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**DETERMINANTS OF RENEWABLE ENERGY
IMPLEMENTATION**

A case-study of Ostrobothnia region (Finland)

Master's Thesis in Industrial Management
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TABLE OF CONTENTS

Page

LIST OF ABBREVIATIONS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

1. INTRODUCTION	1
1.1. Background of the study	1
1.2. Objectives of the study	2
1.3. Scope and limitations of the study.....	3
1.4. Definitions of key concepts.....	4
1.5. Previous studies.....	5
1.6. Structure of the study.....	8
2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK.....	11
2.1. Energy needs and importance.....	11
2.1.1. Global energy system.....	12
2.1.2. European Union energy system.....	15
2.1.3. Nordic region energy system.....	17
2.1.4. Finnish energy system.....	19
2.1.5. Ostrobothnia energy system.....	21
2.2. Energy types	27
2.2.1. Conventional energy	27
2.2.2. Nuclear energy	28
2.2.3. Renewable energy resources (RERs).....	28
2.3. Determinants of renewable energy.....	35
2.3.1. Economic factor.....	35

2.3.2. Energy security.....	36
2.3.3. Environmental impact.....	37
2.3.4. Regional competitive advantage.....	38
2.3.5. Government support-subsidies.....	38
2.3.6. Societal influence.....	39
2.3.7. Political influence.....	40
2.4. Summary of theoretical framework.....	41
3. RESEARCH METHODOLOGY	42
3.1. Research method	42
3.2. Benefits and criticism of case study research.....	43
3.3. Data Collection Instrument	44
3.4. Data interpretation	45
3.5. Validity and reliability	46
4. EMPIRICAL FINDINGS	47
4.1. Introduction to the case company ABB.....	47
4.2. Determinants of renewable energy implementation in case company ABB..	47
4.3. Introduction to the case company The Switch.....	51
4.4. Determinants of renewable energy implementation in case company The Switch.....	51
4.5. Introduction to the case organization Vaasa Energy Institute (VEI).....	54
4.6. Determinants of renewable energy implementation in case organization Vaasa Energy Institute (VEI).....	55
4.7. Determinants of renewable energy implementation in Ostrobothnia region: A comparative analysis of case companies.....	60
5. CONCLUSION	62
5.1. Key findings of the study.....	62
5.2. Managerial implications	64
5.3. Implications for theory and future research	65
REFERENCES.....	67
APPENDIX 1: Interview format and questions.....	72

LIST OF ABBREVIATIONS

ABB	ASEA Brown Boveri
RER	Renewable Energy Resources
RET	Renewable Energy Technologies
Mtoe/a	Million tons of energy per annum
kW	Kilo watt
kg	Kilogram
kJ	kilo Joule
IEA	International Energy Agency
OECD	Organization of Economic Cooperation and Development
VTT	Finnish Energy research organization
CO ₂	Carbon Dioxide
EJ	ExaJoule
EU	European Union
USA	United States of America
Mt	Metric ton
NC	Nordic Countries
GWh/a	Giga watt hour per annum
CHP	Combined Heat & Power
R&D	Research and Development
ICT	Information and Communication Technologies
WNA	World Nuclear Assosiation(UK)

LIST OF FIGURES

Figure 1. Structure of the study.....	10
Figure 2. Dynamics between the environment and society.....	13
Figure 3. Gross Inland consumption by fuel	16
Figure 4. Breakdown of sector-wise energy consumption in industries	18
Figure 5. Sector-wise Primary Energy Consumption in Nordic Regions.....	20
Figure 6. Location of Ostrobothnia region (marked red) in Finland.....	22
Figure 7. Bioenergy potential in five municipalities of Ostrobothnia region with energy demand (in Gwh/a).....	23
Figure 8. Building sector energy statistics.....	25
Figure 9. Residential and commercial final energy demand in the world.....	26
Figure 10. Wind Power Generation Potential in Ostrobothnia region for the development of future Wind Parks.....	31
Figure 11. Theoretical framework of the study.....	41
Figure 12. Respondent's evaluation matrix for the case company ABB.....	50
Figure 13. Respondent's evaluation matrix for the case company The Switch.....	54
Figure 14. Respondent's evaluation matrix for the case organization VEI	60
Figure 15. Further adopted model of the Determinants of renewable energy implementation in Ostrobothnia region.....	64

LIST OF TABLES

Table 1. Definitions of key terms in the present study.....	4
Table 2. Previous studies.....	6
Table 3. Renewable Energy Generation by some countries from the Globe.....	17
Table 4. Summary of technical flow of renewable energy.....	35
Table 5: Determinants of renewable energy implementation in Ostrobothnia region: A comparative analysis of case companies.....	61

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Abstract

Ever rising carbon levels and environmental footprints resulting from energy generation activities are devastating impacts being registered on planet earth. Environmental concerns coupled with threats of globally fluctuating oil prices posing huge economic burdens are bringing a progressive change in society. These factors are provoking the heightened sense of energy security and effective deployment of natural resources. It is eventually leading universe towards a carbon free energy sustainable technologies in the form of renewable energies. Despite of influential effect of existing energy market players, renewables have started to emerge as sustainable energy future.

This study represents the important determinants that are motivating for the implementation of renewable energy in one of the municipality in Finland. This country clearly represents an example of technologically advanced countries with long rooted expertise and highly committed behavior in the development and implementation of energy technology on global level. Various different literature studies provide a deep comparative insight to different factor for the implementation of renewable energy as a literary framework followed a sequential examination of these factors under the criticism conducted by data collected. After performing a comparative analysis, a final model of motivating determinants has been presented. This study presents an insight to the motivating determinants for the implementation of renewable energy technologies in Finland and provides future suggestions for further studies.

KEYWORDS: Renewable Energy, Ostrobothnia, Determinants, Environment

1. INTRODUCTION

1.1. Background of the study

During the last decade, there has been a great concern regarding the increasing air pollution and global climate change on one hand, and increasing world energy demands for residential and industrial needs on the other hand (e.g. Stigka, Paravantis & Mihalakakou 2014). According to the IEA reports, approximately 81% of the world's energy demand was supplied by fossil fuels in 2009. This heavy reliance on fossil fuels is damaging environment and causing pollution on one hand, and increasing the dependence on carbon based fuel supplying nations on other hand. According to Dovi, Friedler, Huising and Klemes (2009: 1), “the global warming related CO₂ emissions, coupled with steeply rising prices and the recent global financial institutional melt-down are causing massive societal concerns and give rise to increasing demand for ways to improve societal and individual energy efficiency and for ways to gradually shift to alternative, low non-carbon based systems”.

These concerns also are forcing the European countries to find alternative sources of energy to secure the environment and energy supply. European Union renewable energy policy report (2011) depicts that European Union is exploring new sources of energy for boosting the European industrial competitiveness, and to avoid massive costs of climate change and pollution. For example, during the last three decades, Nordic countries have continuously reduced their reliance on oil and coal for the supply of energy. In Finland, reliance on oil and coal has dropped from 46% in 1973 to 28.7% in 2009 (Aslani, Helo, Feng, Antila & Hiltunen 2013). These trends depict that European countries are continuously reducing their dependence on conventional sources of energy production and moving to alternative sources of energy.

The Nordic region has been playing a leading role in diffusion of renewable energy technologies such as Finland and Sweden in biomass technologies, Norway in hydropower development, Denmark with wind power, and Iceland with geothermal utilization. Therefore, not surprisingly, Nordic countries have made considerable and successful efforts to improve the diversification strategy of their energy supply with core focus on utilization of renewable energy resources (Aslani et al. 2013). Prior

research has identified that Finland's government energy strategy in is to strengthen its energy security, to move progressively towards a decarbonized economy, and to deepen its integration in the wider European market. According to Anger (2014: 6), European countries are sequentially reducing their addiction to obsolete energy generation methods and stepping towards alternative sources to attain 20-20-20 objectives. Aslani, Naaranoja & Wong (2013) argues that Finland is one of quick adopters. According to these targets, Europe has vision to decrease 20% Carbon from environment; replenishing 20% fossil fuel based generation with renewable generation and increases 20% efficiency in Energy Systems by the end of 2020. Aslani et al.'s (2013) study suggests that diffusion of renewable energy requires consideration to many factors including social, economic, and environmental ones. However, there is limited research on factors that lead to the implementation of renewable energy sources. Therefore, the **purpose of present study is to investigate the factors that promote the adaptation of renewable energy.**

1.2. Objectives of the study

The above identified research gap, and my own professional background in energy sector company Wartsila, where I have worked for 5 years, have motivated me to research the factors that promote the adaptation of renewable energy in Ostrobothnia region. Further, the research at Vaasa Energy Institute (VEI) is trying to understand the regional and national energy distribution network and system in Finland, and thus further motivated me to explore the factors that promote the adaptation of renewable energy.

Therefore, the purpose of present study is to investigate the determinants of renewable energy implementation. Accordingly, the main research question is:

(1) What are the determinants of renewable energy implementation?

The main research question is approached and addressed by the following sub-questions:

(1) How the energy is important and needed?

(2) What are the types of Energy?

(3) What are the determinants of renewable energy implementation

In order to answer the research question and to achieve the sub-questions, this study has an empirical objective. The empirical objective is to:

(4) How to investigate the determinants of renewable energy implementation in Ostrobothnia region?

The purpose of first sub-question is to study the energy need and importance. To achieve the above objective, the need and importance of energy is identified on different levels: global, European, Nordic, Finnish, and Ostrobothnia.

The purpose of the second sub-question is to identify different energy types like conventional energy, nuclear energy, and renewable energy.

The purpose of the third sub-question is to identify the different determinants of the renewable energy implementation. To identify the determinants of renewable energy implementation, previous studies that have discussed the motivations, determinants, and enablers of renewable energy implementation are reviewed.

The purpose of fourth sub-question is to get the primary data through semi structured interview questionnaire with open-ended questions from the multiple case companies to analyse that what factors motivate the implementation of renewable energy implementation in Ostrobothnia region.

1.3. Scope and limitations of the study

The scope of this study is to address the determinants of the renewable energy implementation. The conceptual framework of the study is developed based on the relevant literature on the factors motivating the implementation of the renewable energy. Therefore, seven important determinants of renewable energy implementation are identified: economic factor, energy security, environmental impact, regional competitive advantage, government support-subsidies, societal influence, and political influence.

In spite of investigating a comprehensive set of determinants of renewable energy implementation, the conceptual framework has an important limitation. The framework

does not study the performance outcomes of the renewable energy implementation. Therefore it remains an important limitation of my study. Further, the study only focuses on the renewable energy implementation in Ostrobothnia. Therefore, results may not generalizable to other regions.

1.4. Definitions of key concepts

The key definitions in the present study are identified based on the relevant literature. These terms include: renewable energy, conventional energy, nuclear energy, economic factor, energy security, environmental impact, regional competitive advantage, government support-subsidies, societal influence, and political influence. The definitions of these terms are summarized and presented in the Table 1 along with the references, so that the reader can follow the conceptualization of these terms in this study.

Table 1. Definitions of key terms in the present study

Key terms	Definitions	Reference
Renewable energy	Renewable energy is any form of energy from solar, geophysical, or biological sources that are replenished by natural processes at a rate that equals or exceeds its rate of use	Moomaw, Yamba, Kamimoto, Maurice, Nyboer, Urama and Weir (2011: 178)
Conventional energy	Resources, based upon oil and gas (fossil fuel), are termed as conventional energy sources.	Savolainen, Eerola, Hongisto, Honkatukia, Koljonen, Syri and Wessberg (2008: 17)
Nuclear energy	It is a fission process for generating a major amount of the energy which is practically free of CO ₂ emissions	Helynen et al. (2008: 198)
Economic factor	Economic factor means maximizing outputs obtainable	Aslani et al. (2013: 502)

	from a given set of inputs, or minimizing inputs required obtaining a given set of outputs	
Energy security	Energy security is the security of energy supply	Aslani et al. (2013: 501)
Environmental impact	Necessities of climate change mitigation	Mohammed, Mustafa and Bashir (2014: 530)
Regional competitive advantage	The availability of biomass and other material in the region	Peura and Hyttinen (2011: 934)
Government support-subsidies	Incentives in the form of tax reduction and other benefits by the government	Aslani et al. (2013: 502)
Societal influence	Necessities for social development adjusted by the needs of people in a society	Mohammed, Mustafa and Bashir (2014: 530)
Political influence	The influence political leaders who ensure that electricity is made available to all irrespective of the region	Mohammed, Mustafa and Bashir (2014: 530)

1.5. Previous studies

The most commonly used and relevant studies for the present study are now discussed in table 2. First reviewed paper is based upon empirical studies done via content analysis. Paper spotlights the area of Ostrobothnia for its capabilities and capacities to utilize renewable energy sources. A conceptual framework for the rapid penetration of renewable energy system in existing grid has been discussed. Author critiques upon the enforcement of more environment friendly policies from government to effectively promote and grow renewables in the region of Finland.

Table 2. Previous studies

Previous studies	Sample location	Energy generation technology drivers	Data collection techniques	Study technique	Generation technique discussed	Data mapping instrument	Results	Future research / Gaps / Suggestions
Aslani et al. (2013)	Ostrobothnia Region VAASA (Finland)	-CO2 Reduction -Energy Efficiency -Economic Efficiency -Energy Security	Interviews, structured questionnaire	Content analysis\	-All RERs -Biomass -Geothermal -Solar -Wind	Based on previous framework	Final results	1). Study for more authorizations of Energy Regulatory Authorities. 2). More developmental policies needs to be explored for sources and services.
Mohammad et al. (2014)	-	-Economics of Electricity -Shortage of Electricity -Environment -Socio-political Factor -Subsidies -Availability	-Mathematical Models -Literature review -Previous Studies	-	-Biomass -Solar -Wind -Hydropower	-HOMER (hybrid Optimization Model for Electrical Renewables -HOGA (Hybrid optimization by Genetic Algorithms)	-	Load profile study is suggested to design an optimal future system.
Peura & Hyttinen (2011)	Finland	-Economic Benefits -Self Sufficiency potential -Negative environmental impacts	-	Exploratory Research with case studies	-	-	-Tremendous Bio Energy generation potential country wide. -Expected more RES in Ostrobothnia Region. -RES potential exceeds more than demand	-

Previous studies	Sample location	Energy generation technology drivers	Data collection techniques	Study technique	Generation technique discussed	Data mapping instrument	Results	Future research / Gaps / Suggestions
Aslani et al. (2013)	Nordic Region	-	-Direct Observation - Analysis of previously published material -Scientific references in Energy Field	-	-	NVIVO9 QSR	-Policies and decisions in NCs have resulted in success. -Mix of policy (so called Hybrid Energy Policy) is required to succeed in this field.	1). From Strategic Perspective, dynamic abilities of NCs can be compared with policies and strategies for developing future Energy Policy. 2). Generated framework could be implemented and tested in other locations.
VTT Edita (2009)	Finland, European Union and Globe	-Environmental Mitigation -Economics -Socio-political Factors -Green Policies -Subsidies -Self-reliance potential in EU & Finland -Energy Security	-Previous Studies -International Energy Organizations report studies -Charts -Literature review -Survey Research	-	- Conventional Generation techniques and energy conversion methods - Nuclear Energy -Hydrogen Energy -Biomass -Wind -Solar -Geothermal	-	-Future energy theories representing 2C scenario. -Baseline Scenario -Results are pretty much lying in grey zones as this book presents a complete energy framework for Finland to be adopted in next 40 Years and provides a future perspective till 2050.	1). It gives a supporting literature and graphical interface for the promotion, adaption and success route map for implementing Renewable energy sources in Finland. 2). This 'Future Energy Bible' presents complete visionary framework to handle Energy Drivers ensuring a success path for their implementation.

