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D6.6 Concepts, stakeholders and value chains in smart energy business and services

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Preface

This paper is part of EU FP7 project *Energy-Hub for residential and commercial districts and transport* (E-Hub) WP6 *Business strategies and non-technical issues* Task 6.1.1 *State-of-the art of markets and business models*. The main purpose of the paper is to improve the common understanding of topic services, business models and value chains.

The research was conducted as literature study combined with interviews. The basic text in chapters 2, 3 and 4 is written by Reijo Kohonen and Teemu Meronen from Global EcoSolutions Ltd (GES). Chapter 1 describing background and link to EU-project E-Hub was written by Ismo Heimonen from VTT.

Chapter 3 Stakeholders and Regulatory Environment includes the description of the method for data collection of existing district case studies. The data collection and description of case studies will be part of E-Hub WP6 co-operation. The future work consists of analysis of new business and service models in context of E-Hub.

The writers want to give special thanks to interviewees and e-mail respondents (e-mail interviews) for giving their expertise for use in developing new businesses and services. Thanks to E-hub partners for giving valuable comments on the paper.

Espoo 27.11.2011

Writers

Executive summary

The paper explains the concepts of smart energy and smart grids (electricity and thermal) and gives an overview of possible benefits of smart energy concepts and solutions. The stakeholders in smart energy and smart grid business are described and goals and tasks of them are described. The regulatory environment, the changes and possible changes of the regulations in the future are discussed. The model for analyzing the business and service models is described and value chain, value network and value creation principles are presented. These analyses include the description of the possible business and services, value capturing principles, investment and pricing principles and analysis of possible benefits and risks associated to new business and services. The study was performed combining literature research and interviews of 11 experts in energy sector in Finland, the Netherlands and Belgium. The main advantage of the smart energy concept is seen to be its ability to optimize energy usage in a more holistic way than smart grids and its higher energy efficiency in local areas. The benefits of smart solutions include improved reliability and security of the energy system, maximized energy efficiency and minimized environmental impact for example due to increased renewable energy sources and reduced need for fossil fuels.

Regulation of electricity markets in EU has changed a lot due to liberalization and aim towards single internal energy market. Liberalization has meant decoupling of suppliers from monopoly activities in such way that consumers can choose which supplier to use, suppliers can produce electricity in all EU countries and open access is enabled for all participants Regulation can have a major impact on the business possibilities for smart solutions. Current regulatory frameworks are diverse but it is argued that none of them clearly incentivize for investments in smartening the grids or more generally in smart energy solutions.

There are multitudinous stakeholders and actors identified in smart energy business and thus it's more logical to discuss the value creation models than a business model of a single company in the network. Smart energy solutions enable new business opportunities like services, but it is still an open question, which stakeholders will develop them. New participants such as facilitators and financial organizations might also emerge to help in the development of smart energy districts, solutions and services.

This paper is part of EU FP7 project *Energy-Hub for residential and commercial districts a transport* (E-Hub) WP6 *Business strategies and non-technical issues* Task 6.1.1 State-of-the art of

markets and business models. The main purpose of the paper is to improve the common understanding of topic services, business models and value chains.

The stakeholders, business and service models and value chains will be analysed further in WP6 Task 6.1.2 Business and service models for e-Hub systems.

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Acronyms

AMI = Advanced Metering Technology

BRP = Balancing Responsible Party

CCHP = Combined Cool, Heat and Power

CHP = Combined Heat and Power

CPP = Critical Peak Pricing

DG= Distributed Generation

DSM = Demand Side Management

DSO = Distribution System Operator

ECCP = European Climate Change Programme

ENGO= Environmental Non-Governmental Organization

ESCO = Energy Service Company

ETS = European Trading Scheme

H&C = Heating & Cooling

ICT= Information and Communication Technology

IEM = Internal Energy Market

NPV = Net Present Value

PHEV = Plug-in Hybrid Vehicle

PMU = Phasor Measurement Unit

PPP = Public-Private Partnership

PSC = Public Sector Comparator

RES = Renewable Energy Source

RTP = Real-Time Pricing

T&D = Transmission & Distribution

TOU = Time-Of-Usage

TSO = Transmission System Operator

UoS = Use-of-System

VFM = Value For Money

WAMS= Wide-Area Monitoring System

1 Introduction

E-Hub (*Energy-Hub for residential and commercial districts and transport*) WP6 *Business strategies and non-technical issues* provides the basic business information to define alternative energy service concepts and their business models as well as the ICT solution supporting the implementation. In addition a specific task is included to contribute to the deployment and implementation of the results generated in the other tasks in WP1…WP5, where the feasibility and empowerment/justification of different energy service /business models and energy production configurations will be analysed.

Task 6.1. describes the state-of-the-art of market needs and business models in the area of district level energy services and business. In the original DOW this includes the following subtasks:

- Market analysis and need for energy services
- Analysis of stakeholders in energy networks; business ideas and driving forces of stakeholders, decision making processes and workflow of implementation of district energy network (in different countries)
- Alternative business models for energy services; analysis of current business models and new energy-hub service network based models; Incentives and barriers for the business models.
- Energy service concepts and content
- Earning logics in business networks
- Financial models for energy services, e.g. PPP models
- Risk management methods and mitigation in district energy hub business

The outcome will be description of market needs and business models (concept, content, earning logics, financing models and risk management) in the area of district level energy services.

This paper is part of Task 6.1.1 *State-of-the art of markets and business models*. The paper is describing the concepts of smart energy, describes the main stakeholders and regulatory environment in smart energy sector, describes the approach to analyse value chains and explains the basic terminology. *The main purpose of the paper is to improve the common understanding of topic services, business models and value chains.* The stakeholders, business and service models and value chains will be analysed further in WP6 Task 6.1.2 *Business and service models for e-Hub systems*.

2 Smart Energy

2.1 What is the Smart Energy Concept?

Smart energy is a concept that combines smart solutions in both electricity grid and heating and cooling (H&C)[1] network. In this context, smart means that the whole system is managed and optimized with ICT solutions. Smart electricity solutions are more commonly referred to as smart grids. Furthermore, smart H&C can be referred to as a smart thermal network. Both systems have the capability to predict and adjust to network changes with the help of ICT solutions (GES,Sepponen,Kohonen 2008)

The word SMART in this context consists of the following elements (Webb, 2008, p. 15):

• Standardize: ICT can provide information in standard forms on energy consumption and emissions, across sectors

• Monitor: ICT can incorporate monitoring information into the design and control for energy use

• Account: ICT can provide the capabilities and platforms to improve accountability of energy and carbon

• Rethink: ICT can offer innovations that capture energy efficiency opportunities across buildings/homes, transport, power and urban infrastructure and provide alternatives to current ways of operating, learning, living, working and travelling

• Transform: ICT can apply smart and integrated approaches to energy management of systems and processes, including benefits from both automation and behavior change and develop alternatives to high carbon activities, across all sectors of the economy.

In other words the smart concept is about developing ICT solutions that provide real time information on e.g. energy consumption and emissions and enables end users' interaction which in turn can be used to find energy efficiency opportunities in order to achieve energy use

[1] The acronym H&C is presented for referring to heating and cooling, as the concept is used so many times in this report.

and emission reductions. Integrated approaches to energy management systems and processes can result in developing alternatives to carbon intensive activities due to increasing automation on one hand, and on the other hand behavioral change. (Webb, 2008).

In the SEESGEN project the concept of Internet of Energy is introduced to illustrate the roles of ICT technologies in future energy solutions (Figure 1).

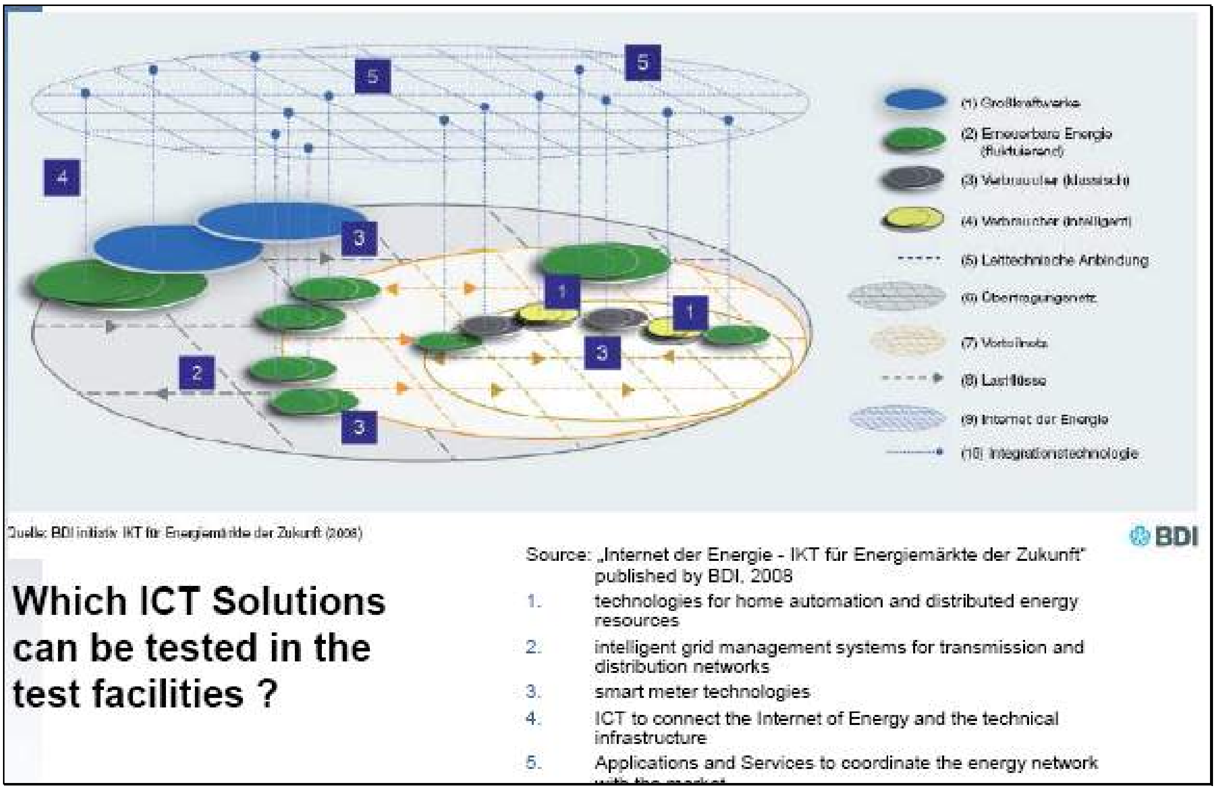

Figure 1. The concept of Internet of Energy (SEESGEN-ICT / Fraunhofer)

The principles of the smart energy network are presented in Figure 2. The network's performance is based on two-way, real-time information between energy producers, the network control systems and energy consumers. It includes the management of energy generators, controlling the distribution of electricity and thermal energy, as well as smart metering and management of demand. Smart management and monitoring helps in increasing the amount of intermitted distributed generation, such as wind and solar power. Automatic reconfiguration and monitoring are included, which means that the network can optimize its performance by self-healing and load-balancing functionalities, which helps in avoiding outages and recovering from them faster. (GES/ Sepponen, 2008)

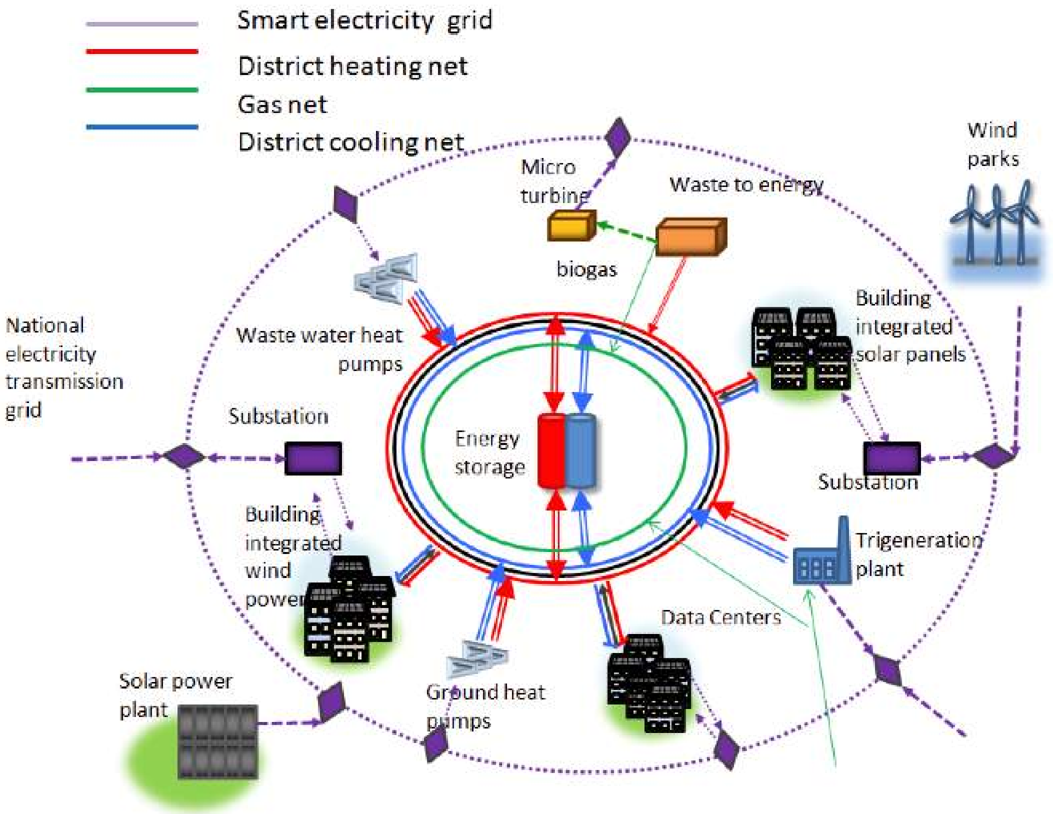

Figure 2. Smart energy concept (GES / Sepponen 2008)

The goals of the smart energy network are to improve energy efficiency, cost efficiency, energy monitoring and data capturing across the whole network, in energy production, distribution and consumption. In addition to this, ICT solutions improve the visibility of the grid by allowing real-time, two-way communication between all involved parties. These changes mean that variation in demand and unusual events in the grid are predicted and responded to faster and with more automation. Smart solutions also enable end user energy consumption management.

According to a case study by Sepponen (2008), the smart energy solutions in a Chinese city neighborhood with population of 100.000 people could reduce its electricity consumption from 40% to 54% depending on the level of ICT solutions. In addition, energy consumption in H&C could be reduced significantly. Also emissions could be reduced enormously. By replacing small coal boilers with a coal fired combined heat and power (CHP) plant and district heating grid, emissions would be reduced 16 % counted as CO_2-equivalents and compared to a baseline. However, if boilers were replaced with a natural gas fired combined cool, heat and power (CCHP or trigeneration) plant and high tech ICT optimization, emission reduction would be 83%. Global EcoSolution Ltd (GES) has introduced a ICT framework for ICT solutions and applications to its smart energy solution (Figure 3).

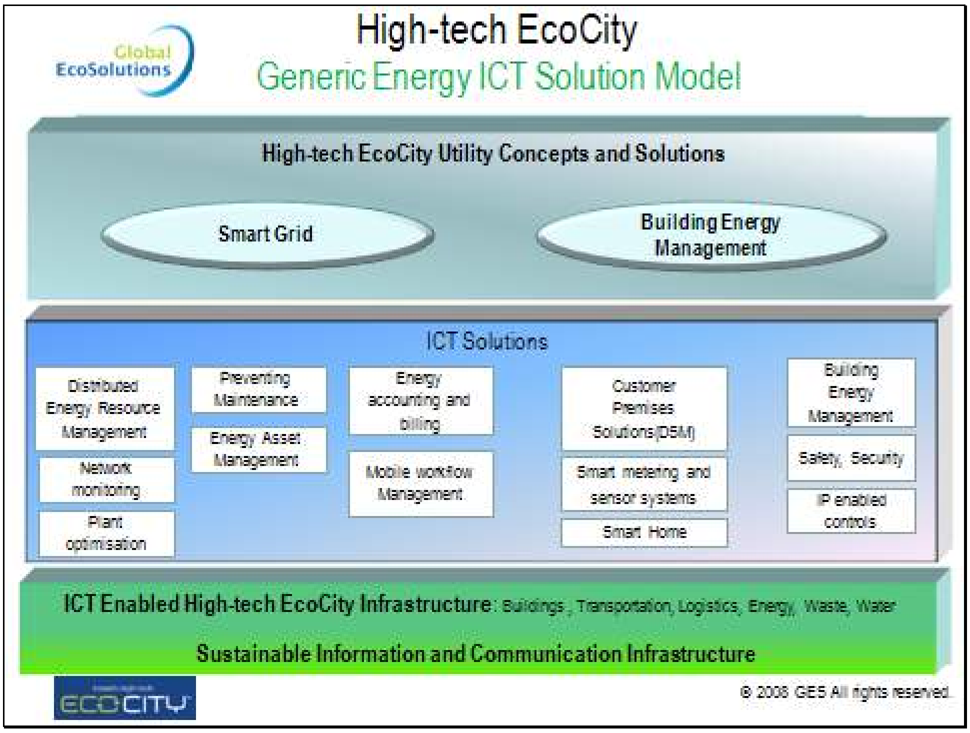

Figure 3. ICT solutions for smart energy (GES 2008)

GES Smart energy network is a similar concept to the Intelligent Energy Network presented by Orecchini and Santiangeli (2011). Similarly to smart energy proponents, they also claim that a smart grid is not enough, but we need intelligent management of the complete set of energy sources. In addition to H&C, they discuss the role of hydrogen and fuels in overall energy management. According to the researchers, the Intelligent Energy Network continuously monitors the energy need in quantity, quality and type and can allocate energy sources where they best achieve both optimum system efficiency and lowest emissions levels. They share a similar claim to the supporters of smart energy that even though adding more components to a smart grid adds complexity, it is a better solution than sub-optimization of electricity in an overall energy system. If we want to have overall systemic optimization of energy production, distribution and consumption, we need to look at all energy components and not just electricity. Writers emphasize the importance of renewable energy sources as well as hydrogen that can be produced from variety of sources and effectively stored at various levels. In addition these sources can be used for on-demand, zero-emission, instant production of electricity and heat. (Orecchini and Santiangeli, 2011)

Also others have noted the importance of smart district H&C in addition to smart grids. For example Nielsen (2010) discusses smart district heating and argues that it has the benefits of flexibility, renewable energy sources integration, CO_2-neutrality and cost effectiveness. In addition, Gullev (2010) notes that in smart grid visions low-grade energy resources are not utilized. He offers a concept of district energy, which is similar to the concept of smart energy discussed here.

2.2 Smart Grid

Current centralized electricity distribution networks are inefficient and require overcapacity since they lose power in transmission and distribution and can't forecast future demand. They are also only able to communicate one-way and in many countries selling energy back to the grid is difficult or impossible. A smart grid is defined as a set of software and hardware tools that improves transmission and distribution of electricity from generators to customers making it more efficient, reducing the need for excess capacity and enabling two-way, real-time communication and demand side management. (Webb, 2008)

Smart grid as a part of a smart energy network or by itself is not a single technology but a combination of different solutions. As said previously, the general definition of smart outlines that the system is managed and optimized with ICT solutions, but there are multiple ways of implementing a smart grid. According to ten Elshof (2009) there is no internationally agreed definition of smart grid concept, so a specific description of it can't be given. Differences of current and smart grids listed by Orecchini and Santiangeli (2011) are presented in Figure 4.

TODAY's GRIDS
large centralized generation
geographical distribution of generation resources
power flow in one direction from the power stations
dispatching of power and network control → centralized facilities (controlling several regions from one place)
There is little or no consumer participation and no end-to-end communications
SMARTGRIDS
they accommodate bi-directional power flows
they allow: • distributed generation management • renewable energy resources management • optimization of DSM (demand site management) • optimization of Storage management
Coordination of local energy management and full integration of DG and RES with large-scale central power generation

Figure 4. Differences in current grids and smart grids. Orecchini and Santiangeli (2011)

The Smart Grid – an introduction report (Litos Strategic Communication, 2008f) states four main factors that are included in smart grid solutions: Advanced metering infrastructure, visualization technology, phasor measurement units and peak shaving.

Advanced metering infrastructure (AMI) is a measurement and collection system that enables detailed real-time information and frequent collection and distribution of data to various parties. It includes meters at the customer end, a communication network between the customer and the service provider and a data management system that allows service providers to utilize the information in the correct form. (Gellings, 2007).

