SWITCHING TO A SMARTER GRID

The Impact of Consumer Engagement
Analysis driven by the literature

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Executive Summary

At the moment the electricity industry is going through the most dramatic change in history and the electricity utilities are facing tough times in order to survive. With the growth of renewable energy generation, a more decentralized system energy generation and the growth in global energy demand, the current electricity system is no longer suitable for the needs of the society. The smart grid technology promises remarkable increases in efficiency for the electricity industry, it integrates renewable sources of energy, allows a two-way energy distribution, brigs savings for the consumer and has a positive impact on eliminating our dependence on fossil fuels. It will positively impact a more sustainable future.

At the current stage of taking steps towards a smarter grid, the lack of consumer engagement has been pointed out as the biggest barrier for the further development of the smart grid. Consumers are not engaged mainly because in the 'old grid' they were only passive ratepayers. However, in the smart grid, there is a role envisioned for the consumer and this is why their engagement is essential in order to develop the smart grid. This involves challenges that are completely new to the industry.

This paper aims to find possible ways of overcoming the barrier of consumer engagement with the smart grid enabled products and services through a meta-analysis of literature and theories in fields where we could find answer to this barrier. I will compare findings from the literature and theories on mainly Lead-User Innovation and Participatory Design in order to find out if higher consumer engagement can be brought by this kind of co-creation already in the innovation process and if we can this way bring the rise of the dominant design for smart grid enabled products and services, which has the potential of bringing more consumer engagement on the way to switching to a smarter and much more sustainable grid.

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1 Introduction

The electricity sector is going through the most dynamic changes in its history. It is unquestionable that our planet needs an extensive adoption of cleantech solutions to provide energy for a fast and exponentially growing population. The World Energy Outlook 2012[1] report forecasts that global energy demand will increase over one-third by 2035. Electricity prices in Europe are predicted the highest increases in history. Also with the alarming state of global warming and pollution it is time for minimizing and eliminating the use of fossil fuels and switching to a more sustainable and independent way of powering the world, where the smart grid plays a big part since it integrates renewable energy from distributed sources. The old electricity system is no longer suitable for current needs of the society. In today's power system, electricity flows mostly in one direction and it is distributed from large central station generation connected by high voltage network of the grid to local electric distribution system. This system is highly vulnerable to various security threats like large power outages, which could be prevented with the implementation of the smart grid.

People across the globe recognize the importance of reducing greenhouse gas emissions in consideration with the negative impact on the climate. However, in the meantime the association between buying energy efficient products and saving the climate stays abstract. Environmentalists and green marketers have been trying to educate about the consequences of the current unsustainable ways of energy consumption, but with not too much success. Consumer behavior and habits do not change from one day to the other.

In my research I will analyze theories, which if applied might have the potential to impact and positively increase consumer engagement and help utilities to overcome this barrier and further develop the smart grid.

[1] International Energy Agency - http://www.worldenergyoutlook.org/publications/weo-2012/

1.1 The Research Gap

There are several theories on consumer engagement and researches on how the users can contribute in the development of a product. However, I am going to focus on from the initial phase of new technology -innovation- and theories related to consumer engagement and innovation. In many industries technological innovation is now the most important driver of competitive success (Schilling, 2010). Since there is a disruptive change and greater openness for new players in the electricity industry, innovation plays a big role for the utility companies to survive in the market. Moreover the lock out and lock in of the dominant design of the 'old' and the smart grid still did not arise. The main research gap is in the possibility of consumer engagement already in the innovation process to increase the likelihood of embracing the consumer needs from the beginning in order to successfully engage them.

The future electricity grid does not only promise to be a radical technological, environmental and economic advancement of the old grid, it will also be a technology influencing the everyday life of its users. Even if users have been involved in some of the innovations of the previous grid, they will play a fundamental role in the development of the future smart grid. However, the amount of willingness of the end users to accept changes in their homes and their routines will not only form how smart grids will look like; it will also have a significant impact on the success of its development and implementation. Consumer engagement has traditionally not been the domain of utilities, and it entails a series of challenges that are completely new to the industry (Sioshansi, 2012).

The Global Cleantech Report of 2012 is stating the lack of consumer engagement as one of the key challenges in the European smart grid market place. More specifically, the lack of demand of smart gird enabled services by consumers who do not perceive a strong value proposition for bringing the smart grid technology into their homes is identified by utility executives as the biggest barrier to smart grid value creation.[2]

[2] The Global Cleantech Report 2012, A Snapshot of Future Global Markets, Showing market growth and cleantech opportunities – By Copenhagen Cleantech Cluster

According to Douthwaite et al. (2001) the success rate of new technologies depends on how the various users and manufacturers are related to the innovation process. In the current grid, there was not too much focus on the user. Engineers in their development of energy technology do often focus more on technology and forget the user of the technology and user needs. However, in the smart grid the user is becoming an important part of the system and should be included in the innovation process.

After the Introduction I will present the literature review and than the research question.

1.2 Overview on the smart grids

I will talk more about what a smart grid is its infrastructure and development in Chapter 4. There are as many definitions of smart grids as there are smart grid projects, experts, or practitioners. In this thesis I chose the definition of smart grid as any combination of enabling technologies, hardware, software, or practices that collectively make the delivery infrastructure or the grid more reliable, more versatile, more secure, more accommodating, more resilient, and ultimately more useful to consumers (Sioshansi, 2012).

According to the European Technology Platform for Smart Grids, a smart grid is a digitalized electricity network, which delivers electricity from suppliers to consumers using technology that can communicate two-way and by these means control appliances at consumers' homes. The concept of smart grids was developed in 2006 by the European Technology Platform for Smart Grids, and concerns an electricity network that can intelligently integrate the actions of all users connected to it - generators, consumers and those that do both - in order to efficiently deliver sustainable, economic and secure electricity supplies. Smart grids employs innovative products and services together with intelligent monitoring, control, communication, and self-healing technologies in order to, better facilitate the connection and operation of generators of all sizes and technologies; allow consumers to play a part in optimizing the operation of the system; provide consumers with more information and options for choosing an energy supply; significantly reduce the environmental impact of the whole electricity supply system; maintain or improve the existing high levels of system reliability, quality and security of supply; maintain or improve the efficiency of existing services; foster the development of an integrated European market.[3]

Since I am concentrating on consumers in this research I am also including the definition of Chandler (2008), which puts emphasis on the role of the user: ‘‘a smart grid generates and distributes electricity more effectively, economically, securely and sustainably. It integrates innovative tools and technologies, products and service, from generation, transmission and distribution all the way to consumer appliances and equipment using advanced sensing, communication, and control technologies. It provides customers with greater information and choice, including power export to the network, demand participation and energy efficiency’’.

	Current Grid	Smart Grid
Communications	None or one-way; typically not real-time	Two-way, real-time
Customer interaction	Limited	Extensive
Metering	Electromechanical	Digital (enabling real-time pricing and net metering)
Operation and	Manual equipment checks, maintenance	Remote monitoring, predictive, time-based maintenance
Generation	Centralized	Centralized and distributed
Power flow control	Limited	Comprehensive, automated
Reliability	Prone to failures and cascading outages; essentially reactive	Automated, pro-active protection; prevents outages before they start
Restoration following disturbance	Manual	Self-healing
System topology	Radial; generally one-way power flow	Network; multiple power flow pathways

Figure 1 – Comparison of the current grid and the smart grid Source: Research Report International

Given these definitions and the problems that the electricity utilities are facing I will investigate on how to fill the research gap by using relevant literature and theories widely accepted on the topic in the literature review. First I will introduce the structure of the paper and its delimitation.

[3] www.smartgrids.eu (June, 2013)

1.3 Thesis Structure

I will give an overview on how this paper is composed. First a definition and the current situation of the smart grid are presented. Afterwards I present the limits of this research. In the following chapter I will present the existing literature related to this topic in order to be able to present the research question in order to close the research gap. I will than move to define and use some of the theory that will contribute for the development of this research. Furthermore, a chapter is dedicated to the presentation and explanation of the smart grids: what they are, how they work and what future developments are possible for their development. In the following chapter, the role of the consumer is defined and explained in relation to all the possible interactions with the smart grids and their development. In the following part of the research an analysis is performed to understand if there is a possible answer to the research question raised in this paper. Finally the discussion and the answer to the research questions are intended to clarify the results obtained by this research. The conclusion is finally provided to summarize the research performed and the results obtained in this paper (Fig. 2).

Figure 2 – Thesis structure

1.4 Delimitation

One of the main purposes of this work is to understand the impact of consumer engagement in the development of a more efficient smart grid system. The focus of this study is more on the active involvement of the consumer rather than analyze the current business models adopted in the different markets. This thesis also does not concentrate on the effects and threats of new entrants in the market, which is now easier to enter. I acknowledge that this is one of the concerns of the existing utilities, however this thesis concentrates solely on innovation and co-creation with the consumers on the way to the dominant design and higher consumer engagement. I will also not concentrate on government regulations and the possible impact on the selection of the dominant design.

One of the main problems that came up during the evaluation of the business size and market is that there are large differences between the technological development of the smart grids in Europe and in the United States. Also within the European Union there are large differences in terms of the development and diffusion of the smart grids, and the reason is because the legislation of each single state rather than the current technological development of the smart grid. There is a great interest from the European Union, that each member reaches the same level of development in the energy market. As a result of the strong relevance of this topic, the EU has promoted a climate and energy package, a set of binding legislations for which each member of the union should meet common climate and energy targets. These targets are known as the ”20-20-20” targets. The first goal is the reduction of 20% in greenhouse gas emissions from the 1990 levels; the second goal is to raise the share of EU energy consumption produced from renewable resource to 20%; the last goal is to improve the energy efficiency by 20% in the EU area. However, due to the large differences among the countries the research will take examples from different countries without focusing on a specific one.

A second problem is that the amount of energy consumption per household drastically differs in the two continents, where in the European market an average family uses about 4,000 kWh, while in the United States the consumption per household is around 11,000 kWh.[4] This large difference can create distortion in the evaluation of the engagement of the end user, especially because the consumer habit differs in the two continents more than within the EU.

The choice of making an analysis that is more driven by qualitative information rather than quantitative is due to the fact that this research does not aim to provide business advice to companies or investors in order to understand if a certain business segment is going to be more profitable than another one. The aim is to understand how relevant the consumer engagement for the development of the technology is and if so how to exploit this underestimated added value brought by the consumer.

[4] Europe’s Energy Portal, www.energy.eu (June, 2013)

2 Literature review

This chapter will attempt to ascertain an applied review on the literature of the main theories that I will use for the development of this research that are the Participatory Design theory and the Lead User Innovation theory. Both theories share a common idea over the important role played by the consumer, which is not considered just as the final piece of a supply chain system, where all the business activities are performed in order to satisfy the client's need. In contrast with the most common business practices, the customer plays a central role in the development of the product that they will buy and use. The central role played by the consumer is reflected in the way they will shape the product, thanks to their contribution in defining the main characteristics of the product itself. To a certain extent the Dominant Design theory has drove my attention for the development of this research, since both the current electricity grid and the smart grid are seen as technological designs and the lead-user participation on the design creation might actually affect the replacement of the current dominant design with the new dominant design.

2.1 The origins and development of the participatory design

I will start with a definition of participatory design and then I will present a short history of the literature regarding this theory and a review of the most influential literature to become familiar with the development in this field.

According to Kyng (2010) participatory design is about design and about participation in design by people who are potential users of the result of the design activities. The notion of participatory design was born in Scandinavia under the name 'cooperative design'. After the concept was presented at a conference in the United States, the name was changed into 'participatory design', since it was not a direct cooperation between the managers and the workers. Instead each group was participating in the process, but they were not directly cooperating.

In Scandinavia, research projects on user participation in systems development date back to the 1970s (Bødker, 1996). In recent years, user participation has gained widespread acceptance as a way of gaining knowledge about work, and various roles for user participation have made their way into the textbooks (e.g., Greenbaum & Kyng, 1991; Newman & Lamming, 1995; Preece et al., 1994). The so-called collective resource approach developed strategies and techniques for workers to influence the design and use of computer applications at the workplace; the Norwegian Iron and Metal Workers Union project took a first move from traditional research to working with people, directly changing the role of the union clubs in the project (Ehn & Kyng, 1987).

In the early projects the key issue was building on peoples' own experiences providing resources for them to be able to act in their current situation (Bødker, 1996). In the later Utopia project, these experiences were the starting point, and they certainly provided a perspective that underlay the whole project (Bødker et al., 1987) Yet, when looking back on Utopia, the major practical and theoretical achievements were the experience-based design methods, which were developed through the focus on hands-on experiences and which emphasized the need for technical as well as organizational alternatives (Bødker et al., 1987). Furthermore, the Utopia project demonstrated the potentials and the problems of working with one group of workers (printers and typographers) in a world (of newspapers) where other groups (e.g., journalists) as well as management have significant interests (Bødker, 1996).