Next reviewed journal article presents a debate between renewable energy and hybrid energy system using mathematical modeling techniques for developing countries in particular. Author has used special renewable energy simulation tools to verify applicability of indigenous renewable energy sources by modeling them at various different sample locations in developing countries around the globe.

Peura & Hyttinen 2011 performs an exploratory research work in Finland in the region of Ostrobothnia at various different locations. The paper positively identifies a very huge self-sufficiency potential of biomass in region. It has been shown via calculated values and performed test experiment at specimen locations in rural areas of Ostrobothnia. This paper provides an important 'milestone' for the successful growth of renewables and justifies adequately with positive results for renewable energy implementation for sustainability in society.

In the next article, Aslani et al 2013 performs a literature review and deep extended study of printed material to determine how renewable energy technologies can be diffused at social level in Nordic countries. He discusses techniques, policies and different system layers for the successful diffusion of renewable energy technologies in the Nordic region.

A thorough study of book published by research organization VTT was also carried out to segregate various different energy regimes in Finland. This book presents future of energy with sustainable development and presents different so called 'scenarios' to be adopted for successful transition towards sustainable energy future. This book acts as a 'bible' for various energy actors in market for their decision making and steering energy technologies future in Finland. (Simila & Savolainen 2009)

1.6. Structure of the study

The present study is structured in the following five chapters (see figure 1). In the **Chapter 1**, the background of the study along with objectives of the study, scope and limitations, definitions of the key concepts, and the study of the study is presented.

Chapter 2: This chapter 2 opens up by describing the energy needs and importance, and the different types of the energy. The chapter further goes on by describing the different determinants of renewable energy implementation. It presents about literature review containing study of energy need and importance, energy types and determinants of renewable energy followed by a theoretical framework

Chapter 3: This chapter explains the qualitative methodology of the study. It discusses the research method, case study research and, criticism and benefits of case study research. Furthermore, case study design for the present study is explained and at the end of this chapter, the validity and reliability of the study is discussed.

Chapter 4: This chapter discusses the case studies and then describes the determinants of renewable energy implementation in those respective cases. Furthermore, empirical results of the study are presented in this chapter.

Chapter 5: In this chapter, the summary and conclusions are drawn on the basis of framework and multiple case analyses. This chapter also presents the final model of the study. Further, managerial implications and implications for theory and future research are presented.

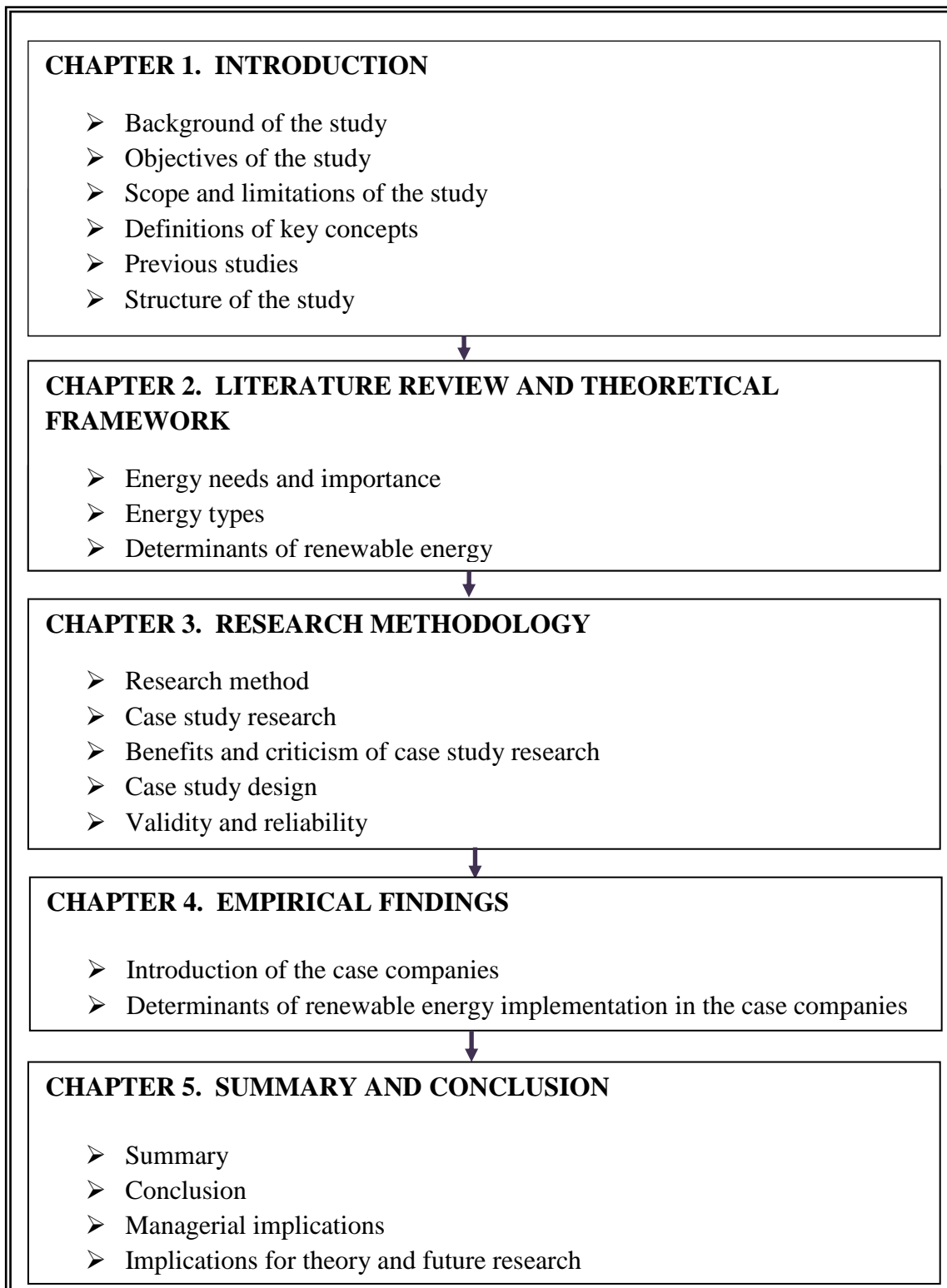


Figure 1. Structure of the study

2. LITERATURE REVIEW & THEORETICAL FRAMEWORK

2.1. Renewable energy need and importance

The spiral of a developing system resembles to the thought of social self-reflection, presented by modern sociology (Beck, Giddens & Lash 1994). Energy systems are core derivatives for services generation needed by society. The intended energy system creates the required services by linking chains of system to form a web of intended energy services supply chain. Stereotype components of this web include energy resources, their conversion into useful and transmittable form of energy by utilizing resources for the production of intended energy services. There are various numbers of energy sources existing in nature including; carbon based fuels, renewable energy sources and nuclear energy. (Simila & Savolainen 2009: 8)

Social processes, including energy production have an impact on environment (i.e. ecosystems) in various different levels and ways. This can be seen in the form of the increased population, the environmental changes, and the deployment of sustainable resources as well as the impacts of a well-being society. Such impacts are exemplified by climatic mitigation and acid rains, and are reflected by direct and indirect effects in society (i.e. health, environment condition, and change in society as a reflective of environment) (Peura & Hyttinen 2011)

Our growth is in a troubled society, where one fatal incident can demolish the entire continent, and unexpected risks could result in non-governable unity. By 1990s, it was foreseen that comprehensive changes are inevitable for the entire world in future. A new pact of social science is, hence, compulsory “to make sustainable move towards biosphere” (Lubchenko 1998).

Petroleum oil, natural gas and coal are among most important energy sources. Among renewables, wind energy, solar and biomass are of considerable importance. Transmission involves using various energy carriers including fuels, electricity and district heating. On the other hand, energy services and their usage are largely variable and dependent upon the end users' needs. It can be elaborated by exemplifying coal, which is burnt to produce heat, while the resulting heat is utilized to produce electricity

in power plants processes. The produced electricity is transmitted to end users by using distribution networks, and these users may utilize this electrical form of energy for the completion of some services like lighting the facility. (Simila & Savolainen 2009: 13) Energy development has a symbiotic relationship with other sectors of society as well. The growth of a country's economy is in consort with its energy consumption. Moreover, progress in technology is an indicator for a positive change in society. It also has an influence upon economic growth and energy sector. Current energy system is largely comprised of fossil fuel based energy resources, out of which fuel resources and a large number of resources are concentrated in certain areas. In fact, this has provoked issues of energy security for many countries for sustainable energy supply. This also has an impact upon rising oil prices and its availability (Simila & Savolainen 2009:11).

Energy systems have a substantial impact upon environment. Producing energy, nowadays, comes with polluting and harming environment, by adding poisonous compounds resulting in acidification and pollution of the air. A major concern, herein, is related with the emission of greenhouse gases which is being considered as the main component for environment change. Carbon dioxide (CO₂) is the most important greenhouse gas, resulting from the energy production processes, and that is released in the atmosphere. These environmental mitigations and their respective resultants are the core derivatives of a revolutionary change in energy production systems and their associated usage. (Simila & Savolainen 2009: 11-13)

2.1.1. Global energy system

Energy sources have emerged into our daily lives with more serious debates, strategies, knowledge, and technology development for the past two decades, particularly after 2000. Traditionally, the origin of energy can be found in the environmental sermon and the “big picture”, i.e., the energy generation has been the rationale of how mankind has affected the environment. So a very powerful connection exists between society and the environment, as demonstrated in figure 2.

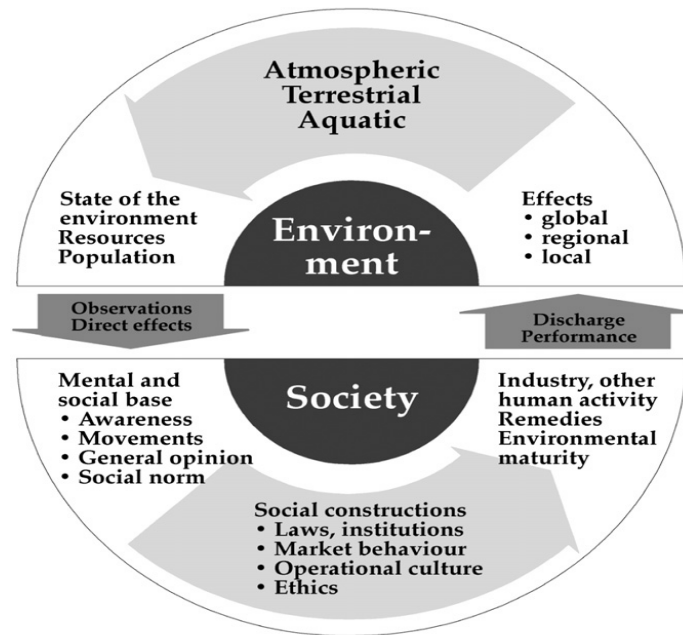


Figure 2. Dynamics between the environment and society (Adapted from Peura & Hyttinen 2011: 928)

Considering a complete energy system network is rather complicated, and therefore it is better to consider different parts of the whole supply chain system. In today's world, almost one and half billion people are living without any access to modern energy services in many of the developing countries. This poses a great obstacle to the progress of society. Energy services are vital component to address most of social issues including environmental variation, health services, diseases' spreading, and betterment for women's entities, equal educational facilities worldwide, fighting hunger and eliminating poverty. Energy is involved in every aspect of our lives, starting from water transportation to food cooking, and from health services to homes/spaces illumination (Simila & Savolainen 2009: 8-11)

Practically, the integration of renewable energy technologies has been slow in Finland so far. Technological advancements are being made by introducing small separate units of energy with a comparatively less impact on environmental and socio-economic system of the region. The first step for the progress is to evaluate the logical potential of renewable energy services and its various mechanisms. This progressive step has been adopted globally and large amount of literary data are available from a global perspective for the implementation of renewable energy services.

Energy demands and challenges: Globally, we have an increase in energy demand, which is mainly due to the ever growing energy demand resulting from global population and role the economy in the current world. A growth in economy is usually related to the increase in its adjacent energy consumption. However, this has also promoted risks and challenges related to environmental footprints. From an environmental perspective, the growing energy demand has increased the chance of more pollution to stratosphere and harming eco-balance in the world. Global energy consumption was approximately 490 EJ in 2006. Nowadays, more than 80% of generation is being done using carbon based fuels, out of which 35% is oil (crude oil petroleum) and 26% is coal (IEA 2008).

From an environmental perspective, the burning of carbon based fuels results in environmental pollution, promoting increased carbon dioxide. In return, the nitric acid promotes acid rain and plays an important factor in greenhouse gas emissions. Therefore, to protect the environment and stabilize the levels of carbon dioxide in the atmosphere, the reduction of emission levels (so that we may promote a clean environment in longer perspective) is necessary. On the other hand, the change in the climate has been accepted as the biggest threat from global perspective and organizations including KYOTO Protocol and EU Commission have been taking multiple steps to address this issue, by venturing into a sustainable solution. With respect to studies, it is suggested that carbon dioxide level will peak by 2015, and then it will start to decline in proceeding years. Kyoto protocol figures of 2005, however, show that 46 billion tons of carbon emissions were registered. (IEA report)

Conventional energy generating sources are usually highly dependent on fossil fuels. Most of the fossil fuel extraction locations are concentrated in the Middle East, Russia and some parts of Asia. Nevertheless, major economies including Japan, USA and Europe are highly dependent upon fossil fuel imports for the generation of energy to run their economies, which results in unsustainable economic growth. This huge dependence often results in economic crisis of the focal country. This factor has also led to increased energy prices in developed economies, making it more difficult to converge to a stable solution.

This growth in economy has promoted awareness upon the conservation of energy and its efficiency promotion in developed countries. This awareness is considered to be one of the important drivers of steering energy sector policies and efficiency in the future. However, the gap between grooming economies and policies of developed economies for energy sector is way too large and therefore cannot be compared, and this gap does not seem to be fulfilled in the coming years.

Approximately one and half billion inhabitants of developing countries are spending their entire lives without having any access to electricity. Whereas dilemma in the developed countries that they are still relying on old energy generating sources, which are inoperable under the new rules and regulations of EU Considering current global scenario regarding environmental variation, environmental friendly solutions should be encouraged in developing countries as well, where the energy demand is growing rapidly.

Special measures including need based policies are required in current era to establish a system that promotes such policies to meet energy future expectations in regard to economic situation and energy security. In order to meet these challenges from the perspectives of the environment, the economy and the energy supply reliability, a scheme can be broadly classified into two categories:

1. Technology drivers
2. Structural reformations in energy consumption

These two classifications are not entirely independent from each other, and therefore have a systematic relationship with each other. (Savolainen 2009: 18-37)

2.1.2. European Union energy system

Millions of Europeans have a tendency towards being 'green'. People are more interested in promoting eco-friendly environment by removing their own 'carbon footprints' from the environment, though it may be complicated. However, now EU is trying to introduce more policies to promote this. One very effective way of making a friendly environment is to promote renewable energy in current energy infrastructure.

There is a growing concern in EU citizens regarding renewable energy awareness and how to best utilize its resources.

Energy source diversification, which reduces the excessive dependency upon fossil fuels, like gas and coal, are the main reasons for the subtle attraction of renewables in EU. This is the most promising way to counter issues of energy security and environmental variation in a single move. It also safeguards economic threats by providing constant opportunities in the job market by the development of new technologies, helping Europe keep its position in the field of technology. A 20 % share of renewable energy could avoid 600–900 Mt CO₂ emissions per year. In addition, renewable energy has direct impact on our daily health, by reducing air pollution.

EU states are relying, currently, on more than 79% exported fossil fuels (particularly oil and gas) for its energy requirements. These huge energy imports result in an economic burden over the whole EU region. This gives a strong motive for the promotion of self-sufficiency in the region. See figure 3.