AMI allows for more efficient energy consumption and faster detection and responses to problems in the grid. For example “Prices to Devices” concept means that the customers can set preferred prices to home controllers or end customer devices such as washers, dryers and refrigerators. AMI informs real time prices of electricity and devices act accordingly. Thus devices respond to customer wishes automatically and energy is used more efficiently. For this kind of concept to work, common standards and low cost communication systems are required. (Litos Strategic Communication, 2008f)

Visualization is already used for real-time load monitoring and load-growth planning at the utility level, but current tools lack the capability to integrate information from various sources resulting in poor situational awareness. Smart grid will improve situational awareness through integrating for example real-time sensor data, weather information and grid modeling with geographical information. As the focus shifts more on efficiency and demand-response programs, there is an increasing need for more data and especially knowledge on using the data well. (Litos Strategic Communication, 2008f)

Phasor Measurement Units (PMU) sample voltage and current many times a second at a given location. They offer situational awareness, and thus ease congestion and bottlenecks while mitigating blackouts. Currently measurements are taken once in 2 to 4 second, but smart grid communication solutions allow for 30 times a second measurements, which gives a dynamic view on the grid. The bottleneck will be the time to process the data and reacting to these more frequent measurements. More visibility will allow for easier access of distributed generation as better visibility enables balancing smaller generation and usage variation. Empowering distributed generation means that production is closer to consumption and thus results in less loss in transfer and distribution. Also it enables more choice for customers as they can decide whether to buy or produce energy. (Litos Strategic Communication, 2008f)

Smart grids improve the estimation of near future demand and thus reduce the need for excessive peak production. Currently estimating how much electricity will be consumed the next moment is rather difficult. Demand is typically low during the night and high during the day and daily peak occurs as people come home from work, but estimating precise consumption is not possible with current information. As electricity production has to meet demand constantly or blackouts occur, there are power plants that generate electricity only on peaks. Peak power is usually both capital-intensive and environmentally inefficient, as the plants lay useless most of the time. Better information on actual consumption reduces the need for excessive peak power thus reducing costs and environmental impacts. (Litos Strategic Communication, 2008f)

2.3 Smart Thermal Network

Smart thermal networks are integrated district H&C systems that consist of thermal energy production and distribution to buildings, possibly including different kinds of thermal storages. The network is managed and optimized by ICT solutions similar to smart grids. The aim is for a smart energy district to use sustainable heating energy sources such as CHP, trigeneration, solar collectors and heat recovery from wastewater. (GES/ Sepponen, 2008)

Even though the focus here is on new districts, it is important to look at existing H&C markets as well. District H&C have currently 10 per cent average market share in European H&C markets. However it is especially widespread in North, Central and Eastern Europe, where market shares reach over 50 per cent. In addition, over 80 per cent of heat supplied by district heating originates from renewable energy sources or heat recovery. It is argued that even though district H&C provides many benefits, it is not very widespread because in current liberalized markets investors are focused on short-term return on capital. Legislators should provide fair allocation of the economic value of the benefits of district H&C to all parties including the investor and the operator. (Euroheat & Power, 2011)

According to Kelly and Pollitt (2010), heat distribution networks that utilize CHP offer many benefits. They conclude that these benefits include opportunities for intelligent system balancing (discussed here as smart thermal solutions), increased energy efficiency, cheapest and largest CO_2 savings compared to competing technologies, lower fossil fuel consumption, the capacity to use local renewable energy sources, minimization of pollution and increased employment for the community. Countries with most CHP units are Denmark, Finland and The Netherlands (Purchala et al, 2006).

The smart thermal network is a solution where thermal energy is distributed by circulating water or hot low-pressure steam through an underground piping system. There are delivery pipes for both heating and cooling for each building that is a part of the smart thermal system. However, there is only one returning pipe for circulating water. Thus, there is an opportunity for saving investment costs associated with constructing and maintaining another pipeline. Technology enabling only one returning pipe is called a *low exergy*[2] *heating and cooling system* and in that system both returning heating and cooling waters are at a similar temperature. (Kohonen, 2006)

Low exergy systems can utilize a variety of low value energy sources, such as heat pumps, solar collectors and heat recovery from wastewater, and the user is not constrained by choices made in the planning phase. In addition to efficient energy supply, a low exergy system provides other benefits such as improved thermal comfort and indoor air quality as well as reduced energy consumption. Low exergy systems save the maximum amount of high quality energy since

[2] Exergy in low exergy heating and cooling systems is a more specific term than energy when evaluating energy utilization processes. Due to the first law of thermodynamics, energy itself can't be consumed, but it will lose quality. Exergy is energy, which is entirely convertible into other types of energy. For example electricity has a high exergy value, but heat close to room temperature has a low exergy value. (Ala-Juusela, 2004)

buildings' heating, cooling and air conditioning system uses the minimum amount of energy with a low temperature difference between the system and the rooms. (Ala-Juusela, 2004)

Low exergy systems are not just one technology, but there are many ways of implementing them. They combine traditional and innovative approaches and consist of both passive and active technologies, such as surface H&C systems including walls, floors and ceilings, and air H&C systems including air-to-air, water-to-air and steam-to-air exchangers. Usually, the same system can be used for both heating and cooling. (Ala-Juusela, 2004)

The life cycle cost of low exergy H&C systems are expected to be quite similar to those of a traditional system. Even though the initial investments are usually slightly higher, the energy efficiency benefits will outweigh the cost increase during the life cycle. The important benefit of these systems is flexibility of fuel choice, so a lock-in situation is avoided. It is also know that the customers are willing to pay more for floor heating than radiators and that they appreciate flexibility in fuel choice. If these systems are installed on a wide scale, transfer to sustainable energy sources can be done at a much faster pace when needed. (Ala-Juusela, 2004)

Problems can also occur when smart thermal networks are combined with smart grids. The whole energy system needs to be optimized instead of optimizing just for electricity which might be a difficult task to do. There are also differences between electricity distribution markets and H&C distribution markets. For example in the Netherlands, the first one is regulated and the latter is not (Knigge and Mulder-Pol, 2011). Thus there are different stakeholders involved in each of these. Orchestrating between both might be a difficult task as there are different rules and different goals amongst actors.

Additionally, district H&C is by itself a very different kind of system compared to an electricity network. It is already decentralized, as a heat source cannot be located very far from consumption due to high losses in the distribution network over longer distances. Thus, it can be argued that optimizing heating with ICT solutions solves different problems and brings different benefits compared to optimizing electricity.

This doesn't suggest that smart thermal solutions should be neglected, but rather that the estimation of benefits and costs are different from those of electricity. In addition, it is fair to note that challenges with regulation and orchestrating multiple stakeholders exist also in the smart grid development. For example public and private actors usually have different goals in business, since private actors aim for profit but public actors can have more complex goals which benefit society.

2.4 District Level Network

Often when speaking about smart grids the scale of the system is ambiguous. The discussion can entail (parts of) the European grid or a small-scale pilot in a certain area of a certain city. In this paper the focus is on district level networks. Even though many references we use focus on larger scale smart grids, insights from them can be applied to district level as well. On the other hand, many arguments from this paper can also be applied to larger systems. In the following paragraphs we discuss key differences between large-scale smart grids and small-scale smart energy networks.

Firstly, the smart energy concept refers always to some sort of district level solution as it includes district H&C. As mentioned, this means that energy sources can't be far away from consumption due to losses in the distribution network over long distances. The fact that the smart energy concept includes a district H&C network also means that the concept cannot be applied very easily to existing districts without district H&C. In this case a large restructuring of existing infrastructure would be necessary, which would lead to a very different estimation of costs and benefits. Thus the concept can best be used for districts with district heating already in place or in newly built districts where decisions of what kind of infrastructure should be built are still to be made.

Secondly, it can be argued that new districts work especially well as pilot projects for both smart thermal networks and smart grids. As there are many smart grid pilot projects currently being initiated anyway, the question arises why it wouldn't be reasonable to start these pilots in new districts where there is no burden of existing infrastructure and thus smart thermal solutions could be added as well. It is argued that this way the pilot would work as a learning opportunity, not just about smart grids, but also for optimizing the whole energy system, a need recognized by both researchers and practitioners. (Orecchini and Santiangeli, 2011; Nielsen, 2010; Gullev, 2010).

Finally, focusing on the district level means that some new business model possibilities won't work. For instance, it may not be economically feasible to create complex platforms where end users and energy retailers can meet if there aren't critical mass of participants.

2.5 Benefits of Smart Energy

There are numerous lists of all the benefits that only a smart grid would bring, not to mention the additional improvements that adding H&C would bring to this concept. The lists differ from each other because they emphasize different benefits for different stakeholders (Nicholson and Richards 2006, Litos Strategic Communication, 2008d). In the following paragraphs, the benefits of smart energy are presented in a general way. Later it is further explained why smart energy provides these benefits, for whom these benefits actually occur and whether there are any downsides accompanied with these benefits. It is important to notice that the following list presents *expected benefits* of smart grids and smart energy solutions. *Actual benefits* must be looked at case by case. Even though the smart energy network promotes for example both active participation from the customer side and distributed generation, there is no guarantee that implementing smart energy solutions will actually increase distributed generation and make customer more active if for example people are not interested or a regulatory framework puts barriers to distributed generation.

The following list covers most of the final benefits of smart energy solutions (Modified list based on Litos Strategic Communication, 2008d):

- Improved reliability
- Increased customer participation
- Maximized energy efficiency
- Management of energy cost (keeping energy costs in reasonable level)
- Full exploitation of renewable energy sources
- Reduced environmental impact of energy usage
- Improved security of energy system
- Reduced dependence on fossil fuels
- Creation of jobs

Improved reliability refers to the fact that smart grid and energy solutions would increase monitoring capabilities across all levels of the grid and would allow timely and accurate response to any disturbance in the grid (Litos Strategic Communication, 2008g). In addition Kelly and Pollit (2010) note that district heating networks can be operated independently from the national grid, in a so called “island mode”, and thus it can offer guaranteed back-up power when required. Even though our current electricity system in Europe is indeed very reliable, increased distributed generation increases uncertainty in the current grid if smart solutions are not implemented. According to Gullev (2010) current reliability is threatened. First, the electricity grid is getting old and worn out. Second, population growth in some areas and the increasing use of electronic devices are causing the transmission system to become over-used and fragile. Third, most of the new appliances that are added are more sensitive to variations in electric voltage than older appliances. These factors make Gullev (2010) conclude that the reliability of electrical power will decline unless we do something about it now. Also Knigge et al. (2011) argue that smart grids are necessary to handle the distribution of increased electricity consumption. They expect that for instance the use of heat pumps and electric transport will increase in the coming decades and thus network capacity has to be improved and extended. Improving reliability is clearly a benefit for the whole society, as we need reliable production, transmission and distribution of energy to all end users in order to keep modern society running.

A smart energy network enables *increased customer participation* by increasing their information and control about their own energy consumption. Customers can get more information of their consumption, because ICT solutions monitor the whole grid in a more comprehensive way and can deliver that data directly to customers. Both information content and frequency are increased. Information can be presented in different formats depending on customer preferences. For example consumption can be presented as Euros rather than kilowatt-hours. A study by IBM (IBM Institute for Business Value, 2010) shows that customers are more demanding and want to be better informed. Furthermore, as smart appliances are included in the energy system, demand side management can reduce consumption in peak hours. The customers can choose eco-programs for their household energy consumption that ensures that their consumption is more stable and thus help decrease the overall peak. This can be done by planning high-energy consuming activities such as washing clothes and dishes on low demand hours and by adding energy storage. In addition to information and demand side management, an optimized grid promotes distributed generation, as it is easier to sell back surplus energy. This means that end users have better economic opportunity to produce their own electricity, which also increases customer choice.

Energy efficiency is maximized by smart energy solutions for fours reasons. Firstly, increased monitoring capabilities helps in predicting consumption thus reducing the need for non-efficient excess capacity at peak times. Secondly, CHP and trigeneration have higher energy efficiency than power plants that produce only electricity (Bruggink, 2010). Thirdly, distributed generation reduces the distance between production and consumption thus reducing grid losses. Finally, knowing their real-time consumption, end-users can manage their consumption by reducing the need for peak capacity and also by decreasing the overall consumption of energy. Efficiency is a benefit for customers as it reduces energy prices. It is also a benefit for producers, as they don't have to invest in expensive peak capacity. If the benefit of efficiency is linked to the environment, then energy efficiency means that the same production can be realized with cleaner generation capacity (or more energy can be produced with the same generation capacity), which benefits the whole society.

Even though smart grid solutions need large investments that are eventually transferred to end customers pay in the cost of energy distribution, those investments will in general help to manage *the end users' cost of energy*. First, by increasing energy efficiency and otherwise reducing energy demand, smart energy solutions decrease the expenditure in energy. For example it is expected that in the USA electricity prices will grow 50 % from 2008 to 2015 (Litos Strategic Communication, 2008c). By reducing peak energy demand and better utilizing network capacity there is also less need for traditional grid extension. Case studies have shown that the potential of saving in costs is around 5-10 % compared to traditional investments, and by extrapolating across Europe this could mean around 1-3 billion Euros in the period up to 2020 (Nieuwenhout et al. 2010). A case study in Spain suggested that distributed generation (DG) with the capability to sell surplus electricity back to the grid could decrease consumer electricity bill by more than 15 % (Gordijn and Akkermans, 2007). Smart energy solutions increase the opportunity for DG with monitoring and optimization of demand and supply.
Secondly, it's not just price of energy that is rising. The EU has a working emission trading scheme (ETS) in which total the allocated credits will decrease in the future in addition to the fact that from 2013 onwards freely given credits will more and more be auctioned instead of just given freely to industry until 2020 when all the credits are auctioned (Ellerman and Joskov, 2008). All this means that more environmental externalities of energy production will be included in the energy taxes and thus the price of both energy consumption and production will increase even more. Third, improved reliability will decrease overall costs caused by blackouts thus improving the cost-efficiency of our energy system.

Improved monitoring of the grid helps in *fully exploiting renewable energy sources*. The so-called plug-and-play ability to connect new generating plants to the grid improves the management of large amounts of wind and solar power, and reduces the need for time-consuming interconnection studies and physical upgrades (Litos Strategic Communication, 2008g). Furthermore, in a district heating network the heat must come from some sort of local energy production, which can be renewable, such as biomass and waste (Kelly and Pollit, 2010).

Some analysts believe that the deployment of the smart grid is a prerequisite for large-scale integration of wind and solar energy (Litos Strategic Communication, 2008g). Improving the utilization of renewables is in itself a benefit for the renewable energy business. However, if linked to other policies such as the EU goal for producing 20 % of energy from renewable sources by 2020 (European Commission, 2011) and other promotion for renewables, it can be claimed that exploiting renewables is a benefit also for society at large. Renewables in general have other benefits such as reducing dependence on fossil fuels, improving security as they are distributed sources and reducing environmental impacts of energy usage.

Smart energy solutions *reduce the environmental impact of energy usage* in many ways. Firstly, allowing better utilization of distributed generation and especially renewable sources means that the carbon intensity of energy production will decrease dramatically. For example DECC (2009) has showed that CHP-based district heating networks have some of the highest technically possible CO_2 savings and some of the lowest costs per ton of CO_2 saved when compared against other competing technologies. Secondly, by improving energy efficiency by peak shaving and by reducing transmission and distribution losses, the same consumption can be achieved with less energy production. Thirdly, by making customers more aware of their consumption it is possible to change their behavior to a more environmentally friendly direction. In addition, increased monitoring and automated responses reduce the need for monitoring and maintenance travel (Cornish and Shepard, 2009). Environmental benefits are benefits to the whole society as it is a common goal to reduce the environmental impact of human actions.

In addition to reliability problems, there can be security problems in energy networks. The term security is used here when discussing human attacks on a system and the term reliability is used when talking about natural incidents. Smart energy solutions *improve the security of the national energy system* by having distributed generation and security design built-in from the beginning. Security issues arise both from the potential attacks on the network and through the network itself. Improving security of the grid is a benefit to both the consumers and the producers since consumers get better quality service and producers will probably get paid a premium for these improvements. Furthermore, the whole society benefits from increased security.

As smart energy solutions increase energy efficiency, potentially decrease overall energy consumption and most importantly support utilization of distributed renewable energy sources it is clear that the *dependence on fossil fuels is reduced*. As more and more electricity is produced by end consumers the need for centralized fossil fuel plants decreases. In addition smart energy solutions enable the use of electric vehicles and also allow cars to insert electricity back to the grid if balancing is needed. By adding electric vehicles to smart energy solutions the dependence on fossil fuels in general is further decreased, as vehicles are currently prominent users of fossil fuels. Reducing dependence on fossil fuels is a benefit for many reasons. Firstly, fossil fuel prices are volatile and increasing due to economic and political factors (EDUCOGEN, 2001). Secondly, they are generally not in the hands of European countries. Thirdly, the amount of fossil fuels is decreasing worldwide and finally, they impose heavy environmental impacts in the form of CO_2 emissions. Thus, reducing dependence means improving national security, decreasing risk of rising prices and reducing environmental impact. This benefit is again an advantage for the society at large.

Kelly and Pollit argue (2010) that in district heating networks *jobs are created to manage and maintain local power stations*. If waste and biomass industries are created, they contribute to local economic growth and employment within the community. It is claimed that taking into account the jobs created by direct smart grid utilities, contractors, direct utility suppliers, indirect utility supply chain, new utility and energy saving companies, and then subtracting old jobs such as meter reading from utilities, there would still be lots of jobs created in the USA if smart grid solutions were implemented (Litos Strategic Communication, 2008c). The report estimates that jobs created between 2009 and 2012 would sum up to 278,600 and even 139,700 more in the period 2013–2018 (Litos Strategic Communication, 2008c). These numbers cannot be directly translated into the European context, but they give an insight to the scale of potential new job opportunities. As these jobs would not be created by subsidies but rather by collaboration of profit-seeking businesses and steady regulation, it is clear that job creation is a benefit to the society.

When there are benefits to some, there are also downsides to others. In order to make good decisions on whether to invest in smart energy solutions we have to critically investigate all the effects that the decisions cause and accordingly understand also the disadvantages, and especially to whom costs will occur. As smart energy solutions promote distributed generation and renewable energy sources, they also decrease the current status of the fossil fuel industry and centralized generation altogether. Biggest opposition to smart energy solutions can thus be expected from those industries. As smart energy networks are a new idea there are risks involved. Districts implementing these solutions might face unexpected problems and the costs of those occur to the investor and businesses and also to the whole society depending on the allocation of risk in agreements.

2.6 Interviewee Opinions On Smart Grids and Smart Energy Concept

Because existing literature on smart grid – not to mention smart energy – business models is not comprehensive we have conducted interviews with experts in new energy business. Interviews are qualitative in nature and they cover opinions on smart energy business model possibilities. Interview questions are presented in appendix A. Methodology for answering interviews were either face-to-face meetings or email answers.

The categorization of interviews is presented in Table 1. Interviewees were chosen from different sectors of the energy business and they were conducted in the Netherlands and in Finland. The interviewees are presented in appendix A. Internet survey shall be carried out to get more representative stakeholders involved.

Table 1. Interviewees categorized by country and sector

Country/Sector	Research/Consultancy	DSO	Lobbying
Belgium	I		
The Netherlands	II	II	
Finland	I	II	I

Most of the interviewees support smart grids and can think of many benefits in the smart energy concept. Hänninen (2011) notes that both concepts are difficult to discuss, as there is not a clear definition of either of them. For example some people might argue that replacing ground electricity lines by cables makes the grid smarter. According to Hänninen, ABB argues that Finland already has a smart grid 1.0 and that we are moving towards 2.0 when we discuss smarter metering and demand response possibilities. Hänninen agrees the Finnish grid is already smart in the sense that we can automatically detect problems and continue delivering electricity to areas that are not damaged. He himself emphasizes the role of smart metering. He knows there are many opinions on this, but thinks the metering is the core of smartening the energy system. He argues that only with smart metering we can have more distributed generation (DG) in the grid, charge electric cars and make demand response an option for customers. According to Koivuranta (2011) there is no big difference between the concepts and they should not be developed apart, but by sharing knowledge. Hyvärinen (2011) thinks smart energy is a better name than smart grid for discussing smart solutions in general, as he emphasizes that it is not about networks but a larger energy transformation.