The main points from the early projects in Scandinavia are summarized in Table 1. The project that followed the Utopia project was called the AT project, the purpose of the project was to design a number of computer applications for the branch and to develop a long-term strategy for decentralized systems development and maintenance (Bødker, 1996). The main difference and advancement compared to the earlier projects was that the management took part as well as the employees and also that they were dealing with an organization that will live with the technology after the project was over.

	Early projects	Utopia	AT
Purpose	Helping people influence technology in their everyday lives Resources for local action	Helping people influence technology in their everyday lives Possible technical and organizational alternatives	Helping people influence technology in their everyday lives Empowering the organization for local action
Partners	Local unions	Central unions	Managers and workers of the organization
World view	Organizations inherently full of conflicts	Organizations inherently full of conflicts	Organization inherently full of conflicts, which may be used constructively in design Fundamental conflicts cannot be dissolved
Work methods	Traditional design and research Education	Participatory, experience-based Alternatives	Participatory, experience-based Applying and tailoring standard technology 2-level strategy. Microcosm

Table 1: Summary of the early projects in participatory design (Bødker, 1996)

For many years now, research around participatory design has explored various methods and tools that aim at actively involving users in (re-)design processes (Greenbaum and Kyng, 1991, Ehn, 2008 and Björgvinsson et al., 2010). These studies have covered a number of different but related subjects. Participatory design has become increasingly engaged in public spheres and everyday life and is no longer solely concerned with the workplace (Björgvinsson et al., 2010). Over the years up until now, the participatory design research has produced numerous useful results in the form of techniques, methods and conceptual frameworks, e.g. to support users in being creative and innovative in design and in exploring design ideas in relation to future use-practices (Greenbaum and Kyng 1991; Schuler and Namioka 1993).

The participatory design theory is useful to understand how smart grid enables products and services could be designed with the participation of the potential users.

2.1.1 The Dominant Design theory in literature

The notion of a "dominant design" has a substantial history in research on economics, management, strategy and innovation. There were originally two schools of dominant design in its evolution. One school was talking about the development of patterns of innovation, where they took in consideration the technology cycles and innovation types. The authors that represent this school are Utterback, Abernanthy, Clark, Anderson and Tushman. The other school was the path-dependence school and it thought mainly about feedback mechanisms in networks. The main authors are Arthur, David and Gould. These two schools of dominant merged together in 1998. The emphasis was put on how industry networks affected technological change and the choosing of designs and standards under different parts of the patterns of innovation. The main authors are Shapiro and Varian (1999) and Renkopf and Tuschman (1998).

According to Suarez (2005), dominant design has received considerable scholarly attention in organization theory and in industrial organization. It has stimulated a surge in empirical investigation over the past two decades (Murmann and Frenken 2006). The first ones to develop the concept of dominant design were Utterback and Abernathy (1975) and Abernathy (1978) from a study of the automobile industry and since than many writers in the field of organization theory and strategy have found the concept an extremely useful tool for studying the evolution of technological products. Seminal contributions to business strategy such as Porter (1980), Teece (1986), and Anderson and Tushman (1990) also have been influenced by, and have contributed to, theories of dominant design. Scholars who have empirically worked with the dominant design concept share a general view that technological change has a powerful and to some extant autonomous causal impact on the development of industries and firms (Murmann and Frenken 2006). Dominant designs are interesting to both scholars and managers, because they signal a change in the nature of the game, with attendant winners and losers (Suarez, 2005).

The definition of dominant design differs from scholar to scholar. The most widely accepted definition comes from Anderson and Tushman (1981) who define dominant design as “a single architecture that becomes widely accepted as the industry standard”.

The smart grid system is still in its early stage of life, so a dominant design did not arise yet. The development of smart grid enabled services and products will define some aspects of the smart grid structure. Is therefore possible that the development of smart grid enabled services and products in participation with the consumer will contribute in the definition of the dominant design of the smart grids.

2.2 Lead User Innovation

Schumpeter (1939) defines innovation as the introduction of new goods (…), new methods of production (…), the opening of new markets (…), the conquest of new sources of supply (…) and the carrying out of a new organization of any industry” Schumpeter was one of the first economist that took into consideration innovation and provided some theories regarding innovation management. He argued that innovation was essential to create economic changes and that led companies to acquire a temporary monopoly until when other firms were able to imitate and reproduce the new products or processes.

Lead-user theory was originally proposed as a way to selectively identify commercially attractive innovations developed by users (von Hippel, 1986). Von Hippels’ views on user-driven innovation belong to the most influential ones and he summarizes his views of the notion of lead-user innovation and democracy in his book ’Democratizing Innovation’. He argues that users who already face needs today that the rest of the market will only experience in the future (being ahead of an important trend in a market place under study) and expect relatively high benefits from a solution that addresses their advanced needs (expecting high benefit from an innovation) are likely to come up with particularly attractive innovations (von Hippel 1986, 2006). His theory and the functionality it offers is still being supported by empirical studies today. A research conducted by Urban and von Hippel (1988) found that 82 percent of the lead-user cluster in their sample had developed their own version of or had modified the specific type of industrial product they studied, whereas only 1 percent of the non-lead users had done this. Thus, Urban and von

Hippel (1988) found that an industrial software product concept developed by lead users had greater marketplace appeal than did concepts developed by conventional marketing research methods. Two studies, which quantitatively compared the results of lead-user idea generation with the results of traditional voice of the customer studies that focus on target market customers, found that the ideas generated by a process using inputs from lead users have much higher commercial attractiveness (Urban and von Hippel, 1988; Lilien et al., 2002).

The most current and rigorous evidence for supporting the lead user theory is empirically provided by Franke et al. (2006). In their research they analyzed the two lead user characteristics, (1) being at the leading edge of an important market trend and (2) high expected benefit from an innovation, in the field of kite surfing using continuous multi-item scales. They discovered that a high intensity of lead user characteristics has a significantly positive impact on the likelihood of generating commercially appealing user innovations. They have continued on the basis built by the research of Eric von Hippel (1986), who defined lead users as users of a given product or service type that combine two characteristics: (1) They expect attractive innovation-related benefits from a solution to their needs and so are motivated to innovate, and (2) they experience needs for a given innovation earlier than the majority of the target market. This concept is shown in the Figure 3.

Lead users "live in the future" relative to representative target-market users, experiencing today what representative users will experience months or years later (Lilien, et al., 2002).

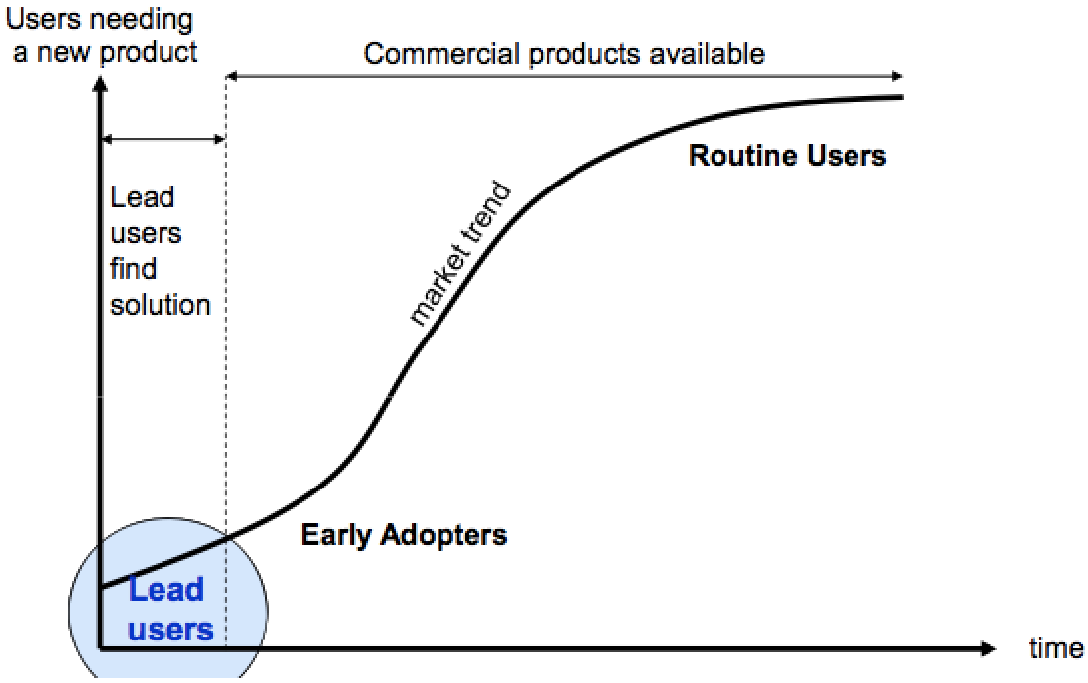

Figure 3 The lead user/market trend. Source: von Hippel/Thomke/Sonnack 1999

The lead-user theory can be used to study the possible co-creation with the leading segment of the consumers in the innovation process.

2.2.1 Co-Creation of Value

In open innovation model, as revised by Pralahad and Ramaswamy (2000), who point out major challenges that have emerged in the new business environment. One such challenge is that a company product-centric view is being replaced by the "co-creation" of value (Pralahad and Krishnan 2008). The term has been introduced by Prahalad and Ramaswamy (2000) to explain the new role covered by the customers, once isolated from the definition of the product that they were purchasing and now placed in the central part of the designing process of it. As this has been already experienced in other industries, for the smart grid, the time of placing the customer as a central part of the designing is most likely about to happen, since the barrier for development is lack of consumer engagement.

The customer has turned from being the passive center of interest, for which the company has developed the product in order to cope with the lack of a certain need of the customer, to an active actor in the development of the product. Starting from this central position the customer is considered as a part of the research process of the company, not as the result of the research process. This collaboration is used by the company to become more competitive in the market and to reach a leading position compared to the competitors. This competitive edge is acquired by the company through the process of co-creation with the customer (Prahalad and Ramaswamy, 2004).

Moreover the companies are starting to realize that the innovation process with the customer becomes for the base for the exchange of knowledge inside and outside the company, through a collaborative relation not only with the end-user, but also with all the other stakeholders of the company, such as suppliers, competitors, workers and other (often referred to as customer co-creation) (Piller et al., 2012). Managers and researchers have for a long time largely ignored the consumer, the agent that is most dramatically transforming the industrial system, as we know it. Thanks fundamentally to the internet, consumers have been increasingly engaging themselves in an active and explicit dialogue with manufacturers of products and services. The dialogue is not controlled by corporations and this leads to the opportunity to exploit this communication advantage in favor of the companies (Prahalad & Ramaswamy, 2004). Products can now be shaped more according to the taste and preferences of the consumers that meanwhile provide directions to producers on how they want their product. This is changing the dynamics of the marketplace, switching the product design from a firm driven output to a client based input. We can see this trend happening in other industries and it is just a matter of time when it reaches the electricity industry, this is why utilities should act before it is too late and new entrants will be faster.

Some industries have already gone further than others in drawing on competencies of customers (Prahalad & Ramaswamy, 2004). This is common especially in the software industry, where a demo (often called beta) version of the product is released to the public in order to test its functionality. At the same time, users provide feedback to the company regarding eventual function problems and they also brought improvements to the software itself by changing the structure. Additionally this process led customers to jointly work on the product by co-developing some parts of the coding structure of the program.

A further step in the development of the co-creation process is the possibility for clients to solve other client's problems. This is possible when there is a common platform where the exchange of information and process is available between two parts. But the idea of the customer as a source of knowledge for the development of the product is starting to be accepted also in fields that are far away from the IT sector, such as the health care industry. The vision of having a common platform and exchanging energy in the 'energy internet', is one of the visions of the future smart grid.

One of the major challenges in the future for the companies is to wisely select the relevant information and competences that can be brought by the customers. The unclear collection of information from the consumers could result in a huge loss of clearness. In order to avoid this situation, companies should engage their customer in an active, explicit and ongoing dialogue, they have to mobilize communities of customers, they have to manage customer diversity and they have to co-create personalized experience with customers (Prahalad & Ramaswamy, 2004).

There are several mistakes that the companies could make in the process of co-creation with their customers, one of these mistakes is to think that all the customers could bring an added value in the co-creation process. Not all the customers are alike, and their differences have also different impacts on their capacity to collaborate with the company. At the core of collaboration between the customer and the firm there is the co-creation, but companies should be aware of the fact that customers are not just customizing; they're collaborating with the firm to create unique value (Schrage, 1995). Companies are often seeking standards and common patterns within their customers, in order to create more tailored marketing campaign.

