

From Greening of ICT to Greening by ICT

EXPLORATION OF AN OPEN ICT PLATFORM FOR ENERGY MONITORING TOWARDS A SUSTAINABLE ECONOMY

CASE: SMART GRIDS IN THE ENERGY SECTOR OF THE NETHERLANDS



Image source: [1],[2],[3]

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EXPLORATION OF AN OPEN ICT PLATFORM FOR ENERGY MONITORING TOWARDS A SUSTAINABLE ECONOMY

CASE: SMART GRIDS IN THE ENERGY SECTOR OF THE NETHERLANDS

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For being the pole star in my life

ABSTRACT

There are two important perspectives in Green ICT (Green Information & Communication Technology). First, is the Primary Level Segment (PLS) which deals with minimizing the negative impact of ICT use on environment and greening the ICT infrastructure of an organization [4]. Second, is the High Level Segment (HLS) which uses ICT as an *enabler* to create a sustainable world (The term HLS in green ICT has been coined from the *International Telecommunication Union conference in Paris, Sept 2012*) [5]. Both perspectives aim at reducing the carbon footprint and solving complex environmental challenges.

The present world is seething with excessive carbon emissions, heat production, chemical wastes, power wastage and abundant usage of natural resources which needs to be controlled. In a technology-driven era, most of these negative impacts are being caused by technologies themselves. PLS aims to manage the ICT infrastructure by introducing smart, intelligent, compact & sustainable trends so that the ICT environment of an organization can be made greener and environment friendly. The companies contribute to PLS through *singular action* where they perform sustainable practices within the company and the impact is felt in the company level. When an ICT trend is used as an *enabler* for achieving sustainability, it is termed as a *green ICT trend* (e.g. cloud computing, smart grids, e-governance) and contributes to the HLS through *collective action* where several actors participate together to create and exchange value in a network. In this research, PLS has been analyzed from an organizational or micro-perspective, whereas the HLS portrays the macro-perspective of an ecosystem or an economy and is dependent on the individual contributions of PLS in establishing a sustainable world. Organizations are increasingly incorporating sustainable practices in their business operations but they often miss out on where these practices are headed and what impact it can have on the macro-level. Channelizing the sustainability objectives of an organization towards that of the ecosystem is one of the major challenges, the world is facing today across various sectors and industries. Literature distinguishes a clear knowledge gap between PLS and HLS which needs to be bridged in order to align the micro and macro perspectives. If the perspectives are aligned, companies can get a better understanding of how they are contributing to the sustainability of the macro ecosystem; which are the fronts they should improve on and what the best method to do so is.

The energy sector presents a case in the research and the smart grids¹ technology is the green ICT trend which will be analyzed on the backdrop of PLS and HLS. Smart grids is a promising technology that has the potential to solve complex energy issues and green the energy sector and therefore it will be used to explain the coordination between PLS and HLS. The research will propose a mechanism to bridge the knowledge gap between PLS and HLS and analyze the value created, to support the possibility of the mechanism in contributing towards a sustainable economy² (further discussed in 1.1). The proposed method will also be used to explore whether public good can be generated through the smart grid network as a value addition.

¹ The technology is a combination of renewable energy grids, hardware, management and reporting software, built over a foundation of intelligent communications infrastructure to provide energy in a sustainable, reliable and economic way by helping consumers to be actively involved in energy management.

² Economy where there is a balance between production and consumption and the value of natural and social capital achieves allocative efficiency.

The research approach is to propose a high level design of an open ICT platform for monitoring energy performance of companies through literature study and exploring the possibility of the platform solution by conducting interviews of experts from businesses, energy companies, and government and academic researchers.

The determined platform design will provide insight into what the necessary conditions are for creating an open ICT platform for smart grids. Furthermore the value network analysis will delineate who the important actors are and what values they can exchange from using the platform. In the results, a risk and a positive attribute analysis will give a practical overview of the developments that need to be made in functional requirements of the platform. Additionally, whether initiatives like corporate social responsibility³ (CSR) can lead to value addition through the platform will also be analyzed in the research.

This study can pave the way for future research on open platforms for smart grids and how they can be useful for controlling the energy trends in the economy. Especially, the financial perspective can be investigated in detail, as to who will fund the platform and what the return on investment will be. Apart from this, the conditions for implementing the platform that will be highlighted in this research, can be further investigated to validate if these conditions are sufficient or more considerations are needed to be addressed for implementation. The perspective of business as users of the platform is taken in this research, future direction can include the perspective of regulators and common households, in order to expand the usability and utility of the open platform in the field of sustainability. Future research can also make this study a base and formulate similar sustainability monitoring mechanisms in top sectors other than energy.

KEYWORDS

PLS (PLS = Primary level segment): Greening of ICT infrastructures of companies

HLS (HLS = High level segment): Greening of the environment using ICT as an enabler

Green ICT trend: An ICT technology that helps in greening of the environment

Collective action: Act of cooperating, collaborating and participating together towards a common goal

Energy sector: The study is based on the top sector of energy in the Netherlands

Smart grids: Smart & sustainable power grids that provides on-demand renewable energy to users

Open platform: A shared platform through which several parties can exchange values like information

Sustainable economy: An economy where there is a balance between production and consumption

Value-creation: Any socio-technical system has some offerings or utility, which can be seen as a value

Value network: A network where several actors benefit by exchanging values

Self-sustainable economy: An economy that is capable of thriving on its own

³ Functions as a built-in, self-regulating mechanism whereby a business, monitors and ensures its active compliance with the spirit of the law, ethical standards, social and international norms 6. Redfame. *CSR*. 2013 30/10/2014; Available from: <http://home.redfame.com/csr/>.

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ABBREVIATIONS

PLS: Primary Level Segment
HLS: Higher Level Segment
ICT: Information Communication Technology
CSR: Corporate Social Responsibility
DRMS: Demand Management Response Software
VNA: Value Network Analysis
PPP: Public Private Partnership
SCADA: Super Control & Data Acquisition
RES: Renewable Energy Sources
B4-B11: Businesses number from 4 to 11
Govt. Government
R&D: Research & Development
GUI: Graphical User Interface
UML: Unified Modeling Language
ext: Extends
TS: Type of sector
TB: Type of business
Co.: Company
CCP: Critical Control Points
SEC: Security
SR: System Regulation
A: Acceptance
DA: Data Abstraction
F: Finance
P: Participation
I: Interface
TEC: Technology
US: User Satisfaction
SCA: Scalability
STR: Strategy
TRU: Trust
NBO: New Business Opportunities
NLB: Network Load Balancing
PRI: Privacy
FLE: Flexibility
CO: Competition
CA: Consumer Awareness
EA: Energy Advice
TRA: Transparency
CE: Consumer Empowerment
SP: Sustainable Policies
CS: Cloud Solution
CAW: Consumer Awareness
RVO: Rijksdienst voor Ondernemend – Dutch (Netherlands)
KVK: Kamer van Koophandel – Dutch (Netherlands)
NGO: Non-governmental organizations
TU: Technical University
MOT: Management of Technology
ROI: Return on Investment
HLD: High Level Design
EDSN: Energy Data Service Netherlands
OP: Overall Possibility
VC: Value Creation

CHAPTER 1

THESIS DEFINITION

Ch1	Ch2	Ch3	Ch4	Ch5	Ch6	Ch7
Thesis Definition	Theoretical Perspective	Domain Description	Platform Development	Value Network Analysis	Feasibility Exploration	Conclusion

1 THESIS DEFINITION

Chapter 1 is the introductory chapter of the thesis and presents the thesis definition. It has been divided into 7 sections. Section 1.1 introduces the problem; 1.2 defines the problem and presents the problem statement. 1.3 presents the specific case of the research; 1.4 discusses the research objective and scope. The research questions form 1.5 and 1.6 presents the research approach and design. The chapter ends with a conclusion in section 1.7.

1.1 INTRODUCTION

This section provides an introduction to the background of the research and discusses the related concepts.

The present world is a witness to the surging negative impacts of technology on environment. Therefore, it has become almost imperative to control and manage these technologies and make them sustainable⁴. The rapid progress and spread of ICT has caused severe negative impacts on the environment because it consumes a lot of energy, generates excessive heat and electronic waste [7]. Green ICT is an emerging field which aims to make ICT infrastructures green but also uses ICT as an *enabler* for greening the environment. Thus, ICT is not only part of the problem of our environmental impact, but also a part of the solution [4]. Owing to the perils of climate change, technology intensive organizations are increasingly implementing green ICT to contribute towards a sustainable environment by practicing sustainable initiatives and contributing to corporate social responsibility activities [6].

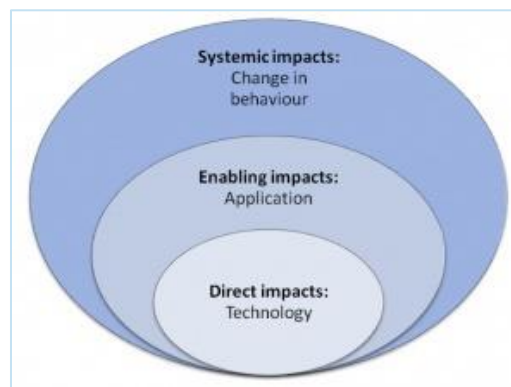


Figure 1: Impacts of ICT [4]

There are 3 impacts of ICT that have become prominent with the emergence of green ICT and needs to be discussed in this context. First, *systemic impacts* which describe behavioral changes that has come about in people with the adoption of new technologies like preferring electronic modes of communication (e.g. email, video conferencing) over traditional methods (e.g. paper mail and face to face interactions) [4]. Second, *enabling impact* which uses ICT to streamline other products, processes to increase efficiency and reduce the negative footprint on environment (e.g. intelligent heating and lighting systems). Third,

⁴ The need for survival and well-being which is dependent on the natural environment, therefore keeping the environment in prime focus, human agency must align themselves through ways and methods best suited for this.

direct impacts comprise of events where ICT producers affect the natural environment during production of ICT hardware, components and services (e.g. infrastructures, offices and vehicle fleets). To counter the direct and enabling effects, R&D and innovation are used to improve the environmental performance of ICTs [8].

When an ICT trend is used for contributing towards a sustainable environment, then it can be termed as a *green ICT trend*. A green ICT trend is based on a *greening principle* and is aimed towards achieving a particular *target* which solves complex environmental challenges. A couple of examples these trends, green principles and targets are presented in Table 1.

GREENING PRINCIPLE	GREEN ICT TREND	TARGET
Energy wastage, excess power consumption	Smart grid networks, smart appliances, smart homes	Achieve energy efficiency
Carbon footprint, excess use of fossil fuels	Fuel cell vehicles, electric cars and charging stations	Curb air pollution, reduce ozone layer depletion
Toxic chemical waste production	Sustainability monitoring software	Curb air, land and water pollution
Excess paper use and wastage	Electronic governance and digitization	Do away with traditional modes of operation
Inefficient Land Usage	Smart homes and smart cities	Protect biodiversity and flora
Excess heat generation from data centers	Cloud computing	Reduce physical space of servers, heat generation increase energy efficiency
Carbon footprint, Fuel wastage	Intelligent traffic diversion system (also mobile app)	Reduce air pollution, save fuel

Table 1: Greening principles, green ICT trends and targets

Some of the *green ICT trends* which are finding their place in the world are, smart grids for achieving energy efficiency, smart homes and structures that comprise of new and sustainable architectural designs; increasing use of fuel cell vehicles and electric cars, use of software by chemical companies to measure toxic waste and recycle them periodically [9, 10]; implementing cloud computing for reducing extensive data centers spread across locations and intelligent traffic diversion system to save battery, fuel and decrease carbon emissions. It is evident from the EU energy policy [11] and white papers of ABB and Alstom [12, 13] that the awareness behind sustainability adoption is spreading on a global scale. ABB and Alstom has conducted extensive research and development on smart energy models and both have a broad portfolio of products and systems that can be utilized to build modern smart grids. They are keen on modernizing the traditional grids into smart ones and convert existing cities into smart cities. The white paper of ABB gives insight on present energy demands of the world and how smart grids can solve the existing energy issues. Alstom's white paper shows the architecture of smart grids and how ICT plays a significant role in the smart energy provision of the grids. These white papers provide a detailed overview of the domain of smart grids which will be discussed further in chapter 3.

Green ICT has 2 important perspectives:

1. Primary Level Segment or PLS: concerns greening of the ICT infrastructure of an organization and hence constitutes the micro perspective. The excessive heat generation from data centers is one of the examples of the negative footprints of ICT on the environment. One of the green ICT trends which is used for curbing this problem is cloud computing thereby reducing physical storage space and excess heat generation in offices. Some of the other examples of ICT's negative impacts are large amounts of e-waste from companies every year, standby losses of ICT equipment and systems etc. In 2010, among 2.4 million tons of electronic equipment disposed in the US, only 27% were recycled [14]. Another study at EPFL shows that, in industrialized countries, ICT consumes about 5-10% of the total demand for electricity and the standby losses are 50% of the order of that electricity consumed [14].

The green ICT trends have been present for quite some time, but it is due to the exigency that climate change has posed on mankind, organizations across diverse industries have started to incorporate sustainability goals in their core business operations. The Dow Jones Sustainability World Index (DJSWI) (Figure 2) shows how different industries are opting towards sustainability, with the telecom sector leading the league which includes the ICT companies [15]. Figure 2 shows that there are several aspects where sustainable practices can be implemented in a company e.g. energy efficiency, material eco-efficiency (can be reused or not), green supply chain and overall green management of the infrastructure. However, to ensure a sustainable economy, not only the production but the consumption should also be green. The emerging picture of green consumption is strongly influenced by consumer's values, norms, habits and plays a very important role in the transition towards smart and sustainable living [16]. There are two concepts in PLS: A) General trends in green ICT and B) Singular action.

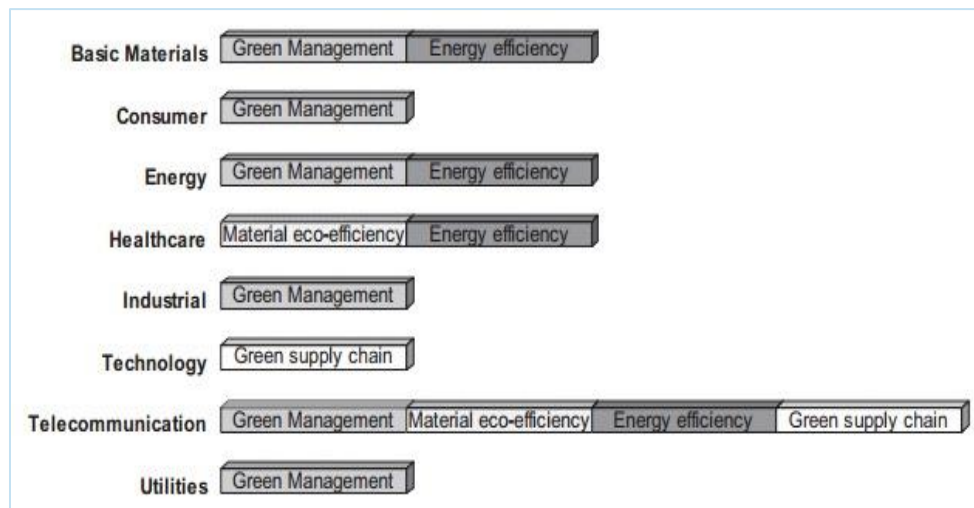


Figure 2: Sustainable practices implemented across global sectors [15]

A) General Trends in Green ICT in PLS

There is an increasing awareness among organizations today to adhere to global standards of sustainable practices like Energy Star, ROHS (Restriction of Hazardous Substances etc.) to efficiently manage their ICT infrastructure throughout the life cycle from procurement, operation to disposal. A 2008 survey by

IDC (International Data Corporation) revealed that energy costs were the most pressing reason for the adoption of green ICT trends apart from the increasing carbon footprint on environment [17]. Green ICT is not a product or application which can be implemented but it is an amalgamation of best practices to contribute towards sustainability. Therefore, the primary aim of green ICT in PLS is to lower operational costs and increase the efficiency of ICT infrastructures through eco-friendly measures. Thus, as part of the green ICT strategy of a company, several green ICT trends and solutions are being adopted. Some of the general reasons behind adopting these trends by companies are shown in the Figure 3.

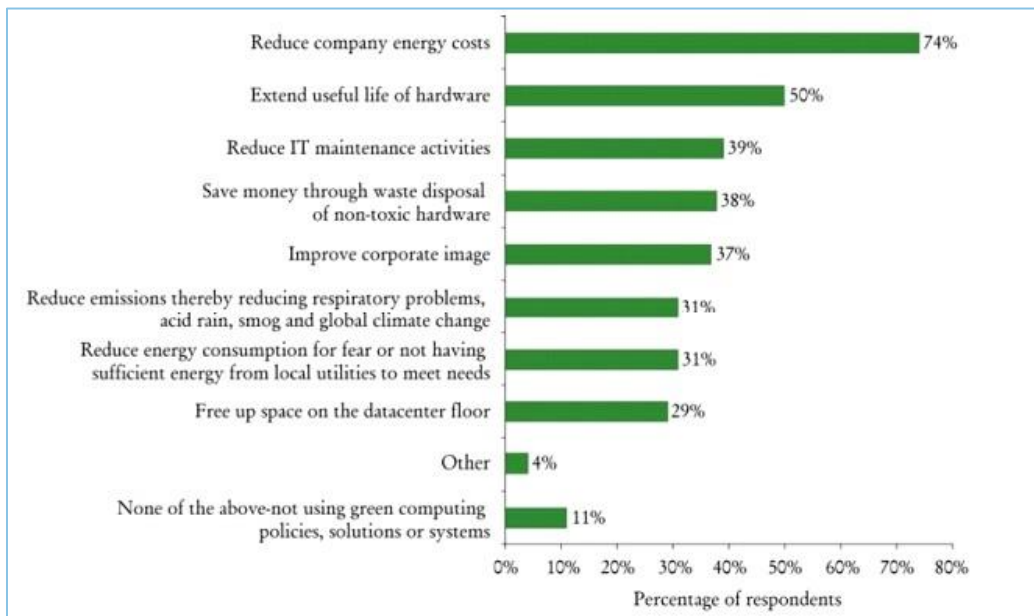


Figure 3: Reasons for adoption of green ICT trends [18]

B) Singular Action

Singular actions are primarily those actions that organizations perform for greening their ICT infrastructure and it forms the core of their green ICT strategy. The actions have been termed *singular* because for implementing them the number of stakeholders are limited and the results and benefits are reaped by the organization only. For example: when a company decides to install sustainability monitoring software to measure and assess the toxic chemical wastes that they produce monthly or annually; it is a company-specific initiative that would earn them incentives from the government, which would in return add value to their productivity and reputation. Most of the green ICT trends mentioned in Table 1, if implemented within an organization for contributing towards a sustainable environment then they can be called as green ICT initiatives achieved through singular action. This is synonymous to the objective of PLS. With green consumption on the rise among consumers, there is a notable impact on market equilibrium and the role various economic instruments in bringing improvement to the ambient environmental quality [19]. But, most of these singular actions taken by green consumers⁵ do not take into account the impact on a total population or macro-economic system, because it is negligible. Therefore

⁵ Consumers who accept or even demand green and recycled products 20. Roberts, J.A., *Green consumers in the 1990s: Profile and Implications for advertising*. Journal of business research, 1996. 36(3): p. 217-231..

there is a need for action where different actors or companies can collectively participate and contribute towards sustainability so that it can have a much wider impact or influence on the economy.

2. High Level Segment or HLS: regards ICT as an enabler to reduce the negative impact on environment and climate and contribute towards a sustainable world. It comprises of the macro perspective. It includes individual contributions of PLS to create an aggregate impact on the ecosystem or an economy. There are 3 concepts in HLS: A) Sustainable Economy, B) Collective action and C) Value-creation, which are discussed below.

A) Sustainable Economy

In an economy where there is a balance between production and consumption of goods (products, services, and capital) and import and export of goods is called a balanced economy. This balance also needs to be achieved in the demand and supply of natural resources in the ecosystem. Therefore an economy which incorporates a balance between the supply and demand of natural resources by using them in an optimum manner through the enabling impact of ICT can be called a sustainable economy. Social capital⁶ and natural capital⁷ must be incorporated into a sustainable economy so that the producers produce only those goods which are desirable for the society, a phenomenon known as allocative efficiency [21]. According to the United Nations Report on Turkey's sustainable development, a sustainable economy promotes use of clean technologies, increases efficiency in the use of natural resources and modifies patterns of production and consumption through the use of ICT to ensure mitigation of environmental damages [22]. The concept of a sustainable economy will be extended in this research, to a *self-sustainable economy*, which is an economy that is capable of thriving on its own, or produces what it needs to consume. This is a unique concept which will be investigated as a value addition to the proposed solution of the problem (it will be further discussed in chapter 5, under the section 5.3).

B) Collective Action

When groups of individuals collaborate to accomplish a common, shared or collective goal or interest, even if the incentives to do so are small then it is called *collective action* [23-26]. In this research, when different stakeholders participate together in a network to implement a green ICT trend and contribute towards a sustainable economy, then it can be stated as *collective action*.

For example, when data is shifted to the clouds, as an alternative to storage in data centers for every business facility, it is an initiative that requires collaboration among several participants since the technology is distributed. There is a cloud service provider who provides storage, software, platform or infrastructure services and on the other end there are several cloud vendors who use the solution. Reliability is ensured by network service providers and the application maintenance and support is given by technology providers. Hence it requires collaborative participation of several actors across different distributed regions to ensure the smooth operation of the technology. Several companies and enterprises

⁶ the interaction and network of people in the society to ensure proper functioning of the society

⁷ the stock of natural ecosystems that yields a flow of valuable ecosystem goods or services into the future

benefit from this arrangement who make use of a common cloud for their business. The smart grid network also operates through collective action because there are utility service providers who provide the infrastructure, energy providers who provide energy on demand, grid operators who maintain the grid; then consumers, who can act according to energy prices and control their consumption and finally the regulators who frame policies for the operation of smart grids. Apart from these main actors, there are customer services, experts in the energy market place and consultants who provide advice on energy management.

It must be remembered that, when the stakeholders come together collectively, sharing a common economic-ecological goal, then apart from the profit they individually get, they also benefit from an improved environmental quality [19].

C) Value Creation

Vargo et al in his work on *Service systems and service logic*, states that value creation is the core purpose and central process of economic exchange by one party for the benefit of another [27]. Therefore it can be said that firms create value for their customers by offering them products and services and receive revenue through the exchange of services. He argues that traditional business models were based on a single firm's output and price but in the modern business models, collaborative participation has become important to create value [27]. Therefore the concept of collective action and value creation can be combined together and extended, to contribute towards a sustainable economy, where different actors collectively participate to create value for each other. Value creation corresponds to another concept, "valorization" which helps in deriving commercial value from a product or service proposition but also adds value in its proposition. Therefore how can a solution be valorized and create benefits for its stakeholders must be analyzed during the analysis of value created to delineate the value for all.

Leap From PLS To HLS

From the discussion above, PLS highlights sustainable practices implemented in the organizational or micro-level and HLS shows collective action that can impact the economy. Literature shows the existence of both PLS and HLS, but there is a knowledge gap between the two segments, due to which companies mostly have been operating their sustainable goals in the individual organizational level. The benefits of collective action in sustainable practices needs further investigation. The 3 impacts of ICT as discussed above: systemic, enabling and direct impacts have a notable influence on a company's sustainable goals; however they fail to establish a link between PLS and HLS. Therefore an interesting question that arises here is how a sustainable economy can be achieved with a combination of PLS and HLS.

This section discussed concepts which provides the foundation of my research and will be revisited in details in the later chapters. The next section introduces and discusses the problem in context.

1.2 PROBLEM DEFINITION

This section defines the problem in context and provides the problem statement.

We are aware that sustainable development has become one of the greatest challenges of the present day. The world's demand is superseding the current supply of natural resources [28]. Climate change is a threat to life. The carbon footprint has taken a toll on densely populated areas. The biggest challenge among environmental problems is with the technological advancement that the human race has made; ICT is both the cause and solution to the problem [4]. Hence it is a social responsibility to control the negative effects of ICT, and organize production and operation by the use of green ICT trends. Industry and academia are working hand in hand to tackle these issues.

The problem addressed in the research is to bridge the knowledge gap between PLS and HLS for establishing a sustainable economy.

1.2.1 MESO-LEVEL – A BLACK BOX

The major issue at stake with regard to implementation of these trends is that, the actors who are involved in implementing sustainable practices do not have a holistic view of how PLS and HLS should be coordinated together to achieve a sustainable economy. In the present day, PLS has solely been sufficient for a company in contributing towards sustainability without knowing the superset of HLS or how their individual actions can affect the ecosystem. For e.g. in November 2012, the International Reporting Council published a prototype for a reporting framework which several companies have adopted, that provides them with a clear narrative of how they can create value over time without compromising on environmental welfare. The creation of an integrated report forces compilers of financial reports to communicate the full range of factors that materially affect six types of capitals: financial, manufactured, human, intellectual, natural, and social [29]. Such reporting frameworks help business leaders to assess their operations on the backdrop of sustainability but these frameworks operate in silo, on the individual company specific level. There is no central monitoring system that can compare the performances of all the companies to control and measure the sustainable practices. Although several companies are using this framework in the market, but they are not collaborating with each other to create value through collective action [29].

Therefore, the knowledge gap from PLS to HLS is a big one. One of the possible methods to bridge this gap is by ideating a meso-level between them. This meso-level is a black-box which needs to be analyzed before the fruits of the HLS of a sustainable economy can be achieved.

There is a need for companies to understand at a micro-level in which direction their sustainability goals are heading and for that, a concrete method in meso-level can help them to make sustainable decisions for the future. From the basic principles of macroeconomics, the impact on a *system* can be achieved only when aggregate or collective action is taken [30]. Therefore, in the meso-level, the prospect of collective

action can possibly contribute to a sustainable economy, where several actors must be involved and create exchange values for greening the environment.

The United Nations Environmental Program (UNEP) underscores the economic dimensions of sustainability in their green economy report of 2011. It states that “there is a growing recognition that achieving sustainability, rests almost entirely on getting the economy right” [31]. It also elements that economic growth and environmental stewardship can be complementary strategies but they pose equally significant tradeoffs between their objectives. These tradeoffs need to be analyzed to unravel the black box in the meso-level.

Table 1, presents several green ICT trends which can be used as enablers to meet the sustainability targets. For a company to be sustainable no one parameter can be sufficient, and ideally it should be a combination of several greening principles. For example, the heat the data centre of the company is generating, the energy savings that the company makes every year with respect to its performance of the previous year, how much water it is saving (electricity, vehicle, building management), the carbon footprint on the environment (from the use of company cars) etc. Therefore several parameters of sustainability needs to be monitored to attribute a company as sustainable in the PLS. These measures can be easily taken on the organization level, but when the scope and diversity increases to the HLS, monitoring of resources become difficult. Therefore the meso-level will help in understanding the coordination between PLS and HLS.

The second aspect of the problem is that several companies are focused on contributing towards corporate social responsibility⁸ initiatives as part of their sustainability strategy which can be seen in the backdrop of PLS, but there is no system or mechanism in place to monitor these developmental initiatives for social good. Therefore an integrated system can help regulators or the government to monitor sustainable initiatives undertaken by different companies which can be a positive step towards HLS.

Since both greening of ICT infrastructure and corporate social responsibility constitute of a company’s sustainability strategy, therefore both are related to each other, currently, operating in silo in the PLS. A method in the meso-level is required to connect these aspects and extend them to the HLS to give a clearer understanding of a sustainable economy; where companies can be empowered to feel responsible for their actions towards environmental welfare. The research will also give insights on value creation through collective action by companies in this process. It will help to determine whether companies can add value to the society through their sustainable actions or not.



Figure 4: Concept of Sustainable economy

⁸ Companies cater to the welfare of the society as part of their social responsibility and must report to the government about their public welfare programs, often to receive tax evasions

From the above discussion, the problem statement has been formulated in the next sub-section.

1.2.2 PROBLEM STATEMENT

The problem statement summarizes two issues which will be addressed in the research.

Primary Issue: The leap from the PLS (greening of ICT) to the HLS (greening by ICT) is a big one, and hence requires an integrating method in the meso-level, which can be possibly achieved by collective action of different companies (or businesses) for contributing towards a sustainable economy.

Secondary Issue: The proposed solution must create value to support its possibility in establishing a link between PLS and HLS

The next section presents the research demarcation behind the choice of a particular parameter of sustainability and the specific sector on the backdrop of which the study will be performed.

1.3 RESEARCH DEMARCATION

To measure the sustainability of a company, several parameters need to be monitored like energy, water, heat, carbon footprint and built environment [17]. ICT applications play a very important role in sustainability monitoring and there are different ICT applications which are used to manage them. A central monitoring system or module can help companies to monitor the efficiency of the resources better and make progress in sustainable development. But, each of the parameters are in themselves, large and have several aspects in them, for e.g. to track the carbon footprint, how many vehicles the company employs, or how much waste do big power plants produce needs tracking, each of which require different measurement techniques. However, a centralized monitoring platform for sustainability can help companies to find all the data under one repository and formulate policies for sustainable development. Due to the vastness of each of the parameters of sustainability, I have based my research on one sector, the energy sector and my study focuses on establishing a green and sustainable environment by monitoring energy in companies.

The energy sector is a major concern for governments all over the world and making it sustainable can contribute to the following [32]:

- Ensure adequate supply of energy in the long term to support economic development
- Improve security of energy supplies to reduce dependence on foreign energy sources
- Provide a healthy, less polluted and sustainable environment
- Contribute towards the global climate change

The Dutch energy industry forms a good 6% of GDP (36 billion euros per year) and is focusing largely on innovation in the sector and transition to green energy [33]. This is enabling the Dutch energy companies and institutions to become a top economic sector [34]. Some of the major goals of the Dutch government in the energy market by 2030, discussed in the book Energy Policies of IEA Countries 2014 [35], is to develop a long term energy policy that addresses economic and social benefits from energy efficiency, by mobilizing the demand side services, invest in energy efficient structures and promote energy efficiency across the top sectors e.g. Agri-food, Chemicals, Creative Industry, Energy, High Tech Systems and Materials, Life sciences and Health, Logistics, and Water [34]. The 2030 objective aligns closely with the primary issue of my research addressed in the problem statement. Additionally, they have formed a strong regime to provide cost-effective greenhouse gas abatement incentives, while securing the position of energy-intensive internationally competitive companies. This particular objective is in sync with the secondary issue of my research to create value through the solution by businesses and achieve sustainability. Moreover, according to the Dutch energy policy, energy provision must be sustainable, reliable and affordable and the government aims to cut carbon emissions from industries by 80-90% by 2050 [33]. Renewable energy is therefore a vital part of the plan but however at present it is expensive. The smart grid technology is being widely investigated in the Netherlands, but due to the expensive infrastructure and policies which need to be developed regarding security and information sharing concerns, there is still time before it can be adopted on a large scale [11]. The energy sector is an interesting field to base my research on, also because it is an emerging sector, where there are several qualified people who can provide their views on sustainability in energy, contributing immensely to scientific literature. This sector makes use of large ICT infrastructure which must be made sustainable, for greening the energy ecosystem.

With a lot of experiments and furor being performed in the renewable energy sector, I selected the green ICT trend of smart grids as an energy efficient model and propose an energy monitoring system in its network. Furthermore, analyzing the value creation and value exchange among stakeholders is an important part of the exploratory study into this proposed solution to bridge PLS and HLS as a demonstration of how collective action can lead to a sustainable economy by means of value creation.

The next section presents the case which helps to ideate a method that can possibly establish a bridge between PLS and HLS and develop the concepts of the research.

1.4 CASE OF SMART GRIDS IN THE NETHERLANDS

This section discusses the case of smart grids, that has been selected for illustrating the concepts of PLS, HLS, meso-level and sustainable economy stated in the introduction.

The smart grids technology form the *green ICT trend* based on the *greening principle* of power wastage and energy inefficiency to achieve a more energy efficient Dutch energy sector as the *target*.

In the current smart grids, the utility service companies and grid operators provide consumers with smart meters and demand response management software (DRMS) that help consumers to monitor energy

consumption according to the trends in the smart grid. This empowers consumers to reduce power wastage and lower their electricity bills, by modifying their consumption pattern. Presently, although the consumer is able to change his energy behavior according to the grid but he does not realize how his consumption patterns can impact the energy market. Therefore the benefit of using DRMS is largely individual and serves the PLS in the energy sector. Although several energy monitoring applications are available in the market, they are not interconnected because they are designed by different energy companies, grid operators and utility companies which makes collective monitoring (HLS) and standardization difficult to achieve.

Moreover, the energy companies, grid operators and utility providers store their customer data in dedicated data centers which contribute to the negative impact of ICT because excessive heat is generated and lots of physical space is used up for data storage. Hankel, manager at SURFNet writes in his work on green data centers that, ICT consumes 10% of our total energy usage and data centers form a large part of it [36]. A mechanism for centralized monitoring can do away with the storage of data in separate data centers of energy and service providers. One of the challenges in this proposition is that energy and service providers would have to share their customer information in a common data server or a cloud, which they may not agree upon. Therefore an important assumption, in the research is that there is a data masquerading technology in the smart meters that only shares the average energy consumption data of a consumer and not that of the individual appliances in the facility to the cloud thus reducing the risks of encroaching into customer's privacy. Additionally, if the energy providers receive sufficient value for data sharing in the form of rewards and have the rights for setting energy prices, then they may have less reluctance in sharing information. Also, if the institutional policies require the energy providers to share information with the public, then it can create positive value for the energy sector, because, by comparing and monitoring energy behavior with others in the network, consumers can compete on sustainable energy performances which can lead to reduction in energy waste and establish a control over high energy prices, contributing to a sustainable energy sector.

Since data becomes centralized in a cloud, an integrated monitoring system can allow consumers to track their individual energy consumptions by comparing with the average consumption data of consumers outside their grid, and receive a better perspective of the energy trends in the market and how they can modify their energy behavior accordingly. A regulatory body like the government can also monitor the overall efficiency in the energy sector through the system and work towards forming sustainable policies. It can also prove to be a tool for matching the production with the consumption patterns, on the part of energy suppliers and grid operators. A cloud based smart grid will generate large amounts of data, therefore smart data analytics and big data application become interesting fields which makes use of ICT in the energy sector in a resolve to green the sector.

The research is an exploratory study for a future smart grid model that allows integrated energy monitoring by collective users. Therefore for the implementation of this monitoring system, certain assumptions will be made which are listed in section 4.1. Additionally, at present, the smart grids operate on the principle of efficient energy consumption and not production by consumers, because most of the companies or households do not have the facility for producing renewable energy. When production facilities are implemented in consumer locations, then the monitoring systems can become a significant

tool, especially for large companies who have the potential to produce large amounts of renewable energy (this will be further discussed in 3.1). Hence, although the regulatory body or the government is a significant user of the energy monitoring system, my research focuses on the perspective of companies or businesses as the primary users.

Another aspect of the problem is the lack of active stakeholder engagement in the smart grid network, especially the consumers and regulators [37]. Katharine Brass, the Program Manager for GE's Eco-imagination program, recently argued that the biggest barrier to more widespread adoption of smart grids is consumer perception [37]. Even if measures are taken to build consumer perception through campaigns, programs, workshops and promotions, the consumers may still face challenges in understanding their contribution towards the energy economy for which an integrated monitoring system can be very useful. As more consumers will adopt the technology, there will be large amounts of data generated in the system, which needs to be managed and organized, from which different actors can benefit.

A Platform-based Solution: Some of the possible methods to bridge the gap between PLS and HLS in the energy sector is by creating a reporting framework or an integrated energy monitoring system such as a platform (e.g. web application or digital display boards) by which companies will be able to monitor and control resources for ensuring a sustainable environment. In my research an *open ICT platform* is proposed for monitoring energy where users can share information (details of open ICT platforms are discussed in section 2.1.2 in the report). The open ICT platform will be designed based on functional requirements from the literature. Then, it will analyze the values that companies can create and receive from using the platform to support the overall possibility of the solution to bridge the gap between PLS and HLS in the energy sector. Whether the solution can be implemented or not will be explored by conducting expert interviews.

The next section gives an account of the research objective and scope.

1.5 RESEARCH OBJECTIVE & SCOPE

The research objective and scope are presented as follows. There is one main research objective and 4 sub research objectives.

Main Objective:

To explore the possibility of an open ICT platform for monitoring energy by businesses that can establish a link between PLS and HLS for smart grids in the Dutch energy sector and contribute towards a sustainable economy.

Sub Research Objectives based on 4 steps of research design:

- To identify the functional requirements and create a high level conceptual design of the open ICT platform

- To analyze the value created, exchanged and added through the platform by businesses
- To use interviews from businesses as consumers, energy companies, experts in the government and academics to explore the possibility of the open ICT platform
- Provide recommendations for an adapted solution based on the interviews

Research Scope:

The scope of the research is limited to the smart grids in the energy sector of the Netherlands.

It has been assumed in the research that energy providers and utility companies agree to share energy market information with businesses as consumers and regulatory institutions and thus comply to open data standards, realizing the contribution of energy sector towards environmental sustainability.

Since the platform is for a future smart grid model, a high level functional design of the platform is made by using use case diagrams of UML. The technical requirements specification to achieve the open ICT platform is out of the scope of this research project, which will be discussed in the future directions of research in section 7.4.

The platform design and analysis of value created has been conducted from the perspective of businesses only and not the regulators who are the providers and users of the platform (for monitoring actions of consumers), keeping in mind the timeline of the research which is 5 months and also the impact that big businesses can have through collective action on the energy economy. The perspective of households as users of the platform, is also not included in this research, which will also be reflected in the future research section in 7.4.

The smart grids in the Netherlands have smart meters operating on the principle of constant connectivity to the grid of the energy companies. My research assumes that smart meter data on individual energy consumption of appliances do not reach the energy companies as the technology to masquerade the usage data has been implemented in the smart grids. The research is an exploration of opening the smart grid platform to the general public for monitoring energy by closing the gap between PLS and HLS and hence the assumptions become a core part of the research. The summary of assumptions is discussed in section 4.1 where the assumptions on role and implementation of the platform pave the way for the design of the platform.

The next section discusses the research question which my research aims to answer.

1.6 RESEARCH QUESTIONS

To meet the research objective, the following research questions have been formulated. There is one main research question and 5 sub-research questions.

Main Research Question:

To what extent can an open ICT platform bridge the gap between PLS and HLS of smart grids in the energy sector and contribute towards a sustainable economy?

Sub Research Questions:

Chapter 2: Theoretical Perspective

Which are the theories that give a perspective to the research?

Chapter 3: Domain Description

Which are the characteristics of the smart grid domain that are important for the development of an open ICT platform?

Chapter 4: Platform Development

How does the high level design of the open ICT platform look like?

Chapter 5: Value Network Analysis

What value can be created, exchanged and added by businesses through the platform?

Chapter 6: Feasibility exploration

Is the open ICT platform implementable for smart grids in the energy sector?

The sub-research questions addressed in each chapter steers the research towards answering the main research question. The next section presents the research design.

1.7 RESEARCH APPROACH & DESIGN

This section discusses the type of research conducted, the research methods used and the structure of the research followed. The research approach and design is combined under this section to keep a continuity of the type of research followed, the methods used, ultimately leading to the design of the research.

1.7.1 TYPE OF RESEARCH

The study is exploratory in nature and uses a case to exemplify the research proposition. The platform design is established by literature study whereas whether it can be implemented or not is explored by

qualitative analysis of the views from experts. Qualitative studies enable the exploration of contemporary phenomenon within its real-life context, allowing for the gathering of multiple perspectives from a range of sources thereby presenting deeper insights into the research problem under investigation [38]. The research question commences with “To what extent” which shows that the evaluation will be conducted *for or against* in order to come to a measured conclusion as to the degree of the agreement. Therefore through the chapters it is more of discovering different aspects of an existing model and building a high level design for a futuristic model. When transition to green energy is the objective of the global energy sector and industries are foraying into smart grid solutions, an explorative study on this case was most suited to explain the concepts of PLS, HLS, meso-level and a sustainable economy.

1.7.2 RESEARCH METHODS

The research methods followed is desk research and interviews with experts. The description of domain, platform design and analysis of the value has been done through desk research whereas the exploration of the possibility has been performed by conducting interviews with experts. Since the platform solution involves 3 main actors who must cooperate to implement the future smart grid model, the interview respondents have been divided according to the following type of actors:

1. Business as consumers
2. Government as regulators and
3. Energy companies
4. Academic Researchers

The first three actors are directly involved in the smart grid platform whereas the academic researchers are not directly involved but their views contribute to evaluation of the solution. Each of the respondents were asked a set of similar questions which helped to evaluate the advantages and risks of the proposed solution of a monitoring platform. The respondents also gave their views on the possibility of the platform from their professional perspectives which helped in understanding the benefits and shortcomings of the future smart grid model and adapt the platform solution and its design in the results section. It also helped in formulating useful recommendations, based on which future directions of research can be conducted. Further details of the interview protocol will be discussed in the feasibility exploration in chapter 6.

1.7.3 RESEARCH DESIGN

The structure of the research has been divided into 4 parts: 1. Research background: provides the theory which helps to analyze the research, 2. Domain Analysis: provides the background of the case which is used to explain the research, 3. Design Analysis: shows the high level design of the platform and analysis of the value created through it and 4. Research Feasibility: explores whether the platform solution can be possibly implemented or not.

The research design in Figure 5 shows the 4 parts of the research, the chapter outlines in the report and the sub questions which have been addressed in each of the chapters from 2 to 6.