According to the interviewees, there are many reasons why smart grids are preferable to traditional grids. Firstly, the energy industry is changing and there will be more decentralized generation. The current grid was not designed for a new type of production, so we need a change in the way we understand electricity business. ICT solutions are needed for unlocking the flexibility in distributed applications, like electric vehicles, heat pumps, data centers and so forth (Bongaerts, 2011). Secondly, European regulation that includes improving reliability, improving security of supply and climate policy demands an energy transition. There are three options: adding renewables, improving energy efficiency or smartening energy usage. Hänninen (2011) argues that all of these need smart metering. Thirdly, the user needs to be taken into account. Demand side management could change the way people consume energy. Peak power will be more and more expensive and people could consume in a more stable way if they knew more about their consumption and were able to control it better. Oostra (2011) argues that there is no real need for people to jointly turn on the washing machine during a time of peak. It is mainly about habits and those habits can be changed for example with financial incentives. According to Bongaerts (2011) another important reason for smart solutions is to introduce more services and products in the liberalized energy market. ICT-solutions are necessary to give customers the products they want or need. Six (2011) notes that smart grids are not the sole solution. They should be developed and exploited in parallel with other solutions such as a better interconnection between countries and harmonization of energy markets. On a larger level the question is still open about how much intelligence there is, on what levels (transmission or distribution) and how much of the generation will be centralized or decentralized.

Integrating and optimizing many energy sources rather than just electricity was seen as an advantage in smart energy compared to smart grids. This was especially noted, when it was made clear that smart energy is a local solution, rather than a nation-wide concept. Interviewees argue that integrating multiple energy sources will increase energy efficiency, for example CHP and trigeneration were mentioned in this context. Knigge and Mulder-Pol (2011) comment that in Enexis they have already discussed about optimizing the whole energy system rather than just electricity. Gordijn (2011) notes that generally consumers want for example good air conditioning and working devices and appliances, not electricity or gas. It seems clear that focusing only on smart grids would result in a suboptimal outcome compared to optimizing the whole energy system.

There is also some criticism towards the smart energy concept. It is not fully understood what smart solutions would actually mean in heating and cooling. Knigge and Mulder-Pol (2011) also note that electricity is a different business compared to H&C. There was not so much knowledge on heating business in the interview group, so the benefits of smart solutions in heating were unclear to them. Firstly, it is argued that centralization is not a problem with heating, as it is already quite decentralized since there cannot be a long distance between production and consumption of heat. Hänninen (2011) notes that both electricity and heating have the infrastructure for delivering energy and that both of them can be measured the same way, but he also wants more clarity on the concept. Secondly, the heating business is not regulated the same way as electricity grids are, at least in the Netherlands (Knigge and Mulder-Pol, 2011). This might make collaboration between those companies more difficult. Hänninen also notes other problems in the heating business: a less advanced market and lack of division between monopoly and market activities unlike in electricity. Auvinen (2011) notes that local integration and optimization of different renewable energy sources are technically challenging and it requires both skills and careful planning. This again increases costs.

2.7 Conclusions on Smart Energy

Smart energy means the same to whole district energy sources as smart grids means to electricity. In the smart energy concept, electricity and H&C of a district are integrated and optimized with ICT solutions. The smart energy concept is created by Global EcoSolutions Ltd, but also academics and other practitioners discuss similar ideas of smart integration of energy sources. The smart energy concept is always a local level solution as heating has to be local due to limited maximum distance between production and consumption. Low exergy solutions are suggested as important technologies in optimizing H&C in smart energy districts. Smart solutions increase the amount of information in the whole energy system enabling the integration of intermitted distributed generation and customer participation by demand side management.

The benefits of smart solutions include improved reliability and security of the energy system, maximized energy efficiency and minimized environmental impact for example due to increased renewable energy sources and reduced need for fossil fuels. Demand side management can increase customer participation, lower energy costs in the whole system and improve grid utilization. It is argued that the investment to smart solutions is affordable when taking into account the benefits they bring. The costs should however always be compared to the benefits when smart solutions are implemented locally.

The interviewees seem to support at least smart grids and also the smart energy concept, but there is also some scepticism. Both concepts need clarification, as some people see no major difference between them. There should be clear definitions on what ICT solutions are included in smart grids and even more importantly, how smart solutions optimize also H&C in smart energy districts. Smart grids are seen as a necessary solution for the future and there is trust in the motivation to develop them. The main advantage of the smart energy concept is seen to be its ability to optimize energy usage in a more holistic way than smart grids and its higher energy efficiency in local areas.

3 Stakeholders and Regulatory Environment

3.1 Stakeholders

Project stakeholders are those entities within or outside an organization that are actively involved in the project, or whose interests may be affected as a result of project execution or project completion, e.g.: sponsor a project, or have an interest or a gain upon a successful completion of a project; may have a positive or negative influence in the project completion.

As energy markets are more liberalized, technology is developing at a rapid pace and the regulatory environment becomes more harmonized across Europe, the amount of stakeholders is increasing and power relationships are getting more complex. For example, Distributed Generation Business Modelling report (Kartseva et al., 2004) recognizes 29 possible actors that can perform some of the 18 recognized value-adding activities. The following chapters present traditional and additional stakeholders in the energy value network and go through implications of smart energy networks for all of these stakeholders.

First, we introduce traditional electricity stakeholders that are present in all energy systems. Then we continue to additional stakeholders, some of which are present also in traditional systems but whose role will be more important in a smart energy district. These include customers, aggregators, ICT solution providers and Energy Service Companies (ESCOs). These sections focus on the business stakeholders in smart energy business. After that we present non-business stakeholders and discuss the role of stakeholder participation in the smart energy business.

It is important to recognize that the goal of energy business might differ a lot depending on what sector is governing it. In general, the private sector aims for profit, the public sector can aim for political goals or reducing risk and society can participate in the energy business to be more independent in their energy production.

Public-private partnership (PPP) is also a possible business ownership model, where at least partly a private actor is given the right to operate a service that was traditionally the responsibility of a public actor. According to Meinander (2011) there is no precise definition of PPP because the term can cover a variety of agreements ranging from short term management contracts to concessions and joint ventures. However, PPPs lie somewhere between public production and full privatization. The aim of PPP is usually either to achieve improved value for money or an improved service level. Transferring the risks to the private sector under PPP is a way to add value for money in public projects. The benefits of PPP solutions are the combination of efficient private operation with public or hybrid financing. The public authorities are able to borrow money more cheaply than private companies, but the private sector has better operating efficiency, reducing both the investment and operating costs (Meinander, 2011). In Figure 5, there is presented a PPP model applied to a local energy service solution.

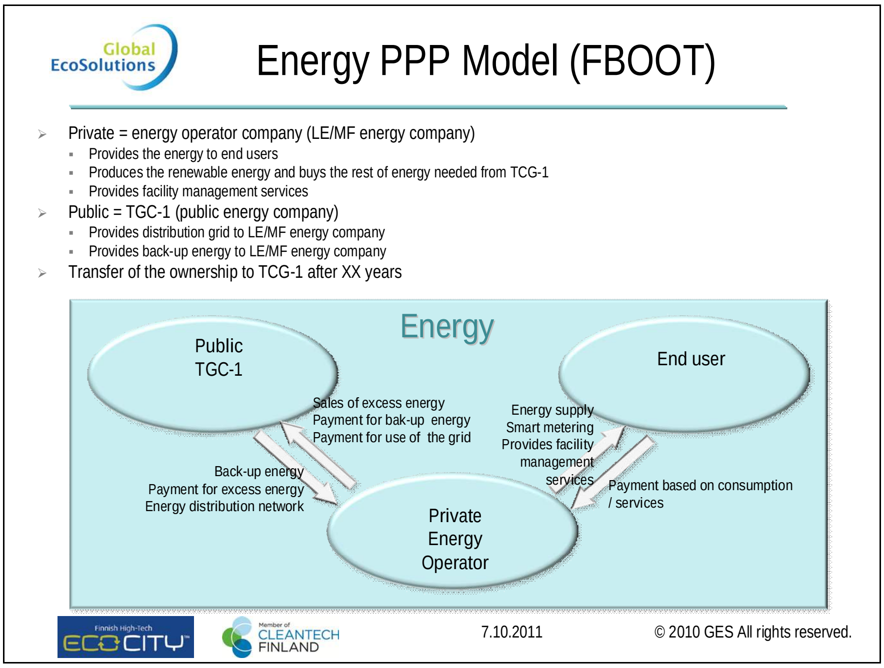

Figure 5. A PPP model for local energy services.

As the focus here is on building solutions to new districts, the roles of stakeholders might differ from those in a regular approach. In a regular situation as a new district is built, transmission and distribution lines are installed and generation and retail businesses are affected only on a national or even a larger scale, as it doesn't matter where the energy is generated and which retailer sells it forward. However in the case of smart energy networks, generation companies have to build local solutions, distribution network companies have to build new kind of grids and retailers have to monitor consumption and set the price in real-time. As all solutions are based on the district level, existing companies have to collaborate and form networked businesses in those new districts or some new businesses will emerge that will take care of all the stages in a particular district only. In the following, business stakeholders are presented and it will be discussed how their situation will change in the future due to a general trend towards smarter grids and if they engage in the smart energy business.

3.1.1 Traditional Electricity Stakeholders

The simplified version of an electricity supply chain presented in Figure 6 can be divided into primary fuel, generation (and trading to suppliers), transmission, distribution and supply (Sanderson, 1999). The words *retail* and *energy services* are also used when referring to supply. We will not present primary fuel stakeholders, as they are outside the scope of the smart energy district.

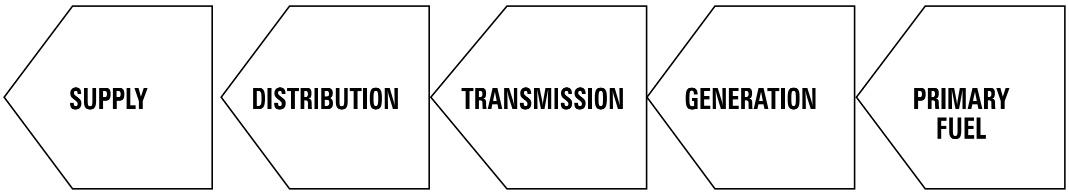

Figure 6. The industrial electricity supply chain. Adapted from Sanderson (1999, p. 201)

Generation refers to the actual production of energy. The role of centralized generation will decrease when smart energy solutions are introduced as they will help welcome new market participants, enable a variety of new load management, distributed generation, energy storage and demand-response options and opportunities. Different visions have a varying degree of centralized generation from total dominance of distributed generation to also the important role of centralized generation, but in general increasing smart energy solutions implies that the current dominance of centralized generation is slowly decreasing. However it is also important to involve existing companies in the future to allow for a smooth transition and understanding of the electrical characteristics of their equipment and their operational dynamics. (Litos Strategic Communication, 2008 and European SmartGrids Technology platform, 2006)

Trading in this context refers to selling generated energy to suppliers, which then sell it forward to end customers. The Market Operator (MO) is the main actor in the trading of energy in this phase. The market operator can be either private or public actor and is independent from the interest of the electricity industry. It handles the process of accepting bids for energy production and consumption and matching supply and demand between the wholesale energy market and the organizations of the power exchange also called a pool (Kartseva et al., 2004). Opening markets, harmonized regulation and increased transparency will facilitate free trade across Europe. When integrating markets in a smaller or larger scale, issues of congestion management and reserve power must be resolved (European SmartGrids Technology platform, 2006).

Transmission is the transport of electricity on the high-voltage interconnected system with a view to its delivery to final customers or to distributors, but not including supply[3]. The actor performing the transmission is called the transmission system operator (TSO). The tasks of the transmission companies include for example managing the ancillary services market, foreseeing and controlling the medium and long-term level of electricity supply of the system, establishing the international exchange schedules and providing electricity producers access to the electricity spot market (Kartseva et al., 2004). Transmission companies are not a part of district level networks, so their role is not important in the context of smart energy districts. However, when discussing large-scale smart grids, transmission and distribution companies that are responsible for these grids need to make large investments to keep old infrastructure in shape and even more to upgrade it to a smarter network. The Brattle Group has calculated that the required electricity infrastructure investments in the U.S. over the next 20 years will total approximately $1,5 trillion (Litos Strategic Communication, 2008g). Even though this sum seems high, it must be compared to the size of capital in the electricity infrastructure industry in general, e.g. TSO is responsible for and has to invest to balancing its grid. .

Distribution is the transport of electricity in medium-voltage and low-voltage distribution systems with a view to its delivery to customers, but not including supply. The actor performing distribution, usually called the Distribution System Operator (DSO), is responsible for operating,

[3] European Commission, op.cit., Article 2

ensuring maintenance and developing and ensuring long-term functioning of the distribution system and its interconnection with other systems[4]. DSOs get revenue from the regulated transmission and distribution fee for providing electricity distribution to end customers (Kartseva et al., 2004). In a district level smart energy network, electricity distribution companies need to acquire new ICT solutions in order to provide possibilities to optimize energy consumption and production. There has to be distribution networks also for H&C systems. In addition to other benefits, a smart energy network benefits distribution companies directly. As smart energy solutions enable better monitoring, control and optimization, they reduce the need for traditional grid investments and enable increased usage of distributed generation. This will benefit distribution companies by minimizing distribution distances and energy losses.

Both transmission and distribution system operators are so-called natural monopolies. This means that it is not cost-effective from a society point of view to build many different electricity networks in the same area. As there is only one operator per area, it is called a natural monopoly. To prevent natural monopolies from utilizing their monopoly power, the operators are regulated. Thus even in otherwise liberalized energy markets these operators are still usually regulated (Finnish Energy Industries Federation, 2003).

Electricity *suppliers* sell the wholesale energy they bought from generator traders forward to end customers. Suppliers can also be called *retailers, marketers* or *energy service companies* depending on whether they offer other services in addition to electricity, for example a bundle of services including innovative billing, gas, water and others (Kartseva et al., 2004). Increasing competition means that cost efficiencies and savings need to be made visible in monetary terms in real-time. The growing needs of customers for differentiated services mean that future trends will divert from the current “infrastructure-driven” business to “service-driven” paradigms (European SmartGrids Technology platform, 2006). In a smart energy district, energy retailers move more to the direction of energy service providers, as they might be able to sell also H&C in addition to electricity. Energy service providers need to create new business models in order to provide new service offering to customers, pay for ICT investments and keep up profitable businesses even when energy consumption decreases.

Balancing responsible parties (BRP) are required to pay for the imbalances created by the parties they represent. The difference between the energy amount that a market participant under a BRP has traded and the energy amount that such participant has injected in or has

[4] These sentences are adapted from European Commission, op.cit., Article 2

taken off the grid, will be the participant's imbalance. BRPs consolidate the imbalances of the parties they represent and are charged for the imbalance in their portfolio by the TSO.

3.1.2 Additional Business Stakeholders

ICT technology providers and equipment manufacturers will play a crucial role in developing innovative solutions with grid and heating companies. Investments in new grid technologies will be an important business opportunity for technology providers and a shared vision with grid and heating companies is critical in insuring strategic developments that provide open access, long-term value and integration with existing infrastructure. Innovation must be emphasized in both distributed and centralized generation, grids and demand management as the current system transforms into a smarter grid in general. (European SmartGrids Technology platform, 2006)

Technology providers can improve the grid in at least five key technology areas categorized by the United States Department of Energy. The same improvements can be applied into smart thermal networks as well. Firstly, integrated two-way communication makes the grid a dynamic, interactive, real-time infrastructure that has open access and a plug-and-play environment.

Secondly, advanced components determine the electrical behavior of the grid with energy storage, power electronics and microelectronics to produce higher power densities and greater reliability. Examples of these components include advanced distributed generation and energy storage, plug-in hybrid electric vehicles (PHEVs), fault current limiters, superconducting transmission cables, advanced switches and conductors and solid-state transformers.

Thirdly, advanced control methods monitor the power system components allowing real-time surveillance and a timely response. In addition they support market pricing and efficient operations. Examples of control methods include data collection and monitoring of all essential grid components, data analysis and calculation of solutions from both deterministic and predictive methodologies, provision of this information to human operators and finally integration with enterprise-wide processes and technologies.

Fourthly, sensing and measurement technologies transform data into information about the condition of the grid, help relieve congestion and enable customer choice. Technology examples include smart meters, asset condition monitors, wide-area monitoring systems (WAMS), advanced system protection and dynamic rating of transmission lines.

Fifthly, improved interfaces and decision support enable grid operators to make more accurate and timely decisions at all levels of the grid. Improved interfaces mean better relaying and displaying of real-time data to grid operators. Technology providers are mainly responsible for developing all of these improvements. (Litos Strategic Communication, 2008e)

As smart energy solutions are in place, *businesses* and *homeowners* become more active business participants. They can choose whether to buy energy from the grid or produce at least partially themselves. They can offer surplus energy back to the grid, demand side response and other services. Especially energy intensive businesses will make these decisions based on changing market prices. In general businesses and homeowners will have wider opportunities than are currently available. (European SmartGrids Technology platform, 2006)

From the customer's side, smart grid implementation has at least two levels. It is necessary to have some sort of advanced metering infrastructure that includes but is not limited to smart metering. Smart metering means that the customer can be informed of tight supply or expensive energy prices real-time and customers can then change consumption behavior if they want to. Another level of implementation means more automation, as certain high-consuming appliances could be predetermined to be working only if energy prices are low enough. Peaks would be shaved across the grid instantaneously as low importance devices would shut down immediately as aggregate consumption increases. This would also mean lower costs for both energy procurers and consumers. (Litos Strategic Communication, 2008a)

The customer side in the energy retail business can be represented, in addition to a single customer itself, for example by a *broker*, *aggregator*, *buying pool* or *load management group*. A customer side broker or procurement manager can act on behalf of a customer who can't directly access the retail market. This way the customer can obtain electricity relatively cheap, but on the other hand has to pay for the broker. An aggregator is an organization for small-scale energy producers, such as homeowners with a wind power plant or solar panel, who can't directly access the retail market. The aggregator pays the market entry fee once and divides it between all participants and manages selling the sum of surplus energy back to the grid. Aggregator can also help in the regulatory aspects of installing a small-scale generator into the grid. For example all generators must comply with standards, security issues and quality control (Vaittinen, 2010). An aggregator is also used within the context of Demand Side Management, see for example ADDRESS project (http://www.addressfp7.org/). Buying a pool means that some customers buy electricity together and thus obtain better deals. They do not sell anything, so they don't have to pay retail market fees. However there are not many buying pools and the amount is decreasing because benefits from buying together are only marginal. A load management group is somewhat similar to buying a pool but it is a group focused at reducing their consumption on peak-hours to reduce their energy bill. They can also be called demand aggregators (Belhomme et al., 2009). Load management groups usually sign a contract with a DSO that they will consume only on non-peak hours and thus get lower prices. Load management can be done with demand management methods or by energy storage. (Kartseva et al., 2004)

It is important to notice that also *home-appliance manufacturers* play a role in smart grids and some of them are convinced of the strong development towards smart grids in the coming years. For example, Whirlpool, the world's largest manufacturer and marketer of major home appliances, plans to make all of its electronically controlled appliances compatible to smart grid technologies by 2015, which means that appliances can receive and send information to the grid. However, Whirlpool has stated that in order to claim their promise there should be a global standard on transmitting and receiving signals with home appliances and there should be policies that reward manufacturers, utilities and customers for using new demand reduction possibilities. Also General Electric has smart demand-response appliances that include a refrigerator, a range, a microwave, a dishwasher and a dryer. In a pilot program these appliances receive a signal from the utility company's smart meter in peak times. This means that the word "eco" is displayed on the appliance screen and appliances are programmed to avoid energy usage and work on lower wattage on these times. Of course consumers can still override this program if they wish to do so. (Litos Strategic Communication, 2008e)

Energy Service Companies (ESCOs), also known as energy efficiency companies, are important stakeholders in improving the end customers' energy efficiency. They implement end customer energy efficiency and load management projects. In addition to their core business they may sell electricity taking the traditional role of a retailer. The ESCO industry is relatively young and it has started around late 1970s after dramatic changes in oil and thus other energy prices after the 1973 Arab oil embargo and Iranian revolutions in 1979. These crises opened up new possibilities to make profit by reducing end customers' energy costs. ESCOs offer a bundle of services including developing and financing energy efficiency projects, maintaining the equipment involved, measuring and verifying energy savings and assuming the risk that the project will deliver the aimed energy savings. The biggest difference between ESCO and other companies that offer energy efficiency solutions such as consultancies and equipment contractors is that ESCO contracts are performance-based in the sense that project financing is directly linked to the actual energy savings. (Kartseva et al., 2004)

Typically, energy saving projects can use a variety of cost-effective measures such as high efficiency lighting, high efficiency heating and air conditioning, efficient motors and centralized energy management systems. In a smart energy district, however, high efficiency heating systems and centralized energy management are implemented to all households even without ESCOs. Still there are always possibilities for improvement and additional measures might be taken. Maintenance of energy efficiency equipment in the contract period, which is usually 7-10 years, is in most cases the responsibility of an ESCO. Costs of maintenance are included in the overall project. When needed, ESCOs are also responsible for hazardous material management, such as removing asbestos and properly handling mercury traces when upgrading fluorescent lighting to something else. In some cases ESCOs offer additional services such as education of maintenance staff so that they can take control of the equipment after the contract period. Similarly, education about customer's energy use and consumption patterns is offered by ESCOs. This way ESCOs can develop energy efficiency partnerships with customers. (Kartseva et al., 2004)

The integration of electricity and H&C is an important issue in smart energy districts. As discussed, heating markets are different from electricity and there is not a clear differentiation between a monopoly and market activities. Thus collaboration between different actors to integrate and optimize energy sources might be difficult. Oostra (2011) suggests that *facilitators* might emerge to deal with collaboration issues so that existing stakeholders can concentrate on their core businesses.

