Completed
  Richard Formby, EA Technology Ltd, United Kingdom

- Task 12 Energy Standards
  To be determined

- Task 13 Demand Response Resources - Completed
  Ross Malme, RETX, United States

- Task 14 White Certificates – Completed
  Antonio Capozza, CESI, Italy

- Task 15 Network-Driven DSM - Completed
  David Crossley, Energy Futures Australia Pty. Ltd, Australia

- Task 16 Competitive Energy Services
  Jan W. Bleyl, Graz Energy Agency, Austria / Seppo Silvonen/Pertti Koski, Motiva, Finland

- Task 17 Integration of Demand Side Management, Distributed Generation, Renewable Energy Sources and Energy Storages
  Seppo Kärkkäinen, Elektraflex Oy, Finland

- Task 18 Demand Side Management and Climate Change - Completed
  David Crossley, Energy Futures Australia Pty. Ltd, Australia

- Task 19 Micro Demand Response and Energy Saving - Completed
  Linda Hull, EA Technology Ltd, United Kingdom

- Task 20 Branding of Energy Efficiency
  Balawant Joshi, ABPS Infrastructure Private Limited, India

- Task 21 Standardisation of Energy Savings Calculations
  Harry Vreuls, SenterNovem, Netherlands

- Task 22 Energy Efficiency Portfolio Standards
  Balawant Joshi, ABPS Infrastructure Private Limited, India

- Task 23 The Role of Customers in Delivering Effective Smart Grids
  Linda Hull. EA Technology Ltd, United Kingdom

- Task 24 Closing the loop - Behaviour change in DSM, from theory to policies and practice
  Sea Rotmann, SEA, New Zealand and Ruth Mourik DuneWorks, Netherlands

For additional Information contact the DSM Executive Secretary, Anne Bengtson, Box 47096, 100 74 Stockholm, Sweden. Phone: +46 8 510 50830, Fax: +46 8 510 50830. E-mail: anne.bengtson@telia.com

Also, visit the IEA DSM website: http://www.ieadsm.org