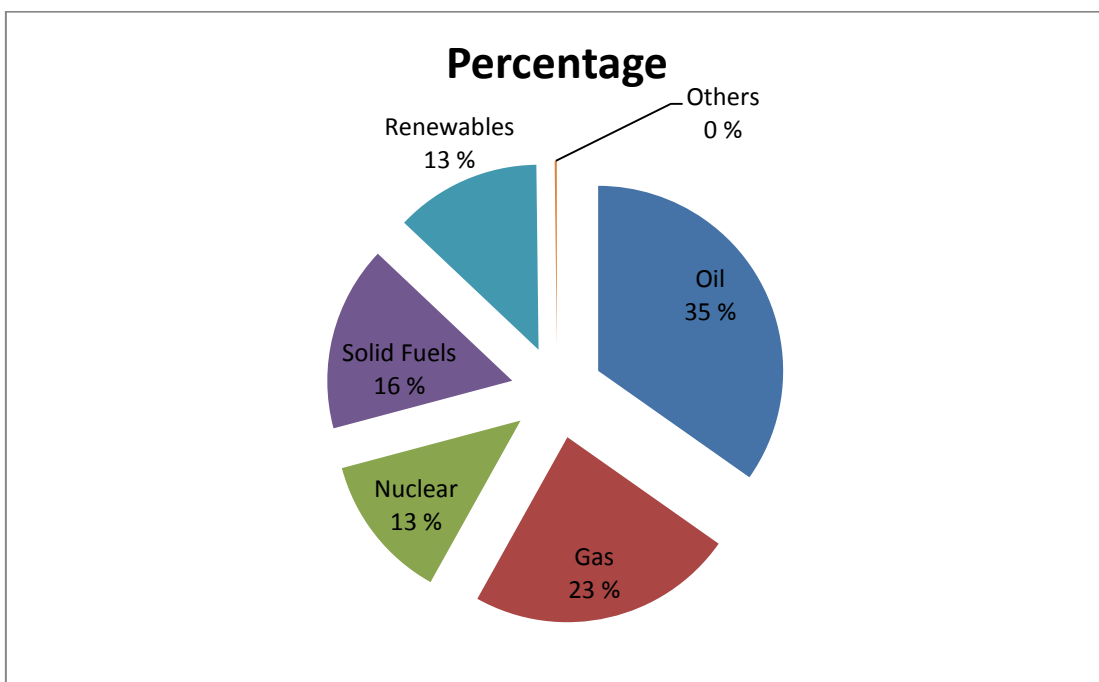


Figure 3. Gross Inland consumption by fuel (EU Energy Policy Report, 2011)

Although Europe has implied such policies promoting the usage of a wide range of fuels for energy generation from numerous resources worldwide, to improve energy production efficiency and thus decreasing price volatility and availability risk margin. A **20%** share of renewable energy systems in current energy demand could result in declining **200 Mtoe/a** of fossil fuel imports.

European competitiveness has a marginal positive influence by renewable energies. Technologies suitable for energy generation with low carbon output or zero carbon are very necessary to refrain from huge environmental costs in the form of pollution. Moreover, these technological innovations are crucial for economy growth and stability. Currently, Europe is a global market leader in the renewable energy field, employing over 1.5 million people with a net turnover of more than 50 Billion Euros. It is foreseen that, by 2020, this sector has potential to triple its turnover by providing another million jobs. (EU Energy Policy 2011)

Table 3. Renewable Energy Generation by some countries from the Globe

Share of Renewable Energy Resources in the total electricity generation (%) in European Union Member States by 2009	
Country of Origin	Total Electricity Produced from Renewable Energy Sources (%)
Finland	31.56
Sweden	58.52
Norway	96.63
Denmark	27.4
Iceland	100
USA	10.5
Germany	20.1
UK	6.18
France	13.34
Belgium	6.53
Nordic Countries Average share	62.82

Source: (Aslani et al. 2013)

2.1.3. Nordic region energy system

The Nordic countries (NCs) comprising of Finland, Sweden, Norway, Denmark and Iceland including three self-governing regions (Aland, Faroe Islands, and Greenland) are located in the northern most part of Europe. The population distribution of NCs was 25,830,631 (approximately 0.37% of whole World) by April 2012 (Wee, Yang, Chou &

Padilan 2012). These countries are among the top developed countries from a social welfare and economic perspective. Nordic region countries are among energy intensive countries owing to the cold climate, intensified energy industry, and a widely distributed population with high living standards. The high end living and intensified energy usage can be explained by the fact that Finland's per capita energy consumption is the highest among EU member states (Energy Vaasa 2012a). Norway and Sweden are both among the top countries according to these economic indicators. (Aslani et al. 2013)

Below are some figures that give us an overview of the primary energy consumption in these countries in the year 2009. It shows that Finland and Sweden are largest most diversified countries for their energy supply infrastructure in comparison with all other Nordic states (see figure 4).

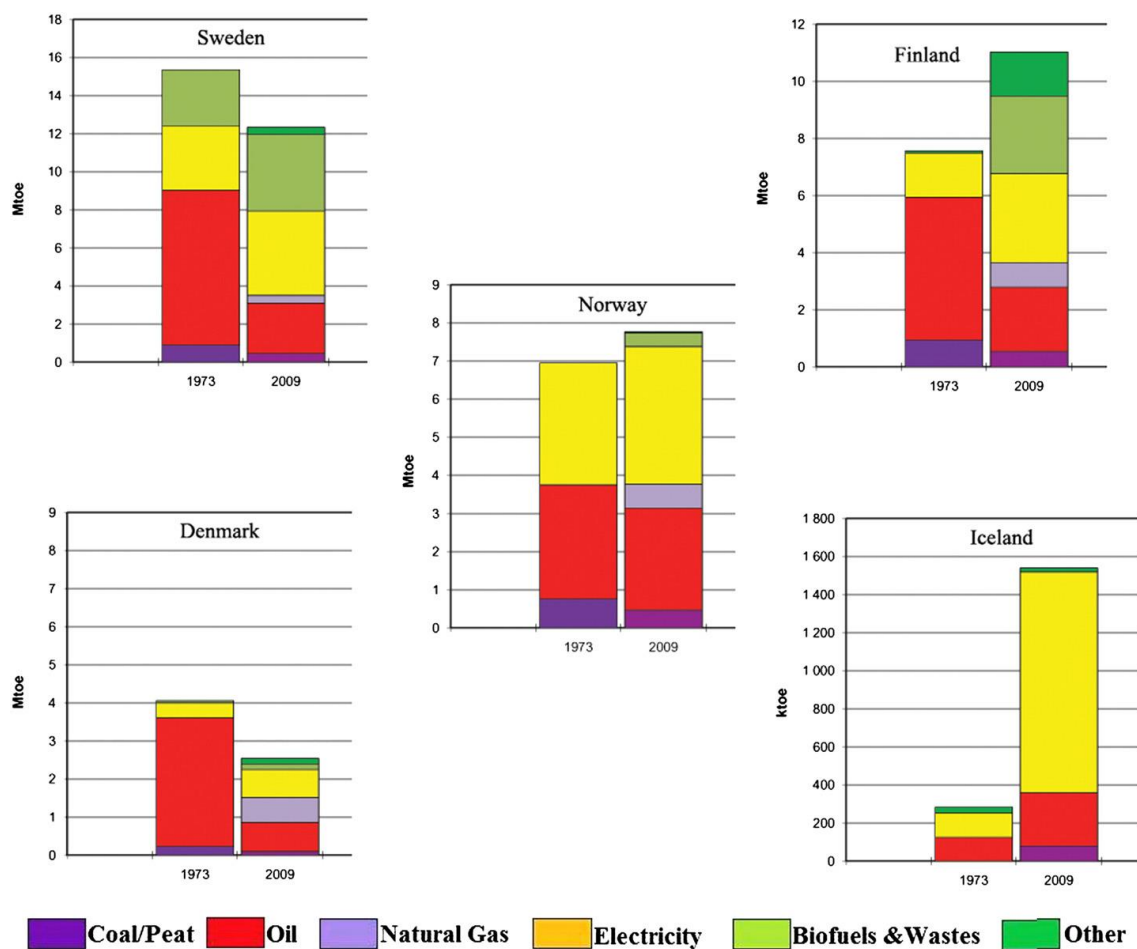


Figure 4. Breakdown of sector-wise energy consumption in industries (adapted from Aslani et al 2013: 499)

It is estimated that Norway produces 10 times of its domestic energy consumption annually, whereas Finland, Sweden and Iceland are importing a large part of energy produced in the form of fossil fuels (Ministry of Energy Finland 2012). Figure 4 compares the percentages of industrial energy consumption in year 1973 and energy consumption in 2009. It explains that oil and coal energy contributions for energy generation have been largely reduced over the past few decades in Nordic Countries, considerably in Finland, Sweden and Denmark. It dropped from to 28.7% in 2009 from 64% in 1973. Renewable energy sources are the main contributors to district heating systems and the electricity generation. Figure 4 also explains the consumed energy which is primarily obtained from electricity plants, combined heat and power systems, and heat plants. Solar energy cannot be prioritized for utilization because of geographic conditions. However, Iceland derives 84.3% of its primary energy from indigenous renewable energy sources (64.1% geothermal and 20.2% hydropower) which cover 100% electricity generation (hydro- power: 12279 GW h, and geothermal: 4553 GW h in 2009) (Hreinsson 2008). Hydropower is responsible for more than 90% electricity generation in Norway (126,077 GW h in 2009). In contrast Finland and Sweden are leading bio-energy users in the world with 8,586 and 11,323 GWh of generation potential in 2009 (NORD POOL SPOT 2012).

2.1.4. Finnish energy system

Finland has a highly industrialized economy with high-tech engineering works, electronics and chemical industry, operating in parallel with paper, pulp industry, and forestry. Finland has majority of its population distributed across rural areas with over one-third of the country above Arctic Circle, except for the southern part. Finland has the world's highest most energy per capita consumption according to the International Energy Agency (IEA).

Finland has scarce hydrocarbon reserves and this factor steers Finnish energy policy and have an influential factor upon energy security in particular. However, this country excels in deploying funds for energy sector innovation and research in comparison with other member states. However, it is heavily relying on biofuels and waste for energy generation as compared to other Nordic countries, but still it also heavily relies on oil for energy generation (see figure 5). The focal point of the Finnish government is to

move towards sustainable economy with a decarbonized cohabitation and strengthened energy security, and to integrate more widely into European markets.

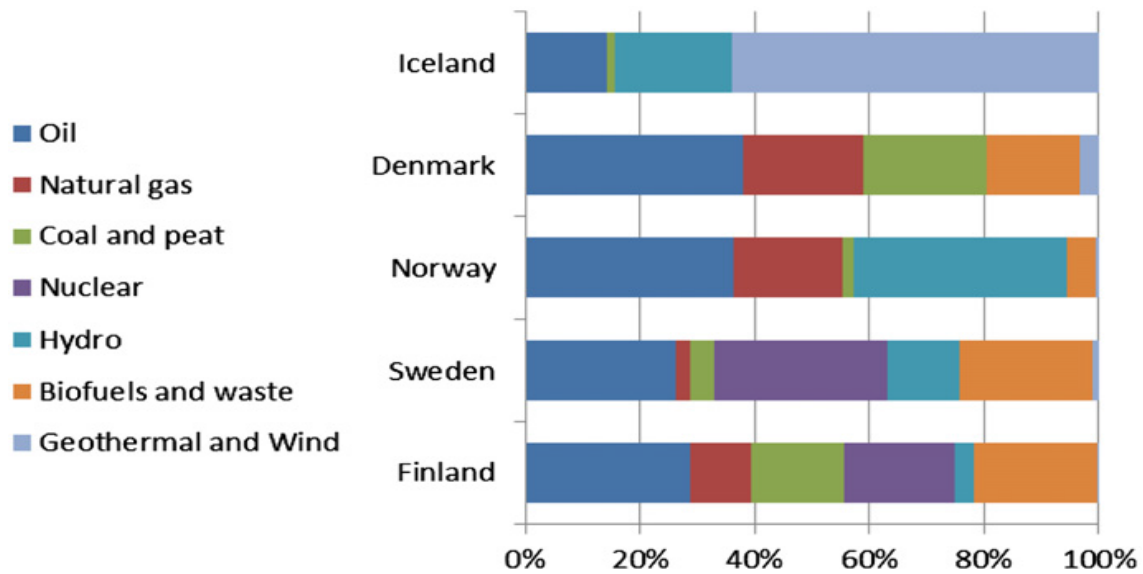


Figure 5. Sector-wise Primary Energy Consumption in Nordic Regions (adapted from Aslani et al 2013: 498)

Finland is strongly reliant on imported petroleum including oil, gas and coal, for its energy sustainability and will remain so, considering inertial transitions in energy sector. Government has introduced various steps to address the issue. As a primary defense line, Finland has passed an Act in 1992 on security of supply, stating that, Finland's public stockholding agency must have alternative sources for oil and gas equivalent for five months consumption. This requirement contradicts with IEA oil stock requirement of 90 days of net imports in EU.

Diversification in energy needs is the second defense line. Finland has successfully divided its energy infrastructure into three equal parts of production from hydrocarbon, renewable and nuclear energies respectively. It has deepened its flexibility by integrating into Nordic energy market including its hydro-dependent Scandinavian market. Nordic countries equalized energy prices in for some months of year 2010 and 2011.

One unavoidable high energy consumption factor is intense weather of Finland that requires most of the lighting and heating energy during peak winter season. But, this

country has transformed its weaknesses into strengths, by developing highly efficient combined cycle power plants, which are responsible for the majority of district and industrial heating networks. Furthermore, combined heat and power plants (CHP's) are responsible for almost half of the country's space heating; almost one third of the total energy requirement and almost 10% of the average proprietary of the European Union.

Now, Finland is among three IEA member states with indigenous supply of hydrocarbon energy, it uses peat for energy generation, which accounts for 6% of total energy consumption. However, this is quite a dilemma in debate for Finnish citizens considering their environmental awareness. Despite the influential negative tax policies and abolished subsidies, peat still continues to benefit, because of its proven efficiency heat margin in CHP and domestic heat generation industry, including co-firing with biomass. However, this is quite an uncertain source of energy because of its emission profile and its biased future in the Finnish energy system.

Although, all these energy 'pillars' are safeguarding and strengthening energy future of Finland, the principal long-term objective for economic policy is to get a 'decarbonized' energy future by developing, promoting and implementing clean energy mechanisms (OECD/IEA 2013).

2.1.5. Ostrobothnia energy system

Ostrobothnia (in Finnish: Pohjanmaan maakunta) is located in the west coast of Finland. It comprises 2.35% of whole Finnish area and imparts a share of 3.31% of the total Finnish population, as of 2012. It consists of 16 regional municipalities including Vaasa as a capital and 34% of foreign population resides in Vaasa. In comparison, Vaasa is the most industrially developed city in Finland. The economy of Ostrobothnia is greatly influenced by its Industrial products, mainly in the field of energy and almost 70% of these products are being exported which constitutes more than 30% of Finland's net energy exports. In addition, Vaasa consumes 40% of energy demand in Ostrobothnia region; There are over 150 registered companies operating in Ostrobothnia and Vaasa region in energy field technologies.