2.3 Research Question

The lack of consumer involvement is considered the biggest barrier for value creation of the utility companies in smart grid development. One of the main reasons why consumers are not involved is that in the 'old grid' there is no interaction with the end user. The user is a passive recipient of energy. However, with the smart grid this is about to change. The users will also become producers of energy; there will be more and more new entrants to the smart grid market that will be competing with the existing energy utilities. This led my attention to the possibilities of overcoming the barrier of lacking consumer involvement through co-creating with the end users and bringing more value to the utility companies. Based on the proposed literature and a clear need of for consumer engagement in the electricity industry, I will in my research answer the following question:

Can electricity utilities overcome the barrier of lacking consumer engagement by co-creating the dominant design for the smart grid enabled products and services with the consumer?

In order to answer this research question I did a meta-analysis of different studies mainly in the fields of participatory design and lead-user innovation, but also other related research that will be helpful in answering this question. I will identify possible patterns among the study results in order to find the answer my research question.

In the following chapter I will select the most important theories that will be useful for the development of the analysis.

3 Theoretical Point of Departure

This chapter presents the theories and the theoretical approaches that will be used for this research. The purpose is to provide a framework for this thesis, which will be used in the analysis and discussion.

I will start with a more analytical approach of the notion of participatory design and its contribution to dominant design and then move on to lead users and their role in innovation, value co-creation and finally to the overall impact of these theories on consumer engagement.

First I will present the general idea behind the participatory design by reviewing the works of the main authors in the field. Then I will present elements of the selected works, in order to provide a more in-depth understanding of the relation between the development of the smart grids and the engagement of the consumers. Lastly, I will take a closer look at the lead user innovation, to see how this method fits into the picture of participatory design on the way to bringing the dominant design for the electricity industry and having more engaged consumers.

This thesis is based on the belief that today's electricity industry needs more consumers engaged with the smart grid enabled services in order to create more value for the utilities and to overcome the obstacle of un-locking the current dominant design of a fixed price electric grid towards implementing a smart grid with flexible prices. However, the first big step that the industry and governments should take in order to have more active users is to change the communication system adopted with the end-user. The reason of this need has to be found in the deep change that the smart grid system is bringing into the life of all the consumers.

In recent years the electricity industry is in the process of switching from a one-way system, in which the consumer was the final link of the long production-distribution chain, to a two-way system where the consumer can actively take part in the production-distribution chain. The first electric system all over the world was built on a one-way system, (as shown in Fig. 4) that did not allow the end-user to provide any feedback on the service.

Figure 4- One way energy creation and distribution system – Own creation

In the early stages of the development of the electric system in Europe, the users were not very much engaged from the electric companies to provide feedback on the services. This is also due to the fact that the energy prices were much lower compared to present days. The distribution of electricity in private households and industries and the diffusion of the home appliances grew steadily from 1930. The price of electricity was lower compared to present days however less importance was also given about environmental issues.

Today smart grids have introduced a revolution in the electric generation and distribution system. The traditional grid was based on a hierarchical tree-like structure, where the power plant was on top of the pyramid and the distribution of energy was than supplied to consumers. (Fig.5)

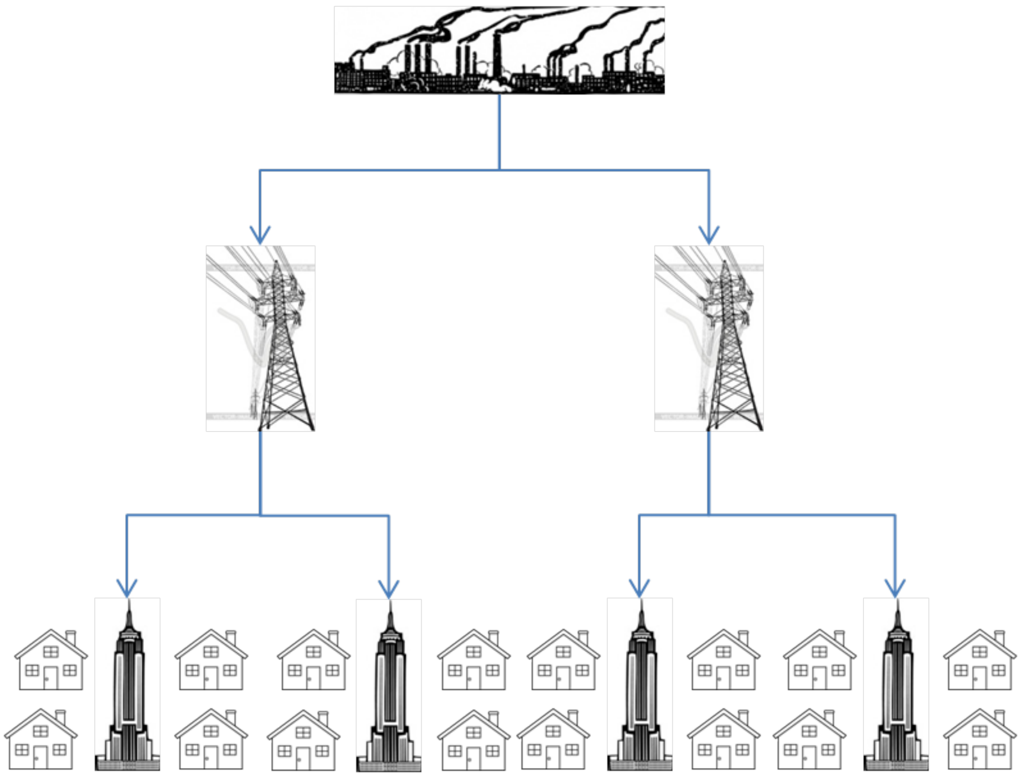

Figure 5 - Traditional electricity grid – Own creation

The traditional system is based on the high-voltage transmission network that carries electricity to the end user across long distances. The power station, where the energy is produced, is usually positioned far away from the end-user. The transmission line brings the energy to a distribution substation where the energy is finally delivered to the consumers through distribution lines. One of the biggest problems, in terms of energy consumption, is that the traditional system cannot rapidly adapt to a change in request and generation of energy that is therefore usually kept at peak demand level thus wasting all the energy that is not used but still provided to the line.

The smart grid system, shown in Fig. 6, has been conceived with a more efficient scheme that allows energy producers to optimize the energy generation and distribution while at the same time keeping operational efficiency. One of the main developments in the technology is that the energy is stored during off peak time, thus reducing or even erasing completely the waste of extra energy provided in the line during peak time but not used. Other relevant aspects of the smart grids are the capacity of the system to anticipate and respond to disturbance in the grid in a self-healing manner and the ability to operate resiliently against physical or technical damages. From the economic point of view this new system gives the opportunity to introduce new products and services in the market and finally it enables the active participation of the consumers.

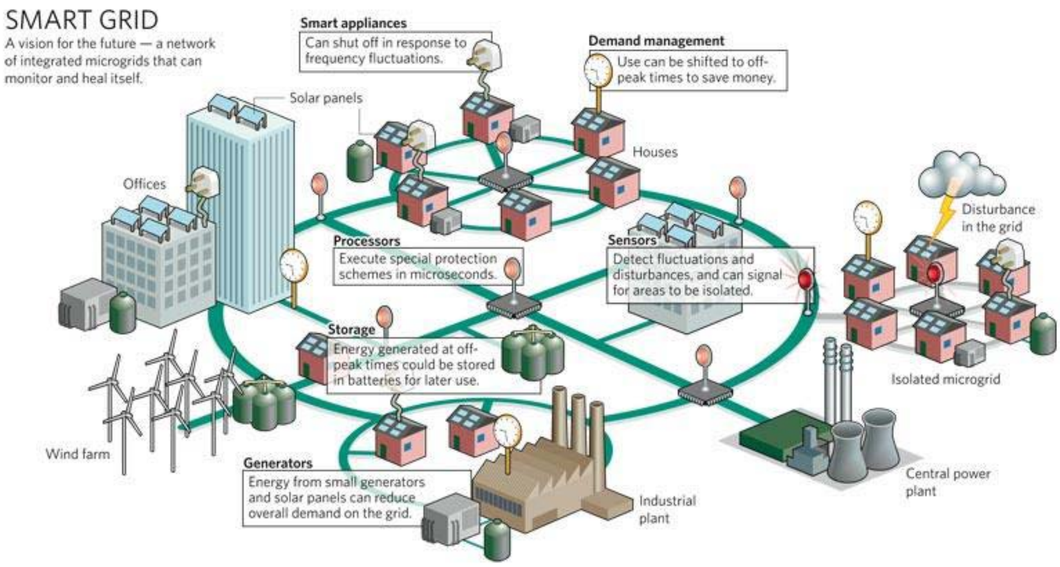

Fig. 6 - Smart grid – Source: http://futurepredictions.com/wp-content/uploads/2011/02/smartgrid.jpg

Since the smart grids allows the consumers to be part of the system, it is important to understand how they can be actively engaged in the definition of its major development in the following years. The dominant design theory and the participatory design theory will be therefore presented and used to create the theoretical background from which the research question will be answered.

3.1 The Participatory Design

The participatory design approach (Schuler and Namioka, 1993) seeks to involve users more deeply in the process as co-designers by empowering them to propose and generate design alternatives themselves. Participatory design supports diverse ways of thinking, planning, and acting by making work, technologies, and social institutions more responsive to human needs. It requires the social inclusion and active participation of the users. Participatory design has focused on system development at design time by bringing developers and users together to envision the contexts of use. But despite the best efforts at design time, systems need to be evolvable to fit new needs, account for changing tasks, deal with subjects and concepts that increasingly blur professional and private life, coup with the socio-technological environment in which they are embedded, and incorporate new technologies (Henderson and Kyng, 1991). To emphasize the cooperation between designers and users Henderson and Kyng (1991) use the term "mutual learning", which implies designers learning about the application area and users learn about new technological possibilities and it encompasses the development and learning of new ways of cooperating that may be required of users and designers.

The user participation has been recognized as a way of gaining more knowledge about work and improving the quality of the computer application to be designed (Bødker, 1996). Generally the majority of the users have little or even no knowledge at all regarding the electricity market. That is why I will direct the attention of my research towards lead-users, who are experts in the field and ahead of the majority of the users. The whole energy industry for several decades has evolved keeping the user far away from the participation in its creation. As a result the majority of the consumers know little about the production and development of the electric system.

On the other hand, the consumer did not have any relevant reason to acquire knowledge on the service, given also the low price paid to use it and the low attention that was given on the ecological impact of the electric industry. In recent years the communication gap between producer and user has been slowly decreasing, especially thanks to the introduction of simple forms of creation of energy by the consumer. This aspect is definitely of great importance to better explain the role that the consumer plays in the creation of value in the grid.

3.1.1 The Dominant Design

At the heart of dominant design thinking lays the empirical observation that technology evolves by trial and error and thus entails risks for the population of firms engaged in its development. When a new product class appears, it is very unclear what kind of inherent potential the technology possesses and what kind of needs its anticipated users will have (Murmann and Frenken 2006). The only way to reduce the uncertainty about technological potential and user needs is to create different designs and receive feedbacks from users (Pinch and Bijker, 1984), on occasion by actively involving users in the product design process (Thomke and Hippel, 2002).

The definition of dominant design differs from scholar to scholar, I chose the one from Anderson and Tushman (1990), that define dominant design as a single architecture that becomes widely accepted as the industry standard.

Teece (1986) states that one must be careful to let the basic design “float” until sufficient evidence has accumulated that a design has been delivered which is likely to become a market standard. A dominant design space appears when a standard is agreed upon, and such a standard is often not in place before the industry has experienced trial and error (Teece, 1986).

One of the first ideas that arises after reading the definition of the dominant design theory, is that the technological determinism of the design, (inferred from architecture used in the definition of Anderson and Tushman) is the most important and relevant aspect for its creation. This fact is partially true and also commonly confirmed among the examples that we can observe in various industries, like the car industry with the definitions of the shape of the car that we use today, or the standardization of the graphical user interface (GUI) operating system in most of the computers. However, the technological aspect of the dominant design can partially explain the definition of the standard. What is presumably equally important is the contribution of the end user in the definition of the standard and this aspect will be consequently more investigated with the use of the participatory design theory. The “War of Currents”[5] in the 1880 defined the dominant design of the current electric power distribution. The main purpose of the war was to find the most efficient way to transfer the mechanic energy from two distant places. A major role back then was played by the engine used to transform the electricity. The result was that the alternative current (AC) was found to be more efficient and economic way to deliver energy. This achievement was driven by the technological determinism of the AC, but the same result might not necessarily be obtained in the case of the smart grid, where the social aspect of its development can keep a central role.