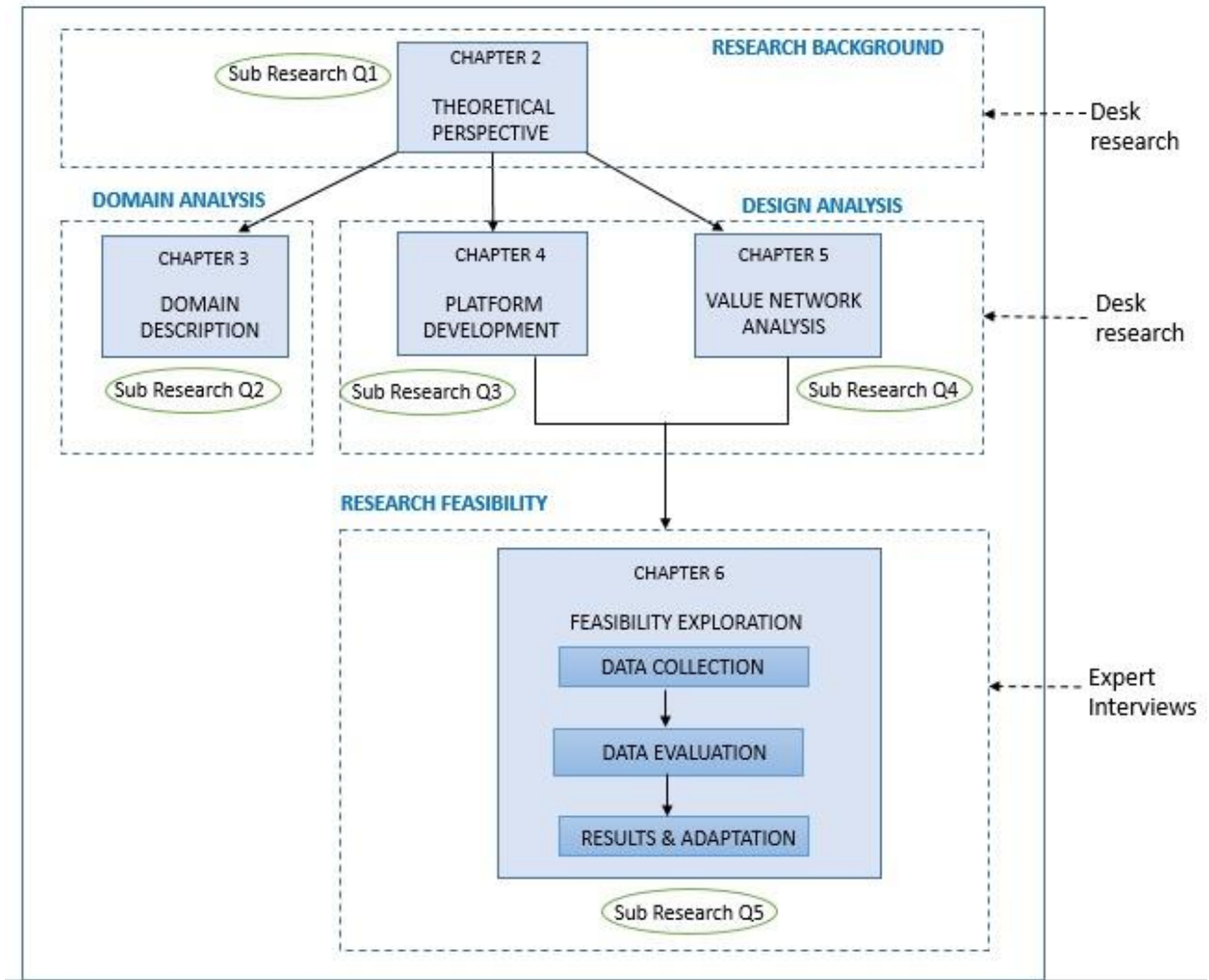


Figure 5: Research Design

The sources from where data has been collected during desk research and expert interviews are shown in Figure 6.

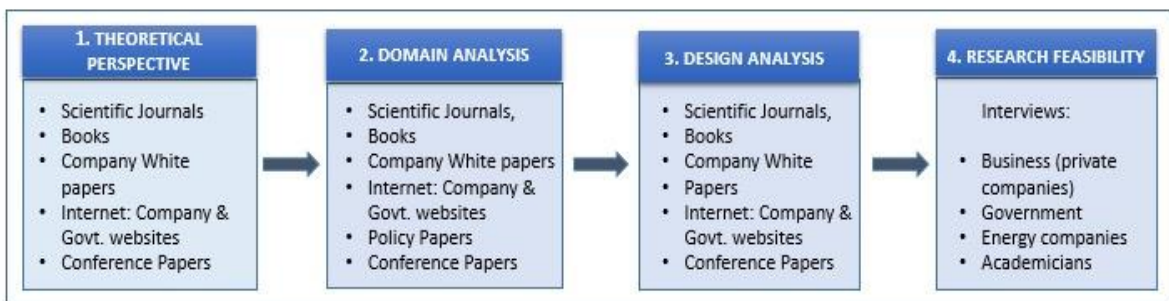


Figure 6: Data collection sources

The next section presents a summary of the first chapter of the report.

1.8 CHAPTER SUMMARY

The chapter introduced the problem, defined it and presented a problem statement. The case of smart grids in the energy sector is used to develop the idea of the meso-level for conducting the exploratory study into the possibility of bridging the gap between PLS and HLS. The chapter also illustrated as to why the energy sector of the Netherlands is an interesting topic for the research formulation. It gave an overview of the research objectives and research questions which will be answered in the thesis to achieve the objectives. Finally, it introduced the research methods and research design which will be used for solving the research problem and providing a structure to the thesis.

CHAPTER 2

THEORETICAL PERSPECTIVE

Ch1	Ch2	Ch3	Ch4	Ch5	Ch6	Ch7
Thesis Definition	Theoretical Perspective	Domain Description	Platform Development	Value Network Analysis	Feasibility Exploration	Conclusion

2 THEORETICAL PERSPECTIVE

This chapter is part of the *Research Background* of the thesis as shown in the research design in Figure 5. It presents the theoretical foundation for the study. It answers sub research question 1: *Which are the theories that give a perspective to the research?* It aims to draw relations between concepts in the literature that contribute towards conceptualization of my research. The chapter begins with the theoretical background in section 2.1, formulates the conceptual model in 2.2 and concludes with a conclusion in 2.3.

2.1 THEORETICAL BACKGROUND

The theories which have helped in concept building of the research are classified according to their chapter-wise analysis. Sections 2.1.1, 2.1.2 and 2.1.3 discusses the theories which provide the perspective for chapters, 3. Domain Description, 4. Platform Development and 5. Value network Analysis respectively, in the report.

2.1.1 DOMAIN DESCRIPTION

The theory which has been used to explain certain aspects in the domain description in chapter 3 is Giddens Structuration theory.

Giddens Structuration Theory

The theory emphasizes that a socio-technical model is influenced by technological determinism (where technology drives society) & social constructivism (where society influences technology) [39]. It focuses on the mutual constitution of structure and agency, where structure is comparable to any new technology and agency is the human action. Theory states that the recursive nature of technology is reflected in the structuration properties of technologies where they are created and changed by human action; but also used by humans to accomplish actions [40]. Structure comprises of rules and resources that give similar social practices a systemic form. Humans create the structure, but with the changing needs of the society these systemic structures must be modified to meet the changing requirements and restore balance, which can be accomplished by human agency alone. Giddens speaks of *conditions of action* which causes modification of a structure in the Stratification Model of Agent and Consciousness, but these actions need to be *monitored* in order to accomplish *targets* or *consequences* from those actions. [40, 41]. These concepts on structuration has contributed to the formulation of the conceptual framework of my research.

Anthony Giddens is a British sociologist, whose theory of structuration gives a holistic view on modern societies [42]. His works are commonly cited by various researchers. His works are hopeful on

institutions coming together to form objectives of a new order which can create institutional elements beyond modernity⁹.

Giddens theory is used to explain the domain chapter, where smart grids are replacing the traditional power grids, due to the changing requirement of society. Mankind is responsible for global climate change, and therefore it is our responsibility to create effective structures that can change the current system and establish new structures which are sustainable and meets the needs of the society. This can be achieved by the coming together of different institutions to implement a change. However, these actions and structures need to be closely monitored if fruitful consequences needs to be derived.

For e.g. ICT was invented by humans to digitize and automate lifestyle and over the recent years it has changed the way people envisage themselves in the community and ecosystem. The widespread use of ICT and advanced technologies caused as much harm as good. There is a need to control and check the negative impacts of ICT, by using itself as an enabler with the participation of different institutions like society, organizations and government. Thus at first there was a need, so technology was invented. Later with changing times to undo the damage done on the environment by the technologies, the structure needed to be modified by the same agent to suit the needs of sustainable living. The role of consumers in shaping and reproducing some of the core institutions of production and consumption [43] finds special place in my research because they have the potential to influence change in the systemic structures and institutions (social constructivism).

2.1.2 PLATFORM DEVELOPMENT

Chapter 4 on platform development makes use of theory on platforms, open ICT ecosystems, collective action and incentives. Before going into the theory on platforms in this section, it is necessary to define what a “platform” is, for my research.

2.1.2.1 PLATFORM DEFINITION

The platform concept has been discussed in several empirical contexts within scientific literature. Platforms can have different meanings in the product development, business management, economic or Information System (IS) fields [44]. A typical “*product platform*” can be defined as “a system consisting of underlying components that are used in common for the development of dissimilar products within a firm” [44, 45]. Gawer uses the term “*industry platforms*” in the business management field to describe it as building blocks that act as a foundation upon which an array of firms can develop complementary products, technologies or services [46]. In economic terms, a “*two-sided market/ two sided platform*” or a “*multi-sided platform*” means a product, service, system or even an organization that mediates interactions between two or more agents [44, 47-49]. In the IS domain, “digital platforms” [50] can be seen as an information infrastructure that is “shared, open, heterogeneous and evolving socio-technical

⁹ Term used to designate the historical period (modern era) as well as the socio-cultural norms that arose in the post medieval Europe.

system of information technology capabilities which are recursively composed of other infrastructures, applications, and IT capabilities”, according to Hanseth et al [51]. In the ICT domain, digital platform technologies are changing the face of service industries [44, 52]. In the theory of collective action, in the seminal book, “*The Logic of Collective Action*” by Olson, he defines collective action, “where several actors can cooperate collectively and contribute towards a shared or common goal” [23-26]. The theory of collective action complements the definition of my platform (discussed in section 2.1.2.4).

Therefore, definition of an ICT platform for my research combines attributes from Hanseth et al and Olson et al. It can be defined as a digital platform or an information system with ICT capabilities that allows different users to cooperate and contribute towards a shared goal by accessing shared resources. The concept of “*shared*” or “*open*” platform has been defined by Smith et al, as “universal over restricted access, universal over restricted participation and collaborative over centralized production” [53] (discussed in section 2.1.2.3). This indicates that an open platform is able to give access to several users, enabling them to participate collectively and share resources through the platform. Eisenmann defines a shared or open platform as, where there is no restriction on its development, participation or use and the actors must conform to its standards [54].

The platform proposed in my study houses information shared by different actors therefore it can be termed as an *open ICT platform*. Through this each user still performs actions on an individual level but has access to the information of other users in an integrated system for comparing performances and acting accordingly. Since the platform connects several users to monitor sustainable actions, a larger impact on the economy can be achieved through collective monitoring.

2.1.2.2 PLATFORM THEORY

The relevant platform theory which has been used in my research are:

Eisenmann’s Open Platform Theory

Thomas R. Eisenmann¹⁰, has researched extensively on platform based strategies for businesses to leverage network effects [55]. His research on platform markets, multisided and two-sided platforms illustrate his contributions in the field of shared or open platforms.

A platform mediated network comprises of “*shared*” or “*open platforms*” where: [54] [56] [57]

- 1) There are no restrictions on participation in its development, commercialization or use;
- 2) There is a requirement to conform to the standards by all actors like:
 - a) Demand side platform users are the end-users
 - b) Supply side users provide complements employed by demand side users in the platform
 - c) Platform providers serve as users’ primary point of contact with the platform

¹⁰ Professor of Business Administration at the Harvard Business School

d) Platform sponsors exercise intellectual property rights and form the rules as to who can participate in the platform interactions

Eisenmann states that, “a platform mediated network is comprised of users whose transactions are subject to direct or indirect network effects along with one or more intermediaries that facilitate users” [49, 54, 58, 59]. This explains that users of the platform will influence each other positively or negatively through their interactions based on the mediation of a facilitator. The platform includes a set of components and rules employed in common user interactions [60]. Components may comprise of software, hardware or service modules along with design criteria that specifies how they fit together [61]. Rules are used to coordinate network of participants’ activities [62]. They include standards that ensure compatibility among different components and protocols that govern information exchange, policies that constrain user behavior and contracts that specify terms of trade and the rights and responsibilities of the participants who are using the platform [54].

Eisenmann’s platform theory finds relevance in the design of my platform, because it explains the platform ownership and who are on the demand side of the users and who are on the supply side. It also throws light on the different roles involved with platform ownership such as providers and sponsors. It also helps to understand who the users of the platform are and how they can benefit from their use, in interaction with other actors or their resources.

2.1.2.3 OPEN ICT ECOSYSTEMS

In his theory of Open ICT Systems, Matthew Smith¹¹ states that “open” or “openness” in ICT represent an opening up of decision making processes to more people through information [53]. Smith argues through his comparative analysis of openness activities that, “openness” is not a binary dichotomy (open or closed) but “openness” is a range from less to more open [53]. Therefore the information that is strictly proprietary at the present, is still accessible to a certain group of actors. The idea is to share with some other actors in a manner in which proprietary information can be made available under specific conditions. These conditions will be analyzed in my study while designing the platform. In his work on open data and open government, Janssen¹² et al also shares a similar view as Smith on moving from closed to open systems, when he states that, “the public becomes part of the data processing system and might process data, enrich data, combine it with other sources and might even collect their own data” [64]. Therefore the concept of open or shared information in the platform forms important design criteria for my platform. There are benefits of open data according to Janssen et al, “The opening of data is expected to create benefits like stimulating innovation and promoting economic growth” [64]. From this, Janssen et al, conclude that “the effective use of public data is vital for the growth of “the knowledge economy” [64]. From this argument it can be said that the data in the platform can also serve as a knowledge base for

¹¹ A Senior Program Officer for Connectivity and Equity in the Americas, ICT4D International Development Research Centre in Canada and has performed significant research in open development and networked innovations

¹² The Antoni van Leeuwenhoek-Professor in ICT and Governance and head of the ICT section of the Technology, Policy and Management faculty of Delft University of Technology. His contributions are manifold in the area of e-governance, open data and open government. His research areas are also in design and service orchestration of public-private service networks 63. Janssen, M.; Faculty of Technology Policy and Management]. Available from: <http://www.tbm.tudelft.nl/over-faculteit/afdelingen/engineering-systems-and-services/sectie-ict/medewerkers/marijn-janssen/research-activities/>.

different actors to exploit business opportunities. Smith mentions transparency and accountability as important characteristics of an open ICT ecosystem from his analysis [53]; therefore the users can be accountable for their actions and interactions in such an ecosystem. The important terms used by him in defining open ICT ecosystems are: “universal over restricted access, universal over restricted participation and collaborative over centralized production”[53]. The theory helps to ideate the energy world not only from an ICT perspective but the term ecosystem” gives connotations for social, psychological and geographical perspectives too.

The relevance of Smith and Janssen et al’s view on open systems in my research lies in understanding how open ICT ecosystems can provide space for amplification and transformation of social activities that can be powerful drivers of development.

2.1.2.4 COLLECTIVE ACTION THEORY

Collective Action theory, was first developed by Mancur Olson¹³ in 1971, in his book, “The Logic of Collective Action”. It states that groups of individuals may collaborate for a common goal, even if the incentives for them to do so are very small [26, 44, 59]. Therefore, it explains why groups of actors collaborate together to accomplish a shared or common goal [66] . Usually this goal is common or shared and carried out due to collective interest in the action [23-26]. Olson argues that individuals in any group attempting collective action will have incentives to “free ride” (take advantage of benefits) on the efforts of others if the group is working to provide public good. Individuals will not “free ride” in groups that provide benefits only to active participants or resourceful members [67]. This explains the aspect of my research where companies collaborate to achieve sustainable targets and social good, of which the benefits can be shared by all and not any particular group. The groups of individuals who may participate in the action can range from diverse backgrounds or organizations guided by their individual interests, but the resultant effect of participation is much larger and deeper. This notion closely aligns with my concept of PLS where individual actions are given importance and HLS where collective action is needed to accomplish bigger goals. From the analysis of Olson and Nikayin¹⁴, 3 factors have been identified which are important characteristics of a group: 1. *Size*: which shows how many persons form those groups, 2. *Heterogeneity*: describes having a group with dissimilar members and 3. *Interdependency*: states whether the groups are dependent on each other to produce the actions. In the context of high technology alliances, Walter et al, argues that when the degree of interdependency between actors reduces, their incentives and willingness to participate in collective action, also decreases [69]. Monge et al argues that participants in collective action are interdependent on each other to provide a collective good [70]. Therefore it can be inferred that if any participant stops collaborating then the common good cannot be achieved.

¹³ An American economist and social scientist. His most influential contributions have been in institutional economics where he extensively researched on public goods, contracts, collective action, private property and taxation 65. Economist, T., *Mancur Olson*. 1998, The Economist: London.. His best academic work is the logic of collective action which has been largely cited by researchers for understanding theory of groups in economic development.

¹⁴ A post-doctoral researcher at the Delft University of Technology, has carried out extensive research on e-health, smart cities, smart energy services and internet of things. Her PhD dissertation was on ICT enabled platforms for smart living services 68. Nikayin, F. *Fatemeh Nikayin*.

The theory of collective action is relevant for my research because it explains the actions in the HLS, which has the potential to create large impacts on the economy. The understanding of collective action is very important to point out in my study, how actors can collaborate to create and use the platform solution.

2.1.2.5 INCENTIVE THEORY

Traditional economic theory has generally espoused the view that rational workers will choose to improve their performance in response to a scheme that rewards such improvements with financial gain, which has been supported by Mason in his work on “Financial incentives and Performance of Crowds” [71]. From this it can be concluded that performance based rewards can be a powerful tool for enhancing improved performance. The theory of incentives used in this research is Myerson’s¹⁵ analysis of Principal Agent problems [71]. Myerson in his work refers to a “*principal*” as “one who sets the rule of the communication and establishes the structure of incentives to which other actors or “agents” react” [73]. He states that the principal-agent can be a part of any organization or socially coordinated system. The central core of the theory states that the agent is aware of information which must be shared with the principal in order to receive incentives and *maximize the utility* [73]. I have proposed an incentive initiative in my research where businesses as consumers will share their energy data with others and be rewarded with incentives for being energy efficient, by the regulators of the platform. Myerson, mentions two constraints of a “*principal*” in his research, *adverse selection* which means the agents may have information which the principal cannot observe also termed as “*information asymmetry*” and *moral hazard* which means they have private decision domains which they cannot directly control [73]. The platform solution also aims to counter these risks because it will provide supervision or control by the actors based on their types (consumers, regulators or energy providers).

The theory is relevant in formulating incentives for businesses by the regulators. It also helps to demarcate under what conditions or rules the incentives will be made available. The details of incentives will be discussed in section 4.3.

2.1.3 VALUE NETWORK ANALYSIS

Chapter 5 of my report comprises of the analysis of value created from the platform and makes use of theories like Value Network analysis and Service Dominant (SD) logic to explain the proposition. The following section gives the definition of “*value*” and in the next, relevant theories is presented.

2.1.3.1 VALUE DEFINITION

The term “*value*” has been defined by academic researchers in different ways. The word “*value*” can be observed to have two different meanings, according to Adam Smith, “it sometimes expresses the utility of

¹⁵ A Professor of Economics at the University of Chicago and has made seminal contributions in the field of economics and political science. His analysis of incentive contracts in economic communication introduced several fundamental principles which are now widely used in economic analysis including revelation principle, and theorems in auctions and bargaining 72.
Myerson, R. *Roger Myerson*.

some particular object, and sometimes the power of purchasing other goods which the possession of that object convey” [74]. Smith calls these values as “*value in use*” and “*value in exchange*” [74]. It can also be defined as “fair equivalent in service or commodities that an owner/buyer receives in exchange for money” [75] Kelly et al defines “*value*” as “a measure fair equivalent in service or commodities that an owner/buyer receives in exchange for money” [76]. Allee states values are of two kinds:

Tangible value: Value which can be perceived physically e.g. money, revenue, cash, and cheque are tangible [77]. However, value which is a good or service and part of a contractual agreement is also a tangible value.

Intangible value: Values which cannot be perceived physically and usually add an additional benefit in strengthening association between two actors are perceived as intangible [77]. For e.g. human knowledge, goodwill, business relationships, business strategy, copyright. The intangible value can be used by a business to convert into negotiable forms of value, e.g. revenue.

The definition of value for my research includes attributes from Smith and Allee and can be expressed as a utility that can be tangible or intangible and can be converted into money, currency or revenues by exchanging with another actor or a group of actors.

2.1.3.2 RELEVANT THEORIES ON VALUE CREATION

Value Network Analysis (VNA)

We are aware how *value chain* as a concept has been used to understand and analyze industries for the past 30 years [78, 79]. Michael Porter describes a value chain as a set of activities that an organization carries out to create value for its customers [78]. With time, new technology has evolved and new business models have been constructed by companies, and reliance on other actors have increased. The competitive realities of a *network economy*¹⁶ require us to rethink the traditional methods of analyzing competitive environments. One such method is a *value network* where value is co-created by a combination of players in the network [80]. The strategic coupling between different actors have moved beyond the value chain dynamics into a value network dynamics where actors themselves invest collectively in building stronger and deeper relationships [81]. Therefore it can be said that value is not only created by collective action (value co-creation) but also exchanged in a value network.

Value network analysis by Allee¹⁷, offers a way to model, analyze, evaluate and improve the capability of a business to convert tangible and intangible value into negotiable forms of value (money) and in this process create greater value for itself [77]. This also helps to understand the importance of other actors involved in value exchange in the network. Chesbrough et al in his paper on capturing value from innovations has mentioned that “the realization of economic value from technology is actually derived

¹⁶ The emerging economic order within the information society. The name stems from a key attribute - products and services are created and value is added through social networks operating on large or global scales.

¹⁷ An American business consultant and founder of ValueNet Works, the leading provider of trainings, tools and methods for value network visualization and analysis. . She is a trusted advisor to more than 100 Fortune 1000 companies, with twenty years of proven business 82. Works, V. Verna Allee. Available from: <http://www.vernaallee.com/>.

from the economic and social structure of the situation, rather than only from some inherent characteristic of the technology itself” [83]. Therefore it will be presented in the analysis how social and economic factors can be influenced by using a platform solution.

There are some concepts in the value network analysis, which needs discussion. In a value network, roles, are agents who help a player to convert intangible assets to negotiable forms of value [77]. They play the role of a facilitator but their task is completed, only, when a value conversion takes place between 2 actors in the network. A transaction is the exchange of value between 2 players in the network [77] and the value to be delivered to another player is called a deliverable.

In my research, VNA will be used to visualize how businesses can create and exchange value with other actors involved in the value network of smart grids proposed through the open ICT platform for energy monitoring.

The relevance of the VNA lies in supporting the possibility of the platform in my research. From the analysis of values created by businesses and the expert interviews it may be seen as drivers for value addition through new initiatives in the society as part of the CSR strategy of businesses. The value created and added through the platform can become the next-steps of a *self-sustainable economy*¹⁸ (which will be further discussed in chapter 6 on feasibility exploration).

Service Dominant (S-D) Logic and Prosumers

The service-dominant logic by Vargo¹⁹ et al, states that “the role of producers and consumers are not distinct and value is always co-created jointly or reciprocally in interactions among providers and beneficiaries through the integration of resources and application of competencies” [27]. The indistinct role of producer and consumer has been termed as a “*prosumer*” in my research. Since consumers are producers of energy as well consumers, therefore in the chapter VNA they will be referred to as a *prosumer*.

From S-D logic, it can be argued that value is created through collective action by participants (businesses, government and energy companies) through the open ICT platform which is a collection of resources and competencies. Vargo also mentions that the created value can be converted, exchanged, to offer value additions which connect different service systems (people, technology and information) together [27].

The S-D logic underlines the value propositions for users of my platform. It is relevant because it introduces the prosumer concept, which is apt for describing the consumer in my research. The concept of prosumer is used to see whether the values created and exchanged through the platform can serve as a value addition or not. A CSR monitoring scheme is proposed as a value addition to the platform which will be explored on the backdrop of a new concept of *self-sustainable economy*. The S-D logic of Vargo,

¹⁸ Balance between production and consumption is created by consumers or members of the society themselves

¹⁹ A Professor of Marketing at the University of Hawaii, who has contributed to academic literature through his work on marketing theory, S-D logic and service evaluation.

extends the VNA of Allee to show how the platform can also add value to society and help in the transition from *sustainable* to a *self-sustainable economy*.

The theories discussed in this section provide an underpinning to the exploratory study of the topic. They help in providing the perspective to the research domain, platform design and analysis of value created. The section propounds concepts derived from literature which develops the conceptual understanding of the research. The scientific papers from which they have been derived are tabulated in Appendix A. The next section presents the conceptual model of my research.

2.2 CONCEPTUAL MODEL

The concepts of PLS, HLS, green ICT trend and sustainable economy introduced in chapter one (section 1.1) long with the above theories help in deriving the conceptual framework of the research shown in **Error! Reference source not found.** The green ICT trend of smart grid, is based on the greening rinciple of curbing power wastage and energy inefficiency. They serve as *conditions of action* or reasons for businesses to achieve energy efficiency by greening of their ICT infrastructure on the company-level. This has been referred to as the micro-level sustainability in the conceptual framework. The HLS involves events where collective action causes greening of the environment using ICT as enabler and these actions have the potential to impact larger economies, in this case, the energy ecosystem of a country. This has been referred to as macro-level sustainability.

The energy management in the PLS indicates singular action by a company; the research aims to show that a business can create impact on the energy economy when it operates through collective action. Since the leap from PLS to HLS is a big one, an open ICT platform in the meso-level can serve as means for *monitoring of actions* or the energy behavior and by that contribute to achieving the *consequences of action* as a sustainable economy. The research explores the possibility of such a platform that can help in value creation and exchange by businesses and thereby extend the sustainable economy to a self-sustainable one through value addition.

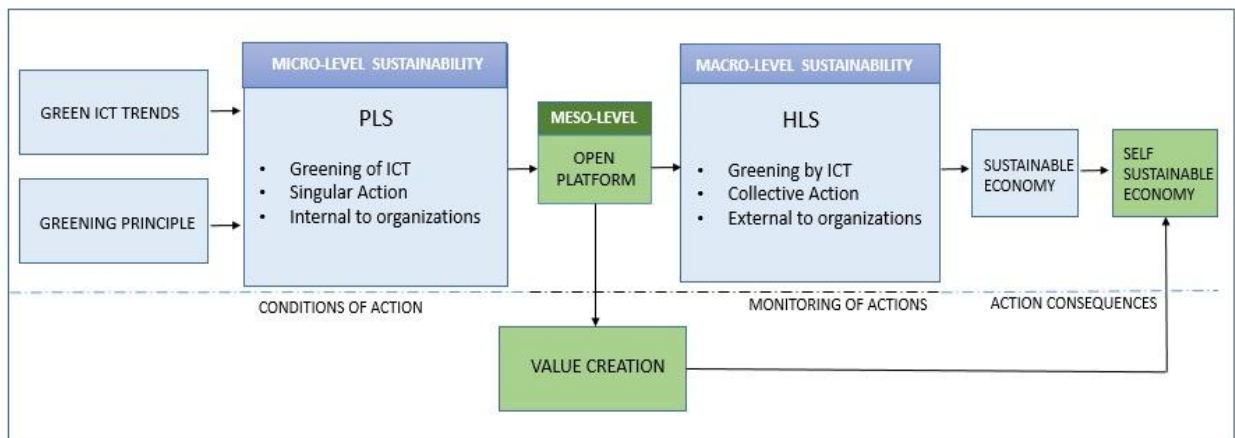


Figure 7: Conceptual Model

The conceptual model in Figure 7 visualizes the main concepts of the research and establishes the relationship between those concepts. Therefore it is a step forward towards developing the platform and implementing the research in the following chapters.

2.3 CHAPTER SUMMARY

The chapter answered the sub-question: Which are the theories that give a perspective to the research? It presented several theories which provided a perspective for the research domain, design of the platform and analysis of the value created from the platform. Each of the theories will be used to explain the research proposition in the next chapters. From the theoretical perspective of the research we now continue with the description of the domain that will give us an overview of the transition to efficient energy models like smart grids, what their service lines are and who are the important actors in a smart grid network

CHAPTER 3

DOMAIN DESCRIPTION

Ch1	Ch2	Ch3	Ch4	Ch5	Ch6	Ch7
Thesis Definition	Theoretical Perspective	Domain Description	Platform Development	Value Network Analysis	Feasibility Exploration	Conclusion

3 DOMAIN DESCRIPTION

This chapter outlines the background of the energy sector on which the case of smart grids has been presented. It forms the *Domain Analysis* part of the research as shown in the research design in fig. 5. It answers the sub research question 2: *Which are the characteristics of the smart grid domain that are important for the development of an open ICT platform?* Its objective is to give the background of the case on which the research is based and understand why there is a need to switch to smart grids. It can be divided into 3 sections. Section 3.1 initiates with an overview of traditional power grids and why they should be replaced with smart grids. Section 3.2 discusses the current smart grid network, its functions and the key players and section 3.3 delineates the generic challenges and system failures behind the adoption of smart grids. Section 3.4 presents the conclusion to the chapter.

3.1 TRADITIONAL POWER GRIDS

The electric power landscape is facing a transition from the traditional grids to a more energy efficient smart grid model. The pitfalls of the existing grid infrastructure such as its dependence on conventional input sources are to be overcome by better deployment of renewable energy sources and introducing ICT to manage the flow of data in the grid and allow in controlling and monitoring of the devices. In the traditional power grid, the flow of energy was unidirectional from the providers to the consumers, but with the transition to smart grids, the idea is to culminate the concept of closed loop value chains in energy, where the flow is bi-directional from the provider to consumer and vice versa, since the latter also have the potential to produce energy. Before discussing smart grids in greater detail, it is important to know about the traditional power grid, since the smart grid is a new phase of development within the traditional grids.

A *traditional electric* grid comprises of different stages in its electricity supply-demand process [84].

- a) Generation: consists of power generation in large power plants
- b) Transportation: energy is transported or transmitted to the area of consumption
- c) Distribution: adequately transformed energy is distributed to the end user (shown in Figure 8)

The present power grid is encountering severe challenges in addressing the energy need of the hour. Energy wastage has become a cause of increasing concern for governments, given the scarcity of non-renewable energy sources and rising energy costs. The distribution stage has experienced several transitions over the last few years with many new players such as distributed generation units, wind and solar farms and co-generation plants entering the arena. These players are bringing new possibilities and flexibilities in the way energy is traditionally managed. The expected growth of storage systems and the introduction of new infrastructures to charge electric or fuel cell vehicles are creating new energy management models.

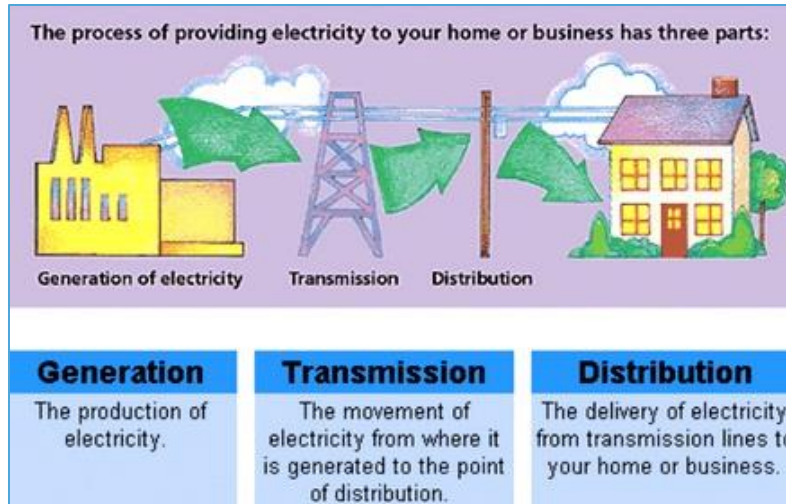


Figure 8: Traditional power grids [85]

87% of the total global consumption of energy as per 2013 (shown in Figure 9) is from non-renewable energy sources like gas, oil and coal and therefore pose a serious threat for our future generations, because these resources are finite. Donella Meadows has modeled the likely impacts of a growing population, limited resources and rising pollution in a finite world, in her book *The Limits to Growth* [86]. The model depicts exponential rise in energy costs due to exhaustion of natural resources, which suggests the economy of the world will also be hit badly, leading to collapse of the system in the 21st century. Thus, there is an imperative need for energy balance and reduction of energy costs.

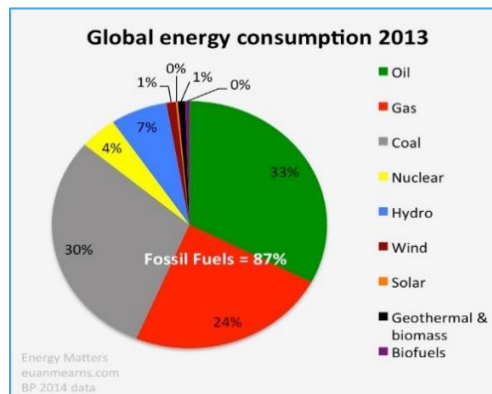


Figure 9: Global energy consumption data 2013 [87]

The next section discusses why we should achieve energy efficiency and what the drivers of such models are.

3.1.1 NEED FOR ENERGY EFFICIENCY

Ecological impacts constitute a silent cost which until recently received little attention [88]. As briefly mentioned above, the traditional power grids have proven insufficient in managing energy wastage and achieving energy efficiency. The drastic changes in climate have caused governments and companies to develop energy policies that focus on energy efficiency. To work towards the 2030 framework of the Dutch energy policy, there is a need for energy efficiency in households, businesses and governments. So, why has achieving energy efficiency become the need of the hour?

- i. **Increasing Energy Cost** - Energy cost is one of the most important factors for adopting green ICT, pointed out by Wang in the literature [89]. The limitations of non-renewable energy supplies are one of the primary reasons of shooting energy prices. Transportation and distribution also incurs heavy costs in places where energy networks are difficult to install and implement.
- ii. **Increased usage of energy and heat production in servers and data centers** - To achieve higher performance in businesses, more servers need to be installed with greater memory and processing capacity [89, 90]. The number of data centers have increased rapidly over the past years and the increased use of servers indicate more energy consumptions. The heating temperature is also increasing and to keep it in normal mode, the use of cooling equipment is essentially needed. It is estimated that servers require approximately 1 to 1.5 watts of cooling for each watt of power used [91]. Moreover, infrastructures and workstations which need to be operational for long hours are also consuming large amounts of energy. Therefore energy efficiency has become an absolute necessity.
- iii. **Environmental Protection** – Power plants and natural gas use are currently responsible for about 50% of greenhouse gas emissions, contributing to the risks of climate change [92]. The energy usage in a typical household contributes twice to the greenhouse gas emissions as a typical vehicle in a year’s time. Therefore energy management models should be such that the common man is also able to contribute towards a sustainable environment by being responsible for his own actions on energy, fuel and gas consumption.
- iv. **Improve energy security** – Energy efficiency also helps to protect national energy security [92]. Reduced energy consumption shields the economy and consumers from price fluctuations and energy service disruptions due to natural disasters or other causes. It also leaves more energy for the use of future generations.
- v. **Energy efficiency improves economy** – Energy efficiency in homes and appliances benefit citizens, but it benefits businesses, governments and cities on a bigger scale because it saves huge costs for them. It also creates jobs from building energy efficient infrastructure and projects. In 2010, energy efficiency created about 830,000 jobs in the US only[93]. It also helps industry leaders to make energy efficient innovations which led the industry to invent LED streetlights, smart bulbs etc. [93].

- vi. **Quality of Life** – Energy efficiency has direct positive impact on the productivity of businesses [89]. Residents also employ smart appliances and transportation systems which are more sustainable and helps improve the quality of life [93].

The need for energy efficiency have led scientists to research and come up with energy-efficient models which can be applied to household and commercial infrastructures. The smart grids are based on the principle of energy efficient models. But what are the drivers which led to implementation of these smart grids? They are discussed below, along with inputs from ABB’s white paper on smart grids.

3.1.2 DRIVERS OF ENERGY EFFICIENT SMART GRIDS

The global concern for environment and the need to counteract the effects of global warming are the most important drivers for an improved energy model. Along with establishing a common understanding of man-made changes in global climate, scenarios have been presented, showing how future carbon emissions can be reduced. The two major proposals are, introduction of renewable energy sources (replace traditional fossil based power generation) and create energy models where digital information can empower consumers to become responsible for energy consumption and integrate the two, to serve the end users. The significant drivers towards energy efficient infrastructures are:

- **Capacity** – Fulfilling the growing global demand of electrical energy [12]

Meeting the rise in global demand of electricity will mean adding a 1 GW (Giga Watt) power plant and all related infrastructure every week for the next 20 years [12]. The International Energy Agency estimates that between now and 2030, global investments in electrical grid infrastructure of around \$6 trillion will be needed to satisfy the world's increasing demand for power [94]. Most of the growth is expected in Asia with the construction of new transmission and distribution systems, but new investments will also be needed in the US and Europe where aging systems must be replaced [94]. To ensure that a grid's capacity is used as effectively as possible, reserve capacity and storage mechanisms, will be needed to balance fluctuations in demand and supply. Small-scale power generation needs expansion to serve local needs establish support for central power generation plants.

- **Reliability** – Providing high quality energy whenever it is needed [12]

Poor reliability is an economic disadvantage for customers [12]. To improve the reliability of the electrical networks, very large-scale monitoring systems are required. Wide area monitoring systems (and supervisory control and data acquisition systems - SCADA) can provide detailed, real-time information on the conditions in the grid[94]. Until now transmission systems have been the focus of technical improvements and distribution systems are still waiting for extended automation technologies that will upgrade their performance and enhance their reliability. From the findings in ABB’s white paper it is evident that to minimize problems with reliability and the economic disadvantages they bring, the future system must deliver top performance at every point in the chain from power generation to consumption.

- **Efficiency** – Increasing the efficiency of power generation, reduces losses in transmission, distribution and consumption of electrical energy [12]

The losses of energy during transmission and distribution account for 5-10% of the energy produced [94]. Consumption of electricity in industrial, commercial and residential applications also incurs losses. Energy management of buildings offers a huge potential for energy saving in the commercial and residential area. With energy savings, comes economic benefits. As energy generators provide more information to their customers, better informed decisions on energy use can be made, reducing consumption, cost and carbon emissions.

- **Sustainability** – Ensuring effective integration of energy models with renewable power generation [12]

Mitigating climate change requires large-scale incorporation of renewable sources into the energy mix like wind and solar. For a country heavily reliant on wind energy, if there is fluctuation in the regular wind level, then proper storage mechanisms must be in place to provide seamless power. However, to achieve this, proper technological systems are needed to connect overseas transmission links to customers' on-shore. The concept of smart grids shows the possibility for citizens to be involved in renewable energy production, consumption and monitoring.

The smart grid works on energy efficient model and is possibly the future of energy management. It can achieve its full potential only if the efficiency of all steps (generation, transportation & distribution) in the smart energy value chain is tapped and improved, which can facilitate mass adoption of this ICT trend in the energy sector. Therefore to extract maximum benefits from the technology, the consumer needs to be aware and empowered with responsibilities in energy management, which my research aims to propose through the open ICT platform for monitoring energy in smart grids. It will allow them to participate in the network through collective action and contribute towards sustainable energy balance.

3.2 CURRENT SMART GRIDS IN THE ENERGY SECTOR

It is necessary to have an overview of the current smart grid technology before advancements can be proposed to efficiently monitor and manage the technology which is one of the significant objectives of my research. A sketch is presented in the next sections.

3.2.1.1 SMART GRIDS

To satisfy the increasing demand for power, energy efficiency and the need to reduce carbon emissions, an energy model that can handle challenges in a sustainable, reliable and economic way was required. Smart grids are a promising technology that has the potential to solve the energy crisis of the world through collective action in a smart network. The technology is a combination of renewable energy grids, hardware, management and reporting software (ICT), built over a foundation of an intelligent communications infrastructure [95]. It possesses demand response capacity (on-demand energy provisioning) and balances energy consumption with the supply. There is a possibility for consumers, energy providers and utility companies to manage, monitor and respond to energy issues in a systematized way.

3.2.1.2 FUNCTION OF SMART GRIDS

The primary function of smart grid is to curb energy wastage, energy inefficiency and integrate renewable energy sources into the grid to relieve pressure off the non-renewable sources. The following list is a summary of the envisaged functions of smart grids that has been enlisted after the study of literature on the Safety analysis of smart grids by Ugboime [95], Vision and framework of smart grids by Li et al [96] and The Path of smart grids by Farhangi [97].

