THE ADOPTION OF PHOTOVOLTAIC MICRO PRODUCTION SYSTEMS IN FINLAND

University of Jyväskylä
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Master's Thesis

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ABSTRACT

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Abstract:

A sustainable supply of energy is one of the most important requirements in order to achieve sustainable development. By using renewable resources society is not dependent on depleting reserves, but instead can have an inexhaustible source of clean energy. The rapid development of photovoltaics has led to lowered prices and increased efficiency making them more attractive alternative as a source of household electricity. Although governments play a key role in setting the constraints of how renewable energy is adopted, the wide-spread adoption of distributed electricity production ultimately depends on consumer decisions to buy them.

This study examined the adoption process of photovoltaic micro production systems in Finland. Furthermore, it concentrated on the characteristics and differences between adopters and non-adopters of photovoltaic systems and tried to recognize the barriers for adoption as well as factors that encourage adoption.

The theoretical framework was built on Diffusion Of Innovations theory which has been previously utilized to model the diffusion of photovoltaic systems. This approach seeks to explain how, why and at what rate new ideas, products and technologies spread through society. The results of this study show, that the reasons and barriers for adoption vary greatly between individuals and the adoption process is far from straightforward. The most common barriers for adoption was economic terms such as high price and long payback time of the initial investment, greater complexity compared to electricity from the grid and fairly low level of knowledge of photovoltaic micro production. Moreover, factors that lead to adoption of photovoltaic systems was economic savings, necessity and the values of the adopter. Finally, when comparing the differences of adopters and non-adopters of photovoltaic systems of this study, they seem to differ in for example demographic characteristics and values. The motivation for this research came from the author's own interests and there was no commissioning company for this Master's Thesis.

Keywords:

Solar energy, Photovoltaic, Electricity, Renewable energy, Consumer behavior, Diffusion Of Innovations

Location: Jyväskylä University School of Business and Economics

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LIST OF ACRONYMS

A = Ampere
AC = Alternative Current
DC = Direct Current
FG-1 = Focus Group 1 (PV adopters)
FG-2 = Focus Group 2 (PV non-adopters)
GDP = Gross Domestic Product
GHG = Greenhouse Gas
IEA = International Energy Association
IPCC = International Panel of Climate Change
MToe = Million Tonnes of Oil Equivalent (equals 11.63 TWH)
kW = Kilowatt
kWh = Kilowatt hour
MW = Megawatt
MWh = Megawatt hour
NGO = Non-Governmental Organization
PCU = Power Conditioning Unit
PV = Photovoltaic

CONTENT

1 INTRODUCTION

Since past decades the evidence of climate change, depletion of natural resources, rising oil and gas prices and high levels of energy import dependence has led to increased recognition of the energy issues. Today, eighty percent of our energy supply is based on fossil fuels (IEA, 2014). The overall energy consumption is predicted to rise by 56 percent between 2010 and 2040 (IEA, 2013). The use of depleting fossil fuels is damaging the environment and causing health problems. Current trends in energy supply and use are clearly unsustainable – economically, environmentally and socially. Therefore, several governments have set targets and launched support schemes regarding the increased use of renewable energy.

Electricity is a convenient and efficient way of distributing the energy our society consumes. Nearly 40 percent of our total energy consumption comes from the use of electricity (IEA, 2012). Without electricity, humans would not be able to enjoy the conveniences of modern society. As electricity can be created from various sources, renewable or fossil origin, the way we produce electricity has got huge impacts on our future.

As renewable energy has become high on the agenda, it has created new market opportunities. Photovoltaic (PV) energy is one of the most promising emerging technologies. While globally the PV industry has experienced a rapid increase, the development has been very geographical. Countries such as Germany and China are increasingly adapting PV in to their energy policies and the potential of PV have been widely acknowledged. Nevertheless, in most countries the investments in PV's have been negligible.

The rapid growth and development of photovoltaics over the past decades has led to lowered prices and increased efficiency making PV more and more available and attractive alternative as a source of household electricity. Furthermore, EU targets, increased use of renewable energy, consumer interest in lowering energy bills and increasing environmental awareness are having an increasing impact on consumer consumption decisions. Although governments and their energy policies play a key role in the adaptation of PV micro systems, the wide-spread adoption of distributed electricity production ultimately depends on customers decisions to buy them. The actions that people take and choices they make to consume certain products and services have direct and indirect impacts on the environment. Consumer expenditures account for a great part of gross domestic product. Therefore, addressing consumption plays a major role in reducing the impact of society on its environment (Jackson, 2005). This research examines the adoption process of micro production PV systems in Finland using the perspective of Diffusion Of Innovations framework.

1.1 Motivation for research

Commonly the biggest barriers hindering the adoption of PV systems have been high capital costs, long payback periods and the lack of confidence in the long-term performance of the systems (Faiers & Neame, 2005). Recently, the prices of PV systems have decreased significantly during the last decades, lowering capital costs and payback time of the investment. Given the current interest in solar energy and its anticipated future growth, there is an opportunity for the study of the consumer behavior process concerning solar energy products.

There are no official statistics available on Finland's overall PV capacity (Motiva, 2014). According to estimates, the on-grid capacity varies from 1 to 3 MW (Gaia Consulting, 2014). There are some hundreds of micro-scale household production systems and some bigger systems. In addition, there are about 40 000 off-grid recreational PV micro-systems (Gaia Consulting, 2014). Solar PV market is estimated to be a 10 million EURO revenue in Finland. The electricity produced with PV accounts for less than 0,1 percent of total electricity generation of Finland. In Germany for example, electricity produced with PV accounts more than 6 percent of overall electricity generation (IEA, 2014). Furthermore, a fairly common misconception is that solar energy is not an economically reasonable option due to the northern geographical location of Finland, while actually the amount of sunlight in southern Finland is equal to Northern Germany (EU commission, 2015).

The author feels that above-mentioned barriers are not sufficient in explaining why in Finland the number of PV systems is fairly low. Moreover, while going through the theoretical framework for this research, the author found that very little is known about the adopters of PV system in Finland. Furthermore, the author did not find any diffusion-research concerning PV systems in Finland. It is predicted that PV micro production in Finland will experience a rapid increase the future (Gaia Consulting, 2014). The researcher hopes that results of this study provide information about the consumers and the adoption process that can be used by actors of the field to further understand the adoption process and promote the development of renewable energy sector in Finland.

1.2 Research objectives and research problem

The objective of this thesis is to get more knowledge about the adoption process of PV micro production systems among consumers from the aspects of the Diffusion of Innovation framework. As usual to every diffusion research, this study focuses on comparing the differences and characteristics of adopters and non-adopters of the innovation, which in this study is a micro production PV system.

The main question of this thesis is:

- *What are the main reasons why some end up investing in a micro production PV system and some do not consider it to be an investment worth investing in? Moreover, what are the factors encouraging adoption and what are the barriers of adoption with this innovation.*

Followed by sub-question:

- *What are the main differences between those who have (adopters) and those who have not (non-adopters) invested in such systems?*

2 THEORETICAL FRAMEWORK

The following chapters form the theoretical framework for the thesis. The purpose of this part was to introduce the author to the topics related to this research. The purpose of this chapter is to combine theory and factors that have an impact on the subject under study. In order to understand the scale of the topic, the first part describes energy and electricity production and use in Finland and globally. Followed by an introduction of the subject of adoption; Photovoltaics. Also, in order to understand the process of adoption more comprehensively, the relation of consumer behavior regarding energy and electricity has to be recognized. Finally, introducing the Diffusion Of Innovations theory which is the approach used in this study.

The theoretical framework is gathered from different sources: Library of University of Jyväskylä, online databases and different web-pages. Gathering of the theoretical framework was the most time consuming part of this thesis, lasting from autumn 2015, continuing until May 2016.

2.1 Climate policies

Energy plays a key role in sustainable development and sustainable supply of energy is one of the most important requirements in order to achieve sustainable development (Dincer, 1999, Rosen, 1996). Defined by the Brundtland commission in 1987, sustainable development is *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (World Commission on Environment and Development in 1987). The European Union and Finland have defined sustainable development as goal principle of their climate policies.

In recently held Paris climate conference, a total of 196 countries agreed on the legally binding measures to ensure that the global temperature increases no more than the 2 °C since pre-industrial times. According to the Intergovernmental Panel on Climate Change (IPCC), that is the critical threshold, above which the planet could experience irreversible impacts. To ensure this does not happen, all 196 nations have agreed to decrease the use of fossil fuels that generate heat-trapping greenhouse gas emissions like methane and carbon dioxide as soon as possible. By 2050, man-made emissions should be reduced to levels that can be absorbed by our forests and oceans.

Finland is committed to the United Nations Framework Convention on Climate Change, the Kyoto Protocol and EU legislation in its climate policy. The core framework of Europe's Energy and Climate Policy is based on parliament decisions taken in December 2008. These include reducing greenhouse gas emissions by 20 percent, raising the share of renewable energy to an average of one fifth of total consumption (38 percent for Finland) while improving energy efficiency by 20 percent by 2020 (TEM, 2015). The objective of the international climate negotiations is to stabilize greenhouse gas concentrations in the atmosphere, at a level that would prevent dangerous anthropogenic interference with the climate system (National Energy and Climate Strategy, 2013).

Finnish energy policy rests on three fundamentals: energy, economy and the environment (TEM, 2015). The key points of the strategy are also to strengthen its energy security and to move progressively towards a decarbonized economy (Energy Policies of IEA Countries, 2013). All Low Carbon Finland scenarios heavily invest in the increase of renewable energy and the improvement of energy efficiency. With its energy intensive industries and its cold climate, Finland's energy consumption per capita is the highest in the International Energy Agency (IEA, 2014). Solar electricity micro production could offer a part solution to reduce greenhouse gases and strengthening Finland's energy security (Energy Policies of IEA Countries, 2013).

2.2 Energy

Due to population growth and economic growth, global energy consumption is to double by midcentury relative to present (Lewis & Nocera, 2006, IPCC, 2013). The economic growth of developing countries will also lead to perpetual increase in the use of energy. Problems with energy supply and use cause environmental concerns as air pollution, acid precipitation, ozone depletion, forest destruction and emission of radioactive substances (Dincer, 1999). These issues must be taken in consideration simultaneously if humanity is to achieve a bright energy future with minimal environmental impacts.

Meeting the needs of society will required increased use of all sources of energy, particularly as cheap oil and gas reserves are depleted. Eighty percent of today's energy supply is based on fossil fuels *(FIGURE 1)* (IEA, 2014). Oil and coal alone account for two thirds of the world's energy supply, whilst only 13,5 percent created using renewable sources of energy, mostly biofuels and waste (IEA, 2014). Moreover, renewable energy sources represent only roughly 20 percent of all energy sources in global electricity production (*FIGURE 2*) (IEA, 2014).

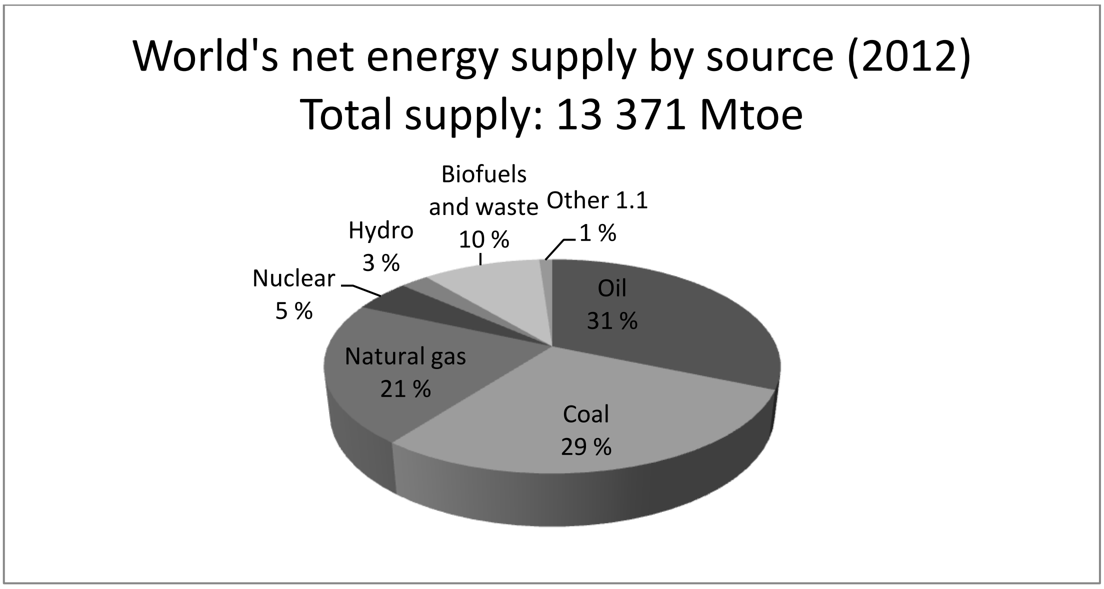

FIGURE 1 World's net energy supply by source (IEA, 2014)

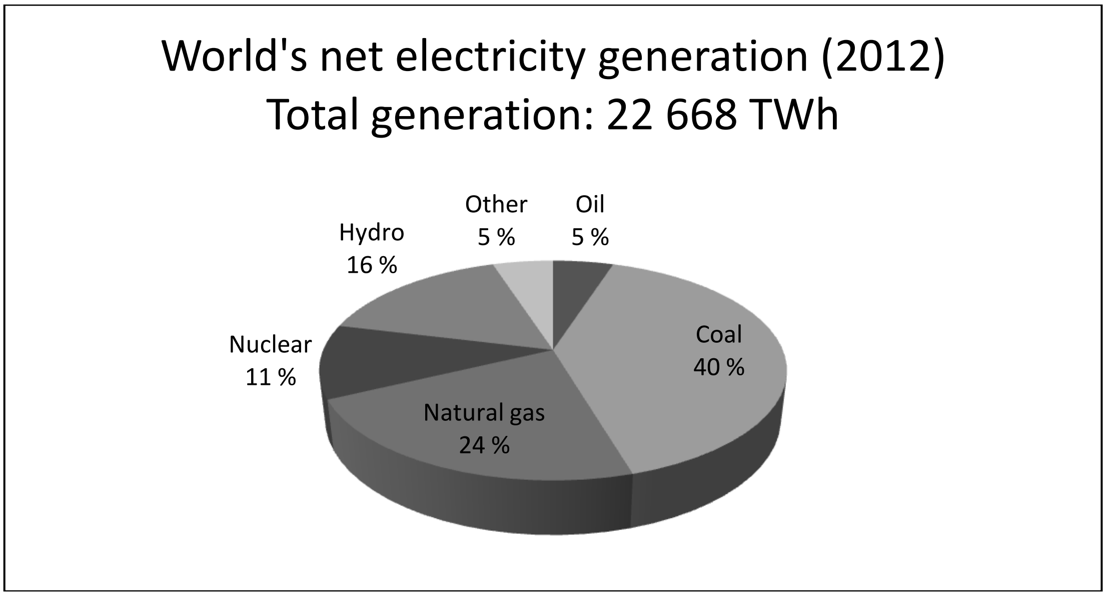

FIGURE 2 World's net electricity generation (2012) (IEA, 2014)

Compared to fossil fuels, renewable sources of energy offer an alternative which reduces environmental impacts such as hazardous air pollutants, climate change, water pollution and major environmental accidents. Therefore, it is clear that meeting global energy demand in a sustainable way will require considerable adoption of carbon-neutral, renewable sources of energy (Lewis & Nocera, 2006).