Figure 6. Location of Ostrobothnia region (marked red) in Finland (adapted from Aslani et al 2013: 406)

Currently, over 10,000 inhabitants are related to the energy industry, which in comparison with its population locates it among top energy industrial fields in the world. By 2020, the goal is to double the energy sector staff with a focused development of energy and renewable energy field development. All these locally existing competences promote and speed up renewable energy utilization and in the development of smart energy projects, including state of the art pilot technologies implementation. Vaasa is also a home of more than 12,000 university students with two Finnish Energy Industrial Giants sitting in the heart of the vicinity namely WARTSILA and ABB with the highest levels of R&D investments and works in the region. (Aslani et al. 2013)

Competitive advantage of Ostrobothnia region: The east coast of Bothnia gulf (Ostrobothnia) is one of the best potential locations for wind power generation in Finland. Vaasa is considered as the sunniest city in Finland. In the meantime, world's top energy market leaders including WARTSILA, ABB, THE SWITCH, and VACON have their head-offices and production facilities including R&D in this region. Owing to

the fact of rapid technological diffusion, these companies impart a major and influential contribution to the implementation and development of renewable energy utilization by speeding up renewable energy adoption and facilitating research and plans. Ostrobothnia and Vaasa have a large number of university students in comparison to the population (in energy field technology and business) and facilities for research provide a focus on increasing the entire energy chain efficiency as well as the elevation of renewable energy exploitation in the provincial level (Aslani et al. 2012; Wee et al. 2012). There is a huge self-sufficiency potential in the various municipalities of Ostrobothnia as shown below in Figure 6.

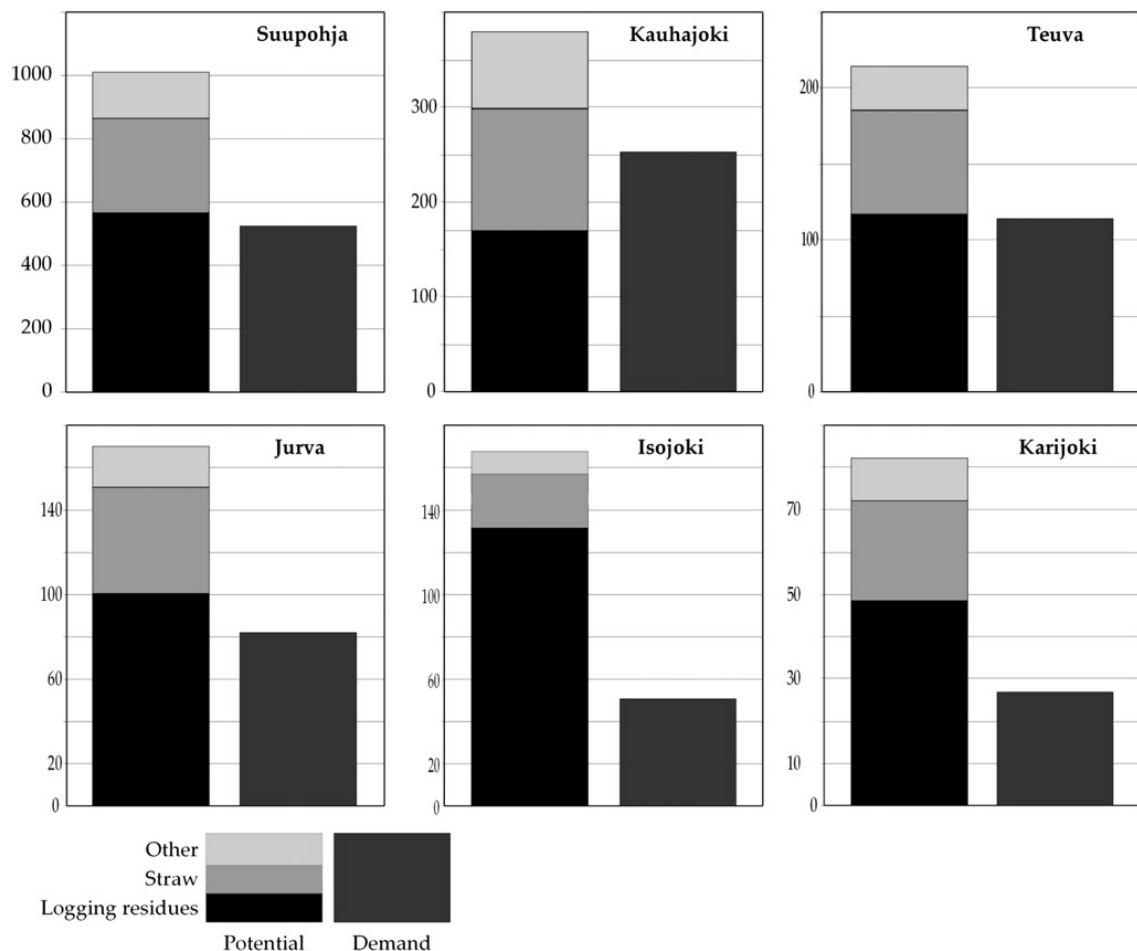


Figure 7. Bioenergy potential in five municipalities of Ostrobothnia region with energy demand (in Gwh/a) (adapted from Peura & Hyttinen 2011: 937)

Residential demands: If building a sector is considered for energy optimizing, then it can be seen that energy is being consumed both in residential and commercial buildings,

and at a gross root level. It includes domestic heating, water heating, chilling, illuminating as for lighting, for food processing, and in various electrical appliances. Now, in order to reduce carbon footprints in energy use as well as in the construction sector, two steps of improvement can be made:

Step 1 may include redesigning the overall building energy consuming equipment and thus making an energy saver design.

Step2: Utilizing and implementing renewable energy sources or sources with less carbon generation comparable to obsolete ones.

Overall energy demand can be reduced by a comprehensive framework of the articulated planning. This professional planning allows restructuring the whole design, the infrastructure, the individual blocks and units, building energy automation, electricity, and system service solutions. (Viinikainen et al. 2009)

The normal age of buildings is several decades and the implementation of infrastructure changes is a creepy process. So, it is quite crucial to come up with sustainable decision making for energy utilization and its framework, both from organizational and individual building perspectives. Now, careful restructuring and reshaping of building energy efficiency technology development has resulted in tremendous amount of energy saving in last twenty years. A very careful estimate suggests a difference of more than 50% energy saving between old and new projects.

Although, energy efficient building system technology is quite at early stages, due to social, environmental, political and economic reason; a huge shift is expected in the near future, considering the environmental footprints and CO₂ mitigation. This will definitely require changes in the building regulations. (Viinikainen et al. 2009)

It has also been demonstrated internationally, that an energy intelligent design is more profitable even though the initial construction cost could vary from 2-5% comparable to the conventional designing of a building. Estimated payback period of this initial investment is within one decade with a tolerance of few years.

According to some statistics shown in figure 7, it is visible that space heating required almost 33% of total energy consumption by 2005, but considering methods and steps being taken for an energy efficient system; these figures will be considerably less by 2050.

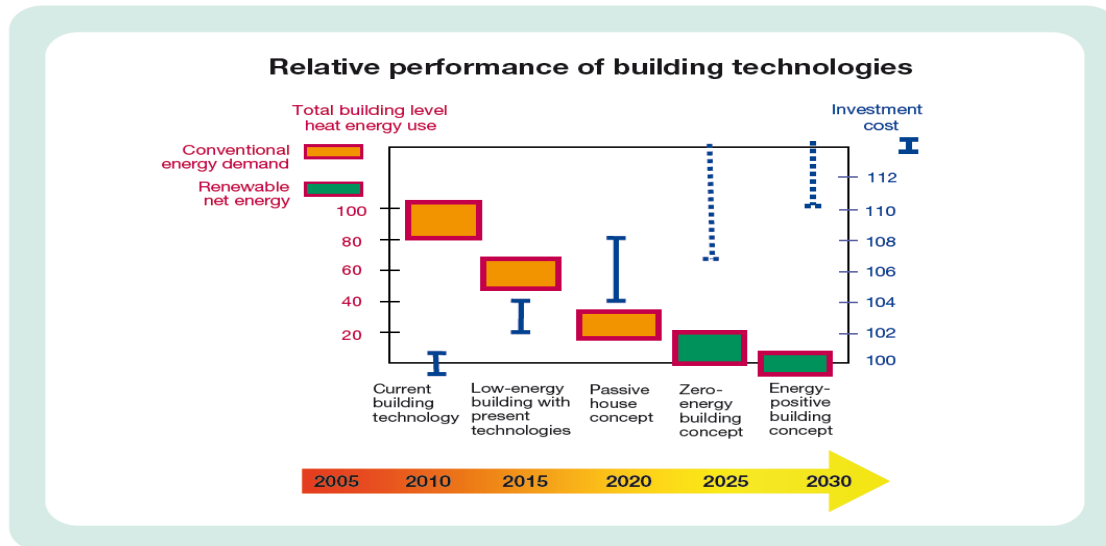


Figure 8. Building sector energy statistics (adapted from Viinikainen et al. 2009)

Industrial Demands: In recent years, Energy consumption has grown non-linearly, in comparison to industrial production. One of the reasons is the abnormal growth of information and communication technology (ICT) and service sectors which are imparting their role in economy development and GDP growth; yet not utilizing much energy comparable to industrial production. So, now process development is an indicator of improved and efficient process utilizing more energy. Thus, product development process should play a vital role in the energy optimization during the design stage.

The chemical and petrochemical industries are the main economic indicators of industries, consuming most of the industrial energy. According to the following figure 8, the chemical and petrochemical industry consumption in 2004 was 30%, with 19% consumption for iron and steel industry, and 9% for other paper, pulp and printing industry. (Viinikainen et al. 2009)

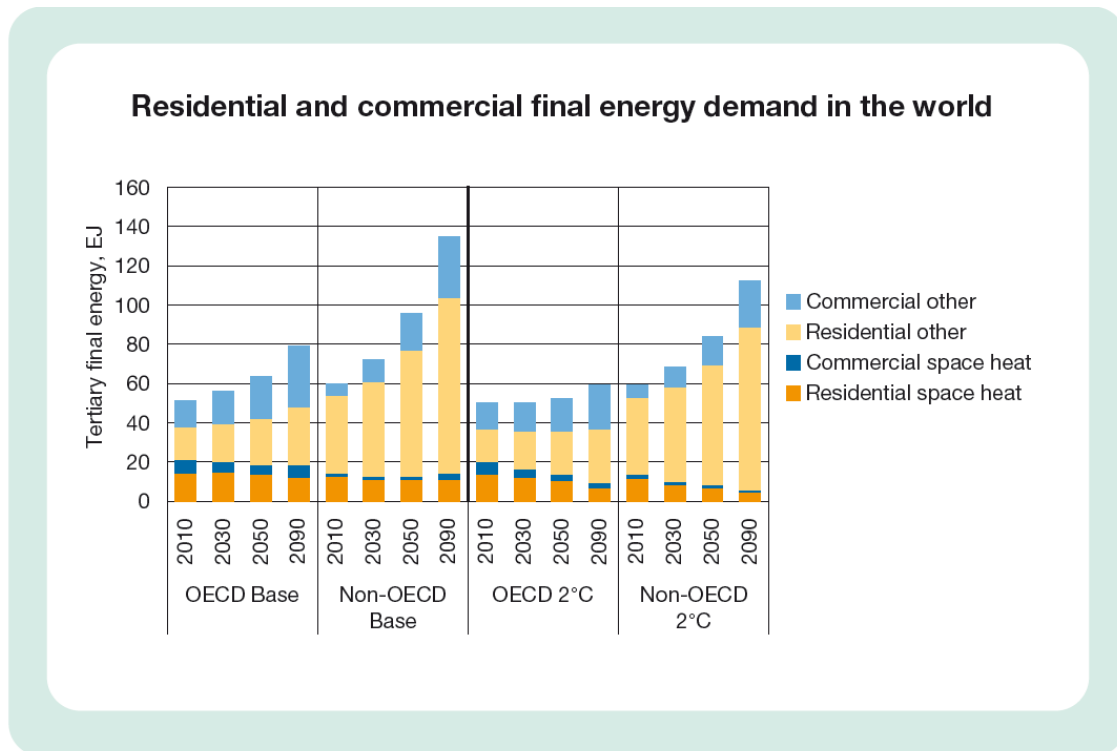


Figure 9. Residential and commercial final energy demand in the world (adapted from Viinikainen et al. 2009)

The industry process energy consumption can be divided into process energy consumption and auxiliaries' consumption. In order to improve energy consumption in industry, one either has to redesign the system thermodynamically for low heat consumption; or the production process has to be shifted for more efficient technique. Thus, major energy infrastructure improvements require huge capital investment; still there are many areas, where system efficiency can be achieved with small investment.

There are variety of processes that can be used in industry for the same product production using entirely different approaches, techniques and algorithms. These external or internal processes make it different from others. Thus, numerous possibilities are available to achieve same product, using various approaches. From the figure, it can be seen that there is a remarkable gap between the technologies recently deployed and the ones elected for future implementation. This represents the potential of the energy efficiency improvement. (Viinikainen et al. 2009).

2.2. Energy types

In this section, we'll discuss the Energy conversion technologies deployed in today's world for the production of useful Energy in the form of electricity and heat.

There are three main types of energy: conventional energy, nuclear energy, and renewable energy. In the following, these types are discussed in detail.

2.2.1. Conventional energy

Conventional energy is basically the resources, either based upon oil and gas (fossil fuel) (Savolainen et al. 2008: 17). In the future, fossil fuels will be among the main energy resources. The transition procedure of renewable energy is not very fast, though, due to its expenses including: the solar and wind energy, the lack of biomass and hydro sources in different parts of the world, and the extended life of extant energy producing plants. Very few countries have initiated nuclear power, because of the different challenges associated with it, such as the lack of public support, and the time needed to commercialize the fusion technology. Besides, carbon capture technologies are also required as actors for intermediate technologies, to store carbon dioxide producing from fossil fuels in developing countries.

Electricity generation structure is quite inertial as many power plants erected in 1970s are still functional as of today. The majority of the plants operating on coal in the past 20 years are built in India, China and some other Asian regions. The Oil importance increases when new regions of the world are initially electrified at some local levels, and then connected with massive grids. The developed nations have merged their former coal power facilities with the flue gas treatment; yet large volumes are still added using natural gas with combined cycles. There is an increase of pollutants in the air coming from the combustion process of the conventional power plants generation cycles. Coal is considered one of the major fuel for energy generation as it generates 38% of the global energy. (Helynen et al. 2009: 145-148)

2.2.2. Nuclear energy

It is a fission process for generating a major amount of the energy which is practically free of CO₂ emissions (Helynen et al. 2009: 198). Fission reaction is the main carbon neutral energy source. It is generating 7% of the total energy consumption and almost 15% of the electricity worldwide. In year 2007, 2,608 TWh electrical generations was recorded with the consumption of approximately 65,500 tons of uranium in raw form (IEA statistics). In year 2009, 436 nuclear generation facilities were recorded in 31 states with total capacity of generation equivalent to 372 Giga Watt Electrical (WNA 2009). The biggest installed capacity lies in Europe, where France contains the highest portion of the electricity generation. Crucial operational factors are its annual outages and refueling amounts as well as the special focus needed for designing a nuclear facility.

The length of refueling outages at the Finnish nuclear facilities at Olkiluoto 1 and 2 have been improved and it requires approximately from one to two weeks to refuel with additional maintenance jobs. Finland has achieved 30% more power output by increasing from 660 to 860 MW per unit at Olkiluoto 1 and 2 locations and by applying new safety legislations. Therefore, The total power generation cost is reduced, including invested money, operation and maintenance expenditures, waste and fuel management by almost a quarter (applying modernization to facilities).(Helynen et al. 2009: 198-202)

2.2.3. Renewable energy resources (RERs)

Renewable energy is any form of energy from solar, geophysical, or biological sources that are replenished by natural processes at a rate that equals or exceeds its rate of use (Moomaw et al. 2011: 178). The fossil fuels benefits are dropping despite being the main generation source of energy in the world, due to their economic and environmental bad impacts (Aslani et al. 2011). As a consequence, local and domestic utilization of these sources is important for various strategies' replacement.