3.1.3 Non-Business Stakeholders and Participation

Non-business stakeholders include regulators and policymakers, research institutes, lobbyists and other non-governmental organizations. Policymakers and regulators exist on local, national and EU-levels. As the scope of this paper is on the European level, we will discuss policies from only that level, even though the attitude of national and local policymakers and the regulatory framework can be of crucial importance in the feasibility of business models. Regulatory development is dealt with more extensively starting from section *Overview of the EU Smart Grid Development and Electricity Market Liberalization.*

Policymakers face contradictory goals while preparing legislation for a new era of electricity and energy production. Increasing competition is expected to keep energy prices low for end customers but the importance of reducing the environmental burden might bring more costs. It is expected that many factors will affect the legislation for electricity and energy markets in the EU, for example technological development and innovation, evolution of grid organization and the need for flexibility and increasing trade across nations. The overall goals are ensuring economic development, competitiveness, job creation and security of supply. (European SmartGrids Technology platform, 2006)

If policymakers set the reduction of environmental impacts and ensuring security of supply as important goals, they need to set a regulatory framework that encourages private utilities to invest at a rate of return that is in line with the risk they take. Risks need to be allocated to those parties that can best handle them. The framework should allow risks to be shared between customers (through utility bills or taxes) and shareholders so that risks and rewards are balanced accordingly. (World Economic Forum and Accenture, 2009)

When discussing important stakeholders in smart energy solutions, we can't forget the role of research and development (R&D). Research plays a crucial role in innovation, which is needed to achieve the development that a smart energy solution should bring. It is emphasized that cooperation among universities, research centers, utilities, manufacturers, regulators and legislators should be facilitated in order to develop new technologies and standards but also solve any non-technical barriers that society faces while implementing smart energy solutions (European SmartGrids Technology platform, 2006)

Environmental Groups: How the Smart Grid Promotes a Greener Future stakeholder report (Litos Strategic Communication, 2008b) encourages also environmental groups to get involved in the development of smart grids. The report states that environmental organizations play an important role in spreading the information about environmental benefits of smarter energy solutions. At least WWF and Greenpeace already support smart grid development (WWF, 2011 and Greenpeace, 2010). In addition to just informing people, environmental non-governmental organizations (ENGO) will probably understand the concerns of locals and act as negotiators between energy actors and local people. For example demand reduction measures might sound frightening to some people, but ENGOs might be able to explain other than monetary benefits better than the energy industry. Furthermore ENGOs can get involved to ensure that all regulatory and technological developments are considered from the climate change prevention -perspective. (Litos Strategic Communication, 2008b)

Communication between different stakeholders is crucially important as noted by Ghafghazi et al. (2010). In their study they present evaluation and ranking of energy sources available for a case of a district heating system in Vancouver, Canada, based on multiple criteria and the view points of different stakeholders. The study shows how communication between the stakeholders would affect their preferences about criteria weights and would change the ranking of alternatives. Without communication the best choice is different for different stakeholders, while addressing concerns through efficient communication would result in general consensus.

Also Adams et al. (2011) note that through incorporating multiple viewpoints and perspectives into the development process, the results in local energy policy are both resilient and adaptive to future conditions and changes in political priorities. Researchers recognize that any process can be captured by political, institutional or individual forces through the explicit or tacit exercise of power through control of knowledge, technical expertise or language. However, they demonstrate how stakeholders and policy-makers can build on a clear political target, and address problems and deliver outcomes that are built on inclusivity, transparency and trust.

3.2 Overview of the EU Smart Grid Development and Electricity Market Liberalization

The current regulatory framework for electricity was not designed to deal with the current situation in which technological and business development directs us towards smart grid and energy networks. Previously, the duty of the regulators has been to avoid market abuse and regulate rates of return. In the old framework, the private sector has made capital investments and earned regulated returns on their assets in a mature market model that has both low risk and low rewards. Low risk has come from following a traditional investment practice in a mature market and low returns from regulated profits. However, the goal of policy makers has been to aim for more competition and customer choice in liberalized markets. The new framework needs to encourage investments by regulatory incentives and align the interest of the consumers with utilities and suppliers so that whatever policy goals are pursued, they can be achieved with the lowest cost to the consumers. (World Economic Forum and Accenture, 2009)

According to the European SmartGrids Technology platform report (2006), in order to achieve open and efficient energy markets in Europe, a stable and clear regulatory framework is needed with harmonized rules across the continent. The regulatory framework should support four goals with aligned incentives. Firstly, the grid should be secure and have open access. Secondly, there should be a clear remuneration system for smart grid investments. Thirdly, transmission and distribution costs should be kept at a minimum and lastly, efficient and effective innovation should be rewarded. (European SmartGrids Technology platform, 2006)

According to ten Elshof (2009) there are alternatives to developing smart grids, but then some disadvantages have to be accepted. The first option is business as usual. This would mean putting a limit to decentralized generation and the production of energy would have to be based on large-scale production. This would also mean limits to energy service innovation and changing end customer energy consumption behavior. Other alternatives include accepting less reliability if decentralized generation continues to grow and making large-scale investments in net capacity when energy demand is not limited. The last alternative is development towards autarkic energy systems. The writer argues that the last alternative is the one closest to the current system, since there are different studies and experiments in different countries but no shared vision on smart grid development. (ten Elshof, 2009)

EU Commission Task Force for Smart Grids (2010) report lists 23 research and pilot projects related to smart grids in Europe. These include EEGI Research, Development and Demonstration (RD&D) projects, E-Energy, ADDRESS, FENIX, Smart-A, EcoGrid EU and many others.

The European Electricity Grid Initiative (EEGI) has proposed a 9-year program, initiated by TSOs and DSOs, to accelerate innovation and the development of the electricity networks of the future in Europe. The program focuses on system innovation rather than on technology innovation and enables validation of result in real life working conditions. The demonstration will allow evaluation of benefits, estimation of costs and scaling up for all network operators. The cost of the entire program is estimated at 2 billion euros covering the expected participation of regulated networks, market players, research centers and universities. It does not cover the costs of deploying the solutions across Europe. (EU Commission Task Force for Smart Grids, 2010)

E-Energy: ICT-based Energy System of the Future is a German initiative, which primary goal is to create regions that demonstrate how the tremendous potential for optimization presented by ICT can best be tapped to achieve greater efficiency, supply security and environmental compatibility in power supply, and how, in turn, new jobs and markets can be developed. Particularly innovative in this program is that the integrative ICT system concepts are developed and tested in real-time regional E-Energy model projects. (EU Commission Task Force for Smart

Grids, 2010)

ADDRESS is a large-scale Integrated Project co-founded by the European Commission under the 7th Framework Programme. It focuses on enabling the active participation of small and commercial consumers in power system markets and provision of services to the different power system participants. *Smart-A* project on the other hand assesses the potential for load shifting by household appliances and analyzes synergies with local sustainable energy generation and requirements of regional load management. The *FENIX project* aims at making EU electricity supply cost efficient, secure and sustainable through aggregating distributed energy resources into large-scale virtual power plants. Already two demonstrations have been successful. Finally *EcoGrid EU* aims at increasing renewables to meet EU goals, to create a bidirectional grid with distributed generation and real-time control and market prices, enhancing production possibilities of consumers and deploying full-scale demonstration with participation of the DSO, industry and the community. (EU Commission Task Force for Smart Grids, 2010)

The European SmartGrids Technology platform report (2006) presents the vision of the European smart grid that includes four objectives. The future smart grid should be flexible, accessible, reliable and economic. Flexibility means that the grid should meet customer demands while having the ability to respond to challenges in a changing world. Accessible implies that connection must be allowed for all network users and especially renewable energy solutions and low emission local generation. Reliable refers to resilience against hazards and uncertainties in addition to having and constantly improving secure and high quality supply. Last but not least the grid should be economic, which implies that energy management should be efficient, innovation should be encouraged in order to provide best value and regulation should create “a level playing field” for all electricity providers. (European SmartGrids Technology platform, 2006)

These objectives are quite similar to the objectives set by Mittra et al. already in 1995, when liberalization of the electricity markets had just begun. They discuss the role of liberalization versus policy in the European context and say that both have merits but both can also fail. Mittra et al. (1995) conclude that energy policy should set the strategic supply framework within which competition is encouraged as far as possible. According to them, the four main energy policy objectives are security of supply, open access, targets and measures for environmental impacts and promoting competition. Security of supply is guaranteed by encouraging diversity of energy resources and the development of renewable energy production, the utilization of indigenous energy resources even if they are uneconomic in the short run, taxation of imported energy, creation of Europe-wide energy networks, and the implementation of energy efficiency and other demand-reducing measures. Open access is enabled by regulating monopolies and allowing fair prices for all network users. There should be minimum standards for performance and service for all providers and penalties should occur if standards are not met. Mittra et al. suggest the carbon tax as a tool in meeting environmental policy goals but the overall objective is to consult environmental policy managers to get realizable benefits with the lowest cost. To avoid trade and market distortions, all policies should be agreed upon at the EU level. Policies should create incentives for the development of renewable energy and switching to cleaner fuels. To achieve these policy goals with the least cost promoting competition wherever possible is suggested. Mittra et al. are strongly in favor of pursuing a single internal energy market by allowing third party access and unbundling vertically integrated monopolies. Researchers also recognize that competition may have contradictory effects against other objectives and suggest phasing in competition for a stable transition. (Mittra et al., 1995)

According to Meeus et al. (2005) the liberalization of electricity markets in the EU has been a top-down process. The development has been driven by the European Parliament and the Council. In addition to these, the process is driven by the Florence forum (biannual meeting on the creation of the Internal Electricity Market), the European Regulators Group for Electricity and Gas (ERGEG) and voluntary associations such as Eurelectric, ETSO, the Council of European Energy Regulators (CEER) and many others. Liberalization of the European electricity markets can be traced back even to the Treaties of Rome (1957) and Maastricht (1993) where the foundation for the creation of an internal market in the European Union with free movement of people, goods, and capital was laid. There has been a discussion on whether electricity and supply of electricity are goods or services and depending on that how these treaties affect electricity markets. Liberalization was put into force in 1996 by Directive 96/92/E3, which led to taking apart generation and supply from transmission and distribution of electricity by setting up separate companies for them. The EU Directive was later on replaced with Directive 2003/54/EC. (Meeus et al., 2005)

Liberalization has meant that electricity generation companies can have production capacity in any EU member state. In addition, market liberalization has increased competition since final customers can choose which supplier to use. However customers can’t choose their TSO or DSO, as electricity networks are natural monopolies. The basic principle is that all market parties have a right to use the transmission and distribution networks at equal conditions and prices.

National regulators monitor the network conditions and pricing of the grid operators. (Finnish Energy Industries Federation, 2003)

According to A European Market for Electricity? -report (Vaitilingam, 1999), liberalization has been a success story across Europe. The technical breakdowns predicted by sceptics have not happened in the EU. The report recognizes that there is variation between different EU nations in several terms of liberalization such as the degree of centralized generation versus DG, stringency of required unbundling between generation and transmission and distribution (T&D), the extent of public ownership, regulatory institution and the general design of the market mechanism. However they have several recommendations for developing national electricity systems and to the emergence of a single internal electricity market (IEM) for Europe. National recommendations include reducing concentration in generation, real separation of ownership between natural monopoly elements and other activities and having universal service requirements and environmental policy objectives to be met with a combination of licensing requirements, taxes and emission permits. Reducing concentration in generation means that the redistribution of generation assets is the preferred approach, whenever market size and minimum efficient scale of existing power plants allow it. The report argues that the distribution of ownership matters more to markets than public or private ownership. The separation of ownership between natural monopolies and others should be real, because changes in accounting or even legal separation are not sufficient. The report argues that presented instruments can achieve environmental and service goals. The report also argues that access charges for electricity transmission are the key to the development of an IEM that allows trading between countries. They suggest that pricing of transmission should be simple, transparent and depend only on the point of connection. There should be at least a small share of access charge to the entry point of access and the same allocation should be used across jurisdictions. Geographical differentiation in access charges should be encouraged to provide incentives to relieve congestion and reduce overall transmission loss. (Vaitilingam, 1999)

A liberalized market differs from a regulated market in the number of actors. Well-functioning markets are necessary for having any benefits from liberalization, as the reliable energy that customers take for granted is delivered by many actors performing different tasks. One option to better ensure market performance is government supported mandatory wholesale markets called power pools. There are pools for example in England, Chile, Argentina and in many states in the USA. Pools have also existed with vertically integrated utilities for better technical dispatch, minimizing generation costs and recognizing network constraints. In liberalized markets generators can submit complex offers to the power pool and thus take into account many technical factors such as the intermitted nature of renewable energy sources. Even though in the power pool prices are determined by supply and demand, the price formation mechanism is not transparent as the offers are complex and due to necessary side payments algorithms are needed for market optimization. (Meeus et al., 2005)

The EU promotes CHP production. According to the European Electricity Market Perspectives report (Finnish Energy Industries Federation, 2003) this has been expressed in many sources such as the European Commission's CHP strategy, an action plan concerning energy efficiency, the EU's Green Paper on the security of energy supply, and in the European Climate Change Programme (ECCP). The report argues that the Commission justifies the promotion of CHP production from the security of supply and climate policy viewpoints. CHP is viewed to increase security of supply by reducing the dependence on imported fossil fuels as CHP plants can use domestic fuels such as biomass. From a climate perspective CHP is beneficial as it enables more efficient utilization of energy sources that can lead to saving of energy and reducing CO2 emissions. (Finnish Energy Industries Federation, 2003)

In the future, if IEM is wanted, attention should be paid to improving the links between the national submarkets according to Meeus et al. (2005). Converging national submarkets into a single market will require both investments in the transfer capacity between nations and optimal use of the current infrastructure and its expansions. Authors present two stages for the improvement that can first be implemented on a regional level and later be scaled up to a Europe-wide system. In the first stage power exchanges should be harmonized and they should work in a coordinated manner. In the second stage TSOs should coordinate their balancing market so that both the procurement of balancing power and the real-time balancing is enabled across borders. As there are regional developments in this direction, the researchers won't comment on whether it is necessary to add European wide regulation to improve IEM from this perspective. However, they notice that the current regulatory framework leads to underinvestment in the grid, so European-wide regulation is necessary to coordinate bottleneck investments. (Meeus et al., 2005)

The European SmartGrids Technology platform report (2006) also recognizes that achieving their vision is not just about building technical solutions but rather requires a broad spectrum of actions, such as changing policies and creating standards. They suggest a list of five measures in order to create a smart grid in Europe. First, creating a toolbox of proven deployable and cost-effective technical solutions to enable generation from all energy resources. Second, harmonizing regulatory and commercial frameworks across Europe to allow trading of power and grid services. Third, developing shared technical standards and protocols that allow open access and a common platform for equipment manufacturers. Fourth, developing ICT systems that enable businesses to create and enhance innovative service offering and improve their efficiency. Last, ensuring successful transition by interfacing of new and old grid equipment. (European SmartGrids Technology platform, 2006)

In order to have a better picture of the eHUB related project developments in Europe, a fact sheet has been drafted (Appendix C). The template will be used to collect information about eHub related projects. It includes the general description and 8 fact blocks of the project: the first 4 blocks for all relevant national projects while the other 4 blocks - more detailed review of non-technical issues- to some selected projects in the second phase.

3.3 Effects of Regulation on Smart Energy Solutions

According to Gordijn and Akkermans (2007) regulatory policies directly impact the feasibility and attractiveness of distributed generation business models. Their studies show that policymakers and regulators are key actors in improving DG and the use of renewable energy sources, as they are in charge of taxes and other instruments that may promote or discourage the use of renewables and demand-oriented measures. They conclude that a stable regulatory framework must be in place: regulatory certainty increases market confidence in the long-term commercial viability of new business models. (Gordijn and Akkermans, 2007)

The researchers' arguments can also be applied to smart energy solutions. Policies and regulation can determine whether a business model for smart energy solutions is feasible or not. It is not enough that different business participants work together for developing a smart energy district, policymakers and regulators are needed in addition to provide an encouraging framework for that development.

Fens (2009) notes that in order to have effective and efficient smart grid implementation, harmonization of governance and standardization of technology is needed. This would require agreed definitions on smart grids and smart metering on a European level. Standardization has benefitted other sectors, especially those industries that extensively use ICT solutions. As the management of the distribution network is based on information technology, standardization would be beneficial in this context also. In addition to technology standardization, also governance should be harmonized, to allow staff and procedures to be exchanged cross borders and to ensure that the same ideas don't have to be invented over and over again. This harmonization should concern not only TSOs but DSOs as well. Currently there is a huge variation between regulation models for monopoly actors. There are rate of return models and cost plus models, but none of them clearly support a transition towards smart grids. (Fens, 2009)

There have been EU level efforts to standardize the technical requirements of the smart meter functionalities. Standardization has provided economics advantages as there is an economy of scale for applied technology as well as governance benefits from uniform processes in the roll out of smart meters. Fens (2009) concludes that standardization provides in general more effective governance at a lower cost. An open dialogue at the EU level between the electricity sector and the regulators should facilitate standardization, as the electricity sector is so important to the society at large. Dialogue is especially important, as currently there is no clear picture on how regulation should be arranged to optimize smart grid development and which standards are essential. (Fens, 2009)

While looking at the role of regulation in smart grid development it is important to understand also the view of the regulator. Dutch regulator Machiel Mulder (2009), argues that the current regulation at least in the Netherlands can facilitate transition to smart grids if distribution companies want so. The Dutch regulatory framework is characterized as light-handed and output oriented. This means that regulation is concerned at the outcome of the networks instead of the inputs. Thus regulators don't intervene in the management decisions of operators. There is a known information asymmetry between operators and regulators as operators have more knowledge of efficient network management than regulators. This problem is solved by giving the operator the freedom and incentive to choose the optimal technical solution. In Dutch regulation the main focus is on total revenues and reliability of the energy supply. Total revenues are regulated but distribution companies are free to determine the level and composition of the costs they want to make. (Mulder, 2009)

Revenues are determined by the following main formula:

$$TR_{o,t} = (1 + cpi - x + q)\, TR_{o,t-1}$$

Here TR is the total revenue of an operator *o* at the time *t* of a given regulatory period and *cpi* is the consumer price index, which means that revenues are corrected for inflation. The so-called x-factor that is said to be the efficient costs of a DSO is represented by *x*. This is determined as an average of the cost of all DSOs in that given period. The term *q* is a quality factor that is a bonus if an operator has a better system average interruption duration index than the average DSO and a penalty if an operator has worse than that. (Mulder, 2009)

If all network operators were to make similar investments in smart grids, all the costs would enter the regulatory framework and revenues of the operators would increase by the cost of the investments. However if only some of the operators decided to invest, revenues would increase only by the share of these operators of the whole industry. Then these operators would be only partially compensated for their costs. If all operators think some technology is the best even if the benefits are not clear, it seems reasonable to cover all the costs. In the case that only some operators invest in the new technology, the actual benefits will determine if those operators will reap the benefits or only suffer from higher costs. (Mulder, 2009)

Mulder (2009) notes, however, that when smart grids provide positive externalities, in other words benefits that the DSOs don't take into account when making investment decisions, it makes the regulatory framework biased towards traditional investments. Similarly to the report, Mulder suggests that externalities should be included in the decision-making. He recommends the definition of tariff products such as energy-saving services or charging option for electric cars that would be included in the regulatory framework to enable more investment in new technologies that increase the possibilities for these products. (Mulder, 2009)

There is also a lot more criticism towards regulatory systems as it is argued that a regulatory framework impedes innovation and the transition towards smart solutions. Veldman et al. (2009) argues that the current regulation in the Netherlands emphasizes cost reduction and there is not enough attention to reliability and sustainability. In addition, the monopolistic nature of DSOs prevents them for controlling generation or demand or applying storage in the operation of the grids. Researchers argue that regulation should allow control of generation and demand and that if no harm is caused to the customer, no compensation by the grid operator should be required. Furthermore, regulation is said to be short-term. According to writers these facts can hamper development towards smarter solutions. (Veldman et al. 2009)

Writers argue that local factors determine the need for DSO investments. Municipalities, project developers, producers and such will make choices on generation and consuming energy and these choices affect needs for distribution grids. Thus benchmarking costs between different operators might be unfair, as some areas are increasing DG a lot and some areas are not. It is also noted that regulators have confirmed that to ensure public interest in the future, large investments are needed, but they still want to investigate alternatives before making changes to regulation. According to writers this could take too much time given the urgency of challenges ahead. (Veldman et al. 2009)

The IMPROGRES project report (Nieuwenhout et al. 2010) notes five key issues in how regulation affects the development of smart grids and active network management and how that in turn has an impact on how much DG is implemented across the network. The issues are: network cost recovery, network innovation, network planning, network charging and providing incentives for demand response.