2.2.1 Renewable energy

Renewable energy is energy derived from natural processes that are replenished at a faster rate than they are consumed. The most commonly used sources of renewable energy are hydro, wind, solar, geothermal and some forms of biomass (IEA, 2015). Renewable energy technologies produce marketable energy by converting natural phenomena into useful energy forms. Renewable energy technologies are identified as potential solutions to current environmental problems and can have beneficial impacts on environmental, economic and political issues of the world (Dincer, 1999). By using renewable resources like wind, solar radiation, geothermal, hydropower and biomass, society is not dependent on depleting reserves, but instead can have an inexhaustible source of clean energy.

Security of energy supply and inexpensive energy are key prerequisites for growth in the current global economy (National Energy and Climate Strategy of Finland 2013). Although one of the main principles of Finnish government's energy strategy is energy security, Finland is highly dependent on imported fossil fuels such as oil, gas and coal (*FIGURE 3*) (IEA, 2013).

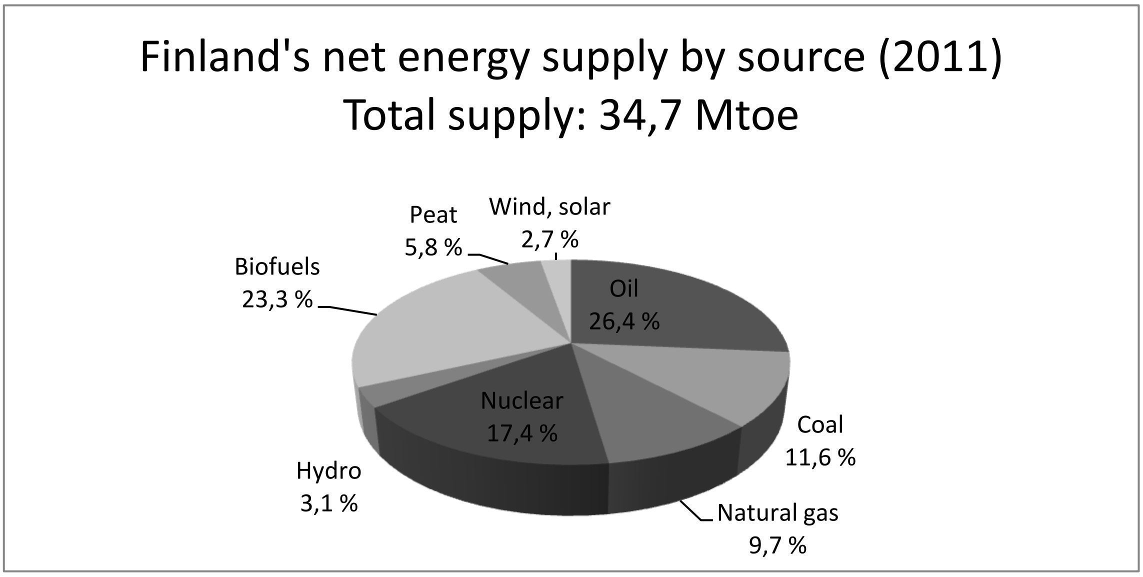

FIGURE 3 Finland's net energy supply by source (2011) (IEA, 2014)

2.2.2 Energy from the Sun

Every hour the surface of the Earth receives more energy from The Sun that mankind consumes in a year (Lewis & Nocera 2006). The energy of the Sun is created by a fusion reaction inside the star, where four hydrogen atoms are transformed into a helium atom. This energy radiates into space in all of the wavelengths of electromagnetic radiation. Most of the radiation is visible light and infrared radiation. Except the energy derived from nuclear, geothermic and tidal power, all energy we use is from the fusion reactions in the Sun (Ursa, 2015, Motiva, 2014).

The energy radiating from the sun can be transformed into heat and electricity by using technology. This energy can be collected actively or passively. Passive use means using the energy without any devices as light or heat. In active use the radiation of the sun is transformed into electricity with photovoltaic (*PV*) panels, or to heat with solar collectors. Solar energy is widely available throughout the world and can contribute to reduced dependence on energy imports. Solar power increases energy diversity and hedges against price volatility of fossil fuels, thus stabilizing costs of electricity generation in the long term (IEA, 2014).

The overall radiation emitted from the sun consists of direct radiation and diffuse radiation. Diffuse radiation is radiation reflected from the atmosphere, clouds and the ground. Diffuse radiation plays an important role to electricity production in Finland. In southern Finland, about half of annual radiation is diffuse radiation (Motiva, 2015).

Local circumstances like seasonal changes and weather affect greatly to the performance of a solar energy production system. Due to the Sun's trajectory, the amount of radiation reduces when moving northwards from the equator *(FIGURE 4)*. In Finland the Sun's radiation is concentrated to summer months, making solar electricity production more seasonal compared to southern Europe. The annual solar radiation in southern Finland is roughly similar to Northern Germany. According to Finnish Meteorological Institute, the overall solar radiation energy to a horizontal plane is about 980 kWh/m^2 in southern Finland, 890kWh/m^2 in Central Finland and 790 kWh/m^2 in Northern Finland.

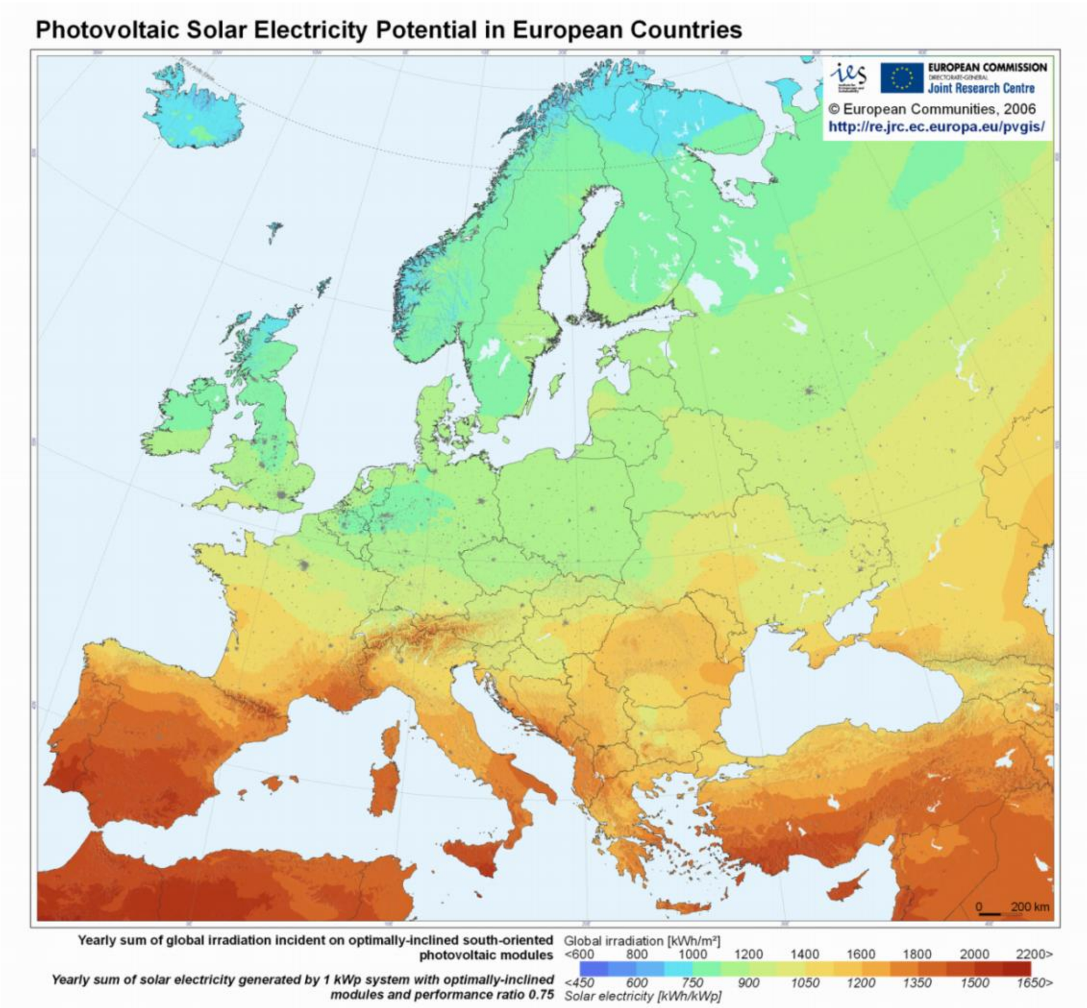

FIGURE 4 Photovoltaic solar electricity potential in EU (EU Commission, 2015)

2.3 Photovoltaic (PV) technology

Consisting of words *photo*, derived from Greek word meaning light and *volt*, after pioneer of electricity Alessandro Volta, photovoltaic literally means transforming light into electricity. Some materials have a property known as photoelectric effect, which causes them to absorb photons of light and release electrons. When these electrons are captured electric current results - that can be used as electricity.

PV systems are important to our everyday lives. They provide power for small consumer items such as calculators and wristwatches and more complicated systems like satellites, appliances and machines in homes and workplaces. PV systems can offer the least expensive form of electricity especially when electrical grid is not available.

During the last decades, the rapid development of renewable technologies and policies has lead photovoltaics to become even more applicable source of clean energy. Since 2010, the world has added more solar PV capacity than in the previous four decades combined (IEA, 2014). In the last ten years cumulative installed capacity has grown at an average rate of 49 percent per year *(FIGURE 5)* (IEA, 2014).

For half of a century, photovoltaics have experienced a 20 percent cost reduction every time cumulative production doubles (Energy.gov, 2016). This rate of technological improvement is highest among competing energy technologies (Energy.gov, 2016). The prices of PV systems have divided by three in less than a decade in most markets (IEA, 2014). Moreover, PV module prices have been divided by five (IEA, 2014). Photovoltaic technology has the potential to reduce national carbon emissions because it does not produce greenhouse gas emissions during operation. Manufacturing, engineering and installing of PV systems create jobs which make it attractive at a national policy level (Timilsina et al. 2000). At a global level, the PV industry has been estimated to represent about 1.4 million full-time jobs (REN-21, 2015).

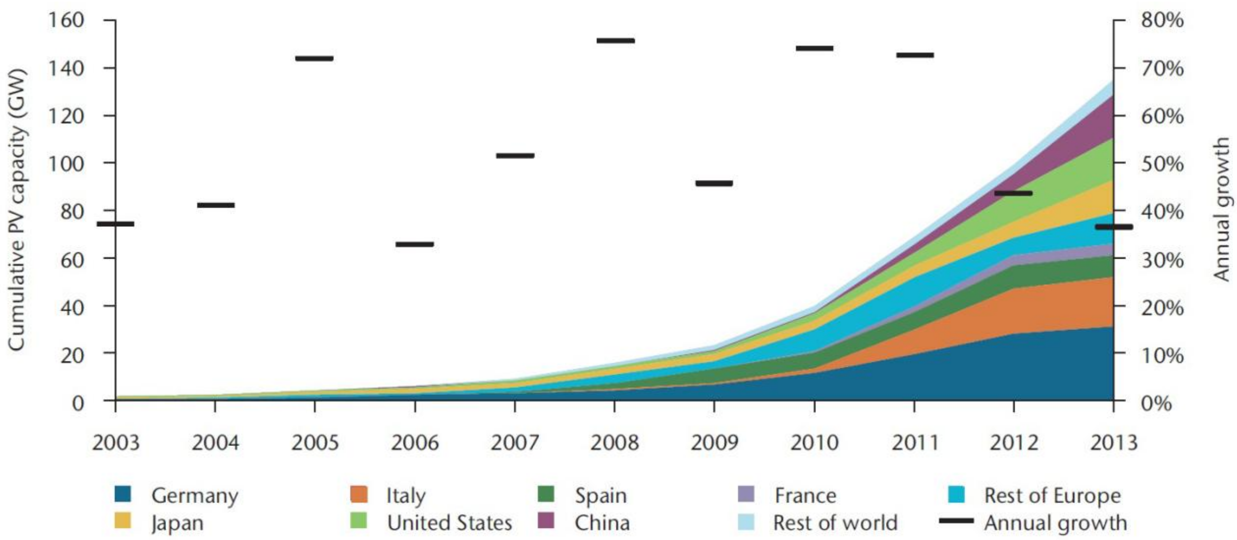

FIGURE 5 Annual cumulative PV capacity (IEA, 2014)

2.3.1 PV-cells

PV systems consist of PV cells, which are electricity-producing devices made of semiconductor materials, most commonly silicon (Motiva, 2015). When light shines on a PV cell, it may be reflected, absorbed or pass right through. In PV cells, a thin semiconductor wafer is treated to form an electric field, positive on one side and negative on the other (Nasa, 2015). As the energy of absorbed light hits the electrons in a semiconductor material, they escape from their normal positions in the atoms and become part of the electrical flow in an electric circuit (Nasa, 2015). These flowing electrons can be captured in the form of electric current. PV cells vary in size and shapes and are often connected to form PV modules. These modules are then connected to create larger units, panels and arrays *(FIGURE 6)* (Energy.gov, 2015).

The *conversion efficiency* of a photovoltaic cell, or solar cell, is the percentage of the solar energy radiating on a PV device that is converted into electricity. In most commercial PV cells, 15-17 percent of solar energy is transformed into electricity (Motiva, 2015).

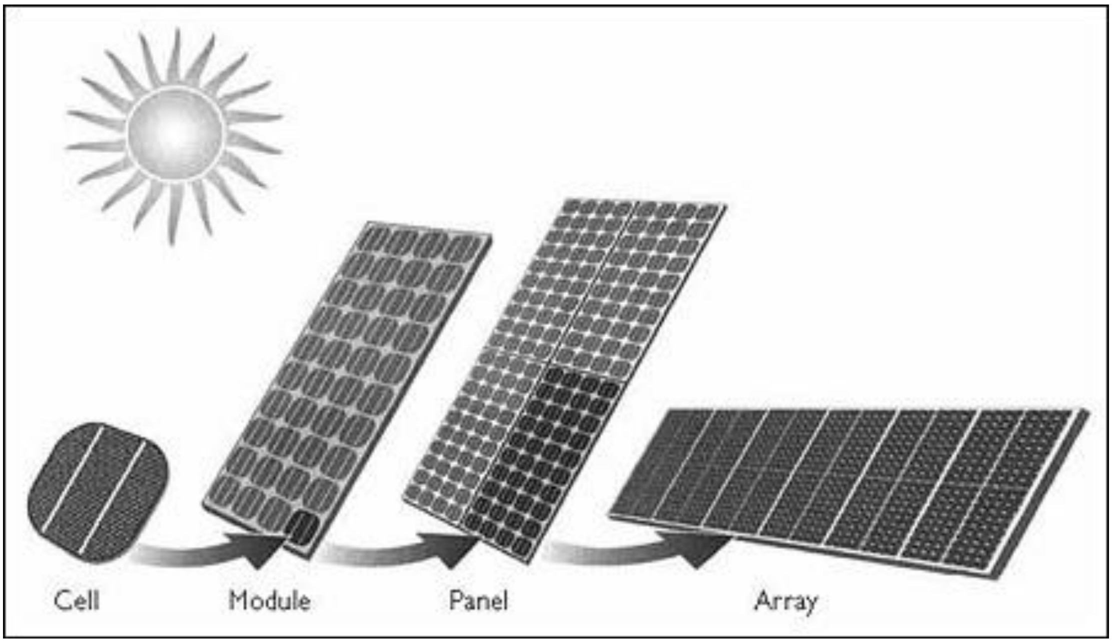

FIGURE 6 Components of a PV array (CMHC 2015)

2.3.2 PV-systems

PV systems include structures that enable photovoltaic cells, modules and arrays to face the sun (Motiva, 2015). Depending on the system type designed, they also include components such as charge controllers, batteries and inverters that convert the produced direct-current electricity to alternate-current electricity (Energy.gov 2015). There are various factors that determine the efficiency of a PV system: The amount of radiation, operating efficiency, cell temperature, angle it is installed and the cleanness of the cells (Motiva, 2015).