Finland stands among the countries with the biggest chunk of renewable energy contribution in the energy supply. The carbon emission reduction and exploitation of the

renewable sources are the gist of the Finnish energy policy for enhancing the energy security. Naturally, policies, strategies and geographical conditions play an important role in the prioritization of investments and potential development in renewable fields, and is a balancing factor in highly authorized municipalities like the case of Finland. Ostrobothnia with its capital of Vaasa are among the high potential renewable energy regions, due to the special focus of the Finnish governments upon solar, wind and geothermal energy (Aslani et al. 2013).

Peura and Hyttinen (2011) present various definitions from the literature of renewable energy supplies which are well abridged from Vebruggen et al. (2010)'s work. These various types of sources are "obtained from the continuing or repetitive currents of energy occurring in the natural environment and including non-carbon technologies such as solar energy, hydropower, wind, tide and waves and geothermal heat, as well as carbon neutral technologies such as biomass" (Peura & Hyttinen 2011: 930).

There are four types of renewable energy. In the following, these types are discussed in detail.

Wind energy: There has been a rapid wind energy use worldwide after the 1990s. The wind energy is a viable generation source because of technology. The wind energy was responsible for roughly 1% of the whole globe's generation by 2008. The figure exceeds 3% for the European Union. It is estimated that there is a growth of more than 30%, since 2008, in installation capacity of wind sources and expected to be double in the next 4 years. It is also expected by the "Global Wind Energy Council" (GWEC) that the wind energy has almost tripled its market energy share since 2008.

GWEC claims a total share of 12% in the global energy generation with wind sources by 2020 by adding 1200 GW additionally, whereas IEA (2008) forecasts 1,176 TWh/a addition by 2030 in energy production. These highly contradicting figures reveal upcoming technological developments and huge wind generation potential to be explored for safeguarding the emerging generation technologies.

The wind power growth spreads all over the globe, but its most rapid development is forecasted in Europe, India, North America and China. The Danish government have set a very ambitious goal of achieving 50% electrical generation via wind energy by 2030.

The wind Energy generation is the most essential energy security component for improving energy security, coping with environmental mitigations and reducing carbon emissions from energy generation, while creating new businesses and employment opportunities worldwide (Helynen et al. 2009:177).

The wind energy generation is a structured organization for the exploitation of the blowing kinetic energy, to convert it into a useful transmittable form of energy, via aerodynamic equipment. These devices have imparted a significant role for a small scale generation in areas with higher wind production potential. The wind turbines are integrated nowadays in grids in most of the developed countries. The high altitude and offshore locations are best suited for wind generation installations due to sufficiency of wind energy. However output and peak performance is affected by wind speed, blade angle and density of wind in air surroundings. Wind power generation potential in a certain area is a main measure for determining exploitation potential as shown in figure 9 for Ostrobothnia. Investment decisions are usually made upon the availability of such data. It is very crucial to judge all influencing factors for a wind park design that could affect its generation potential and optimal performance and reducing risk for being more financially tangible (Mohammed et al. 2014)

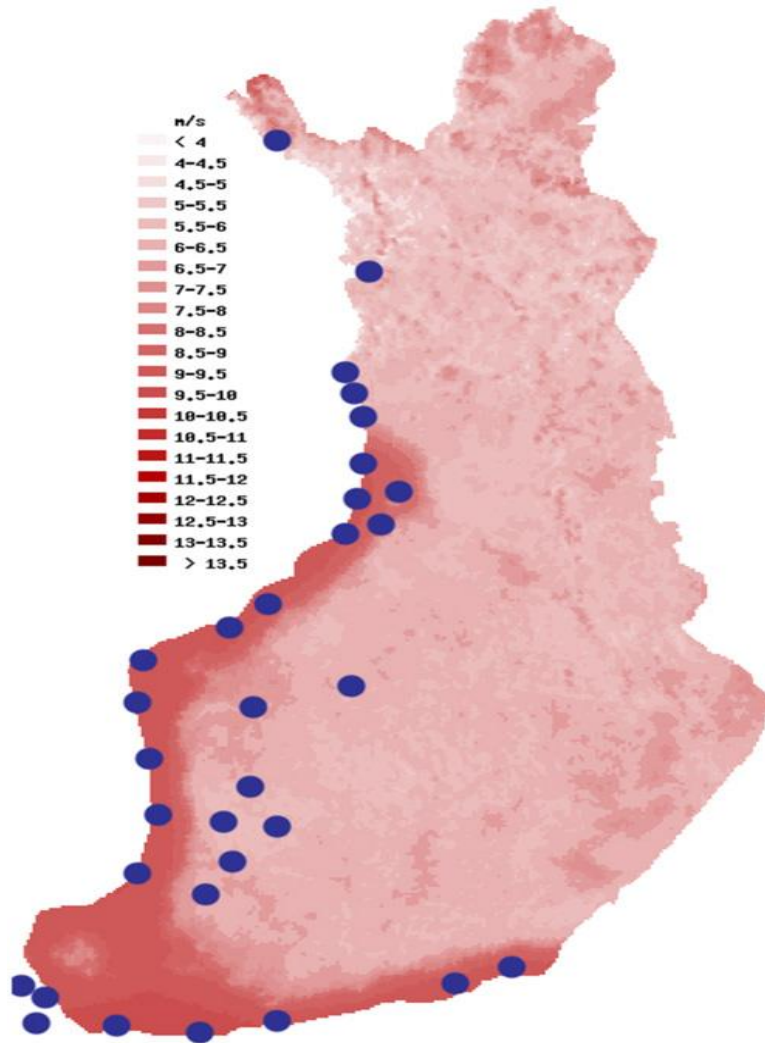


Figure 10. Wind Power Generation Potential in Ostrobothnia region for the development of future Wind Parks (Adapted from Aslani et al 2013: 409)

Biomass: The biomass fuels available for energy production range from wood residues and crops, to energy-grown crop fields and industrial process slurries. Emission contents and quantities in case of biofuels are largely diversified upon the basis of high moisture percentage, volatility, and presence of sulphur and metal elements as these properties are impacting its combustion performance and heat release values. In turn, they are affected by growing conditions and regional diversity. So diversities exist within various plant components as well as biomass characteristics for stem wood are different from bark and branches.

The biomass energy conversion is a vital role player in Finnish combined heat and power (CHP) energy generation system, responsible for most of the district space

heating and major percentage of electrical generation. Finland adopted a novel concept of most efficient with highest performance efficiency combining heat and power generation using biomass as fuel. It is more convenient to process woody biomass for thermal conversion such as gasification and combustion comparable to agricultural crops. (Helynen et al. 2009:165-166)

The bioenergy generation potential in Ostrobothnia region was calculated by Peura and Hyttinen (2011) with individual energy demand and generation potential for all areas in this region. The results of the study shows a remarkably huge generation potential in especially rural areas of almost 2.7 TWh/a, whereas the total demand is 4.3 TW/a, that shows an overall self-sufficiency with a 63% potential. However, there is a remarkable regional variations with this promising fact, that population centered areas marginally exhibit a larger energy consumption volume comparable to other rural areas and it covers most of the Ostrobothnia region.

Vaasa and Pietasaari are energy intensive population rich areas responsible for almost 2/3 of Ostrobothnian region's entire energy consumption. Official population statistics range Vaasa's population around 60,000 Inhabitants in 2011 and if these high population density areas are out ruled from calculations then the per capita energy generation potential approaches to 154%. This figure shows that the biomass energy generation potential in the regions outside Vaasa, Pietasaari and Kaskinen exceeds by far the demand. Peura and Hyttinen (2011) argues that a considerable generation potential can be identified in almost all rural areas of Finland, with more than 100% self-sufficiency potential. (Peura & Hyttinen 2011)

Co-firing: Finland possesses unique capabilities in the field of high-efficiency energy producing power plants, in the field of biomass, and co-firing biomass with carbon based fuels. Finland has achieved this high level of technical advancement by effective networking and strong product development procedures.

VTT institute has probed into analyses and determination of hazardous components in furnaces and conditions that could create combustion problems, by conducting small prototype studies of these furnaces for the development of sustainable techniques to be deployed in power plants for combustion and thermodynamic activities. It has

developed specialized techniques to measure the extent and thickness of deposition layers inside superheats by thermo-chemical methods. (Helynen et al. 2009:169-170)

Solar energy: Solar Energy represents the largest energy source in the globe. The Earth surface annually receives almost 1,000 times more than the current global energy demands. There is a tremendous amount of 81,000 TW average energy being received by the earth core. The solar energy has a very important potential; badly diversified, though. In the Sahara desert, the recorded maximum density of energy for short time is 1 kW/m² and annual average falls below 7 kW/m² per day. In northern areas, this average falls below 2 kWh/m²/day with seasonal fluctuations. It has been observed that the solar radiation performance is better for tilted objects with tracking devices, but is largely dependent upon the use of technology. However, solar energy is the main driving factor for almost all the other renewable sources. So, indirectly all renewable sources are basically depending upon solar energy. The biggest part of the absorbed solar energy is by wind, with an average flow capacity of 1,500-3,500 TW in atmosphere.

A small amount of solar energy is transformed into wave kinetic energy. This value fluctuates to almost zero for idle and static lakes and goes as high as 90 kW/m at Ireland's Atlantic coasts and Britain. According to IEA statistics (2008), Ocean Energy generation potential lies in the range of 1-10 TW. (Vuori et al. 2009: 249)

The solar radiation exhibits a great difference in variation potential in various different areas of the globe and even within one region as well. So, exploitation potential of these radiations is hugely different and an efficient data containing subtle information about solar radiation is very important for determining the feasibility of solar projects in certain regions. Hence, as per zone, there are many variations in applications. They include solar cooker, space cooling and heating systems and water heaters. Advanced solar technologies are much cost optimized and friendly to use. Using heat energy from solar radiation also prevents deforestation in countries that are at developmental stages for a better sustainable future contribution. However, solar potential decreases during cold and winter periods, as it is dependent upon sun availability time. This problem has contributed to an innovative solution of hybrid energy generation. (Mohammed et al, 2014)

Hydropower: The hydro power generation is largely region suitability dependent. It is chiefly a site specific with conflicts in land use, downstream water usage, ecological constraints, and migration of aquatic species, greenhouse emissions and earthquake factor. It requires huge investment potentials to block world's biggest river flows, and requires extreme civil engineering for the construction of suitable heads from dam to produce power, to turn turbines for generation.

In turbines field, excellence has already been achieved with efficiency of more than 90% and no breakthrough technological innovation is expected in coming days. Turbines can be broadly classified into four main categories:

- Francis
- Tubular
- Kaplan
- Pelton

Each type has its own distinct features and head requirements for enough flow generation depending upon application type.

There are many possibilities for future hydro power generation. One possibility is to utilize conventional method for hydropower generation with the exploitation of naturally existing large water basins and then modifying it for storage head reservoir creation. Second alternative is hydro pumping of water to attain height and then using turbines for electricity generation. This technique becomes attractive when energy prices rise comparable to hydro pumped generation costs. (Helynen et al. 2009:186)

Hydropower could be exploited for electrical generation because it is maintenance free and have small operational costs. As water distribution, worldwide, is not equal, so naturally there is a large variation in hydropower generation potential across the globe. (Mohammed et al. 2014)

Approximately, 30-45 TW of heat flows on average from the earth core, because of nuclear decomposition in earth inner layers. A part of this geothermal energy can be utilized for useful energy production. Tides have an average energy of 3.5 TW, and

almost 20% of this energy is dissipated. A small portion of this energy can be used by bays or turbines using tidal currents to produce energy.

There is a huge difference between technical and theoretical potential of renewable energy resources. (Vuori et al. 2009: 251)

Table 4. Summary of technical flow of renewable energy

	Size of Energy Flow(EJ/a)	Current technical potential (EJ/a)	Global electricity generation capacity 2007-2008 (GW)	Global electricity generation 2005 (TWh)	Global Heat Generation 2005 (PJ)	Total Production in EJ/a
Current global energy demand	490					
Solar, at earth surface	2,600,000	Very large	13	2.7	164	0.01
Wind	47000-110000	2500-4700	100	101	0	0.4
Hydro		59	778	2837	0	10.2
Geothermal	950-1400	2.2	8	58	1713	0.2
Tides and tidal currents	100	1	0.3			
Wave	30-300		approx.0.02			
Ocean temperature gradients	30		Prototypes	0.6	0	0
Ocean currents	3		none			

Source: IEA 2006

2.3. DETERMINANTS OF RENEWABLE ENERGY

Several different factors exist for the successful penetration of renewable energies in the EU and Finland. The study here discusses some of the vital determinants which positively influence renewable energy sources.

2.3.1. Economic factor

Economic factor means maximizing outputs obtainable from a given set of inputs, or minimizing inputs required obtaining a given set of outputs (Aslani et al. 2013: 502).

Moving forward with the previous debate upon economic variations governed by Energy field, we are currently facing a global economic problem. This challenge has affected many perspectives of modern development. Energy generation prices dependent upon fossil fuels are quite fluctuating and frequently volatile. These energy price fluctuations have triggered many factors including governmental policies, economic uncertainties, different internal conflicts at country level and regional agitations. (Mohammed et al. 2014)

The reduction in fossil fuels consumption is the main aspect for developing RE in NCs along with increased dependency on indigenous resources (Aslani et al. 2013). This in turn will reduce the Energy Security risk by enhancing diversification in coal and oil imports for countries like Finland, Iceland and Sweden. Iceland is an example being Europe's former poorest country during the 20th century dependent on peat and imported coal for energy generation. Conversely, they have achieved, today, a high living standard all over the country and produce more than 85% energy from indigenous renewable energy resources (Wee et al. 2012). Renewable Energy is a local potential and thus it helps in promoting technology and economic growth, bringing new job opportunities and developing social welfares (Aslani et al. 2013). There are almost 4000 job positions active in the field of Renewable Energy sector within Finland at 500 different locations in almost 200 private entrepreneurs (Aslani et al. 2013).

2.3.2. Energy security

Energy security is the security of energy supply (Aslani et al. 2013: 501). Reliable energy supply for maintaining energy security is a debatable topic among governments and common population in Nordic countries including Finland, Sweden, Denmark and Iceland. Vulnerability of Energy Security can be reduced by diversifying energy supply sources and it may also help in prices volatility risk reduction and monopoly from certain suppliers. Studies depict that Finnish and Swedish energy economy has diversified most portfolios for energy reliability all over the world. (Aslani et al. 2013)

2.3.3. Environmental impact

It refers to the necessities of climate change mitigation (Mohammed et al. 2014: 530). The front issue in today's energy sciences is environmental impact assessment (EIA). It is due to strong connection between energy related actions and their impacts upon environment. Production of Energy from fossil fuel based sources is producing greenhouse gases (GHG's) and the impact is ever rising on global warming potential. In today's economy, such practices should be adopted to prevent climate mitigation, and avoid future expenditures. By change in climate (Jyoti & Gokarn 1992; Nemaa, Nema & Roy 2012), it is meant that an alteration of climatic condition predictable in the form properties change that sustains for longer periods of time (Nemaa, Nema & Roy 2012), decades. Changes in the climate will result in a global impact on environment. A country by itself cannot resolve its aftereffects because of the cohesion of the world's atmosphere. The more suitable solution is to synchronize national strategies for the unification of international frameworks. In order to confront environmental hazards, various different plans of action are required. These plans should be proficient, long-term (IEA 2010) and responsive to handle unplanned events and uncertainties. They should have adjustability to match with new information's as soon they are identified (Nemaa, Nema & Roy 2012). One effective solution is facilitating the system by the development of Renewable Energy Sources (Mohammed, Mokhtar, Bashir & Saidur 2013) in an effective fashion, by involving mixed or hybrid energy solutions in existing grids. (Mohammed et al. 2014)

In conclusion, lowering fossil fuel consumption for energy generation reduces environmental and pollution impacts by bringing sustainability in environment. In this view, Nordic countries have been deploying most successful plans for carbon emission reduction globally. Reducing Carbon footprints from earth is defined as minimizing CO₂ production from the combustion activities of fossil fuels by humans. This is being done as a dual end process by simultaneously increasing efficiency from supply side, thus reducing consumption of energy being utilized and generating alternative energy from alternative sources using low carbon or carbon neutral technologies promoting to cleaner production of energy. (Aslani et al. 2013)

2.3.4. Regional competitive advantage

It refers to the availability of biomass and other material in the region (Peura & Hyttinen 2011: 934). Renewable energy sources are naturally present in abundance including Solar, Wind, Geothermal, Hydro and Biomass. Among these resources, Biomass has the most potential with its applicability with various different conversion technologies for diversified energy use. (Mohammed et al. 2014)

According to various studies by Aslani et al. (2012, 2013) and Peura and Hyttinen (2011), Finland possesses a natural competence for renewable energy sources and Gulf of Ostrobothnia has huge potentials for wind energy generation. Despite of severe and long winters in Finland, prospect of biomass in rural areas for energy production, by far, exceeds the current utilization potential (Peura & Hyttinen 2011).