- Smart grids efficiently manage demand and supply response of the grid
- Improves power quality due to on-demand provisioning
- Reduces carbon emission and delivers a sustainable solution for energy
- Matches increased demands of energy that require complex and critical solutions
- Proactively manages energy networks during emergency situations of power outages [95]
- Ensures profitability for distribution companies by transparent billing and collection
- Ensures profitability for consumers in terms of energy transparency through real time data
- Saves cost as energy flow becomes bi-directional with flexibility in consumption and storage, as reserve for later use [95]
- Empowers consumers by allowing them to participate actively in the network

The next section describes who the key players are and what the service lines are in a smart grid. The following section will give a clear understanding of the position of businesses as consumers in the smart grids network, from whose perspective my research has been conducted.

3.2.1.3 INDUSTRIAL CONVERGENCE

By and large, the smart grids implementation runs over the intersection of Energy and High-Tech Systems and Materials top sectors of the Netherlands with ICT as an enabler. Each of these sectors not only makes use of the smart grid network but also contributes to its application. As part of the Dutch Energy Policy, 17 projects on smart grids have been launched in the country with a total investment of 25.9 million euros and 56% share from companies in 2012 and 5.7 million euros was allocated by the Dutch government in 2013, when another 24 project proposals were received for launch before 2015 [98]. The Dutch government has plans to create an energy ecosystem by 2020 at both local, national and international level, where they shall facilitate match making by bringing different stakeholders together in the energy innovation network for R&D and implementation purposes [98]. The pilot projects will play a significant role in the implementation of smart grids on a large scale across the country and neighboring countries stimulating top sectoral co-operation and market application, which will be the first steps towards the 2030 energy policy framework.

3.2.1.4 KEY PLAYERS IN SMART GRID & SERVICE LINES

The smart grid is an integration of new capabilities over the foundation of traditional power grid. With the introduction of smart technologies, scientists looked for ways in which they could utilize smart devices in efficient energy management. This paved the way for constructing smart home & appliances, integrating renewable energy sources in the power grids, charging electric vehicles, empowering consumers with energy data through smart meters and on-demand energy provisioning and consumption. With time, digital information became an intrinsic part of technology and business models and also comprised of the top layer of the smart grid architecture. Apart from smart grid's technical infrastructure, a lot of emphasis is being given to data security, big data analysis, and efficient data management techniques, data reporting and real time data monitoring, currently. It is believed by researchers that with the development and fast evolution of the top layer, the challenges involved in smart grid implementation and adoption can be solved. The engineered components of the top layer help to analyze, monitor and control utilities and electrical assets 24x7, including functioning of digital elements and software applications [13].

The smart grid architecture by Alstom aptly sketches how ICT forms the top layer in the architecture, thus building upon the traditional structure and new capabilities of smart technologies and devices. The architecture presented in Figure 10 gives a clear understanding of the meso-level of my research which constitutes specific features in the top layer. The open monitoring platform that will be proposed includes some of the capabilities of data monitoring and reporting of the top ICT layer.

The new capabilities are being developed and experimented as part of the 17 pilot projects launched by the Dutch government across various places in the Netherlands [98]. The top layer in the architecture comprising cyber security, big data analysis, community energy management and online stability still presents many challenges which needs to be investigated and solved. Each component in the grid must work in sync with the other to extract the maximum benefit from the technology. Energy flow generates

huge amounts of data which needs to be managed and organized efficiently, so that the actors involved in a smart grid network can benefit equally.



Figure 10: Smart Grid Architecture by Alstom [13]

Key players in Smart grids network

A smart grid network has several actors and they can be classified under the following 3 categories.

1. *Technology users:* Households, businesses and academic institutions comprise of consumers who use the technology to consume and manage energy.
2. *Technology Regulators:* Policy makers in government institutions comprise of regulatory bodies.
3. *Technology Providers:* are the energy companies, grid operators, utilities and service providers, distribution and operation units, high-tech electronics and ICT companies.

The aforementioned actors are the primary players in the smart grid network. There are other actors too, e.g. energy traders and energy market analysts and customer service units of energy providers, who participate in the network which have been shown in Figure 11.

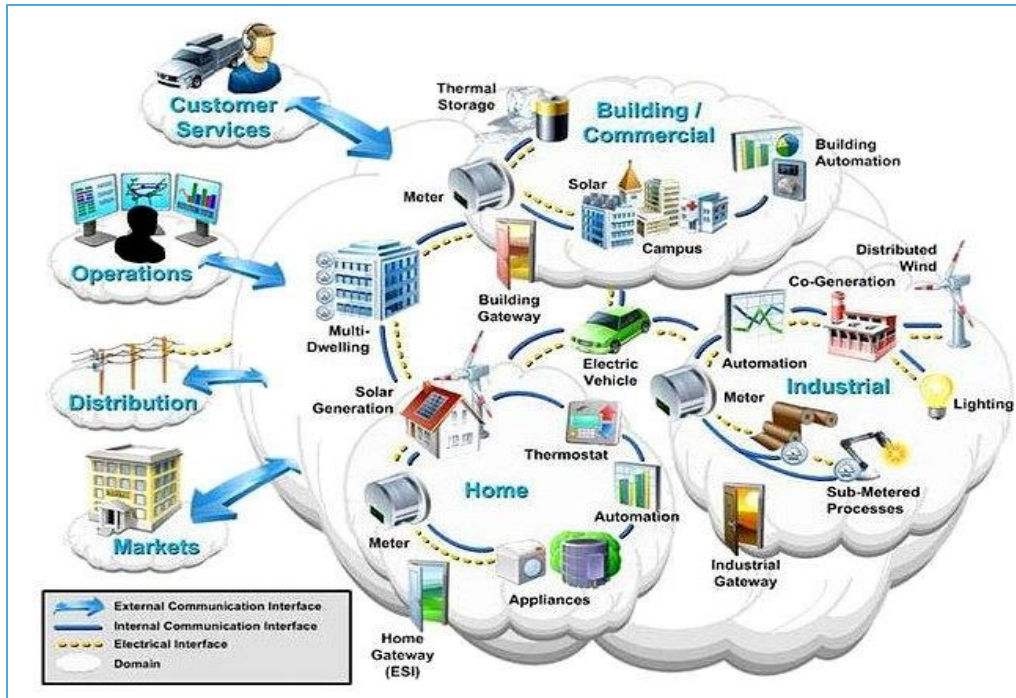


Figure 11: Smart Grid Network [99]

The energy efficient smart grid can be seen as a socio-technical model with the presence of a structure (grid infrastructure) and agents (actors) which are inseparable according to Giddens structuration theory. There needs to be a balance in the operation of the structure, guided by rules and conditions formulated by the agents, which can be termed as the “*duality of structure*” [39]. Hence each actor involved in the smart grid network is responsible for certain management aspects. The energy providers and grid operators monitor the energy supply and balance the network, the regulators frame policies for the future based on the operations, and the consumer controls their consumption. Without the balance, the model cannot operate. Giddens refer to change of established structure by agents to suit the present needs of the society; similarly future efficient energy models must be established in place of high energy consuming traditional power grids, to protect the finite resources of the earth. When a present structure renders inefficient, the agents must cooperate to transform the structure. The *conditions of the action* as referred by Giddens can be compared to the need for energy efficiency, which leads to creation of smart grid model that requires monitoring (*monitoring of actions*) for achieving a sustainable target as a *consequence of the action*.

The focal point of my research constitutes of the businesses as consumers and how they can create value for the society and contribute towards sustainability.

Service Lines in Smart Grids

The service lines of smart grids need to be discussed to understand the role and participation of the actors in the smart grid. The smart grids have internal, external and electrical communication interfaces which are depicted in the Figure 11, indicating how each component communicates with the other. The service lines are as follows:

Production: Electricity is provided from grids which are connected to renewable energy sources e.g. solar panels and wind farms. Non-renewable energy grids are also connected to the micro-grids to ensure continuous energy provision for an existing city in the process of receiving smart make-over. Later, when efficient storage mechanisms are investigated, energy provision can be solely from renewable energy.

Transmission: Traditionally electricity has flown from a power grids to consumers, but with smart grids, power enters the network from multiple locations, including the distribution networks. These sources are cleaner and more efficient. For example, combined heat and CHP power plans are 75% more efficient, compared to traditional generation which is only 49% efficient on an average [100].

Distribution: From the micro-grids where renewable energy is being fed, power is distributed through transmission lines to localities where smart homes, commercial hubs and institutions are all connected in the smart network. The sustainability monitoring open platform proposed in my research presents opportunities in the distribution and operations line of services.

Storage: Additional energy produced has extensive and sophisticated provisions for storage. When some regions are in need of more energy than others during peak hours, the excess power can be transported to those places. For this, super electricity highways may be built as part of the grid, which can transport electricity at a rapid rate in the future.[100]

Operations: It comprises of monitoring the grids and energy flow in the system. State of the art applications and reporting software are used for tracking the performance of the smart grid. It is possible to detect routine problems and treat them, minimizing downtime and financial loss for businesses. All the data that is generated from the energy flow in the network has to be managed and organized so that it serves the required demands, hence the operation services ensure proper data communication and information systems integration.

Customer Services: It is a key service line which deals with all aspects of customer information and billing. Some of the common issues faced by consumers are data transparency and payment issues, electronic billing, energy sale through the grid, interoperability of all the smart appliances with the smart meter etc.

Markets: A well evolved market for energy trading exists presently. With the improvement in smart grids, this market will only evolve. Markets represent the buyers, sellers, energy traders, bidders and analysts who organize and manage energy exchange at the financial level [101]. The energy trader must be aware

of detailed information on energy pricing and the quantities of energy that a company is producing or selling through the grid. The trader has the task of registering offers and bids from energy provider companies and matching them with the needs of other buyers [101]. Currently individual consumers do not have access to these markets.

Commercial: This line of service is where consumers like businesses can sell the energy they produce and make profits from the energy sale into the grid. It has been seen that individual contribution to the grid can be very less, since the solar panels installed on a smart building office may not have the capacity to contribute as much energy to the grid as to receive profit from it. Technical challenges can also be a cause of concern if the businesses as producers of renewable energy are selling the energy to the grid operators, because they need to install expensive storage mechanisms where they will store the reserve energy. Hence an efficient energy management model must be investigated, so that maximum value can be extracted from the network using new methods.

From Figure 11, it is clear that there are various actors in a smart grid network, who must cooperate to implement the system. The end consumers who benefit from the network are businesses, consumers in smart homes, commercial complexes, institutes etc. The energy providers are central renewable and non-renewable energy power plants which are connected to the network through smaller grids (micro grids), processors and sensors. Then there are grid operators who distribute the energy from the plants to the end consumers and control the transmission through the micro grids and storage facilities. The utility service companies are responsible for servicing the equipment in the grid and those in the locations of the consumer.

The next section describes what the current setting of the smart grids looks like and understand the roles and interactions of the main actors: business and local government as consumers and energy companies.

3.2.1.5 CURRENT SETTING OF SMART GRIDS MODEL

The current setting of smart grids are depicted in Figure 12 where smart meters send real time energy information of consumers (businesses) to dedicated servers of energy companies through the 3g network. (In Figure 12, the energy companies and grid operators have been viewed together as energy companies, for the ease of research modeling; in the Netherlands, both are separate entities or actors) Presently energy companies and grid operators have access to data, of how much energy, the individual appliances of a consumer (business) location consumes, consequently, there lies a huge risk of encroaching into customer privacy.

The red lines in Figure 12 shows the electrical connections between the businesses and energy companies and the blue lines depict data flows between consumers and servers of energy companies. The diagram is an overall representation of power and data flows in the current smart grid network and does not specify the technical details of components installed in the network. The hubs are locations where grid operators maintain and control the flow of power in the grid. The energy companies produce electricity from renewable energy sources which flows through the smart grid and reaches the businesses (consumers).

The energy consumed by individual appliances in a business facility is recorded by smart meters and sent over the 3G network to servers owned by energy companies. Against the energy consumption information the energy companies set the energy prices and the billing information is transferred over the 3G network to the smart meters thus providing consumers with real time information on energy prices, which will help them to adapt their energy behavior. Usually the energy companies also provide consumers with demand response software through which consumers can visualize the energy consumed by them against the average energy being used in the grid at a particular time. Thus the present system operates on a subscription model, where energy consumers subscribed to a smart grid operated by an energy company is provided with a demand response management software (DRMS) for monitoring the energy behavior apart from the information that gets displayed on smart meters. Several energy companies also provide demand response mobile apps to their customers to make monitoring easier and less time consuming. The present system of energy monitoring through DRMS can be compared to contributing towards sustainability through singular action. The DRMS and smart meter in homes or businesses operate between the energy providers and consumers. Due to a lack of open standards in data sharing, consumers can access energy trends of the grid they are connected to only, and not the consumers outside their grid to compare the usage trends. In the current system, the energy trends and energy market information is not easily available to the consumers.

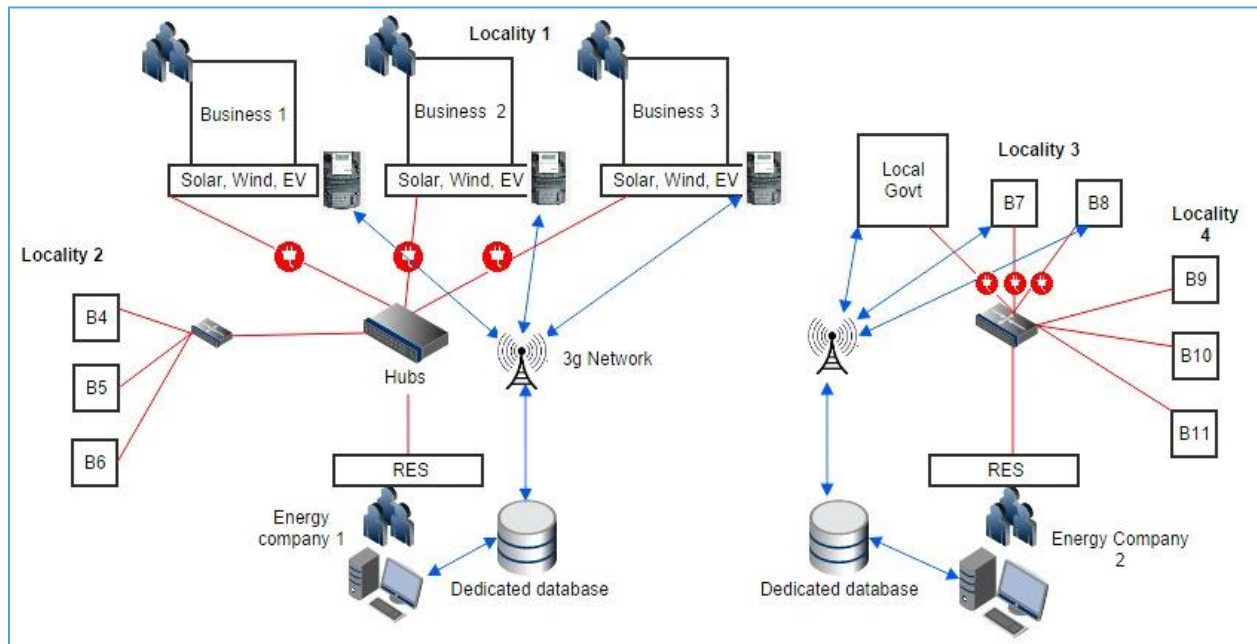


Figure 12: Current Smart Grid Network

The following section discusses the challenges that the implementers of current smart grids are confronted with.

3.3 CHALLENGES IN ADOPTION OF SMART GRIDS

This section discusses the challenges to give an overview of the hindrances which must be tackled before the proposed platform solution can work at its full capacity in the future. It is possible that the platform-

based solution can also become a driver for actors to adopt smart grids technology, since it provides them with more control over monitoring their energy behavior.

The McKinsey report of Smart grids in Europe states that adoption and implementation of smart grids in Europe has been slow due to multifarious reasons of which uncertainty about standards and lack of support among consumers are significant ones [102]. The challenges can be classified under Technical challenges, and Generic problems in adoption. The open ICT platform for energy monitoring in this research aims to tackle the consumer challenges.

3.3.1 TECHNICAL CHALLENGES

The challenge concerning smart grids is that, the current infrastructure requires technical and collaborative augmentation to support growth. There are system failures which has impeded its growth in large scale applications which must be analyzed to establish the research objective.

- **Technical Inadequacy:** The traditional power grid infrastructure needs to be woven into the new smart grids system which requires major overhaul and augmentation for supporting new infrastructures [103]. Renewable energy sources cannot be solely relied on, for producing energy and needs to be integrated with grids from non-renewable sources of energy like coal, thermal and hydro power stations for seamless energy supply. Some of the old legacy systems cannot be retrofitted with smart systems due to incompatible components and in such cases entirely new systems have to be installed [103]. Even if the smart infrastructure is in place, efficient storage mechanisms need to be investigated to store the excess power produced during off-peak powers, since the micro-grids can operate with a certain capacity.
- **Information Challenge:** The dependence on ICT has increased exponentially with the implementation of smart grids but from the consumer's perspective the challenges have become bigger. With deployment of smart grids the customers have become involved shareholders in the energy value chain who can either help in faster adoption or hinder its growth [104]. Hence there is a need for consumers to be aware of the energy consumption data which has been possible through smart meters. The smart meters record energy consumption by individual households or organizations, facilitate electronic billing and establishes two way communication between the meter and central systems [105]. The demand response software support consumers to minimize consumption during peak hours, thus reducing energy costs. The current smart grid operates on the basis of singular action based on demand response management software where consumer can only view real time information of the peak and off peak hours but does not realize how their action will affect the macro energy ecosystem. The element of collective demand and supply response management is missing in the present system. For consumers who are also expected to produce energy from renewable energy sources, the availability of information should be there for them to see the market trends and make their respective energy trading decisions. The lack of information can be perceived as a hindrance in the faster adoption of grids by users, because they do not have substantial additional value to receive other than lowering costs during peak hours. The current demand response technology emphasizes the importance of consumers in energy control but restricts the understanding to an individual level.

- **Business-It Alignment (BITA):** The ICT applications which are driving the smart grid technology often meets with poor support management, inadequate requirements gathering and ineffective communication between business and technical stakeholders. This often leads to the failure of incremental value provision which complicates the roadmaps of technology in reaching the consumers. Therefore it is important to note that communication and management between technical and business stakeholders form an important aspect of the smart grid technology. When certain new features are installed in a smart meter or the demand response software application changes, then the new modes of operation needs to be communicated to consumers efficiently.
- **Institutional Challenges:** With the implementation of smart grids, new energy and regulatory policies will be needed for efficient governance and management of the systems. A common standard formulation cannot be possible over a short period but will come with development and testing of the infrastructure and negotiation with various stakeholders [106]. Also, regulatory policies for controlling the consequences of smart grid operations like fixing peak and off-peak hour tariffs are essential aspects which must be in place before making these grids operational widely. The quest for smart grids standards to facilitate interoperability between systems, best practices over cyber security, data management and governance of collaborative behavior are some of the major institutional challenges which are being faced today.
- **Data Management:** The smart grid generates massive amounts of data which raises concern for management and governance. At the present, for every 5 million smart meters installed about 30,000 devices are used to monitor them in the grid. As the smart grid develops and is adopted widely the number could increase thousand-fold with each device carrying thousand times more information compared to the current situation. Erik Udstuen, general manager at GE Fanuc Intelligent Platforms has aptly quoted “though so much data may be difficult to process, it could also create opportunities for entrepreneurs to develop new monitoring applications, especially if open standards are developed” [107]. With the grid being inundated with information, there is a possibility that efficient customer service systems need to be installed, because consumers should be able to clarify their doubts over the energy behavior with tele-callers for example.
- **Security:** As more technology paves its way through the grid, providing more connections into the energy infrastructure the concerns for protecting the environment will increase [107]. Since majority of the connections will require high speed internet to transport energy data to the grid and central systems there is going to be an imperative need to address cyber security. The smart metering and control system relies heavily on wired and wireless networks thus increasing the risks of cyberspace attacks. There can be issues like financial frauds, miscommunication of authentic data, environmental accidents and a host of potentially other disastrous effects [108].
- **Spill-Over Effects:** Smart grids have caused information overload in systems. The big data needs to be managed efficiently. While implementing the grid, much of the focus has shifted to manage the big data through modern analytic tools and software, so that seamless operation can be performed. The slow adoption of the smart grid has given edge to some businesses over the others. There are often delays beyond the control of the key players, for example, a policy or regulatory issue or a complex decision making issue by the government or simply a technical feasibility analysis of a region failed to meet some criteria. Such disparity in the process of adoption and transition has left some businesses to profit over the others thus assuming negative spillover effects in the way of smart grids.

3.3.2 GENERIC PROBLEMS IN ADOPTION

Some of the general issues that are impeding the adoption of smart grid networks are as follows:

- *Lack of market power for smaller utilities:* Deployment of advanced technology is easier for bigger utilities because they have more internal resources and can deploy them to a large number of sites where they have much to offer to their vendors. Alternatively smaller utilities do not possess economies of scale²⁰, which means their infrastructure is not as smart or cost effective [109]. The smaller utilities often confront with challenges of market power which can be possibly overcome by key business partnerships or foraying into the production specialized products.
- *Collaboration between stakeholders:* Bringing together stakeholders with a common goal usually takes some time, because in order to understand partnership preferences, consortiums need to be formed, conferences are held through which match making takes place. Often online bidding is also launched by governments to bring actors together in the network, for e.g. energy companies, utility companies etc.
- *System and Application Interoperability:* For infrastructures which are getting upgraded to smart grids, there are a lot of interoperability issues. Total overhaul to the smart infrastructure can incur very high investment costs. Hence re-use of traditional systems in the infrastructure is bringing these issues to the forefront. In the current system, the demand response software operated by the grid operators also need to be interoperable with applications of other providers, if they wish to connect systems and market.
- *Communication standards:* Organizational barriers and legacy information systems have made it difficult to share information. Transparent processes can help to conserve energy and benefit the consumers. Therefore more open data standards need to be encouraged and developed by policy makers to extract full value from smart grids and minimize data duplication.

3.4 CHAPTER SUMMARY

The domain chapter answered the sub-question: Which characteristics of smart grids are important for the development of an open ICT platform? It gave an overview of the transition from traditional power grids to the smart grid model and pointed out the reasons for the transition. It provided a background of smart grids, what their functions are, the key players involved in the network and explained the current setting of the smart grids. The chapter ends with discussion on multifarious technical and general challenges which the smart grid is facing in its adoption, which must be tackled before the proposed platform solution can function at its full capacity. The next chapter focuses on the development of the platform based solution in future smart grids.

²⁰ Increase in production causing the costs of production to decrease.

CHAPTER 4

PLATFORM DEVELOPMENT

Ch1	Ch2	Ch3	Ch4	Ch5	Ch6	Ch7
Thesis Definition	Theoretical Perspective	Domain Description	Platform Development	Value Network Analysis	Feasibility Exploration	Conclusion

4 PLATFORM DEVELOPMENT

Chapter 4 presents the platform design for the future smart grid solution, after the domain has been discussed in chapter 3. It forms the *Design Analysis* of the research as shown in research design in fig 5. It answers sub research question 3: *How does the high level design of the open ICT platform look like?* The objective of the chapter is to design the platform solution for future smart grids which can serve as a link between PLS and HLS in the energy sector. It is divided into 5 sections. Section 4.1 explains the assumptions made in the study. Section 4.2 introduces the platform based smart grid model in a network diagram. Section 4.3 discusses the incentive initiative in the solution. Section 4.4 formulates the design criteria which leads to the construction of a high level design of the platform and delineates its functions. The chapter ends with a conclusion in section 4.5.

4.1 OPEN ICT PLATFORM

The “platform” label has found use in many industries and businesses, often quite liberally [110]. The traditional definition of platform includes interaction, mediation and network externalities²¹ as important conditions, but to this, in the present day, complementary innovation, value creation, value exchange and a necessary role of ICT has been added [110]. The theoretical perspective provides several definitions of a platform in section 2.1.2, but the one that defines my proposition is, *an open ICT platform is a digital information system with ICT capabilities that allows different users to cooperate and contribute towards a shared goal by accessing shared resources* [26, 51]. The open ICT platform gives *access* to more actors, allows them to *participate* in monitoring actions and *collaborate* over the value that they create for each other [53]. The “*openness*” of the platform according to Smith and Janssen et al, is seen as a platform that houses information which are in the range from less open to more open and can be effectively used for promoting growth of a knowledge based economy [53, 64]; The proposed platform allows more actors to participate and contribute towards value creation, of which sustainable growth of the economy is the most important. Smith’s argument indicates that information was being shared earlier too, but now the scope of recipient’s increases. This is true because, currently energy companies do share their data for contributing to better user experience with the grid operators, which will be extended to consumers in my research. From Janssen et al’s view, we can conclude that the open data will be beneficial for consumers, and can influence the knowledge growth, from where consumers will be able to make informed choices about energy consumption.

Next, we move on to some of the assumptions that my research makes which are addressed in the following section.

4.1.1 PLATFORM ASSUMPTIONS

The research is an exploratory study of a future platform which can be implemented when the following conditions or assumptions are met.

²¹ Effects that several users of a product or service has on a particular user. If the effects are positive, they called positive externalities and if the effects are negative they are called negative externalities

Eisenmann's open platform theory is used in this section to understand briefly the assumptions on the governance of the platform. His theory states that every platform has 4 major actors: demand side users, supply side users, platform providers and platform sponsors. The assumptions made in this research are:

- The *technology users* or businesses as consumers are the *demand side users* since they will use the platform as an instrument to monitor energy behavior.
- The platform can be also used by the *technology regulator* or the government to assess the energy performance of businesses, therefore they are also a demand side user, but this analysis of the government from a user's perspective is not included in this research. The government acts as the *platform sponsor*, in my research, who governs the platform interactions and holds the IP and operation rights. It is possible that a consortium of companies can also become platform sponsors along with the government to fund the project and implement it on a mass scale.
- The *supply side user* are actors who provide complements that will be employed by the users of the platform for e.g. technology companies providing add-on features or plug-in software. The *platform providers* are the technology companies who provide technological components to implement the platform and provide support for it. It is possible that third party technology companies can be appointed by the government or consortium to develop the platform, and to maintain it. This role of supply side user and platform provider has not been analyzed in my research. The primary focus is on the demand side users of the platform and also the platform sponsor for explaining the ownership.
- The energy companies abide by the government's policy on open standards, i.e. individual businesses will be able to view the real time average energy consumption in the grid, consumption of a similar cluster of companies distinguished by their industries, business units or types. Therefore energy companies agree to share their customer's data into a cloud from where the platform receives data.
- My research explores a case where smart meters are widely used in business locations, but this comes with the assumption to meet the privacy concerns of the Dutch government and consumers. In the current smart grids, energy companies collect the energy consumption data from the smart meters of consumers which include data of individual appliances in the household or business location of consumers. Therefore a large chunk of private data is also passed on to the energy companies which they can use for encroaching into customer privacy. The energy companies can track the preferences of an individual based on this data and give customers lucrative deals and offers or sell the information to other companies who can market their products and services based on this information. For e.g. from the energy consumption data of a coffee maker in the household of a consumer, energy companies can know a lot about the beverage preferences of a consumer and direct consumer electronics companies to advertise similar products to the consumers.

The smart meters in this research are implemented in business locations with the technology of data masquerading that sends the summation of energy consumption data to the energy companies and not individual energy consumed by appliances. This prevents other companies from encroaching into customer privacy and can also serve as drivers for energy companies to share the information.

The 2020 energy policy by the Dutch government states that 80% of the country must have smart meters implemented by 2020 and not abiding to switch over to smart meters can lead to penalty of 17,000 euros or six months in prison [111]. However owing to privacy concerns, the government has recently backed down and announced that use of smart meters should be made voluntary for customers [111].

- The smart meters are always connected to the grid, network and cloud, thus providing accurate real time information for monitoring energy through the platform.
- Security standards have been well investigated and implemented for moving energy information in a cloud, from where consumers, energy companies employing the smart grids in a city and the government can access energy consumption information of their customers and citizens respectively through the open ICT platform.
- The consumers (businesses in this case) and also households are both producers and consumers of energy in the smart grid. Each of them have facilities for renewable energy production and participate in green energy production and smart consumption.
- The energy companies and grid operators are seen as a single entity in this research for simplification of illustration and value network analysis, but in the Netherlands they are two different entities.

This section discussed the assumptions made in the research. The following section introduces the platform-based smart grid model of the future.

4.2 PLATFORM-BASED SMART GRID IN FUTURE

This section presents a network diagram of a platform-based solution for future smart grids and shows how the new scenario will look like when the data is stored in a cloud or a common server from where the government, energy companies and businesses can access data through the platform.

The platform based smart grid network operates keeping into consideration the assumptions stated in section 4.1. Unlike households, an average business facility is big and therefore requires several smart meters to monitor the energy consumption. These smart meter recordings are offline and collected by a collection smart meter which is connected to the network but equipped with data masquerading technology such that energy consumed by individual appliances by a business does not get transferred over the network. The business is able to view the data consumed by individual appliances on the smart meter displays, but only the summation of the energy consumed by the entire facility gets transferred over the network. This can ensure privacy over customer data and also become a driver for energy companies to share data with others in the network.

In the platform based network, the energy data from a business subscribed under the network of a specific energy company is transferred to a data cloud which also stores data of consumers connected to grids of other energy companies. Advanced security standards are investigated and implemented for transporting

data into a common cloud (the back end of the open platform), is one of the assumptions that the analysis makes. The data flow lines (blue) in Figure 13 now not only transfers energy data from the smart meter to the cloud and receive billing information (set by energy companies under price regulation of government) but with the introduction of the open ICT platform they can monitor energy through it and the platform sponsor (government or a consortium), monitors the energy performances of all consumers through the information available in the cloud.

The energy companies owning smart grids share their data in the common platform which can be aptly termed as open but under specific conditions of data layering. Data layering conditions mean that no business or Energy Company can view the exact energy consumed by other businesses but only see the average real time energy consumed by others based on groups and segments for which they have permission (decided by the platform sponsor or government). This will enable a particular business house to keep their consumption below the average consumption of the groups and segments they are subscribed to in order to contribute towards sustainability. Incentives can be a possible method of reward by the government to the energy efficient businesses, which will be discussed in detail in section 4.3.

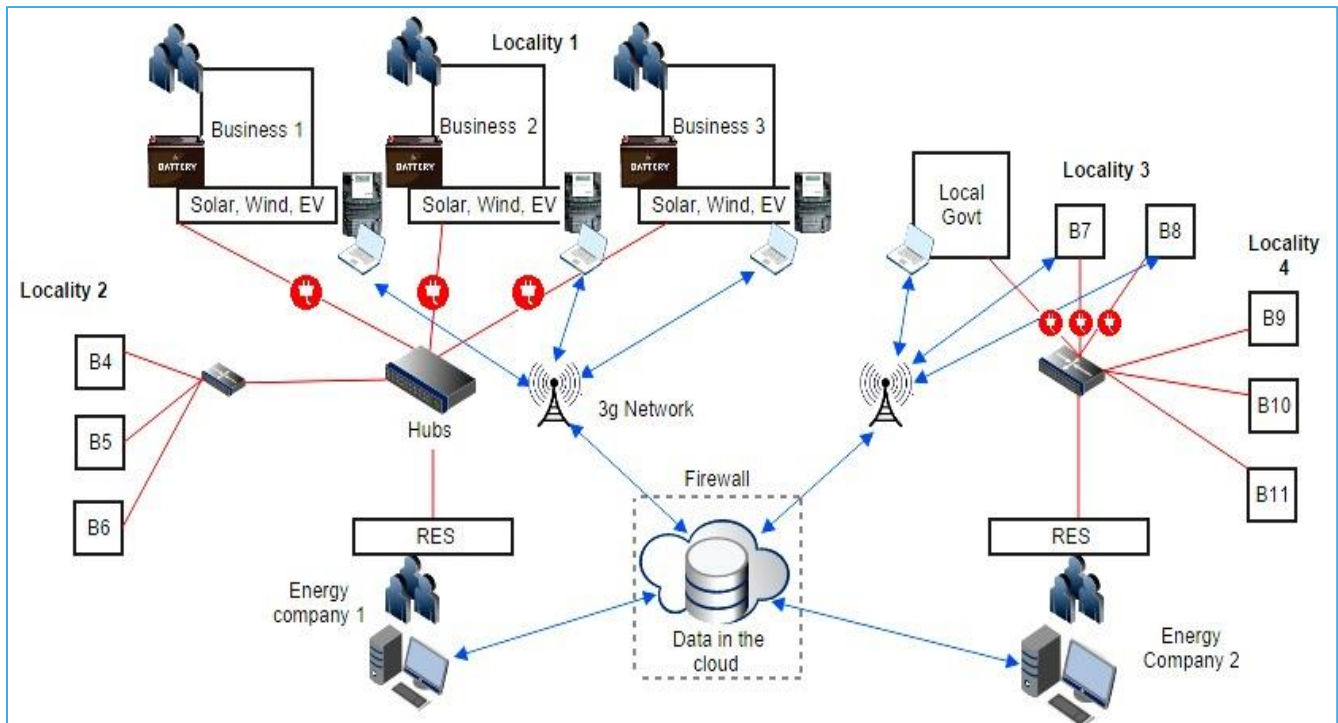


Figure 13: Platform based Smart Grid Network (blue pointers: data flow | red pointers: energy flow)

The energy companies and businesses can contribute towards sustainability in a number of ways by sharing their data through the open platform:

By monitoring the real time energy consumption of its own facility compared to that of other businesses in the grid, locality or city, through the platform, a company can understand exactly its position in the energy consumption trends of the similar type of business, sectors and the energy market.

If each company tries to monitor their energy behavior and reduces their energy consumption the level of average consumption of the grid, then it brings down the energy consumption of the whole grid, or several grids in the locality and city. The collective action of consumers in this respect can drive the total consumption of energy in the economy lower, towards the average energy consumption of the grid.

This platform solution is more useful when businesses also produce energy in their facility, because when the demand is high in the grid, they can use their own energy to reduce the soaring energy prices and during off peak hours when the demand in the grid is low, they can switch to receiving power from the grid. The control over this energy behavior can be provided through the open platform, because it not only shows the consumption of a group of companies in the grid, but also outside the grid.

The other metric, through which a company can monitor its energy sustainability is by comparing its energy savings with respect to the previous year, month, or week. The platform can be a form of self-assessment based on which they can receive incentives, and since the initiative aims to involve several companies to compare their own energy savings, therefore the resultant collective action can lead to a sustainable economy.

In the theory of collective action, Olson as well as Nikayin, point out that collective action is dependent on 3 characteristics of a group [26, 44]:

Group Size: The businesses who can use the platform can range from small to big businesses and the platform sponsor must record the size of the business, the resources they employ and the average number of customers they serve to be able to categorize them according to groups of segments. This can lead to a more fair assessment of sustainability performance in terms of energy behavior.

Group Heterogeneity: The heterogeneity of a group is about the type of members who are present in it. Each business belongs to a particular sector and type. For e.g. Unilever is an FMCG company (Agri-food top sector) and is a production company by the type of business. The data layering strategy discussed below will give further insight into this.

Group Interdependence: This shows whether a business is dependent on another in terms of resource or knowledge sharing through the platform. The platform can function only when different businesses participate and share the information with others, therefore the interdependence in terms of running the platform is high for businesses.

The following data layering strategy is an important aspect of the platform based smart grid. They appear in the order in which they will be categorized to access energy monitoring information easily.

- *Business to business based on size and resources:* The businesses need to be categorized according to metrics like the size of their facility, scale of operation, number of resources that use energy, number of physical resources employed to be able to classify them for the incentive based sustainability drive by the government. This categorization is essential to bridge the large gap between big businesses and

corporations and small and medium scaled companies. The categorization with the help of metrics shall allow fair assessment for monitoring sustainability by the businesses. This information can be registered with the local government who provides license to these companies for doing business.

- *Business to business in the city:* The companies will be able to view information on average energy consumption of different businesses in the city-level based on the following 2 categories.
 - *Industrial sectors:* The industrial sectors are the top sectors of the Netherlands e.g. Agri-food, Chemicals, Creative Industry, Energy, High Tech Systems and Materials, Life sciences and Health, Logistics, and Water. For e.g. Eneco, Amsterdam energy company can view average energy trend of energy providers like Essent, E.ON and DGB Energie in Amsterdam etc.
 - *Type of business:* The type of business is whether a business is retailer, manufacturing, research, production, IT outsourcing, service consulting, banking and insurance, welfare, cottage industry, handicraft, construction etc. For example, IBM Amsterdam can view the average energy consumption of all IT consulting companies in Amsterdam like Accenture, HP, and HCL etc.
- *Business to business in the municipalities or districts:* A company can view the energy trends of other companies which are located in their municipality or districts. For e.g. Wippolder, Tanthof in Delft. These businesses are also based on the same classifications as mentioned above.
 - Industrial sectors
 - Type of business
- *Business to business in the grid:* A company connected to a particular smart grid can view the average energy trends of other companies in that specific smart grid based on the following groups.
 - industrial sectors
 - type of business

The initiative of rewarding the energy efficient businesses is taken up by the platform sponsors (government/consortium). With such an arrangement of an open ICT platform under specific conditions of data layering, businesses can be empowered to monitor their energy behavior and bring down the average consumption in the grid and therefore the consumption of energy of a country.

A business in a smart grid is capable of producing energy from renewable energy sources like solar panels, wind farms (if it is situated in a big area) from their facilities and use it themselves or sell it to the grid. In the proposed platform based smart grid, the flow of energy is unidirectional, from the grid to the consumers, where the latter uses the energy they produce themselves and does not sell it to the grid. The open ICT platform helps consumers to monitor when they should use energy from their own production and when they should use energy from the grid. Possible models can be constructed in the future, where energy flow is bi-directional, from the grid to the consumers and also from consumers' flowing to the grid to help the grid operators maintain network balance.

In the proposed solution, the scenario, during off peak hours when energy consumption of the grid is low, offices can use power from the smart grid and pay lower prices for the energy. During this time they can store the energy produced by RES in their facilities in a battery (shown in Figure 13). During peak hours of office (morning and afternoon) when the energy demand of the grid or that of the sectors and business types shown in the platform, is high, the power in the battery can be used for consumption. This can bring down units of energy consumption during peak hours and simultaneously energy prices with it. In this arrangement, a large upfront cost must be invested by businesses for installing sufficient and high powered batteries in business locations, but the incentive initiative by the government can act as positive driver for creating value for themselves and the society as part of their green ICT strategy or corporate social responsibility²² endeavor. The incentive initiative will be discussed further in detail in the next section.

4.3 INCENTIVE INITIATIVE

The incentive initiative launched by the government can act as a driver for businesses to participate in the platform based smart grid solution and monitor their energy performance. The initiative is analyzed on the backdrop of the incentive mechanism of the Principal-Agent theory in economics as analyzed by Myerson [73].

Following the terminology of Myerson, the actor with the control of the platform i.e. we term the government as the *Principal* and the businesses using the platform as a monitoring tool are termed as *Agents* [73, 112]. The general criteria which allows a company or business to receive sustainability ratings and become liable for incentives are:

- They must be producers of renewable energy (e.g. solar, wind etc.) and employ batteries in their facility for storing reserve power produced during off-peak hours (irrespective of the size of business)
- They must have achieved *energy efficiency* by reducing their average consumption of energy over a specific time period
- Energy efficiency can also be assessed based on their energy savings in the current year as compared to previous year, also with other businesses of a particular sector and type.
- They must have increased cost savings in terms of energy consumed over a specific time period

As a consequence of following the above criteria, a business can receive incentives from the government. The role of the *principal* here is to also inculcate a spirit of healthy competition among different companies to become energy efficient by monitoring their energy performances. The government through the platform mediated solution creates a mechanism through which they can observe the energy consumption trends of companies and establish the incentive mechanism to encourage more companies to use the platform. Therefore the platform provides the government a structure to influence the decisions on sustainable energy consumption. It creates an environment through which businesses may be interested to use the platform and share and receive information on energy trends. This eliminates the risk of

²² Responsibility towards social initiatives by corporate companies, often to extract benefits from the government and otherwise enhance the image of the company

information asymmetry as referred by Myerson, where an *agent* tries to hide away information from the *principal* [73].

Myerson, also states that not all firms are focused on profit maximization [73]. From this it can be stated that some companies are possibly focused on improving business partnerships, generating knowledge capital, excelling in R&D, improving sustainability performances and practicing CSR activities. At present, the Dutch government assesses corporate annual reports of 500 Dutch companies to track the CSR contributions they have made. Based on their contributions and the *Transparency Benchmark* (marks the quality of CSR reports of Dutch companies [113]), the companies are given scores and awarded a prize: the Crystal, a leading prize in the field of social reporting in the Netherlands [114]. The incentive mechanism currently exists in the socio-economic policy of the Dutch Government, but it is an initiative mainly for the CSR contributions of five hundred Dutch companies and does not include rewards for sustainability performances of businesses. Therefore my solution aims to integrate monitoring of energy and CSR initiative through the platform.

The new platform can help the government to monitor trends in the entire energy sector of the country and also track the CSR activities that the company is willing to undertake with the incentives provided or otherwise. The Dutch governments provides subsidies to companies for investing in sustainable projects, for e.g. the 17 pilot projects on smart grids in the Netherlands that are subsidized by the Dutch government. Since the incentives which are usually attractive for companies include cash or tax reductions, these alternatives have been explored, coupled with some other incentives in the following section.