There are two main classifications of PV systems: *Grid-connected* and *Stand Alone Systems*. Grid-connected PV systems *(FIGURE 7)* are built at all scales, from just a few kilowatts (kW) to hundreds of megawatts (MW). Off-grid systems can be even smaller while providing power where electricity network is not available. Grid connected PV systems are designed to operate in parallel with and interconnected with the electric utility grid. They consist of an inverter, or power conditioning unit (PCU). It converts the direct current (DC) power produced by the array into alternative current (AC) power which is compatible with the electricity supplied by the grid (Solardirect, 2016). Solar power plants of energy companies or residential small scale PV systems are examples of grid connected systems. Stand-alone PV systems operate independently, of the electric utility grid. Usually they consist of a PV array designed to supply power to certain DC and/or AC electrical loads (Solarserver, 2016). Stand-alone PV systems are often equipped with batteries for storing the energy. These systems are often used for example in summerhouses, boats, campers, or to charge batteries in distant locations. In DC stand-alone systems if no battery is used, the load only operates when sunlight is available.

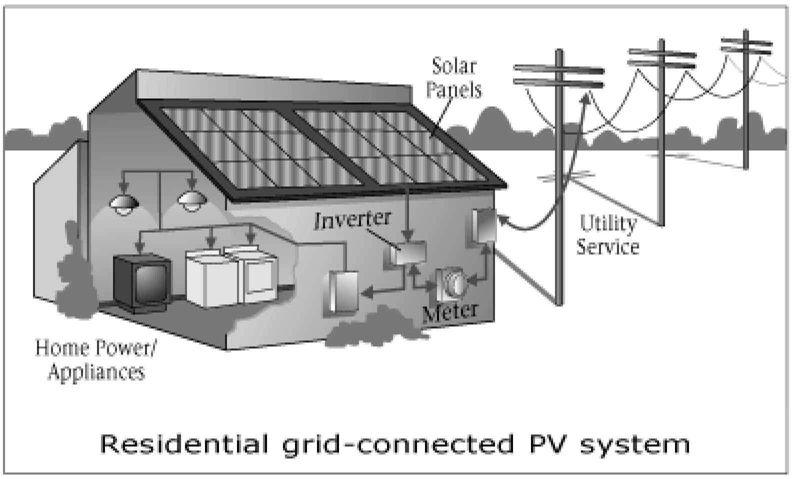

FIGURE 7 Residential grid connected PV system (Solardirect)

2.4 PV Micro production in Finland

According to a research by Finnish Ministry of Employment and Economy, one of the biggest challenges in meeting the goals set by EU and Finnish government are energy issues. Furthermore, 80 percent of Finland's GHG emissions come from the use and production of energy (IEA, 2014). Finland has to increase the share of renewable energy to 38 percent by 2020 according to the EU 2009/28/EY directive. The Finnish government has urged small-scale energy production forward in accordance with the 2013 updated energy and climate strategy. In the strategy there are several procedures for advancing small-scale production systems. Energy created with renewable sources help Finland to meet the targets set on the use of renewable energy and emission deductions. Moreover, renewable energy production systems can also help to achieve energy efficiency targets in constructions. In addition, locally created energy also reduces the amount of imported energy.

PV micro production means small scale electricity production which is primarily for producing electricity for onsite purposes (Energiateollisuus ry, 2009). With a PV micro production system, feeding to the network is not the primary reason for electricity generation and supply to the grid is low and infrequent. Therefore, micro-generation mainly refers to small-scale electricity generation installations acquired by individual consumers or small-scale enterprises, connected to the electricity system of their own place of consumption. Most commonly electricity micro production units are small wind, solar and bio power stations (Energiateollisuus ry, 2009). Standard EN 50438 "*Requirements for the connection of micro-generators in parallel with* public low-voltage distribution networks" defines the limit for a micro production unit's fuses to 3X16 A which give them a theoretical maximum power output of 11 kW. This thesis concentrates on solar PV micro-production based on these definitions excluding the systems of enterprises.

There is no official statistics available on Finland's overall PV capacity (Motiva, 2014). Estimates of on-grid capacity vary from 1 to 3 MWs. Solar PV market is estimated to be 10 million EURO of revenue in Finland, of which 3 million EURO comes from on-grid systems. There are some hundreds of micro-scale household production systems and some bigger systems (Gaia Consulting, 2014). In addition, there are about 40 000 Off-grid recreational PV micro-systems (Gaia Consulting, 2014).

According a to research made by Gaia Consulting, the operators in the field believe, that within 5-10 years, there are approximately 150 000 on-grid PV systems, with a total of 600-700 GWh of production. This would account for less than a percent of total electricity consumption in Finland. During last years, the amount of PV systems purchased has been steadily increasing. Due to the global price reductions and the increase of domestic suppliers, the on-grid cumulative solar capacity has doubled during few years and is projected to keep increasing rapidly in the near future (Gaia Consulting, 2014).

PV operators in Finland are focused mainly on marketing, designing and distribution and installing PV systems of the distributors import system parts abroad (Gaia Consulting, 2014). Consumers also order PV systems from abroad, mainly from Germany and China. It is estimated, that about half of micro-scale PV systems are purchased through distributors and half directly from abroad.

2.5 Nordic electricity market

The power system in Finland consists of power plants, nation-wide transmission grid, regional networks, distribution networks and electricity consumers (Fingrid, 2015). The transmission grid serves electricity producers and consumers, enabling trading between them on a nation-wide level and also across national boundaries (Fingrid, 2015). The transmission grid is connects Finland to the electricity systems of Baltic states and Europe, which makes a common market possible.

Finland is part of the common Nordic and Baltic wholesale electricity market. It uses Nord Pool Spot of Norway as its trading centre. The wholesale electricity price hourly based and determined on the balance of demand and supply in the common market (Nordic Market report, 2014). The common transmission grid enables transfer of electricity across national borders, which ensures that the most affordable electricity production methods are always used.

The Nordic power system is a mixture of generation sources: Hydro, wind, nuclear and thermal power. During 2013, the total generation of electricity in the Nordic countries was 380 TWh. During the same time period, consumption in the four Nordic countries totaled 380.5 TWh (Energiavirasto, 2015 & Nordic Market report, 2014). The electricity prices in the Nordic region are fairly low due to a large share of low-cost hydro and nuclear power. The electricity price of Nordic system averaged to 28.10 EUR/MWh in 2013 (Nordic Market report, 2014). Due to low electricity prices, there is a large share of electricity heated houses and energy intensive industry (Nordic Market report, 2014). In comparison with other European countries, electricity consumption in the Nordic region is relatively high. The overall energy consumption in Nordic region is affected by GDP and average temperatures during the year. The low temperatures and limited daylight hours make the electricity demand in Finland peak during winter. Also as many households are heated with electricity; the electricity consumption increases in wintertime while being lower in summer (Nordic Market report, 2014).

In 2011, Finland's gross generation of electricity was 73,5 TWh of which about 30 percent was produced with renewable sources *(FIGURE 8)* (IEA, 2014). Furthermore, the electricity consumption was 84,2 TWh *(FIGURE 9)* (Tilastokeskus, 2015). The available domestic production capacity in Finland is not able to cover winter peak demand. On a yearly basis, approximately 19 percent of the Finnish electricity supply is imported (IEA, 2015). The government forecasts that the electricity supply will continue to grow by approximately 1 percent per year, reaching 93.8 TWh in 2020 and 104.6 TWh in 2030 (IEA, 2015). In 2014, Finland's households and agriculture combined used 22 781 GWh (49,8 percent). Households alone accounted for 27 percent of the total electricity consumption
(FIGURE 9) (Tilastokeskus, 2015).

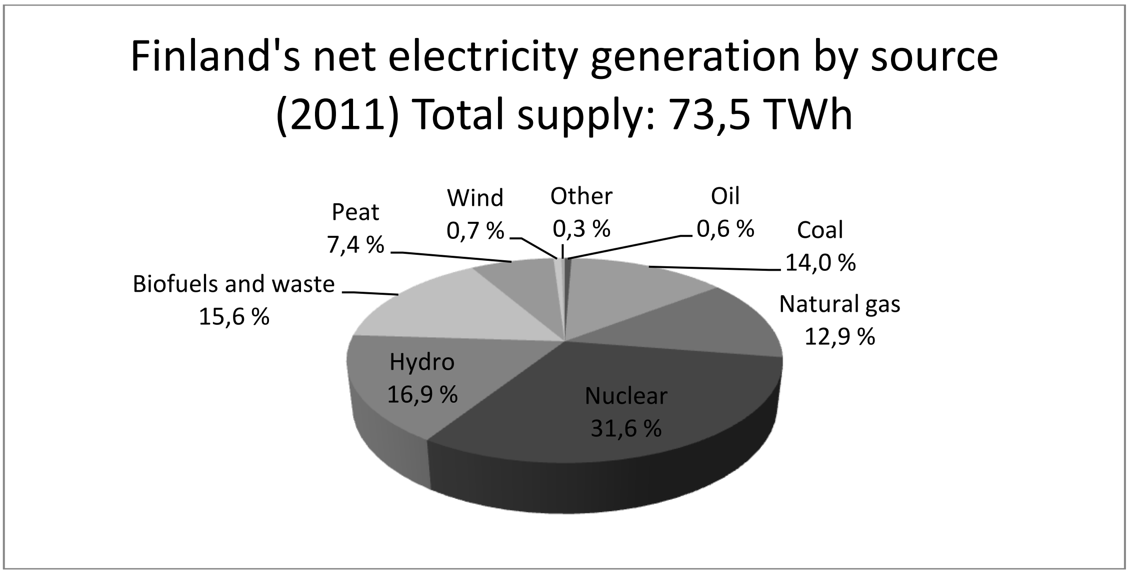

FIGURE 8 Finland's net electricity generation (2011) (IEA, 2014)

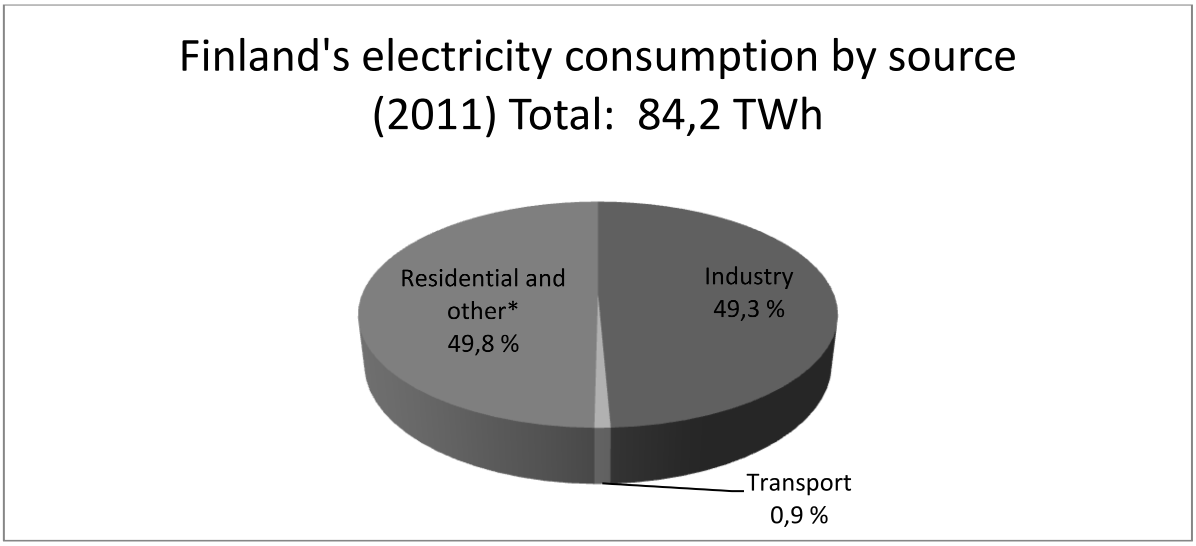

FIGURE 9 Finland's electricity consumption by source (2011) (IEA, 2014)

In 2010, household electric heating and warm water heating consumed 13371 GWh, which accounts for 57 percent of the household electricity consumption. Electricity for household equipment consumed 10 278 GWh and accounted for 43 percent of total household electricity consumption (Kotitalouksien sähkönkäyttö, 2013, Energiatilasto vuosikirja, 2011). The biggest shares of household equipment electricity consumption come from lighting (8 percent) and refrigerators/freezers (7 percent) (Kotitalouksien sähkönkäyttö, 2013).

The price that consumers pay for electricity consists of the wholesale element of prices (cost of fuel, production, shipping, costs of constructing, operating and decomissioning power stations, as well as the retail element that covers costs related to the sale of energy to final consumers (Accenture New Energy Consumer Handbook, 2015). In addition, there are network costs for the transmission and distribution infrastructure and taxes according to the governments taxation (Accenture New Energy Consumer Handbook, 2015).

3 CONSUMER'S ROLE IN ENERGY ISSUES

There is nothing new of Earth's atmospheric, biological and geological changes over a course of time. The Earth has undergone natural events which has altered the planet and affected the lives of species dwelling it forcing them to adapt to new circumstances. According to Stern et al. (1992) global environmental changes are alterations in natural (e.g., physical or biological) systems whose impacts are not and cannot be localized. In the scale of the Earth the changes can involve small but dramatic alterations such as shifts in the mix of gases in the stratosphere or in levels of carbon dioxide and other greenhouse gases throughout the atmosphere.

Since before recorded history, environmental changes have affected things people value (Stern et al. 1992.) For example, people have migrated or changed their ways of living as polar ice advanced and retreated, altered their farming when temperatures and climate changed and made numerous other adjustments in individual and collective behavior (Stern et al. 1992.) But the global environmental changes occurring now differ from those of the past in ways that have consequences for our thinking about the subject. Some of these changes are anthropogenic in origin. Humans are no longer innocent victims compelled to adapt to changes in environmental systems from forces beyond control. Instead, in order to succeed in hindering the global change, human behavior must be changed.

Current trends in energy supply and use are clearly unsustainable. Problems with energy supply and use are related not only to global warming, but also to environmental concerns such as air pollution, acid precipitation, ozone depletion, forest destruction and emission of radioactive substances. These issues must be taken into consideration if humanity is to achieve a bright future with minimal environmental impacts. Moreover, sustainable development within a society demands a sustainable supply of energy resources (Dincer, 1999). Recently, according to Dincer (1999), the concept that

consumers share responsibility for pollution and its costs has been increasingly accepted.
It seems clear that anthropogenic changes in global environment have got anthropogenic solutions. Some have relied on technological breakthroughs to solve problems related to global environmental change. Ways such as improving resource efficiency of the production systems, reusing, recycling, using wastes in production process inputs, redesigning products, processes and supply chains are some of the currently known ways that offer environmental benefits to current society. But such interventions will not by themselves, deliver sustainable development (Jackson, 2005). It is not enough for us to devise ever more efficient industrial processes or create cleaner and more clever technologies and more environmentally friendly and more ethical products. Although, they play an important role in the matter, they will not ensure that consumers choose to buy the greener products. The actions that people take and choices they make to consume certain products and services have direct and indirect impacts on the environment. Because consumer expenditures account for a great part of gross domestic product, addressing consumption plays a major role in reducing the impact of society on its environment (Jackson, 2005).