3.2.5. Government support-subsidies

It refers to the incentives in the form of tax reduction and other benefits by the government (Aslani et al. 2013: 502). The most attractive and important strategy for the successful adoption and penetration of renewable energy sources in Nordic countries, is the fruitful benefits in the form of tax incentives and subsidies by government. Finland is an example for such tax subsidies and incentives being paid for energy generation from sources based upon renewables (Ministry of trade and industry energy department, Finland). There are subsidies up to 30% for incurring costs of Biomass based power plants (Ericsson, Huttunen, Nilsson & Svenningsson 2004). In addition, all Biomass Plants have a subsidy for each megawatt hour generation of energy equivalent to the consumption tax for industrial electricity. Similarly, the Danish government has introduced 'Green Certificate scheme' to subsidize for buildings taking energy saving measures. There are also many promotion packages available for Hydrogen fuelled cars. (Aslani et al. 2013)

The subsidies in renewable energy schemes and low carbon generation techniques may facilitate long-term benefits for environment and economy (World energy outlook 2011). Recently, subsidies on a wider global policy level are provided for structured growth of RE to neutralize carbon emissions. However, there is a remarkable difference in subsidies 'policies being governed by developed and developing countries' energy

policy makers. There has been a huge explosion of investments in the renewable energy field in the past decade because of subsidies, feed in tariff, research grants and the provision of capital for its promotion and growth. (Mohammed et al, 2014)

Feed-in-tariff (FIT) is a strategy adopted to promote investments in Renewable Energy utilization (National renewable energy laboratory, US Department of energy). Originated from the United States, now FIT system is being used by approximately 35 countries around the globe to develop, facilitate and promote renewable energy technologies in respective countries including Finland (Aslani, Naaranoja & Zakeri 2012; Aslani, Naaranoja, Antila & Golbaba 2012). FIT system allows and facilitates various renewable based generations to get premium payments for long periods of time over each kW hour energy, fed into the national grid in all the Nordic countries including Finland. (Aslani et al, 2013)

2.3.6. Societal influence

Necessities for social development adjusted by the needs of people in a society (Mohammed et al 2014: 530). We live in an era with fast technological developments and even quicker in new technology adoption. Energy Generation is an essential component for interfacing environment and culture representation schemes, and so it leaves its negative effects on environment. It's been strongly acknowledged via official graphs and figures and displayed for past many years that over-exploitation and environmental destruction is being done at a massive scale. (Peura & Hyttinen 2011)

Our society is very complex, where one fatal incident can destroy the entire continent, and unexpected risks could result in non-governable society. By 1990s, it was foreseen that comprehensive changes are necessary for the entire world in future. A new pact of social science is compulsory to replace polluted society with a biosphere. (Peura & Hyttinen 2011)

Regardless of the large scale research and monitoring over climatic changes since the sixties, climatic variations alarmed and alerted the global political sphere. Emissions, pollution and increasing population were partly indicators of such issues, easily measured and understood. On the other hand, resources extinction, subtle disturbances

in economy as well as poverty is the kind of impacts difficult to judge and assess (Peura & Hyttinen 2011).

2.3.7. Political influence

The influence political leaders who ensure that electricity is made available to all irrespective of the region (Mohammed et al 2014: 530). It is worth mentioning how the sustainable generation needs have originated from existing establishment for energy production. It has been in discussion characterized by dialectics and polarizations clearly solidified by the researchers (Verbruggen, Fishedick, Moomaw, Weir, Nadai, Nilsson, Nyboer and Sathaye 2010), where the other looks for future options of RES and the former is playing with its importance. Before this, it was believed that renewable energy sources can contribute little to energy needs. It was a common thought to replace renewables with non-sustainable energy sources. National European Union (EU) policies have an established idea for more common Energy production by renewable energy resources as a response to gradual climatic changes. (Peura & Hyttinen 2011)

Based upon these examples, it has, become a part of “official thinking” and therefore many nationwide plans have been launched and triggered. These circumstances have been presented at the EU table and also in various different states across the member countries (Reiche and Bechberger 2005), including Finland (Vehmas, J. 2013).

Renewable Energy Resources are an integral component of International Panel for climate change (IPCC-WGIII, 2001, 2007). In order to achieve 2 C baseline targets, argumentation has been presented to struggle for 100% renewable electricity in European Union member states. This goal is theoretically plausible by merging area wide power generation as per concept of large Super Smart Grid approach (Battaglini, Lilliestam, Haas & Patt 2009). The practical answer to this issue is creating a decentralized grid in which other energy resources can be combined for efficient output for better future. (Klemes & Huising, 2008).

2.3. Summary of theoretical framework

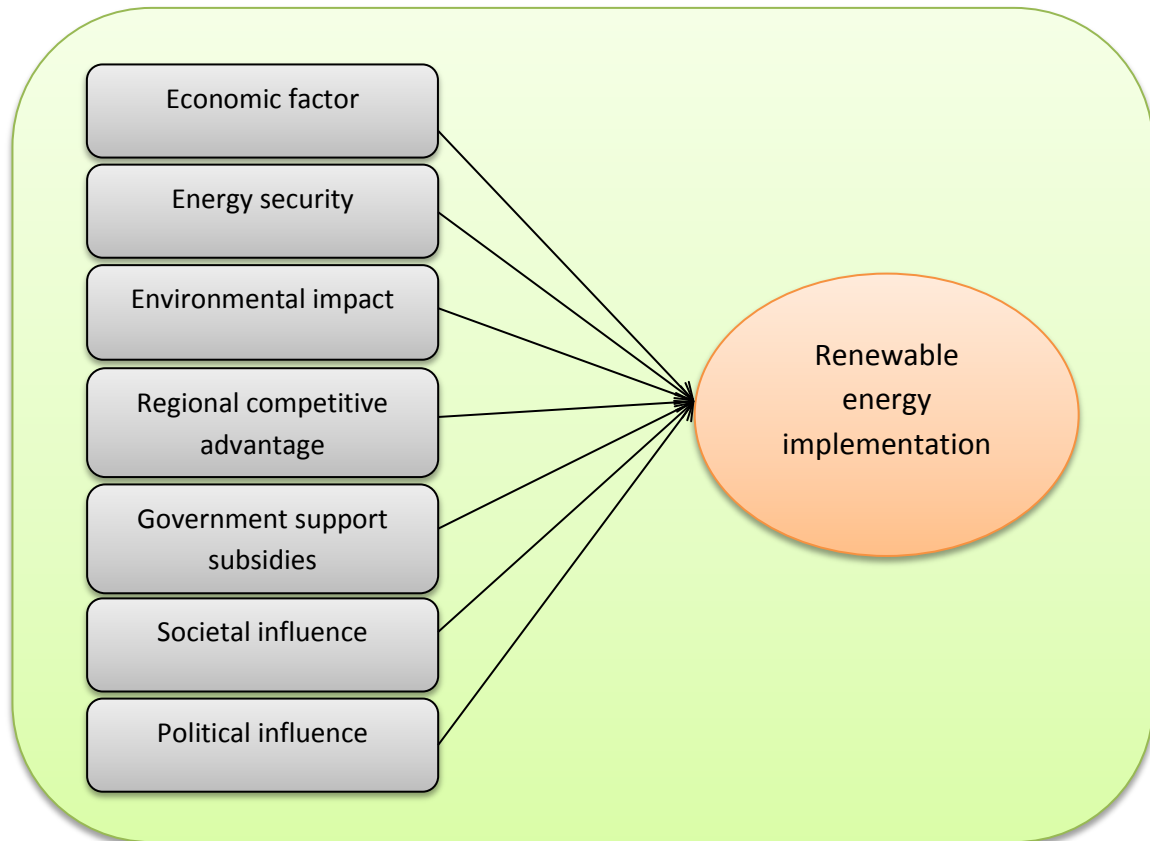


Figure 11. Theoretical framework of the study

The above framework consists of seven factors which impact on the implementation of renewable energy. The seven are, namely, economic factor, energy security, environmental impact, regional competitive advantage, government support subsidies, societal influence, and political influence.

3. RESEARCH METHODOLOGY

In this section, the methodology of the study is discussed. Firstly, the research method, case study research, criticism and benefits of case study research and case study design for the present study are explained. Finally, the validity and reliability of the study is discussed.

3.1. Research method

A research phenomenon can be studied from different approaches, and these all approaches offer an alternative view of the research object. Different methods are available for researchers, but the choice depends on the researcher to choose the best method that is in accordance with the research objectives of the study.

There are two main research methods called qualitative research method and quantitative research method. Quantitative research uses quantitative measures like structured questionnaire with well-developed measurement scales to test hypotheses from data collected from a large sample size. This method is a systematic research method with a structured approach. Although, it has little flexibility but, it has great ability to replicate the results. The aim of quantitative approach is to measure and explain the phenomenon by statistical analysis of the collected data. This method is commonly used when the researcher wants to answer the questions using approaches: how many, how much, and how often. The qualitative approach, on the other hand tries to understand the phenomena in context-specific settings and it provides answers to the questions like what, why and how (Saunders et al. 2007: 472). It provides deep insight to the research subject. This method consists of several methods of data collection and represents higher flexibility than quantitative research. This flexibility allows the researcher to pursue new areas of interest. However, it is very important that the researcher should nicely frame and plan the qualitative research design to eliminate the risk of not producing anything useless. In Qualitative research, the researcher tries to study the research issue in its real setting, therefore qualitative research gives the researcher a chance of getting a deep insight into the subject under-study.

According to Ghauri, Gronhaug and Kristianslund (1995: 81), qualitative methods are used when the nature of the study is exploratory and when researcher wants to study the phenomenon in natural setting as opposed to quantitative methods that focus on hypothesis testing and verification, and where the investigator has control over the phenomenon.

In previous studies, mostly qualitative research has been widely used to explore the determinants of the renewable energy implementation. Further, the choice of qualitative research methods is decided based on following reasons:

(1) The research on the determinants of renewable energy implementation is still at early stage of investigation. Thus, it is more reasonable to investigate the determinants of renewable energy implementation by using qualitative research methods.

(2) The main purpose of current research is to explore the determinants of renewable energy implementation, and for exploring purpose, the qualitative study is best suitable.

(3) The main research question of the study is: What are the determinants of renewable energy implementation? And according to Saunders et al. (2007: 472), research questions starting with “what” are best suitable for qualitative study. Therefore, based on the above three mentioned reasons, a qualitative research method is chosen for the present study.

3.2. Benefits and criticism of case study research

An important decision that is made in qualitative research method is the choice of number of cases. A case study can be either single or multiple case studies. The advantage of multiple case studies is that it helps in searching the cross case patterns. According to Eisenhardt (1989) multiple cases should be chosen to develop the theory.

Furthermore, Eisenhardt (1989: 537) suggest that an advantage is qualitative data in multiple cases that can be collected from different sources. The main sources are:

- Archival records
- Interviews
- Observations

On the other hand, the multiple case studies have also faced several criticisms. The following mentioned are the main criticisms in regard:

- (1) Results of the multiple case studies cannot be generalized.
- (2) A great deal of time is involved in data collection and analysis and massive amount of documents are produced.
- (3) Results may be biased because of researcher's interpretations (Yin 2003; Eisenhardt 1989).

In this thesis, the qualitative approach has been used with a multiple case method. Since the research question was to study that what are the determinants of renewable energy implementation, so lack of existing knowledge on determinants of renewable energy implementation has made the thesis a multiple case study. As, I study at the University of Vaasa, Finland which is the same town which is becoming an energy hub of European Union and many energy sector companies are located in this region. Therefore, a natural choice was to select the energy sector companies and organizations located in the region. The chosen case organizations are:

- ABB
- The Switch
- Vaasa Energy Institute

3.3. Data collection instrument

According to Yin (2003) and Eisenhardt (1989), the data in multiple case studies can be collected through archival records, interviews, and observations. For present study, the basic information about the above mentioned case companies is collected from their web-sites. Therefore, company websites were visited and basic information about their introduction was collected from there. Further, the primary data about the main research purpose is collected through interviews.

According to Saunders et al. (2007), interviews can be either structured, semi structured or unstructured. A totally structured interview gives the respondent a limited space to answer and data gathered lacks the richness because the number of possible responses is

often limited and participants may be forced into giving responses which might not be a reflective of their true feelings about an issue, while unstructured interviews gives freedom to the respondent to talk more openly (Ali 2008). Semi-structured interview lies in between, where the interviewer use an interview guide with questions and areas that should be covered, even if the questions might vary during the process (Saunders et al. 2007: 314).

For this study, face to face and telephonic interviews were conducted with a semi structured interview questionnaire with open-ended questions. The main purpose behind semi structured interviews was to give the respondent a time to recall freely and can take up a direction in the response. The response may then be followed up with more specific questions from the interviewer (Saunders et al. 2007: 320). Saunders et al. (2007: 321-324) say that an interviewer should be open during conducting interviews, and should be open to ask new questions and should not lock interviewees by asking closed questions. Furthermore, for this study I used the judgment selection, which is a common method in qualitative research. Judgment selection takes place when the interviewer, from certain criteria, chose respondents that in advance can be estimated interesting for the study. It is important that a respondent possesses much knowledge of the subject that is being studied, which will increase the information content.

3.4. Data interpretation

Data interpretation means: working with data, organizing it, breaking it into manageable units, synthesizing it, searching for patterns, discovering what is important and what is to be learned, and deciding what you will tell others. In qualitative research, it's important for the researcher to search for common themes, place the raw data into logical, and to find a way to communicate this interpretation to others (Bogdan & Biklen 1982). In other words, interpretation is about making sense out of text and imaged data. According to Saunders et al. (2007: 479), the goal of data interpretation is find out common themes that can be communicated to readers. In this study, while interpreting data, I have tried my best to eliminate superfluous material such as deviations and repetitions and I have used theoretical framework as a lens to analyze the data. Therefore, theoretical framework was used as a lens to make sense from the collected data.

3.5. Validity and reliability

Reliability means if some other researcher follows exactly the same procedures as described by current author and conducts the same case studies all over again, the other researcher should arrive at the same findings and conclusions (Yin 2003: 37). In this study, interviews were conducted through semi-structured questions. It would have been better for the study if I could interview more than one person from each case organization, but was not possible for all and this remains an important limitation in the study. All interviewees had well knowledge about the constructs of the study and the research subject. However, the results of this study are based on subjective evaluation of situations by respondents and also subjective interpretation of the results by the author, therefore results can vary if another person from the case companies answers the questions. However, this is common limitation in qualitative research methods.