- *Tax benefits:* Governments influence income distribution of profit making companies by charging taxes [115]. The tax is spent by the government in social and developmental programs. With the incentive mechanism the government can propose an integration of public-private socio-development initiative, whereby with the tax reductions, the companies can contribute towards their CSR activity funds and develop the locality they are based in. This will help the companies to establish a social connection and also can become a value addition to their brand image and reputation. The government can also ask companies to use creative and innovative approaches to develop new social models through research and experimentation. Some of the examples of socio-developmental activities which a company can take up as part of their social responsibility are: beautification of landscapes, parks, creating awareness campaigns, improving education and research standards. They can also identify their customer segments through the social initiatives they undertake.
- *Cash benefits:* The government can also give cash incentives to businesses directly, so that they can spend them for CSR activities. The preference of a tax reduction benefit or cash benefit is a sole choice of the businesses which can be influenced by the culture of the company or the ease of using incentives towards the programs.
- *Discounts on electricity bills:* Since the smart grids are owned by energy companies, the government can partner with energy companies to incentivize the businesses; and the energy companies can provide energy efficient businesses with discounts on electricity bills. For big businesses the discount on electricity bills may be especially attractive since they employ big ICT infrastructures that consume lot of energy.

- *Scores/ Points*: The government can provide scores or points to the energy efficient companies, which can be a symbol of goodwill, enhancement of brand value and a mechanism to redeem other benefits. For e.g. if a company appears in the *energy efficient* list by receiving high sustainability ratings then they may receive benefits in their fields of business like lower interests on credit for investment, reduced price of real estate under government for business expansion, reduction on trade tax, excise duty for companies involved in import & export, or generous grants for research and innovation purpose.
- *Carbon credit*: This is a permit given by the government to companies to emit one ton of carbon dioxide [116]. The credits are normally awarded to countries or groups who have lowered their greenhouse gases below their emission quota. It is also possible to trade these credits in international markets at the competitive current prices [116]. Some of the manufacturing or chemical companies may need the credits to fully exploit their resources, utilize their potential to manufacture goods or chemical and thus influence the growth of an economy.

The incentive initiative can thus become one of the drivers for businesses to use the platform and participate in value creation with each other in the smart grid network. A detailed analysis on value creation and exchange will be discussed in 5.1. To exploit the incentive initiative, which is more on the functional side of the platform, the platform needs to be designed keeping in mind a range of functional requirements. It is these choices which will be responsible for creating a platform that capitalizes the operational and functional advantages. The next section discusses the functional requirements for the design of the platform.

4.4 FUNCTIONAL REQUIREMENTS

The functional requirements for the open ICT platform serves as conditions of action which must feature in the design of the platform. They are important because it helps the designer to focus on the user needs and to fulfill those needs. It has been stated earlier in the report that the meso-level is like a black box and the platform solution is possibly one of the methods to bridge the gap between PLS and HLS. Therefore it can be rightly pointed out that the requirements serves as input to the platform and the value that will be created will be the output that will be analyzed in chapter 5. The functional requirements are formulated from the perspective of the businesses as users.

Some of the attributes in the functional requirements are a result of the study on *Open Cities* (Open innovation in Smart cities) project, which is an initiative funded by the European Commission (Europe's Information Society) and is a collaboration between the countries - Germany, The Netherlands, Spain, France and Finland and the ENGAGE open data platform [117]. The functional requirements proposed is a combination of several specifications which I have classified under 4 attributes: 1. Platform GUI, 2. Platform Content 3. Platform Usability and 4. Platform engagement. They are presented below:

1. **Platform GUI** (Graphical User Interface): constitutes of the front end of the platform and the criteria necessary for design of the front end. The Open Cities project considers the user interface very important for sharing data between the users [118]. The specifications which are important for my platform are:

- *Data visualization* – It is one of the most important requirements for the design of the platform. The contributors and users of the ENGAGE open data platform visualizes the datasets on the map, which has been showed by Arief in his use case diagram for the platform [117]. In this case, the businesses must be able to view the data in the open ICT platform in a way in which they can understand the energy behavior of other companies and easily track their position in the consumption trend. Therefore the graphical user interface needs to be made attractive with the use of graphs, pie charts and bar charts for easy visualization, communication and understanding of the real time energy information.
- *Data Segmentation* – The concept of data segmentation comes from the data filtering and subscribing specification of the ENGAGE platform [117, 119]. Since different types of businesses connected to different grids will be stored in the data cloud, the segmentation of data needs to be effective in order to classify and organize the information, so that it is easy for users of the platform to use and benefit from the data. Based on the group (sector or type) a business is subscribed to and the data-layering strategy discussed in section 4.2, they shall be able to derive real time energy consumption about those business communities and compare the trends with their own business.

2. Platform Content: constitutes the data and information that is displayed in the platform.

- *Open Data* – Open data relates to shared data that brings the possibility of extracting value that is largely untapped [120]. When the resource is shared, it can enable organizations to make informed decisions and design new strategies, e.g. sustainable strategy of the business or corporate social responsibility policy. Additionally, the data of the platform can allow the government to monitor energy trend of a country digitally and thus introduce performance measurement and control mechanism as part of a smaller and efficient government also called a lean government²³ [121]. There are several characteristics of open data which are important for the design of the platform and discussed below [120].
 - *Transparency* – The right information from the right provider can reach the right people. Hence transparency is very important between the exchanges of consumers, energy companies and the government. There will be no scope to tamper with any data, since the grid would report all the energy data flowing through it in the cloud. The consumers will feel more empowered to take decisions based on the truthfulness of the data. The government can accurately assess the demand and supply scenario of the energy market and formulate long term energy policies that contribute to a sustainable economy.
 - *Information Sharing* – The concept of data sharing has connotations on energy companies agreeing to share their proprietary data to benefit the consumers and empower them in monitoring energy behavior and allowing the government to track performance and launch useful initiatives for rewarding the energy efficient companies. The businesses can

²³ Successor of electronic governance where governments focus on doing more with less or achieving maximum governance with minimum government. As part of lean governance, the majority of operations are conducted digitally with more efficiency and less time. A lean government is a small government with better governance techniques and processes.

learn about the energy trend of markets for a particular timeline and at the same time help the government to monitor energy performance of groups and segments and the economy as a whole.

- *Value-creation* – Open data helps to free information that was once trapped in dusty pages of overlooked reports, offer new products and services and create greater accountability [122]. Therefore the responsibility of utilizing the data largely depends on the people using them. The opening of energy data, can enable both businesses and governments to create value that can help the society and economy collectively.
- *Collaboration* – An important characteristic of open data is that it should be able to be used by a number of actors. Therefore a number of actors collectively can use the data and generate value. It has the potential to generate positive external effects, whereby a public community receiving benefit from the data spreads the utility among others too. When a business or a group of business commits to subscribing to the government platform for energy monitoring, this can impact other businesses to contribute towards sustainability too.

3. Platform Usability: The Open Cities project considers scalability, availability and inter-dependence of resources (inter-connectedness) very important factors for a platform to be made usable for all actors and further improvise to rope in new technical changes.

- *Scalability* – The platform should be scalable, because new technologies are being developed, therefore it should be easily able to incorporate those into the system. For example a mobile app can be launched to monitor smart energy data of the platform. Advanced security features will also need to be designed to implement mobile apps from the platform in the future.
- *Interoperability & Interconnected applications* – The technological components from different energy companies and utility service providers (DRMS or smart meters) need to be developed in such a manner, that they can receive and transport information to the data cloud. The platform should be able to use information coming from various sources. A sophisticated big data analytical tool in the back end of the cloud can analyze and organize the data; generate patterns according to the data layering strategy. Shifting data to clouds, can do away with large number of data centers that the energy providers maintain. This can be an efficient leap in PLS, in the implementation of smart grids.

4. Platform Engagement: An open data platform should be able to engage its users, stimulate participation and connect them to perform management functions [117-119]. The important requirement in this respect are:

- *User satisfaction* – To provide the actors with a good user experience, the end user computing satisfaction survey by Ilias et al, enlists five most important factors – content, accuracy, format, ease of use and timeliness [123-125]. Users must be able to make decisions about their energy

behavior based on the information they receive. Therefore, the responsibility of action depends on the reliability of the information and so user satisfaction becomes an important criteria for the platform. User satisfaction can be further divided into 5 factors which are to be kept in mind during the design.

- *Content* – It describes the user trust in the provided content. Security methods in the cloud and network will ensure this.
- *Accuracy* – It describes the precision of the site provided information. The network must be robust and reliable in order to transmit real time information in between the technical components like smart meters, 3G network and cloud servers.
- *Format* – It shows the clarity of the information presented. The units of energy consumed, the currency of prices, graphical presentation.
- *Ease of use* – It shows the subjective impression of the user. How easily the user is able to handle the platform and navigate from one page to the other, track information and create value.
- *Timeliness*- It includes the temporal relevance of information. This is very important because the platform needs to represent the energy trends not only real time but also historic trends of businesses and the user company in context. They should be able to track the energy consumption trend of a day, week, fortnight, month, quarter, bi-annual, year, lustrum etc. based on which incentive initiatives can be launched by the government.

The next two requirements for platform engagement have a functional perspective, and influences the design of the platform based on the ability of users to visualize the data and understand the information easily.

- *Informed decision-making* – Businesses can monitor the energy trends of different groups and modify their energy behavior as to when should they use the energy produced by them using RES and when it is wiser to use energy from the grid based on peak hour and off peak energy price rates. Market forecasts can be made based on consumption trends, which can allow them to make efficient decisions regarding energy policy of the company. If the government initiative can link sustainability monitoring with healthy competition between companies then the platform will become a significant tool for informed decision making and receiving incentives.
- *Consumer awareness* – The objective behind data centric platform having detailed information of energy production and consumption data of other consumers is to foster a sense of healthy competition where consumers realize that, energy consumption & energy production by collective action can be beneficial for their locality, a cluster of businesses or top sectors. The incentives rewarded by the government to the businesses can stimulate social good which can have a visible effect on consumer awareness.

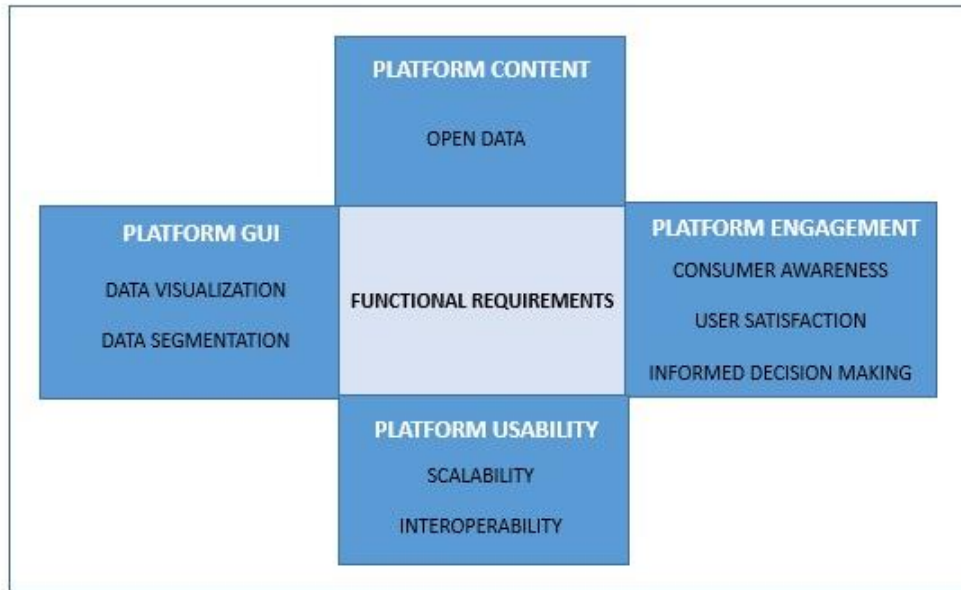


Figure 14: Functional Requirements of Platform

Figure 14 shows the functional requirements of the platform combined under 4 attributes of platform GUI, content, usability and engagement. No specific theory has been used to formulate the requirements because the platform design proposed in the next section is a high level design of a future model, and providing a specific underpinning of theory seemed rather complex. The high level design in this research is at a functional level, which shows what the platform should be able to do, rather than how it can accomplish it, which is usually addressed in a technical design. The functional design makes use of use cases to formulate the actions and events of the user to simplify understanding of the services it can generate. The design is on a functional level rather than system or architectural level.

Based on the functional requirements discussed above, the next section presents the platform design for energy monitoring.

4.4.1 PLATFORM DESIGN

The open ICT platform serves as a system which receives as its input the design criteria and generates output in the form of value created through it. It has been portrayed as a mechanism to unravel the black-box in the meso-level and establish a link between the PLS and HLS. The platform will be accessed and monitored by several businesses thus collectively contributing to the HLS of sustainability.

The high level design of the platform is presented using a use case diagram of UML (Unified Modeling Language). The UML technique helps to easily visualize any abstract concept and represent it in a simple fashion through different kinds of modeling diagrams [126]. The use case scenario in my design, depicts the actions that a business as a consumer is able to perform through the platform.

In a use case diagram, there are 4 main components: actors, use cases, association and the subsystem [127]. The *actors* are the businesses and the data cloud and it shows the design from a business to business perspective. The *associations* are presented in the diagram showing whether a use case extends from another use case or uses that of another, to accomplish an action. The *subsystem* is the web platform for energy monitoring and tracking energy performance by businesses over a timeline. The platform sponsor or the government also uses the platform to assess and monitor energy performance of businesses, but this analysis concerns the businesses only. The *use cases* are actions that an actor performs in a subsystem [127].

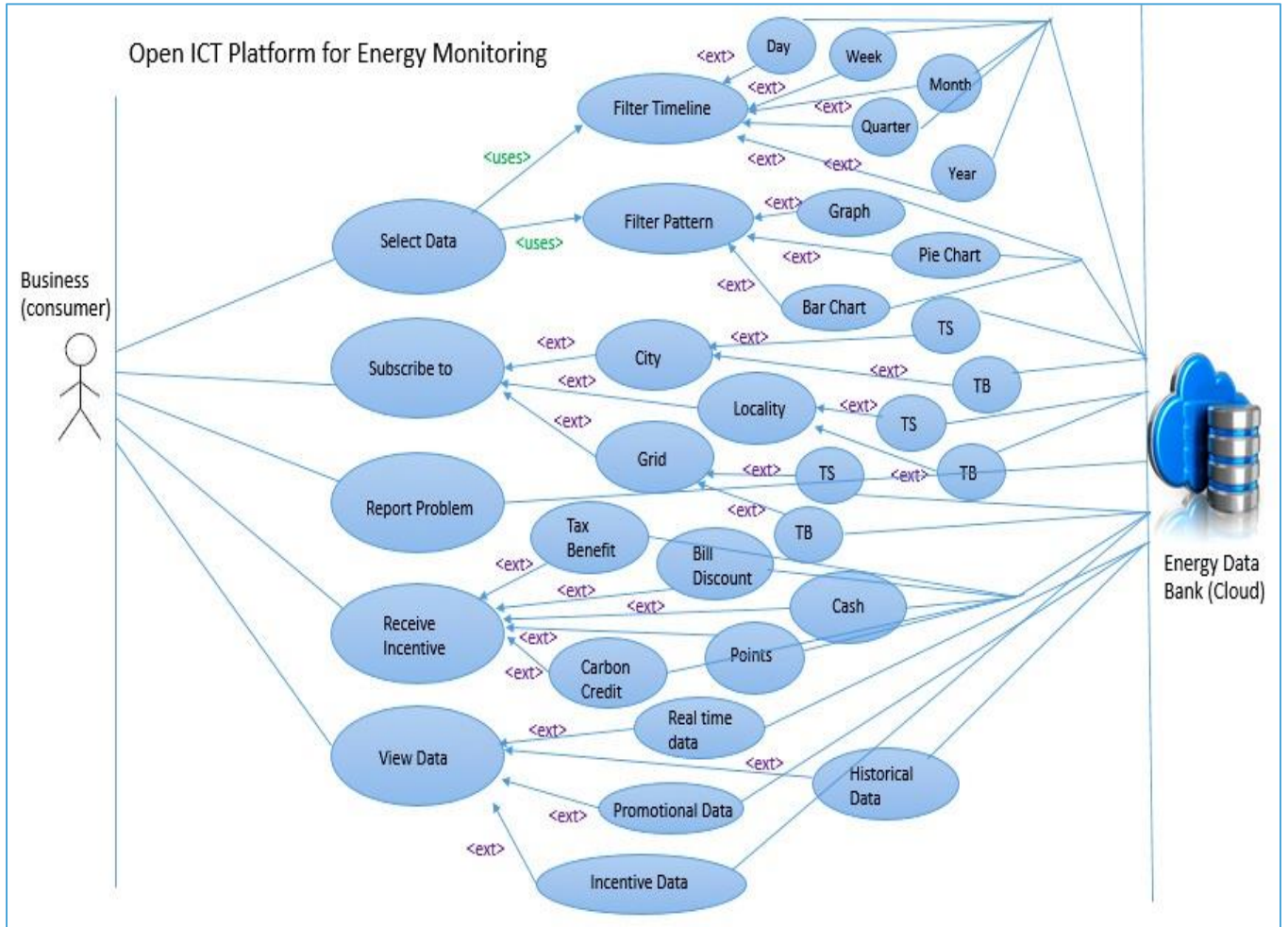


Figure 15: High level design of an Open ICT platform (Index: <ext.>: extends, TS = Top Sector, TB = Type of Business)

The use cases have been enlisted and discussed below:

➤ View Data

The business as a user of the platform is able to view the following kinds of data.

- *Real time energy data:* the current energy consumption of the business in comparison with the average energy consumption of the group it is subscribed to.
- *Historical Data:* the data of any particular day, week, month, quarter, bi-annual or a year.
- *Incentive Data:* this is the information that the government uploads based on the energy performance of the business and the rewards it receives for being energy efficient. It also includes data of top companies based on groups who have a good sustainability record.
- *Promotional Data:* It is possible for energy companies and utility service providing companies to promote products or services through this medium. The government may also announce new initiatives through this section. It helps the company to stay informed about latest updates in the energy market.

➤ Subscribe to

The business is able to subscribe to a community based on the city, the locality or the grid it is connected to. Each city, locality and grid is further classified into top sectors and type of businesses to easily categorize the company and also systematize the incentive initiative by the government. This helps the business to compare its energy consumption real time in this particular community or with other communities. It is possible that it will be able to access information about other communities based on a licensing fee. The subscription to a particular community by a business can be made using the unique KVK (Kamer van Koophandel) number [128] that the Dutch Government provides to every business registered under profit companies.

➤ Select Data

The businesses can select data and perform actions through which they can monitor their energy performance.

- *Filter Timeline:* allows them to track their performance for a particular period of time for e.g. day, week, month, quarter, bi-annual or a year
- *Filter Pattern:* they are also able to visualize the pattern of data in energy consumption in graphs and view the performance ranking of other businesses in bar charts or pie charts.

➤ Receive Incentive

The businesses receive positive incentives from the government based on their sustainability performance i.e. how much energy efficient they are in terms of energy consumption. If collectively companies can monitor their energy usage using the platform then this can bring down the average consumption of a city, locality or grid. This can have an unprecedented impact on the energy ecosystem of the country as it brings down the national average of energy consumption. The incentives received by businesses can be either tax benefits, discounts on electricity bills, cash prize, carbon credit or even scores and points which they can use to redeem

other benefits from the government. The incentives are a part of the value generated through the platform and will be discussed in chapter 5.

➤ Report Problem

The platform also allows the businesses to report problems they are facing regarding energy consumption and grid to service providers and about policies and incentives like requests for tax evasions, carbon credits to the government through a communication form.

Table 2 provides a summary of the use case diagram.

USE CASE CRITERIA	USE CASE DESCRIPTION
Description	The open platform helps to monitor energy behavior by businesses and also track the sustainability performance over a timeline
Actors	Business as consumer, energy data bank (cloud)
Trigger	A business wanting to monitor energy behavior real time and track performance
Preconditions	A business (licensed under KVK) is able to register in the platform and hence possesses login credentials. The platform shows average consumption data of businesses and not individual consumption of any company
Basic Flow	<p>The platform enables a business to:</p> <p><i>Subscribe to:</i> the grid it is connected to, the locality it is situated in and the city it is based in to be able to view the energy consumption.</p> <p><i>View data:</i> 1.Real time energy information</p> <ul style="list-style-type: none"> • Of own grid, locality, city • Of other grids and locality in the city <p>For access to the latter it can pay a licensing fee to the government</p> <p>2.Historical energy consumption data</p> <p>3.Incentive data from government</p> <p>4.Promotional data (new offerings from energy providers & policy information)</p> <p>For viewing the average real time energy consumption of the grid, locality and city it is able to filter the data according to</p> <ul style="list-style-type: none"> • top sector or industry • type of business <p><i>Select Data:</i> It can select and filter the way it wants to visualize the data e.g.</p> <ul style="list-style-type: none"> • Graph • Pie chart • Bar chart

	<p>It can also filter the data based on the timeline it wishes to view the historical data of consumption to generate a trend, e.g.</p> <ul style="list-style-type: none"> • Day • Week • Month • Quarter • Bi-annual • Year <p><i>Receive Incentive:</i> The business receives incentive based on its sustainability performance which the government tracks. The rewards can be based on the performance in a month, quarter, biannual or year. The types of incentive are:</p> <ul style="list-style-type: none"> • Tax benefit • Discount on electricity bill • Carbon credit • Cash reward • Scores/ Points for redeeming other benefits <p><i>Report problem:</i> A business can report problems regarding energy consumption, policies and incentives to the government and about the grid to the grid operator who also fetches data from the cloud.</p>
Exceptions	Business tries to modify any data in the platform
Post condition	Business modifies energy usage by making informed decision on whether to use battery charged power or power from the grid based on off peak and peak hour energy trends and prices

Table 2: Use case explanation of high level design

In the next section we discuss the functions of the platform.

4.4.2 FUNCTIONS OF THE PLATFORM

The most important function of the open ICT platform is that it helps the users to monitor energy behavior through *collective action*. Although each business still monitors the energy consumption of their individual facility (PLS), they can do this with the help of the data shared by other businesses in the platform. Comparing of energy trends, assessing energy plans and developing the company’s sustainable energy policy become easier and systematic due to the access of real time energy trends of businesses. The historical trends of consumption is also recorded in the platform, which helps businesses to compare their performances with respect to those of previous periods (year, month, quarter, week, and day). When different businesses participate in the platform and perform monitoring actions, then the resultant effect brings down the energy consumption of the grid, locality and the city, thus contributing towards a sustainable balance in the HLS of the energy ecosystem. As pointed out by Olson in his *collective action theory*, all actors should collaborate towards accomplishing a common goal [26], which in this case is achieving a sustainable energy economy.

While formulating the functional requirements, one of the aspect stated was - platform engagement, and certain attributes discussed there, also highlights some of the functions that the platform will be able to perform in the energy ecosystem.

1. Consumer Awareness: The platform makes consumers conscious of their responsibility towards the environment. The energy efficient companies can go a long way in protecting the finite resources of the earth. Each business must realize the need to contribute towards sustainability and when it can be coupled with a healthy spirit of competition among other peers then the positive external effects of the platform can increase exponentially. The bid to share data with consumers and government by the energy companies should also be underscored as a social responsibility towards protecting the environment. The energy waste and consumption that has increased with the shift to a global digital economy must meet a trade-off somewhere. Therefore a platform in the smart grid network to monitor the energy performance can prove to be a much needed tool in the energy ecosystem.

2. Informed Decision making: The platform is a tool that will allow businesses to make informed choices about using power from the grid in their facility during off peak hours (when the consumption of the grid is low) and use their house produced power from the batteries during peak hours when energy demand and prices are high. Thus businesses can be empowered to make their self-decisions based on the data provided to them by the energy providers and government. The energy companies and grid operators can use the data to balance the network during fluctuations and the government can use it to monitor the overall sustainability of companies in the energy domain.

3. Integrated Platform: The energy monitoring platform can enable a business to view its own energy consumption and compare it with the average consumption of the grid and other groups of businesses through which it can modify its energy behavior. Thus the platform is a visual interface that integrates several components through a modular approach. The data from the consumers over the 3G network gets stored in the data cloud. Energy companies have access to the data of their customers (connected to the grid) and can set the energy prices according to the market standards and price regulation of government. The government uses the platform to track sustainability performance of businesses Therefore the platform brings together several actors under one roof through which exchange of value takes place. The data from the cloud is accessed by businesses, energy companies and governments. It also discards the need for maintaining separate data centers by energy companies for their customers and employ DRMS application for each of the grid they operate on thus contributing to energy savings and less extensive physical locations of datacenters. The platform based smart grid network must ensure interoperability between different technical components and scalability to meet future upgrades before it can be implemented.

4. Virtualization: The platform displays virtualized data of several parts of the smart grid network and services offered. The cloud disguises the true complexity of the data flow in the network by storing data in several layers and storage spaces which are then managed by algorithms to display the right data to the right recipient at the right time. Virtualization spares the user from understanding complicated details of how data is transmitted, processed and displayed through the platform. Therefore virtualization in the

cloud serves two-fold purposes: it centralizes the regulating or monitoring activities by the government but decentralizes the monitoring action performed by the users [129].

5. *Communication*: Service related functions can also be performed through the platform. The businesses can report their problems regarding smart grid to energy and service companies and about policy issues and incentives to the government. Through the section on promotional data, the energy and service companies can communicate new service offerings or energy related instructions to businesses. The government also can communicate relevant legislation, local procedures, rules and policy documents through the platform [130].

6. *Sustainability tracking through collective action*: The platform plays an important role is the incentive initiative of the government, to track the sustainable companies in terms of energy efficiency. The businesses can track their energy consumption trend real time and through historical data of a year and generate patterns of consumption which can help them to frame their sustainability policies. The idea behind incentivization is to encourage a healthy spirit of competition through which small to big business houses can be rewarded by the government.

7. *Public good on the grid*: With the rising urbanization, demand for energy will increase with time. Urbanization is projected to reach 70% in 2050 [131], therefore it can be concluded that the demand for power will reach its peak towards the end of the 21st century. Smart grids are the energy model of the future. When a technology is implemented on a large scale, proper mechanisms must be in place to monitor and manage it. Therefore the platform based smart grid solution can monitor the energy need of the ecosystem. The impact of which can be largely felt in a green environment, the energy balance of a country, cost savings on electricity bills by consumers and new social-developmental schemes born out of a joint endeavor of corporate social responsibility by business houses and incentive initiative by the government. In a nutshell, it can be stated that the platform based sustainability monitoring can facilitate public good on the grid.

4.5 CHAPTER SUMMARY

The chapter answered the sub-question: How does the high level design of the open ICT platform look like? It described the assumptions made in the platform based future smart grid network. It introduced how the new platform based solution will look like and based on what strategy it can be constructed. The incentive initiative by the government gave an idea of what kind of rewards businesses can have for participating in the platform solution. Next, it formulated the functional requirements which are essential aspects for the construction of the high level design of the platform. The use case diagram depicted the platform design. The chapter ended with delineating the functions of the open ICT platform. The output from the platform will be analyzed in the next chapter as the value that can be created and exchanged by the businesses in interaction with other actors of the platform.

CHAPTER 5

VALUE NETWORK ANALYSIS.

Ch1	Ch2	Ch3	Ch4	Ch5	Ch6	Ch7
Thesis Definition	Theoretical Perspective	Domain Description	Platform Development	Value Network Analysis	Feasibility Exploration	Conclusion

5 VALUE NETWORK ANALYSIS

This chapter includes a detailed analysis of the value created as an output from the platform use. It can be seen as an evaluation of the platform design in chapter 4, which provides a visual effect of the different values that can be possibly created and exchanged by the users of the platform in the smart grid network. It addresses the secondary issue of the problem statement: i.e. to analyze the value created and to support the implementation of the platform solution for energy monitoring. It forms the Design Analysis of the research as shown in the research design in Figure 5. It answers sub-research question 4: *What value can be created, exchanged and added by businesses through the platform?* The platform design in chapter 4 and value network analysis in this chapter constitutes the *monitoring of actions* according to Giddens structuration theory, to manage and reorganize the existing structure of smart grids network, so that it meets environmental and societal needs. This chapter is divided into 4 sections: Section 5.1 sketches the value network analysis and section 5.2 delineates the critical control points in the network. Section 5.3 discusses the value addition by businesses through the platform and the chapter ends with a conclusion in section 5.4.

5.1 VALUE NETWORK ANALYSIS

This section describes the value created by a business through the use of the platform, in interaction with other actors in the network and how the value is exchanged between them. This analysis is done to delineate the benefits for different actors in the platform based smart grid network. It also discusses whether businesses can convert these values to receive tangible benefits like money. Therefore the possibility of the proposed smart grid model is largely dependent on this analysis, apart from the expert interviews in chapter 6. Before discussing the value network of an open ICT platform based smart grids network, we shall re-state the definition of “value” in my research. The definition includes attributes from Smith and Allee and can be expressed as *a utility that can be tangible (product, service) or intangible (reputation, trust) and can be converted to money, currency or revenues by exchanging with another actor or a group of actors* [74, 77].

Peppard defines a value network, “*where value is co-created by a combination of players in the network*”[80]. Fig 16 shows a value network of business as consumers using the platform solution in a smart grid network. The red pointers indicate the value created by the business exchanged with other actors and the black pointers show the value that is received by the businesses from others through the use of the platform. The value network diagram is drawn with the help of Gliffy, an online flow-diagram software.

The value network shows value is created, perceived and exchanged by business with different actors through several transactions. Therefore a very important aspect of the value network is co-creation or making things happen through *collective action* [26, 44], accomplishing actions in the HLS towards a sustainable economy. This enhances the dependence of one actor on the others for services and value creation, and has the potential to contribute towards the macro-economic goal of reducing energy wastage and inefficiency of the ecosystem. The value network can operate when businesses are motivated to use the platform on a regular basis and perform value transactions (increasing the number of exchanges)

which can be ensured by the incentive initiative (discussed in section 4.3). With more transactions or value-exchanges, association with other actors in the network can get enhanced and become more stable. The value network groups the Government, application maintenance (platform providers) and customer service into one unit, although the exchange of values are separately shown. The energy company, grid operator, customer service and utility service company has been grouped into a single unit, with the values exchanged between them shown separately and the revenue or money for the service is paid directly to the energy companies. This simplification has been made to easily understand the value network.

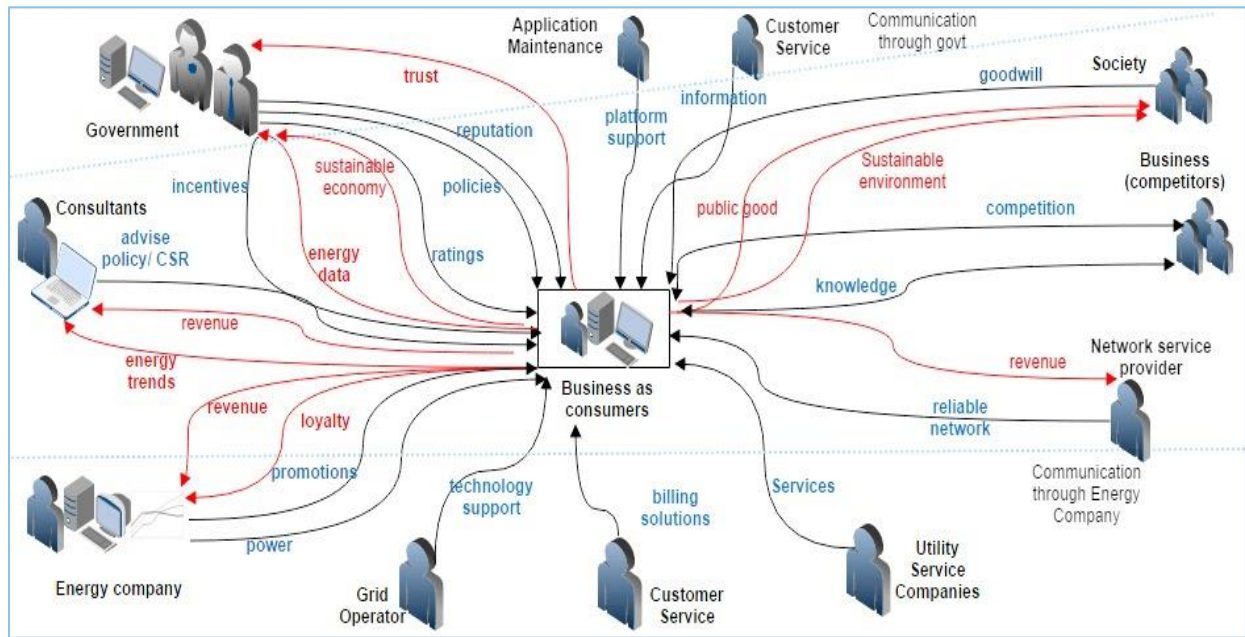


Figure 16: Value network of business as users of the platform solution

Figure 16 shows the tangible and intangible values exchanged through the value network. These values have been classified in the following tables based on the respective transaction between actors.

1. *Business to energy company*: Value exchange between the business and energy company is shown in Table 3. The grid operator, customer service and utility service providers have been considered to be subsidiaries of the energy company and hence the money paid for electricity to the energy company also includes payment to the subsidiaries.

VALUE EXCHANGED	DESCRIPTION	TYPE OF VALUE
Business to Energy company (direct)		
i. Power	Electricity is produced by energy company from RES (solar, wind) and is transmitted through the grid and distributed to business houses (consumers)	Tangible (energy co. → business)
ii. Promotional data	The energy company can display new service offerings, products through the platform to the businesses as promotions	Intangible (energy co. → business)
iii. Customer Loyalty	The energy companies enjoy loyalty of customers due to the user-experiences they provide through their services.	Intangible (business → energy co.)
iv. Revenue	The business pays money to the energy company for consuming energy from the smart grid on a monthly basis	Tangible (business → energy co.)
Business to Grid Operator (indirect)		
v. Technology support	The grid operator provides technology support to the business in the smart grid, e.g. manage, control and upgrade the technical components	Tangible (grid operator → business)
Business to Customer Service (indirect)		
vi. Billing solutions	The business can resolve billing and pricing issues by contacting the customer service unit of the energy company	Tangible (customer service → business)
Business to Utility Service providing company (indirect)		
vii. Services	The utility company provides business with services on utilities like smart meters, electrical components, battery etc.	Tangible (utility company → business)

Table 3: Business to energy company value exchange

2. *Business to Government*: Table 4 discusses the value exchanged between the business and the government. The customer service unit and application maintenance team have been considered as a single unit for simplification of the network diagram, along with the government, and can be accessed through communication forms on the web platform.

VALUE EXCHANGED	DESCRIPTION	TYPE OF VALUE
Business To Government (Direct)		
i. Policies	With the energy consumption data of different consumers the government can make effective policies for the future	Intangible (govt. → business)
ii. Reputation	By assessing the sustainability performance of companies the government provides ratings which can have a strong impact on the reputation of the company and thus stimulate collective action.	Intangible (govt. → business)
iii. Incentives	The business can receive incentives from the government based on their energy performances. For e.g. tax benefits, cash incentives, discounts on electricity bills, scores or points to redeem other services of the government and carbon credit.	Intangible (govt. → business)
iv. Ratings	Based on the sustainability performance of businesses, governments provide sustainability ratings or rankings, which can have an impact on the reputation of the company to its customers. Based on the ratings, the incentives can be decided.	Intangible (govt. → business)
v. Sustainable economy	With efficient consumption of energy businesses can contribute towards a sustainable economy through collective action, and balance the production and supply of energy in the economy, reducing the average national consumption	Intangible (business → govt.)
vi. Trust	Businesses need to trust the government and their policies behind the implementation of this initiative to establish a sustainable economy and therefore conform to open data platform from which several actors can benefit	Intangible (business → govt.)
vii. Energy data	Businesses provide the government with energy data from where they generate patterns and energy consumption trends which help in formulating energy policies for the future	Tangible (business → govt.)
Business To Customer Service (Indirect)		
viii. Information	Businesses report issues on incentives, taxes or policies to the government's customer service unit through the platform, which they service by providing relevant information	Tangible (govt. → business)

Business To Application Maintenance (Indirect)		
ix. Platform support	The government (or a consortium of companies led by the government) is seen as the possible platform sponsor in this research. The government appoints a platform provider or technology company to develop the platform and maintain the application. Therefore the application maintenance team solves technical issues reported by the businesses through a contact form in the platform.	Tangible (govt. → business)

Table 4: Business to government value exchange

3. *Business to Business*: The value exchange between businesses is shown in Table 5.

VALUE EXCHANGED	DESCRIPTION	TYPE OF VALUE
Business To Business (Direct)		
i. Competition	Businesses provide competition to each other in terms of being energy efficient and receive a good sustainable rating (with incentives) from the government	Intangible (business → business)
ii. Knowledge (awareness)	By viewing the average energy consumption of businesses and groups of other grids, localities and cities, a company is more aware of energy trends. Therefore there is more awareness generated through the platform	Intangible (business → business)

Table 5: Business to Business value exchange

4. *Business to Society*: Table 6 shows the value exchanged between a business and society.

VALUE EXCHANGED	DESCRIPTION	TYPE OF VALUE
Business To Society (Direct)		
i. Sustainable environment	By adopting sustainable performance in energy sector, businesses cater towards a greener and sustainable environment by using ICT as an enabler (platform based smart grids).	Intangible (business → society)
ii. Public good	The incentive initiative can be utilized by businesses to launch various CSR activities in the locality they are based in. They can contribute towards the public good by ensuring the needs of the society e.g. providing education for destitute children, awareness campaigns,	Intangible, tangible (business → society)

	construction of local infrastructure e.g. sanitation, water etc. This can be seen as a value addition that the platform can also perform which will be addressed under section 5.3.	
iii. Goodwill	The active role that a business plays in contributing towards the society with the incentives received, can have a direct impact on the goodwill of the company, since the reputation of the business will be associated with a visible initiative in the locality.	Intangible (society → business)

Table 6: Business to society value exchange

5. *Business to Consultants*: The value exchange between the consultants and businesses are presented in Table 7.

VALUE EXCHANGED	DESCRIPTION	TYPE OF VALUE
<i>Business To Consultants (Direct)</i>		
Information	Businesses share information on energy trends with consultancy firms who can provide insight into improvement of sustainability rankings by market analysis	Tangible (business → consultancy co.)
i. Revenue	Businesses pay money to the consultancy firm for the services they use	Tangible (business → consultancy co.)
ii. Policy advise (CSR)	Consultancy firms provides businesses with advise on policy, CSR activities and statistics for improvement of sustainability rankings	Intangible (consultancy co. → business)

Table 7: Business to Consultants value exchange

6. *Business to Network service providers*: The value exchange between the network service provider and businesses are given in Table 8.

VALUE EXCHANGED	DESCRIPTION	TYPE OF VALUE
<i>Business To Network Service Providers (Direct)</i>		
i. Reliable network	The network service provider, provides a seamless and robust network to the businesses over which data is transmitted in the smart grid	Intangible (network service provider → business)

ii. Revenue	Businesses pay money to the network provider for the services they use	Tangible (business → network service provider)
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Table 8: Business to Network service provider value exchange

The exchange of tangible value or revenue has been considered as a part of the contractual agreement between the businesses and other actors and the intangible values can be converted to tangible benefits through the transaction between actors. The value network diagram positions the business in the centre, who uses the open ICT platform in front end and the data cloud in the back end to complete the exchange of information and thus contribute towards value creation and exchange. Since the data cloud is but the back end technology of the platform, therefore it has not been specified as a separate actor in the value network diagram in Figure 16. Next we discuss the conversion of values by businesses.

Value Conversion

It shows whether the intangible values created and exchanged by businesses in interaction with other businesses, government or society can possibly be converted to tangible benefits like money or not. The value conversion analysis en-cashes the intangible values and outlines the utility for the energy ecosystem and society as a whole and not any sole actor in the network. This aligns with the collective action theory, where Olson specifies that actors collaborate together towards a common goal even if the incentives for them to participate are small [26]. Herein, lies the significance of collective action in the HLS.

The intangible values exchanged between the businesses and government that can be realized are:

Trust: Businesses can use the trust gained on the government in other spheres of their operation. For example, using platform-based sustainability performance monitoring can encourage companies to participate in other initiatives launched by the government. In establishing an initiative as large scale as this, the government can foster a public-private partnership (PPP) between the corporate and public sector. This PPP initiative can lead to other forms of initiatives which will be discussed under 5.3 in value addition. A large part of this will be ensured by the policies formulated by the government, driving the sustainability initiative.

Sustainable economy: The businesses through collective monitoring of on-demand energy production and consumption can contribute towards a sustainable economy where the average energy consumption of the country can be reduced and monitored, also catering to the base-load²⁴ power requirements. This also has connotations of channelizing the resources of a country towards other needs by reducing the spending on energy by efficient management techniques and greening of the energy ecosystem. The platform based solution in smart grids can have impacts on the economy w.r.t cost savings of the government and promoting international partnerships on sustainable technologies as well.

²⁴ Minimum amount of power which the energy company must make available to the consumers or the minimum power required to meet the demands based on reasonable expectations and fluctuates from hour to hour in most commercial and industrial areas.

Ratings: The ratings are a metric to categorize different companies according their energy efficiency and sustainable consumption. Therefore the ratings given by the government can be standardized over a country consequently impacting the reputation and brand of the company

Incentives: The incentives received by businesses from government can be utilized towards CSR activities of the company by contributing towards development of society (discussed further in section 5.3).

Reputation: The sustainability performance of the companies can earn them sustainability ratings which can become an important credential of reputation of the company in society and thus impact the brand image. The worth of the company can be assessed by the energy performance of the company and how it can contribute towards the CSR activities.