First, the current network regulation doesn't take into account the fact that increasing the amount of DG causes extra costs. These costs are not accounted for in the efficiency assessments of DSOs and thus the cost of smart grid investments can't be fully recovered and this hampers the development of the grids. Since investing in smart grid development is risky, regulators should allow cost recovery through revenue cap regulation or otherwise provide financial support in the first phase of the innovation process until there is better knowledge of the benefits of smart grid solutions. (Nieuwenhout et al. 2010)

Secondly, network innovation is decreased if regulation doesn't take into account benefits occurring to other parties than DSOs such as generators, suppliers and end customers. Of course network companies are responsible for developing electricity grids but many of the benefits of smarter grids occur to other parties. As the cost occurs only to the DSOs and their revenues are regulated, it is expected that the DSO will decline from some societally beneficial smart grid investments since they are not beneficial from their own point of view and they will be biased towards traditional grid investments instead. In the UK there is, however, the Innovation Funding Incentive (IFI) that enables recovery of innovative investments. Similar systems of taking into account the external benefits in the regulated amount of investments that DSOs have are encouraged also in other countries. Developing smart infrastructure and demand response measures is more viable when viewed from a larger electricity system perspective and not just network companies. (Nieuwenhout et al. 2010)

Thirdly, network planning should include mid-term planning procedures to anticipate future flexible and additional load. The challenge here is to find an economic optimum between a traditional network extension and flexibility enhancing smart grid investments at DSO level. (Nieuwenhout et al. 2010)

Fourthly, network charging affects the amount of DG in the grid. Currently it varies between EU countries whether only end customers pay for transmission and distribution or whether generators pay for those as well. According to the report, grid charges for generators are in use in the UK and in Denmark for new wind and CHP installations. As increasing integration of DG to the grid demands additional investment, it is argued that a part of the costs should be allocated for generation also, but this should be done in a transparent and fair way for both existing and emerging generation. Thus, the report encourages the Member State governments and regulators to harmonize use-of-system (UoS) grid charges for generators so that they are forced to internalize the consequences of their production decisions in network costs. These charges should be the same per kilowatt-hour for both existing generators and emerging DG and connection charges should be minimal in order to prevent bias for existing generators. Furthermore, time-dependent network charges would signal generators and end customers to shift production and consumption away from peaks and thus optimize network capacity. Similarly UoS charges could even be location dependent so that prices would be lower where DG investment has a positive network impact and higher where the impact is negative. All this is argued to improve network utilization and ultimately increase social welfare. (Nieuwenhout et al. 2010)

Finally, demand response should be encouraged in energy pricing in addition to network UoS. Currently customers don't have possibilities for demand response since so few contracts have real-time price information. Several Member States are demanding the increase of smart meters for households and this demand should include new pricing signals in order for customers to really respond by changing their consumption patterns. Three common pricing models are time-of-use (TOU) price, real-time pricing (RTP) and critical peak pricing (CPP). Pricing models are presented in section *Pricing Models*. The report argues for a clear definition and implementation of demand response programs. As demand response provides benefits and includes different participants, the roles of participants should also be clearly defined. The report emphasizes the role of smart meters integrated with extended home automation to enable larger use of demand response. (Nieuwenhout et al. 2010)

3.4 Conclusions on Stakeholders and Regulatory Environment

In this chapter we have presented key stakeholders in smart energy districts and discussed the role of the regulatory framework. DSOs play a crucial role in smart energy districts, since they are in general responsible of grid development and have a natural monopoly status. Due to the natural monopoly status of DSOs, policymakers and regulators have a lot of power regarding smart solution development. Also suppliers play an important role and their role will change to energy service providers, as they are able to sell H&C in addition to electricity and provide new services to end customers. New participants, such as ICT providers and facilitators will emerge in a smart energy district's value network to create and capture new value. The collaboration between all the stakeholders is important part of successful transition to smart energy district.

Regulation of electricity markets in EU has changed a lot due to liberalization and aim towards single internal energy market. Liberalization has meant decoupling of suppliers from monopoly activities in such way that customers can choose which supplier to use, suppliers can produce electricity in all EU countries and open access is enabled for all participants. In addition to numerous political goals and objectives that describe the vision for smart grids there are also many concrete programs to develop new solutions for actual implementation. Many objectives describe how smart grids are not just about technology, but also very much about policies and regulation.

Regulation can have a major impact on the business possibilities for smart solutions. Standardization and harmonization of governance is needed to support smart grid development. Current regulatory frameworks are diverse but it is argued that none of them clearly incentivize for investments in smartening the grids. Some regulators argue that current regulation works generally fine, but many practitioners and researcher criticize it for being short-sighted and cost-based rather than supporting sustainability and innovation. It is suggested that regulation increases the cost recovery of DSOs, internalizes the positive externalities that smart solutions create to other stakeholders, harmonizes network charging for all generators and encourages new pricing methods in energy markets.

Based on the previous material we have drafted a mind map of possible stakeholders of smart energy solutions (figure 7).

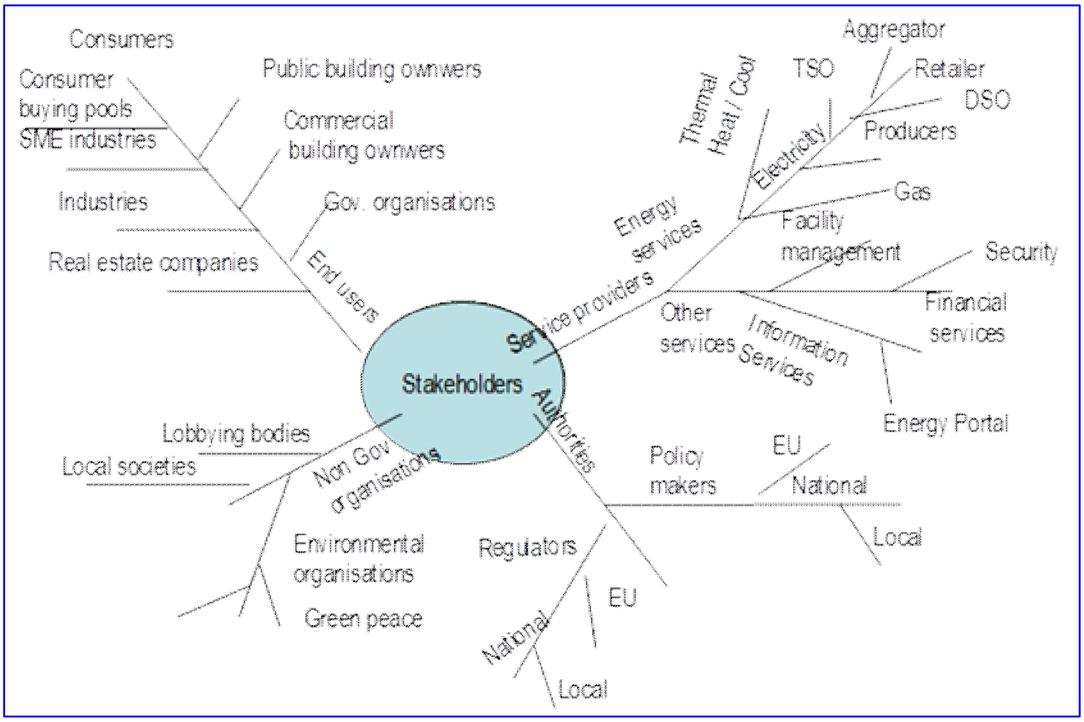

Figure 7. A mind map of possible stakeholders of smart energy services.

4 Business Models

4.1 What are Business Models?

The concept of the business model has been discussed more and more over the last years in management theory and practice (Magretta, 2002, Osterwalder et al 2005). The popularity of business models both in management research and in practice can be explained by three factors. Firstly, the popularity of the business model concept has a clear link to the emergence of e-commerce and Internet companies in the late 1990s. The new economy allowed and demanded new ways of value creation and capture. Secondly, new technological opportunities increased entrepreneurship and capital funding and thus encouraged new business models that were unconstrained by traditional strategies used in large existing companies. Thirdly, even in traditional industries such as airline, computer hardware and furniture retail, new business models have boosted the profitability of companies that adopted them and even opened up totally new market areas.

Despite its popularity, there is no widely accepted definition of a business model in the management literature (Magretta 2002, Osterwalder et al 2005, Shafer et al 2005). There is similar confusion in the management practice and most business people can't explain the concept in a satisfactory way (Linder and Cantrell 2000). Shafer et al (2005) have conducted a literature review of business model definitions in established publications between the years 1998-2002. Based on their findings they give their own definition of a business model:

"a representation of a firm's underlying core logic and strategic choices for creating and capturing value within a value network."

Or

"*Business model is a description of the operations of a business including the components of the business, the functions of the business, and the revenues and expenses that the business generates."*

This definition combines four elements: core logic, strategic choices, creating and capturing value and value network. By core logic the researchers mean that a business model articulates and makes explicit key assumptions about cause-and-effect relationships and the consistency of strategic choices. All companies have to create value for their customers in a way that differentiates them from competitors; this is the fundamental that businesses have to meet. The word value proposition is often used in this context. In order to create profit for the company's owners, there must also be a way to capture the value. This can also be called earning logic or a revenue model.

Osterwalder has introduced a so called business model canvas having nine elements grouped into four blocks to be addressed:

Business Infrastructure

- Key Activities: The activities necessary to execute a company's business model.
- Key Resources: The resources necessary to create value for the customer.

  Partner Network: The business alliances which complement other aspects of the business model.

Offering / Value Proposition: The products and services a business offers. Quoting Osterwalder, a value proposition "is an overall view of services that together represent value for a specific customer segment".

Customers

- Customer Segments: The target audience for a business' services.
- Channels: The means by which a company delivers services to customers.

- Customer Relationship: The links a company establishes between itself and its different customer segments. The process of managing customer relationships is referred to as customer relationship management.

Finances

- Cost Structure: The monetary consequences of the means employed in the business model.
- Revenue streams (income): The way a company makes money through a variety of revenue flows.

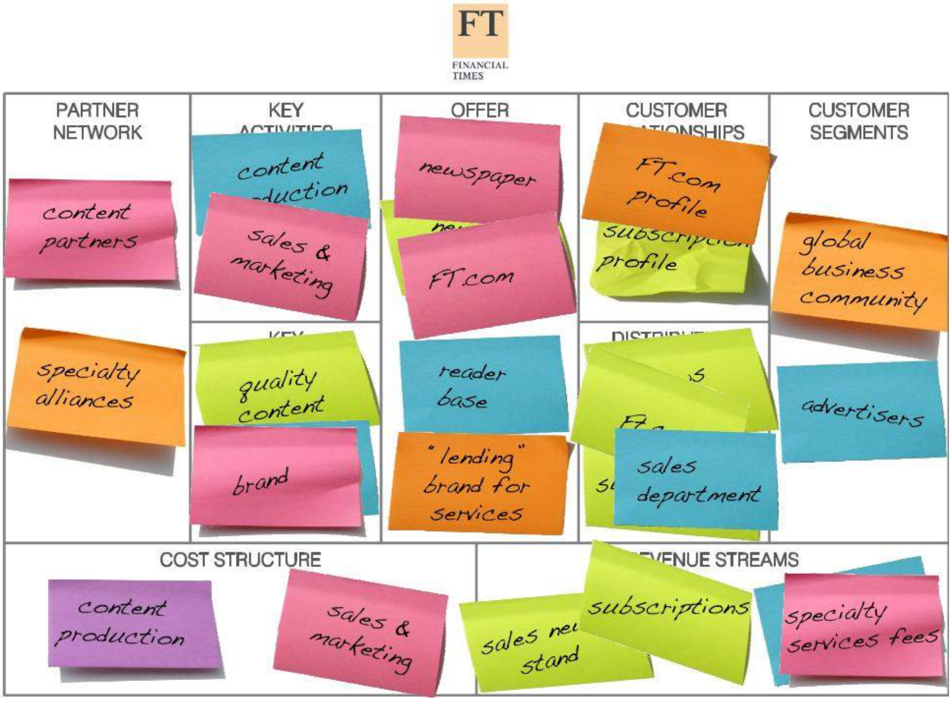

Figure 8 : Example of Osterwalders business model canvas – Financial times (http://glennas.files.wordpress.com/2010/07/business-model-canvas-ft.jpg)

Shafer et al (2005) discuss also the relationship between a strategy and a business model. They cite Mintzberg (1994) as viewing strategy in four different ways: strategy as a plan, a pattern, a position or a perspective. If strategy is viewed from a backwards perspective, it can be understood as a pattern of choices made over time. In a more forward-looking context strategy can be viewed as a plan of choices much like a roadmap. For example, the leading strategy researcher Michael Porter sees strategy as a position, which means that strategy is about making choices about which products or services are offered in which markets based on differentiating features. The perspective view is a grand vision in which strategy is seen as choices about how the business is conceptualized. All of these views share the notion of making choices. Shafer et al explain that in some cases a set of strategic choices can be translated into a single business model that is analyzed, tested and validated. In other cases a company can have multiple business models in consideration, each representing a different set of strategic choices before choosing the most appropriate business model for the organization. (Shafer et al, 2005)

There are also different definitions of business models and some of them are presented here briefly, because later on there will be references to articles that use these definitions. Wüstenhagena and Boehnke (2008, Stähler 2001) define business models as a description of business that includes value proposition, configuration of value creation and a revenue model. A value proposition explains how the company's offerings, i.e. services and products, generate value for customers. Configuration of value creation refers to decisions which parts of the value network the company is going to cover and how it differentiates itself from competitors. Revenue model is an explanation of how the company generates its sales revenue. Kettunen et al. (2007) define a business model as an intermediary between a strategy and a process model. Okkonen and Suhonen (2010) have a two-part definition, which includes business architecture for product and service flows in addition to established earning logics or in other words the strategies to generate and maintain profitable and sustainable business operations. Even though there are some substantial differences in these definitions, many of them have similar ideas expressed only in different terminology. For example all definitions of business models include some sort of description of how the company generates its income, whether this is expressed as a revenue model, earning logic or value capturing.

In addition to different definitions of the business model itself, there is certain confusion on whose business models are talked about. When discussing business models people usually refer to a business model of a single company. However in the context of smart grids there is discussion of a need for new types of business models without pointing out which companies in the electricity value chain need to have these new business models. The key term in a business model is the value network and a company's role in it. To discuss the changes in business models that smart energy solutions will provide, we will first explain the general aspects of how smart energy solutions change the value network compared to a traditional district and then look more in depth into what new services smart solutions offer and thus how value is created and finally what is the earning logic in a smart energy district.

4.2 Value Network Models

A value network is a business analysis perspective that describes people and technical resources within and between businesses. The nodes are connected by interactions that represent tangible and intangible deliverables. These deliverables take the form of *knowledge or other intangibles and/or financial value. The value network is often driven by so called node company.*

As mentioned above, Hamel (2000) notes that companies are usually part of a value network since very rarely one company produces something totally by itself without any suppliers and sells it directly to the end customer. In the management literature there are many concepts used to refer to the group of companies producing something to end customers. Porter (1985) has discussed the concept of a value chain, which refers to the notion that many companies together and a single company on its own can have a sequential process of adding value to a product. Inside a company, value chain can be seen as the synthesis of activities performed to design, produce, market, deliver and support its products (Kotler and Keller, 2006). Externally, a value chain refers to the companies performing these actions to deliver a product for the end customer.

The concept of a value chain is still much used today, but it has been criticized for its one-dimensional view of seeing companies as a linear flow. Thus Kotler and Keller (2006) recommend using the concept of a value network instead. According to them this notion takes into consideration the fact that multiple companies in each step can participate in the production and delivery of the final product. They define a value network as “a system of partnerships and alliances that a firm creates to source, augment and deliver its offerings”. They argue that a superior value is created and delivered to the target market by orchestrating the different parties of this network.

In the following we present the IBM value chain model for traditional and smart electricity and continue to a more detailed explanation of a traditional electricity value network. These models need to be explained before presenting the value network for a smart energy district.

4.2.1 IBM Model for Electricity Value Chain

The IBM view of traditional and emerging electricity value chains is presented in Figure 9. In the current model, power and information flows go only in one direction and the customers are mainly passive, except for the largest industrial customers. Smart grid technologies enable information and power flows to multiple directions and at a more frequent rate. As grids enable more distributed generation, customers become an integral part of value creation. They will be able to provide demand response, power and energy storage to the system. New technologies and possibilities will add complexity to the value network and allow for new participants and business models. In addition to complexity, the value proposition and value model of the whole electricity industry will change as changes in the grid technology and the participants take place. (IBM Institute for Business Value, 2010)

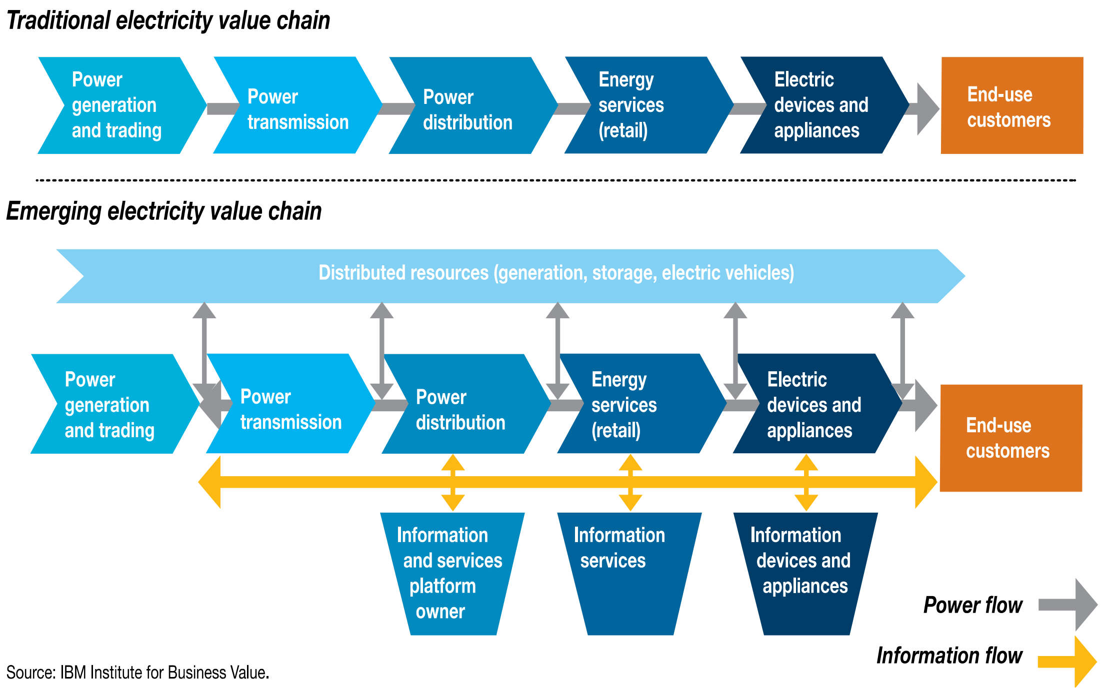

Figure 9. Traditional and emerging electricity value chain (IBM Institute for Business Value, 2010, p. 4)

According to IBM, a value model means a combination of value generated to customers and the value that customers or other parties (e.g. advertisers in case of many media industries) give back to companies. In a traditional electricity value model different steps in a value chain together provide customers with reliable and universal power at reasonable rates, for which customers pay usually a monthly fee. A consumer survey by IBM concluded that customers nowadays are more demanding and want more frequent and in depth information and control over their consumption and environmental impact. In addition to being demanding, customers are able to provide more value in return by demand response, load profile flexibility, distributed power and storage, all of which can be used to improve operational performance and asset utilization across the electricity network. Other value will be generated by increasing information on customer energy consumption patterns. Such companies might emerge that create platforms where customers can choose preferred energy retailers and retailers get customer behavioral information and demographics for marketing purposes. (IBM Institute for Business Value, 2010)

A district level smart energy value chain has many similarities with the model presented by IBM, but it also has some crucial differences. First, transmission is not an integral part of a district level system. Of course there will be transmission lines coming to smart energy districts as well, but they would be similar transmission lines as anywhere else. Similarly generation from elsewhere would still probably be used to some extent, but it would be similar that of any other district. Secondly, some value generation models – such as tapping into value that increased information from consumption differences and patterns provide – won't work in as small a scale as district level. IBM suggests that there is a possibility to develop platforms, in other words web-based marketplaces, where customers can choose from different retailers and energy services and retailers get information on customer consumption behavior and thus can focus on wanted market segments.