Baldwin et al. (2006) show that innovative users and user communities often affect the future organization of an industry and give rise to a dominant design. Theories of dominant design have been criticized, however, as often lacking a clear causal logic explaining the role of dominant designs in industry evolution (Murmann and Frenken, 2006). They have also been criticized of under-emphasizing the role of demand in industry evolution in favor of engineering imperatives on the supply-side (Klepper, 1997). Is therefore of great importance to clearly identify the role played by the participatory design in the definition of the dominant design, since the results of this research are intended to clarify the important role played by both theories in the development of the smart grid system, rather than arbitrarily choose which theory is more able to explain a certain results.

3.2 Lead User Innovation

The concept was first introduced by Eric Von Hippel, arguing that a need is generated in the market by the users before most of the attention gets into it and consequently the marketplace satisfies it. Moreover the lead users tend to benefit in a significant way by obtaining the solution to their needs. As a result the users, of a

[5] Even if it was not a real war the term has been commonly accepted to refer to the definition of the standard electric power transmission.

certain service or good that is still underdeveloped and mostly unknown in the market, receives great benefits when the lead users find a solution to their needs. The result can be obtained by a single individual or from a group of people, generally with expertise in different fields.

In many industries technological innovation is now the most important driver of competitive success (Schilling, 2010). Innovation often originates with those who create solutions for their own needs. Users often have both a deep understanding of their unmet needs and the incentive to find ways to fulfill them (Hippel, 2001). However, most innovative ideas do not become successful products (Schilling, 2010). Even if the product is the result of an innovative idea that results from a user innovative process. The aggregate impact of technological innovation can be observed by looking at gross domestic product (GDP) (Schilling, 2010). It is therefore possible to observe different development in terms of technological development, according to the level of the GDP. In a series of studies of economic growth conducted at the National Bureau of Economic Research, economists showed that the historic rate of economic growth in GDP could not be accounted for entirely by growth in labor and capital inputs (Schilling, 2010). In few words the lead user faces the need that the rest of the market will face in the future.

How can this theory be helpful in explaining the possible definition of a dominant design for the smart grids? The lead user has usually an expertise on the field. The problem is solved through the use of experience and it therefore reveals an important part on the market that has been unexplored. Lead users generally also expect high benefits from their innovation, but at the same time they are conscious of the social impact that they can produce.

The smart grids are still in what we can define as an early stage of the market. Most of the curtail aspects of the development has to come from the end-user, especially in terms of communication and feedback that he can provide to the grid. Some energetic producers and suppliers have introduced the electric smart meter (ESM), as a first attempt to create an extended network to connect with the smart grids system. The ESM is able to provide real-time information to the user, such as the instant energy consumption, which tariff is used in that specific time frame and moreover is able to tell the amount of energy that the consumer sells back the grid, whereas the consumer is able to produce energy through solar panels, wind mills and other ways. The result of this new device is a greater involvement of the consumer into the smart grid system, especially for those consumers that introduce energy into the grid, since they can experience an economically positive return.

3.2.1 User Innovation Improves Manufacturers' Success Rates

It is striking that most new products developed and introduced to the market by manufacturers are commercial failures. Mansfield and Wagner (1975) found the overall probability of success for new industrial products to be only 27 percent. Elrod and Kelman (1987) found an overall probability of success of 26 percent for consumer products. Balachandra and Friar (1997), Poolton and Barclay (1998), and Redmond (1995) found similarly high failure rates in new products commercialized. Although there is clearly some recycling of knowledge from failed projects to successful ones, much of the investment in product development is highly specific.

This high failure rate therefore represents a huge inefficiency in the conversion of R&D investment to useful output, and a corresponding reduction in social welfare. Research indicates that the major reason for the commercial failure of manufacturer-developed products is poor understanding of users' needs by manufacturer-innovators. Maidique and Zirger (1990) report close contact with leading customers as one factor that influences outcome positively. Alam (2006) argues that: "customer interaction in new services development has a positive impact on the performance of new services". There are many motives for customer integration service innovation process. First, what makes it difficult to understand customer needs is the sticky and difficult to transfer information that the customer and their context possess (von Hippel, 2001). Customer engagement means an opportunity to learn from, with and about individual consumers.

Market oriented companies have mainly focused on satisfying the expressed needs of the customer, typically by using verbal techniques such as focus groups and customer surveys to gain understanding of the use of current products and services (Slater and Narver, 1995). It has been claimed that the result has been minor improvements rather than innovative thinking and breakthrough products or services, but few empirical studies support this opinion. Customer engagement has to be seen from the company not as a mere reference to understand the quality of the service or product delivered, but it has to be used more as a tool to develop a stronger connection with the customer. This stronger relationship can put the basis for the development of the innovation brought by the end-user. Companies should see the lead user innovation as an opportunity rather than a threat since new markets can develop in close related fields.

3.2.2 The Democratization of the Lead-User method

As the technology advances, innovation affects every part of our life, from the business activities to most of the social aspects of our lives. This continuous involvement of the individuals in every aspect of the life, from science to sport and even religious movements, has moved our society towards life standards. Few individuals in developed countries could live without mobile phones, internet, tap water and electricity. As long as someone wants to be integrated in the society all these technological developments are accepted without particular limitations from the users. The technological progress has also been the cause of the productivity increases in the US in the first half of the past century, has demonstrated by the Nobel-prize winner economist Robert Solow (1957). While there are several models that explain the innovation process I would like to highlight the important social aspect that the technological development has.

The main differentiation among the types of innovations is between the radical and incremental innovation. Radical innovation refers to the "development or application of significantly new technologies or ideas into markets that are either nonexistent or require dramatic behavior changes to existing markets" (McDermott and O'Connor, 2002). While users have generally been considered to only generate incremental innovations as their familiarity with existing products often limits them from thinking 'outside the box', (Lettl et al., 2006) demonstrates that users can also play an essential role in the development of radical innovations.

For several decades a common believe was that technological development comes entirely from R&D, especially in all those cases where companies put together the most advanced technologies available in the market in order to create innovation in either the product or the production system. This idea is more connected to the Industrial Revolution era, where little importance was given to the consumer. Today the interaction between companies, their products and the consumers have led to a revolution in the relationship system between firms and consumers, especially in the high tech companies, as we will later see in this research. In order to explain this change in the innovation system, Eric von Hippel has coined the term of a user-dominant innovation and customer- active paradigm, against the common idea of the manufacturer-dominated innovation. In von Hippels' idea, the consumer is not just a passive actor in the production process, instead is seen as an active part of the process.

The innovation diffusion literature calls this process "re-invention": "the degree to which an innovation is changed or modified by a user in the process of its adoption and implementation" (Rogers, 1978). So the user-innovation involves users developing a solution to their currently unmet need, creating a product on that basis and diffusing the results (von Hippel, 1976). Re-invention will also be referred to as successful tinkering, experimentation or modification of a product. However, the definition of the whether an innovation is generated by a user or a manufacturer may thus frequently be a difficult one involving subjective judgments. As shown on the Figure 6 there are several phases to follow for the development of the lead-user process. Most of the customers involved in surveys appear to be unable to free themselves from the product that they are currently using.

Companies cannot get relevant information over the future development of the market from the surveys, given this strong tie that the customer has with the present product. In order to cope with this problem and to move forward with the development of a new product, the lead-user innovation can help the companies to identify the new trends and idea that can be therefore applied to future products.

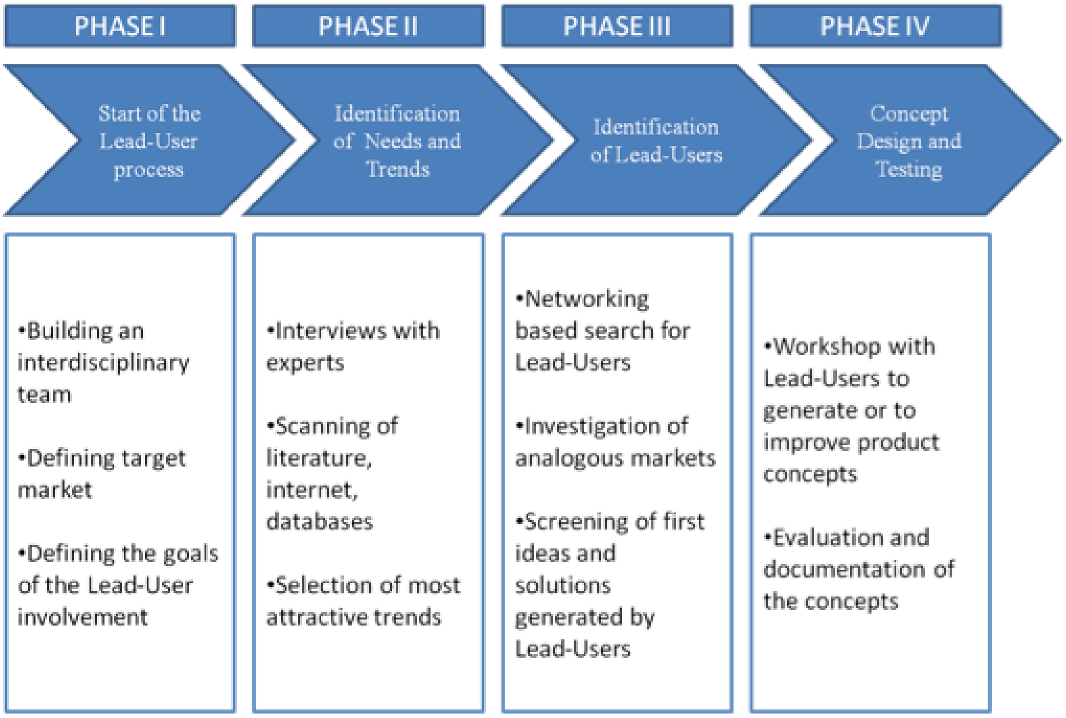

Figure 6: The process of lead-user method (Herstatt1991, Lüthje and Herstatt 2004)

After the definition of the market target, a company should define the goals on what the lead-user should do. It is a common practice that firms build an interdisciplinary team on the topic, since it is very important to get as many different ideas from the team members as possible. The diversity helps also to develop a more critical reasoning and to "think outside the box". After the target and the goals are defined, the company should identify a team of experts to clarify the current needs and trends of the consumers. This involves several activities such as scanning the literature on previous research and topics, search on internet and databases on trends and therefore select those attractive trends. The third step of the process includes an important phase of networking, where the lead-user should be found, in order to investigate what are the possible outcomes of the research and which ones are the current market trends. Finally the lead-user should be able to generate ideas and solutions for the current market need. In the final phase of concept design and testing, the products are shaped or improved with the help of the lead-user and is therefore made an evaluation and documentation of the concepts.

The result of this process should bring the company to the creation of the new product or service to deliver in the market. The product should not be necessarily a completely new product; it could be also an innovation of a previous version that is already in the market.

Since the introduction of von Hippels' theory of the user-innovation, the interest on this topic has increased among various fields and countries. Denmark itself is considered one of the leading research centers in the world on this field. The outlooks for the future are very optimistic and the constant intervention of the users gives an important added value to the growing trend of users dealing with innovative practices and products.

Eric von Hippel (2005) argues that the world is moving towards the idea that innovation is being "democratized and that users of products and services- both firms and individual consumers- are increasingly able to innovate for themselves". This path could therefore lead in the future to what we could call the "Democratization of the Innovation"? There is a severe lack of empirical foundation in this assertion; however future development on the field will surely cover part of the question raised by the scholars and professors.

3.3 Impact on Consumer Engagement

Consumers are increasingly seeking engagement in active dialogue with manufacturers of products and services (Prahalad and Ramaswamy 2000). The only way to reduce the uncertainty about technological potential and user needs is to create different designs and receive feedbacks from users (Pinch and Bijker, 1984), on occasion by actively involving users in the product design process (Thomke and Hippel, 2002). Prahald and Ramaswamy introduced the term co-creation in 2000, and later discussed the firm's co-creation process with costumers, arguing that they went from being isolated to connected, from unaware to informed and from passive to active (Prahald and Ramaswamy, 2004).

The authors build a bridge between the concept of innovation and the concept of value, suggesting that the use of interaction as a locus for co-creating value/innovation is at the crux of our emerging reality (Prahald and Ramaswamy, 2004). The customer or user is in a focal position in this perspective and there are two main strings of research forming the field of co-creation at the moment: the strategic use of co-creation with customers to gain competitive edge, which is the value co-creation process/experience (Prahald and Ramaswamy, 2004), and the ‘innovation‘ approach emphasizing co-creation as collaborative innovation based on inflows and outflows of knowledge between complementary partners, which could be users, suppliers, competitors, etc. (often referred to as customer co-creation; Piller et al. 2012).