Since the time of its invention, electricity has been one of the most important commodities and the backbone of the modern society. Now, electricity
is becoming more than a commodity. It is a product, a platform of lifestyle that can be increasingly personalized to deliver a number of outcomes for individual consumers (Accenture New Energy Consumer Handbook, 2015). As other industries work to deliver enhanced levels of personalization, consumers are becoming increasingly accustomed to choice in terms of tailored solutions, services and methods of interaction. For example, consumers might have the option to choose electricity created from renewable energy sources. Due to the structure of the electricity markets and its nature as a commodity, energy providers have traditionally struggled to enable choice and execute personalized approaches (Accenture New Energy Consumer Handbook, 2015). Now, choice has emerged as driver of consumer satisfaction and a powerful lever to create a more personalized experience. In the case of distributed generation, consumers can save money by generating their electricity rather than buying it from the grid. According to Kotler (1971), for purposes of market penetration, issues such as relatively low price and early cash recover stimulates growth of the market. In general, higher prices within the range will result in a lower density of adoption among the target population and vice versa (Kotler, 1971).

Currently there are approximately 2,8 million apartments/homes and 500 000 recreational homes in Finland (Stat.fi, 2016). When comparing the amount of apartments/homes to the number PV systems, it is clear that there is still room for more far spread adoption of these systems. Although the amount of PV micro production systems currently in Finland is fairly low (some hundreds residential, 40 000 recreational), the estimates (Gaia Consulting, 2014) for the near future predict a rapid increase in the number of systems and installed capacity. According to these estimates, the amount of capacity could increase threefold by the year 2025. For a more widespread adoption of renewable technologies such as residential PV systems, the changes have to come from not only consumers, but organizations and governments to set the constraints to a level where the acquiring of these systems is more economically reasonable, convenient and less complex. Furthermore, targeting so called green consumers by these actors could pave the way for sustainable energy technologies and help renewable energy sector to move from econiche to mass market (Kaenzig, 2008). Consumers have to be also open to change regarding consuming habits and electricity acquisition and willing to adopt new, less environmentally harmful technologies.

When it comes to human behavior and changing our consumption habits towards more sustainable ones, it is far from straightforward. There is a variety of factors that influence our decision making. There are economic and institutional factors, or habits, by which consumers are not exactly free to exercise free choice about what to consume and what not to consume (Kaenzig & Wüstenhagen, 2008). Consumers often act through instinct, emotion or habit rather than reason, hence deviating from the homo oeconomicus model, in which a consumer calculates individual costs and benefits to maximize utility and choose the most beneficial option (Kaenzig & Wüstenhagen, 2008). In addition to our personal choice, we are also guided by what others around us say and do. According to Jackson (2005), our individual behaviours are deeply embedded in social and institutional contexts. Moreover, environmentally responsible behavior usually involves various motivational conflicts, arising from the fundamental incompatibility of environmental protection – related collective goals and individual consumers personal or self-interested benefits (Moisander, 2007). Pro-environmental behaviors are rarely motivated by purely altruistic concerns and that awareness in itself is not enough to foster pro-environmental behavior (Kaenzig & Wüstenhagen, 2008). Values seem contribute to the explanation of various environmental attitudes and behaviors of individuals, especially in household energy issues (Poortinga et al. 2004).

Increasingly, consumers have started choosing more ecological products and services in their daily lives. Not only because of egotistic reasons but also because it helps to sustain the environment for future generations (Fraj & Martinez, 2006). Still, despite the positive characteristics of solar electricity, PV systems remain fairly unattractive to individual householders as a home improvement (Timilsina et al., 2000). Issues such as long simple payback periods, high capital costs and a lack of confidence in the long-term performance of the systems are limiting widespread adoption (Faiers & Neame, 2005). Also, long term energy investment decisions occur very few times in a person's life and imply important investments. For a more widespread consumer adoption, it is important that consumers identify the relative advantage of solar energy over their current sources of energy (Kaenzig & Wüstenhagen, 2008). According to Luque (2001), unless electricity prices rise, or cheaper and more efficient panels are developed, solar PV will not become competitive with conventionally produced electricity.

Although this research concentrates on the adoption process and behavioral aspects of individuals, it is noteworthy, that adoption of innovations is not only a matter of individual choice (Brown, 1981). It is also necessary to consider market and infrastructure factors that comprise the supply side of diffusion and shape its course. Furthermore, the government, non-profit and commercial organizations establish and control the set of constraints by which the market operates (Brown, 1981).

4 DIFFUSION OF INNOVATIONS

The aim of this study is to find out more about the adoption process of PV micro production systems and the characteristics of PV adopters and non-adopters and whether there are notable differences between these two groups. In research about the adoption of solar power systems, the Diffusion Of Innovation theory developed by E.M. Rogers in 1962 is often utilized (Labay and Kinnear 1981). In these studies, the differences between adopters and nonadopters are assessed. Therefore, this approach was chosen to study the adoption process.

Innovation diffusion theory seeks to explain how, why and at what rate new ideas, products and technologies spread through society Rogers (2005). The diffusion process can be defined as a process by which (1) *an innovation*, (2) *is communicated through certain channels*, (3) *over time* (4) *among the members of a social system (FIGURE 10)* (Rogers, 2005).

There are different approaches within diffusion of innovations framework. This research uses the *adoption perspective*; which is the traditional approach to diffusion studies (Brown, 1981). This approach concentrates in examining resistances to adoption, the congruence between innovation and the social, economic and psychological characteristics of the potential adopter as well as the flow of information in the diffusion process (Brown, 1981). The author sees that this approach is the most suitable in answering the research questions of this study. In order to understand the process of innovation diffusion, the four elements of the process should be explained in more detail. These four elements also form the structure for the results chapter of this thesis.

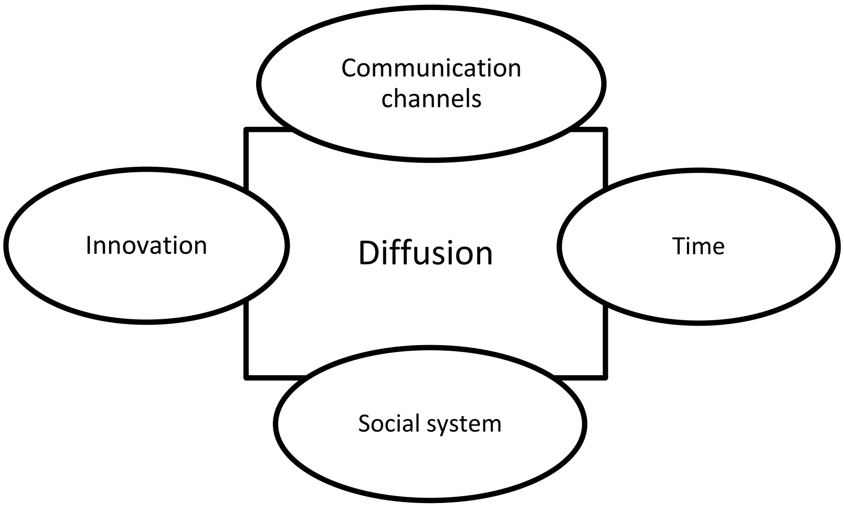

FIGURE 10 Elements of diffusion process (Rogers, 2005)

Innovation

Generally, an innovation is an idea, practice or object that is perceived as new by an individual or other unit of adoption (Rogers, 1995). In this research, the word innovation refers to a PV micro-production system. PV systems have been commercially available for decades. Though, when human behavior is concerned, it matters little whether or not an idea is "objectively" new as measured by the lapse of time since its first use or discovery (Rogers, 2010). More important is the perceived newness of the idea for the individual, which determines his or her reaction to it. If an idea seems new to the individual, it is an innovation (Rogers, 2005).

Past research indicates that the following five qualities are the most important characteristics of innovations in explaining the rate of adoption (Rogers, 2005). Innovations that are perceived by individuals as having greater *relative advantage, compatibility, trialability, observability* and *less complexity* will be adopted more rapidly than other innovations. *Relative advantage* is the degree to which an innovation is perceived as better than the idea it supersedes. It may be measured in economic terms, social prestige factors, convenience and satisfaction (Rogers, 2005). *Compatibility* is the degree to which an innovation is perceived as being consistent with the existing values, past experiences and needs of potential adopters (Rogers, 2010). *Complexity* is the degree to which and innovation is perceived as difficult to understand and use. Some innovations are readily comprehended by most members of a social systems while others are more complicated and adopted more slowly (Rogers, 2005). *Trialibility* is the degree to which an innovation may be experimented. New ideas that can be tried and tested will generally be adopted more quickly (Rogers, 2005). *Observability* is the degree to which the results of an innovation are visible to others. The easier it is for individuals to see the results of an innovation, the more likely they are to adopt (Rogers, 2005).

According to Brown (1981), with technological innovations the most important characteristic regarding adoption is relative profitability and the required investment. In other words, the more profitable the innovation and smaller the required investment, the greater the rate of adoption. The new technology may do the same task than its substitution, but more *relative advantage* or cost savings. Moreover, innovations are often dynamic in nature. According to Brown (1981), the form and function of the innovation and the environment in which it is adopted can be modified throughout the life of the innovation. Photovoltaic systems have been available to consumers since the 1970's. Since then, PV cells have gone through continuous development. When comparing PV systems in the 1970's to modern systems they differ much in price, operating efficiency, size and availability. Hence, innovation can be defined as a continuous process, instead of a set, non-changing phenomenon (Brown, 1981).

Communication channels

Diffusion process is a subjective and social process and often involves interpersonal communication relationships (Brown, 1981). Studies show, that most individuals do not evaluate an innovation on the basis of scientific studies of its consequences (Rogers, 1995). Moreover, mass media channels are usually the most rapid and efficient means of informing an audience of potential adopters about the existence of innovation. Nevertheless, according to Rogers (1995), most people depend mainly upon a subjective evaluation of an innovation that is conveyed to them from another individual like themselves who have already adopted the innovation.

Time

The time dimension is greatly involved in diffusion of innovations. Innovation-decision process is the process which an individual passes from first knowledge of an innovation, to the formation of an attitude toward the innovation, to a decision to adopt or reject, to implementation and use of the new idea and to confirmation of this decision (Rogers, 1995). The length of time required to pass through the innovation-decision process can vary greatly among individuals. The process can lead either to adoption, or rejection of the innovation and those decisions can be reversed at a later point (Rogers, 2010). It is possible for an individual to adopt an innovation after previous decision to reject it, or vice versa to reject it after adopting it, if for example the individual becomes dissatisfied with an innovation or it is replaced with a newer and better technology (Rogers, 1995).

Social system

Diffusion process occurs within a social system. The social structure within the system affects the innovation's diffusion. The structure can either facilitate, or impede the diffusion of innovations (Rogers, 2010). Rogers (2005) has divided adopters into five adopter categories based on their innovativeness, the relative time at which an innovation is adopted: (1) innovators, (2) early adopters, (3) early majority, (4) late majority and (5) laggards. He proposes general profiles for each adopter category, based on socioeconomic status, personality and communication behavior characteristics.

Solar PV systems are an innovation designed for reducing environmental effects of producing electricity and it seems logical that 'green' consumers should be attracted to buy them. However, previous research findings relating to 'green consumers' are often inconclusive and incompatible with the profile of Rogers' adopter categories and that demographics are less important than knowledge, values and attitude in explaining environmentally friendly behavior (Laroche et al., 2001). However, demographics can be useful for understanding perceptions, environmental knowledge and attitudes of 'green' consumers (Diamantopoulos et al., 2003).

Stages of Innovation-decision process

Considering the complex nature of social sciences and human behavior, the reality can be sometimes rather difficult to comprehend. The complex reality of the innovation-diffusion-model is simplified here with five stages of innovation-decision process model. The innovation-decision process *(FIGURE 11)* systematically follows five phases that adopters will follow when deciding whether or not to procure an innovation (Rogers, 2005). The stages are**: (1) knowledge, (2) persuasion, (3) decision, (4) implementation** and **(5) confirmation.**

> Innovation-decision process is essentially an information seeking and information-processing activity in which an individual is motivated to reduce uncertainty about the advantages and disadvantages of the innovation (Rogers, 2005).

Firstly, adopters need to know of an innovation and then be motivated to raise their awareness about it. At the awareness stage, the adopter is concerned with the attributes of the innovation, particularly any advantages it has over another product (Rogers, 1995). The *persuasion* stage in the process is the optimal point at which to gain a full understanding of the product attributes and reducing the risks related to the innovation (Rogers, 1995). At the *decision* stage, an adopter can choose to either adopt or reject the innovation, although if adopted, use of the innovation can be later discontinued (Rogers, 1995). The actual *implementation* of the innovation follows the decision to adopt, after which an adopter will *confirm* that the product meets all expectations (Rogers, 1995).

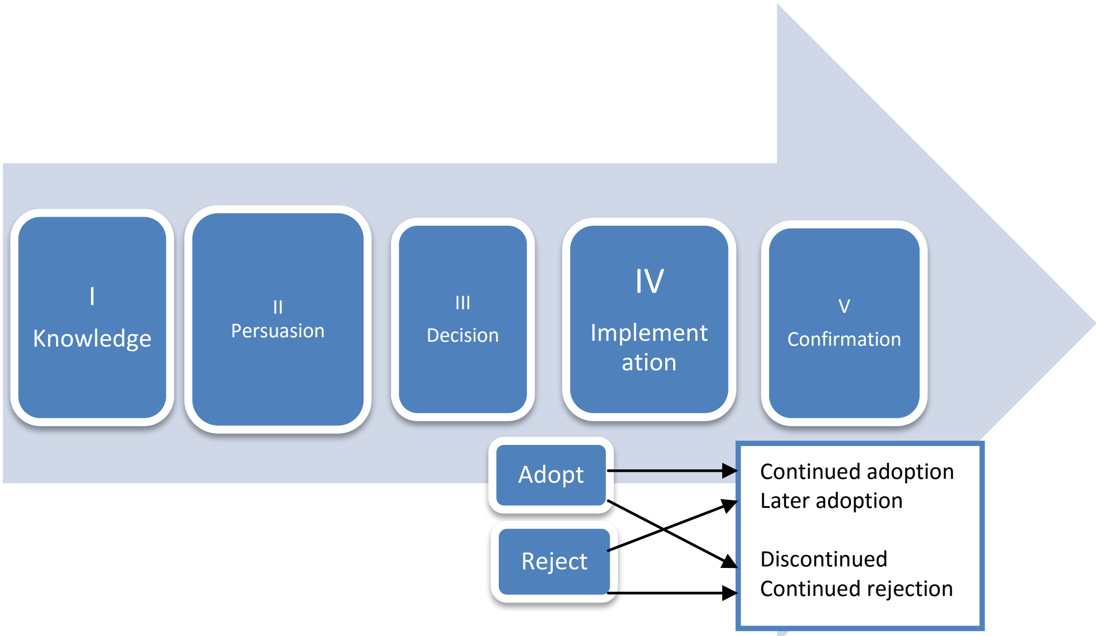

FIGURE 11 A model of Five Stages in the Innovation-Decision Process (Rogers, 2005)

5 METHODOLOGY

This chapter discusses the methodological choices in this research. It includes the background and justification for the data collection methods and data analysis methods used in order to provide the most relevant information and result regarding the research questions.

5.1 Research design

In behavioral research, it is common to use a combination of quantitative and qualitative constructs (Newman & Benz, 1998). Quantitative data consist of numerical information, such as scores on a test, whereas qualitative data consists of non-numerical information, such as descriptions of behavior (Whitley & Kite, 2007). Quantitative research's weakness is in understanding the context or setting in which people talk and the voices of participants are not heard (Jick, 1979). In qualitative research, the results are interpreted by the researcher thus ensuing bias and there is difficulty generalizing findings into a larger group because of the limited number of participants studied. The historical argument for mixed method research is that it provides strengths that offset the weaknesses in both quantitative and qualitative studies (Jick, 1979). Nowadays, researchers and graduate students across social sciences have started combining these methods in mixed method designs (Creswell & Plano Clark, 2007).