Validity means that all parts of the study are coherent. Validity is concerned with whether the findings are really about what they appear to be about (Saunders et al. 2007: 150). According to Yin (2003: 35), an important way to check the quality of the case studies is construct validity. It concerns the establishment of correct operational measures for the concepts studied. It means the underlying features of the constructs are well understood and asked the same underlying features from the respondents (Yin 2003: 35-36). However, in my study, there were altogether eight constructs and their definitions were taken from exiting study and these definitions are also well understood by executives of the case organizations. As it was revealed during the interviews that the all interviewees were well aware about these constructs, so construct validity in my study is very high.

Secondly, external validity means whether the findings of the study can be generalized (Yin 2003: 37). In case studies, instead of statistical generalization, the results rely on analytical generalization. In this study, data is collected from multiple cases and collected data is analyzed based on existing knowledge. So, in this way analytical generalization can be made to some extent.

4. EMPIRICAL FINDINGS

The chapter presents the empirical findings of the current study. Firstly, the four case companies are introduced and then the developed framework of the study is analyzed for each case company. Finally, a table is made to analyze the all four cases to see the commonalities in the cases.

4.1. Introduction to the case company ABB

ABB is a world market leader in power and automation technologies. Based in Zurich, Switzerland, the company holds a total employs of 145,000 people operating at more than 100 countries. The firm's shares are traded on the stock exchange of Zurich, Stockholm and New York.

ABB comprises of five main business divisions to effectively serve customers and fulfilling industrial needs. The group is well known for its state of the art innovation – recognized widely through awards and scientific achievements. Many of technologies including ultra-efficient high-voltage direct current power transmission to revolutionary ship propulsion were developed and commercialized by ABB.

Today ABB is the largest supplier of generators to the wind industry, industrial motors and drives and power grids solution in the world. (ABB Website)

4.2. Determinants of renewable energy implementation in case company ABB

Representative from big energy tycoon ABB has been performing his duties in the section of power conversion equipment dealing with solar power convertors. Interviewee had a background of working with another renewable technology company 'The Switch' previously as a concept system designer for full-power electrical convertors for solar and wind technologies. Most of his experience is related with renewable energy.

Answering to a question regarding role of renewable energy technologies and future prospect of these technologies, respondent said that:

“Prospects are looking very good these days. If we look few days back, business in Finland was non-existing and limited to few megawatts of energy generation from renewable energy, but now they are building 02 to 03 wind parks in Ostrobothnia region only and there will be more wind parks in southern Finland soon, which are in planning phase yet.”

Explaining the reasons behind recent growth of renewable energy resources in Finland and Europe, interviewee told that behind the picture of all these major diffusions, main concerns are: climate changes, new subsidies and planning.

Especially in Finland, subsidies have made it easier to invest in this field.

“There is also a positive push by government by lowering the amount of paper-work in investing wind-parks with added benefits in the form of feed-in-tariff system.”

While describing some of the motivating factors from the perspective of interviewee, he said that ecological or environmental issue is acting as a motivating factor for the adoption and growth of renewable energies.

“Cost of electrical generation is at least competitive by renewable solutions, if not less.”

He informed later during the discussion that considering the longer run perspective and the fact that no renewable technology requires any fuel, cost of generation would go less and less with the time and eventually it will turn into a total profitable mechanism. Recently, even the cost of renewable energy technology components have gone lower thus attracting more potential customers towards investment in this field. This factor promotes more investment coupled with influential subsidies programs and recently promoted business plans by government for the penetration of renewable energies. “Energy generation companies are also becoming more and more interested because of subsidies and feed-in-tariff as they know that they can get pretty much ‘steady income’ from investment.” (Interviewee)

Interviewee referred this investment shift as a ‘ruthless reason’ but a successful business man always keeps on eye what, when and how much he is going to make for a certain amount of investment and most of all, how much sustainable it is.

He added a remark about wind power generation cost effectiveness:

“Leveled cost of energy from wind generation is very much interesting as exhibited by CEO of Siemens at a fair of renewable energy workshop and it should interest more investors.”

ABB’s representative explained that bottleneck in increasing market share of renewable energy comes from ‘balancing the feeding system’ especially in case of wind energy.

“We need a rapid supporting power system with fast ramping support for wind power systems because power out from wind turbines can go to zero any time.” (Interviewee)

In order to counter this ‘power buffering issue’, interviewee suggested that Finland should incorporate more energy solutions including water power generation system (hydro power), gas plants (engines or turbines capable to fast electricity generation during the peak load timing) or make a collaboration with Nordic countries for unified electrical grid. He presented and stressed upon the need of developing a ‘Superpower Grid’ system with neighboring countries so that electrical energy could be shared easily and in this way a steady generation with more stable and reliable grid system is possible.

While answering regarding measures to be taken in Ostrobothnia region for integration of renewable energy sources, he explained that there is ‘unreasonable resistance’ that comes from the behavior of people when we talk about wind power. So, more awareness and realization about sustainable energy future is the critical need of time.

While discussing obstacles and barriers for the promotion and growth of renewable energy, representative of ABB said that there are some parties and lobbies, putting lot of efforts involving governments to demote promotion and growth of renewable energy. Regulations from government and other societies also pose certain barriers for the successful diffusion of renewable technologies in many cases. There are also some

geographical restrictions and it requires in-depth research for viability of wind/solar parks in certain regions regarding their generation potential.

However, growing environmental concerns, check and balance on environment and increasing eco-friendly awareness is behaving a promoting factor.

While closing this session, the interviewee registered his concluding response:

“I would say, a very balanced mix of conventional energy (coal or nuclear) system combined with renewable energy technologies is needed.”

In conclusion, the interviewee from ABB considers that economic factor, societal influence, political influence, government support subsidies, regional competitive advantage influence the implementation of renewable energy in Ostrobothnia region. The interviewee does not consider the energy security and environmental impact as motivators of renewable energy implementation (see figure 12).

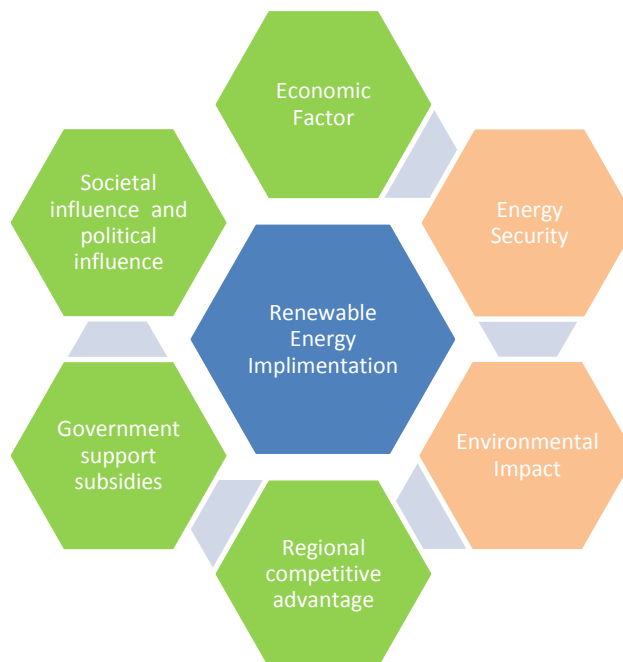


Figure 12. Respondent’s evaluation matrix for the case company ABB

Note: (■ : Agrees), (■ : Neutral), (■ : Not in agreement)

4.3. Introduction to the case company The Switch

The Switch is a leading supplier of megawatt-class permanent magnet generator and full-power convertor solutions to capture effectively power. With 6.5 GW installed capacity of wind power, The Switch is among top European manufacturer for highly variable renewable energy sources including wind and solar. It presents optimized energy yield solutions in compliance with future-proof grid with highly reliable technology.

The company profile is backed up by premium outdoor solar inverter and photovoltaic invertors for solar generation. It produces variable range (1 to 8 Mw) wind power drive trains for effective conversion of wind energy to efficient electrical energy by superior grid connections and full power convertors based upon wind energy technology. It has a vision to be world energy leader by providing low cost energy production solution. Recently, company has merged with Japanese Yaskawa industries with a total of 210 Employees in head office at Helsinki, Finland. (The Switch Website)

they are producing permanent magnet generators, motors and high power convertors for wind energy market, marine industry and many of their solutions are being used in combined heat and power industry. Most of the business opportunities are in China and in Asian and European markets.

4.4. Determinants of renewable energy implementation in case company The Switch

During a semi-structured face to face interview with their Business & marketing strategy manager, company vision and policy was discussed after brief introduction. According to the source, recent merger of company with Yaskawa, a Japanese group is a corporate strategy to groom renewable energy technologies more globally and penetrate into Asian markets along with the European ones. While talking upon role of the switch in the field of renewable energy resources growth, he confirmed that important dragging factors are:

‘Today’s Legislation’, ‘people’s View’ and ‘Media View’ about renewable technologies. He says that *“Legislations are not so much comfortable for the success of renewable energy and should be more compromising and helping in favor of renewable energy resources”*.

While talking about a comparison between RER and conventional energy technologies, he affirmed that:

“Obviously whenever there is a discussion which one is better, ‘optimal & optimistic’, cost-effective in the longer run and ‘the one that renews itself’ is undoubtedly renewable energy, so there is no debate about its comparison with conventional technologies.”

He furthermore during the discussion, mentioned that:

“There are some barriers in the field of sustainable energy technology which are affecting it adversely because of ‘conflict of interest’ between ‘coal burners’ common hood of Finland.” The Switch has this opinion that renewable energy is the only ‘environmentally sustainable and safe choice for future’ and thus agrees with environmental concerns.

He agrees that most of the masses in Finland are in the favor of renewable energy promotion, growth and implementation in Finland on larger scale. Specially, after the unsuccessful project of Olkiluoto III, people’s view point is in more favor of renewable energy but even then there are many Finnish citizens who believe in having ‘rather an open view in their backyard’ comparable to the ‘whirling noise of wind turbines’. He said that adoption of renewable energy is as an inevitable move to be taken in future and Finland needs to be more ‘responsive’ from its legislation’s point of view. The representative of the Switch affirms that

Ostrobothnia area is the hub of leading industrial companies and it is ‘natural and must to do for us’ that we rather ‘show case’ and ‘demonstrate’ our technology more and more in our own ‘yard’ and especially when it comes with an opportunity.

He told us that recently many wind power park projects are being carried out in the vicinity of Ostrobothnia and pretty soon, he sees that, in future, region will be ‘more or less hybrid’ with high dependency upon renewable energy and low dependency upon conventional generation. During another talk, he told that ‘ideal future strategy for a sustainable energy future is using a combination of renewable technologies adapting according to geographical location and preferring whether we should use Solar, Water or geo-thermal or even combination of all in various proportion according to availability and suitability in that particular area’.

“We cannot replace 100% conventional generation with renewable energy, but partly could be implemented easily.” (Interviewee)

Respondent claims that increasing share of renewable energy in Finnish market could avoid more and excess usage of nuclear sources and as a result, less nuclear waste would be produced.

He further mentions that: ***“Finland is far behind in comparison to other European countries in the field of renewable energies.” (Interviewee)***

“European Union should be using renewable energy more and more because it is coming from sun and ‘renews itself’.” (Interviewee)

The Switch’s Representative sees it as an inevitable move to sustain energy future that more investments must be made in the field of renewable energy is:

“This energy move is economical because it is not based upon ‘Black Gold Import’! Rather it is based upon a ‘commodity’ that ‘renews itself’.” (Interviewee)

In conclusion, the interviewee from The Switch considers that: economic factor, energy security, environmental impact, and regional competitive advantage influence the implementation of renewable energy in Ostrobothnia region. The interviewee does not consider the societal influence, political influence, and government support and subsidies as motivators of renewable energy implementation (see figure 13).

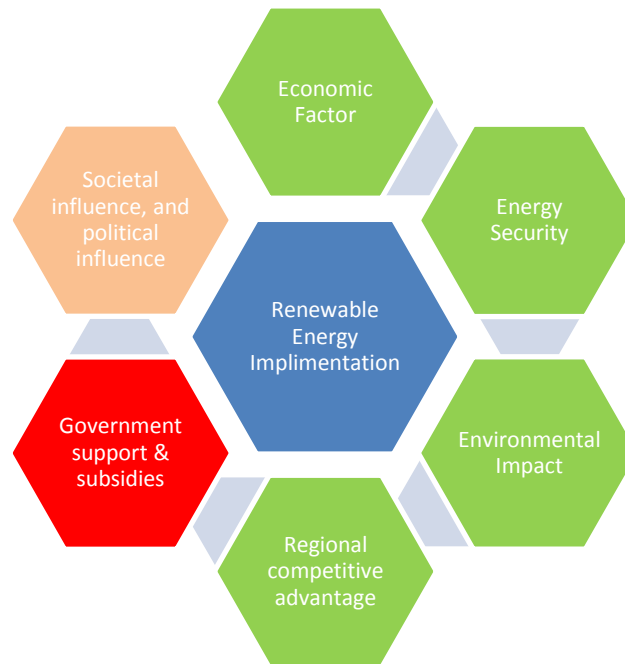


Figure 13. Respondent's evaluation matrix for the case company The Switch

Note: (■ : Agrees), (■ : Neutral), (■ : Not in agreement)

4.5. Introduction to the case organization Vaasa Energy Institute (VEI)

Vaasa energy institute (VEI) is an independent organization operating under the umbrella of Levon Institute in the heart of university campus at Palosaari area of Vaasa. The function of VEI is to provide unique energy research, consultancy and supplementary training services to all levels of energy actors including local and global matching business and technical expertise.

This institute in collaboration with TEKES and other organization is performing a tremendous research in the field of renewable energy sources and their promotion and growth in Finland. VEI has performed many research projects to predict feasibility of Biogas production and utilization in the area of Vaasa. Many projects are successfully implemented including Biogas Plants and Wind Parks in the region of Ostrobothnia. Vaasa Energy Institute is a small group of academically proven professionals from various business and sciences industries collected at one platform to promote sustainable energy in the area (Vaasa Energy Institute website)

4.6. Determinants of renewable energy implementation in case organization Vaasa energy institute

There were two chosen respondents from Vaasa energy institute who were interviewed. The purpose of two interviews from this organization was to validate respondents cross functional integrity and to strengthen dataset for better evaluation of results.

During the ‘ice-breaking’ introduction session, it was well noted that both persons belong to highly qualified and skilled category with philosophy of doctorate degree in their respective fields of Renewable Energy & Physical Sciences. I came to know that this prestigious organization has been working and performing their research activities for past 12 years and now include a team of 09 members. The idea of this indigenous research institute is to collect and utilize all expertise from various fields to come up with a ‘heavy-weight project matrix organization’ dedicated for sustainable energy field research projects. This organization is concentrated on sustainable and renewable energy solutions development. According to representatives:

“Energy is a societal phenomenon.” Thus, energy is considered as ‘social process’ for dwelling and satisfying research needs of this institute. Respondents told that transformation in the field of energy are rather transitional and multi-dimensional: moving from social to societal and environmental change with diffusion of innovations.

While answering to question regarding promotion of renewable energy in the region of Ostrobothnia in Finland, it was told that the organization has developed an innovative concept of ‘Energy Village’. While describing it more:

“We have energy village concept at Levon Institute. It means that we try to implement renewable energy technologies by understanding the characteristics of region.”
(Interviewee)

It includes a proper research identifying the needs in that specific region, potentials (from animals, wood, solar, wind etc.) and who are the major stakeholders. After this ‘Identification’ process in regional territory, a ‘tool-box’ consisting of various renewable technologies is applied in accordance with the demands, characteristics and wishes of people.