This thesis aims to push the boundaries of innovation to accompany the changing environment in the electricity industry in which utilities have to maneuver and survive. It is suggested that the concept of co-creation allows exactly that. Innovation is a value creating process, and it has also become a widely distributed process; co-creation is a strategic choice through which a firm, or several firms, creates value with available and interested actors (Prahald and Ramaswamy, 2003; 2004). This perspective will be applied to accommodate the remaining theoretic framework, in an attempt to emphasize interaction and end user engagement as the locus of innovation. Co-creation is about involving consumers as active participants in the product development and value creation process, primarily to help firms reduce the fuzziness of the front end of innovation (Constantinides, 2011).

4 Smart Grid infrastructure and development

In this chapter I will briefly summarize what is a smart grid infrastructure and how it works. I will therefore discuss the composition of the software infrastructure of the smart grid, followed by the description of the categories of products and services in the smart grid energy system. After I will take a look over the important role played by the stakeholders and the consumer for the development of the grid. Finally I will discuss how the smart meter helps the utilities companies in engaging the consumer.

4.1 What is a Smart Grid?

The smart grid is often referred to as an "energy internet" because it is a decentralized system that turns the electric power infrastructure into a two-way network. The smart grid system allows utilities and customers to share information in real time so they can more effectively manage electricity use.

Most existing electricity transmission and distribution systems in the world were put in place 30-50 years ago. They organize one-way distribution of electricity from large central generation plants to the end users. However, the old grids suffer from significant losses of electricity in transmission and distribution. There is also an important inefficiency related to peak demand. Demand varies, but capacity and generation are normally kept at peak demand level, leaving large amounts of electricity unused. Moreover, the addition of highly intermittent electricity from renewable sources to the current grid presents important challenges for the management of the grid and the quality of electricity it delivers. The smart grid is able to balance out supply and demand over a region and it uses advanced types of control and management technologies to efficiently distribute power and connect decentralized renewable. (The Global Cleantech Report, 2012)

We can summarize the smart grid value chain in eight functional main categories:

- **Integration of renewable:** solar panels, wind farms and energy storage stations are connected to the grid in addition to the standards forms of energy production. Some forms of energy produced in a renewable way should be transformed in order to be implemented into the grid, converting them from direct current (DC) to alternative current (AC). To connect the grid to an energy storage device the device which is necessary to accommodate the variable nature of renewable energy, the storage device itself is required along with converters and traditional field equipment associated with conventional power.

- **Automation and control:** an intelligent system is added to the grid in order to better monitoring and control the voltage. The improvements have the potential to improve the overall system efficiency, making the electricity grid more reliable and saving energy.

- **Demand response:** is a service model in which a pool of capacity to reduce peak power loads is created in order to limit the service provided. This service is delivered by one or several firms that aggregate the demand of the customers and supply the energy in the grid. These companies become the only contact with the utility service company.

- **Electric vehicles and Vehicle to grid (V2G):** they rely on energy storage present in the grid. The cars are attached to charging station and accumulate energy in batteries**.** The charging stations work both ways in downloading energy to the car and uploading from the batteries, managing the electricity demand in peak hours.

- **Home energy management / Home area network (HEM/HAN):** the HEM system includes smart appliances and displays that allow customers to monitor and manage their energy use and remote capability from any location outside home.

- **Commercial and Industrial Building Energy Management:** integrated building automation systems use networked sensors and monitors and incorporate data from individual systems such as lighting and heating, ventilation and air conditioning (HVAC).
- **Distributed Generation:** accommodating small-scale, distributed power sources e.g. rooftop solar requires different capabilities from those for grid-scale renewable energy sources. A key technology for small-scale solar is micro inverters.

- **Advanced Metering Infrastructure (AMI):** the foundation of the smart grid's two-way flow of data and is the underlying infrastructure that combines smart meters, communications and data management. The one-way version of these smart meters is called advanced meter readers (AMR). These meters automatically collect consumption, diagnostic and status data from water meter or energy metering devices and transfers that data to a central database for billing, troubleshooting and analyzing. The AMR technology mainly saves utility providers the expense of periodic trips to each physical location to manually read meters. (The Global Cleantech Report, 2012)

As we can see, several instruments and services compose the smart grids. Some of them are more able to increase the communication between the utility company and the consumers, such as the HEM system and the AMI, while others cover a more technical role and no space for customer interaction exists. However, barriers are mainly present in the number of activities that the user can perform on the grid and in the amount of parts of the chain that the consumer can access.

I will further investigate the importance of the AMI and how this instrument can increase the role of the consumer in the development of the smart grid enabled product and services and what are the possible drawbacks of this instrument.

4.2 Software infrastructure and smart grid applications

Just as a computer is useless without its operating system software and software applications, smart grid capital investment can deliver little of the desired benefits without the necessary accompanying information technology (IT) systems. And just as with computer, the IT system includes both software platforms – analogous to the PC's operating system and software applications. Smart grid software platforms are the underlying elements that support applications. (King and Strapp, 2012).

The presence of a software platform for the development of the smart grid software development is fundamental. The reason has to be found on the management of the whole infrastructure, in order to make possible a constant transmission of information from to the grid to the consumer and the other way around. The platform is therefore needed within the utility back office to link individual applications with smart grid communications networks. This allows multiple applications to use the same network, such as having the billing system receive outage alarms from the same meters and over the same smart meter application network. (King and Strapp, 2012).

On the application side, a set of products have already drawn the attention of the major players in the field. According to a McKinsey study on smart grid, most of the attention of the consumer, the next wave of smart grid application will be seen especially in the future development of the integration between the distribution automation (DA), the AMI and the distributed generations. Users eventually will not build their own AMI or DA networks. The products and the markets, both for AMI and DA, are still under construction, so it’s not clear yet which path they will follow and how they will develop, however there is the chance that the networking of the system will characterize the next big step in the evolution of the smart grid applications.

Most of the capital investments that utilities companies can make are associated with the IT infrastructure. The infrastructure should be invented in a way that allows the integration of the smart grid with the applications. A basic application is the Meter Data Management functionalities (MDM) that is used for the bills generations from the utility companies. Another application is the Dynamic Pricing Rates that allow the consumer to change the type of rate according to its required need. The rates become flexible as the user changes his consumes of electricity. As a result the greater active involvement of the consumer can lead to a reduction in the bill that changes from a fixed rate system to a flexible rate system. A further application is the Net Metering a method of simplifying the measurement of energy produced by a renewable or distributed energy generator when it is connected to an electronic utility distribution system. As with dynamic price, net metering introduces new functionality requirements for utility IT systems to calculate bills and credits. The terms of utility tariffs typically require a customer to pay the monthly customer charge, regardless of the net energy used. However for energy billed, the customer only pays for energy that is used, netted against any generation produced by the customer. (King and Strapp, 2012).

4.3 Categories of products and services in the smart grid system

As previously described there are several household energy consumption and production products and services in the market. Most of these products are a combination of technology and end-user behavior. In a smart grid in which end-users are expected to play a more active role in the management of the electric power system, products and services would have to support end-users in their role as co-providers. Over the past years, several projects have been initiated that deploy smart grid products and services in households with the aim to enable households to take part in the management of the electric power grid.

The following categories of smart grid products and services can currently be discerned from the end-user perspective. We can divide the products into different categories and on the research conducted by Geelen, Reinders and Keyson, these categories of products and services are identified:

- **Micro-generators:** allows household to produce their own electricity. The most known types are the photovoltaic solar panels, the micro-cogeneration units and the small wind turbines. In order to reach the maximum utility for the consumer the production phase should coincide with the consume phase. All the extra energy produced can be transferred to the grid.

- **Energy storage systems:** enable households to use energy at different time compared to when the energy was initially produced. The storage method could differ in the form, varying from batteries to storage heaters. The greatest advantage is during the peaks of the demand, when the energy stored is released and used by the household without incurring in extra costs.

- **Smart appliances:** are appliances that can be programmed and that communicate with the energy management system about the appropriate hours to operate. All the goods such as dishwasher, washing machine refrigerators and others are included in this category.

- **Smart meters:** is the digital electricity meter that measure consumption and production of electricity and it communicate with the supplier. The smart ability is that is able to communicate the data it measures to the user and to the utilities company.

- **Dynamic pricing and contracting:** is a service that allows the user to change its cost of electricity by switching to a different plan and paying for the energy provision at the time they ask for it.

- **Energy monitoring and control systems:** are the one with least interaction with the end-users. They are mainly intermediary devices that facilitate the interaction between the end-users and the system.

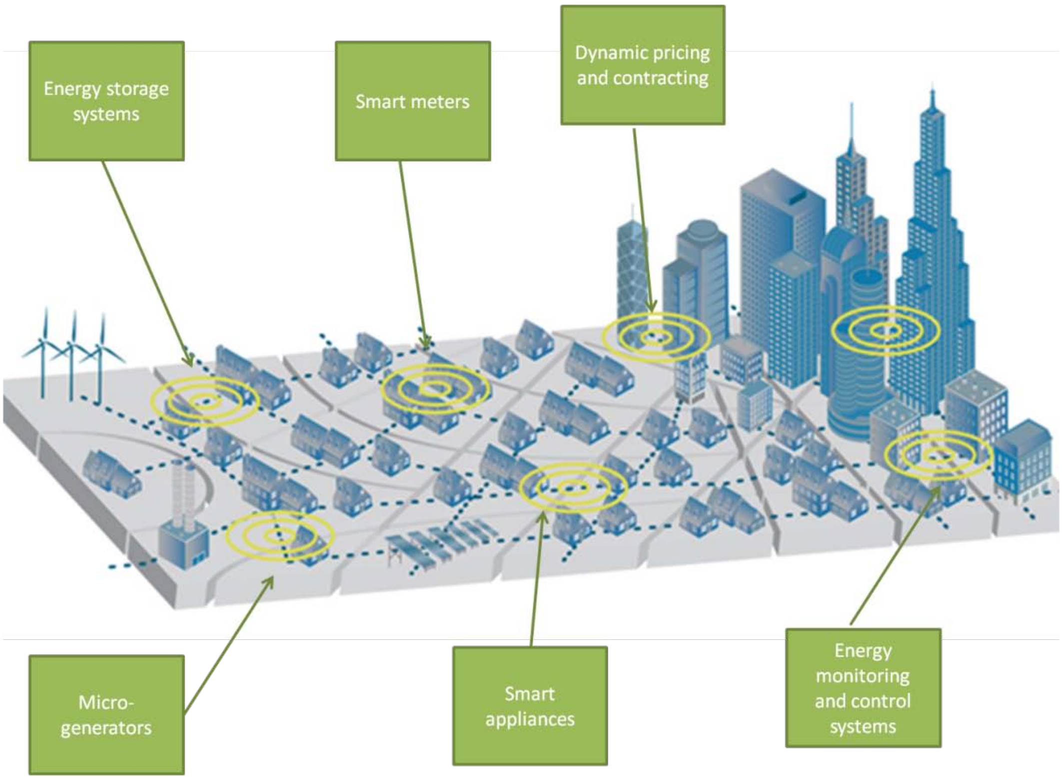

Figure 7: Smart grid infrastructure and development: own creation based on Geelen,Reinders and Keyson table.

In the Figure 7 the products are summarized and divided into categories. Some of them, such as the meter data management, the dynamic pricing rates and the net metering have been briefly described in the previous paragraph. What is important to note is that there are some element in the smart energy system that cannot possibly work separately from other parts. There are some core technologies, generally the physical's one, that cannot work without other subsidiaries technologies, such as the services. Combined together these technologies, allows the smart grid system to fully operate, while all the other services, such as the dynamic pricing rates can further develop the system in which they operate.

There is not much available research on the effects on end-user behavior in the context of co-provision. The available researches focus on specific aspects of the system rather than the system as a whole. It is clearly recognized the need to investigate on other aspects on products and services, especially in relation with the social impact that the involvement of the users in the production of energy and services in the grid.

4.4 Smart Grid opportunities for solutions providers

According to the report conducted by McKinsey (2010), the smart grid market is growing and accelerating this growing trend, but the opportunities for solution providers is still unclear. What is claimed to miss is a comprehensive overview of the developing applications and their interaction with the evolving market. The research estimate the global market potential for smart grid equipment manufacturers and solutions providers between $ 15 billion and $ 31 billion annually by 2013, divided into three main business segments: customer applications advanced metering infrastructure/smart meters and grid applications.

Across the different business segments the growth and value will be determined by several variables, mostly related to the level of technology and competition, regulation and policy. For the traditional energy infrastructure vendors, the benefit will be mainly related to the renewal of utility assets as customer and grid applications are deployed, while all the other players, such as IT and telecommunications companies will benefit from the technology investments. The market is therefore concentrated on customer applications, smart meters and advanced metering infrastructure and grid applications.

- **Customer applications:** the level of functionality of these applications can vary from a simple in-home display (IHD) that shows energy consumption to a fully automated home with smart appliances and a centralized energy-management system. All the appliances will receive information about prices and energy consumption and a home-area network (HAN) will manage the energy consumption.