In conclusion, the IBM model explains how smart solutions affect the whole value chain and allows for bidirectional flows in both power and information. However this model is also quite simple and straightforward. Firstly, it doesn't differentiate between electricity produced at transmission and distribution level like for example the BUSMOD model in the next section. Secondly, it doesn't include possible stakeholders presented in section *Additional Business Stakeholders*, such as an aggregator or an ESCO.

4.2.2 BUSMOD model for Electricity Value Network

Presenting a complete value network even for a traditional electricity system is a difficult task, because there are so many alternatives on how the network can be arranged. As mentioned earlier, with the multitudinous recognized actors and value-adding activities discussed in chapter 3 the combinations for a complete value network are numerous. However, simple models can be used as a reference and more actors can be added when looking at more complex cases.

The BUSMOD methodology (Kartseva et al., 2004) for presenting and evaluating networked business models for distributed generation has its roots in generic conceptual modelling and is based on the e3value-methodology by Gordijn and Akkermans (2001, 2003). According to them formal modelling means defining aspects of the physical and social world around us for the purpose of understanding and communication. Formal means the abstraction, structuring and representation of knowledge so that it enables computational reasoning. Conceptual modelling has been widely used in computer science, artificial intelligence and information systems. However this kind of modelling is quite absent in management literature (Gordijn and Akkermans 2007).

In this section we discuss only different actors and value adding activities. However BUSMOD can also be used for the evaluation of networked business models. According to Gordijn and Akkermans (2007) their systematic methodology helps in answering the following questions in the case of networked business models of distributed generation:

- *What precisely is the market offering, and which actors are involved?*
- *What are the goals, and who 'own' these?*
- *What DG technology is (to be) used?*
- *What is the business case: how do the actors create and exchange value? And how can they act to make a profit?*
- *What are estimates on cash flow, operational and ICT expenses, and investments?*
- *What-if analysis: for example, what is the impact of existing or emerging regulation on the business model?*

A reference model of the BUSMOD report (Kartseva et al. 2004) for a traditional electricity system is presented in Figure 10. In this model, actors and value-adding activities are presented more specifically compared to the IBM value chain. Firstly, value-adding actions such as network management, market management and even manufacturing equipment for electricity generation are included. Network management refers to the operation of the electricity system to ensure continuity and security of electricity supply and the coordination of the transmission systems. Market management refers to the process of accepting bids for energy production and consumption and thus matching supply and demand. Energy efficiency refers to ESCO businesses presented in section *Additional Business Stakeholders*.

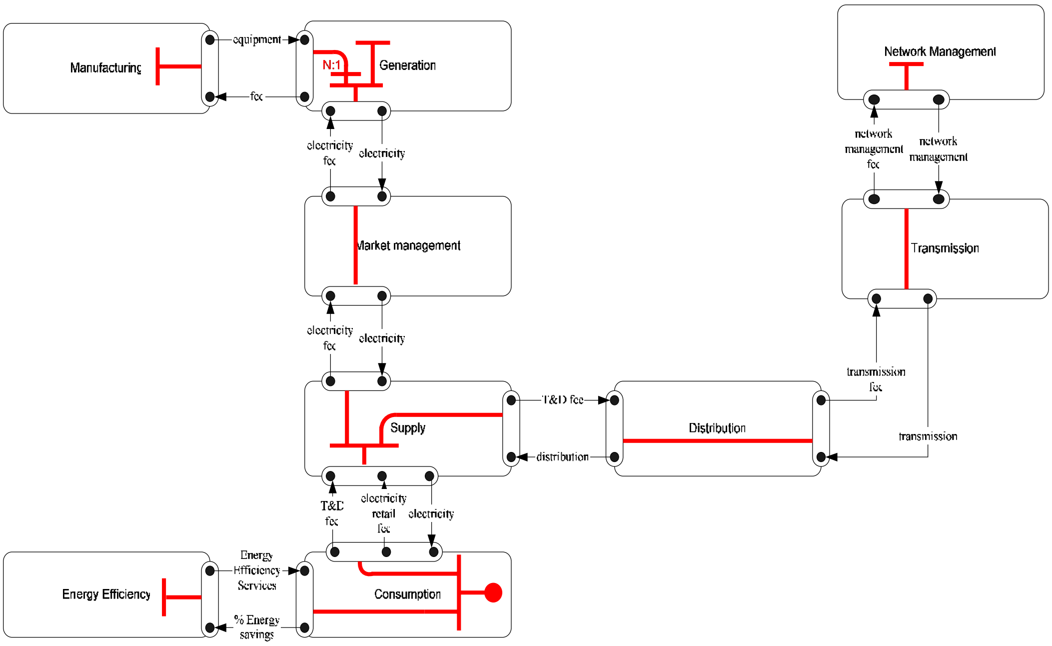

Figure 10. Electricity value network. (Kartseva et al., 2004, p. 78)

Secondly, different actions are not presented as a linear chain. Instead, electricity flows from generation to the supplier without connection to transmission and distribution. This representation is closer to real life, since suppliers buy the actual electricity from market management and its distribution from DSO rather than everything from the distributor. In this model the consumer buys both electricity and its distribution from the supplier, but in some countries the distribution fee might be paid directly to the distributor.

Thirdly, value exchanges between different steps are explicitly mentioned. For example the payment from the supplier to distribution is called a transmission and distribution (T&D) fee and the DSO distributes the energy to the end customer in return. The fees for different services get higher as the value adding steps increase. For example the electricity retail fee is higher per kWh for the customer than the electricity fee for the supplier. The fee for the supplier is lower because they can only buy a bulk amount of electricity beforehand and they have to pay even if all the electricity is not consumed. The end customer retail fee is higher, because they usually buy less and pay only for the consumed electricity (Kartseva et al., 2004).

4.2.3 Example of Smart Energy District Value Network

Even though there are many different options for arranging a value network also in a smart energy district, all of them share some common aspects. Firstly, a smart energy district has a district H&C network with local energy production. Electricity generation inside the district can be locally produced or bought from the outside depending on how independent the district wants to be in its electricity production and the cost structure of different energy generation options. Secondly, a smart energy district by definition has ICT solutions handling energy consumption and production in the district. They both measure and optimize operational efficiency and asset utilization. Thirdly, due to changes in the distribution and generation side, also business models across the sector need to change. For instance, increased monitoring and optimization means in addition to increased efficiency that customers can reduce their consumption and may result in reduced earnings in traditional energy business. Thus, innovative revenue models are needed. Finally, as mentioned already, customers have more power due to more accurate and frequent information but also due to possibilities to generate their own energy and offering demand response.

An example of a smart energy network is presented in Figure 11. This model has been created using the e3value-methodology (Gordijn and Akkermans 2001, Gordijn 2011b, Kartseva et al. 2004). In this model the end customer buys H&C and electricity from different suppliers. Both of these different suppliers provide customers also with frequent and detailed information about their energy consumption. That information is valuable, because it can be used to estimate customer demand better and thus retailers don’t have to buy so much excess energy. They can also sell the information to end customers that demand more frequent and detailed information about their consumption according to the IBM survey (IBM Institute for Business Value, 2010). The cost of additional information can be included in the transmission and distribution (T&D) fee. Here the fee is called a distribution and information fee, since transmission is outside the scope of the smart district model, even though it is of course incorporated in the distribution fee.

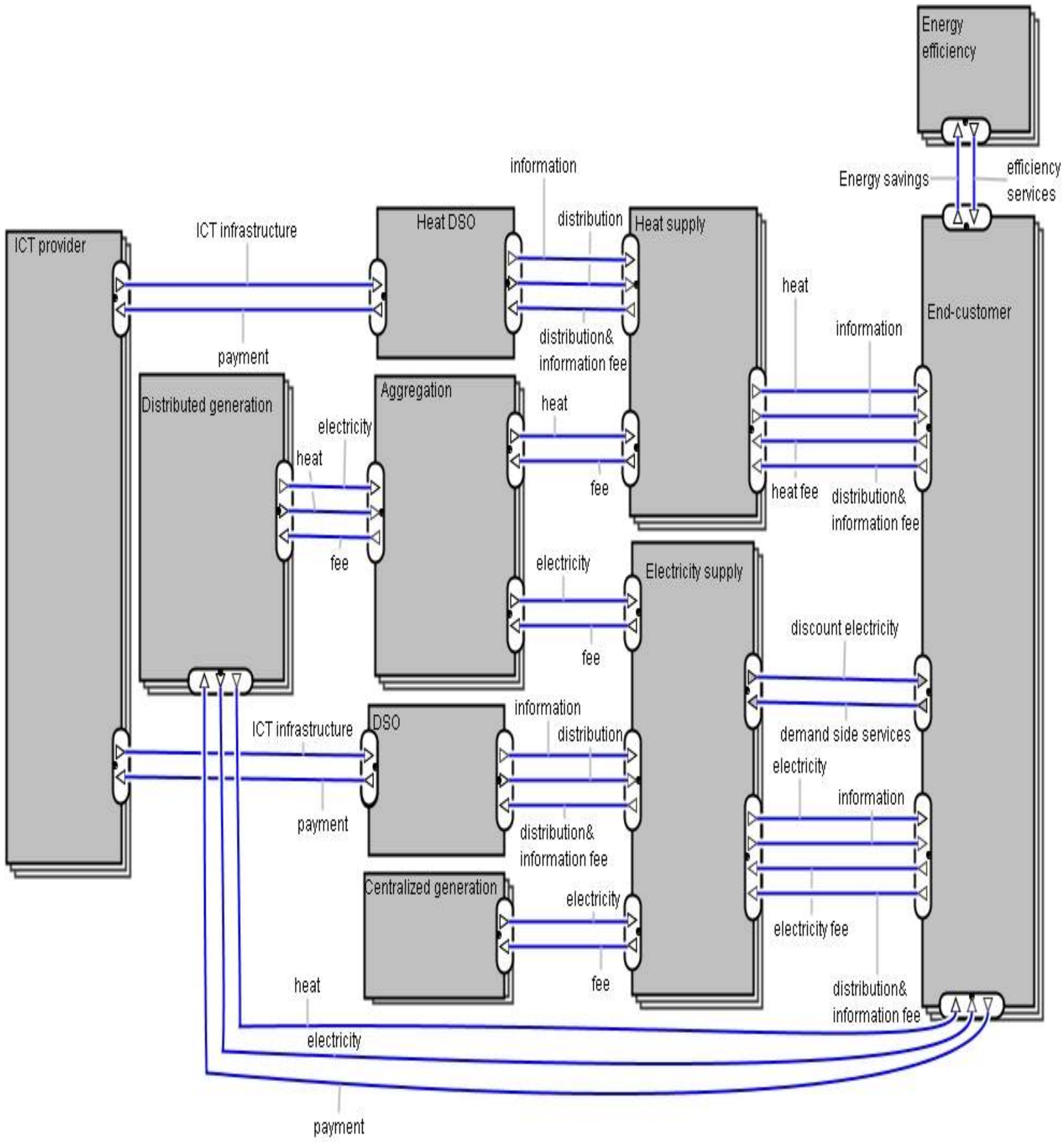

Figure 11. Value network model for a smart energy district. Created with e3value-model. (Gordijn, 2011b)

Suppliers again buy their energy and distribution respectively from producers and distributors. In this model electricity can be bought both from centralized sources outside the district or from DG sources. Heat is naturally produced inside the district by different DG sources. Also in this model small-scale distributed generators can't access suppliers directly, because accessing markets requires fees. Thus an aggregator is needed. An aggregator bundles many distributed generation sources and sells all surplus energy to markets. This is a classic example of economies of scale since the fixed market fee can be shared between the DG units. The aggregator might also be a necessary condition for small-scale generators to be able to sell their electricity since individually they produce so little that trading might not be economically feasible. DG selling possibilities depend of course on national regulation. For example in Germany DSOs must buy all the electricity produced by DG with a regulated minimum price (Koivuranta, 2011).

If customers have their own DG source, such as a wind power plant or a solar thermal panel they can consume the produced energy. However, then they have to pay for DG investments and operation and maintenance (O&M) costs themselves. In addition customers can offer demand side management services to suppliers or other actors. They can for example agree to certain programs that limit their maximum energy usage during peak periods. Demand side management services can be offered by individual customers or by a group, usually called a load management group. Limiting energy consumption can be done for example by smart devices that work on eco-settings or by energy storage.

ICT providers provide ICT infrastructure to DSOs and get payments in return. This ICT infrastructure allows increased monitoring, which can lead to both more efficient usage of the distribution system and energy sources and more detailed information for end customers. As in the reference model in Figure 10, energy efficiency services can be provided in smart energy districts as well.

As mentioned earlier, this is only an example of a smart energy value network. There can be a huge variety in models depending on which actors perform which value generating actions and what are the ownership models. For example there can be suppliers that offer both H&C and electricity or one actor could be in charge of distribution in general rather than differentiated DSOs for electricity and heating. In some countries also generators pay for transmission and distribution even though here only the end customer pays for it. Because the amount of different combinations is huge, all possible alternatives can't be presented here. Thus we mainly focus on the key elements a smart energy district adds to a regular district, which are firstly, the new service offering and thus new value propositions that ICT solutions provide and secondly how the pricing model changes, how large the investments are and how they are paid for.

4.3 Value Creation in Smart Energy Businesses

4.3.1 Interviewee Opinions on New Service Possibilities of Smart Solutions

In order to form a basis for the future work, a small number of people were interviewed regarding to new services possible enabled by smart energy solutions

According to Hänninen (2011), before discussing what new services smart solutions can provide we should discuss who should develop and provide those services. As there is a division between monopoly and market activities in electricity markets, the question is with whom the end customers interact when it comes to new services. Hänninen argues that there should be a clearly defined role for monopoly actors, which in general are operating the grid so that security of supply is guaranteed and that a market place is created for suppliers and end customers. Thus the suppliers should be the ones to develop and provide new services. It is also possible that third parties become active in providing new services. For example ThereCorporation (2011) develops products and services in household automation. Unfortunately in Finland there has not been much of this kind of service development, as the price seems to be the only thing that matters for the end customers. (Hänninen, 2001)

Hänninen (2011) notes that there is currently discussion in the Nordic countries whether there should be only one interface to customers in the electricity markets. This means that the current situation, in which customers get different bills from a distribution company and an electricity supplier would be replaced by only one bill from the supplier. The supplier would then pay for distribution to the distributor, so the customer could only work with one energy company. England has this kind of model already. Hänninen thinks that one interface model could also improve market development to more service-driven competition instead of just price competition. Different suppliers would start offering new services.

Auvinen (2011) continues that their key finding is that there is demand for turnkey solutions and some kind of service integrator. End customers can't sort out all different technology providers, processes, licenses and subsidies. Thus there should be only one interface or service provider for end customer that deals with all that, and coordinates the processes with subcontractors and partners. Otherwise it is too complicated for the end customers. She notes that new service design is needed to get consumers involved and willing to pay for new technologies. Oostra (2011) also notes that facilitators might emerge to help existing businesses with their smart solution transition, by providing information about business opportunities and enhancing collaboration between different industry actors.

Suppliers must also think whether they want to participate in developing new services at all. They might fear that new services could indirectly reduce their profits by enabling customers to reduce their consumption. Koivuranta (2011) argues that there are two reasons why suppliers have to adapt to smart grids even if all of them would not want to. Firstly, at least Finnish law demands retailers to inform customers about their energy consumption. Thus regulation sets the boundary that the companies must obey. Secondly, markets will determine if there are profitable opportunities in energy efficiency. If there will be opportunities to reduce end customer energy consumption in a profitable way, there will be some other company delivering that service if retailers won't start providing it. Koivuranta notes that current retailer companies might disappear from markets altogether if they can't adapt to the new situation.

The interviewees mention a lot of different services, but most of them are mentioned in the literature as well. Hyvärinen (2011) notes that all kinds of software applications are needed to control power flows, energy storage and loads and to provide price signals and information on energy use to the different parties. Most mentioned services are targeted at customers, but especially Six (2011) discusses services for suppliers and distributors. New information could be used for supplier risk management and portfolio management so that suppliers can do their business in a more efficient way so that they might become more competitive and offer lower prices to their consumers compared to a market player who does not benefit from intelligent options. Grid-related services include voltage control, transformation load reduction, balancing services and others to manage grids in a more cost-efficient way. Six continues that there is a challenge in bringing them all together but they are important at the same time. He argues that demand side management and other grid control should take into account both the commercial objectives of reducing market price peaks and the boundaries of the grid so that load peaks would also be reduced. Also Knigge and Mulder-Pol (2011) note that DSOs and suppliers might have contradicting goals and even different actors' internal goals might be contradictory. For example Enexis has three goals. Firstly, they want to optimize grid capacity, secondly, they want local demand to be met by local sustainable production, and the third goal is to increase market participation.

Most new services are targeted at end customers. Customers can be informed of their consumption for example by displays showing real-time consumption possibly distinguishing between different home appliances. Maintenance of appliances could be done from a distance (Bongaerts, 2011). Monitoring could be possible also with mobile devices. Vattenfall already has a service that customers get a text message, if there is a blackoutin their household. This is a suitable service for example for Finnish summer cottages, since many of them are located in areas that have electric lines above ground and are vulnerable to thunderstorms and falling trees. Fortum has a pilot project called Hand Held (Koivuranta, 2011). In that project around 200 test users have been given a mobile device that they can use to monitor their home energy usage. The aim is that in the future people could both monitor and control their home appliances by a real-time mobile system. There are also pilot projects where the customer interface includes information about consumption, energy prices and the type of production. Some equipment might be able to use different types of energy, for instance gas or electricity. With a smart system these devices can decide automatically which source of energy to use depending on price or convenience (Gordijn, 2011a). When customers have their own DG, the system could optimize almost real-time when it is best to use electricity from the grid and when to use own production. Hänninen (2011) argues that this development reduces the customers' dependence on the national grid and eventually we will get rid of all outages. In general, the opportunities of current IT systems will be available in energy consumption as well.

Another example of new services is demand response. If the end customer electricity price would start following market prices there could be possibilities for reduced demand when feasible. For example the supplier could agree with the end customers that their consumption will be cut automatically, if the market price goes over a certain limit. This could be combined with outside temperature metering at consumer's premises, since of course heating can't be turned off when it is cold outside, even if there is a peak. Automation is needed, so customers don't have to pay attention to their consumption on an hourly basis, but rather agree to certain conditions and let the system optimize energy usage within the customer's preferences and without comfort loss.

Furthermore, increased information will provide possibilities for data mining. This would enable better understanding of consumption behavior and thus improved possibilities to understand customer needs. When needs are understood there is a better chance to create additional services that customers are willing to pay for. For example different customers might want to use energy at different times and certain bundles of services could be targeted at certain segments of customers. All depends on when and how the customer uses energy.

In addition smart solutions could provide charging for electric cars and possibly using them as a grid balancing method when necessary. Fortum has a project called Charge and Drive, in which they have established load points for electric cars (Koivuranta, 2011). Customers can use the electric charging point via text message. The text message identifies the customer and thus adds the electricity bill to their phone bill. The project is done together with Nokia Siemens Networks.

Hänninen (2011) argues that in general, energy sectors lack innovation capability, as it is a quite conservative field. Developers should be more innovative, create new needs and verify if different services would work. He continues that for example the text message was invented by accident and it was offered to customers just to try if it might work. And as we know, it was a huge success. Thus, energy sector needs courage to try new thing and be more innovative.

Auvinen (2011) notes that the energy sector needs innovation both in service and in product design. The problem in the new energy business is that in general there is not a huge demand for energy efficiency or saving. Energy efficiency is not an interesting or tangible issue, so it is difficult to commercialize products that people would be willing to pay for. She argues that people don't want a smart meter in itself but it has to be sold to them in some other way that really adds value to them. Even the possibility to save money doesn't seem to help in many cases, new services have to relate to other needs, such as control, security or social needs. More people from creative fields are needed to design new services and help in usability and selling. For example the British company GEO has developed smart meters with similar panels to car speed meters. This appeals to people's need to control the household economy rather than just saving money, since the panel shows how well the customers are in line with the energy and carbon budget they have set themselves. Auvinen argues that the concept has worked because it is simple and understandable. GEO works together with British Gas, because a small company couldn't produce the meters themselves in a profitable way.