“Our philosophy is not to test a certain solution, but we provide custom made solution according to the region. Starting with a project; and then move towards a visionary goal.” (Interviewee)

While exemplifying some success stories of renewable energy in the region of Ostrobothnia, it was told that: ***“A Biogas plant few km away from Vaasa has already started its production and is responsible for the energy generation for a slaughter-house facility. This carbon-free energy generation facility is one of the ‘Energy Village Implementation concepts.’ (Interviewee)***

Another project done by VEI is to use Biogas for public sector transport. It was claimed that soon enough, there will be at least 12 buses including one research bus, rolling on roads of Ostrobothnia(Vaasa) region being powered by Biogas, which is hundred percent recovered from renewable waste and treatment. This would be a next ‘milestone’ achieved by VEI in the context of renewable and sustainable energy. However, these projects are very much ‘inertial’ as it took this institute almost ten years to realize their dreams.

While responding to a question regarding policies and legislations for renewable energy implementation, it was told that: ***“The worlds of legislation and general rules are changing all the times. But, as a rule of thumb, they first have to gain social acceptance and social support. Then it’ll be a social norm and then it transforms into legislation” (Interviewee)***

Interviewees declared that most of the social sector agrees upon the promotion and implementation of renewable energy technologies considering economic and environmental factors. However, there are ‘Big Boys from Energy Industry’ who are still sticking to their counter arguments and putting all their efforts to barricade this change process of energy transfusion and diffusion towards renewable and sustainable energy sides. But, with every passing day, role of renewable energy is becoming more and clearer and the cost-effectiveness and societal factors are changing. These factors have left decreasingly small space for the lobby against this approach. One of the respondents added:

“Coal-burners are fighting for their lives to be coal-burners” (Interviewee)

But, the proofs and numbers are stronger counter arguments to bring the positive change.

It was claimed that change process is still in progress slowly, but still there are many structural barriers. There are many policies that prevent growth of renewable energy adoption and promote generation of electricity from fossil based resources which are imposing a rather bigger economic impact and adding pollution to environment as well. There are also many supportive policies, especially by EU, that promote and favor for the growth of renewable energy technologies in the region and at national level, respondents added. It was further told that, despite of these governing policies by EU, Finland is quite conservative in adaption, and it supports nuclear power.

Referring to the unsuccessful Olkiluoto Extension 3 project with multi billion euro investment being trashed, respondents stressed upon preferring renewable as clean future energy source without any ‘spent fuel repository’ to be maintained for unlimited number of years. It is worth mentioning that even though Nuclear energy unit cost looks more cheaper than any other generation potential, but the cost of ‘nuclear waste’ being produces from reaction has never been mentioned because one have to keep and store it for unlimited period and there is no disposal or recycling of this hazardous waste.

“As a whole, the regulation packages for energy system are still in favor of old system (conventional and nuclear generation) but they are changing!”(Interviewee)

Interviewee had a dichotomy point of view about future energy system that centralize system will never disappear but they can change their raw material to transform the process which is more green, environment friendly and have less impacts upon socio-economic view. They also added that renewable energy could act as de-centralized solution at the start-up, serving most of the rural and sparsely distributed population and population intensive areas can be dealt using previous centralized systems. so, there could be a combination of both these systems.

“If I am the decision maker, then I’ll systematically promote distributed systems (renewable energy) and then change centralized system. The energy infrastructure is so huge that no dramatic changes are possible; changes must be gradual and slow. Hopefully there will be structural changes in a time frame of 10 to 20 years.”(Interviewee)

Respondents added that:

“There are huge impacts on global environment by energy production in past two centuries. Human activities have effect on globe and climate change is one indicator. Although it is a slow process but now we have seen this impact. This will have an impact on society and then society transforms itself to negate the impact.”(Interviewee)

Dilemma discussed by interviewee argues that there is no hiding from global change because it is on world-wide scale and it is hugely done by energy generation activities. From this perspective, fundamental approach is to move towards renewable energy system and improve performance of the energy system.

While responding to query regarding renewable energy potential in Ostrobothnia region, interviewees claim that Only Bioenergy potential is large enough to meet with current energy demands including space heating. But, by combining geo-thermal energy with wind energy, the potential is almost inexhaustible. According to interviewees, wind parks in Ostrobothnia would be alone enough to fulfill all energy needs of this region. They described main regional potential for renewable energy is Wind power, Biogas, and combustible material including wood chips that can be utilized in combined heat and power(CHP) system to produce heat and electricity both considering cold resion’s needs.

Some commonly discussed points are listed below by respondents:

- Major barriers are from Powerful influential actors in this system, who are trying to negate and fog this analysis of climate change.

- There should be distributed energy system in parallel to Central energy system and it should be groomed and promoted in parallel.
- Inertia in system is also a main barrier.
- There is inexhaustible energy generating potential in region of Ostrobothnia that goes far beyond self-sufficiency level. Supported by researches, scientific data collected and published reports.
- Main energy conversion technologies in this region could be Wind Energy, Biogas, Combustion of wood by CHP and Gasification potential.

“Technology and innovation emerge when the environment is suitable enough. Ostrobothnia region despite of being very small has huge potential and it is happening here.”(Interviewee)

In conclusion, the interviewees from Vaasa Energy Institute consider that: societal influence, economic factor, energy security, environmental impact, and regional competitive advantage influence the implementation of renewable energy in Ostrobothnia region. The interviewees do not consider the government support and subsidies as motivator of renewable energy implementation (see figure 14).

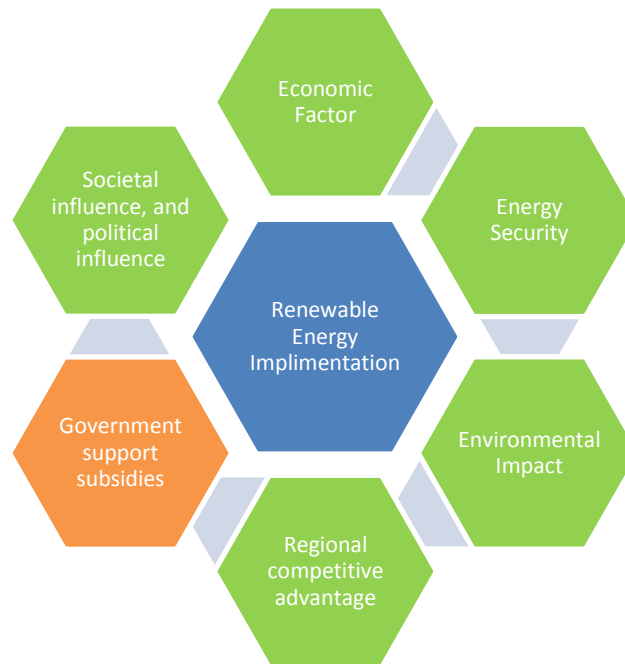


Figure 14. Respondent's evaluation matrix for the case organization VEI

Note: (■ : Agrees), (■ : Neutral), (■ : Not in agreement)

4.7. Determinants of renewable energy implementation in Ostrobothnia region: A comparative analysis of case companies






















A comparative analysis of case companies is conducted in below table 4. The comparative analysis reveals that interviewees from the case companies stressed the importance of the following factors in the implementation of renewable energy in Ostrobothnia region:

- (1) Economic factor
- (2) Energy security
- (3) Environmental impact
- (4) Regional competitive advantage
- (5) Societal influence
- (6) Political influence

However, interviews highlighted that the government support and subsidy is not the motivator for the implementation of renewable energy in Ostrobothnia region.

Especially, the case companies The Switch and Vaasa Energy Institute did not consider the government support and subsidy as a reason for the implementation of renewable energy in Ostrobothnia region.

Table 5: Determinants of renewable energy implementation in Ostrobothnia region: A comparative analysis of case companies

Determinants of renewable energy implementation	Case company ABB	Case company The Switch	Case company Vaasa Energy Institute
Economic factor			
Energy security			
Environmental impact			
Regional competitive advantage			
Government support-subsidies			
Societal influence			
Political influence			

5. CONCLUSIONS

This chapter concludes the key findings from three case companies. Furthermore, concluding model of the determinants of renewable energy implementation is presented. Finally, managerial implications and some implication for theory and further research are suggested that emerge from the present study.

5.1. Key findings of the study

The Nordic region has been playing a leading role in diffusion of renewable energy technologies such as Finland and Sweden in biomass technologies, Norway in hydropower development, Denmark with wind power, and Iceland with geothermal utilization. Therefore, not surprisingly, Nordic countries have made considerable and successful efforts to improve the diversification strategy of their energy supply with core focus on utilization of renewable energy resources. However, diffusion of renewable energy requires consideration to many factors including social, economic, and environmental ones. However, there was limited research on factors that lead to the implementation of renewable energy. Therefore, this study has focused on investigating the factors that promote the implementation of renewable energy in Ostrobothnia region by analyzing the three case companies and several key findings of the study are:

Firstly, the study indicates that economic factor plays an important role in the implementation of renewable energy in Ostrobothnia region. This finding is consistent with the earlier studies of Mohammad et al. (2014) and Aslani et al. (2013), Peura and Hyttinen (2011), and VTT Edita (2009) that has highlighted the important role of economic factor in the implementation of renewable energy.

Secondly, energy security also plays as important in the implementation of renewable energy in Ostrobothnia region. This finding corroborates the findings from earlier studies of Mohammad et al. (2014) and Aslani et al. (2013), and VTT Edita (2009) that has highlighted the important role of energy security in the implementation of renewable energy.

Thirdly, the findings further show that environmental impact plays an important role in the implementation of renewable energy in Ostrobothnia region. This finding is

according to the earlier studies of Mohammad et al. (2014), Aslani et al. (2013), Peura and Hyttinen (2011), Simila and Savolainen (2009), and Lubchenko (1998) that has highlighted the important role of environment in the implementation of renewable energy.

Fourthly, an important finding of the study is that regional competitive advantage is an important motivator for the implementation of renewable energy in Ostrobothnia region. This finding confirms the findings from the Mohammad et al. (2014), Aslani et al. (2013), Peura and Hyttinen (2011), and VTT Edita (2009) that has highlighted the important role of regional competitive advantage in the implementation of renewable energy.

Fifthly, in relation to the role of government support and subsidies, the findings of the study show that this factor is not a motivator of the implementation of renewable energy in Ostrobothnia region. This result is against the findings from the studies of VTT Edita (2009), Mohammad et al. (2014), Aslani et al. (2013), and Ericsson, et al. (2004) who identified the important role of the government support and subsidies in the implementation of renewable energy.

Sixthly, the study found that societal influence is an important factor in the implementation of renewable energy in Ostrobothnia region. This finding confirms the findings from the Mohammad et al. (2014), Peura and Hyttinen (2011), and VTT Edita (2009) that has highlighted the important role of societal influence in the implementation of renewable energy.

Lastly, the current study also finds the important role of political influence in the implementation of renewable energy in Ostrobothnia region. This finding confirms the findings from the Mohammad et al. (2014), and VTT Edita (2009) that has highlighted the important role of political influence in the implementation of renewable energy.

Overall study confirms the important role of economic factor, energy security, environmental impact, regional competitive advantage, societal influence, and political influence in the implementation of renewable energy in Ostrobothnia region. However,

the study confirms that there is lack of support from the Finnish government in the implementation of renewable energy in Ostrobothnia region.

Figure 15 shows the adopted model of the determinants of renewable energy implementation in Ostrobothnia region. Model highlights the role of six important factors in the implementation of renewable energy: economic factor, energy security, environmental impact, regional competitive advantage, societal influence, and political influence

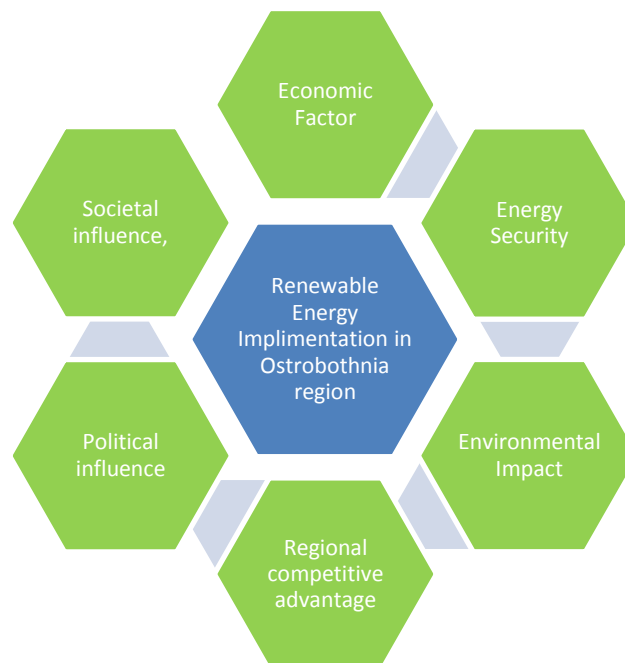


Figure 15. Further adopted model of the Determinants of renewable energy implementation in Ostrobothnia region

5.2. Managerial implications

Energy sector organizations are in constant struggle to match their future strategies in alignment with ongoing and future trends for energy adaption. Energy business is largely complex and deeply integrated with other sub-functions. So, it is difficult to predict market energy trend as it is largely volatile and fluctuating.

This study addresses the important factors in the field of renewable energy and provides managers a clear picture of motivators for renewable energy including discussion of factors and growth potential.

According to the study conducted for determining factors for the penetration of renewable energy in Ostrobothnia region of Finland. Positively identified determinants include:

Economic factor

Energy security

Environmental impact

Societal influence

Political influence

Regional competitive advantage

The above listed factors have been positively identified by our studies which are among motivating factors for the growth and implementation of renewable energy in Ostrobothnia region of Finland.

Present study shows that people have shown concerns regarding green energy future and have an important role in triggering further innovation and research opportunities in the field of renewable energy.

Our study motivating relationship of economic factor along with energy security for growth of renewable energy and especially after the unsuccessful project of Olkiluoto nuclear plant 3, renewable energy systems have vote from environmental and energy security perspective as well.

5.3. Implications for theory and future research

Building upon theoretical framework, empirical findings and end model of research of the present study, there are some future research areas that are worthy for future

research. Some of these research areas arise primarily from current studies, whereas others are due to lack of attention and limitation of scope for study. Firstly, present study should be checked upon the basis of energy sector system performance and impact of these identified factors upon overall energy sector (collective impact) and renewable energy sector performance(energy technology-wise impact).

Secondly, a comparative study with other Nordic countries could be performed to test the developed and proposed framework for its integrity.

Thirdly, more diversified data collection scheme could be adopted using more energy field organization including various energy market actors in data collection. It might include data collection from competitor technology producers as well as existing energy companies utilizing conventional resources for generation.

Finally, more factors could be probed including conducting data collection survey at three different layers: 1). Data collection and interviews from Government personnel's and policy makers, 2). Questionnaire-based survey from general population, 3). Interviews from energy field technology manufacturer.

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APPENDIX 1:

Interview format and questions

Q: Could you please formally introduce yourself?

Q: What is the role of (organization/case-company) in renewable energy resources?

Q: Please explain role of (organization/case-company) in renewable energy resources implementation in Ostrobothnia region?

Q: What are motivating factors for the promotion and growth of renewable energy resources?

Q: How renewable energy resources diffusion can be increased in Ostrobothnia and Finland to meet EU 2020 targets?

Q: What are the benefits of renewable energy generation with respect to:

- Cost
- Profit
- Economy
- Environment
- Energy sustainability
- Social
- Political

Q: What are the barriers (organization/case-company) has been facing currently?

Q: What is the effect on total performance of energy sector if conventional generation is replaced by renewable energy technologies?