- **Smart meters and advanced metering infrastructure (AMI):** they support a two way communication between the customer and the utility and between the meter and the HAN. The AMI system technology allows utilities to connect or disconnect remotely to the grid. At the current stage the AMI market is the most developed segment of the smart grid value chain.

- **Grid applications:** are the applications that automate the grid to make its infrastructure more efficient and flexible. They include voltage optimization (VVO) and conservation voltage reduction (CVR); monitoring and diagnostics (M&D) that monitors the grid performance and reduces the maintenance costs thanks to a constant monitoring system; fault detection, isolation and restoration (FDIR) which automates switching and routing and also locate and isolate eventual faults on the grid; wide area measurements (WAM) which works at the transmission level by measuring the electricity phase to improve the grid reliability and prevent cascading outages.

The growth of the smart grid varies across the markets in relation to factors such as the level of development of the existing grid, the regulatory regimes and the wealth of the economy. Even if the smart grid market is still young and relatively undeveloped there are already some emerging characters that could gain most of the gains and attention of the market.

The identification of the right opportunities depends on a large number of variables, as previously noted the level of technological development, the regulations and policy and the wealth of the economy. There are already some new companies that entered the market offering some low-functionality products. The utilities companies should look more on the service part of the business in order to match the customer needs with products and services. There is the opportunity also that the market for home area network develops with a variety of products, such as the IHD and other products closely related to the appliances.

In the area of the software applications, the value of the market increases as the information transmitted to the utility becomes more complex, allowing for more detailed analysis and quicker responses to changes on the grid. This trend is projected to continue as vendors provide additional functionality and integrate multiple devices, reducing the lock-in effect associated with physical devices. However the most important aspect for all the actors in the market is to fully understand the value in the evolving smart grid and therefore to focus on a specific aspect that relates with business related knowledge that the company has. Utilities have to understand the full value drivers and take consequently action on specific operations, such as increasing the efficiency of the grid, improve the capital productivity and other.

Finally a deep understanding of the government regulations, incentives and legislation constraints is of vital importance in order to have a clear forecast of where the market will go and how it will develop.

5 The role of the consumer

Technology has transferred our society in dramatic ways. What Schumpeter (1968) first termed 'creative destruction' involves giving up of existing social and economic structures to embrace the new. In the long run the success of technology will not necessarily depend on its merit, but rather on its social acceptance and use. As argued by some authors, the only aspects of the smart grid that can be truly smart are the people within it (Honebein et al., 2011). In other words, consumer involvement is the fundamental driver.

Since the early days of electrification, consumers have been passive ratepayers, since meters only collect usage information for the utility, and do not communicate to the customer the real-time cost of their consumption. Traditional metering only allowed the utility to bill for monthly consumption, using rates that reflect average cost of electricity (Sioshansi, 2012). The culture of electricity consumption that has developed encouraged consumers to plug in and without much thought about the cost until they get a bill at the end of the month, without any further engagement. Even after receiving the bill many people do not give it a second thought, since it represents just a small amount in respect to their monthly income. However, with the rising cost of electricity due to increasing price, because of the scarcity of fossil fuels and other factors, there has to be a change in the industry and the way consumers behave. Rising energy costs have made customers more and more sensitive to electricity bill savings (Gangale et al., 2013).

Incentives to install renewable sources of energy have already converted a large number of consumers into prosumers in countries like Germany, Spain, the U.K. and others, allowing consumers to sell electricity back to the utility. While smart grid utilities focus on economic incentives and the on technological issues many argue in favor of increasing focus on consumers and their daily routines (Verbong et al., 2013). Observing consumers in their social context (e.g. household or community) and engaging and including them at an early stage is fundamental for the future electric power system to deliver the expected goals (Gangale et al., 2013).

Technology increases the distance among the consumers and employees making it more challenging for employees to understand the consumer. It also has an influence on consumers' ability to articulate what they need and want; they do not understand the possibilities and boundaries that a complex technology carries. In 1994 Eric von Hippel introduced the concept of "sticky" information describing it as information, which is difficult to transfer. In a concise way "the stickiness of a given unit of information in any given instance is defined as the incremental expenditure required to transfer that unit of information to a specified locus in a form usable by a given information seeker. When this cost is low, its stickiness is said to be low, when it is high its stickiness is high" (von Hippel, 1994).

The changing role of consumer in production of services also has consequences for the role of the consumer in the development process of products and services. Technology gives us the possibility to learn from consumers' behavior over time and on an individual level. To understand the consumer it is no longer enough to simply conduct a survey or interviews. The consumer should become an active participant and co-creator in the development process of new products and services. Participatory design has the potential to bring more understanding of the consumers, through co-creation with the consumers in the development of products and services. Up until now participatory design research has produced numerous useful results in the form of techniques, methods and conceptual frameworks, e.g. to support users in being creative and innovative in design and in exploring design ideas in relation to future use-practices (Greenbaum and Kyng 1991; Schuler and Namioka 1993).

As a consequence, employees have a much better chance to understand the consumer and therefore the consumers' potential can be better utilized as a source of new ideas. As a result consumer integration has been suggested as one such new and important way of listening to the consumer and translating consumer information into value-creating offerings (Alam, 2006). Research on the sources of innovation shows that particularly lead users are capable of coming up with new product concepts that are both truly novel and of value to the market as a whole in the future (von Hippel 1986, Urban and von Hippel 1988, Morrison et al. 2000).

5.1 Consumer Behavior

The challenge of achieving higher consumer engagement with smart grid technology is one of behavioral change. In recent years as the smart grid development is increasing and the challenge of involving the consumer is becoming more clear, there is starting to be more research dedicated to this field. Gangale et al. (2013) is one of the most recent researches that provide an insight into consumer engagement in smart grid projects in Europe. The study also reveals that projects involving consumers are characterized by the pursuit of two main objectives: gaining deeper knowledge of consumer behavior (observing and understanding the consumer) and motivating and empowering consumers to become active energy customers (engaging the consumer) (Gangale et al., 2013).

Consumers do not always make rational choices. Observations of consumer behavior show that people often make quick and irrational choices, which are often associated with satisfying current desires that will be satisfactory only for a short term without thinking about long term impacts and consequences. Consumers also tend to behave in a way that is same as everybody is behaving and that it socially accepted as the 'normal' way to behave. Consumers are mostly locked into unsustainable consumption patterns influenced by routines, social norms and expectations as well as incentive structures, institutional barriers and restricted choice (Gangale et al., 2013). Most people have the desire to fit in. That is why this thesis is focused on the group of consumers who already face the needs today that the rest of the market will only experience tomorrow, the lead users.

Through design the utility companies can make the technology more interesting in a way that it will motivate people and it will enable them to do things that they could not do before. It may be surprising to consumers to realize that there is a role envisioned for them in the smart grid, but it may also surprise them to realize that their new role does not require changing their lifestyle significantly (Sioshansi, 2012). It is important, at this early stage, to understand and involve consumers in order for them to successfully assume their new role as active participants in the electricity system (Gangale et al., 2013). The goal is to enable their electrical devices to respond to variable energy prices or other information, following guidelines set up by the consumers themselves. For consumer the first step is to install a home automation system and gradually transition to a smart home by investing in smart electrical devices, including appliances, or retrofitting existing ones with add-on functionality. Then, using a friendly user interface via their computer tablet or smart phone, they can tweak present responses established by the manufacturers. From that point on, consumers can go about their lives knowing that their home is performing their energy management for them. In the long term, customer engagement models for energy efficiency and demand response will look more like smart phone apps and less like the cumbersome regulated models that exist today. (Sioshansi, 2012).

The opportunity of creating more value for the smart grid and for the creation of a dominant design that will be successful lies in making people the integral part of the development process. The new smart grid enabled services and technologies should adapt to people's needs rather than the other way around. The utility companies need to start thinking what people want, and see how technology can help. However, the idea of getting consumers to become active participants in the market is still novel to many, and is a completely new idea to the average consumer who has been successfully trained to be a passive consumer (Sioshansi, 2012).

Positive involvement of consumers with electricity consumption and service selection is considered a vital success element for realizing the potential gains of the smart grid. The lack of involvement stays a challenge for the utility companies, since the consumers represent a large share of the smart grids potential savings. Consumers are motivated by different factors, some by convenience others by environmental cautiousness, etc., as this paper argues they should be involved since the initial phases of the development proses in order to achieve higher involvement in the future. Some utilities are already starting to realize that smart grid is not just about the smart meter rollout, but also about the consumer engagement. This paper is trying to go a step further and bring the engagement already to the innovation process.

5.2 Engagement Challenges

According to Gangale et al. (2013) in their study of smart grid projects with focus on consumer engagement, the two points most frequently referred to as critical are the lack of trust by consumers, and uncertainties regarding the use of different motivational factors.

5.2.1 Trust

Building trust among consumers is a crucial step to overcome consumer resistance to new technical, regulatory and market solutions and to successfully engage them in any (energy related) project (Gangale et al., 2013).

5.2.2 Motivational Factors

Motivational factors play a fundamental role in activating behavioral change and are increasingly being used by utility companies in their smart grid projects. The recent survey of Gangale et al. (2013) revealed that the motivational factors commonly used by smart grid projects in Europe are: the reduction of/control over electricity bills; environmental concerns, and better comfort, i.e. the provision of technological solutions allowing the optimization of comfort and more control over own energy use.

5.2.3 Control over the electricity bill

A study on ‘Energy Efficiency‘ by McKinsey shows that there is a lack of desire on the consumer side to pay premium price for energy efficient products. From these studies it is clear that the mainstream consumers are largely influenced by price when buying sustainable products. Consumers are willing to spend on products that enhance their entertainment and convenience (Sioshansi, 2012).

According to the Smart Grid Consumer Collaborative report, messages promoting monetary savings have broad appeal and have proven more effective in the US at driving participation in energy-related programs than other messages (SmartGrid Consumer Collaborative, 2011). It is uncertain to say whether this kind of motivation will work in the European market, since the majority of smart grid projects are still ongoing and final results are either limited or not available.

Nevertheless, consumers often make choices based on factors beyond price. It is questionable that lower prices alone will engage mainstream consumers to change their current choices and behavior. "The massive middle", the group of mainstream consumers that offers the biggest opportunity to create the change the world so needs (Ogilvy & Mather, 2011).

5.2.4 Environmental concerns

Convincing consumers to switch to sustainable products still remains a challenge. Consumers have other priorities than their electric bill and environmental concerns (Sioshansi, 2012). Even if this is positively changing over the years and there is a certain group of consumers, who is already convinced. While some consumers will make purchases with energy efficiency in mind, to appeal to a broader segment of society the industry needs to think in terms of what consumers think about (Sioshansi, 2012). This majority still represents a challenge for the utilities and the value creation of the smart grid. Concerns about the consequences of energy use on the environment and on climate change are growing and messages that refer to these topics have started to resonate with the average consumer (Valocchi et al., 2007).

5.3 Listening to Customers to Overcome the Barriers

The smart grids technologies are able to perform a great amount of actions and activities, including:

- **Customer participation in energy usage:** smart grid can provide consumer information that helps them modify how they use and purchase electricity. It can provide them with choices, incentives and disincentives in purchasing patterns and behavior, which in turn can help drive new technologies and markets.

- **Accommodate diverse generation and storage technologies:** these power generation options range from centralized power plants distributed energy resources (DER) such as system aggregators, grid-scale power projects like wind farms and building-scale DER such as solar photovoltaic energy or combined heat power systems.

- **Enable markets for new products and services:** a smart grid can help enable markets that give consumers greater access to competitively provided energy related services, from unregulated power purchasing to enhanced information, communication and control features.

- **Improve power quality:** smart grid technologies if deployed in an integrated power grid, can improve the reliability and quality of power supply. With digital technologies increasingly ubiquitous, uninterrupted power supply with consistent voltage, frequency and related characteristics is increasingly important to individual homes and business operations as well as the productivity of the economy as a whole.

- **Improve utility system asset utilization and operating efficiency:** a smart grid helps manage customer loads and system asset in a more coordinated fashion, such that the system can provide more useful energy services from its total asset base. It also reduces system inefficiencies and operating costs.

- **Minimize outages and system disruptions:** a smart grid can be self healing to a greater extent than current power grid technologies permit. It identifies and reacts to system disturbances, using largely automated mitigation methods that enable problems to be isolated, analyzed and restored with little human interaction. It can use predictive analysis to detect existing and future problems and initiate corrective actions.

- **Improve system security and resilience:** smart grid designs can resist both physical and cyber attacks. Sensing, surveillance, switching and intelligent detection, analysis and control software can be built into grid operations to detect and respond to threats. This can make smart grid system more resilient, with self-healing technologies that can respond faster and with less impact on human-made and natural incidents.