Auvinen (2011) continues about another model that has worked in Japan, where smart meters are sold as complementary products with household security systems. Here again energy is not the main issue. According to Auvinen, service designers and psychologists emphasize, that product and service concepts should be simple, usable and appeal to people. Social sharing and visualization usually helps. There are models in which end customers see their consumption compared to a similar household's average and people can get small rewards if their energy consumption is less than average and they belong to group of top 10 % having lowest energy consumption (or highest energy efficiency). This has lead to an overall reduction in energy consumption. A service that seems to have demand in Finland according to market research is a platform where people could compare energy efficiency and renewable energy production options for their household. Currently people don't know of the choices they have and it is very difficult to compare for example whether one should buy LED lamps or invest in something else. The platform should not only compare the costs of different options, but also the effort and user experience.

In conclusion, it is an open question who should develop new services in the first place, but some interviewees argue that it should be the role of suppliers and third parties. Services will be created to both industry actors and end customers. Thus some services benefit suppliers and

DSOs directly while others are beneficial if the customers are willing to pay for them. Industry services may include e.g. risk and portfolio management, voltage control and balancing services. End customer services include demand response with automation, remote monitoring and control, bundle of services such as broadband connection in addition to electricity and taking care of the whole energy system rather than just electricity or heat. It is emphasized that energy is a difficult thing to sell and thus a new marketing approach and service design is needed. Energy could be associated with control, security and social sharing. In Finland there is demand for a platform where customers could compare the energy services available to them.

4.3.2 Value Propositions in Smart Energy District

A customer value proposition refers to the total benefits a customer is supposed to receive delivered by a company usually in return for a payment. In the case of the smart energy concept, we can't discuss a value proposition of a single company to its customers but rather the value propositions that applying the smart energy concept will bring to different actors in the value network. Benefits and new services provided by smart solutions should be translated into value propositions so that different customers clearly understand what is the value for them.

Direct and possible benefits and risks of smart energy (including energy, services and solutions) are presented in Table 2. This list is based on what has been previously presented in this thesis. We don't claim that this is a complete list of all the benefits involved, but rather a general explanation of benefits. A more detailed list should be created in each particular case where smart networks are implemented. Direct benefits are those that will definitely come with smart energy solutions. For example smart technology will definitely improve the end customers' knowledge about their energy consumption because that is an integral part of smart energy solutions. Increased DG is an example of a possible benefit, since even though smart solutions improve the possibility to integrate DG into the energy system it is possible that DG companies are still not interested for some reason, for example if there is regulatory barrier. Risks describe the possible disadvantages that smart energy solutions might bring to a stakeholder.

Table 2. Direct benefits, indirect benefits and risks that Smart Energy provides to different actors. Own categorization based on what has been presented in this paper.

	Direct benefits	Possible benefits	Risks/possible drawbacks
End customer	More information and possibility to reduce consumption, possibility for demand side management, easier to produce own energy, more possibilities to implement DG without regulatory barriers	Sustainable consumption, interesting service bundles Lower energy costs	Increased price of T&D fee Increased price of additional information services
Supplier	Profit from selling information, need to buy less reserve capacity, opportunity to sell service bundles	Demand shifting services leads to reduced energy costs	Reduced selling
DSO	Profit from selling information, increased efficiency in operations due to increased information, increased reliability	Demand shifting optimizes grid capacity, increased DG reduces grid losses due to minimized distances	Implementation failure, high initial costs Untolerble disturbances for network
Policymakers	Increased reliability and security	Distributed generation, clean energy, reduced fossil dependency	Costs and benefits are unclear
TSO		DG reduces grid losses due to minimizing distance	Risk of losing current position
Centralized generation		Demand side management reduces need to invest in high risk peak power plants	Risk of reduced selling and loss of market power
BRP	More accurate prediction of network load due to more accurate information		Payments to TSO in cause of imbalances caused by limited prediction in DG
Technology provider	Profit from selling ICT systems	Partnership with energy business, new market opportunities	Implementation risk
Aggregator		Possibility for new businesses	Business failure
DG producer	Improved business opportunities	Optimized revenues	Business failure

In a smart energy district, the end customer value proposition is not based anymore just on reliable and universal electricity with reasonable prices (IBM Institute for Business Value, 2010). New value is created by more detailed and more frequent information on energy consumption for consumers and thus possibilities to understand and affect their own consumption patterns. In addition to just knowing about their consumption, consumers will get additional ways to affect it by being able to provide demand shifting services and generate their own energy and sell it back to the grid when appropriate. Remote monitoring and control will increase. If suppliers or other parties will develop and design the demanded services mentioned in the interviews, then customer can benefit from increased comfort, bundling options and an individualized service offering due to data mining. Akkermans et al. (2004) have written more about defining service bundles for example in the energy business. Demand shifting services and distributed generation might be done by individual end customers or by groups. As discussed, in many countries selling electricity produced by DG to the markets is impossible, because there are costs for entering the markets and minimal trading volumes. This can however be overcome by aggregating consumers or by changing regulation. Also demand shifting can be easier with a load management group.

Kobus et al. (2011) argue that emotional gain is also important for end customers. Smart solutions should lead to increased DG and more sustainable energy production and that gives end customers a good feeling of achieving reduced environmental impact. However Wüstenhagena and Boehnke (2008) point out, that there are problems with value propositions of sustainable energy, because reduced environmental impact doesn't usually translate into reduced private cost for the end customer. This happens if environmental externalities such as CO_2 are not internalized in the market prices. Thus the reduced environmental impacts are more of a public than private benefit and one solution to solve the issue is to internalize the benefit in prices by regulation, such as an emission trading scheme, carbon tax or subsidies.

End customers might fear the change that smart solutions bring and thus oppose to them. Even though the new system should be more reliable with increased monitoring, customers might fear that reliability is reduced just because a new technology is used. If the technology implementation fails, customer will pay for that probably as of increased T&D fees (ompared to planned with good implementation) and high price for provided information. These fears and risks should be taken into account when formulating a value proposition for end customers.

Suppliers benefit from smart energy solutions by being able to sell information to an end customer in addition to using the information themselves. This may also make the end users irritated, because the supplier is selling consumers own information. Suppliers can use more detailed information about their customers' consumption for improved predictions on future consumption and thus buy less reserve capacity. They can thus improve their risk and portfolio management. This will reduce their cost structure and selling information increases their profits. In addition smart solutions will improve possibilities to bundle services as electricity can be sold together with H&C and for example a broadband connection. In the current electricity markets it is difficult for suppliers to compete with each other, so there is a trend towards differentiation by complementary and additional services and home comfort management (Baida et al., 2004). Different pricing methods can be used in service bundling to better capture the value created. Furthermore, offering demand side management possibilities for end customers can further decrease costs as suppliers can reduce their buying of expensive peak energy. Of course they also need to sell energy forward with lower price, but in general peak energy production is costly for all participants in the electricity value network since its low usage and high-risk (Knigge and Mulder-Pol, 2011). Some suppliers might be reluctant towards smart energy since new end customer possibilities might lead to decreased consumption and thus decreased revenues for suppliers.

When it comes to DSOs, in addition to selling information to suppliers, DSOs benefit from smart energy by increased operational efficiency and reliability. New ICT solutions will undoubted change the whole way of monitoring and responding to grid changes. Efficiency and reliability is increased by knowing the status of the whole grid also in remote locations (and more precisely) and by automated response. New solutions can improve voltage control and balancing. This way investing in smart solutions will decrease the need to invest in traditional grid capacity. If demand side management proves successful, grid capacity and asset management can be optimized and increased DG will reduce grid losses and optimization of the grid even further. DSOs might have problems with smart solution investments as the initial costs are high and there is risk of failure with new technology implementation.

Policymakers benefit from the smart energy network by increased reliability and security. Increased monitoring and automated response means that grid failures are minimized. This is a benefit for policymakers, as they want to guarantee working conditions of the energy system for the society. They will also benefit from the increased opportunities for cleaner and more decentralized production of energy and thus reduced fossil fuel dependencies. These are all benefits to those policymakers that are committed to reducing environmental impacts and increasing security, reliability and independence of the energy system. However, just adding ICT solutions to the grid will not by itself result in a total change of the energy system, but incentives from policymakers and regulators might be needed to ensure the increase of sustainable DG. The risk for policymakers and regulators is that currently the costs and benefits of smart solutions are unclear. The cost of new solutions might become high for society if the regulatory system is changed to incentivize solutions that in the end won't deliver the expected benefits.

TSOs and traditional energy generators don't benefit directly from district level smart solutions, as they both work on a nation wide or even larger level. However both might benefit from smart energy districts indirectly. TSOs don't have to transfer so much electricity and balancing needs will be decreased if the smart energy district will become more independent in its energy production and thus there will be more capacity left for other purposes. Similarly, working demand side management in smart energy districts would reduce pressure to invest in high cost peak energy production. However, increased DG can be seen as a threat to both centralized generation and TSOs as both of their roles in the energy system will become less important and they might lose profits.

Apart from the most important actors in the current energy system smart solutions would provide benefits to many other participants as well. Obviously technology providers would benefit from being able to sell their products to improve the grid. In the long run they could form partnerships with DSOs to continuously improve smart solutions. This would open up totally new markets for many kinds of ICT hardware and software companies. As smart energy solutions would enable better monitoring of the grid, also possibilities for DG would be increased. This is a benefit for DG producers, as their business opportunities would grow. Again when DG would increase, possibilities for aggregation business would grow. All these companies face a risk of business failure, if there is no demand for new services created and if they face additional problems with DG.

In conclusion, we have identified the benefits of smart energy solutions for different actors in the district and outside of it. We have presented that numerous participants gain directly from smart solutions and there are even more possible benefits, if demand side management proves successful and if DG is actually increased due to a smartening grid. There are also a number of risks involved that need to be addressed in order to describe a clear and convincing value proposition. If the benefits are greater than the risks, one should look at who pays for smart solutions and how they are paid for.

4.4 Value Capturing in Smart Energy Businesses

In addition to the extra value that smart energy solutions will provide to different participants, there will also be extra costs. Firstly, large initial investments are needed to build smart thermal and smart electricity grids in a new district or upgrading existing grids to smart energy grids. As mentioned before, pilot project can be seen as more suitable for new districts, as there is no burden of existing infrastructure and thus best practices can be used. Secondly, there might be income losses to some participants if customers will use their increased ability to reduce their consumption. Thus, new models for generating revenue are needed to cover both the initial investment and the risk of reduced consumption. In the following section we will discuss the available pricing models for achieving efficient demand response, the amount of expected investment costs of smart energy solutions and the ways to pay for those investments.

4.4.1 Pricing Models

Pricing models for both energy and its distribution are important factors in smart energy earning logics. The three most common types of pricing models are real-time pricing (RTP), critical peak pricing (CPP) and time of usage (TOU) pricing. TOU means that the day will be divided in a number of time periods in which specific electricity prices apply. Hourly prices for example are also possible.. For example different prices during night and day are already common in the EU. Also prices can be different between summer and winter times. These kinds of changes are not going to shave peaks however. One more version of TOU is peak-time rebate, where traditional blended rate applies, but customers receive rebates for reducing load during peak periods (Litos Strategic Communication2008g). In the RTP model the price fluctuates according to wholesale markets, which allows customers to save on their energy bill by consuming during low rates. If prices would not fluctuate enough, consumers might not care about timing their consumption and peaks would not be shaved. The CPP model is a way to ensure customer reaction. In that model prices can increase by 500 per cent during peak periods of an agreed small number of hours per year. Customers agreeing to reduce usage in such hours would pay slightly lower rates for the remainder of the year (Litos Strategic Communication2008g).

In an interview, Auvinen (2011) emphasizes that automation is needed for customers to adapt to at least the RTP model, since it is not reasonable to assume that people want to spend time checking the prices and thinking about their electricity consumption many times a day. Rather there should an automated system, in which consumers can just choose pricing limits for their different household devices. The system would then turn devices on and off depending on preferences and prices. Similar automation could be used also with other pricing models so that during peak periods in CPP, customers are not allowed to use more than the most critical devices.

It is important to note that energy market players might have contradicting goals in demand response and choosing a pricing method. Peaks can occur in the energy wholesale markets and in the electricity grid and these peaks are not necessarily at the same time (Koivuranta, 2011). Thus in addition to determining what pricing method to use, it is necessary to determine how peaks are defined. For example RTP might be a sufficient market based solution according to suppliers, but DSOs might think that CPP is needed to facilitate grid capacity. The fact that a combination of price models is also possible adds to the complexity in pricing of energy and its distribution.

4.4.2 Investment Costs

Also Veldman et al. (2009) note that several studies demonstrate that the costs for the needed ICT investments are much less than the investments for reinforcements of the infrastructure. Examples of these studies are Djapic (2007), Berende (2008) and Bell (2008). They argue that automation technology is currently mature enough to justify investments in appropriate metering, communication and control.

Almost all interviewees seemed to agree that smarter solutions don't mean more costs either to customers or grid companies in the long run, since the benefits will outweigh the costs. Knigge and Mulder-Pol (2011) say that estimated regular grid investments would amount to about 20-70 billion Euros up to 2050 in the Netherlands. They continue that the price of ICT solutions can't be estimated as a percentage, because by investing in them we might reduce the need for regular grid investments, as ICT solutions optimize asset management. Currently Enexis invests around 1-3 million Euros yearly in pilot projects where also ICT solutions are developed. That is quite a small amount compared to its total yearly investments of around 500 million Euros.

Proper implementation of smart grids would however require cooperation with regulators and a shared vision throughout the industry. In addition, it is emphasized by many that in general grid improvements should be made gradually while making replacement investments in traditional grids. So those grids that anyhow need replacement would be upgraded to smart grids rather than trying to fix the whole grid at once. Hänninen (2011) notes that most of the European networks have been built between the 60s and the 80s so replacement throughout Europe is necessary even without smartening. Many benefits listed in the literature are also mentioned in these interviews, such as reduced need for manual intervention as automation increases and so forth. Due to smartening, grid companies need fewer investments in increasing grid capacity and customers can reduce their energy costs by demand response.

On the other hand many interviewees say that customers always pay the cost of additional investments and that is also the case in smart solutions. This raises the question, how can customers pay, if it was just said that customers wouldn't see a rise in their bills. As discussed, smart grids provide efficiency benefits that will pay back the investment, but then customers are not the one who pays, but the system's efficiency pays itself back. Thus, there seems to be some misalignment in the way the cost estimation is presented depending on the perspective taken.

In general, interviewees have difficulties in answering how much more investments, as a percentage, smarter grids will require compared to traditional grids. Hänninen (2011) notes that an actual cost estimate would require a more specific definition of the technology used, but it was surprising that nobody gives even a rough estimate of the additional costs. The only real cost estimation came from Hänninen and was only about smart meters rather than the whole grid. He said that smart meters, including installing, cost around 190 euros in Finland, which is not that much compared to 140 euros for traditional meters.

4.4.3 Investment Payback

At first it seems reasonable to think that a local DSO is the one who invests in smartening the grid, as it is the actor who is responsible of grid development in general at district levels. However, as discussed, other participants gain a lot from smartening the grid so it is reasonable to assume that they have to pay for the benefits they get. For instance, some kind of a fee for valuable services could be feasible. On the other hand it is possible that the DSO is not willing to invest alone in smart solutions, because they require large initial investments and there are risks involved. Firstly, DSOs and their investment amounts are regulated and they might not be able to invest enough. Secondly, there are risks in implementing the solution and the DSO might not be the best participant to bear that risk. Thus there are alternative possibilities for smart energy investments.

Wüstenhagena and Boehnke (2008) have identified high capital intensity and long lead times as the major barriers in sustainable energy business models. Firstly, from a company's viewpoint developing a new sustainable energy product takes a lot of time and money and building a factory to produce it does so even more. Secondly, even if for example solar PVs were profitable to customers in the long run, they might not have enough money to buy them because of high upfront costs. Similar problems can be seen in the smart energy business. Capital intensity is very clear in developing smart grid solutions and customer side problems can occur for example in the smart meter, even though costs are much lower in that case. Researchers suggest leasing and contracting as a solution to high capital costs. In a smart energy context this could mean that the actor most capable of managing the risk of smart energy investments would lease the solutions for DSOs.

Many interviewees still argue that the general business model should be based on the DSO who invests in ICT related smart solutions like smart metering in new districts. These investments should be allowed by regulation. According to Hänninen (2011) it is the general view in Finland that at least smart grid development is headed by DSOs. The Argument is that it is natural for DSOs to invest, since they are generally responsible for grid development. In addition, when having investors from many sectors of the energy business, the ownership becomes too complex and it is difficult to solve conflicts of interest (Koivuranta, 2011). Regulation should stimulate more smart solution investments and there should be more cooperation with DSOs and regulators in general when it comes to smart solutions. Regulation is criticized for being too much backwards looking, which is not a feasible model in a rapidly changing business environment (Knigge and Mulder-Pol, 2011). It is also emphasized by many, that regulation should take into account benefits occurring to other parties and not just benefits for DSOs. It is also seen as important, that those who benefit will somehow participate in financing of smart solutions. Oostra (2011) says that grid companies would need to think of ways to reap benefits from the grid, if they bear all of the investment costs.

However, also many interviewees note that the business model can't be known yet, since everything is still in development. The business model depends on the application and on the market size (Hyvärinen, 2011) and is determined by who gets benefits and services and how much different actors value them (Gordijn, 2011a). If there is enough valuation for new services, then business cases are feasible. Currently different DSOs are having pilot projects on their own or with other energy business stakeholders and there has not been a clear business model on how responsibilities and profits should be divided between different actors. Auvinen comments that in general profitability of local energy solutions is a difficult challenge. A common problem is that there should be a critical mass of customers in order for service providers to have a real business case. If pilot projects are encouraging, DSOs can invest in smartening the grid themselves. If not, they might need to look for new financing options. Oostra (2011) notes that we should not discuss just changing business models but rather a change in a whole business environment. The key question is how to make the change happen with so many different participants.

Knigge and Mulder-Pol (2011) note that grid companies will only think of their own interest when deciding whether to invest in smart solutions or not, while benefits of those solutions will occur to many other stakeholders, as presented in earlier sections. Six (2011) agrees with the rest that in the first steps government and grid companies play a key role in initial financing, but he adds that the largest part of the initial investments should come from deregulated markets, since they will potentially get the largest benefits also. Gordijn (2011) says that the initial investment depends on a business case and Auvinen (2011) adds that public-private partnerships might work in financing new smart district investments. It is not covered what those people, which suggested other models than initial investments of DSO, thought of regulatory possibilities to include external benefits in a reasonable way. In addition it remains unclear how to allocate costs between different stakeholders and what are the ways to solve conflicts of interest.

Suppliers must also think whether they want to participate in developing new services and paying for smart grid investments. They might fear that new services could indirectly reduce their profits by enabling customers to reduce their consumption. Koivuranta (2011) argues that there are two reasons why suppliers have to adapt to smart grids even if all of them would not want to. Firstly, the law demands retailers to inform customers about their energy consumption. Thus regulation sets the boundary that the companies must obey to. Secondly, markets will determine if there are profitable opportunities in energy efficiency. If there will be opportunities to reduce end customer energy consumption in a profitable way, there will be some other company delivering that service if retailers won't start providing it. Koivuranta notes that current retailer companies might disappear from markets altogether if they can't adapt to the new situation.

Auvinen (2011) and Oostra (2011) note also the importance of financial organizations. Similarly to Wüstenhagena and Boehnke (2008), they also think that generally sustainability-increasing solutions have high initial investment costs and long payback periods. Thus financial organizations play an important role in making investments possible by leasing and contracting. They suggest some kind of an ESCO model, where investments are paid over the long period by the cost saving compared to a traditional situation. Oostra mentions, however, that currently financial organizations have difficulty in weighing risks and benefits of smart solutions, as they don't know enough about them. She adds that financial markets could still play a crucial role. After the financial crisis many financial organizations need to find new markets to invest into and to polish their image in general. Smart energy solutions and energy efficiency could help in both problems as they are profitable and they are seen as something positive compared to many other investments. Thus the financial markets could show a new face to the world.

In conclusion, interviewees think either that DSOs should be the one to make the initial investments, or that all actors should participate in the investment costs. Arguments for a DSO lead are that smartening the grid is a regular grid development that is the responsibility of the DSOs and that it is a clearer model where only one actor is responsible. The arguments for many investors are that the one who benefits the most should pay and that with multiple participants also multiple viewpoints can be taken into account. It is also noted that big suppliers fearing reduced consumption might hamper smart grid development. However, it is argued that development will be inevitable as other participants get so many benefits, so suppliers will have to adapt even if all of them would not proactively develop new solutions. Financial organizations are also seen as a crucial part of a feasible business model for a district level smart energy concept, as they could lower the burden of high initial investments. The ESCO model is suggested to cover costs for financial organizations.