Policies: From the access to the energy consumption trends of business houses, the government can formulate effective energy policies for the future by forecasting trends. This can help consumers save much on their electricity bills and big business houses to invest in more energy technology related research operations. Socio-economic development will be largely impacted with the help of effective policies framed by the government.

The intangible values exchanged between the businesses and society which can be converted to tangible benefits are:

Sustainable environment: The businesses contribute towards a sustainable environment through the platform solution and this can be further realized through the incentive initiative of the government. The benefits of sustainability can help to reduce business risk by largely reducing the cost of energy and reducing the risks of climate change. The atmosphere created by contribution of each of the companies can be utilized by smaller businesses to produce and market green products and services to consumers.

Public good: The public good can be produced on the grid by the businesses and they will not only be reducing the carbon footprint on the environment and locality but also use green energy to run their operations. The rewards and incentives from their economic energy behavior can be spent on developing the locality they are based in and holding awareness campaigns on a range of social and health issues, which always have a greater impact when they are supported by big corporations with which people can identify themselves and lifestyles.

Goodwill: The goodwill earned from the sustainability ratings can be used by the businesses to shape their brand image to their customers all across the world, especially for multinational companies. Public organizations, government buildings and academic institutions can also receive a value addition to their image from the sustainable ways in which they do business.

The intangible value exchanged between different businesses which can be converted to benefit them are:

Competition: The competition between companies in terms of energy performances can be supported by the incentive initiative by the government which will reward them for being energy efficient and enable sustainable production and consumption of energy. This will allow the companies to save costs on energy and invest in other areas of business. Therefore the sustainability performance ratings can give businesses a sustainable competitive advantage over others. Moreover the knowledge gained from understanding the energy trends of different companies can help companies to formulate green ICT strategies. The knowledge received will also add to the “knowledge capital” of the firm which can be coupled with other inputs to generate revenues.

Usually with every value conversion there is a translation of the value into tangible benefits or revenue stream. This also depends on the needs of the business and where they are more focused in their operational strategy; whether it is the CSR activities or following of sustainable practices, expansion of operations, enhancement of knowledge capital or using benefits for the purpose of business.

The next section discusses where in the value network there is a higher possibility of extracting value, among the various values created and exchanged. The delineation of these areas can help to augment the utility and importance of the platform and will be a positive step towards evaluating the possibility of the platform in the research.

5.2 CRITICAL CONTROL POINTS

Eaton et al in his work on the role of control points, shows the areas where value can be extracted in the value network of Apple app store [132]. The analysis he carried out was in the environment of a new business model being constructed for mobile systems. The application of using control points to delineate areas of value extraction has been applied to the platform based solution for energy monitoring in Figure 17. This study was carried out to specify where the value can be extracted in the platform based smart grid network for understanding which points need to be emphasized and developed further.

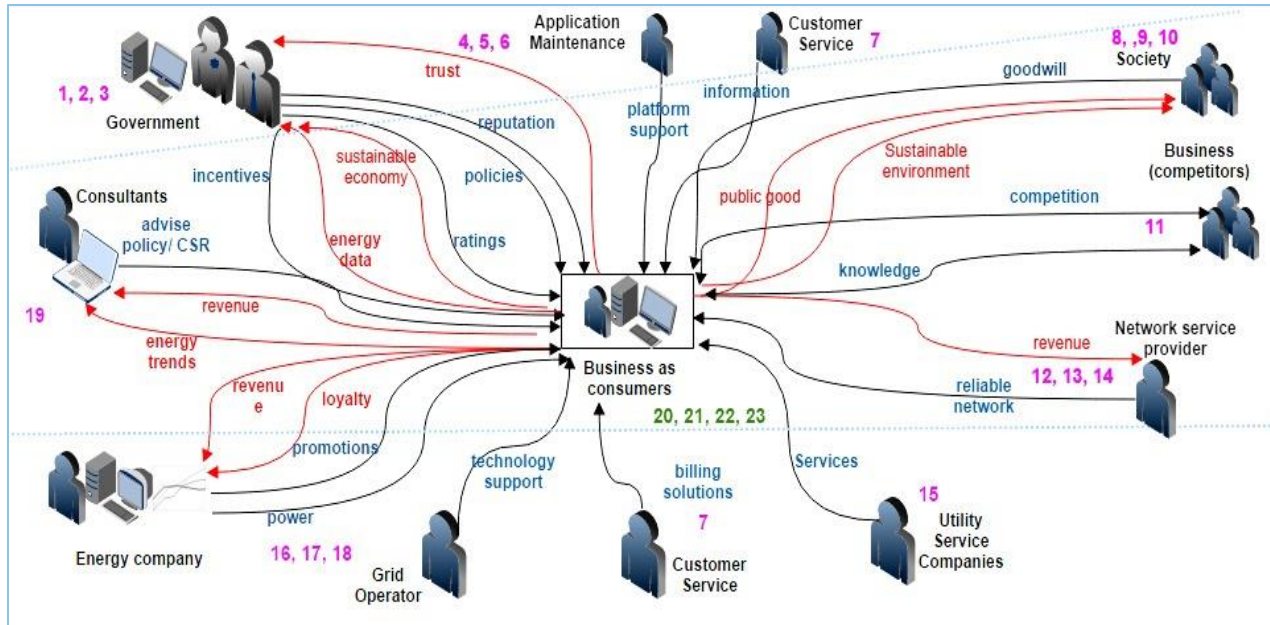


Figure 17: Critical Control Points in value network for businesses in platform based smart grids

Eaton describes critical control points as areas in a value network where maximum value can be extracted by the constituent members [132]. Eaton emphasizes on the transformation to value networks from Porter's concept of value chain, because the trend for modern day industries are to move towards constellation or networks of organization in a constant flux rather than static linear value chains [132]. From this transformation there not arises a need to analyze the value created, exchanged and converted between different members of the value network but also throw a light on the points of value extraction. This analysis can help to understand the dynamics of value network analysis and thus provide us with the potential that the platform based smart grid network has to make the energy sector sustainable.

Figure 17 shows numbers beside each of the actors which signify the critical control points in the value transactions, which I have proposed from studying the value network. The ones in purple depict the control points of other actors who create value for businesses and control points of the businesses have been portrayed with green color.

Government

1. *Up-to-date information:* By ensuring up-to-date information in the web platform the businesses can make well informed decisions about modifying their energy behavior.

2. *Categorization:* Large, medium and small enterprises need to be classified according to their size, physical resources and human resources they employ in order to make fair assessment of sustainability performance.

3. *Value conversion through public-private partnerships:* The incentives to be rewarded by the government to the businesses is an important value conversion that takes place and can be redeemed by

the companies in various forms depending on their sustainability focus, interests, culture and policies. The idea of public private partnership in giving a shape to the incentive initiative is basically creating a regime or framework by the government for businesses in which they can creatively develop society with innovative measures. A detailed discussion of incentives has been presented in 4.3.

Application Maintenance

4. *Application:* The web application poses to be one of the most significant points of value extraction, because the content, presentation, ease of use and the technology used in the application will have a big role to play in making the platform user friendly and easy for monitoring purpose. The regular changes and updates in the information are important requirements to increase the user satisfaction among consumers using the web platform.

5. *Platform interface:* The platform interface is also source of value extraction, because data from multiple data source is coming which needs to be organized and filtered according to the data layering strategy. Therefore back end interface and the algorithms running will be largely responsible for data representation and visualization in the front end for businesses. It needs to provide a framework for easy integration of third party and partner capabilities [133]. It should be able to provide continually-updated service, by spanning connected devices and create network effects through an *architecture of participation*, thus delivering rich user experiences [134].

6. *Real time information:* The real time information display in the web platform allows businesses to make informed decisions about adapting their energy behavior and thus reducing the average energy consumption of the grid. This can leads to cost savings by the company and earn them incentives from government.

Customer Service units (Government & Energy company)

7. *Availability of information:* The provision of updated information regarding incentives, taxes, polices from the government unit and information on energy prices, billing solutions from energy companies can be a positive characteristic of the platform. Since the energy data bank is the main provider of information, therefore it can be expected that information is synchronized, updated and available for easily to suit the requirements of the consumers.

Society

8. *Social connect:* This can prove to be a very important attribute in defining the relationship between the businesses and citizens. The companies will need to present themselves clearly with the intention with which they want to help develop the locality and bring socio-developmental initiatives in place. The brand image and reputation of the company may not be sufficient for this purpose unless they outline the objectives they have for the development of their localities. This chord of communication needs to be struck by companies with the citizens, so that they can acknowledge the development.

9. *Participation:* The citizens need to participate in the development initiatives of the locality along with the businesses, so that they can be empowered and the sense of accountability can be instilled in them. For active participation, the social connect will need to be established first by the companies, only then a social responsibility endeavors can be launched by companies.
10. *Tangible initiatives:* When companies help in the development of the localities as part of their CSR activity, the society will be interested to participate more when they witness a tangible development in their neighborhoods.

Businesses

11. *Knowledge Base:* The data on average energy consumption of different groups of companies based on the sectors they belong to or the type of businesses they constitute, a business as a consumer can build a knowledge base and become more aware of the market trends and informed about conscious decision making. This information can also help consultants to analyze sustainability performances of a particular cluster of companies and present their results using a survey. Therefore such an effort will add to the knowledge base of the energy sector and help government to make effective policies.

Network Service Providers

12. *High speed network:* The role of high speed network is especially important because huge amounts of data will be transmitted through the network and its provision should be seamless, robust and reliable. In case of network failure, the entire platform based solution will be at risk. Since real time data forms the core of the platform therefore high speed networks are a necessity. The challenges of the platform will be discussed in section 6.1 under evaluation of possibility from interviews conducted.
13. *Traffic Management:* The businesses should be able to access networks that can manage traffic efficiently, because they need to have access to the data all the time in order to monitor energy consumption and adapt their sustainability performances. Therefore networks should be engineered conservatively to handle higher load than expected [135]. In the platform based solution, the energy data bank is the central reservoir from where different actors access the data through distributed streams and interfaces and so network providers must have state of the art technologies in place to avoid network congestion.
14. *Concurrency Management:* Another relevant control point is the concurrency management and how many actors are able to use the web platform and perform their tasks. This is related to traffic management and congestion avoidance but also robustness of the network and application developed and maintained to cater to all the users. The concurrency control should be manageable mainly because the open web platform is a visualization and monitoring tool rather than a networking tool.

Utility service providers

15. *Standardized tools:* The implementation of smart grids with various technical components like smart meters, micro grids, meters, gateways and DRMS tools will require standardization in order to be able to operate easily with the energy data bank from where different actors will derive information for various purposes. It has been pointed out by researcher Ali Ipakchi et al in *Grid of the future* that most utility companies have limited interoperability across the different systems for operation and business management and currently the information in each organizational “silo” is not easily accessible to users and application in other functional units. This scenario should see a rapid change, before the platform-based solution can be introduced and standardization of tools and equipment will be necessary.

Energy Company & Grid operators

16. *Grid management:* For the effective functioning of the web platform, the smart grid must be always functional. Therefore grid operators should have backup systems to ensure that energy provision and data transmission in the grid can take place continuously with minimum failures.

17. *Grid Servicing:* The smart grid will need to undergo regular upgrades, checks, software up gradations to ensure the security, reliability and stability of the system. This should be conducted without causing any inconvenience to business as usual.

18. *Disaster management:* Self-healing is an important characteristic of every smart grid, which indicates that in times of power outage, the system breaks itself into isolated islands each of which has to fend for itself in reporting the problems to the grid controller using intelligent devices and this can ensure speedy detection of the type of problem and resolution of the same [136].

The control points in this research underscores the principal areas where value can be extracted and act as pointers to indicate the potential development of these areas are necessary in the present smart grid network for the platform based solution to become fully functional. The next section discusses how businesses can add value through the platform.

5.3 VALUE ADDITION BY OPEN ICT PLATFORM

Value addition helps businesses to offer something extra other than the usual offering. Therefore value addition has been analyzed using the theory of service-dominant (S-D) logic of Vargo et al. Vargo states in his theory that, “*the role of producers and consumers are not distinct and value is always co-created jointly or reciprocally in interactions among providers and beneficiaries through the integration of resources and application of competencies*” [27]. This helps us to conclude that the role of the producer and consumer in my proposition is indistinct and can be called as a “*Prosumer*”, who interacts with other actors to co-create value. The integration of resources and application of competencies can be seen as the open ICT platform for energy monitoring, which is a digital platform that displays real time energy information to the users and help them make informed choices about energy consumption. The

The businesses are prosumer in my research, since they act as both producers of renewable energy and consumers of the energy. The previous section discussed a range of values which businesses can co-create, together with other actors in the network. The value addition by the business through the use of platform can be viewed as value addition because it closes the loop in production and consumption and has the potential to convert a sustainable economy to a self-sustainable one. For e.g. the businesses use the platform to monitor when they should use energy from their production facility and when should they use the energy from the grid, having monitored their consumption by comparing their trends with others companies and reducing their average annual consumption, they can join the race to become energy efficient companies. The government rewards the businesses for achieving energy efficiency and provides them with sustainable ratings, based on which they can be rewarded incentives. These incentives can be spent by the businesses towards corporate social responsibility initiatives which will contribute towards social good. Thus, the investment which the government can directly make in the development of localities, can now be spent by companies by establishing a PPP for social initiatives. The prosumer creates value through the platform, earns incentives which is returned to the society for developmental initiatives, closing the loop. Hence, the open ICT platform serves as a means for establishing a self-sustainable economy which produces, consumes and spends the money earned through their “prosumption” on social good, thus spanning a public good on the grid. Moreover the corporate social responsibility strategy of a company is a part of the sustainable development strategy. In a self-sustainable economy, the government can also become facilitators for keeping a track on different CSR initiatives which will be carried out different localities all over a city.

5.4 CHAPTER SUMMARY

The chapter answered the sub-question: What value can be created, exchanged and added by businesses through the platform? It helped to produce a visual effect of the possible values which can be exchanged between the businesses and other actors in the network and how they can benefit from using the platform. The value network depiction served as a method to evaluate the output from the platform and strengthened the possibility of implementation of the solution that will be explored through the expert interviews in chapter 6. It analyzed the value that is created and how businesses can exchange this value to convert into tangible benefits or monetary rewards. The critical control points are identified where maximum value can be extracted and those which need potential development. These control factors also substantiated the argument for implementation of the solution. The next chapter evaluates whether the platform is implementable or not from the perspective of design & implementation, value creation and overall possibility.

CHAPTER 6

FEASIBILITY EXPLORATION.

Ch1	Ch2	Ch3	Ch4	Ch5	Ch6	Ch7
Thesis Definition	Theoretical Perspective	Domain Description	Platform Development	Value Network Analysis	Feasibility Exploration	Conclusion

6 FEASIBILITY EXPLORATION

This chapter presents the feasibility exploration of the thesis. Feasibility can be seen here as whether the platform solution can be possibly implemented or not. The expert interviews are conducted with the objective of finding out whether the open ICT platform-based solution is implementable in a smart grids network or not. The chapter answers the sub-research question 5: *Is the open ICT platform feasible for smart grids in the energy sector?* For development of the platform and analysis of value, use of theory is made to analyze and explain the concepts, and for feasibility exploration, a more practical approach is adopted by conducting expert interviews. For evaluating the design and implementation of the platform, a risk and positive attribute analysis is conducted. The positive attribute analysis uses the STOF theory (services, technology, organization and finance) [137] where only STO contributes to its evaluation and since the financial perspective is not included here, it will be reflected in the future research in 7.4. The theory that serves as an underpinning for the evaluation of value creation is Allee's value network analysis [77]. This chapter is divided into 3 sections: Section 6.1 describes the method of data collection and the protocol followed during the interviews. Section 6.2 evaluates the platform solution based on the views of experts. Section 6.3 presents the results and adaptation in functional requirements, value network and high level design of the platform based on the data evaluation. The chapter ends with a conclusion in section 6.4.

6.1 DATA COLLECTION

The method of feasibility exploration was expert interviews, to receive a perspective on the research topic, the underlining problem and the proposed solution. Interviews help to obtain specific information on the research context and is a relatively quick way to receive views from multiple experts. When the interviews are coupled with an exploratory study like mine, then it helps to gain understanding of a solution for the future from different dimensions. It follows a specific trajectory to be able to compare the data from multiple respondents and to evaluate them [138]. Section 6.1.1 presents the interview respondent selection and section 6.1.2 provides the interview protocol followed.

6.1.1 INTERVIEW RESPONDENT SELECTION

The selection of respondents was made according to the actors in the smart grid network. The respondents have been divided into four groups, namely 1. Business as consumers, 2. Energy companies and 3. Government, and the fourth comprises of academic researchers whose views are important in understanding the proposed solution from the aspect of scientific literature. The total number of respondents interviewed are fifteen, of which there are two business as consumers, three energy companies, two government professionals and eight academic researchers. The respondents are experts in their respective fields of work; their background and details are presented in Table 9.

SNo.	Interview Category	Designation/Profession	Organization/Institution	Date and Type of Interview
B1.	Business as consumer	Director, Smart Energy Cities	<i>DNV GL</i>	10.10.2014, Telephone

B2.	Business as consumer	Director, Energy management	<i>KPN Energy</i>	15.10.2014 Telephone
E1.	Energy company	Project Manager, Maintenance and Support	<i>Essent</i>	17.10.2014 Telephone
E2.	Energy company	Co-owner and Business Developer, Energy solutions	<i>EnableMi B.V</i>	9.10.2014 Email
E3.	Energy company	Offshore Energy Researcher, Cost Reduction in offshore energy support structures	<i>ECN</i>	6.10.2014 Email
G1.	Government	Senior Advisor ICT in long term project agreements in the Top Sectors of the Netherlands	<i>RVO (National Enterprise Agency)</i>	16.10.2014 Face to Face
G2.	Government	Advisor Energy R&D, (smart grids policy making) Energy Research Grant	<i>Agentschap Netherlands, RVO (National Enterprise Agency)</i>	24.10.2014 Telephone
A1.	Academic Researcher	Facilitator and Researcher, Systems Engineering, TPM	<i>Delft University of Technology</i>	6.10.2014 Face to Face
A2.	Academic Researcher	Assistant Professor Strategy and Innovation, TPM	<i>Delft University of Technology</i>	9.10.2014 Face to Face
A3.	Academic Researcher	Professor & Chair, Computer Architectures for Embedded Systems group. Electrical engineering, project: energy autonomous smart micro grids	<i>University of Twente</i>	21.10.2014 Telephone
A4.	Academic Researcher	Professor of Cloud computing, database management, Ex-Head of the Department, Computer Science and Engineering Faculty	<i>B.P. Poddar Institute of Management and Technology (India)</i>	14.10.2014 Email
A5.	Academic Researcher	Post-Doctoral Researcher, Smart living and e-health systems, Smart cities, ICT section, TBM	<i>Delft University of Technology</i>	9.10.2014 Telephone
A6.	Academic Researcher	Doctoral Researcher, Electric Vehicles and Photovoltaic cells, Electrical Power processing group, Faculty of Electrical Engineering	<i>Delft University of Technology</i>	6.10.2014 Face to Face
A7.	Academic Researcher	Postmasters PD-Eng. Researcher, Smart Buildings and Cities Program	<i>Technical University of Eindhoven</i>	9.10.2014 Skype
A8.	Academic Researcher	Post-Doctoral Researcher, Systems Engineering and Simulation, Multi-Actor Systems Department, TBM	<i>Delft University of Technology</i>	25.09.2014 Email

Table 9: Overview of Interview Respondents

6.1.2 INTERVIEW PROTOCOL & PROCESS

The interview protocol comprised of two steps. First, was to make a power point presentation of 15 slides with the gist of my research which included the research problem, conceptual framework, the domain of

current smart grids and the platform based smart grid solution for the future, the design criteria and data layering strategy which led to the construction of a high level design of the platform. It also presented the value network analysis and the functions of the platform. The last slide included a list of interview questions, which were divided into 3 categories: 1.Design and Implementation (D&I), 2. Value Creation (VC) and 3. Overall Possibility (OP) of the solution. The presentation was emailed to each of the interview respondents. The second step in the process comprised of conducting the interviews which were face to face, by telephone, by Skype and by email (details of which are tabulated in Table 9). The interviews lasted from 45 minutes to 1.5 hours maximum. The questions asked to the respondents are given in Table 10. Most of the questions were the same, except the last question where each of the respondents were asked to give their views on the proposed solution from the perspective of their backgrounds.

Set	Questions Asked	Category
1.	a) What are the risks of this platform according to you? b) What are the positive features of the platform solution in the research? c) In an open platform, what are the 2 most important functions? Have they been addressed in this research?	Design and Implementation
2.	a) What are 2 values which can be created by businesses through the platform, according to you? b) What is your feedback on the incentive initiative by the government to encourage businesses to monitor sustainability? c) Which type of incentive would be more suitable for government to give? d) Do you see merging Corporate social responsibility (CSR) of companies with energy monitoring platform a value addition? e) How do you think government could monitor whether companies are indeed contributing to CSR or not?	Value Creation
3.	a) Do you think the open platform in smart grid network is implementable in the future? If yes, why yes (what consideration is most important), if not, why not? b) What is your comment about the possibility of the solution from your professional perspective?	Overall Possibility
4	a) Do you think the conceptual framework of the research can be applied to other green ICT trends?	Generalization

Table 10: Overview of questions asked

During the interviews running notes were taken with notebook and pen. The data was later put into an Excel Sheet, based on which, 4 tables were constructed for question set 1:*Design and Implementation*, (in Table 10**Error! Reference source not found.**) based on the views of four groups of respondents: 1. business as consumers, 2. Energy companies, 3. Government and 4. Academic researchers (Table 22, Table 23, Table 24, Table 25 - Appendix C). For question set 2: *Value creation*, four similar tables (Table 26, Table 27, Table 28, Table 29 - Appendix C) were formed based on the four respondent groups. Finally,

for question set 3: *Overall Possibility*, (Table 30, Table 31, Table 32, Table 33 - Appendix C) were constructed according to the four groups of respondents. Based on the data collected in these tables, evaluation of the open ICT platform solution is made in the next section.

6.2 DATA EVALUATION

The raw data collected from the interviews is presented in Appendix C, based on which evaluation of the solution is performed here. The approach for evaluation is sequenced according to the set of questions in Table 10. The expert views on the last set of questions, generalizes the conceptual framework of the research in chapter 7 (conclusion).

6.2.1 DESIGN & IMPLEMENTATION

The design and implementation issues comprise of the risks and positive aspects of the platform solution. The expert views on these issues will lead to the adaptation of the design criteria of the platform. According to the risks pointed out by the respondents they can be classified under 3 types:

1. *System or technical risks*: are those which are related to the design of the platform.
2. *Platform or implementation risks*: are related to the implementation of the platform.
3. *User control risks*: can be termed as risks in which participation of the user plays an important role and also those risks, which could not be specifically classified under the system/technical or platform risks.

Table 11 shows the overview of risks pointed out by all respondents, irrespective of their groups.

System/ Technical Risks	Platform/ Implementation Risks	User Control Risks
1. Security (SEC) <ul style="list-style-type: none"> • Data privacy • Access control • Hacking • Information vulnerability 	1. System regulation (SR) <ul style="list-style-type: none"> • Centralized market control • Bureaucracy over new business opportunities • Misinterpretation as dictatorship • Inadequate government policies 	1. Acceptance or adoption (A) <ul style="list-style-type: none"> • Lack of awareness in using data • Understanding collective action • Undefined data recipients • Position of platform in value chain
2. Data Abstraction (DA) <ul style="list-style-type: none"> • Complex database organization • Demarcation between data produced and used • High level design 	2. Financial (F) <ul style="list-style-type: none"> • High upfront IT investment • High energy costs • Sustainable or operational risk • Funding the platform 	2. Participation (P) <ul style="list-style-type: none"> • Democratic participation • Data sharing • Type of businesses • Commitment to continue

<p>3. Interface (I)</p> <ul style="list-style-type: none"> • Complexity • Navigation and access 	<p>3. Technology (TEC)</p> <ul style="list-style-type: none"> • Advanced technical equipment (e.g. energy storage mechanism) • Reliability of advanced equipment 	<p>3. User satisfaction (US)</p> <ul style="list-style-type: none"> • Price control
<p>4. Scalability (SCA)</p> <ul style="list-style-type: none"> • Interoperability 	<p>4. Strategy (STR)</p> <ul style="list-style-type: none"> • Mix of consumer and business model • Market forecasting and planning • Compromise on business profits 	<p>4. Trust (TRU)</p> <ul style="list-style-type: none"> • Between energy companies and government • Between business as consumers and government • Reluctance to trust energy companies by consumers • IT and telecom operators for implementing large and expensive IT infrastructures

Table 11: Overview of risks of the platform-based smart grid network

The risks are classified according to the groups of respondents in Table 38 (Appendix C) for evaluating what kind of risks are of primary concern to the respondent groups. An analysis of the risks is presented below.

Business as consumers:

They are concerned about *system/ technical risks* from the security point of view because they would be sharing their energy consumption data to a common data cloud from where the information will be used by other actors; for e.g. other businesses will use the data to monitor energy behavior, energy companies will use the data to provide good user experience and the government will monitor energy sustainability using the information shared. They are specifically apprehensive about hackers stealing information from the data cloud. The second concern is data abstraction where businesses feel that there needs to be a proper definition on the information that is produced and that which is used by different actors.

Among the *platform or implementation risks*, businesses are concerned about centralization in the market control which will make it difficult for them to exploit new business services which could be provided with shared information. Financial streams are a big cause of concern according to them, since, large upfront IT costs have to be borne by them. Furthermore, technology needs to be advanced to ensure a seamless flow of energy and data.

Among the *user control* risks business as consumers think acceptability of the platform can be an issue, if there is no proper demarcation between who receives the data and what do they use it for.

Energy companies:

The *system/ technical risks* which are emphasized by energy companies are security issues on data privacy, because they will share the information in the data cloud, then they would demand that the platform sponsors and providers have strict and advanced security in place, to protect the information of their customers against misuse. They are also concerned on whether the data layering strategy can be properly implemented in the database of the cloud, because it would increase the complexity of classification due to large number of businesses participating in the platform, and each of them are different. Therefore data abstraction will be a great challenge.

Among the *platform/implementation risks*, the project manager of Essent, pointed out that the proposed platform solution mixes up the business and the consumer model in certain aspects; therefore proper delineation would be necessary. Also, the participation in the platform should not be a means of compromise for energy companies to carry out their regular business activities. Finally, for lowering of energy costs and making energy saving plans, analysts or consultants needs to be hired, which can substantially lead to extra costs, which has not been considered.

The *user control risks* which are important are participation in the platform by businesses and energy companies, because if they do not have sufficient incentives they may not want to share data. In addition to this, there are different types of businesses who can participate but the small medium enterprises consume a flat rate of energy, and therefore it can be difficult for them to show a standard energy consumption and receive benefits for participation. The project manager of Essent, expressed his views that consumers do not trust energy companies and hence this can get reflected in their trust on the platform sponsors too.

Government

The *system/ technical risks* pointed out by the government experts are security issues of the platform which must not be compromised during platform design and the information flowing in the system should be safeguarded against misuse. The complexity of the platform is also another risk, so the interface should be easy to use.

The *platform implementation risks* include, large and expensive ICT infrastructures which can significantly increase energy costs, which must be kept under control, because the objective of the platform solution is to monitor the energy towards sustainable consumption and lowering of energy prices. Additionally, the high upfront cost of investing ICT also needs to be tackled. Olivier Ongkiehong, a Senior Advisor in Energy and Innovation in RVO, mentioned that cost of funding the platform will be high and therefore big players in the market will be required to implement this initiative.

The *user control risks* from the government's perspective comprise of user satisfaction by establishing control over energy prices through the use of platform, and also users should have a visible effect of the same, otherwise they may not be motivated to use the platform. Another very important risk is trust, which will have to be established between energy companies and the government for implementing this solution. The government should give the energy companies incentives and subsidies to participate in this open ICT platform. Ongkiehong, the Senior Advisor at RVO also stated that position of the platform in

the value chain can also be an important risk, because it must be clear who provides information and who uses it in bringing the platform closer to the marketplace.

Academic researchers

The academics indicated that security, data abstraction and scalability are risks of the platform from the *technical* perspective. The design of the platform must ensure that information is safeguarded. The high level design of the platform can be made specific in order to understand the abstraction of data and offerings of the platform better. The platform needs to be scalable, to improvise new technologies in the future, for e.g. internet of things, as indicated by Jaco Appelman, a senior researcher in TU Delft. Fatemeh, a post-doctoral researcher of TU Delft, mentioned that the interface and APIs should be accessible to platform providers for app development in the future which can greatly benefit end users.

Among the *platform/ implementation risks*, centralized market control is perceived as risk by academics. With the data shared in the platform, businesses will not be able to exploit them for new business opportunities and the process can become time-consuming. Davide Garufi, a PD Eng. researcher from TU Eindhoven mentioned that, the government’s monitoring of energy data can be perceived as dictatorship to several companies, which they may not like. Moreover the government will need to develop adequate policies to implement this solution.

From the user control risks perspective, the academics indicated that consumer awareness needs to be specified in terms of data use, collective action so that they are able to make better use of the platform. Why energy companies and businesses should share the information and what benefits will they get in return is a big question, according to the researchers. Finally, building of trust seems to be another big risk, and not only between businesses and the government or energy companies and the government but also between IT and telecom service providers who will be responsible for implementing a large ICT infrastructure to support the platform based smart grid solution, says, Nikayin.

Table 12 shows the evaluation of the risks according to the groups of respondents. The risks which are pointed out two or more than two times by the respondent groups, will be adapted in the design criteria of the platform. The risks that are indicated once will be proposed for further research in the future.

Groups	System/ Technical risks				Platform/Implementation risks				User Control risks			
	SEC	DA	I	SCA	SR	F	TEC	STR	A	P	US	TRU
Business as consumers	X	X			X	X	X		X			
Energy companies	X	X						X		X		
Government	X		X			X					X	X
Academic Researchers	X	X		X	X		X		X	X		X

Table 12: Evaluation of risks based on groups of respondents

Therefore, it can be inferred, that *security, data abstraction* are significant risks among *system or technical* risks selected by the respondents from all groups. Among the *platform or implementation* risks,

system regulation, finance and technology have been emphasized by the respondents. In the *user control risks* category, *acceptance, participation and trust* are the significant risks.

Next, the positive features of the platform as expressed by the respondents are shown in Table 13. The positives of the platform solution are classified into 3 groups according to the STO of the STOF (Service, Technology, Organization and Finance) model for mobile service platforms [137]. The financial perspective does not contribute to this evaluation and will be reflected in the future directions of research in 7.4. The STOF theory has been used to analyze new business models; and since the platform-based smart grids can be seen as an energy model for the future therefore it is used here to explain the positive attributes highlighted by the respondents. The respondents' views can be categorized under services which the platform can offer, technical advancements which it promises to its users and features where organizational cooperation and participation is necessary.

1. *Services*: combine the various services which are offered by the platform solution.
2. *Technology*: indicates the positive features which have been addressed from the technical design perspective
3. *Organization*: implies the positive features which result from the interaction between the actors.

Services	Technology	Organization
1. New Business Opportunities (NBO) <ul style="list-style-type: none"> • Enriched data • Big data applications • Smart use of data 	1. Flexibility (FLE) <ul style="list-style-type: none"> • Energy flow and balancing network • Personalized data 	1. Competition (CO) <ul style="list-style-type: none"> • Positive and healthy competition between businesses • Reputation
2. Network load balancing (NLB) <ul style="list-style-type: none"> • Energy management • Sustainable production & consumption 	2. Privacy (PRI) <ul style="list-style-type: none"> • Average energy consumption trends displayed only • No individual data 	2. Collective Action/ Collaboration (CA) <ul style="list-style-type: none"> • Sustainable development • Sustainability monitoring
3. Energy Advise (EA) <ul style="list-style-type: none"> • Consumption trends • Energy pricing • Energy efficient solutions 	3. Transparency (TRA) <ul style="list-style-type: none"> • Accountability for actions 	3. Consumer Empowerment (CE) <ul style="list-style-type: none"> • Producer + consumer = prosumer • Monitoring and control • Community energy management
4. Sustainable Policies (SP) <ul style="list-style-type: none"> • By government • By companies 	4. Cloud Solution (CS) <ul style="list-style-type: none"> • No physical storage • District heating application • Integrated monitoring 	4. Consumer Awareness (CAW) <ul style="list-style-type: none"> • Accessibility to data • Comparison of data • Perception of energy trends • Demand response management

Table 13: Positive features of the platform solution according to respondents

The positive attributes are shown group wise in Table 39 (Appendix C), from which the following summary is made in Table 14. The features which have been selected twice or more than twice will be included. The features that were indicated only once will be proposed for future research.

Groups	Services				Technology				Organization			
	NBO	NLB	EA	SP	FLE	PRI	TRA	CS	CO	CA	CE	CAW
Business as consumers	X	X			X	X	X		X	X		X
Energy companies	X		X					X	X			
Government	X		X		X		X				X	X
Academic Researchers	X	X		X	X		X	X		X		X

Table 14: Evaluation of positive features of the platform solution

From Table 14, it can be seen that there are several positive features which have been commonly pointed out by the four groups of respondents. The features which will be included in the adaptation of the design criteria are: *new business opportunities*, *network load balancing* and *energy advice* from *services* perspective and *flexibility*, *transparency* and *cloud solution* from the *technological* perspective. From the *organizational* perspective, *competition*, *collective action* and *consumer awareness* are determined. The attribute, consumer awareness is already existent in the functional requirements and is supported by the respondents. Consumer awareness specifically includes aspects like accessibility to data, comparison of energy trends, perception of trends and managing energy consumption as per the demand in grid and will not be included again in the adaptation.

The next section presents the evaluation of value created from the open ICT platform.

6.2.2 VALUE CREATION

The values proposed group wise by the respondents are shown in Table 40 (Appendix C). Some of the values proposed by them are already represented in the value network analysis in Figure 16 in chapter 5; which are: creating a sustainable environment by businesses towards the society, incentives provided by government to businesses, reputation provided by the ratings given by the government to the businesses, and establishment of trust between businesses and government for companies agreeing to participate in the platform and sharing energy data.

The new values proposed by the respondents are shown in Table 15 under two categories:

1. Direct values: are those which will result from the direct operation of the platform
2. Indirect values: are those which can be converted to tangible forms of value by exchange and are the intangible values as expressed by Allee [77].

The categorization of direct values was not made in the theory, but according to the respondents these are values which will be certainly generated from the use of the platform by businesses. The value network

analysis diagram will be adapted in the results section to depict the new values proposed by the respondents under direct and indirect category as shown in Table 15.

Direct Values	Indirect Values
Informed decision-making Network balancing by grid operator Validation of taxes by government Flexibility in energy provision to places of high demand Lower energy prices Transparency in the system Disaster avoidance: maintenance management advice Collective action between businesses Community energy management Sanctions	Sustainable future/ economy (with no one excluded from benefits) New business opportunities Business partnership or cooperation Consumer empowerment Consumer awareness Sustainable ICT infrastructure employing business can become attractive employer

Table 15: Value created through the platform according to the respondents

Incentives Analysis

The incentive analysis is a part of value creation and shows the views of respondents on the initiative and which incentives they think is more lucrative for businesses to possess. The following graph in Figure 18 has been plotted from the data in Table 41 (Appendix C). The respondent numbers are shown according to their serial numbers in Table 9.

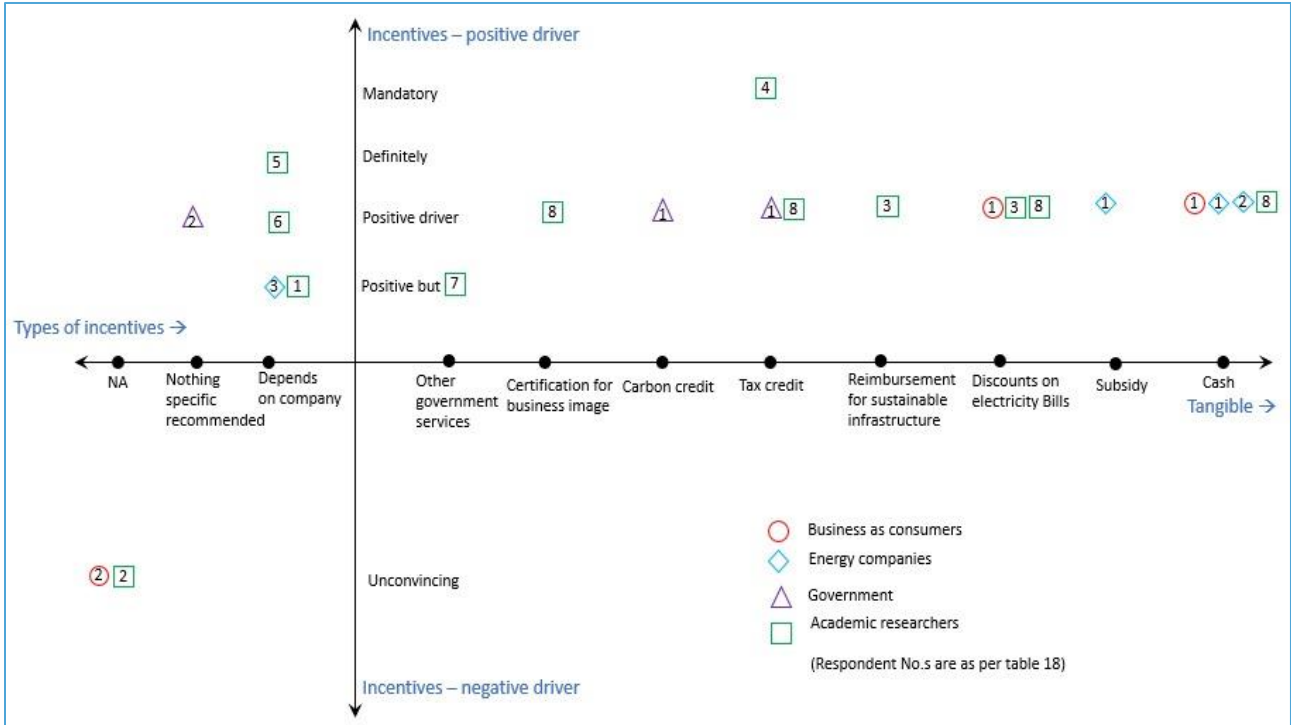


Figure 18: Graphical representation on incentive analysis data from the respondents

The graph in Figure 18 helps to evaluate the kind of incentives that can be provided through the platform to the businesses. Along the x-axis, the type of incentives in the degree of tangibility is shown and along the y-axis the positive or negative driver of incentives is shown. The levels of incentives as a driver are given by the levels: “mandatory”, “definitely”, “positive”, “positive but” and “unconvincing”. *Mandatory* means incentives are an absolute necessary for the platform to be functional, *definitely* shows incentives are an obvious choice, *positive* indicates incentives will be a positive driver of the platform, *positive but* implies that there are still certain conditions which will need addressing and *unconvincing* indicates the respondent’s belief that incentives cannot drive the platform.

It can be said from the graph that most of the respondents have a positive choice for incentive initiative as a driver of the platform. Among the incentives plotted, the most commonly preferred choices are discounts on electricity bills and cash incentives. The second most commonly preferred are tax evasions and preferences depending on the company. Two of the academic respondents have stated that the incentive initiative is mandatory and a definitive driver of the platform solution. Three respondents find the initiative positive, but have made a consideration which is presented in Table 41 (Appendix C). The consideration is that, they believe, incentives are needed but sanctions are equally important drivers of the platform. Two respondents from a business and academics found the initiative unconvincing. The respondent from business stated that the concept of being sustainable to receive incentives is related to controlling energy operations, which can impede services to customers, thus impacting the growth of the company and GDP of the country and so she did not find incentives very convincing. The academic thought that incentives have to be very attractive which he did not think the government could provide businesses with, so he found the scheme unconvincing. Overall, the positive connotations indicate that the incentive initiative can be a possible driver of the platform solution. The incentives which are selected maximum number of times, will contribute to the adaptation of the high level design of the platform.

Value Addition towards a self-sustainable economy

The value addition offered by the platform is shown in Table 42 (Appendix C), where respondents have answered whether the platform can also serve as a mechanism for investing the incentives in corporate social responsibility (CSR) activities as a value addition and how can the CSR activities be monitored. This evaluation is carried out to support the concept of self-sustainable economy discussed in section 5.3 in the value network analysis chapter.