The reason for choosing mixed method study is in the methods central premise – that the use of both approaches in combination provides a better understanding of research problems than either approach alone. Moreover, the combination of qualitative and quantitative data can provide a more complete picture by noting trends and generalizations as well as offer a more in-depth knowledge of participants perspectives (Creswell & Plano Clark, 2007). Individuals tend to solve problems using deductive and inductive thinking and talk about problems in both words and in numbers – hence, it is natural to employ a mixed-method research as the preferred mode of understanding behavior (Creswell & Plano Clark, 2007). In this research quantitative and qualitative approaches are mixed throughout the study. Both, quantitative and qualitative questions are posed, both types of data collected and analyzed, followed by both type of interpretations.

5.2 Data collection: Online survey

The data was collected with an online survey. Surveys are one of the most often used techniques of collecting information from or about people to describe, compare, explain, or predict their knowledge, attitudes, or behaviors (Fink, 2003). Online questionnaires can be sent to a vast number of recipients and it can include many questions. Collecting the data with a survey is also less time consuming for the researcher when performing the data analysis, provided that the questionnaire is carefully planned and the researcher has the proper analytical methods in use (Hirsjärvi, Remes & Sajavaara, 2000).

To best answer the research problem, the survey included a combination of qualitative and quantitative constructs (open-ended questions and likert-scale questions). In order to assess the behavior and characteristics of solar PV adopters and solar PV non-adopters, these two groups were divided into two focus groups: **Focus group 1 (FG-1**) *Those who have PV micro production systems* and **focus group 2 (FG-2)** *Those who do not have such systems.* Two types of surveys were designed to each focus group.

The sample of this research was limited due to the limited number of owners of residential PV micro production system in Finland and the limited knowledge about these adopters. For this survey, lists of owners known installations were obtained with the help of Finnish Energy association (Energiateollisuus ry), solar dealers, energy companies and social networks of the publisher. The surveys were released in February 2016. The data collection took 2 weeks with a total of 109 respondents (FG-1; 55 respondents, FG-2; 54 respondents).

5.3 Data analysis

Data analysis in mixed methods research consists of analyzing the quantitative data using quantitative methods and the qualitative data using qualitative methods. The choice of data analysis depends on several factors such as type and nature of variables and study design (Singh, 2007). Qualitative data measures behavior which is not computable by arithmetic relations and is represented by words (Singh, 2007). Quantitative data is a numerical in form and results from a process of measurement and on which mathematical operations can be done (Creswell & Clark, 2007). Moreover, in quantitative methods, the analysis consists of analyzing scores collected to answer research questions or test hypothesizes. In contrast, qualitative data consists of open-ended information gathered by the researcher (Creswell & Clark, 2007).

Two popular methods of analysis of qualitative and quantitative data are **thematic analysis** and **cross-tabulation analysis**. In this research, thematic analysis was used to analyze the qualitative data and Cross-tabulation analysis was used to analyze the quantitative, numerical data of the study. The analysis of the quantitative data was done with statistical analysis software called SPSS (version 23). After the analysis of quantitative and qualitative data, the two types of data was merged and transferred into the findings of this research *(FIGURE 12).*

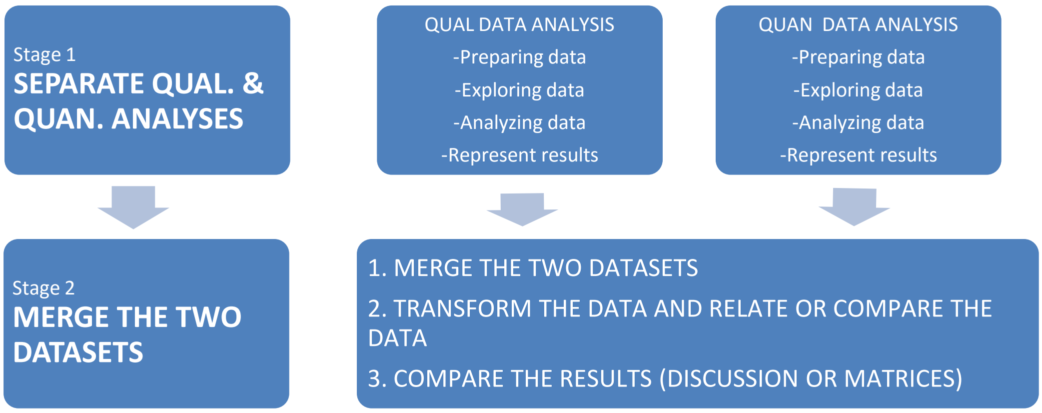

FIGURE 12 Data analysis process

5.3.1 Thematic analysis

Thematic analysis is a qualitative analytic method which focuses on identifiable themes and patterns of behavior. The central task of thematic analysis is to understand the meaning of test (Marks & Yardley, 2004). Moreover, it is used for identifying, analyzing and reporting patterns (themes) within data (Braun & Clarke, 2006). A *theme* refers to a specific pattern found in the data of which one is interested (Marks & Yardley, 2004). Themes capture something important about the data in relation to the research question and represents some level of patterned response or meaning within the data set (Braun & Clarke, 2006).

In this research, both focus groups were asked open-ended questions about the reasons for adoption (FG-1) as well as the barriers of adoption (FG-2) of PV systems. The results were first divided into sub-themes based on the emerging patterns from the data *(TABLE 1 & 2).* According to Rogers (2005), the following five qualities are the most important characteristics of innovations in explaining the rate of adoption (Rogers, 2005): *relative advantage, compatibility, trialability, observability* and *complexity.* After gathering the subthemes from the data, subthemes were then categorized into themes according based on these five most important characteristics of the innovation.

In the results chapter, these results were then further divided into the elements of the diffusion process proposed by Rogers (1995): 1) *Innovation*, 2) *Communication*, 3) *Over time* and 4) *Social system*.

TABLE 1 FG-1. Thematical analysis - Subthemes and characteristics of innovation

CODE/SUBTHEME	THEMES
Environmental reasons	COMPATIBILITY
Interest in technology	NEEDS
Economical reasons	RELATIVE ADVANTAGE
Necessity	RELATIVE ADVANTAGE
Reliability	RELATIVE ADVANTAGE

TABLE 2 FG-2. Thematical analysis - Subthemes and characteristics of innovation

CODE/SUBTHEME	THEMES
Economical reasons	RELATIVE ADVANTAGE
Technical difficulties	COMPLEXITY
Lack of knowledge	COMPLEXITY
Reliability	CONVENIENCE

5.3.2 Cross-tabulation analysis

Cross-tabulation analysis is quantitative research method used for analyzing the relationship between two or more variables (Holopainen et al. 2004). Moreover, cross-tabulations provide a way of analyzing and comparing the results for one or more variables with the results of another (or others) (Holopainen et al. 2004). The quantitative data was analyzed with cross-tabulation analysis to compare and data variables and understand the relationships between FG-1 and FG-2. First, in order to figure out whether and how the focus groups differed from each other, a cross-tabulation analysis was used to the data about demographic properties such as gender, age, education, occupation and level of income *(TABLE 3)*. Furthermore, cross-tabulation analysis was also used to compare data regarding for example the level of knowledge *(TABLE 13)* and environmental values *(TABLE 6*) of the two focus groups.

Pearson's chi-squared test

Chi-square is a statistical test that tests for the existence of a relationship between two variables and whether there is a statistically significant difference between the data sets (Holopainen et al. 2004). Statistically significant means the difference in the results did not occur by random chance. For the purposes of this research, the level of significance was defined as **p=<0,05**.

5.4 Data reliability and validity

Validity and reliability are two different concepts. Validity tries to assess whether a measure of concept actually measures the thing it was designed measure (Singh, 2007). Reliability signifies the consistency of measures, that is, the ability of a measurement instrument to measure the same thing each time it is used (Singh, 2007). For a study to be accurate, it is imperative that the findings are both reliable and valid. One way to avoid threats to validity and reliability is to ensure internal validity by using the most appropriate research design for study (Singh, 2007). External validity signifies the extent to which a research study can be generalized to other situations. Internal validity refers to the true causes, which result in an outcome.

The data was collected with an online survey, combining both, quantitative and qualitative approaches. The quantitative data was analyzed with SPSS -software, enabling anyone with the same data and methods to result in the same outcome. Furthermore, a part of the quantitative data is available in the appendices, enabling repetition of the analysis. The methods of analysis such as thematic analysis require a comprehensive understanding of the subject under study. The structure and results of this research provided support in resolving the research problem and a better understanding to the sub-questions. With this in mind, Thematic Analysis was capable to detect and identify, e.g. factors or variables and issues generated by the participants.

As far as internal validity goes, the *Diffusion Of Innovation* framework is widely applied in solar PV adoption research. The results of this study concur with earlier research. Moreover, it uses the same theoretical approach and similar research methods. Nevertheless, due to the limited sample size (n = 55(FG-1) + 54(FG-2) = 109) and homogenic demographic profiles, the results of this may give guidance about the adoption process of PV systems in Finland, but cannot be generalized.

6 RESULTS

In the following paragraphs the results of this research are presented followed by conclusions. As diffusion research in general, this research also concentrates on the differences between PV adopters and non-adopters. The results are presented in chapters according to categorization by Rogers (1995), the elements of the diffusion process: *1) Social system, 2) Innovation, 3) Communication* and *4) Over time.* In each chapter, the main findings related to the topic are presented (*FIGURE 13*). The results from both, quantitative and qualitative data analysis are combined within these four categories.

Social system contains the results that have to do with the respondents of the study, mainly demographic findings. The *Innovation*-chapter provides the most important findings regarding the research problems of this study. *Innovation* contains the results that have to do with the characteristics of the innovation and how the focus groups perceive the innovation. *Communication* chapter presents the results that have to do with the knowledge and the flow of information within the focus groups. Finally, *Over time* presents the results that have to do with the time aspect of the innovation-decision process.

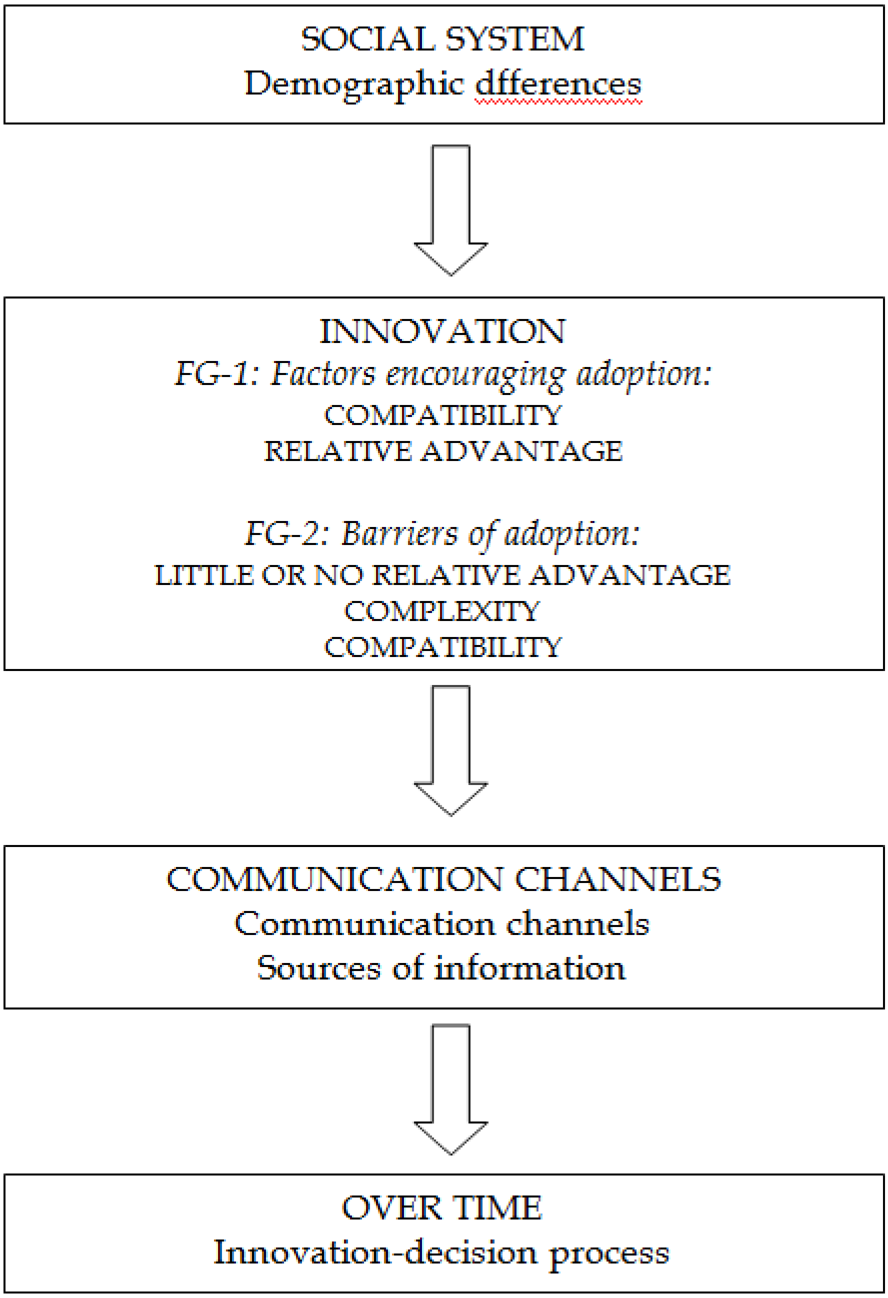

FIGURE 13 Results of this research

6.1 Social system

In this chapter, '*Social system*' refers to the respondents of this study, FG-1 and FG-2. The social structure within the system affects the innovation's diffusion. It can either facilitate or impede the diffusion of innovations (Rogers, 2005). First part of the questionnaire was about demographics. Rogers (1995) proposes five adopter categories based on demographic properties. Yet, some research (Laroche et al., 2001) has shown, that these properties are often inconclusive. Still, general consensus (Faiers & Neame 2005, Islam & Meade 2011, Labay & Kinnear 1980, Keirstead 2006) show, that solar PV adopters share some characteristics regarding demographics and other qualities. Moreover, adopters of PV systems and green consumers are often found to be wealthier and more highly educated than their conventionally consuming counterparts.

When comparing the demographic properties between FG-1 to FG-2, the groups had statistically significant differences **(*p*=<,05)** in 1) *gender,* 2) *age, 3) occupation, 4) income* as well as in *5) form of residence (TABLE 3).* For example, 87 percent of FG-1 was men, compared to 48 percent of FG-2. Also, the level of occupations are higher in FG-1. Moreover, considerable amount of FG-1 are pensioners whereas in FG-2 only one is retired *(APPENDICES 2 & 3)***.** Only demographic property where no significant difference was seen is *education.*

Because the focus groups differ so drastically in the demographics, it is noteworthy, that before making any conclusions about the demographic findings of this research the limitations of this study should be acknowledged. Nevertheless, when comparing the profiles of adopter and non-adopter, people of FG-1 are generally higher in occupational status, level of income, age and live more in houses instead of apartments. As one of the objectives of this research was also to gather information about PV system adopters in Finland, the characteristics of FG-1 is available in appendices *(APPENDICES 1,2 & 3).*

TABLE 3 Demographic Crosstab & Chi-square

	Cases						Chi Square tests
	Valid		Missing		Total		Asymptotic Significance (2-sided)
PERUSTIEDOT	N	Percent	N	Percent	N	Percent	
Sukupuoli	109	99,1%	1	,9%	110	100,0%	**,000**
Ikä	109	99,1%	1	,9%	110	100,0%	**,000**
Koulutus	109	99,1%	1	,9%	110	100,0%	,620
Ammatti	109	99,1%	1	,9%	110	100,0%	**,001**
Tulot (€ / kk, brutto)	108	98,2%	2	1,8%	110	100,0%	**,000**
Asumismuoto	109	99,1%	1	,9%	110	100,0%	**,000**

6.2 Innovation

One of the research problems was to examine the factors leading to adoption within adopters and barriers hindering adoption within non-adopters. This chapter concentrates on the findings related to the characteristics of the innovation and factors that has encouraged adopters to adopt and contrarily preventing non-adopters to keep rejecting adoption. According to Rogers (1995), the characteristics of the innovation plays a major role in the diffusion of innovations. The following five qualities are the most important characteristics of innovations in explaining the rate and willingness of adoption: *relative advantage, compatibility, trialability, observability* and *complexity* (Rogers, 2001). Innovations are not equivalent units of analysis and there are different characteristics of innovations as perceived by individuals (Rogers, 2001).