4.5 Conclusions on Business Models

There are many definitions of business models, but here we use the definition that states business models as being the description of how a company creates and captures value. However as we are discussing business models for a energy service concept, we are not focusing on a single company but rather on a value network and looking how business models of different companies change in that network. Since local regulation and market structures are so different, a general value network is difficult to describe, but an example of a value network is given. Important questions to be solved in forming value networks for smart energy arise from the integration of electricity and H&C, the collaboration between different actors and the emergence of new participants.

Smart solutions enable new services, but it is still an open question, which stakeholders will develop them. It is argued that DSOs should concentrate on their core business and suppliers and third parties should be the ones to develop the services. If there are profitable business opportunities in smart solution development, it is expected that those suppliers that don't want to participate in their development will vanish. The whole market structure might also change as it is discussed that customers should have only one interface when dealing with energy issues. New participants such as facilitators and financial organizations might emerge to help in the development of smart energy districts.

New services will be created to both industry actors and end customers. Some of the services will then benefit industry actors directly by increasing their efficiency and others will benefit them if customers are willing to pay for them. In our opinion these types of services should be separated and evaluated how much of the total economic value each type is expected to account for. Thus we could get a clearer picture on how much end customer pays for smart solution development and how much investments pay for themselves due to efficiency improvements.

Industry services include risk and portfolio management for suppliers and voltage control and balancing services for DSOs. For end customer there are numerous service opportunities as ICT solutions add information to the system. Example are demand response with automation, remote monitoring and control, bundling of services such as broadband connection in addition to electricity and taking care of whole energy system rather than just electricity or heat. Data mining could improve service offering to individual customers.

Different benefits and risk were allocated to different parties in and outside smart energy district. General allocation is presented in Table 2. For example increased information and demand side management will bring benefits to many participants including generation, DSOs, suppliers and the customer. There are numerous benefits listed, but also risks and costs should be taken into account when designing a business model.

Almost all interviewees think that costs of smart solutions are lower than continuing with business as usual. The amount of cost reductions are difficult to know, since so many issues are still unclear. Different real-time or peak hour pricing models can be applied to alter the consumption behaviour of consumers.

Generally it is argued by the interviewees, that business models should be based on DSO investments. DSOs are natural investors, since grid development is their responsibility and too many investors would increase complexity. However it is also noted that business models cannot be known yet, since smart solutions are still in the development phase. Thus the allocation of investment cost, other cost and benefits is unclear. The role of financial organizations is emphasized in enabling required investments.

Business models can be evaluated from profit perspective with NPV or real option methods. Profitability of different business participants can be estimated for example with the e3value-methodology. Public sector perspective includes also other points than profitability. These can be evaluated with different decision support methodologies. Key points in business model evaluation includes relationship to regulatory framework, researching actual market demand and improving it with innovative service design and by structuring the markets to reduce complexity from the customer perspective and finally ensuring smooth collaboration with different participants via a facilitator or some other way.

A further detailed study is going to be carried out to understand the energy services offered, value networks and business models applied in European eHUB related projects.

5 Conclusions and future work

The main advantage of the smart energy concept is seen to be its ability to optimize energy usage in a more holistic way than smart grids and its higher energy efficiency in local areas. The benefits of smart solutions include improved reliability and security of the energy system, maximized energy efficiency and minimized environmental impact for example due to increased renewable energy sources and reduced need for fossil fuels.

Regulation of electricity markets in EU has changed a lot due to liberalization and aim towards single internal energy market. Liberalization has meant decoupling of suppliers from monopoly activities in such way that consumers can choose which supplier to use, suppliers can produce electricity in all EU countries and open access is enabled for all participants Regulation can have a major impact on the business possibilities for smart solutions. Current regulatory frameworks are diverse but it is argued that none of them clearly incentivize for investments in smartening the grids or more generally in smart energy solutions.

There are multitudinous stakeholders and actors identified in smart energy business and thus it's more logical to discuss the value creation models than a business model of a single company in the network. Smart energy solutions enable new business opportunities like services, but it is still an open question, which stakeholders will develop them. New participants such as facilitators and financial organizations might also emerge to help in the development of smart energy districts, solutions and services.

This paper is part of EU FP7 project Energy-Hub for residential and commercial districts a transport (E-Hub) WP6 Business strategies and non-technical issues Task 6.1.1 State-of-the art of markets and business models. The main purpose of the paper is to improve the common understanding of topic services, business models and value chains. The stakeholders, business and service models and value chains will be analysed further in WP6 Task 6.1.2 Business and service models for e-Hub systems.

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Appendix A: Interview Introduction and Questions

Business Models for District Level Smart Energy Networks in Europe

Interview Questions

Introduction:

- What is your background in the energy business?

- As you have now learned about the smart energy concept do you think it is preferable to smart grids or do you not prefer smart solutions at all? Why or why not?

Business models:

- What kind of new services might be created due to the increased amount of information provided by smart solutions?

- How much more investments do you expect the smartening of the grids to require compared with regular grid investments (as a percentage)?

- In your opinion, who should finance the initial investment in smart energy (generators, distribution system operators, retailers, public sector, other)?

- What business models are applicable to finance smart energy? What model do you prefer? Why?

Participation and barriers:

- It seems clear that both smart grids and smart energy solutions enable more sustainable and distributed generation and more participation from the customer side, but this is not automatically the case. What would be possible ways to ensure that smart energy solutions really bring the benefits they promise to deliver?

- In your opinion what are the biggest barriers in implementing smart energy districts in Europe?

- In your opinion what would be the solutions to these barriers?

Presentation of Interviewees

Interviewees classified by stakeholder category they represent

DSO:

Joris Knigge, Innovator and Maaike Mulder-Pol, Innovator
Enexis
Arnhem, the Netherlands.

Kari Koivuranta: Senior Advisor
Fortum Energy Solutions and Distribution
Espoo, Finland

Martijn Bongaerts: Manager, Innovations
Liander
email answer

Markku Hyvärinen: Head of R&D department
Helen Sähköverkko Oy
email answer

Research/Consultancy:

Jaap Gordijn: Associate Professor of Service Science and Innovation, creator of e3value-editor
VU University Amsterdam
Amsterdam, the Netherlands

Daan Six: Project Leader, Energy Technology
Vito
email answers

Mieke Oostra: Senior Researcher, Energy, Comfort & Indoor Quality
TNO

Delft, the Netherlands

Karoliina Auvinen: Senior Lead in Ecoefficiency

Sitra

Helsinki, Finland

Lobbying:

Kenneth Hänninen: Director, Electric Networks

Finnish Energy Industries

Helsinki, Finland

Appendix B: Internet interviews

Interview Questions to end users

Research Questions

Is there a need for Smart Energy (eHub) services among end-users?

Is the Smart Energy Service (eHUB) concept more attractive than traditional model of Energy distribution?

What are the meanings of the claimed benefits to end users? How do they benefit?

Do consumers accept the local energy production where the production is green and closer to the consumers?

What kind of information end-users need and are willing to use to adopt their behaviour

Are consumers actively willing to be integral part of the Smart Energy (eHUB) concept? And what are the drivers?

Are end-users willing to produce energy by themselves?

Interview questions to non- end user stakeholders

Have you heard about the Smart Energy or Smart Metering ever?

How important is it for you that the energy service providers would start to use the Smart Energy concept in the future?

Generally, would you like to get frequent information about your energy consumption and costs of: energy, heat and water?

How likely would you use a smart meter that shows the energy, heat and water consumptions of your house, cost of the consumption, and prediction of consumption and costs?

How likely would you adjust your energy consumption and costs by your self thought the smart meter system from your home's electricity closet?

Would you like to use a smart energy management system (including security service) in which you could do the same matters in internet from your phone , computer, tv?

How likely would you buy the smart energy management system to your home from a small but security-proved company than from a large energy company?

- if the prices of both providers are equal
- if the prices of the small company are cheaper than the prices of the large company
- Please give an explanation:

How many years would you like wait until a smart energy system would payback your current total costs of energy bills during that time?

How likely would you use a smart energy service (provided by an energy service provider) that would automatically optimize your home's energy consumption and cost levels?

How would you like to get updates from a smart energy service provider in the future regarding to billing and energy consumption services

How would you rate trusting the smart energy concept when it is supported by ?

- Largets energy techonology companies in the world
- Largest software companies in the world

How likely would you buy the smart energy service from small but security-proved company than from a large energy company?

- if the prices of both providers are equal
- if the prices of the small company are cheaper than the prices of the large company

How do you accept that you cannot use electricity, heat or water at the full capacity (limited capacity) during some time periods:

- like the most expensive peak hours in the evenings to reduce energy bills.
- like the day hours when most of the people are not at home to reduce energy bills

How important is it for you that the renewable energy sources such as wind, solar and water power are used by your current energy service provider?

Would you like that renewable energy sources such as wind, solar and heating power would be used in your neighbourhood because of

- reducing the energy distribution loss and your energy bills? (energy efficiency aspect)
- because of reducing the use of fossil fuels and increasing the use of renewable energy sources? (the environmental aspect)
- because of the environmental outlook of your neighborhood?

Would you like to use solar or wind power integrated directly to your house energy system reducing the energy distribution loss and your energy bills? (energy efficiency aspect)

How likely would you place the solar panels or a wind turbine to your house or house area? You could choose the amount of solar panels or wind turbines.

Comparing to the current situation, do you think that the energy service providers should listen and make decisions more based on the opinions of:

- environmental groups (such as...)
- regulators (such as…)
- consumers

Extras

Please rate the performance of the following features according to the delivered information of your current service provider through post or email?

- Useful topics

- Quality and efficiency
- Enough detailed information

Please rate the performance of the following features according to Internet website of your current service provider?

- Useful topics
- Quality and efficiency
- Enough detailed information
- Easiness of finding information
- Please give suggestions for improvements:

Comparing to the current situation, do you think that the energy service providers should listen and make decisions more based on the opinions of:

- the environmental groups (such as...)
- regulators (such as...)
- consumers

Please rate between two aspects according to your preferences:

- Lower current monthly energy expenses versus lower total cost of ownership after X years of using smart energy system

How would you like to leave complaints?

- email
- phone
- service provider webpage
- personal internet account of your service provider
- other

How would you like to be contacted by the service provider regarding to the complaints to resolve the problem?

- email
- phone
- personal internet account of your service provider
- other

Interview questions to non- end user stakeholders

Research Questions:

- *What are the major barriers and drivers in implementing smart energy in Europe?*
- *What would be possible ways to ensure that smart energy solutions really bring the benefits they promise to deliver?*
- *Who should be on the drivers seat to make the initial investment in smart energy*

As you have now learned about smart energy concept , do you think smart energy systems contributes to

- Improved reliability
- Increased customer participation
- Maximized energy efficiency
- Management of affordable energy cost
- Fully exploiting renewable energy sources
- Reducing environmental impact of energy usage
- Improving security of energy system
- Reducing reliability of fossil fuels

In your opinion, smart energy systems is preferable to smart grids because

- It is not about networks but a larger energy transformation
- The outcome optimizes the whole energy system , electricity, thermal (heating / cooling) and gas
- Integrating multiple energy sources will increase energy efficiency
- It is unlocking the flexibility in distributed applications
- New service industries created contribute to local economic growth and employment within the community
- Other

In your opinion, what kind of new services might be created through smart energy solutions?

- Bundled energy services (electricity+ heat / cool + gas)
- Bundled services (energy+ facility management+ security)
- Controlling own consumption and costs
- Energy efficiency (ESCO) services
- Information services
- Flexible pricing
- Others

In your opinion, who should on the drivers seat to make the initial investment in smart energy?

- Energy producers
- Distribution system operators
- Retailers
- Public sector
- Other?

In your opinion, what would be possible ways to ensure that smart energy solutions really bring the benefits they promise to deliver?

- New value added services
- Reliability in energy supply
- Regulation to increase decentralised production amount
- Measures to get people involved (i.e. participation)
- Pricing models / price variation (i.e. real benefits for being active)
- Regulations, legislation, policy to give space for private initiatives
- Others

In your opinion what are the biggest barriers in implementing smart energy districts on Europe?

- Political awareness
- Reluctance of the present players in energy business to change conventional business models.
- Technological complexity and risks
- Consumers ' interest in energy efficiency
- Lack of innovative value added services offered
- Lack of experience and knowledge of smart systems.
- Payback times of many new solutions are very long.
- Affordable capital
- Cyber-insecurity and potential for misuse of private data
- Others

In your opinion what would be the solutions to these barriers?

- Promotion of research programs and demonstrations
- Regulation encouraging investments
- Incentives and subsidies
- New financial models
- Requirements for decentralised energy generation
- Customer-driven new business models and service offering
- Others

Appendix C. Fact sheet for collection of information on eHub related cases studies.

eHUB	Part I: Identified national eHUB projects			
WP #6 : Task 6.1.1				
eHUB project fact sheet	Describe the district model acc. to D 1.1	List the stakeholders acc. to the stakeholder mind map in the instruction paper	Lists down the service provided: heating, cooling, electricity gas, facility management, others	Describe the energy system acc. to the D1.1 " First-level (conceptual) system definition of the E-Hub" , e.g. Local heating network, eletcricity driven HP , smart metering,...
	District / admin model applied	Stakeholders involved	Service scope	Technology scope
Project [name]				
Location				
Developer [private, public, PPP joint venture]				
Status [developement, construction, operation]				
Drivers	Part II: Business and value models for selected projects only			
	Describe the value network acc. to instruction, or a insert a simple flow chart or detailed network model produced by e3VALUE	Describe the applied businees model acc. to e.g. Osterwalder's method.	Describe here the principal financial model of the project: i) public, private, or PPP financing ; ii) source of financing : private project funding , institutional financer(e.g. EIB); iii) pay-back scheme: on-bill financing (OBF), energy savings contracting (ESCO), etc	Describe here operational model, e,g, who is responsible for operating of the energy system. List what kind of ICT solutions are applied.
	Value network (hierarchy)	Business model applied	Financial model applied	Operational model / Business solutions
	Node company:			
Source of data [project report, web site,..]				

Project information

- Project name: Give the name of the project
- Location: Give the address of the project / urban or rural area
- Developer: Give the name of the developer
- Drivers: Motivation of the project, e.g, . a pilot, demonstration etc,
- Source of data: Give the major reports, web sites etc

Part I: Identified national eHUB projects

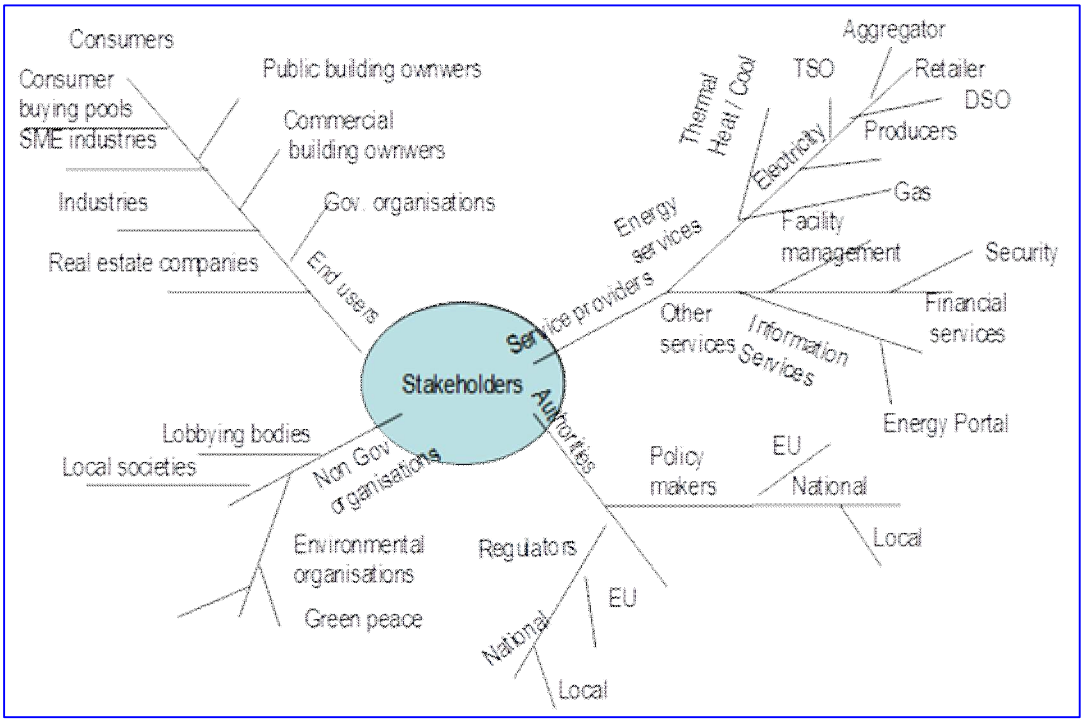
Block #1: District / admin model applied

Describtion of the district model (city, community, village,...) of the project, decision making regarding e.g. the selection of the energy system, who has been the promoter of the project. Also the size (e.g. the floor area served) and if a single building, a group of buildings or a district.

Block #2: Stakeholders involved

Project stakeholders are those entities within or outside an organization that are actively involved in the project, or whose interests may be affected as a result of project execution or project completion, e.g.: sponsor a project, or have an interest or a gain upon a successful completion of a project; may have a positive or negative influence in the project completion.

Potential stakeholders involved in the project are given in the mid map picture below.



Block #3: Service scope

Scope is an arbitrary detail that is used to define the limits of a Business Service. Scope items can be of any type or granularity and are used to define what the Business Service can provide (In Scope) and what it cannot provide (Out of Scope).

For the eHUB projects, break down of the services provided to the end user, e.g. heating, cooling, electricity, gas, water,… facility management, information , other services like financing, ESCO,… will be given.

Block #4: Technology scope

Describtion of the solution and technologies applied to the energy system :

- Energy production
- Energy transmission
- Energy distribution

- End user premises

For instance, there is a local low Ex heating network, heat is produced from waste water by electricity driven heat pump) , smart energy metering,...etc . Give also the capacity of the system (e.g. heating energy supplied XX GWh/ a), and costs of the project if available.

Part II: Business and value models for selected projects only

Block #5: Value network

A value network is a business analysis perspective that describes people and technical resources within and between businesses. The nodes are connected by interactions that represent tangible and intangible deliverables. These deliverables take the form of knowledge or other intangibles and/or financial value. The value network is often driven by so called node company.

Description of the value network applied in the project is given here: how the business is organized, i.e. the value network hierarchy, e.g. through contractual situation: who has made the service contract with the end user (node company), who are the suppliers to the node company and who are their suppliers etc , are there end user groups formed (e.g. consumer buying pools, producers' aggregator, DSM pools / load management groups).

Also a simple flow diagram can be used / added : the actors involved and services vs fees between them .

A more detailed network model can be produced by e.g. the e3VALUE tool.

Block #6: Business model applied

Description of the business model of the node company.

Business model is a description of the operations of a business including the components of the business, the functions of the business, and the revenues and expenses that the business generates.

Osterwalder has introduced so called business model canvas having nine elements grouped into four blocks to be addressed:

Business Infrastructure

- Key Activities: The activities necessary to execute a company's business model.
- Key Resources: The resources necessary to create value for the customer.
- Partner Network: The business alliances which complement other aspects of the business model.

Offering / Value Proposition: The products and services a business offers. See above “Block #3 Service scope”. Quoting Osterwalder, a value proposition "is an overall view of services that together represent value for a specific customer segment.

Customers

- Customer Segments: The target audience for a business' services.
- Channels: The means by which a company delivers services to customers.
- Customer Relationship: The links a company establishes between itself and its different customer segments. The process of managing customer relationships is referred to as customer relationship management.

Finances

- Cost Structure: The monetary consequences of the means employed in the business model.
- Revenue streams (income): The way a company makes money through a variety of revenue flows.

Block #7: Financial model applied

Description of the principal financial model of the project: i) public, private, or PPP financing ; ii) source of financing : private project funding , institutional financer(e.g. EIB); iii) pay-back scheme: on-bill financing (OBF), energy savings contracting (ESCO), etc

Breakdown of who has invested to / owns :

- Energy infra (production, transmission/ distribution, end-use devices)
- ICT solutions

Osterwalder business model canvas produced by tools available (http://www.businessmodelgeneration.com/)

Block #8: Operational model / business solution

Description of the operational model, e,g, who is responsible for operating of the energy system. Listing of ICT solutions are applied, e.g.

- Interactive Smart meters
- End user info system
- Energy system operating system
- Billing and invoicing