All these actions listed (Prindle and Koszalka, 2012) that are performed by the smart grid creates space of action in which the utility companies can apply their knowledge to enhance their communication with the customers. For each activity described there is a specific action that should be performed by the utility company in order to make the dialogue with the customer more efficient and useful for the development of the smart grid system in the future.

The introduction of the digital meter itself is not enough to argue that the customers are involved in the smart grid system. Various methods for the definition of the amount of energy consumed already existed, however this only communication system did not enhance the relation between the company and the user. The establishment of a two-way communication system via the smart grid technologies provides the opening for the marketplace to deliver new technologies and devices that can aid consumers' management of their energy use and cost.

Several researches have been performed on the first customer experience with smart grid and related customer offerings. Pilot programs and other initial field experience with smart grid related customer offerings tend to show that customers reduce energy use as well as peak demand. Most of this experience comes from dynamic-pricing-based offerings, though some also include customer feedback and control options. The study shows that smart-grid-based programs can save energy as well as reduce peak demand, suggesting that there is no inherent conflict between energy savings and peak reduction goals. What is more important is to examine the factors that support success in gaining customer acceptance and regulatory approval.

As a result of the researches there are several important activities that should be performed by the companies in order to enhance the customer satisfaction and involvement in the smart grid development:

- **Measure annual energy savings:** too few smart grids demonstrations and pilots have been able to generate robust data on customer energy savings over annual cycles and longer. Most of these efforts have focused on demand response, dynamic pricing and related topics. Appropriately, the focus of such programs is on short-term demand impacts, measured as kilowatts of power capacity coincident with the utility system peak. There is a need for more robust data on the energy demand impacts of smart-grid-based customer offerings. This would help utilities, regulators and other parties develop fuller estimates of the smart grid technologies can offer.

- **Give customer feedback they can use:** the customer feedback has been shown in many of the program described above to be effective in producing both peak reductions and longer-term energy savings. But the information has to be designed and delivered to fit the specific needs of the customer segments. The use of a web portal where the bill of the customer can be split in different part of energy costs and consumptions with the peak reduction option could be a simple and good option.

- **Give customers control options they will use:** residential programs can suffer from overkill promising too many control features. Many customers will use only one option, while others may be interested in managing home electronics and major appliances as well as heating, cooling and hot water. Customer segmentation and program design should accommodate these differences. It may require only two to three differentiated offerings to capture these differences and gain wider customer acceptance and program impacts.

Even if the next generation of customers offerings is developed and perfected to the point of being ready for mass market deployment, utilities and other parties will need to develop program logic models that are persuasive to regulators. This is a critical step: to date, program logic models that are simple to use for the end-user. Such programs should be designed as a physical-technological-economic-model structure, in which the program is designed to install or replace a physical device containing a specific technology, offers an economic incentive to the customer for purchasing/installing the device. Smart grid customer offerings typically depend on customer and behavioral responses to price signals or usage feedback. (Sioshansi, 2012)

The programs can be finally designed in a way that would allow the consumer to take part in its development, as previously mentioned, in order to enhance the opportunity for the development of user innovated technologies. The greater involvement of the user could increase its relation with the utility company, but the system should be designed in a way that it would allow the user to design some of its parts.

5.4 Diffusion of Innovation Impact on Consumers in Smart Grid Market

The Diffusion of Innovation Theory by Rogers (1962) argues that people differ with respect to their willingness to adopt unfamiliar behaviors or technologies. The individuals in a social system do not adapt to an innovation at the same time (Rogers, 1962). Consumers can therefore be divided into different groups, based on a time sequence of when they first start using a new technology or adapt to a new idea.

The theory is particularly relevant to the development of the smart grid on the basis of adoption by different consumer groups. In marketing it is common practice to use segmentation and the diffusion of innovation theory highlights the need for electricity utilities to better understand their customers and increase their engagement via design of service and product offerings and targeted approach to individual consumer segments.

Adopter Category	Definition
Innovators	We can also call them the lead-users, since they are the ones who are often first to develop new ideas and are ahead of the others. They are venturesome, want to be the first ones to try new innovation; they are willing to take risks.
Early Adopters	This group of people is the second fastest to adapt to an innovation. They represent the opinion leaders and embrace change opportunities. They are less willing to take risks than innovators. They do not need information to be convinced to change.
Early Majority	These people are rarely leaders, but they do adopt new ideas before the average person. That said, they typically need to see evidence that the innovation works before they are willing to

	adopt it. Strategies to appeal to this population include success stories and evidence of the innovations' effectiveness.
Late Majority	These people are skeptical of change, and will only adopt an innovation after the majority has tried it. Strategies to appeal to this population include information on how many other people have tried the innovation and have adopted it successfully.
Laggards	These people are bound by tradition and very conservative. They are very skeptical of change and are the hardest group to bring on board. Strategies to appeal to this population include statistics, fear appeals, and pressure from people in the other adopter groups.

Figure 8 - Five established adopter categories (Rogers, 1962)

Figure 9 shows that the most of the consumers belong to the middle categories of early and late majority.

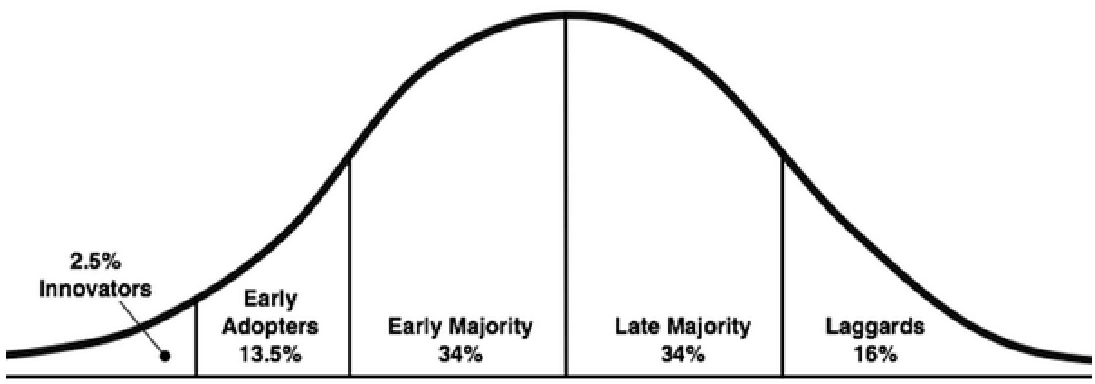

Figure 9 – Distribution of the adopter categories (Rogers, 1962)

This segmentation of consumers based on their adaptation patterns, can help the electricity utilities in targeting the involvement and engagement methods and strategy according to different groups. This is why it is so important to involve the lead users (innovators) in the co-creation of the design, which will than have a bigger chance of becoming the dominant design. By achieving the lock-out of the old dominant design and the lock-in of the new dominant design, the early adopters will be motivated to adapt to the new technology and trigger the diffusion of the behavior through other segments of the population.

6 Analysis

This chapter reviews all the literature used for the development of this research and proposes selected development of previously cited theories. The analysis is therefore carried out through hypothesis that indicates a possible path for the development of a user-innovation technology in the smart grid system and how this could help for the definition of the dominant design.

6.1 Hypothesis on user barriers and innovation

In the previous part of this research we have looked over the impact that the democratization of the innovation has on the development of the user-innovation. As previously said, Eric von Hippel (2005) argues that the world is moving towards the idea where innovation is being "democratized and that users of products and services -both firms and individual consumers- are increasingly able to innovate for themselves". This concept should not be misleading in the sense that the innovation is just carried by individuals for the individuals. At the same time we cannot diminish the value of manufacturer that has been on the first place the originator of the product, at least in the sense of the product sold on the market.

To start with the first hypothesis I will follow an example developed by Braun and Herstatt (2009). Therefore I will adapt this hypothesis on the discussion over the development of smart grids in order to bring us closer to answering the research question:

Can electricity utilities overcome the barrier of lacking consumer engagement by co-creating the dominant design for the smart grid enabled products and services with the consumer?

It is hard to imagine a world where the manufacturers does not exist and at the same time is impossible to develop a product without users. Braun and Herstatt (2009) state that: while some factors have made user-innovation in regard to information goods easier, various factors have had the opposite effect. There will be a constant struggle between encouraging and discouraging effects which will allow user-innovation in some areas at some occasions to flourish, while at others to vanish. In order to clarify this idea within the smart grid system, I will adapt the hypothesis proposed by Braun and Herstatt (2009) for my research, based on the belief that further investigation should be performed on the topic and that the collection of relevant and reliable data should be performed in order to test this hypothesis.

Hypothesis 1: *The degree of user-innovation changes over time as well as the barriers that users have to overcome before being able to innovate.*

The term barriers here used with a broad meaning, I will concentrate on the technological barriers that users faces in the development of innovations of various types.

6.2 Sticky Information and other aspects on the user innovation

As previously mentioned in this paper, the world is going towards specialization in every field, from the health care industry to the media industry, from the engineering schools to the economic and business schools and so on. The example can be made virtually on every field, however the specialization is bringing some positive and negative aspects. One of these drawbacks can be seen from a common practice followed by several firms around the globe: the outsourcing. This practice is often used by the companies, which do not have the time or the knowledge to produce a specific good. On the other hand, outsourcing custom design to customers can help slash development times and costs, but customers are not experts in a supplier's business (Thomke and Hippel, 2002).

Outsourcing can be applied in several fields and different dimension of the company, from R&D to production. In this research I would like to draw the attention of the reader on the information that a company can acquire through consumers conceiving them as a part of the knowledge of the company. The assumption is that not all the companies have the same capabilities and skills in their field. The more efficient company should produce the good or service and as a consequence other companies should acquire this good from this producer and specialize in something else. The specialization can be on the same business line, can be related to the product, but not necessarily. This observation shares some similarities with the one expressed by Baumol (2004) “inventive activity will be undertaken primarily by the more effective inventor, while production of the resulting products will be undertaken predominantly by the more efficient producer.” The logic is applicable to the end-user innovation where the lead-user can be seen as the most ‘effective’ producer. The transfer of knowledge between a user and a producer is a central issue in exploring the locus of innovation, as innovation entails locating, evaluating, and assimilating information about user needs as well as integrating technical (solution) knowledge into new products that users want (Cohen and Levinthal, 1990).

I believe the fundamental asset of a company is the knowledge that it produces or acquires. The knowledge shapes the products of a company. Traditionally, specialized information used by a manufacturer to design and build custom products has been locked in the minds of the company’s development engineers. This knowledge is accumulated over decades of experience. (Thomke and Hippel, 2003). It drives the choices made by the management and influences the stakeholders in different ways. Moreover, a potentially interesting avenue for future research is to explore how the nature of the innovation—or the nature of the underpinning knowledge, more generally—affects the locus or process of innovation (Nonaka, 1994). In contrast to explicit knowledge, tacit knowledge is highly personal and not easily made visible and therefore difficult to articulate, identify, and valuate (Nonaka, 1994). Tacit knowledge means that users are not always able to express their needs, making it problematic for a manufacturer to innovate by not being able to translate their knowledge.

Eric von Hippel on the topic shared his idea by coining the term ‘Sticky Information’. Opposed to the common idea of the researchers that regards information as slippery, expensive to generate but with a cost of replication or diffusion close to zero, the sticky information are the ones expensive to acquire, transfer and use in a new location. Von Hippels’ concept of sticky information is that they can have a significant influence on patterns of problem-solving and innovation, requiring that problem-solving activities must shift to and among sites of sticky information as problem-solving proceeds. Because of the importance of the use of local information and of sticky information, the innovation process will be accomplished in the future more often by the end-user rather than the expert.

6.3 User Toolkits for Innovation

The idea proposed by von Hippel on sticky information is completed with another concept developed few years later that is the “toolkits” for innovation that allow manufacturers to “abandon their attempts to understand user needs in detail in favor of transferring need-related aspects of product and service development to users along with an appropriate toolkit”. Co-creation entails enabling users to autonomously experiment and innovate by providing a platform for collaborative innovation, for example by hosting user communities (Jeppesen and Frederiksen, 2006) or providing “toolkits” for innovation (von Hippel and Katz, 2002).

The traditional product development process starts with the identification or with the prediction of the potential customer needs in the market, which they than sell to buyers. This identification is often carried out through surveys and research on consumer preferences. The role these users play during innovation of the products that they ordinarily buy from producers has been the subject of research since at least Adam Smith. This information can be unsatisfying for the company and expensive or in von Hippel words “sticky”. The reason can be related to the fact that the surveys are not well prepared or simply the communication gap between the company and the consumer is large and not easy to cover using an instrument that can provide information as the company would expect them to be. In other words a survey might not be the best tool to communicate with and to understand the consumer, since it has been created by the company’s translation of consumers tacit knowledge, which is hardly possible to capture by traditional methods like surveys. The transfer of knowledge from consumer to company should be taken with a different approach.