When asked about the reasons of investing in a PV micro production system, the research shows that the most important characteristics of the innovation are *1) Compatibility* and *2) Relative advantage*. 3 out of 4 of FG-1 (73 percent) have *values, experiences* and *needs (Compatibility)* as their main reasons of adoption. Also, more than half (62 percent) see *economic terms*, *convenience* or *necessity (Relative advantage)* as a reason for adopting a PV system. Moreover, when FG-2 was asked about the reasons why electricity from the grid is a better option for them than household PV-systems, more than half (63 percent) saw *economic terms*, or *convenience* factors *(Relative advantage)* as barriers of adoption. Furthermore, PV-systems was perceived *as difficult to understand or use* (*Complexity*) by one third (31 percent) of FG-2 and not *compatible* with their *needs* or *experiences* by 25 percent of FG-2. The following tables include examples of themes and subthemes that repeatedly emerged from FG-1 within the qualitative, open-ended questions of the survey: (**Q=Quote, T= Translation).** First, the factors encouraging adoption within FG-1 is introduced in more detail, followed by the barriers of adoption in FG-2 *(TABLE 4).*

TABLE 4 FG-1: Reasons for adoption, FG-2: Barriers of adoption

FG-1 1. COMPATIBILITY (40 of 55) VALUES NEEDS EXPERIENCES 2. RELATIVE ADVANTAGE (32 of 55) ECONOMIC TERMS CONVENIENCE NECESSITY
FG-2 1. LITTLE OR NO RELATIVE ADVANTAGE (20 of 32) ECONOMIC TERMS CONVENIENCE 2. COMPLEXITY (10 of 32) DIFFICULT TO UNDERSTAND OR USE 3. COMPATIBILITY (8 of 32) NEEDS EXPERIENCES

TABLE 5 FG-1. Compatibility

FG-1 **COMPATIBILITY (40 of 55)** VALUES NEEDS EXPERIENCES
VALUES
Q ***"Ympäristösyyt. Uusiutuva energia."***
T *Environmental reasons. Renewable energy*
Q ***"Ympäristöasiat - äänetön, savuton, hajuton, pölytön...ei co päästöjä"***
T *Environmental issues - silent, smokeless, odourless, dust-free, no CO-emissions*
Q ***"Omavaraisuus, mahdollisuus käyttää uusiutuvaa luonnonvaraa ja lähienergian omaan käyttöö"***
T *Independency, possibility to use a renewable resource and local energy to own use.*
Q ***"Paikallisenergiatuotanto"***
T *Local energy production*
NEEDS
Q ***"Kokeilun halu ja halu toimia esimerkkinä"***
T *Will to try and to work as an example*
Q ***"Puhtaasti halu kokeilla, rakentaa, tutkia ja harrastaa"***
T *The will to experiment, build, explore and to take an interest in*
Q "***Mielenkiinto tekniikasta"***
T *Interest towards the technology*

When asked about the reasons that lead FG-1 to invest in PV-systems, nearly 80 percent out of the adopters stated value-based reasons for adoption. Issues such as low CO2-emissions, use of renewable resources and local energy production was seen as important factors encouraging adoption *(TABLE 5).* Complying with the qualitative data, the quantitative data also shows differences in how FG-1 and FG-2 value environmental issues. There was a statistically significant difference **(p=<,05)** when comparing the importance of the environmental impacts of the electricity (*TABLE 6).*

TABLE 6 The environmental effects of electricity, Crosstabulation & Chi-Square

		Tuotetun sähkön ympäristöystävällisyys					
		1	2	3	4	5	Total
TYYPPI	ADOPTER	1	2	4	13	34	54
	NONADOPTER	0	4	10	22	18	54
Total		1	6	14	35	52	108

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	11,475[a]	4	,022

Furthermore, 58 percent of FG-1 saw that PV systems offer them *relative advantage* in terms *of economic terms, social prestige factors, convenience* and *satisfaction (TABLE 7).* Economic reasons included things such as will reduce costs of electricity bills or not having to pay transmission fees nor electric connections. Other important factors within FG-1 were *necessity* and *convenience*. As PV systems are mostly used in recreational homes where electricity grid might not be available or expensive to acquire, for some members of FG-1 solar PV systems have offered a less costly alternative. Due to their remote locations recreational homes often have long power lines which result in the decrease of the reliability of the network. PV systems are seen as a *convenient* option in ensuring a continuous feed of electricity.

TABLE 7 FG-1. Relative advantage

FG-1 - RELATIVE ADVANTAGE (32 of 55)

ECONOMIC TERMS
SOCIAL PRESTIGE FACTORS
CONVENIENCE
NECESSITY AND SATISFACTION

ECONOMIC TERMS

Q ***"Halu säästää sähkökustannuksissa"***

T *The will to reduce in the costs of electricity*

Q ***"Haluttomuus maksaa turhasta: liittymä, siirtomaksut, nousevat sähkön hinnat verrattuna pieneen kulutukseen"***

T *Not willing to pay for nothing: electric connections, transmission fees, rising electricity prices compared to small amount of use*

Q ***"Mökki on saaressa. Sähkön hankkiminen sähköverkosta olisi sinne kallista. Koska mökillä ei olla talvella, olisi turhaa maksaa siirtomaksua ympäri vuoden"***

T *The cabin is in an island. Getting electricity from the grid would be expensive. Because the cabin is not used during win ter, it would be useless to pay for transmission fees all year long.*

NECESSITY

Q ***"Mökilleni ei tule muuta sähköä"***

T It *is the only source of electricity available in my cabin*

CONVENIENCE

Q ***"...taata (akuilla) katkoton sähkönsaanti"***

T *... quarantee constant supply of electricity (with batteries)*

Q ***"Varavoima. Kyse on puhtaasti varautumisesta. Tarkoitus on var mistaa sähkönsaanti kaikissa oloissa."***

T *Auxiliary power. It is about preparing. Meaning to ensure elec tricity supply in all condition.*

FG-2 was asked about the reasons why purchased electricity from the grid is a better option to them compared to a PV micro production system. When analyzing the data, three major themes emerged: 1) *Relative advantage*, 2) *Complexity* and 3) *Compatibility (TABLE 8,9,10).* For majority (63 percent) of FG-2 PV systems would seem to offer no, or little *relative advantage*. This was mainly due to *economic reasons* such as high price of PV systems, long payback time or lower price of electricity from the grid as well as *convenience* factors such as easiness of use. For many, PV system was seen as a more expensive option compared to electricity from the grid. Also, electricity from the grid was seen easier to use and an effortless way to provide electricity to households compared to acquiring of a PV system.

TABLE 8 FG-2. Relative advantage

FG-2 - RELATIVE ADVANTAGE (20 of 32) ECONOMIC TERMS SOCIAL PRESTIGE FACTORS CONVENIENCE NECESSITY AND SATISFACTION	
ECONOMIC TERMS	
Q	***"Järjestelmät ovat kalliita ja niiden takaisinmaksuaika on pitkä"***
T	*The systems are expensive and their payback time is long*
Q	***"Taloudelliset hyödyt aika mitättömät"***
T	*The economic benefits are insignificant*
CONVENIENCE	
Q	***"Helppous ja totuttu tapa"***
T	*Easiness and a customary habit*
Q	***"Helppokäyttöisyys"***
T	*Ease of use*

Furthermore, one third (31 percent) of FG-2 perceived *complexity* to be a barrier of adoption *(TABLE 9).* Moreover, for these non-adopters PV systems and the acquiring process of these systems was seen as as difficult to understand or use. Some respondents also had clear misbelieves or false information about the PV systems. According to Rogers (1995), low level of knowledge around innovations creates uncertainty and higher the perceived risks which can result as a barrier of adoption.

TABLE 9 FG-2. Complexity

FG-2 - COMPLEXITY DIFFICULT TO UNDERSTAND OR USE	
Q	***"Ostosähköön liittyminen on niin helppoa ja halvempaa, kuin aurinkojärjestelmän rakentaminen talooni..."***
T	*Connecting to electricity from the grid is so easy and cheaper than building a PV system into my house*
Q	***"Yksin asuvana naisena koen, etten tiedä asiasta tarpeeksi ja en usko, että löytäisin luotettavaa toimittajaa."***
T	*As a woman living alone, I feel like I do not know enough about it and do not believe I would find a reliable supplier.*
Q	***"Tällä hetkellä tietoa on liian vähän ja alkukustannukset on melko suuret."***
T	*At the moment I have too little knowledge and the initial invest- ment is quite big.*
Q	***"Asiasta mitään tietämättä. Aurinkosähkössä mietityttää mahdolliset kustannukset, luotettavuus, hyötysuhde, kunnossa pito/huolto. Rivitalossa mahdolliset julkisivuongelmat paneelien asennuksessa"***
T	*Without knowing anything about it. In solar power I am con cerned about the possible costs, reliability, effeciency, mainte nance. In a row house, problems with the installing the panels.*
Q	***"Asun kerrostalossa"***
T	*I live in an apartment*

TABLE 10 FG-2. Compatibility

FG-2 - COMPATIBILITY VALUES NEEDS EXPERIENCES	
Q	***"Koska tarvitsen jatkuvasti sähköä, myös silloin kun aurinko ei paista"***
T	*Because I constantly need electricity, also when the sun is not shining*
Q	***"Aurinkosähkö näillä leveysasteilla on hieman epävarmaa, varsinkin talvella"***
T	*Solar electricity within these longitudes is a bit uncertain, especially during winter.*

Rogers (2005) state, that an idea that is incompatible with the values and norms of a social system will not be adopted as rapidly as an innovation that is compatible. Some respondents saw that PV systems could not offer them what they need making it not compatible with their values, needs or experiences.

6.3 Communication

"Innovation-decision process is essentially an information seeking and information-processing activity in which an individual is motivated to reduce uncertainty about the advantages and disadvantages of the innovation" (Rogers, 2005).

In order for the innovation to be adopted, the information and experiences have to be spread through communication channels. The following four communication channels came up when asked about the communication channels by which the members of FG-1 heard about PV systems*:*

1) Friend/Relative (19 of 55)
2) *Magazine (18 of 55)*
3) The Internet (15 of 55)
4) *Other (fair/company)* (7 of 55)

FG-1 has acquired the needed knowledge for adopting PV systems through *friends or relatives*, *magazines*, *The Internet* or *fairs or companies*. With FG-2, 25 percent felt that *Lack of information* was a barrier for adoption. Moreover, there was a statistically significant difference **(p=,00)** when assessing in how difficult FG-1 and FG-2 perceive the acquiring process of a PV system (*TABLE 11*)**.** Furthermore, when FG-1 was asked about how hard it was to find information about acquiring a PV system, 70 percent stated it was fairly easy or very easy *(FIGURE 14).*

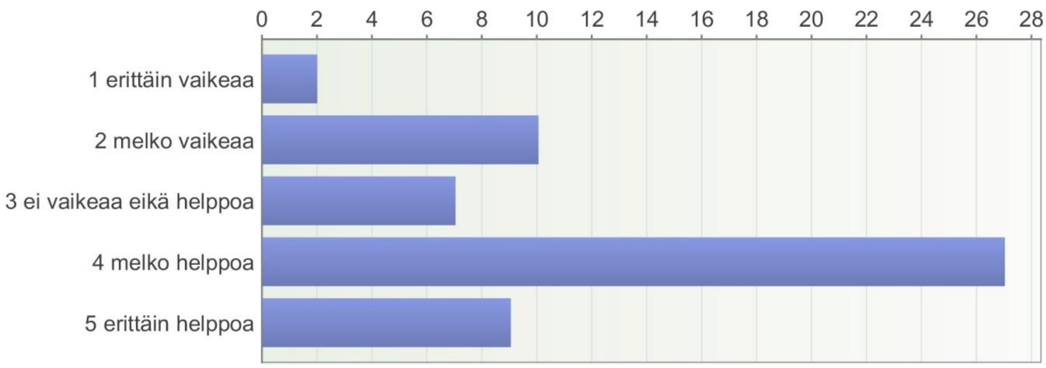

FIGURE 14 How hard was it to find information about PV micro production ?

Q	**"Tällä hetkellä tietoa on liian vähän ja alkukustannukset on melko suuret**
T	*Currently, I have too little information and the initial investment is quite big*

TABLE 11 Acquiring of a PV system is a hard process, Crosstabulation & Chi-Square

		Aurinkosähköjärjestelmän hankinta on hankala prosessi 1= Täysin eri mieltä, 2= Jokseenkin eri mieltä, 3= Ei samaa eikä eri mieltä, 4= Jokseenkin samaa mieltä, 5= Täysin samaa mieltä:					
		1	2	3	4	5	Total
KYSELYNTYYPPI	ADOPTER	15	23	8	7	2	55
	NONADOPTER	0	11	25	13	5	54
Total		15	34	33	20	7	109

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	31,072[a]	4	,000

TABLE 12 It is hard to find information from PV micro production, Crosstabulation & Chi-Square

		Aurinkosähkön omatuotannosta on vaikeaa löytää tietoa 1= Täysin eri mieltä, 2= Jokseenkin eri mieltä, 3= Ei samaa eikä eri mieltä, 4= Jokseenkin samaa mieltä, 5= Täysin samaa mieltä					
		1	2	3	4	5	Total
KYSELYNTYYPPI	ADOPTER	11	22	11	6	5	55
	NONADOPTER	0	11	21	16	6	54
Total		11	33	32	22	11	109

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	22,421[a]	4	,000

Furthermore, in addition to perceived level of knowledge regarding PV micro production there seem to be a difference in the actual level of knowledge between FG-1 and FG-2. For example, when assessing the lifespan of a PV system, the estimates the estimates of FG-2 was considerably lower **(p=,00)** (*TABLE 13).*

TABLE 13 Lifespan of a PV system, Crosstabulation & Chi-Square

		Minkä arvioisit aurinkosähköjärjestelmän käyttöiäksi?				
		1	2	3	4	Total
KYSELYNTYYPPI	ADOPTER	0	13	26	16	55
	NONADOPTER	8	26	18	2	54
Total		8	39	44	18	109

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	24,670[a]	3	,000

As mentioned earlier, the social structure of the social system and the innovativeness of a member within a social system affect the diffusion of the innovations. It seems that FG-1 and FG-2 are different in terms of their approach towards PV systems (*innovativeness*). According to Rogers (2005) knowing of a technological innovation creates uncertainty about its consequences in the mind of potential adopters. Members of FG-1 have taken the effort to learn more about the innovation, reducing the amount of uncertainty related to the innovation whereas members of FG-2 have not.

6.4 Over time

As suggested in the innovation-decision process by Rogers (2005), the innovation decision-process can lead either to adoption, or rejection of the innovation and even these decisions can be reversed at a later point. It is possible for an individual to adopt an innovation after previous decision to reject it, or vice versa to reject it after adopting it. Interestingly, 34 of 54 of the non-adopters state that they are interested in PV systems *(FIGURE 15).* Furthermore, 20 of 54 non-adopters say that they have considered a PV system *(FIGURE 16).* For example, some of the current non-adopters were planning to get a PV system into their recreational home, or next house.