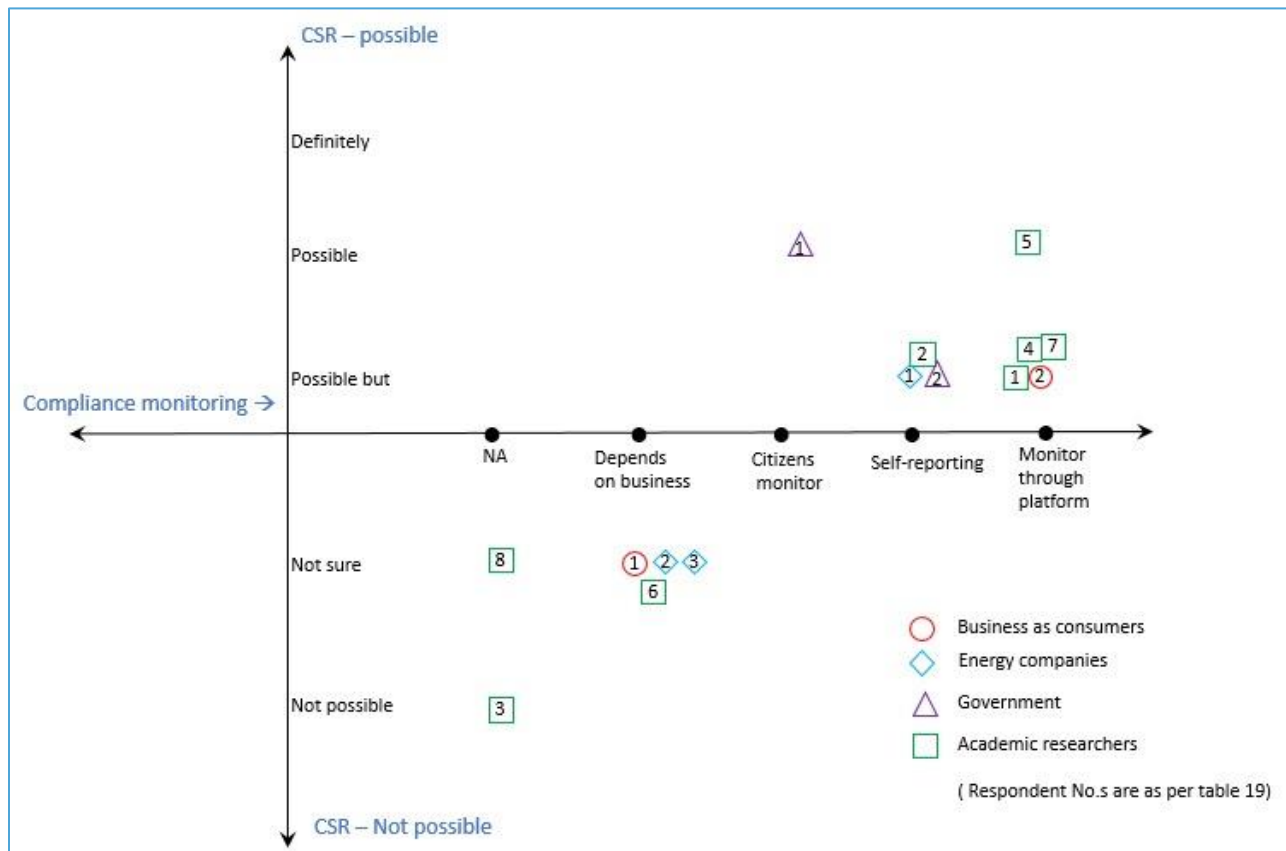


Figure 19: Graphical representation of CSR as value addition analysis data from the respondents

From the graph in Figure 19, it can be stated that seven respondents have expressed their views on the possibility of CSR as a value addition to the platform with a “but” or a specific concern mentioned in Table 42 (Appendix C). An equal number of respondents said the initiative is *possible* and *not sure* at the same time; and four among them selected, monitoring compliance through the platform, and four others left the choice of CSR to businesses. Considering only two respondents have said that the CSR is a value addition and the remainder thirteen respondents belong to the category with doubts on the possibility, therefore, the proposition of CSR needs further research and investigation. There may be other value additions to the platform apart from the CSR initiative.

The next section presents the evaluation of the overall possibility of the platform solution.

6.2.3 OVERALL POSSIBILITY

Figure 20 analyzes the data of Table 43 (Appendix C) for evaluating the overall possibility referred to as feasibility of the platform solution in Figure 20, based on the views of respondents. The x axis in Figure 20 shows the considerations which need to be kept in mind for feasibility of the platform. The y axis shows the feasibility and non-feasibility with levels: “definitely feasible”, “feasible under consideration”, “not sure” and “unconvincing”.

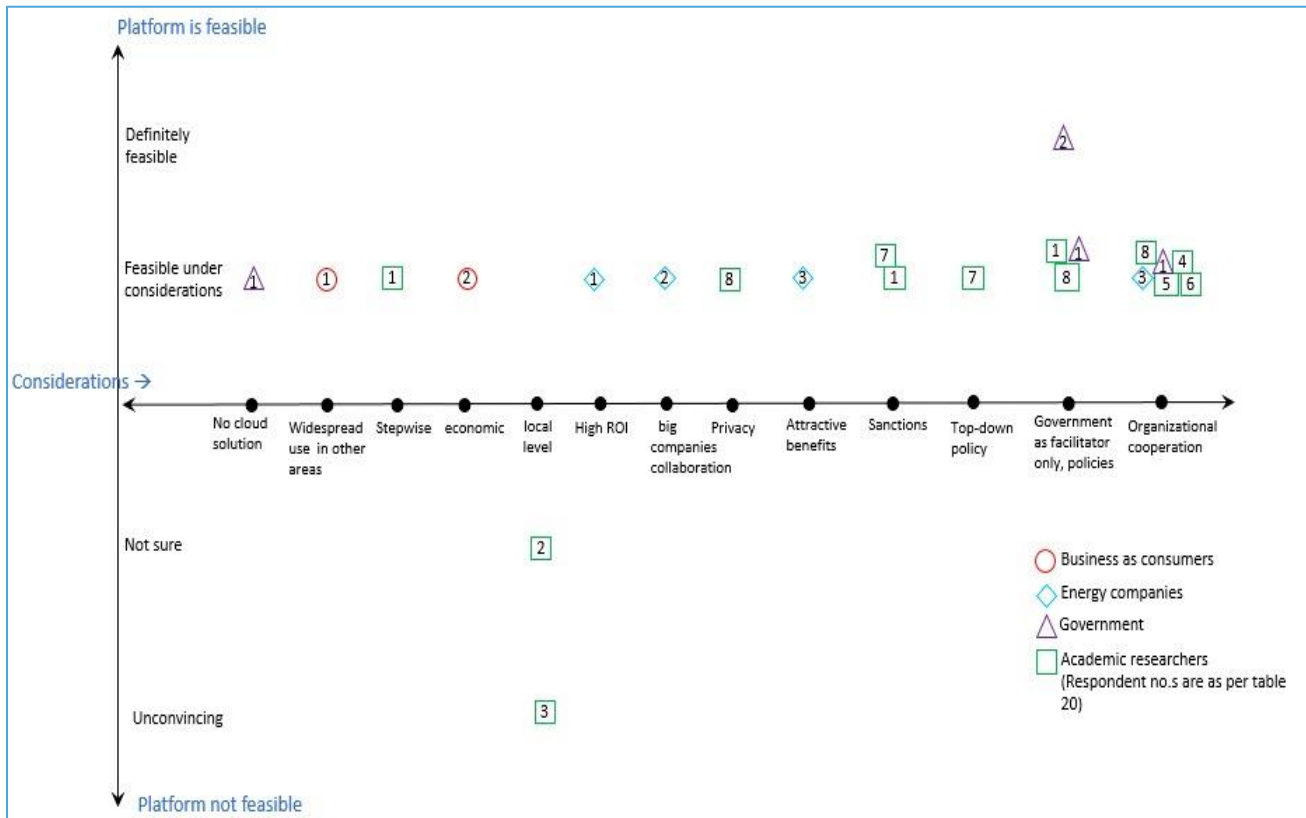


Figure 20: Analysis of overall possibility of the platform solution from the data of respondents

It can be seen from the graph that twelve respondents have stated that the solution is feasible under certain considerations (plotted on the x-axis). One respondent found the solution definitely feasible and among the remaining 2 respondents, one is not sure how it would work out and the other believes that the solution in the cloud is unconvincing. Based on the maximum number of responses in *feasible but under consideration* category, it can be said that the platform solution can be implemented keeping in mind that considerations under which it might work needs to be addressed. The considerations will be summarized in the adaptation of the platform design for outlining where further attention and research is required.

The next section presents the results of the evaluation of interviews by adapting the functional requirements of the platform and value network.

6.3 RESULTS & ADAPTATION

After exploring the possibility of the platform solution in the previous section, the final results are presented in this section which leads to the adaptation of the functional requirements, the value network and the high level design of the platform. The results are presented in the order of the analysis conducted: 1. Design and Implementation, 2. Value Creation and 3. Overall possibility.

6.3.1 FUNCTIONAL REQUIREMENTS

The adaptation in the functional requirements of platform is contributed by the risks and positive features which have been highlighted by the four groups of respondents: 1. Business as consumers, 2. Energy companies 3. Government and 4. Academic researchers. The adapted functional requirements with the risks and positive features identified from the evaluation of the design and implementation issues are presented in Figure 21. The attributes circled in red are the new features added in functional requirements. The element of risk which was not addressed earlier, are now included in the adapted requirements.

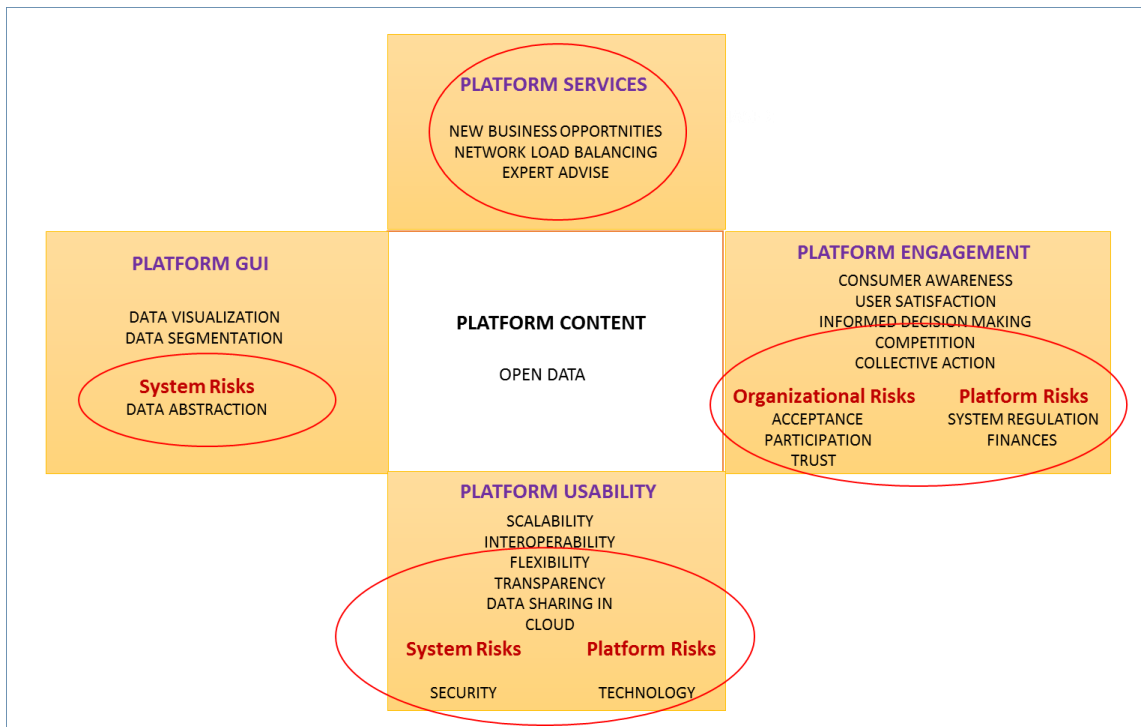


Figure 21: Adapted functional requirements

A new block on *platform services* is proposed by the respondents. It includes *new business opportunities* which can arise from using the data in the platform, *balancing of load in the grid by grid operators* and *expert advice* which can be given by energy companies to the consumers. An example given by the project manager of Essent on providing expert advice was, for e.g. when the demand in the grid is high, the energy companies can advise their consumers not to use washing machine today but instead use it twice the next day to lower energy prices.

In the *platform engagement* block, *competition* and *collective action* are the new features included from the evaluation.

The *platform usability* now includes three additional features: 1. providing *flexibility* through the platform to the consumers e.g. if a consumer produces extra energy then it should be possible for him to provide the surplus power to the consumers in need; 2. *Transparency* in the system can be maintained, because energy information is traceable and 3. *Data sharing in the cloud* (back end) can help to create an integrated monitoring platform.

The 3 types of risks identified by respondents: system, platform and user control risk have been placed according to the blocks of functional requirements: platform GUI, engagement and usability.

The *system risk* for *platform GUI* is *data abstraction*, which relates to organization of the database, defining clearly the demarcation between production and use of data and narrowing the high level design of the platform to specific form.

The *system risk* for *platform usability* is implementation of advanced *security* features. The *platform or implementation risk* for *platform usability* is installing advanced *technological equipment* for the deployment of the platform based smart grid network.

The *platform/implementation risks* for *platform engagement* are *regulation* in the energy market by the government which can be viewed as centralization of power by some stakeholders and arrangement of *finances* for funding the platform solution, investing in the *IT infrastructure* and maintenance costs. The organizational risks identified are acceptance of the platform, establishing trust between the stakeholders and participation of businesses.

6.3.2 VALUE NETWORK

The adapted value network has been constructed from inputs of Table 15. The dark blue pointers in **Error! Reference source not found.** indicate the *direct values* that are created from the use of platform and the red pointers indicate the *indirect values*.

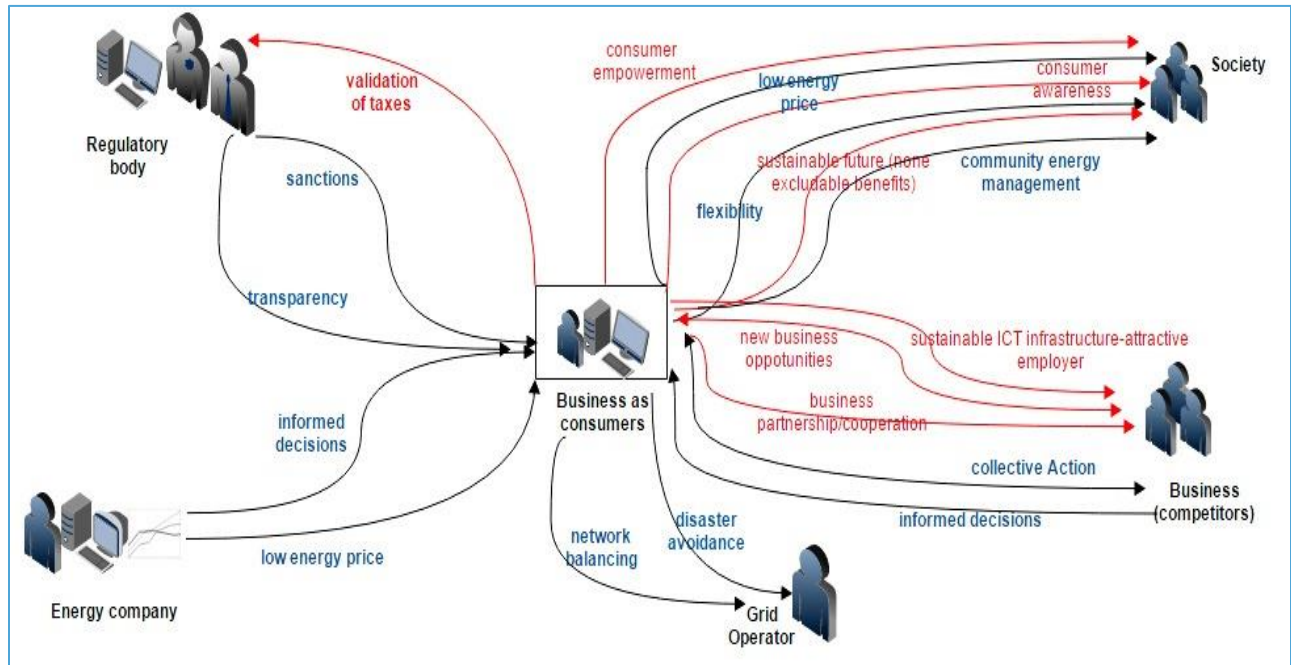


Figure 22: Adapted Value Network of open ICT platform for business as consumers

The values proposed by the respondents can be viewed as drivers which can lead companies to participate in the platform. The indirect values can be converted to benefits or revenues if the businesses can utilize the opportunities and act on them.

The values created for the businesses by the regulatory body are first, transparency in the system by pushing the project and bringing in key players, second by providing sanctions which will keep businesses motivated to reach their performance targets. The data shared in the system by businesses can help government to validate taxes by tracing their performances. The energy companies allow businesses to make informed decisions which lowers their energy price, by agreeing to participate in the platform. The grid operators become an important player in the network since businesses help them balance the load in the network and provide them useful data for disaster avoidance. Several grid operators can benefit from the shared data on grid disasters and their solutions. In the value network diagram that was proposed in Figure 13, energy companies and grid operators were assumed to be a single entity for simplification of the figure but in the Netherlands, the roles of energy companies and grid operators are distinct as pointed out by the Senior advisor of Energy and Innovation of RVO, to which the Director Energy of KPN added that, through this solution the role of grid operators will receive more importance. Fatemeh, a Postdoctoral researcher in TU Delft emphasized that the grid operators and regulators can be the initiators of the platform solution, since consumers in the Netherlands do not trust energy companies with their information.

The values created by businesses for other businesses are manifold. Companies can foster business partnership or cooperation by forming communities or groups and participate in the platform, through which they can collectively prove their energy sustainability and receive massive funds from the platform sponsors. This can translate to collective action between businesses. On the other hand if a business is competing with another in terms of energy sustainability then they will be motivated to employ sustainable ICT infrastructure and can become an attractive employer. This can be a significant benefit for an employer to create a good business image to its employees and customers. Moreover the data in the system can become source of new business opportunities in which small medium enterprises may be greatly interested in, since they can have access to the energy information. By sharing information the business also equip each other for making informed decisions about controlling energy behavior.

The Director Energy of KPN, believed that the platform can benefit the local households if the companies provide the surplus energy that they produce to them, thus creating flexibility in the system and lowering energy prices during peak hours of the grid. This can give rise to community energy management initiatives, through which communities can become self-sustainable with the help of big companies. The overall value from these energy management initiatives can contribute towards a sustainable future where no one can be excluded from the benefits. The platform serves as a foundation for empowering the consumers to control their energy consumption by being aware of consumption patterns around them, therefore consumer awareness and empowerment are also among other values created.

The respondents believe that values depicted in the adapted value network are enable businesses to participate through collective action.

6.3.3 HIGH LEVEL PLATFORM DESIGN

In the high level design of the platform, adaptation is made based on the incentive initiative and considerations proposed for the overall possibility of the solution. The incentives and considerations which have been selected multiple times by the respondents are included in the adaptation. The adapted design includes the relevant use cases shown in Figure 23 and those which are new use cases are marked with a red circle.

The incentives which are preferred over the others are discounts on electricity bills and cash incentives. The second most preferred incentive is tax credit and the choice depending on the business. The consideration which the respondents found most important and critical for the implementation of the platform is organizational cooperation with proper dialog between the stakeholders. The unanimous view was that technically the solution is feasible, but it will be interesting to see how organizations conform to the rules of the open platform and participate in the network by sharing their energy consumption data. Therefore communication with other businesses through the platform can stimulate partnership which will help businesses to form communities and track their energy consumption. Therefore communication is a use case that has been added to the platform HLD. Additionally, in the consideration, organizational cooperation, a form of feedback is included, through which the businesses can interact with the regulators or policymakers to provide their views on energy policies and sustainability which can enable a two-way communication. Therefore feedback is another use case that has been included in the HLD.

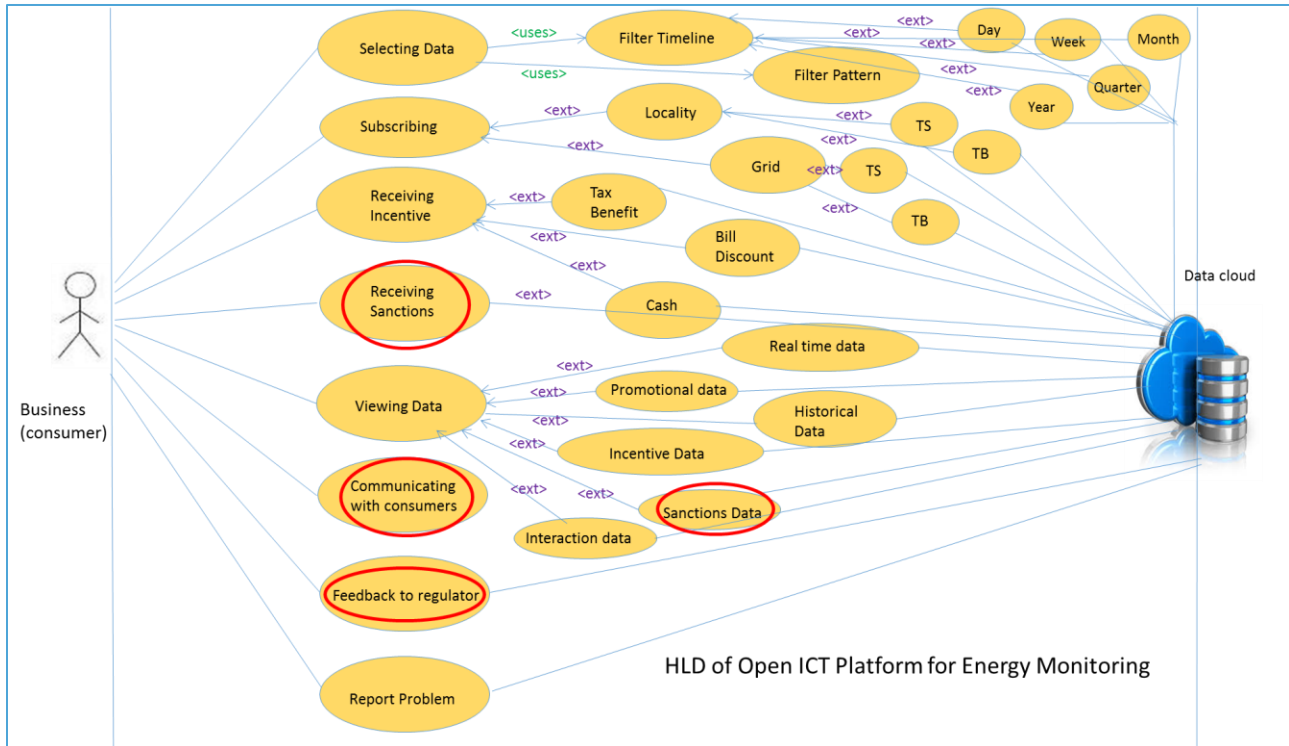


Figure 23: Adapted HLD of open ICT platform for energy monitoring

Both, the communication and feedback use cases are added to stimulate the organizational cooperation that was pointed out by a majority of the interview respondents.

The next significant consideration is that the government should act as a facilitator only in the implementation and operation of the platform. The role of monitoring sustainability with respect to energy can be entrusted to a separate regulatory body or a third party. The government can only be involved in formulating policies and supporting the initiative as a positive driver of sustainability. Olivier Ongkiehong, a senior advisor of Energy and Innovation at RVO mentioned that, as a facilitator, the government should act as a matchmaker in the energy market bringing players under a common roof, who will be interested to implement the platform and also explore other business opportunities through this initiative.

The next consideration pointed out during the evaluation, is receiving sanctions from the regulatory body for not achieving energy efficiency targets. Sanctions have been considered to be a very important driver of the platform. Davide, a PD Eng. researcher from TU Eindhoven believes that negative incentives can work better for companies to reach their energy savings target. Hence, sanction is also added as a use case in the adapted HLD.

Another consideration which was selected by more than a single respondent was implementation of the platform based solution in the grid or locality level, rather than a city. At first, granting local autonomy to the solution can work better rather than implementing it on a large scale. Therefore only grid and locality is shown in the HLD under the *subscribing to* use case. These use cases were present in the proposed HLD, hence they are not circled.

Since, the value addition to the platform through CSR initiative was concluded as uncertain according to the respondents' views, they are not included in the adapted design.

A list of all the considerations is presented in Table 16, which must be addressed before the platform based smart grid network can be implemented.

CONSIDERATIONS FOR OVERALL POSSIBILITY
1. <i>Organizational cooperation needed</i>
2. <i>Government should act as a facilitator and not platform sponsor and regulator</i>
3. Implementation of platform solution must be a top down policy from the regulators
4. <i>Sanctions should be implemented for better functioning of platform</i>
5. Companies should be given attractive benefits for participation
6. Privacy is of utmost concern for the consumers which must be established
7. Collaboration of big companies can help in the easier roll out of the platform solution
8. The system should pay for itself, i.e. the return on investment (ROI) should be high
9. <i>It should be implemented first in the smart grid or locality level</i>
10. Financing the platform should be possible and economic
11. The solution should be implemented stepwise
12. It can be first implemented in other areas of business (monitoring actions through cloud based platform)
13. Cloud solution may not be implemented in the beginning and the DRMS of energy companies and grid operators can be interconnected by standardization to fetch the consumption data.

Table 16: List of considerations for overall possibility of platform

For, the last consideration in the list, the Senior ICT Advisor of RVO and Project manager at Essent are of the same opinion that in the commencement phase of the platform solution, data can be fetched from Energy Data Service Netherlands²⁵ (EDSN) [139] by applying the data layering strategy proposed in the research through which the average energy consumption data of the companies can be shared without storing data in a common cloud. Constant connectivity to EDSN can provide real time data to consumers, alternatively plugging into EDSN three to four times a day, can provide energy trends of those peak and off peak hours through which companies can track their consumption patterns. When organizational cooperation for sharing information in a cloud becomes possible, then the cloud solution and real time data provision can be implemented in a pilot project.

The Director of Smart Energy Cities of DNV GL believes that the platform solution is a possibility because companies can cooperate and work together to participate in one energy monitoring platform rather than ten different platforms. Since it is not easy to steer production of renewable energy from local households due to efficiency losses in conversion and expensive storage mechanism needed, therefore the platform solution is possible from the perspective of companies only, thinks the Director Energy of KPN. Hence, from the business as consumers group the platform solution is a possibility, but a strategy or policy for cooperation needs to be established and big companies should be the first to come forward and implement the solution.

The group of respondents from energy companies, are not very keen to share their customer data, since they utilize it to provide better user experience which is their tool for establishing competitive advantage over other energy companies.

²⁵ EDSN supports the data traffic between parties in the energy market. A great deal of administrative information needs to be exchanged between parties in the energy sector when changing a supplier, when moving home and when amending customer data.

From the government's perspective, a regulatory body for monitoring sustainability (here, energy) can be very useful and the rich data circulating in the system can enhance the quality of services and provide new business services as well. The Senior Energy Advisor of RVO thinks, "Regulation plays an important role in the implementation, however the position of the platform in a value chain has more priority than anticipating now on regulatory barriers in terms of sustainability; therefore the involvement of a third party regulator other than the government can make the implementation very much feasible." He also stated an accurate design of the platform and functionality will be important in the next step from the present high level design for business to business.

The academic researchers have mixed views, but overall consider the solution possible on meeting the stated conditions. The platform has the potential to provide a control mechanism over the energy economy, achieve cost reduction for consumers and generate mass profit from the employment of smart grids. Concrete incentives and facilitator's presence can be stimulants needed for companies to establish trust and to participate.

From the overall evaluation, it can be concluded that an open platform-based smart grid solution can be implemented when the considerations are addressed, to bring it a step closer to the marketplace. In conclusion, it has been referred to as a positive step in an increasingly complicated energy world, by the Senior Advisor of Energy and Innovation at RVO.

6.4 CHAPTER SUMMARY

The chapter explored the possibility of the platform solution for smart grids and answered the sub research question: Is the open ICT platform implementable for smart grids in the energy sector? It gave an overview of the interview respondents selected and the interview protocol followed. It then collected the data from the interview respondents and analyzed them in the data evaluation section. Different views were recorded on design and implementation issues, value creation and the overall possibility of the platform. The evaluations led to the adaptation of the functional requirements, value network and HLD of the platform. This chapter steers the way for the conclusion of the thesis for answering the main research question.

CHAPTER 7
CONCLUSION.

Ch1	Ch2	Ch3	Ch4	Ch5	Ch6	Ch7
Thesis Definition	Theoretical Perspective	Domain Description	Platform Development	Value Network Analysis	Feasibility Exploration	Conclusion

7 CONCLUSION

This chapter presents the conclusion of the thesis. It aims to answer the main research question, i.e. “*To what extent is an open ICT platform feasible for bridging the gap between PLS and HLS in the smart grids of the energy sector and contributing towards a sustainable economy?*” It presents the main findings of the research in section 7.1 along with scientific contributions and societal relevance of the research. Next, the limitations of the research are presented in section 7.2. The reflection on the contents and research process is given in section 7.3. The report concludes by giving future directions for research in 7.4.

The research is an exploratory study which investigates whether the knowledge gap between PLS and HLS can be bridged to create a sustainable economy and what is the possible method to do so. It has been seen that companies contribute towards sustainability on the company specific level in silo by greening their ICT infrastructure, but they are not aware of how their actions can impact the larger ecosystem. This understanding is needed for companies to contribute towards sustainable development of the world. It is seen that collective action can create larger impact on a system rather than operating in isolation. Therefore, companies can possibly contribute towards sustainability through collective action. The case of smart grids in the energy sector is used to ideate and develop the concepts of the research. The possible method proposed for bridging the gap between PLS and HLS, is an open ICT platform for energy monitoring by businesses who can contribute towards a sustainable energy sector by controlling their energy behavior through the platform, by means of collective action.

The functional requirements of the platform were identified from a literature review which helped to construct a high level design (HLD) of the platform. The value created and exchanged by businesses through the use of the platform was illustrated using a value network diagram. Whether the platform solution can be implemented or not was investigated through expert interviews with business as consumers, energy companies, the government and academics. The evaluation of the interview data led to the adaptation of the functional requirements, value network and HLD of the platform. A summary of the findings is presented in section 7.1.

7.1 MAIN FINDINGS

This section presents the main outcome of the research.

The findings of this study show that an open ICT platform for energy monitoring in future smart grids is possible in the Dutch energy sector, to the extent where certain considerations are addressed.

For the remainder of the section, the findings with regard to the factors below, in Figure 24 are discussed.

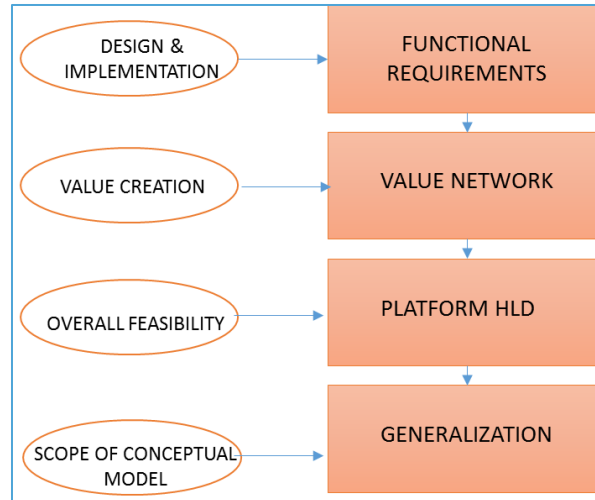


Figure 24: Main findings of research

Functional Requirements

The functional requirements proposed by studying the literature included 4 main attributes: platform content, platform GUI, platform usability and platform engagement, but with the inputs from experts and evaluation, it was seen that a new attribute *platform services* is also important and throws light on potential services that the platform can provide apart from energy monitoring, which can be a driver of the platform implementation.

The element of risks was not included in the requirements, but findings show risks are a significant part of the functional requirements which must be underscored and identifying them for each block to help to understand what type of risks are associated with the attributes. No risks were identified for platform services, because they are service propositions for the future.

The adapted design criteria are shown below in Figure 25, where the red circles highlight the new requirements added.

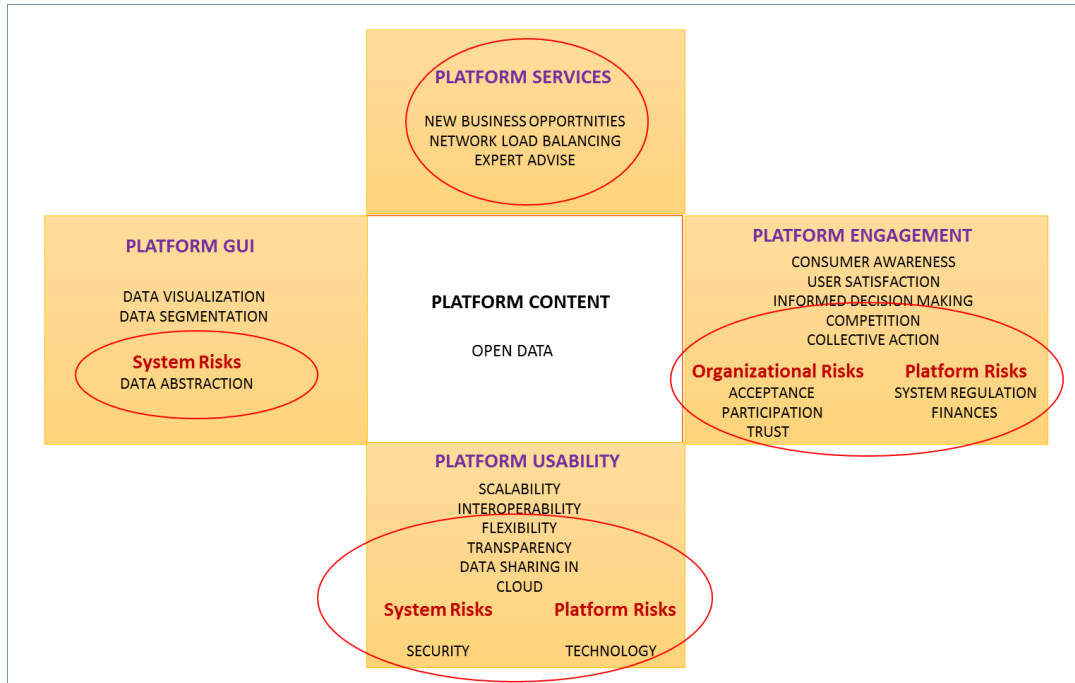


Figure 25: Adapted functional requirements with risks

Value Network

The sub-research question addressed here is: *What value can be created, exchanged and added by businesses through the platform?*

Based on the interview findings, it was seen that values were recommended which were common to the ones I proposed in the research, like: creating a sustainable environment by businesses towards the society, incentives provided by the government to businesses, reputation provided by the ratings given by the government to the businesses, and establishment of trust between businesses and government for companies agreeing to participate in the platform and sharing energy data.

Direct Values	Indirect Values
Informed decision-making Network balancing by grid operator Validation of taxes by government Flexibility in energy provision to places of high demand Lower energy prices Transparency in the system Disaster avoidance: maintenance management advice Collective action between businesses Community energy management Sanctions	Sustainable future/ economy (with no one excluded from benefits) New business opportunities Business partnership or cooperation Consumer empowerment Consumer awareness Sustainable ICT infrastructure employing business can become attractive employer

Table 17: Value created through the platform according to the respondents

The new values recommended by experts and classified based on direct and indirect values are shown in Table 17 and illustrated in a value network, in Figure 26.

The indirect values are given in *red* and the direct values are shown in *dark blue*.

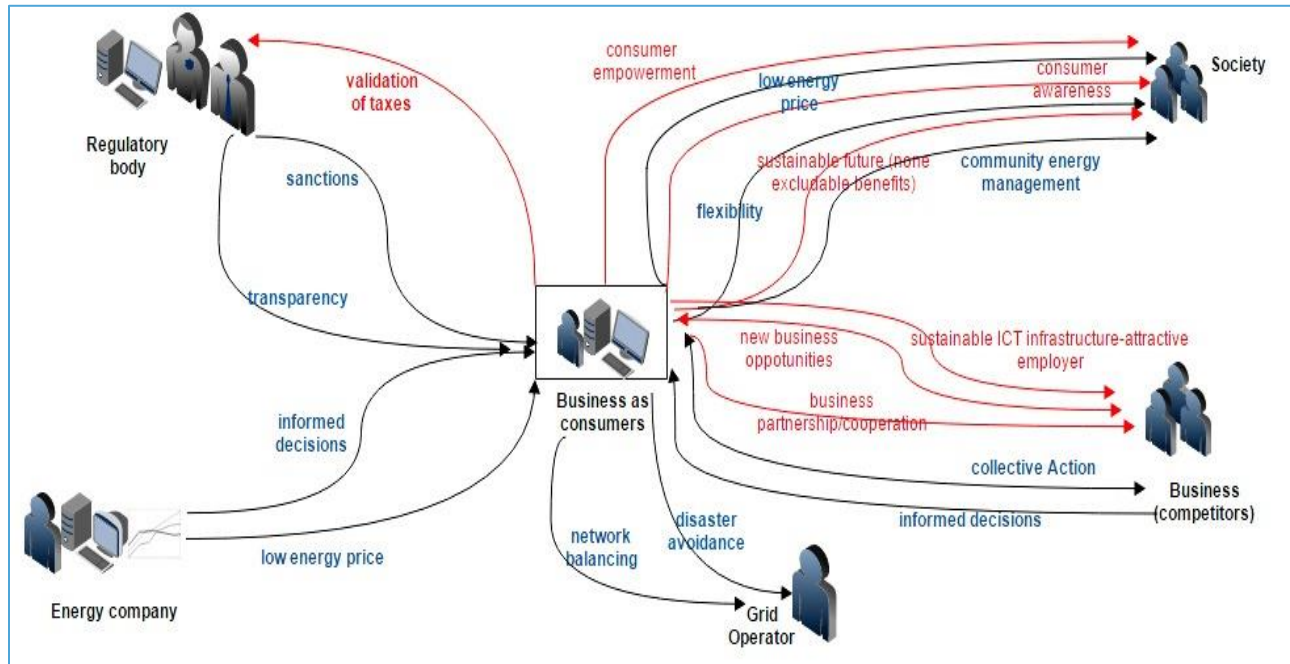


Figure 26: Adapted Value Network of open ICT platform for business as consumers

Furthermore, the findings delineate who the important actors are for implementing the platform solution and who would gain from the use of the platform. The adapted value network shows the outcome where some actors have emerged as important players in implementing the platform solution.

Grid Operators: With the flexibility provided by the businesses to the society, the grid operators can balance the grid and maintain a steady energy balance. The data shared by businesses can be used by them to provide better user experiences by avoiding disasters or power outages.

Businesses: The businesses who are primarily competitors of each other in energy performances, can strike partnerships by creating clusters and producing energy collectively to where the demand is, in the grid. They can achieve this collective action. New business opportunities on big data and smart data analytics can also come their way which they can exploit to create new services for customers.

Society: The society can enjoy the benefits of community energy management and flexibility created by businesses i.e. households situated in the vicinity of the large companies, can consume energy produced by large companies, at lower prices in times of high demand in the grid. With such seamless energy provision, no household is excluded from the benefits of energy consumption.

Regulatory body: They can get the system kick-started by bringing different players in the market to implement the platform and thereafter incorporate sanctions for consumers who do not fare well on their energy performances, as a driver of the solution. They can use the energy data from the cloud to validate taxes, on whether businesses have paid their corporate tax or not.

Platform HLD

The sub research question addressed here is: *How does the high level design of the open ICT platform look like?*

From the research findings, the overall possibility of the platform is dependent on the considerations presented below:

1. *Organizational cooperation needed*
2. *Government should act as a facilitator and not platform sponsor and regulator*
3. Implementation of platform solution must be a top down policy from the regulators
4. *Sanctions should be implemented for better functioning of platform*
5. Companies should be given attractive benefits for participation
6. Privacy is of utmost concern for the consumers which must be established
7. Collaboration of big companies can help in the easier roll out of the platform solution
8. The system should pay for itself, i.e. the return on investment (ROI) should be high
9. *It should be implemented first in the smart grid or locality level*
10. Financing the platform should be possible and economic
11. The solution should be implemented stepwise
12. It can be first implemented in other areas of business (monitoring actions through cloud based platform)
13. Cloud solution may not be implemented in the beginning and the DRMS of energy companies and grid operators can be interconnected by standardization to fetch the consumption data.

The HLD of the platform is modified based on the evaluation of overall possibility denoted in italics in the above list. The most important consideration is organizational cooperation between companies who would share their energy consumption data to participate in the platform. Under organizational cooperation two aspects are important, i.e. communication between the stakeholders and feedback on the platform use to the regulators. My research proposes the government as a platform sponsor, but findings show that the government can also be a good facilitator who can help to bring players together and provide mobility for implementing the platform solution. Once the solution is in the marketplace, a third party regulatory body is needed to monitor sustainability performance of companies. Such a regulatory body can be a consortium of big companies, consultants or even NGOs. The incentives for energy performances of companies are considered to be a positive driver of the platform by the respondents and findings show that incentives in the format of discounts on electricity bills, cash incentives and tax credits are the preferred ones to stimulate collective action. The choice can also be left to the companies to decide their preferred incentive types. Among other considerations, sanctions have been proposed as a positive driver, which is included in the modified HLD. Furthermore, it is recommended that instead of implementing the solution on a city-level basis, it can be stepwise implemented in grid and locality level first. These considerations which led to adaptation of the HLD are marked in red in Figure 27, below.