Companies should provide a ‘Toolkit for user innovation’ in order to support them in their innovation process (von Hippel, 2001). This concept introduced by von Hippel that is closely related to the theory of the sticky information and it is based on the idea that companies have the knowledge of the solution possibilities, while the users hold the knowledge about needs. This information is sticky and therefore is not easy to transfer them from the user to the manufactures or the opposite way. However, Nonaka et al. (1996) highlight the importance of tacit knowledge. In their eyes tacit and explicit knowledge is not completely separated and is interrelated through a knowledge conversion process during social interaction.

By investing in new forms of communication and technologies, companies can provide a set of tools to the users in order to involve them in the manufacturing part of the product at all the stages of the development process. This will also diminish the redundancy of information provided by the customers that will perform small tasks within the development of the full product by consequently allowing both parts to design the product.

The process described by von Hippel includes several steps:

1. *Learning by trial-and-error:* the user through the understanding and experience of the whole cycle necessaries to design the product can get a better understanding on the product that he's developing and can thus choose more precisely its components and parts.
2. *An appropriate solution space*: defined as the flexibility that the producer has to reach a desirable result. The space is delimited by the limitations that that production procedure carries. The lower are the limitations the greater will be the space of innovation that the user can bring.
3. *A user-friendly toolkit:* the easiness of use of the toolkit should make the users more comfortable with it. This includes the knowledge of skills and language embedded with the toolkit provided so that the manufacturing process becomes familiar for the users.
4. *Commonly used modules:* some parts of the design procedure should be set on standards modules. This would allow the users to concentrate on the parts that they can develop on their own, without erasing or modifying completely the main characteristic of the product.
5. *Result easily created by user:* in order to avoid the loss of some parts of the procedure, the result must be free of error and converted into the language used in the production system. This would allow the replication of the process from other users.

All the minor tasks that involve the creation of a sticky solution are performed by the company, while on the opposite the sticky information tasks are assigned to the users. As this process happens the collaboration process starts to develop and when the appropriate tasks are given to users and manufacturers the development of the products can proceed in a more precise and efficient way (von Hippel 2001).

"To understand why this is so, consider that the development of a new product proceeds via an iterative process of trial and error. User or manufacturer based designers begin by designing what they think they want; then they test the initial solution, find drawbacks, and try again. This iterative process is sometimes called “learning by doing”” (von Hippel and Katz 2002). There is the acknowledgment from the company that the problem has to be carried back and forth between the user and the manufacturer in the trial and error phase. This task could be therefore eliminated when the task has been split between the user and the manufacturer. As a result all the available solutions are provided by the expert on the field while at the same time the learning by trial and error process is still carried out, but in a separate way rather than jointly.

This toolkit process is commonly used by the computer programmers, where several information and relevant parts of the work produced are made available from the software companies and a set of other digital tools is often provided to create the product that reaches the needs of the consumer.

Finally the toolkit has another great characteristic: is it able to generate something that is commonly known as the mass customization. The products created by the customer and the manufacturer are unique, but at the same time they are able to satisfy the specific needs of the individuals. This way of development of a product with the use of a toolkit has become an ideal method for the development of all kind of products that are characterized by different needs from the users. This is especially common in the software and web market, where the needs of the different users can be easily gathered and therefore the main parts of the products are released with feature that allows the users to customize them.

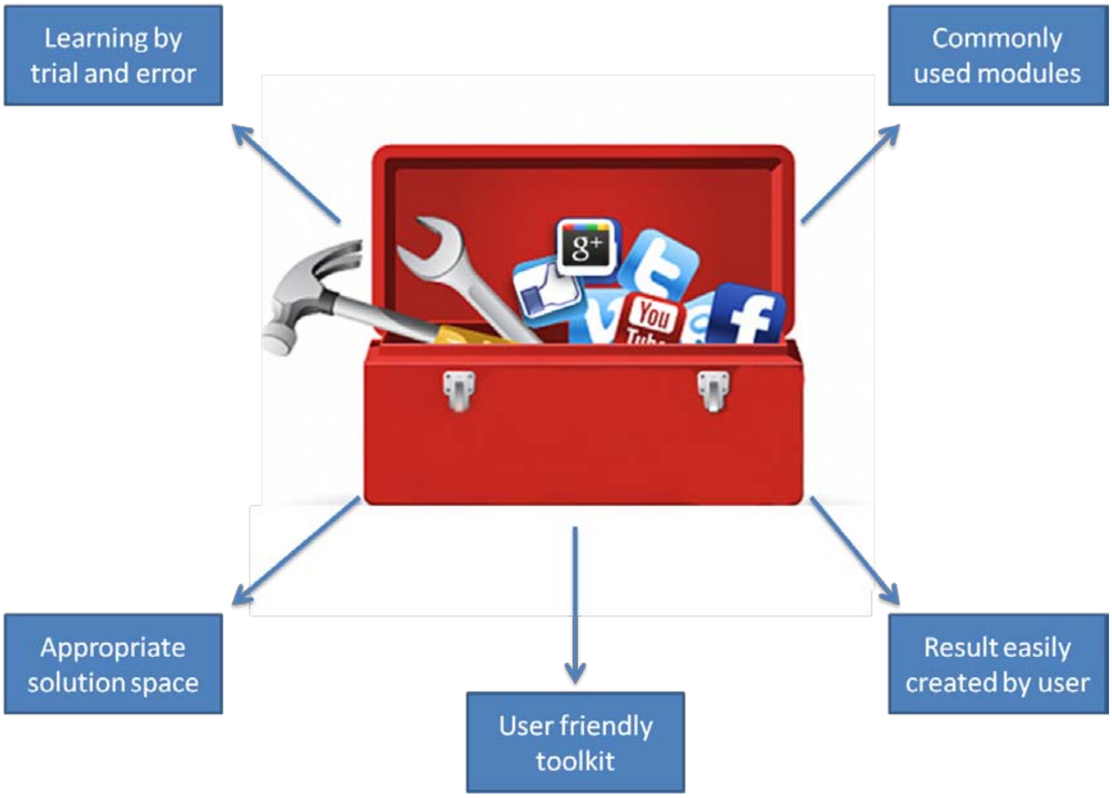

Fig.10 - User Toolkit for innovation - Own creation based on von Hippel 2003.

This process is finally carried out by the manufacturer with a high level of production efficiency, given the fact that the manufacturing tasks are performed only when the product is ordered by the customer.

6.4 Definition of the hypothesis

So far the analysis conducted on the consumer involvement in the smart grid space has focused mainly on theories that could help to understand what kind of approach should be used with the consumer and how the companies should interact with its users in order to overcome berries for co-creation. In the case of the smart grids, consumers are acquiring a service especially important in their everyday life. The importance of services and therefore their availability has become part of our life standard, like electricity, water, heating systems and all the other services that shape our modern life.

In order to follow the structure used so far I would like to introduce a second hypothesis that will be useful to draw some conclusions on the research question raised in this paper.

Hypothesis 2: *Since the utility companies are on the free market, there is no monopoly, consumers can choose to disconnect from the power grid and reconnect with another provider. The price of electricity fluctuate according to the consumption, thus the demand for electricity is elastic.*

Considering that the electricity has become a necessary need and consequently we can assume that its demand elasticity is < 1. There is low change in the quantity of energy demanded with every variation of the price.

This hypothesis is of great importance to understand which path should be followed by the utilities companies in order to increase their involvement with the consumers. If the demand was inelastic, how it used to be for several decades, since the electricity companies were usually state owned and thus operated without competitors – monopoly – the involvement of the consumers would have been of little importance for the development of the smart grid system. This is because consumers were obliged to acquire the service under the only provider available in the market, therefore their feedback would have been only related to the status of the service and few other minor types of communications.

With the development of a market in which the electricity can be supplied by several operators in the market the client has become also in this sector the contended aim of the companies. It will be therefore necessary a strong effort from the electricity utilities companies in order to get a greater engagement from the consumers, since they should also keep their customers and gain new ones in order to stay in the market. While a great involvement of the customer is seen as necessary with certain market conditions, in others the lack of communication is often determined by the market itself, where no communications between the parts are considered relevant for the development of the product.

With all the hypothesis set, the research can now move towards the definition of the answer to the research question raised in this paper.

7 Discussion and Conclusion

In the discussion and conclusion chapter, I will revise the main findings and answer the research question based on the meta-analysis of different studies that I introduced throughout this paper.

7.1 The purpose of the study and its main findings

The purpose of this study was to find possible ways of consumer engagement with the smart grid enabled products and services. Since consumer engagement has not been crucial for utilities it is bringing a completely new challenge to the electricity industry. This thesis attempts to contribute to overcome this barrier by analyzing theory, which aims to understand the relevance of consumer involvement for the development of the smart grid technology on the way to switching to a smarter grid. To my knowledge there is no present research taking the same approach to consumer engagement and that is why I will analyze theories previously mentioned in this work from various fields, yet interconnected.

Can electricity utilities overcome the barrier of lacking consumer engagement by co-creating the dominant design for the smart grid enabled products and services with the consumer?

To give a theoretically supported answer to the research question I will first state my first hypothesis:

Hypothesis 1 ***–*** *Lead user innovation in the context of design participation has a higher chance bringing the dominant design to the market faster.*

To begin with, I would like to emphasize the importance of the dominant design and the correlation with consumer engagement. The dominant design is the first step to bringing a higher adoption rate, hence engagement. One principal reason for selecting a dominant design, rather than a variety of technological options in the industry is that many industries exhibit increasing returns to adoption, meaning that the more a technology is adopted, the more valuable it becomes (Arthur; 1994). Also plentiful evidence shows that the more a technology is used, the more it is developed and the more effective and efficient it becomes (Levy, 1965; Yelle, 1979; Lapre et al. 2000).

The customer is often the one most able to recognize the maximum performance capabilities and minimum service requirements of a new product. Including the customer in the actual development team or designing initial product versions and encouraging user extensions can help the firm to focus its development efforts on projects that better fit customer needs (Butler, 1988). Many studies suggest that firms should focus on the input of the lead users rather than large samples of customers. This is mainly because the lead users face the same needs of the marketplace, but are likely to experience them months or even years in advance than the rest of the market and also highly benefit from the outcome. Research on the sources of innovation shows that particularly lead users are capable of coming up with new product concepts that are both truly novel and of value to the market as a whole in the future (e.g. von Hippel 1986, Urban and von Hippel 1988, Morrison et al. 2000). Baldwin et al. (2005) shows that innovative users and user communities often affect the future organization of an industry and give rise to a dominant design. Consumer interaction in new services development has a positive impact on the performance of new services (Alam, 2006). According to the research and studies conducted on lead user innovation, I think they have the potential to influence the lock in of the new dominant design for the smart grid enabled products and services.

During my research I came across some factors that indicated that in order to achieve successful co-creation between the lead user and the electricity utility, collaboration is necessary in order to reach the dominant design. These factors are sticky information and tacit knowledge of the lead users. Tacit knowledge means that users are not always able to express their needs, which means that this information is sticky and it makes it problematic for the manufacturer to innovate. This is where participatory design comes into the picture. As the definition of Kyng (2010) states, participatory design is about design and about participation in design by people who are potential users of the design activities results. This means that when the lead user and the manufacturer (utility) of the smart grid enabled products and services participate on the new design development there is a better chance of overcoming the problem of sticky information.

H2 – Diffusion of Innovation Theory and the adopter categories can be used as an engagement strategy, if the dominant design is co-created with the lead user.

Rogers' (1962) in his Diffusion of Innovation Theory argues, that people differ with respect to their willingness to adopt unfamiliar behaviors or technologies. The theory divides consumers to adopter categories based on their adoptability to new technologies. In this case the led users are on the forefront as "Innovators", the ones that are often first to develop new ideas. This segment represents just a small part of the consumers. The next group of consumers are the early adopters, who are the second fastest in adapting a new technology. The largest segment of consumers is the early and the late majority, followed by the laggards, who are the slowest to adopt a new technology.

If the dominant design is co-created in a participatory way with the utility and the lead user, than the lead user is already engaged and this product and service has a higher chance to be adopted by the early adopters and than by all the other segments of users.

7.2 Conclusion

As a result of the research conducted on the consumer engagement this paper has shown that the existing theories and literature developed on the topic can be considered relevant to answering the research question. If we assume that the hypothesis (H1, H2) are true than we can say that by co-creating the dominant design for the smart grid enabled products and services, electricity utilities can overcome the barrier of lacking consumer engagement. However, the utility companies should focus on co-creation with the lead users rather than large samples of users. If the innovation is co-created with the lead user, it represents the needs that the consumers will have in the future that they did not realize yet, rather than what the manufacturer thinks the future needs of the consumers will be. Utilities need to put consumer engagement on the top of their innovation agenda, instead of forcing the technology to unengaged consumers.

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