Q	*"Tällähetkellä kun asumme kaksiossa, niin emme koe tarpeelliseksi asennuttaa paneeleita, mutta on mielessä uutta asuntoa hankkiessa"*

T At this stage while living in a two room apartment, we don't feel the need to install solar panels, but we will think of them while getting a new place

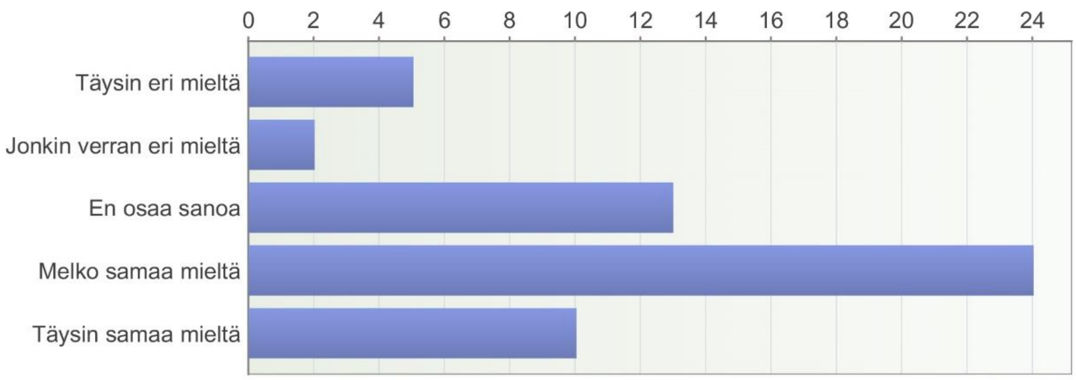

FIGURE 15 PV micro production is an interesting option

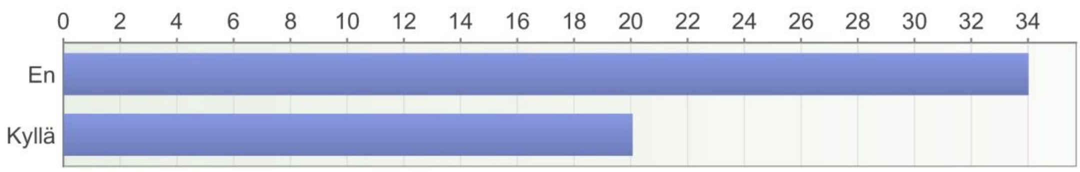

FIGURE 16 I have thought of getting a PV micro production system

Some earlier studies (Keirstead, 2007) suggests that acquiring a PV system has had reducing effect to the adopters use of electricity. When asked whether if PV adopters feel that the acquiring of their own PV system has affected their electricity consumption, 34 of 55 (62 percent) *(FIGURE 17)* state, that it has had a reducing effects to their electricity consumption.

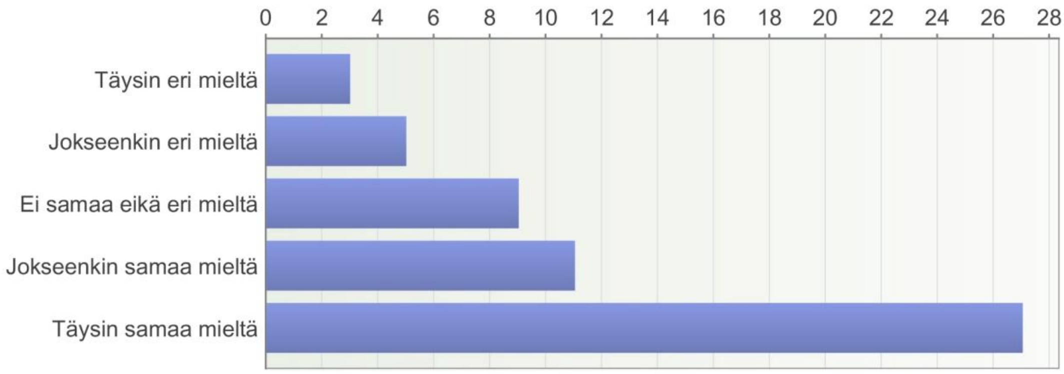

FIGURE 17 PV system and electricity consumption

In this research the time required for the innovation-decision varied greatly among individuals from 23 years to one month from first hearing about the innovation. The time of adoption of PV systems in FG-1 was divided as follows:

1985	1
1993	1
1994	2
2005	1
2010	1
2013	16
2014	21
2015	11
2016	1

7 CONCLUSIONS

Commonly the biggest barriers of adoption of PV systems has been high capital costs, long payback periods and the lack of confidence in the long-term performance of the systems (Faiers & Neame, 2005). The results of this research also suggest that economic aspects play a key role in the adopting willingness of non-adopters, as well as adopters. Some of the non-adopters of this research saw that the initial price of the investment and the payback time of PV systems are still fairly high, which reduces their willingness to invest to such systems. Interestingly, not only being a barrier for adoption with non-adopters, economic terms were also seen as a factor encouraging adoption with adopters.

Furthermore, there seem to be differences within the characteristics of adopters and non-adopters. Firstly, the knowledge and awareness on photovoltaic micro power systems was very limited among some non-adopters, showing also some false beliefs. According to Rogers (1995), the innovation-decision process revolves around seeking and processing information about an innovation and reducing uncertainty about its advantages and disadvantages. Where adopters of PV systems have been motivated to increase their knowledge about PV systems, eventually leading to adoption of such system, some non-adopters have not gone through this information-seeking process. This limited knowledge and false information about the characteristics and advantages of the innovation is clearly a barrier for adoption as the possible benefits of PV systems are left unfamiliar.

Moreover, adopters and non-adopters seem to differ in their values. Many PV adopters stated to have adopted a PV system out of the compliance with their values or interest towards the technology whereas non-adopters seem to be generally more interested in economic aspects. Furthermore, many non-adopters felt that electricity from the grid is more convenient and easier option compared to PV systems. Based on this study, it seems that as long as electricity from the grid is considerably cheaper, more convenient and the efforts required to acquire the PV system are lower, to some PV systems cannot compete with conventional electricity. Nevertheless, as The 'Diffusion of

Innovation' -theory suggests, the process of diffusion can lead to adoption at a later point. In this research, most of non-adopters were interested in PV systems and many had considered PV systems. Considering the fast development of photovoltaic technology, increased amount of suppliers, decrease of market prices and government schemes to support renewable energy, current non-adopters could end up adopting PV systems in near future.

This thesis provides three main contributions. First, this thesis provides information about little known micro PV markets in Finland (*APPENDICES*). Secondly, the research shows barriers of adoption within non-adopters, as well as factors that adopters perceive has positively affected the adoption of PV systems. Thirdly, it examines and compares the characteristics of adopters and non-adopters of PV systems. The author hopes that the information gathered in this research can be used by actors in the field and hopefully have a positive effect on the adoption of solar PV micro production systems in Finland.

7.1 Limitations of this research

As most studies, this research contains limitations which should be acknowledged. A little is known about the PV adopters in Finland. To this research only 54 PV-adopters was available. Due to limited amount of solar PV adopters in Finland and limited amount of resources of the researcher, the sample size of the study was limited to a total of 109 respondents. In order to get a more profound understanding about the adopters of PV systems, the sample would need to be bigger. Furthermore, the sample in this research turned out to be rather homogenous in terms of demographic properties. The two focus groups represent different socioeconomic groups, FG-1 being older, generally wealthier and mostly male, whereas FG-2 being mostly women, lower in income and younger. However, the interrelation of these constructs and how much this affects the actual behavior remain unclear remain unclear.

The common assumption in diffusion of innovations is that innovations as such do not change during the time of inspection. Still, some innovations are dynamic in nature. PV technology has experienced very drastic improvements in terms of efficiency and material technology making the prices decrease many folds over the last decade. This might have an effect to the rate and willingness to adopt such technologies over even a fairly short period of time. Combined with governmental renewable energy incentives, the adoption of PV technology might experience a rapid increase even over a fairly short period of time. In this research the time of adoption varied from 1985 to 2016. Within these 3 decades PV technology has experienced considerable development technologically, which has resulted in increased efficiency and drop in market prices. Therefore, although the innovation is the same, nowadays PV system is not fully comparable to a PV system decades ago.

7.2 Suggestions for further research

Given the current interest and anticipated future growth of renewable energy technologies and policies, there is a need for further behavioral research concerning the adoption of solar PV systems. This research only concentrated on consumers role in the adoption of PV systems in Finland. However, there are also other factors besides consumer behavior which have major impacts on how new renewable technologies are adopted. The implementations of some countries (Germany, China) climate policies have resulted in a rapid increase in the use of renewable energy sources. Meanwhile in some countries the efforts moving towards renewable energy have been negligible. It would be interesting to assess the barriers and factors encouraging adoption of PV systems on a national scale.

Moreover, some previous diffusion research around solar PV systems are inconsistent with for example the demographic characteristics of adopters and non-adopters and their role in the individuals buying behavior. Despite the numerous research on the matter, the author feels that there is still not a general consensus of which factors are the most dominant in determining the buying behavior of consumers regarding energy issues. Though, given the complex nature of consumer behavior, it remains unclear whether such consensus is possible to achieve.

Also, many of the non-adopters in this research had misbelieves or a fairly low level of knowledge regarding solar PV systems. It would be interesting to study, how often lack of information or misbelieves are the reasons behind consumers rejection when adopting new innovations.

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APPENDICES

APPENDIX 1 Information about PV adopters

Demographics

Men	48
Female	7

Year of purchase

1985	1
1993	1
1994	2
2005	1
2010	1
2013	16
2014	21
2015	11
2016	1

Type of systems
Residential accommodation (43 of 55)
Recreational homes (12 of 55)

Price of system
The price of the installed systems averaged 6 937 €, 400€ being the cheapest and 14 000€ the most expensive.

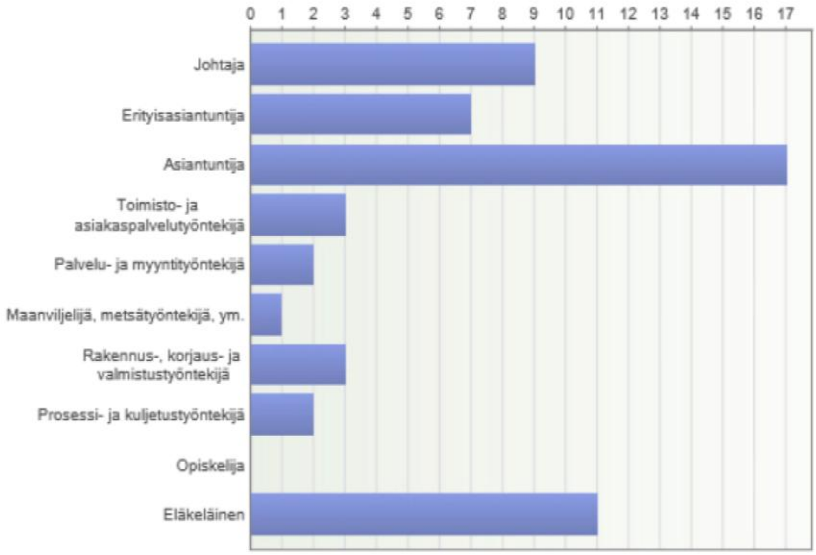
Electricity output
Electricity output of the FG-1 was 3649,39 kWh on average.