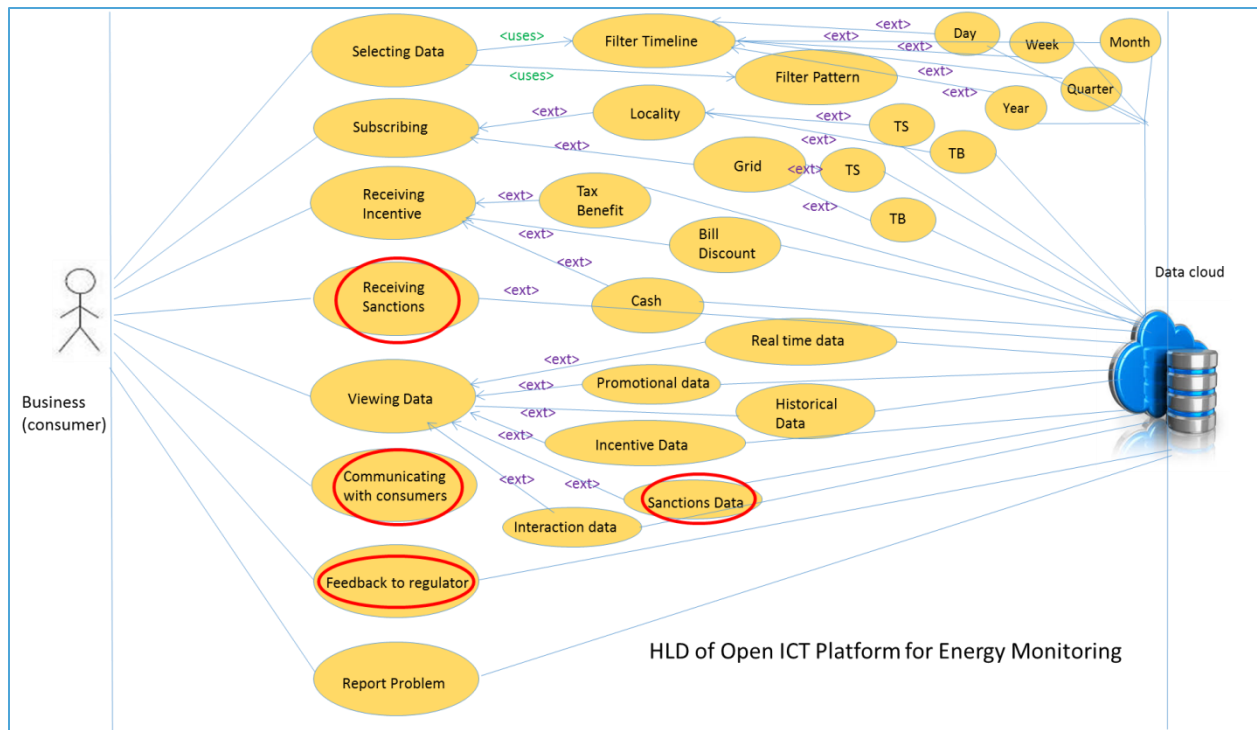


Figure 27: Adapted HLD of platform

The evaluation on CSR as a value addition was found inconclusive for modifying HLD. A method of CSR proposed by one of the respondents that can lead to the concept of *self-sustainable economy* is where big companies create flexibility by producing surplus energy and provide it to the households in the neighborhood during peak hours of the grid. Through this, companies can help households to reduce energy prices. This service by big companies can be seen as a CSR or social good where they can create positive external effects in the society. Therefore the platform can help to monitor energy production and provision to the locality as well. This will be discussed further in future directions of the research.

Generalization

In the interview with the experts, a question on generalization of the conceptual framework was asked. The raw data on generalization are given in Appendix C. The consensus among respondents showed that the conceptual model is applicable to other green ICT trends as well. One of the examples given by the Senior Advisor of ICT at RVO.nl is the intelligent traffic diversion app that saves money, fuel, time of the day and generates new information. It also influences choice of driving. The data of an individual, driving (PLS), can be shared and monitored in a central system that can help to route traffic in the city (HLS) from which all the passengers can benefit from smooth experience on the road and avoid congestion. This is an apt example of ICT as an enabler in the greening of environment. The other interview respondents, irrespective of businesses, energy companies, the government or academics, said that the conceptual framework can be applied to other sectors and domains for monitoring sustainability. Two respondents' recommended slight changes in the proposed conceptual model of my research, which will explain the idea more clearly. The Senior Advisor of Energy and Innovation believed that since the HLS is dependent on the individual actions of PLS therefore the HLS is a superset of PLS, the latter being a part of the HLS.

Associate Professor van de Kaa of TU Delft, recommended that the green ICT trend and PLS can be combined together since the PLS is about greening of the ICT infrastructure in the company level using some green ICT trends. This implies that actions in PLS also use ICT as an enabler for greening of infrastructure. Based on the recommendations of the Senior Advisor in Energy and Innovation at RVO.nl and van de Kaa, a possible variation of the original conceptual model is shown Figure 29. The original conceptual model is also presented in Figure 28.

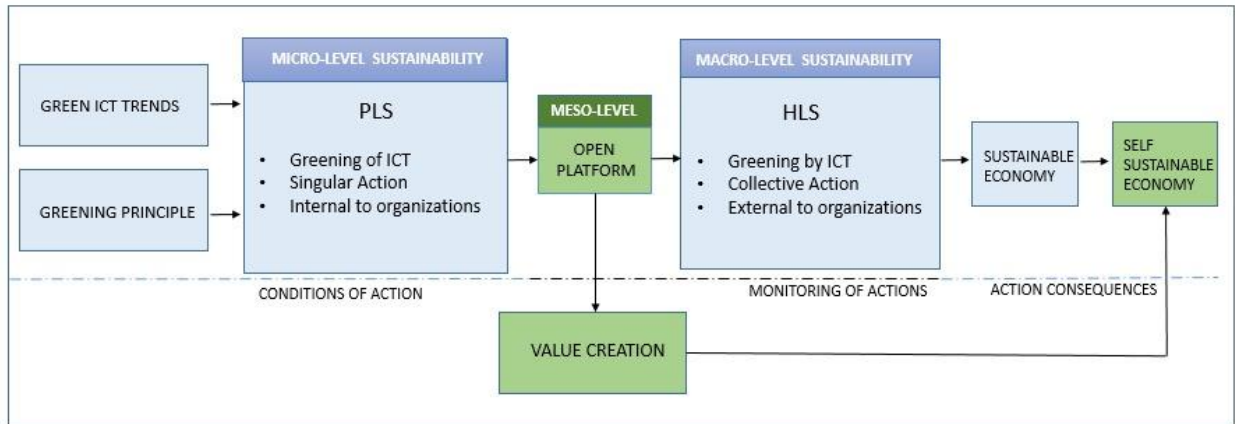


Figure 28: Conceptual Model

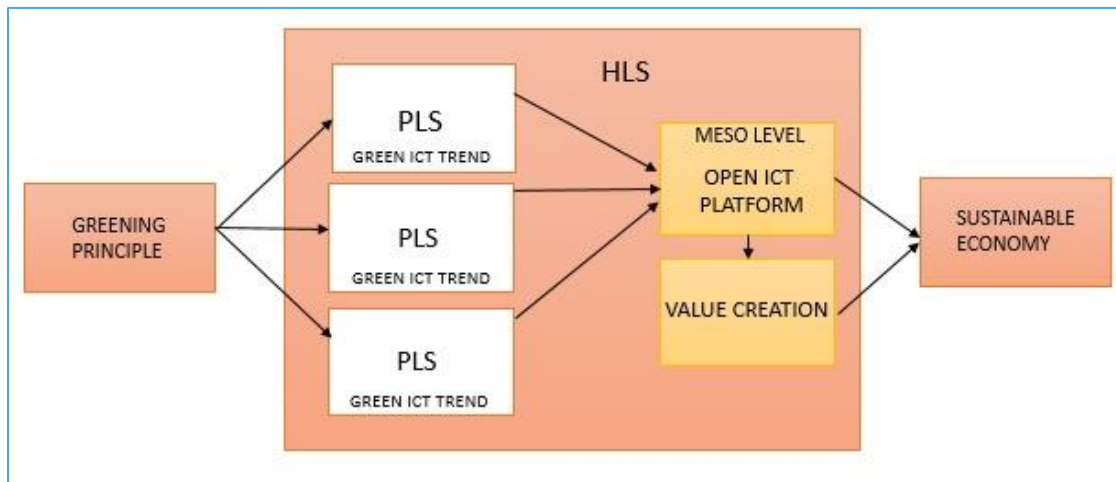


Figure 29: Variant of my conceptual framework

In my conceptual model, the green ICT trends are based on a greening principle and aims to achieve the target of a sustainable economy by creating a link between PLS and HLS by ideating a meso-level in between them. My research also proposed that through value creation and value addition from the meso-level, it may be possible to extend the target of a sustainable economy to a self-sustainable one.

In the variant conceptual model, several actions of PLS uses green ICT trends to contribute to the larger superset of HLS. The idea of a control mechanism in the meso-level for monitoring actions of PLS and contributing towards a sustainable HLS, is similar to the principle of my conceptual framework and does

not change in the variant model. The direct and indirect values created and exchanged through the platform, shows benefits for the actors in the network, which is also true for the original conceptual framework. Since majority of the respondents agreed that the present conceptual model can be applied to other green ICT trends, therefore it holds good for this research, and the variant model is proposed for future research.

In my research, the CSR as a value addition was not a convincing conclusion from evaluation, therefore the concept of self-sustainable economy needs further investigation. The framework shows how the meso-level integrates actions of PLS to contribute towards the HLS target of sustainable economy.

From the findings²⁶ on overall possibility of the open ICT platform solution, it can be concluded that the platform for energy monitoring in the meso-level can serve as a mechanism for establishing a link between the PLS and the HLS in the energy sector, when the conditions of implementation of the platform are met in the future. The significant conditions being, cooperation between organizations for participating in the platform, changing role of the government from a regulator and platform sponsor to a facilitator of the solution, introduction of sanctions as positive drivers of the platform and that implementation should be a phased process starting on a local or grid-level and scaled up gradually. The next steps towards implementation of the platform can be a pilot project in a locality or smart grid level, through which the challenges in the process can be identified, modified and improved and the opportunities can be exploited for providing better services to consumers. The success or challenges confronted by the pilot project can lead to major breakthrough solutions in the platform based smart grids. From the generalization of the conceptual framework, it can be concluded that a platform solution in the meso-level may be one of the possible mechanisms for bridging the knowledge gap between the PLS and HLS and contributing towards a sustainable economy.

The next sections discuss the scientific contributions of the research and its societal relevance.

7.1.1 SCIENTIFIC CONTRIBUTIONS OF RESEARCH

This study contributes to scientific literature in several ways. Firstly, it is one of the few studies that analyze the knowledge gap between individual contributions of a company working on sustainability objectives and the impact that these actions have on the macro-environment. Both PLS and HLS have

²⁶ One of the interesting findings regarding the PLS and HLS link was given by the Senior Advisor of ICT at RVO, who cited a very interesting example from his association with a multinational giant in the Netherlands. He mentioned that the company was able to monitor energy savings from its products and infrastructure in its own facility which he referred to as the PLS. The company was also able to monitor the energy savings from its products in facilities across the globe, which he referred to as the middle-level but the company was unable to track the energy savings from its products in use outside their facilities or in the HLS. Therefore he mentioned, that when the scope is small, companies are able to monitor energy savings but when the scope gets big, a concrete monitoring system needs to be employed, on which the further research is essential. He viewed my research on platform-based smart grid as a positive step towards bridging the link between the PLS and the HLS in the energy sector, whose implications can be applied to other scenarios or top sectors.

been widely researched in their respective fields. The company white papers from ABB [94], Alstom [13], CGI [140] and KPN [141] shows extensive research activities in the PLS. Literature provides several studies on climate change [142] and rising carbon footprints in the world [143], but there was no particular research carried out on the intersection of PLS and HLS. Therefore choosing to address this knowledge gap and creating a conceptual model, by combining the elements of green ICT, sustainable economy, collective action and smart grids is new and not investigated earlier.

The domain of smart grids has been researched widely from a technical or organizational perspective in the literature, but my research analyzes it on the backdrop of PLS and HLS, which unravels a new perspective of the smart energy management model. Furthermore the value creation from the proposed platform in smart grids and value network analysis opens an array of value exchange between the actors in the network, which provides a visual effect of the benefits of the platform use. The value network analysis also delineates who the important actors are in the network and how can they derive maximum benefit from the exchange. From the evaluation of value creation a range of direct and indirect values are sketched that has the potential to advance new business opportunities and establish new business models in the energy sector. My study contributes to the background of socio-technical know-how, on which detailed technical research for implementation of smart energy models can be based.

The research also contributes to the literature on corporate social responsibility by companies. It gives insight into the compliance of CSR policies by the regulators. The analysis of incentive initiative contributed to study on behaviors of corporate firms adopting sustainable practices and competing with other companies on sustainable performances.

In the literature, several cloud based studies on smart grids have been found from a technical perspective but they do not throw light on how different companies can contribute towards the HLS in sustainability through collective action using the cloud solution. This research also acknowledges that a cloud solution in the back end of smart grids is possible under certain conditions of implementation. My research on platform based smart grids can be attributed as a starting point from which extensive cloud based energy management models can be investigated in scientific literature.

7.1.2 SOCIETAL RELEVANCE

The research can be useful for GreenICT Foundation of the Netherlands, because they are a research organization that promotes sustainability through the use of ICT. The organization facilitates scientific research and the project in which my research can contribute is the ICT Innovation platform (IIP) for Sustainable ICT, where ICT research is done from the perspective of an enabler for greening environment (greening by ICT) in the fields of energy efficiency, recycling, sustainable software, innovative use of materials, and (standards) sustainable (wireless) network infrastructures and components. My research shows the possibility of an open ICT platform for smart grids in the energy sector which aligns with the energy efficiency fields of the Foundation. The objective of the research was to establish a link between the PLS and the HLS for creating a sustainable economy and to explore the possibility of an open ICT platform solution in smart grids as a case. The study can be useful for future researchers in the organization who would want to have a clear perspective on the conceptual framework of how PLS can contribute towards HLS, because my research shows, one of the possible mechanisms, is by creating a

monitoring platform in the meso-level in between the PLS and HLS and involving actors through collective action.

The research is especially useful for those researchers who are experimenting on cloud based smart grids, as my study gives an insight into a high level design of a front end platform and how energy monitoring can be performed by companies through sharing data in the cloud. The study also underlines the risks of an open platform-based smart grid and the important considerations to implement the solution. In addition the value network analysis gives a visual effect of the actors involved and how they can benefit by the use of the platform. My research simplifies the actor and value interactions in an open platform based smart grid network. Apart from academic researchers, the study can be helpful for energy companies to understand the grounds of cooperation between different players in the market and why should they share their data. It is useful for the government to develop and harmonize policies within the regulatory framework. The businesses can formulate sustainability strategy and energy policies based on their energy performances compared to the energy trends of their competitors. An entire new generation of business reputation and image can be formed with the sustainability ratings provided to the companies by the regulatory body. The brand reputation can be enhanced by incentives or degraded by sanctions. For e.g. a consumer electronics company who receives a negative rating from the regulators can be viewed as unsustainable by their customers, since their energy performance is not efficient. The incentive initiative and value network analysis is important for each group of actor to realize their takeaways from cooperating and participating in the open ICT platform.

The research is also useful from the perspective of the society, because consumers or local households can benefit from the implementation of the platform, because they will be in the receiving end of flexible energy provision by large companies in the locality, during peak hours of the grid. This can allow common households to decrease their energy prices. Therefore by monitoring energy production, consumption and provision through the platform, companies can span a social good on grid. The regulators can also incentivize sustainable local communities (comprising of large companies and local households) based on sustainable energy consumption and balancing of the network. This can give rise to community energy management initiatives in the future.

Valorization of Platform-based smart grid solution: The concept of valorization highlights extraction of commercial value from a product, service or solution and how they can generate practical benefits for users. It is not only used to explain the financial value from a product or service but also explains how value can be added while receiving commercial interests. The aspects where commercial value can be created from this platform solution are formulated in the following points.

- The research is interesting for grid operators who have emerged as important stakeholders in the network who can be involved in network balancing operations from the flexibility provided by prosumer (businesses in this case).
- The government can act as a facilitator in bringing the players together in the market and kick starting the implementation of the platform as a pilot project in the beginning in the local level. Their involvement as a facilitator can encourage big players to cooperate and participate in the platform, provided they are given attractive incentives.
- A regulatory body who will monitor the energy performances can be entrusted to NGOs, a consortium of companies, or even consultants. This can prove to be an interesting business case for these actors.

- The energy savings from using the platform solution can lead to drastic lowering of prices.
- Companies can sell the energy they produce and create flexibility for others in the grid who need the energy. The recipients can be households who enjoy the lower energy prices due to the flexibility created by big companies. This can lead to a new way of catering to corporate social responsibility by companies.
- The implementation of a pilot project on the local level, can pave the way for community energy management (CEM) initiatives where consumers can be involved in managing energy behavior, creating flexibility in energy production and receiving incentives from the government. Actors like educational institutions, common households and small companies can be a part of such initiatives where they can be clustered with big companies providing them with energy and thus lowering their energy prices. New energy management models can be constructed from the CEM initiatives.
- New business opportunities can be exploited by small medium enterprises from using the energy data of companies which is now shared through the open ICT platform.

7.1.3 RELATION TO MOT MSc PROGRAM

There are 6 MOT courses which significantly contributed in the writing of the thesis. First, is Inter and Intra organizational decision-making (MOT1451), because the assignment on decision-making in the course was a good rehearsal of scientific paper writing with all the essential elements yet critically analyzing a decision making issue. Next, Economic Foundations (MOT1420) helped to understand the basic concepts of macro-economy, sustainable balance, Principal Agent theory, incentives, information asymmetry, adverse selection and positive and negative external effects, all of which have found a place in explaining theories used in my research. Third, is E-Business (SPM9310) which provided the foundation for understanding theories on business models, platforms, business ecosystems, value network, mobile platforms and service oriented architecture. ICT Management (SPM9640) also contributed to understanding concepts of business-IT alignment, cloud computing and green ICT. The course on Quantitative Research Methods (MOT2311) helped to understand the core concepts of doing a scientific research. Finally, Preparation for the Master Thesis (MOT2003) introduced the methods of conducting a literature review and paved the way for commencing the thesis.

7.2 RESEARCH LIMITATIONS

This section presents the limitations of the research that were caused during design or execution of the project.

Perspective of research: The first limitation was choosing the perspective of business's only, as the users of the platform, because the proposed platform could also be used by households or citizens for monitoring energy and by the regulator to monitor energy performances of the companies. Addressing the perspective of citizens and the government was insufficient for the time span of the project. Furthermore, as an MOT student, it is recommended that a student works on the Master's thesis from the business or company's perspective.

Exploratory study and HLD: Since the study is exploratory, designing the specifics of the platform appeared to be a challenging task. Hence, midway through the thesis, the use case diagram of the UML was used to explain the actor's interaction with the specific functionalities of the platform through a HLD. The level of abstraction of the platform design being high, made it difficult for the respondents to grasp the concept initially, but the explanation of the conceptual model simplified the exploration.

Open ICT platform: The research proposed to bridge the gap between PLS and HLS by creating an open ICT web platform for energy monitoring in the meso-level. Nevertheless, the platform could be a mobile app, dashboard or interactive display boards. Also, the control mechanism could have been some a method other than a platform.

Collective action: From the principle of Economics, since collective action has the potential to create a mass impact on the aggregate economy, therefore, collective action was selected for combining efforts of singular action in the PLS to contribute towards the HLS. Some other possible methods could also have been selected to establish the causal link between the segments. For example, an intermediary action could collect the responses of different companies separately and submitted the response to the regulator. This is also an example of monitoring, but is not achieved through collective action, rather exercises centralized control over monitoring of individual data.

Interview Analysis: Each interview respondent expressed their views in detail on the questions asked to them. However, not all the exact data could be recorded in the tables in Appendix C, but bullet points are made to simplify the representation. Furthermore, not every feature mentioned in the risks and positives could be included for data evaluation, otherwise the tables would have been lengthier.

Assumptions: There are certain assumptions which were made for this research to be implemented which are discussed in section 4.1.1. These assumptions are important because the study at hand is an exploratory research on a future smart grid model. The assumptions made relate to the roles of the research relating to ownership and governance of the platform and implementation assumptions which are about the technical components used in the platform solution.

CSR not a value addition: CSR was proposed as a value addition to the platform in my research which has the potential to create a self-sustainable economy. However, most of the expert views found CSR, not the best of choice to include with the energy monitoring platform, and hence CSR does not feature in the adapted HLD. The suggestion proposed by one of the respondents was, where companies can provide energy to local households during peak hours can be viewed as a CSR, but the phenomenon could not be adapted in the research due to time constraints and will be proposed for future research.

New business opportunities: The expert interviews showed that the platform has the potential to exploit new business opportunities especially in the field of data analytics and big data application, because the smart grid network would be over flooded with data in the platform-based solution. The possibilities of new business opportunities with energy data and who the important players can be, is not analyzed in this research.

Functional Requirements and VNA: The formulation of functional requirements of the platform and the analysis of value was carried out based on desk research only and a practical approach designing the platform from survey or interviews was not included.

7.3 REFLECTION

This section presents my views and choices on the design and execution of the project.

The graduation assignment was not any specific research topic, but the suggestion was made by Roel Croes, the CEO of GreenICT Foundation, my external supervisor, to emphasize on the use of ICT in the energy sector. Through literature study, a knowledge gap was identified between the PLS and HLS in terms of sustainability. Thereafter a combination of various aspects led me to study the possibility of establishing a link between PLS and HLS by creating an open ICT monitoring platform in the meso-level.

The smart grids in the energy sector was selected as a case to develop the concepts of my research. The narrowing of scope from a wide range of concepts in the literature took me quite some time. Open ICT platforms, green ICT and smart grids are very different fields from each other, creating a conceptual framework appeared difficult in the beginning, but after careful study of the literature and analysis of the background and domain, a perspective was found. The scarcity of literature in the intersection of the PLS and HLS domains of the energy sector made it difficult to outline the boundary and play with the concepts within the scope.

From literature it was seen that, smart grids have been researched extensively but their actual applicability has not seen much progress. This led me to analyze the challenges that are present behind the mass adoption of smart grids and propose a solution which will include collective action by actors in the network and participate in contributing towards a sustainable economy. The proposed solution required transformation from the present smart grid setting towards an open platform based smart grid network with cloud solution in the back end. This proposition came with its own risks and positives which were identified in the research.

Since the study was exploratory in nature, a high level design of the open ICT platform was constructed to understand the most important propositions of the platform. Also, due to the exploratory nature it was difficult to hand-pick a specific theory from literature, therefore several attributes of an open platform were identified from literature and they were classified according to four groups of platform features. The testing of possibility was conducted through expert interviews which was another challenging aspect of the thesis. The respondents were selected based on their groups, availability and network opportunities, and the categorization in groups gave a clear understanding of the opinions and views on the solution from their professional backgrounds. Scheduling appointments with the fifteen interview respondents were time-consuming and difficult due to their busy schedule. Receiving of answers from some of them while collecting, recording and analyzing the data of the others was also a challenge that had to be overcome. Normally in case research, the main concepts of the research are explained by theory and data collection is performed to propose a method to solve the research problem; in my research the theoretical

analysis was extensive which helped in formulating the design criteria and building the HLD of the platform, whose possibility was tested through the fifteen interviews conducted among the four groups of respondents. The complexity and wide scope of the problem, coupled with lengthy deskwork research in the first phase pulled the research to an extent from where the expert interviews instilled practical relief to the project. The segmentation of the research in formulating the design criteria, constructing the HLD and value network was also followed during planning the interview questions, evaluating the data and presenting the results. This systematic approach of the interview analysis phase made it possible to draw logical conclusions from the evaluation and generalization of the research framework.

If more time was available for the research, then the things which could have been included in the research are: 1. Creating flexibility models on energy provision by large companies to the local households during peak hours, which can also be viewed on the backdrop of CSR activities. 2. Whether the platform solution could have earned sufficient returns on investment could be investigated, by taking into consideration average monetary figures on infrastructure investment and energy production, 3. A regulatory body other than the government would be investigated who could facilitate the monitoring of energy performances by companies, 4. More interviews could be arranged to have about 5 respondents from each category, which could help to analyze the solution better in an even manner (Currently there are more academics are interviewed), 5. The distinction between grid operators and energy companies could have been made, which would have led to a complex network diagram for explaining the current and future model of smart grids, but would have clarified the proposition even better. Apart from this, on a personal level, I would have scheduled the interviews well in advance to prevent last minute hassles of scheduling the interviews.

7.4 FUTURE DIRECTIONS OF RESEARCH

The limitations discussed in the previous section provide avenues for future research to build upon this study. The research ended on the note, where considerations are needed to be addressed for implementing the open ICT platform in future smart grids. The list of considerations is given below:

1. *Organizational cooperation needed*
2. *Government should act as a facilitator and not platform sponsor and regulator*
3. Implementation of platform solution must be a top down policy from the regulators
4. *Sanctions should be implemented for better functioning of platform*
5. Companies should be given attractive benefits for participation
6. Privacy is of utmost concern for the consumers which must be established
7. Collaboration of big companies can help in the easier roll out of the platform solution
8. The system should pay for itself, i.e. the return on investment (ROI) should be high
9. *It should be implemented first in the smart grid or locality level*
10. Financing the platform should be possible and economic
11. The solution should be implemented stepwise
12. It can be first implemented in other areas of business (monitoring actions through cloud based platform)
13. Cloud solution may not be implemented in the beginning and the DRMS of energy companies and grid operators can be interconnected by standardization to fetch the consumption data

Of the considerations mentioned above, the four most important ones (shown in italics) are organizational cooperation, government in the role of a facilitator and not platform sponsor, introduction of sanctions

and implementing the solution in the grid or locality level. Each of these considerations are influenced by several risks and positives which needs to be investigated. Based on the findings, strategies can be developed by the facilitator for bringing key players to participate in the platform and then roll it out for other businesses to participate.

The second consideration is entrusting the role of platform sponsor to a regulatory body or a third party, can enable future researchers to investigate who can take the responsibility of platform governance and perform the task in an unbiased way without any opportunistic behavior, since the system will comprise of rich and sensitive data.

The third consideration is to introduce sanctions which can be as essential as the incentives to drive the platform. The future path of research can analyze what kind of sanction plans can be implemented, will they be based on not conforming to energy savings target, or on paying higher bills for electricity, or generating excessive carbon footprint in the environment. This can lead to the next interesting topic of measuring energy efficiency and when can a company become liable for receiving the sustainability ratings and incentives based on their energy efficient performances.

The fourth consideration is to first implement the platform in a locality and then test the technical and organizational feasibility before rolling it out on large scale because the cloud in the back end will need to be robust for housing the complex data layering logic from different smart grids in a locality. The implementation can be in the form of a pilot project with a step-wise implementation and when the challenges in every step are addressed then it can be scaled up to implement over a large area.

The platform solution centralizes monitoring and control in the market but decentralizes the value exchange by business through collective action because different consumers can participate in the platform and create or receive benefits. The evaluation of value exchange was carried out based on views of fifteen respondents, in the future, more responses can be investigated to get a clearer understanding of the value created from the platform.

Most of the respondents were of the opinion that open data in the system is of rich quality and can be utilized for exploiting new business opportunities. These applications can be further investigated in the future as to how big data, smart data analytics can capture insights from the energy data transaction with the use of advanced ICT techniques. Moreover, this can also create other benefits which can be seen as a value addition to the platform. Smart assets like the internet of things which is the next talk of the future can also be roped inside the platform-based smart grid network, and this can have huge potential in absorbing, transmitting information on a massive scale with new capabilities. Sustainability has become a corporate performance metric, therefore the monitoring system in the meso-level can be applied to realms outside the energy sector using an open ICT platform or some other methods to test the possibility of the solution in those domains. The evaluation of the possibility of the platform is made based on the views of fifteen respondents; nevertheless, more experts can be interviewed to receive feedback on the open ICT platform and more questions can be asked to test the possibility from other aspects too, like technical and financial aspects. Other research methods can also be used, for e.g. a survey to receive reactions on different short questions. The data of the survey can be analyzed quantitatively to attribute numbers and percentages to the reactions on different questions. The quantitative analysis will help in understanding accurately what can work and what cannot work for the platform.

The financial perspective is excluded from the research, but it is one of the important aspects that will either drive or impede the implementation of the solution. There are several questions which can be addressed in future research, with respect to funding the platform, for e.g. who can be approached for receiving funds? What kind of infrastructure needs to be employed? What will be the cost of the technical infrastructure? Will the return on investment be high enough to sustain the platform and provide incentives? Would alternative modes contribute to the same objective but cheaper? Answering these questions can make the bottlenecks in the path of platform based smart grids clear and put forward a clearer case to assess the possibility of beyond the high level perspective which is adopted in the research.

The variant of the proposed conceptual framework is recommended for future research, where it can be analyzed using a case to support whether HLS is indeed a superset of PLS or not for green ICT trends in the field of sustainability. The future study can be possibly explored by conducting interviews or survey with several experts.

The risks identified from this research on the system/technical, platform/implementation and user control level will need to be addressed in the future, for the platform to be implemented. More research can be conducted on the formulation of functional requirements, and views of experts can be taken to design the choices suitable for developing the platform and conducting the VNA to support the value proposition of the solution. The solution at present poses several risks and technical challenges which we have identified and discussed, but future research can investigate other types of challenges that need to be addressed, for e.g. societal, economic, human resources and legal challenges. The platform based solution has the potential to create a breakthrough energy management model with massive knowledge and strength in the field of ICT and power systems [144].

Finally, the public good on the grid or CSR can be combined in way to add maximum flexibility in the smart grid network, such that whoever needs energy in the grid can always receive it at low energy prices. Big companies in the future on becoming a prosumer, can provide surplus energy to the households in the neighborhood, who can benefit from this energy at low price, during peak hours in the grid. This can lead to the formation of sustainable communities in society that thrive on community energy management initiatives. This kind of a service by large companies can be seen as CSR which adds value to the platform based solution, because the companies will be able to monitor their energy production, consumption and provision real time through the use of this platform. Diverse initiatives on community energy management providing a local autonomy amidst a centralized market control can be investigated in the future.

8 APPENDIX A

This section of the Appendix sketches the literature referred for my research. The literature which contributed to the theoretical background of the research are shown in Table 18.

Title of Paper	Authors	Journal	Pages	Year	No. of Citations
1. Introduction: coming to terms with Anthony Giddens	Bryant, C GA Jary, D	Giddens' theory of structuration: A critical appreciation	1-31	1991	(Google Scholar) 72
2. Opening platforms: how, when and why?	Eisenmann, T. R., Parker G, and Alstynne M.V	Platforms markets and innovation	131- 162.	2011	(Google Scholar) 105
3. Open ICT Ecosystems Transforming the Developing World	Smith, M. Elder, L.	Information Technologies & International Development	65-71	2010	(Google Scholar) 19
4. Benefits, Adoption Barriers and Myths of Open Data and Open Government	Janssen, M, Yannis C, Zuiderwijk A	Information Systems Management	258- 268	2012	(Google Scholar) 74
4. The Logic of Collective Action: Public Goods and Theory of Groups	Olson, A. R.	Book	NA	1971	(Google Scholar) 28999
5. Common Platform Dilemmas: Collective Action and the Internet of Things	Nikayin, F	Book	.NA	2014	
6. Optimal Coordination Mechanisms In Generalized Principal-Agent Problems	Myerson R.B	Journal of Mathematical Economic	67-81	1982	(Google Scholar) 773
7. Value network analysis & value conversion of tangible & intangible assets	Allee, V J	Journal of Intellectual Capital, 9 (1)	5-24	2008	(Google Scholar) 172
8. On value and value co-creation: A service systems and service logic perspective	Vargo, S. L. Maglio, P. P. Akaka, M. A.	European Management Journal	145- 152	2008	(Google Scholar) 890

Table 18: Main Literature Study Sources

The literature which contributed to the building of concepts of the research are shown in Table 19:

Title of Paper	Authors	Journal	Pages	Year	No. of Citations
1.The Challenge of Sustainable Development	Jansen. L	Journal of Cleaner Production	231–245	2003	(Google Scholar) 106
2. Sustainable consumption: a theoretical and environmental policy perspective	Spaargaren, G.	Society & Natural Resources	687-701	2003	(Google Scholar) 304
3.From green to sustainability: Information Technology and an integrated sustainability framework [145]	Dao, V., I. Langella, et al.	The Journal of Strategic Information Systems	63-79	2011	(Google Scholar) 76
4.A key issue in product life cycle: disassembly	Jovane, F., L. Alting, et al.	CIRP Annals-Manufacturing Technology	651-658.	1993	(Google Scholar) 240
5.Harnessing green IT: Principles and practices	Murugesan, S.	IT professional	24-33	2008	(Google Scholar) 405
6. The evolving world of power opportunities and challenges	ABB Ltd. Power Products and Power Systems	ABB Company White Paper			
7. Grid Home - About Smart Grids - Components of the smart grid	Alstom	Alstom Company White Paper			

Table 19: Other literatures referred

The key words that I searched in the internet construct the concepts of my research were: green ICT, micro-economic sustainability, macro-economic sustainability, sustainability, sustainable economy, sustainable ICT, ICT platforms, open platforms, open data, open ICT ecosystems, corporate social responsibility, energy sector, energy monitoring, energy efficiency, smart grids, socio-technical systems, value network, value creation. These concepts were then further developed to build the conceptual framework of my research, which helped in formulating the research objectives and research questions that my research aims to meet and answer respectively.

9 APPENDIX B

This section of the appendix includes definitions on *platforms* which was noted, during the formulation of a platform definition in the research.

Platforms
The term platform basically means a physical foundation to establish activities. [146]
The primary difference between the traditional discussion manufacturing oriented platforms and digital platforms is that digital platforms are either entirely software-based or they are mixtures of physical and digital elements [146]
Platform development is also a technical issue because it needs specific problem solving procedures and is related to other development issues such as product architecture and modularization. Indeed the concept of platform is closely tied to that of modules and product architecture [147]
The three groups of participants in a platform ecosystem – platform owners, app developer and end users – have unique needs and motivations for participating in it. Therefore a platform must uniquely appeal to each group in how it aligns with their interests relative to a product or service [148].
Technically, a service platform is a combination of hardware architecture, network, and an operating system or a software framework required to offer software services to end users [47]
A software platform is an extensible code base of a software based system that provides core functionality shared by the modules that inter-operate with it and the interfaces through which they operate [149]
Platforms have modular architectures in which core independent modules are being used and reused across multiple products and services [150].
An industry platform creates strong interdependencies between the platform and its complementary products and services in a way that there is no demand for complementary products when they are isolated from the platform [151]
A service platform coordinates interaction between two or more groups of participants (i.e. end users and complementary providers), and also exhibits network effects [44].
In the context of ICT platforms, this implies that gatekeeper functionalities, corresponding to a number of specific business roles, are instrumental in strategies to make available information and communication resources and thereby attract great numbers of customers, but at the same time allow to control various types of customers [152].
Platform leaders have built a business model around a set of crucial gatekeeper functionalities and roles that help them to exercise a form of control over the wider value network, and to add and capture

significant value in the process. [152, 153]
ICT platforms exerting different forms of control in the market through the employment of different business models – and thus potentially giving rise to different regulatory concerns – the first step to refine the analysis of platform markets is to introduce a platform typology, based on the value and control configurations associated with these platforms. [153]
Platform depends on the implementation of consistent changes across the domains of product, organization and knowledge [46]

Table 20: Definitions of platform

10 APPENDIX C

Appendix C comprises of details of the interview respondents in section 10.1, tables with data collected during the interviews in section 10.2 and tables for evaluating the data collected in section 10.3.

10.1 INTERVIEW RESPONDENTS

The overview of interview respondents from business as consumers, energy companies, the government and academic researchers have been presented in Table 21.

SNo.	Name of Interview Respondent	Interview Category	Designation/Profession	Organization/Institution	Date and Type of Interview
B1.	Frits Verheij	Business as consumer	Director, Smart Energy Cities	<i>DNV GL</i>	10.10.2014, Telephonic
B2.	Marga Blom	Business as consumer	Director, Energy management	<i>KPN</i>	15.10.2014 Telephonic
E1.	Marco Spoel	Energy company	Project Manager, Maintenance and Support	<i>Essent</i>	17.10.2014 Telephonic
E2.	Erik Matien	Energy company	Co-owner and Business Developer, Energy solutions	<i>EnableMi B.V</i>	9.10.2014 Email
E3.	Koen Hermans	Energy company	Offshore Energy Researcher, Cost Reduction in offshore energy support structures	<i>ECN</i>	6.10.2014 Email
G1.	Frank Hartkamp	Government	Senior Advisor ICT in long term project agreements in the Top Sectors of the Netherlands	RVO.nl (National Enterprise Agency)	16.10.2014 Face to Face
G2.	Olivier Ongkiehong	Government	Advisor Energy R&D, (smart grids policy making) Energy Research Grant	RVO.nl (National Enterprise Agency)	24.10.20 Telephonic
A1.	Jaco Appelman	Academic Researcher	Facilitator and Researcher, Systems Engineering, TBM	<i>Delft University of Technology</i>	6.10.2014 Face to Face
A2.	Geerten van de	Academic	Assistant Professor Strategy	<i>Delft University of</i>	9.10.2014

	Kaa	Researcher	and Innovation, TBM	<i>Technology</i>	Face to Face
A3.	Gerard Smit	Academic Researcher	Professor & Chair, Computer Architectures for Embedded Systems group. Electrical engineering, project: energy autonomous smart micro grids	<i>University of Twente</i>	21.10.2014 Telephonic
A4.	Somenath Roy Choudhury	Academic Researcher	Professor of Cloud computing, database management, Ex-Head of the Department, Computer Science and Engineering Faculty	<i>B.P. Poddar Institute of Management and Technology (India)</i>	14.10.2014 Email
A5.	Fatemeh Nikayin	Academic Researcher	Post-Doctoral Researcher, Smart living and e-health systems, Smart cities, ICT section, TBM	<i>Delft University of Technology</i>	9.10.2014 Telephonic
A6.	Gautham Ram	Academic Researcher	Doctoral Researcher, Electric Vehicles and Photovoltaic cells, Electrical Power processing group, Faculty of Electrical Engineering	<i>Delft University of Technology</i>	6.10.2014 Face to Face
A7.	Davide Garufi	Academic Researcher	Postmasters PD-Eng. Researcher, Smart Buildings and Cities Program	<i>Technical University of Eindhoven</i>	9.10.2014 Skype
A8.	Yilin Huang	Academic Researcher	Post-Doctoral Researcher, Systems Engineering and Simulation, Multi-Actor Systems Department, TBM	<i>Delft University of Technology</i>	25.09.2014 Email

Table 21: Overview of Interview Respondents

The next section presents the data collected during interviews.

10.2 DATA COLLECTION

This section comprises of data recorded during feasibility exploration of the thesis. It consists of raw data from the expert interviews, which were first organized in an Excel sheet and then structured into tables. The data is presented according to 3 sets of question: 1. Design and implementation, 2. Value creation and 3. Overall possibility and for each set, the views of the respondents are recorded based on the 4 groups of actors: 1. Business as consumers, 2. Energy companies, 3. Government and 4. Academic researchers. This raw data captured from the interviews is analyzed and evaluated in section 6.2 of the report.

10.2.1 DESIGN & IMPLEMENTATION

This section presents the interview data from the four groups of respondent on design and implementation issues of the platform. It answers the following interview questions:

- 1 a) What are the risks of this platform according to you?
- b) What are the positive features of the platform solution in the research?
- c) In an open platform, what are the 2 most important functions? Have they been addressed in this research?

The views on positive features and functionalities of the open platform are combined under positives of the platform.

10.2.1.1 BUSINESS AS CONSUMERS

This section presents the interview data from business as consumer respondents. Table 22 comprises of their views on risks and positive features about the platform solution.

SNo.	Interview Respondents	Risks of platform solution	Positives of platform solution
1	Frits Verheij	<ol style="list-style-type: none"> 1. Market control is decentralized at the present, centralizing control is a big risk 2. Investment on IT infrastructure will be huge due to large number of consumers 3. Lack of understanding among consumers on how to use the data 4. Clarity on who is the data provided to 	<ol style="list-style-type: none"> 1. Healthy and positive competition between businesses 2. Flexibility in the availability of energy consumption data 3. Increased smart use of data 4. Generation of rich quality data for service of other client 5. Big data and analytics field will find importance 6. To provide personalized data to users 7. Data will provide a range of other services 8. Other functions will depend on what type of data and how frequently the data is collected or whether it is constantly connected to the network
2	Marga Blom	<ol style="list-style-type: none"> 1. Needs advance technology for energy storage mechanism 2. Not so easy to steer production of energy by households, does that mean they will be kept out of the scope of platforms? 3. Information in the cloud can be hacked, advanced security needed 4. The information which is generated, needs good demarcation between what is generated and what is really used 	<ol style="list-style-type: none"> 1. Exchange of information stimulating competition between businesses 2. Privacy is there, since average energy consumption gets shared and displayed in the platform 3. Contributes to energy efficiency improvement, balancing load and network by grid operators' i.e. sustainable production and consumption 4. Accessibility of users to see about energy consumption data of others and energy trends in market, therefore the functions are data sharing and transparency is receiving data through the platform

Table 22: Business as consumer's views on design and implementation issues

10.2.1.2 ENERGY COMPANIES

This section presents the interview data from energy company respondents. Table 23 comprises of their views on risks and positive features about the platform solution.

SNo.	Interview Respondents	Risks of platform solution	Positives of platform solution
1	Marco Spoel	<ol style="list-style-type: none"> 1. Mixing of consumer + business model in this solution which may make it difficult to extract the benefits for either parties 2. Participation of all companies and stakeholders may not be possible 3. Unwillingness of small companies to participate, since they only consume flat rate energy, and may not be able to show sufficient energy consumption to be liable for reward 	<ol style="list-style-type: none"> 1. Possibility of independent evaluation of sustainability, currently stakeholders are trying to monitor it separately by themselves. a good monitoring platform, 2. With big data around the corner companies may have edge over others to use the data smartly and create competitive advantage, 3. The energy data can create new business propositions for small startups 4. Information sharing primarily (For e.g. advise on how to reduce or manage energy consumption and what can be changed to consume less) 5. Market forecasting by energy companies who can advise customers about energy usage (don't use washing machine today, use it twice tomorrow due to high price)
2	Erik Matien	<ol style="list-style-type: none"> 1. Privacy issues 2. The scope of the solution needs to be defined because we are talking about global data. Where stops the database in terms of borders? But again, it may be complex to organize the database. 3. Added value for the customer/ inhabitant of a city, which is not addressed. 	<ol style="list-style-type: none"> 1. Short and fast way to include participants for a research project. 2. Possibly deliver new services from data by combining alpha, gamma and beta research i.e. different elements of the research to ultimately add and quantify the value
3	Koen Hermans	<ol style="list-style-type: none"> 1. Inability to carry out business activities by a company because other businesses will affect the energy flow & prices ('neighbors'), in which case there is a changing energy price that can harm the profit of the company made during its activities. 2. Strategies have to be made on how to get the cheapest energy price which costs me well qualified personnel/analysts and this falls outside of my main focus. Current policy is better predictable and thus more reliable. 3. A guideline on what actions to take is needed, but every business is different so this might be too much to ask and the platform may not be able to provide that. 	Getting a better insight in the impact of greening activities to perform the greater good. This connects well to corporate sustainability, and provides a good image to the consumers.

Table 23: Energy companies views on design and implementation issues

10.2.1.3 GOVERNMENT

This section presents the interview data from respondents in the government (policymaking). Table 24 comprises of their views on risks and positive features about the platform solution.

SNo.	Interview Respondents	Risks of platform solution	Positives of platform solution
1	Frank Hartkamp	<ol style="list-style-type: none"> 1. Privacy is a concern for consumers but if average consumption data is transported then it should be less of concern. 2. Platform should be easy to use, with no complex interface. 3. Data should generate visible changes in energy trends, otherwise it will be difficult to satisfy consumers 4. Building trust is a challenge as energy companies need to be ensured that their data is safeguarded and no misuse is done. 5. Energy costs should not shoot up due to expensive infrastructure installation by energy and utility companies 	<ol style="list-style-type: none"> 1. Prices can be reduced and consumers can sell energy other than monitoring, which will lead to consumer empowerment 2. When the data is collected, new business opportunities can be exploited in the form of breakthrough initiatives 3. Managing of flows (energy +data) which aims at more energy efficient solutions 4. Enriched data is produced due to sharing and contributing by many actors. 5. Transparency is present which enhances accountability for actions 6. Comparison of consumption trends
2	Olivier Ongkiehong	<ol style="list-style-type: none"> 1. Position of platform in value chain, who actually uses the data produced, who sells and buys which products and services, which can trigger broader dialogs with the stakeholders. 2. Financing the platform - operation, rules of commercial trade (for example calibration of measuring equipment in the context of billing systems) 3. Data privacy and cyber security 	<ol style="list-style-type: none"> 1. A positive step to act in a increasingly complicated energy world. 2. Local energy initiatives or community energy management can get impetus due to the information shared. 3. Enabling flexibility within the energy system (e.g. if PV generation increases, flexibility should be deployed to increase demand somewhere, maintaining the balance between supply and demand)

Table 24: Government's view on design and implementation issues

10.2.1.4 ACADEMIC RESEARCHERS

This section presents the interview data from academic researchers. Table 25 comprises of their views on risks and positive features about the platform solution.

SNo.	Interview Respondents	Risks of platform solution	Positives of platform solution
1	Jaco Appelman	<ol style="list-style-type: none"> 1. Government's monitoring can be seen as a chance of manipulating 2. Safety in the service needs to be ensured, customer privacy should be given it's duly importance 3. Companies are altruistic we all hope but the reality may be different 4. Businesses cannot act on opportunities since the system proposed seem to be regulated, they need to have interim dialog with regulators which can be time consuming 5. It is an evolutionary solution, therefore should be scalable and ready for change to keep abreast with new technologies and implement change management e.g. the IT infrastructure should be scalable and interoperable with future devices and internet of things 	<ol style="list-style-type: none"> 1. Supports collaboration between actors 2. Businesses contribute towards a mass sustainable development in which CSR is the next step 3. There is relative flexibility of data - in collection, display, integration, organization and use 4. Transparency of data, actors more accountable is a big potential in the platform 5. Energy market can do forecasting and the data can be used for different services

2	Geerten van de Kaa	<ol style="list-style-type: none"> 1. Making private data accessible can create information security risks. This increases possibility of actors/ hackers to break into cloud 2. Acceptability of the platform is a risk - consumers may want to use it but difficult to convince the energy companies which can lead to difficulty in adoption of the platform 3. Information balances the energy market, therefore it becomes source of information that is highly sensitive to market trends 	<ol style="list-style-type: none"> 1. Driver towards a sustainable environment 2. Information can be used for other services by businesses 3. Energy efficiency and energy management in the energy ecosystem can be achieved since it gives a control and balancing mechanism 4. Information is more open, exploits new business opportunities and balances the market 5. Displays consumption patterns which is nice for consumers to have since they can use it for monitoring purpose and make sustainable energy policy for the future
3	Gerard Smit	<ol style="list-style-type: none"> 1. People (consumers and energy companies) may not like the concept of big brother collecting all data 2. In spite of average data on consumption feeding into the cloud, consumers may not want to share that data 3. Presently consumers do not trust energy companies, hence they may not want to share the data into cloud too (Household consumers consume 1/3rd of energy produced, hence they are a big segment to influence the market) 4. The high level design may not be enough for people to understand the benefits of the platform so it needs to be specific in its design 	<ol style="list-style-type: none"> 1. Easy to understand the direction of energy flow in the value analysis, hence the VNA is a nice visualization of the values that can be possibly created 2. It will give a lot of information on the demand response management and energy consumption patterns of consumers, which will be very useful data to provide services to consumers 3. Informed choice making through open platform empowers its users. 4. Increasing awareness of consumers because of information sharing through collective action. However, this would become more complete, if there is a feedback system in the platform, through which consumer opinions can reach the platform sponsor or regulators
4	Somenath Roy Choudhury	<ol style="list-style-type: none"> 1. Computer security threats from International groups/Hackers/Unwanted persons. (layers of security may be required, data may distributed and nobody should get access to the full database) Stealing of data for other unlawful use 2. Every energy company has their own proprietary database and data-warehousing facility. But the problem is that how much they will share the information with others. 	<ol style="list-style-type: none"> 1. More awareness for the common users of the facility. Proper Smart-phone app can be designed for creating awareness. 2. It can create new business opportunities for the future. E.g. it can serve as a future buying proposal for any gadgets, utility companies like gadget-maker may be interested in this. 3. Sharing of information 4. Transparency of data
5	Fatemeh Nikayin	<ol style="list-style-type: none"> 1. Convincing energy provider - difficult 2. Building trust would be difficult - data shared should not be misused by any party 3. Energy companies will have to deploy in large IT infrastructure - high trust needed for IT and telecom providers 4. Trusting the data in cloud and installing advanced security 	<ol style="list-style-type: none"> 1. The idea is very good and the collective action achieved towards a sustainable environment is a plus 2. The implementation of cloud is technically feasible, which can be a driver for the solution to work
6	Gautham Ram	<ol style="list-style-type: none"> 1. Privacy will be a big issue for transporting data in the cloud, advanced security features needed to safeguard data 2. Data itself is money, therefore is of great value to energy companies, they may not be very positive about sharing it, so trust and cooperation on the front of energy companies looks difficult 	<ol style="list-style-type: none"> 1. Data is always available and there is certainty on the grid and platform, 2. Incentives can be a positive driver of the system, 3. Government can regulate the energy sector, have more streamlined policies in place from the data available of consumers

7	Davide Garufi	<ol style="list-style-type: none"> 1. Consumer awareness - explaining to people what the platform is about? What are current trends? How can collective action be achieved through the solution? 2. Type of business participating must be different, because level of sustainability is different for every business (all companies want to be sustainable in different ways) 3. Democratic participation is a big issue - strong political willingness can appear like dictatorship and can be deterrent 4. Grid is overcharged, need to use battery - but the reliability of storage mechanism needs to be tested 	<ol style="list-style-type: none"> 1. Cloud solution is a good proposition <ol style="list-style-type: none"> a) no physical storage needs to be maintained at different companies, b) data center heat from the cloud can be utilized for district heating c) creation of transition to a sustainable society 2. Perceptions of trends 3. Availability of information at hand 4. Consumer awareness
8	Yilin Huang	<ol style="list-style-type: none"> 1. User/business participation and commitment 2. Data safety and information security 3. Adequate government policy 	<ol style="list-style-type: none"> 1. It will foster collective action 2. Sharing of data can lead to new business services 3. Incentive initiative is a plus 4. Consumer Awareness 5. Sustainability tracking through collective action

Table 25: Academic researcher's view on design and implementation issues

10.2.2 VALUE CREATION

This section presents the interview data from the four groups of respondent on value created from the platform. It answers the following interview questions:

- 2 a) What are 2 values which can be created by businesses through the platform, according to you?
 - b) What is your feedback on the incentive initiative by the government to encourage businesses to monitor sustainability?
 - c) Which type of incentive would be more suitable for government to give?
 - d) Do you see merging corporate social responsibility (CSR) of companies with energy monitoring platform a value addition?
 - e) How do you think government could monitor whether companies are indeed contributing to CSR or not?

10.2.2.1 BUSINESS AS CONSUMERS

This section presents the interview data from business as consumers in Table 26, on the value created and added through platform and the incentive initiative proposed.

SNo	Interview Respondents	Values Created	Incentive Initiative (and specific type)	Value addition	Compliance over CSR Initiatives
1	Frits Verheij	<ol style="list-style-type: none"> 1. Informed decision making through automated real time information 2. Through energy transition, decentralized local scale community energy management schemes can be developed 3. Stakeholders contribute towards a sustainable system for the future 	<ol style="list-style-type: none"> 1. Incentives can be a positive driver, but data aggregation will be very important for fair assessment 2. Government's direct role may not be appreciated by companies, so third party regulatory body can be appointed by government, e.g. consultants 3. Best to keep government in the role of a facilitator only 4. Cash is good, companies can be made to follow energy savings target and be rewarded. Electricity discount is also a good option. 5. Industry needs more stimulus to implement this 	<ol style="list-style-type: none"> 1. Industry needs more stimulus for CSR perhaps, not very sure how it would turn out 2. The data generated should be analyzed and it can provide insights into consumption trends and compare it with peers by participation in the platform. 3. Achieving energy savings, or cost reduction is a value addition 4. Enriched data is a value addition too 	For larger industry the top down approach can be taken and centralized monitoring can be done but for small scale industries it is not possible to monitor by inspection, other methods needs to evolve
2	Marga Blom	<ol style="list-style-type: none"> 1. Highest value can be seen for grid operators since they can balance the network with the energy produced from consumers. 2. For consumers the availability of information is a value for them to make informed decisions 	Incentives are not quite understandable because more business growth by servicing more customers will make one unsustainable because business is consuming more energy. Therefore energy may not be the only parameter for giving incentives based on sustainability. Other parameters can be integrated too.	Provision of energy produced by companies to local households which can be an activity of CSR and a value addition	The platform itself can help in monitoring of how much energy is produced and sold to the grid, but it will need to be adapted for this function

Table 26: Business as consumer's views on value creation

10.2.2.2 ENERGY COMPANIES

This section presents the interview data from energy companies in Table 27, on the value created and added through platform and the incentive initiative proposed.

SN o	Interview Respondent	Values Created	Incentive Initiative (and specific type)	Value addition	Compliance over CSR Initiatives
1	Marco Spoel	<p>1. Information always available at hand</p> <p>2. Government can also give sanctions to one who pollutes, and thus pays more,</p> <p>3. Validation of taxes can be done through the monitoring</p> <p>4. New business models for energy management based on available data, smart and big data analytics is possible</p>	Cash is always a benefit for companies, subsidy schemes can be arranged	Value addition will be for firms which who are not doing well on the energy efficiency front. For other jumbo firms, it may not be that lucrative to have incentives from government	Self-reporting is possible through the platform by businesses, but since the solution aims for collaborative participation therefore it is better to empower the consumers with some methods to monitor the CSR activities
2	Erik Matien	New services can be provided for consumers, companies and communities with the data generated. Better power quality and balance on the grid (is also a kind of service for the TSO and DSO's).	This is a political driver. Talking about sustainability in the field of electricity you should think about the financial perspective and/ or comfort benefits for people and organizations. The role of the government (represented by the DSO's) is to collect and secure data and give companies (after approval of the data-owner; you and me) access to this.	Not sure about the CSR, if that will work, but incentives or benefits can be a value addition for sure for companies	This will depend on the companies, if otherwise not imposed by the government
3	Koen Hermans	<p>1. It can stimulate cooperation between businesses on the field of sustainability</p> <p>2. Create new business partnerships among stakeholders for co-creating services</p>	Incentive is necessary to make up for the added costs. Negative incentives might work better. Government shouldn't interfere with the energy price too much.	To create new business services, alliance with new stakeholders in the energy market	Not possible to say, without the actual incentives that will come in the way of a company

Table 27: Energy companies views on value creation

10.2.2.3 GOVERNMENT

This section presents the interview data from respondents in the government (policymaking) in Table 28, on the value created and added through platform and the incentive initiative proposed.

SN o	Interview Respondents	Values Created	Incentive Initiative (and specific type)	Value addition	Compliance over CSR Initiatives
1	Frank Hartkamp	<p>1. New services nonexistent at the moment can be created.</p> <p>2. It facilitates an energy consumer to produce energy and sell it also monitor it through the platform - which is in itself consumer empowerment</p> <p>3. Creates better understanding of the system for the consumer through platform</p> <p>4. Discounts on PV cells for producing solar power on terraces can motivate consumers</p>	<p>Carbon credit is attractive for companies in manufacturing and chemicals who trade carbon permits, for common households it does not apply.</p> <p>Apart from incentives, sanctions should also be in place to drive the system, subsidy schemes can also be awarded to companies. For e.g. those that prove to be energy efficient can be given a 50% evasion on taxes, but they should contribute to social initiatives</p>	<p>Social initiatives can be a feasible idea in the plan</p>	<p>Inspections not a good idea, the system should be well tested and consumers as in citizens should be empowered to monitor compliance of local initiatives by businesses</p>
2	Olivier Ongkiehong	<p>1. Community energy management initiatives will develop fast with such a platform</p> <p>2. Flexibility will be produced in the system which can benefit consumers like households too.</p>	<p>Incentives should come from the way markets are organized and from the rules on the playing field, not directly from a government.</p>	<p>CSR activities can be a value addition with the platform, but the government may not be willing to monitor it, so a 3rd party should be introduced to sponsor the platform and monitor the energy data and CSR, because once the platform is rolled in the marketplace, the government does not want to interfere much. However, the data can be definitely useful for the government to make assessment of policies</p>	<p>Reporting can be done by companies to the platform sponsor on a regular basis, based on which the platform sponsor can monitor the progress or suggest improvements.</p>

Table 28: Government's views on value creation

10.2.2.4 ACADEMIC RESEARCHERS

This section presents the interview data from academic researchers in Table 29, on the value created and added through platform and the incentive initiative proposed.

SNo	Interview Respondents	Values Created	Incentive Initiative (and specific type)	Value addition	Compliance over CSR Initiatives
1	Jaco Appelman	<p>1. Cost reduction from financial perspectives, prices of energy can be controlled by consumers</p> <p>2. Firms can make their workplace better with state of the art ICT and enhance brand image to customers, people will want to work for such an employer (attractive),</p> <p>3. The solution offers levers for big firms the license to operate with focus on strategy and sustainable development</p>	<p>Incentives are a good driver of system, but sanctions need to be in place too for ensuring that the system really works. Incentives can be provided such that 50% is for use of firm and 50% for CSR</p>	<p>1. Awareness, agency and ability to act upon resources.</p> <p>2. Association and cooperation within a network</p> <p>3. Company's profile will be assessed with sustainable energy production and consumption</p> <p>4. The information that companies share should be a source of competition for each other but not threat to business activities</p>	<p>Compliance can be achieved through the platform and cloud solution, since all the data is in the cloud and the government can use it to monitor progress</p>
2	Geerten van de Kaa	<p>The proposition for sustainable environment and a sustainable economy with a balance in production and consumption is the biggest value created, because no one can be excluded from the benefits</p>	<p>I am not really sure if the incentives will work, but there has to be attractive incentives to ensure that energy companies will join the platform. No specific incentive is recommended. Firms can be given some complementary goods as incentives through their use of the platform</p>	<p>Companies usually have a CSR strategy, especially large companies, therefore works well for the solution if it is implemented alongside monitoring of energy. But CSR monitoring is more a utility from the perspective of government and less from business perspective.</p>	<p>Compliance is a difficult issue to monitor the CSR initiatives, perhaps can work best with self-reporting through the platform then each business will be responsible for accountability of their actions to some extent</p>

3	Gerard Smit	<p>1. Tracking sustainability in terms of energy over timelines is an important value created</p> <p>2. The information on energy data is a value, which can be utilized for providing other services</p>	<p>The ratings can be a driver for companies to compete for incentives and also participate in the platform solution. The specific type of incentives preferred are reduction in energy prices, carbon credits may be only useful for some companies, but not in general. There should be a provision that one who creates maximum flexibility should be rewarded with benefits. For e.g. if a consumer employs advanced energy storage technology by making large investments, then they can be reimbursed for the equipment they have installed in their facility by the platform sponsor</p>	<p>Considering CSR as a value addition through the platform is a very subjective issue. Companies may want to spend it or may want to have other benefits (reimbursement for equipment's invested) which will add to their sustainability too. Therefore I think, spending on CSR may not happen, unless it is a policy imposed by the platform sponsors.</p>	<p>NA (if it is implemented then reporting and monitoring should also be made through the platform)</p>
4	Somenath Roy Choudhury	<p>1. More transparency in the system</p> <p>2. Disaster avoidance with the available data for maintenance management advice for grid operators, and also boilers, air-conditioners etc.</p> <p>3. Tax benefits to the businesses</p>	<p>It may be mandatory. It will be helpful for tax-compliance. Tax credit is more suitable</p>	<p>The CSR initiative can lead to value addition, but can be asserted only after the implementation of a pilot project</p>	<p>Compliance can be monitored through the platform</p>
5	Fatemeh Nikayin	<p>1. Businesses will have to trust the government in this arrangement, with their data and also in using the platform</p> <p>2. Reputation of the party governing the platform will influence the building of trust. These values are somehow interrelated. The energy</p>	<p>1. The cost of the government to support the incentive initiative will be very high.</p> <p>2. The grid operator and the government can collaborate together to implement this, since I see them also very influential in bringing all parties together and implementing the solution.</p> <p>3 Incentives are definitely a driver of this solution</p>	<p>I wouldn't go for any specific type of incentive, but the municipality and grid operators can partner together and create awareness for consumers, in making them believe that they are separate entities from energy companies and they can be trusted with their information in the common data cloud. When the system is in place and running it will</p>	<p>Compliance over the CSR initiative can be made through self-reporting through the platform to the regulator. This will enable the government to be updated of all the activities and monitor progress. Control mechanisms are essential in any platform based initiative, and the energy monitoring platform can have</p>

		companies and businesses as consumers have to trust and cooperate and there should be reasons for doing so.		become a doorway for several other applications, which may be cannot thought of presently, but the applications are bound to increase	these additional services provided through the platform
6	Gautham Ram	1. Creation of a sustainable environment is definitely the value created through using the platform 2. modification of energy behavior allows consumers to make efficient choices	The incentive initiative is a driver for sure, because the benefits of sharing the data for energy companies have to be high enough to make the platform successful, no particular incentives which may be wanted by the businesses is recommended, it depends on the company and its culture and objectives	Before the system can be implemented it is difficult to point out what value it can add. Value additions from non-existent business models are difficult to have	In case of a top-down approach to the platform solution, compliance and monitoring is left to the government and the businesses to figure out, whether reporting through the cloud is feasible or physical inspections.
7	Davide Garufi	The data generated is of prime value, awareness can be spread based on the trends, energy behavior of households and businesses can see significant improvements. 2. For big businesses this means savings on money, and they can reserve the budget for CSR (5-7% of savings on money can go to CSR), 3. Next value created is trust - among the stakeholders using the cloud - -> this can be extended among participants of topologies like locality, city, country etc., Mass adoption	Incentives are risky because government must at first ensure a balance of money, whether sufficient inflow is there to cause outflow. Overall incentives are good, helps a business to work and keeps them motivated, but sanctions are more important to actually keep them motivated. Rather than tangible incentives like money or cash, extra services can be provided by the government, which can be very interesting for companies; because it may help them to save money	1. Government can understand trends in energy data which can lead to better policymaking 2. There will be connectedness of consumers to the grid who will see the visible effects of improvement in energy behavior 3. The solution will result in information awareness for both regulator and consumers 4. Informed decision making and rational choices will be easier to make 5. Historical trends can be saved and compared	Segmentation is necessary to maintain compliance -grid, locality, city level operations. These topologies should be identified and companies can be given incentives based on their location. Sustainable neighborhoods can be distinguished and local households can benefit from the positive network effects as a small fish. Moreover with the cloud solution, reporting and monitoring of CSR also becomes easy because each and every transaction or data is traceable. Before and after graphic reports can also be generated

		can also drive trust and control			
8	Yilin Huang	Collective action towards sustainability and data sharing	The incentive mechanism can be a driver for the solution. They can be also related to some kind of certification good for business image. Cash, tax benefit and discounts on bills more or less belong to the same category and can be grouped together	The data shared by all actors in itself is a value addition, a transition from the traditional models	NA

Table 29: Academic researcher’s views on value creation

10.2.3 OVERALL POSSIBILITY

This section presents the interview data from the four groups of respondent on the overall possibility of the platform solution. It answers the following interview questions:

3 a) Do you think the open platform in smart grid network is implementable in the future? If yes, why yes (what consideration is most important), if not, why not?

b) What is your comment about the possibility of the solution from your professional perspective?

10.2.3.1 BUSINESS AS CONSUMERS

This section presents the interview data from business as consumers in Table 30, on the overall possibility of the platform solution.

S No	Interview Respondents	Possibility of Solution	Overall Possibility
1	Frits Verheij	Open platforms are increasingly finding interest with stakeholders, but it needs to be implemented with other relevant areas of businesses before it can be implemented to monitor energy. When the use is tested, challenges are overcome then it can be implemented	Possible but with more widespread usage in other areas
2	Marga Blom	Possible, if funds are available and infrastructure implementation is economic.	Possible under the considerations mentioned. Incentive plan not so feasible

Table 30: Business as consumer’s views on overall possibility

10.2.3.2 ENERGY COMPANIES

This section presents the interview data from energy companies in Table 31, on the overall possibility of the platform solution.

SNo	Interview Respondents	Possibility of Solution	Overall Possibility
1	Marco Spoel	<p>1. In the presence of funds, it is possible, also if the platform pays for itself, i.e. there are streams of revenues always present. 2.</p> <p>3. Sanctions should be present to drive the system</p> <p>4. Incentives should be good for companies as businesses are willing to carry out initiatives which are subsidized by the government</p>	Possible, but under considerations.
2	Erik Matien	<p>1. Feasible, because there are large companies (e.g. Google and IBM) working on similar solution. They are in the position and have license to operate in a global way.</p> <p>It's like Android and iOS. There is only space for 2 or 3 big players. 2. When you make it open, new companies can deliver new services, which will bring opportunities</p>	Addressing the risks can make it possible
3	Koen Hermans	<p>Yes, already a lot of data monitored in a smart grid and this asks for data sharing in a format that the users would want. Not sure if all companies would want to be actively involved and how much the statistics known from other business might improve my own habits. Again, having someone to show me the way can be useful (if I can benefit from that path as well).</p>	<p>Possible but with more benefits for sharing of information energy by an energy company. Great idea, but show me the benefits more of having data of others (e.g. with some real-life examples). Not possible to say whether ECN would cooperate but chances seem less because of the nuclear facility on our terrain and the security of the consumption data.</p>

Table 31: Energy companies views on overall possibility

10.2.3.3 GOVERNMENT

This section presents the interview data from respondents in the government in Table 32, on the overall possibility of the platform solution.

SNo	Interview Respondents	Possibility of Solution	Overall Possibility
1	Frank Hartkamp	<ol style="list-style-type: none"> 1. Smart grids benefit from the solution, information flows are well managed. 2. Solution in the cloud is not mandatory, it can be a virtualized cloud 3. The regulatory body can be a third party who monitors the sustainability of companies, but the government and the 3rd party must work closely to implement the idea. 4. Large quantity of rich data will be produced which can be mined and utilized for other services as well 5. Trust needs to be developed, under these conditions the platform is feasible 	Possible keeping in mind the conditions mentioned
2	Olivier Ongkiehong	Governments will generally not implement trading platforms. But they will encourage them if the concept to support sustainability are clear and if the rules for all players are fair. Regulation plays an important role. But the position in a value chain has more priority than anticipating now on regulatory barriers in terms of sustainability. Therefore if it can be sponsored by a 3rd party, then very much feasible. Also the accurate design of the platform needs to be specified from the present high level design	Very much feasible.

Table 32: Government's view on overall possibility

10.2.3.4 ACADEMIC RESEARCHERS

This section presents the interview data from academic researchers in Table 33, on the overall possibility of the platform solution.

SNo	Interview Respondents	Possibility of Solution	Overall Possibility
1	Jaco Appelman	<ol style="list-style-type: none"> The solution is feasible, but under considerations: sanctions needs to be there as drivers of the solution 2. It has to be a stepwise implementation - a single roll out of the initiative can be harmful for stakeholder participation and consumer awareness 3. Government can outsource the monitoring activity to a third party e.g. NGO or other body which can make the governance effective. Government is not the best idea to monitor the overall sustainability of energy or other sector 	Possible under considerations

2	Geerten van de Kaa	Adoption of the new platform seems bit difficult, unless consumers can see visible benefits from the platform, and the issue of security and customer privacy is addressed. Alternatively if regulators enforce the platform use on consumers then the platform is a possibility	On a local (locality level) or smart grid level possible. In the city level can be difficult
3	Gerard Smit	I am more of a believer in a local autonomy than centralized. The model can work if it operates on the local level with the same objective of sustainable competition in place for companies. It will be interesting to see a VNA on a local scale to visualize the values better	On a local (locality level) or smart grid level possible.
4	Somenath Roy Choudhury	Possible taking into consideration the risks mentioned and those which will be confronted during the implementation of the solution (for e.g. Information Security at every level)	Feasible with the considerations
5	Fatemeh Nikayin	Technically very much feasible, since ICT has advanced in the present day to bring smart meter to every home, connect them in the cloud and monitor data, but organizationally still have doubts, whether the stakeholders will find the incentives attractive enough to participate, unless it is top-down policy of the government, where companies have to conform and comply to using it	Technically possible, organizationally doubtful
6	Gautham Ram	The structure needs to be defined clearly, risks have to be addressed, and technically very much feasible, but voluntary participation of companies seem difficult unless it is enforced or imposed. Nice to have a more detailed incentive plan worked out, which can be visible for companies and act as motivation to participate	Possible but under conditions
7	Davide Garufi	It is very much feasible, but the push has to come from the bureaucratic corridors so a high level policy is required to implement the platform solution, taking into confidence all the stakeholders and giving them attractive benefits	Feasible
8	Yilin Huang	Feasible	Feasible keeping in mind the risks

Table 33: Academic researcher's views on overall possibility

10.2.4 GENERALIZATION

This section presents the data on generalization of the conceptual model of the research. It answers the set 4 of the interview questions:

4 a) Do you think the conceptual framework of the research can be applied to other green ICT trends?

The views of the respondents have been tabulated according to their groups.

10.2.4.1 BUSINESS AS CONSUMERS

Table 34 presents the generalization data of conceptual model of business as consumer respondents.

SNo	Interview Respondents	Scope of conceptual model
1	Frits Verheij	Definitely applicable E.g. Amsterdam parking lot, free app can be downloaded which routes the cars to find empty parking spaces, also can be applied to intelligent traffic diversion systems, other examples are energy management at home which operates on similar conceptual model
2	Marga Blom	Can be applied to other green ICT trends, whichever needs monitoring by several actors

Table 34: Views on generalization of conceptual model of business as consumer respondents

10.2.4.2 ENERGY COMPANIES

Table 35 presents the generalization data of conceptual model of respondents from energy companies.

SNo	Interview Respondents	Scope of conceptual model
1	Marco Spoel	Can be applied to other communities
2	Erik Matien	Can have various applications. All systems require monitoring for providing better service
3	Koen Hermans	Can be applied to other applications which need monitoring. It could be any ICT technology used for creating a sustainable environment, because all require monitoring at a certain level.

Table 35: Views on generalization of conceptual model of respondents from energy companies

10.2.4.3 GOVERNMENT

Table 36 presents the generalization data of conceptual model of respondents from the government.

SNo	Interview Respondents	Scope of conceptual model
1	Frank Hartkamp	Other applications of the conceptual model is definitely a possibility. More the application, greater is the value created and added to the system. For e.g. if the monitoring system is applied to a traffic diversion system, then it saves money, fuel, time of the day, and generates new information. It also influences choice of driving. Therefore every platform creates value, but it needs to be captured or extracted well to reap benefits

2	Olivier Ongkiehong	Can be applied to other sectors but it should depend on the type of platform, whether it shows best practices of PLS and HLS (matching supply of existing platforms and demand for proposed platforms) or is the platform more an online platform with short reaction times (seconds). The method in the meso-level must be clear.
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Table 36: Views on generalization of conceptual model of respondents from the government

10.2.4.4 ACADEMIC RESEARCHERS

Table 37 presents the generalization data of conceptual model of academic researchers.

SNo	Interview Respondents	Scope of conceptual model
8	Jaco Appelman	For different model and applications even if this same conceptual framework does not work or fit then it can always be customized and adapted according to the requirements of a change. I cannot apply what works for X to Y. But the overall idea of PLS and HLS exists in the sustainability aspect of companies and our society
9	Geerten van de Kaa	The green ICT trends and the PLS is a single entity in the conceptual model, since the ICT infrastructure in almost every organization needs to become sustainable. Otherwise the conceptual framework can be applied to initiatives where collective action is necessary
10	Gerard Smit	Each green ICT trend is a different technology trend, therefore the conceptual model can be applied but the monitoring platform will need to be adapted for each of them. Having said that, I am not so much in favor of cloud solutions due to privacy issues.
11	Somenath Roy Choudhury	It can definitely be applied to other areas of green ICT technologies
12	Fatemeh Nikayin	It can be applied to other ICT infrastructure as an enabler for a green environment, traffic data can be monitored, and crowd sourcing data can be monitored through collective action creating a macro impact on the system. Further apps can be developed keeping this conceptual framework in mind
13	Gautham Ram	Can have applications in other domains of ICT infrastructure
14	Davide Garufi	Can have widespread applications in contributing to collective action or HLS of other sectors, because the basic principle is monitoring of actions to create a sustainable economy, this holds true for any other ecosystems - water management, biodiversity, built environment etc. Only the role of facilitator can also be added to the conceptual model which can define the perspective better
15	Yilin Huang	It can have widespread applications

Table 37: Views on generalization of conceptual model of academic researchers

The next section presents data which contributed to the evaluation of the platform solution in section 6.2 of the report.

10.3 DATA EVALUATION

The evaluation of the platform in section 6.2 was conducted based on the data presented in this section.

10.3.1.1 DESIGN & IMPLEMENTATION

This section highlights the risks and positive features pointed out by the interview respondents.

The 3 types of *risks* identified from the design and implementation data of the experts are: 1. System/ technical risks, 2. Platform/ Implementation risks and 3. User control risks. These risks are categorized based on the groups of actors in Table 38. The evaluation of the risks contribute to the adaptation of the design criteria of the platform in section 6.2.1.

Groups of Actors	System/ Technical Risks	Platform/ Implementation risks	User control Risks
Business as consumers	SEC: hacking DA: Demarcation between data produced and used	SR: centralized market control, bureaucracy over new business opportunities F: high upfront IT investment TEC: advanced equipment	A: Lack of awareness in using data, undefined data recipients
Energy companies	SEC: data privacy DA: complex database organization	STR: mix of consumer and business model, market forecasting and planning, compromise on business profits	P: democratic participation, type of businesses
Government	SEC: data privacy information vulnerability I: complexity	F: high energy costs, high upfront IT investment funding of the platform	A: Position of platform in value chain US: price control TRU: between energy companies and government

Academic researchers	<p>SEC: data privacy hacking information vulnerability</p> <p>DA: high level design, complex database organization</p> <p>SCA: interoperability</p>	<p>SR: centralized market control, bureaucracy over new business opportunities, misinterpretation as dictatorship, inadequate government policy</p> <p>TEC: Reliability of equipment</p>	<p>A: Lack of awareness in using data , understanding collective action</p> <p>P: data sharing, democratic participation, type of business,</p> <p>TRU: between energy companies and government, between business as consumers & government, reluctance to trust energy companies by consumers, IT and telecom operators for implementing large and expensive IT infrastructures</p>
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Table 38: Risk overview according to the groups of respondent

The positive features of the platform is classified under 3 groups: 1. Services, 2. Technology and 3. Organization in Table 39, based on views of the respondent groups. The evaluation of this data contributed to the adaptation of the design criteria in section 6.2.1.

Groups of Actors	Services	Technology	Organization
Business as consumers	<p>NBO Enriched data, Smart use of data</p> <p>NLB Energy management, Sustainable production & consumption</p>	<p>FLE: Personalized data</p> <p>TRA: Accountability for actions</p> <p>PRI: Average energy consumption trends displayed only, No individual data</p>	<p>CO: Positive and healthy</p> <p>CA: Sustainability monitoring</p> <p>CAW: Accessibility to data, Perception of energy trends</p>
Energy companies	<p>NBO: Enriched data, Smart use of data</p> <p>EA: Consumption trends, Energy pricing, Energy efficient solutions</p>	<p>CS: Integrated monitoring</p>	<p>CO: Reputation</p>

Government	NBO: Enriched data, Smart use of data EA: Energy efficient solutions	FLE: Energy flow and balancing network TRA: Accountability for actions	CE: Producer + consumer = prosumer, Monitoring and control, Community energy management CAW: Accessibility to data, Comparison of data
Academic researchers	NBO: Enriched data, Smart use of data NLB: Energy management, Sustainable production & consumption SP: By government, By companies	FLE: Personalized data TRA: Accountability for actions CS: No physical storage, District heating application	CA: Sustainable development, Sustainability monitoring CAW: Accessibility to data, Comparison of data, Perception of energy trends, Demand response management

Table 39: Positive features of platform solution according to groups of respondent

The next section presents data on the values created from the platform.

10.3.1.2 VALUE CREATION

The values created from the use of the platform based on the respondent groups are presented in Table 40.

Groups of Actors	Values created
Business as consumers	<ul style="list-style-type: none"> • Availability of information at hand • Informed decision-making • Community energy management • Sustainable future • Network balancing by grid operator
Energy companies	<ul style="list-style-type: none"> • Availability of information at hand • Sanctions • Validation of taxes • New business opportunities • Network balancing by grid operator • Business partnership or cooperation
Government	<ul style="list-style-type: none"> • New business opportunities • Consumer empowerment • Consumer awareness • Community energy management • Discounts on PV cells as a motivation • Flexibility in energy provision to high demand
Academic Researchers	<ul style="list-style-type: none"> • Lower energy prices

	<ul style="list-style-type: none"> • New business opportunities • Sustainable ICT infrastructure employing business can be attractive employer • Sustainable economy – no one excluded from benefits • Transparency • Disaster avoidance: maintenance management advice • Incentives • Reputation • Trust between businesses and government • Informed decision-making • Consumer Awareness • Collective action between businesses
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Table 40: Value created according to groups of respondent

10.3.1.2.1 INCENTIVE INITIATIVE

The data for evaluating the incentive initiative of the platform solution is presented in Table 41 according to the groups of respondent.

Groups of Actors	SNo.	Incentive Initiative	Type of Incentives
Business as consumers	B1	Positive driver but from non-governmental players	Cash incentives Discount on electricity bills
	B2	Not quite convincing	NA
Energy companies	E1	Positive driver	Cash, subsidy
	E2	Political drivers but can be positive	Cash, comforts to people
	E3	Needed to make up for costs but sanctions also equally important	Depends on company
Government	G1	Positive driver	50% tax evasion, carbon credit attractive for manufacturing companies
	G2	Positive but from non-governmental players	No specific recommended
Academic Researchers	A1	Positive driver but sanctions also equally important	Depends on company
	A2	Not quite convincing	NA
	A3	Positive driver	Reduction in energy prices, reimbursement for expensive energy efficient infrastructure
	A4	Positive driver and should be mandatory for this solution	Tax credit
	A5	Definitely a positive driver	Depends on company
	A6	Positive driver	Depends on company
	A7	Positive driver but sanctions will be more effective	Extra services from government
	A8	Positive driver	Certification for good business image, Cash, tax benefit and discounts on bills can be combined since they are similar

Table 41: Views on incentive initiative by groups of respondent

10.3.1.2.2 CSR AS A VALUE ADDITION

The data for evaluating CSR as a value addition to the platform solution is presented in Table 42 according to the respondents.

Groups of Actors	SNo.	CSR as Value Addition	Compliance or monitoring CSR
Business as consumers	B1	Not sure. Industry needs more stimulus	Large companies possible, small companies not possible to monitor
	B2	CSR possible but energy provided to local household can be a CSR	Platform can help monitor the flow
Energy companies	E1	CSR possible but value addition for small firms working on energy saving targets not big firms	Self-reporting through platform but empower consumers to monitor
	E2	Not sure. Incentives are value addition	Depends on company
	E3	Not sure.	Not possible to say without concrete incentives
Government	G1	CSR possible	Citizens can be empowered to monitor progress
	G2	CSR possible but government may not monitor	Self-reporting by companies through platform
Academic Researchers	A1	CSR possible	Monitor through platform
	A2	CSR possible, but utility for government not business	Self-reporting by companies through platform
	A3	Not possible since it is subjective choice unless otherwise imposed	NA
	A4	CSR possible but with certainty after pilot project	Monitor through platform
	A5	CSR possible	Monitor through platform
	A6	Not sure	Depends on business, government
	A7	CSR possible	Before after graphic report through platform, monitor through platform
	A8	Not sure	NA

Table 42: Views on CSR as a value addition according to the respondents

The next section presents the data which contributed to the evaluation of the overall possibility of the platform solution.

10.3.1.3 OVERALL POSSIBLITY

Table 43 constitutes of data that represents the overall possibility of the platform solution according to the respondents.

Groups of Actors	SNo.	Possibility of Solution	Overall possibility
Business as consumers	B1	Feasible but with more widespread usage in other areas	Feasible under considerations
	B2	Feasible, if funds are available and infrastructure implementation is economic.	Feasible under considerations

Energy companies	E1	Feasible if platform pays for itself	Feasible under considerations
	E2	Feasible as big companies are working on this front	Feasible under considerations
	E3	Feasible with more benefits & incentives for companies and if they cooperate to share data, communicate with each other and provide feedback on the platform use	Feasible under considerations
Government	G1	Feasible if cloud is not made compulsory, connectedness of applications are present with organizational cooperation, communication and feedback	Feasible under considerations
	G2	Feasible if government acts as a facilitator only	Very much feasible
Academic Researchers	A1	Feasible but needs to be implemented stepwise and sanctions are important	Feasible under considerations
	A2	Not sure, on local level feasible	Not sure, feasible in local level
	A3	Unconvincing cloud solution not feasible	Unconvincing feasible in local or grid level
	A4	Feasible if organizations cooperate on data sharing, interact with each other and provide feedback	Feasible under considerations
	A5	Feasible technically, organizationally difficult	Not sure, feasible technically only
	A6	Feasible technically, organizationally difficult	Not sure, feasible technically only
	A7	Feasible if the push comes from bureaucratic corridors	Feasible under considerations
	A8	Feasible if risks of privacy, organizational participation and adequate government policies are addressed	Feasible under considerations

Table 43: Views on overall possibility of the platform solution according to the respondents

The next section presents data which contributed to the generalization of the research's conceptual framework in section 7.1 in the conclusion chapter.

10.3.1.4 GENERALIZATION

Table 44 presents the data which helped to evaluate in the conclusion of the thesis, whether the conceptual framework can be applied to other green ICT trends or top sectors.

Groups of Actors	SNo.	Scope of conceptual model
Business as consumers	B1	Definitely applicable
	B2	Applicable
Energy companies	E1	Applicable
	E2	Applicable
	E3	Applicable
Government	G1	Definitely applicable
	G2	Conceptual model can be adapted since PLS is a subset of HLS
Academic	A1	Conceptual model can be adapted to different green ICT trends

Researchers	A2	Conceptual model can be adapted by merging green ICT trend and PLS together
	A3	Conceptual model can be adapted to different green ICT trends
	A4	Definitely applicable
	A5	Applicable
	A6	Applicable
	A7	Applicable
	A8	Applicable

Table 44: Views on generalization of the conceptual model according to the respondents

The evaluation for generalization of conceptual framework is presented in Table 45.

Groups of Respondents	SNo	Definitely Applicable	Applicable	Applicable after adaptation
Business as consumers	B1	X		
	B2		X	
Energy companies	E1		X	
	E2		X	
	E3		X	
Government	G1	X		
	G2			X
Academic Researchers	A1			X
	A2			X
	A3			
	A4	X		
	A5		X	
	A6		X	
	A7		X	
	A8		X	

Table 45: Evaluation for generalization of conceptual framework

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