APPENDIX 2. FG-1 (Adopters) Quantitative results

A. Gender, Age, Education

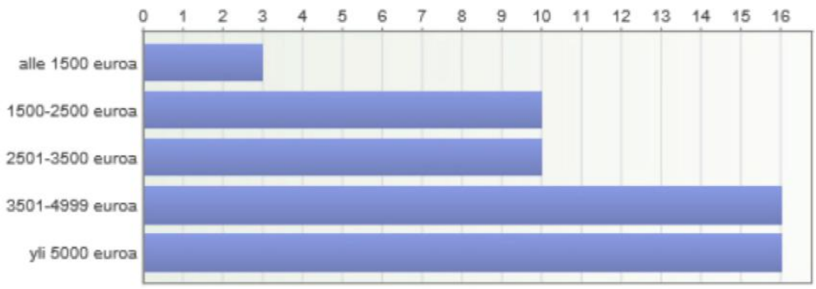
4. Ammatti

Vastaajien määrä: 55

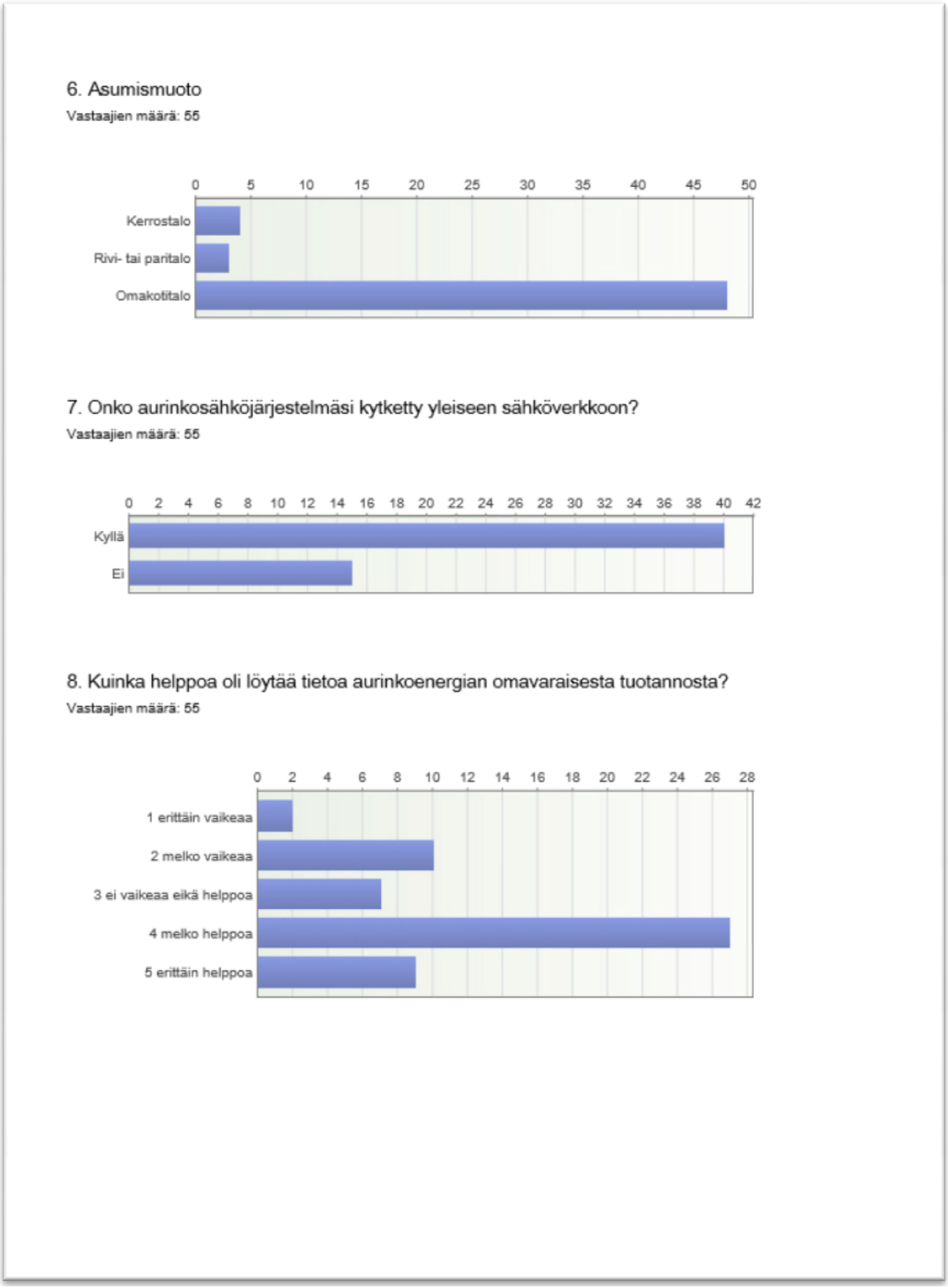


5. Tulot (€ / kk, brutto)

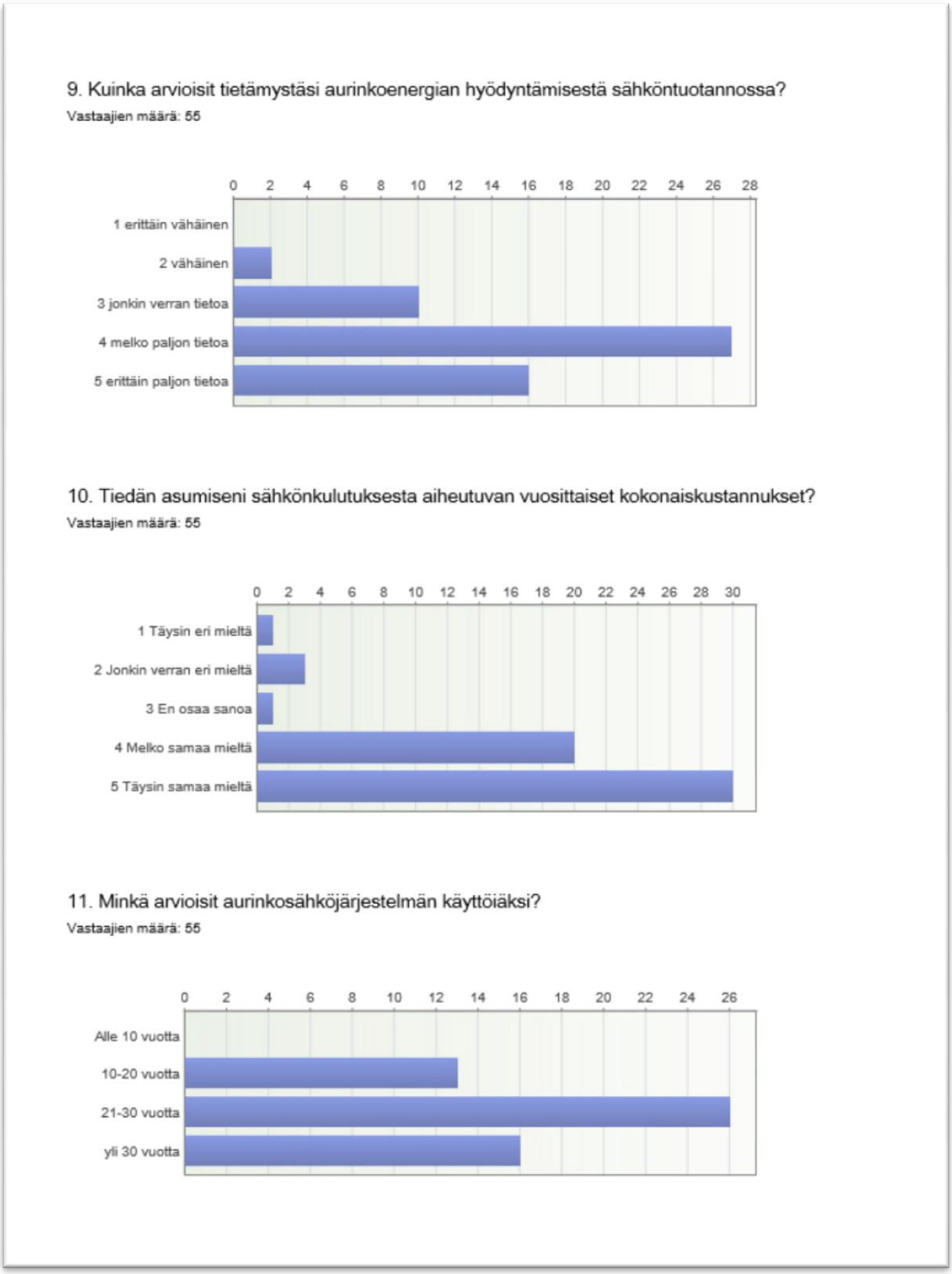
Vastaajien määrä: 55



B. Occupation, Income



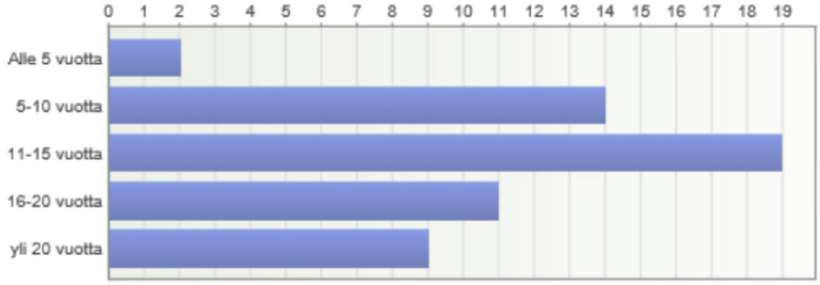
C. Resicence, Grid or not, How easy was it to find knowledge about PV micro production



D. Level of knowledge about PV micro production, Awareness of the costs of electricity, Working life of a PV system

12. Minkä arvelisit kiinteistösi aurinkosähköjärjestelmän takaisinmaksuajaksi? (järjestelmän kokonaiskustannus huoltoineen verrattuna ostosähkön hintaan vuosien aikana)

Vastaajien määrä: 55



13. Näkemyksiä aurinkosähkön omatuotannosta 1= Täysin eri mieltä, 2= Jokseenkin eri mieltä, 3= Ei samaa eikä eri mieltä, 4= Jokseenkin samaa mieltä, 5= Täysin samaa mieltä

Vastaajien määrä: 55

	1	2	3	4	5	Yhteensä	Keskiarvo
Aurinkosähkön omatuotanto on ympäristöystävällistä	1	1	1	11	41	55	4,64
Aurinkosähkön omatuotanto on kokonaiskustannuksiltaan Suomessa taloudellisesti kannattamatonta verrattuna ostosähköön	11	14	13	13	3	54	2,69
Aurinkosähkön omatuotannosta on vaikeaa löytää tietoa	11	22	11	6	5	55	2,49
Aurinkosähköjärjestelmän hankinta on hankala prosessi	15	23	8	7	2	55	2,24
Aurinkosähköjärjestelmä pilaa maiseman	37	13	3	0	2	55	1,49
Aurinkosähköjärjestelmä talon katolla kertoo talon omistajan vastuullisemmasta suhtautumisesta ympäristöasioihin	1	0	11	22	21	55	4,13
Yhteensä	76	73	47	59	74	329	2,94

E. Payback time, Views on solar PV production

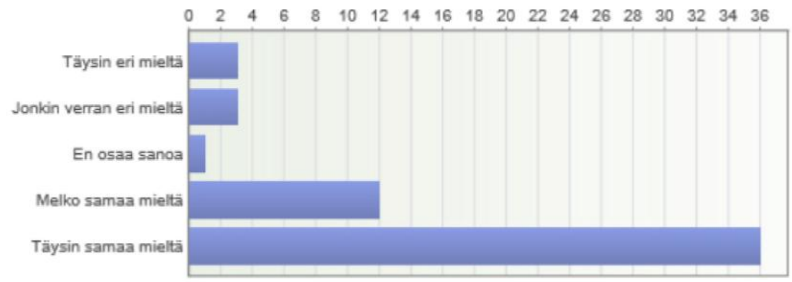
14. 15. Kuinka tärkeitä seuraavat asiat ovat sinulle? 1= Ei lainkaan tärkeää, 2= Ei kovin tärkeää, 3= Melko tärkeää, 4= Tärkeää, 5= Erittäin tärkeää

Vastaajien määrä: 55

	1	2	3	4	5	Yhteensä	Keskiarvo
Sähkön hinta	1	5	9	22	18	55	3,93
Sähkön tasainen hinta tulevaisuudessa	1	8	12	18	16	55	3,73
Sähköliittymän luotettavuus	1	2	4	13	34	54	4,43
Sähköntuotannon ympäristöystävällisyys	1	4	8	19	23	55	4,07
Sähkön kotimaisuus	2	2	13	16	22	55	3,98
Sähköliittymän käyttöönoton helppous	0	1	13	22	18	54	4,06
Energian säästäminen	0	3	7	16	29	55	4,29
Suomen energiaomavaraisuus	0	1	3	22	28	54	4,43
Yhteensä	6	26	69	148	188	437	4,11

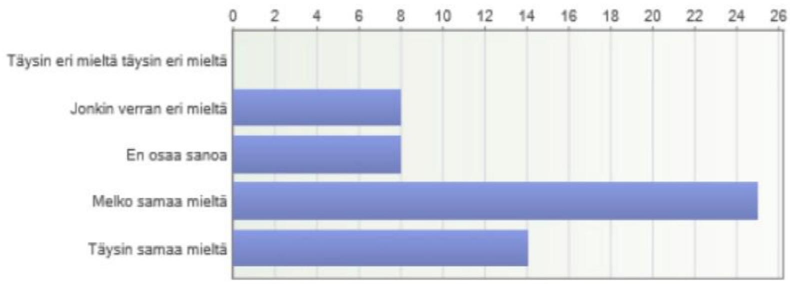
15. Uusiutuvia luonnonvaroja tulisi käyttää mahdollisimman paljon

Vastaajien määrä: 55



16. Teen omalta osaltani tarpeeksi edistääkseni kestävää kehitystä

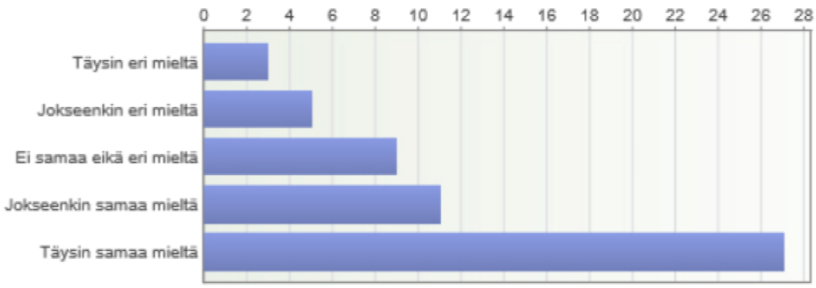
Vastaajien määrä: 55



F.
How important the following things are to you? Renewable resources should be used as much as possible, I contribute enough to support sustainable development

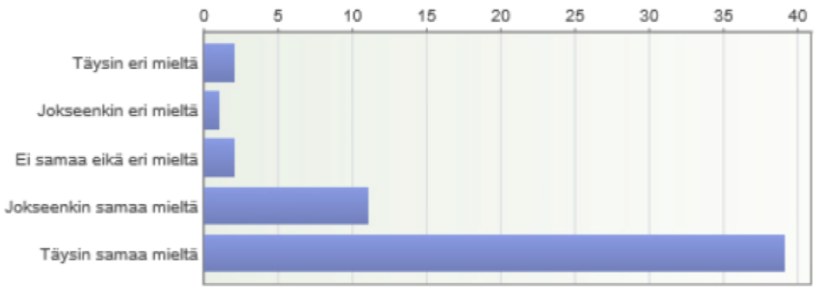
17. Oman aurinkosähkön tuotantolaitoksen hankkiminen on vaikuttanut energiankulutukseeni sitä vähentävästi

Vastaajien määrä: 55



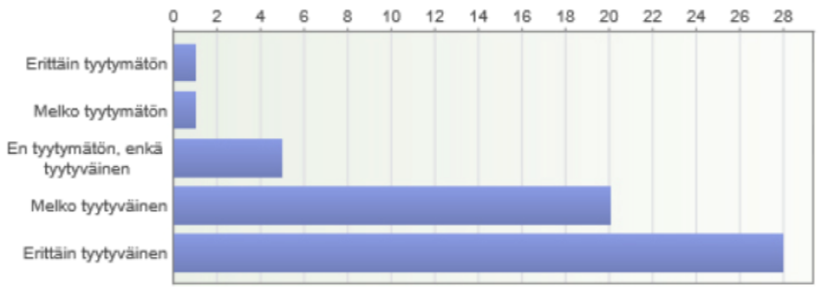
18. Koen mielihyvää siitä, että tuotan itse osan käyttösähköstäni

Vastaajien määrä: 55



19. Kuinka tyytyväinen olet aurinkosähkön tuotantojärjestelmääsi

Vastaajien määrä: 55



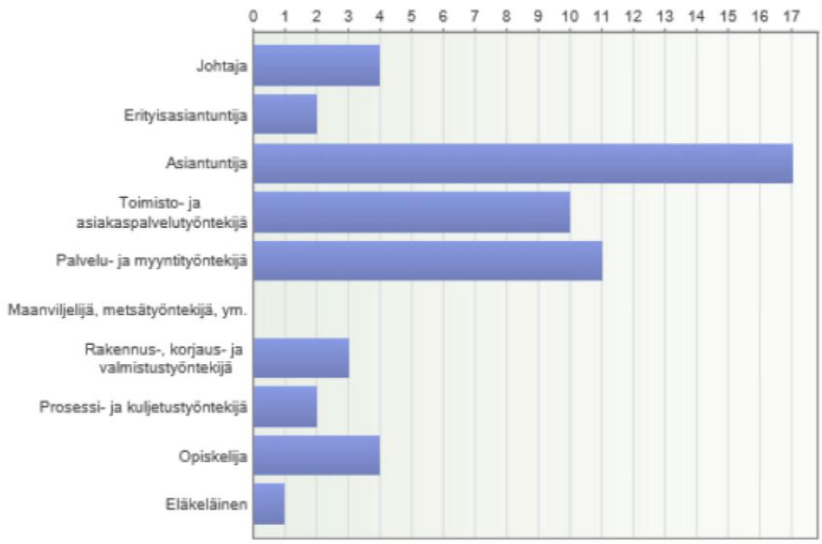
G. Own PV system has had effects on my use of electricity, I feel good about producing my own electricity, How satisfied are you to your PV system?

APPENDIX 2. FG-2 (Non-Adopters) Quantitative results

H. Gender, Age, Education

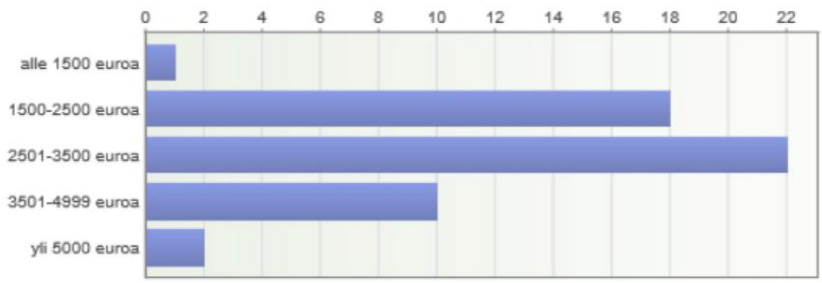
4. Ammatti

Vastaajien määrä: 54



5. Tulot

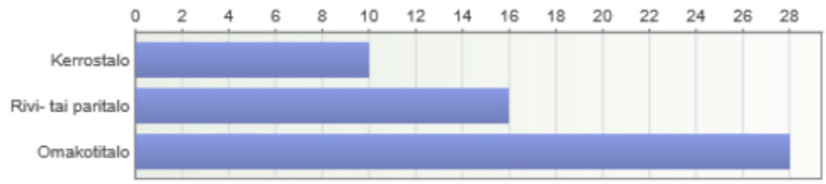
Vastaajien määrä: 53



I. Education, Income

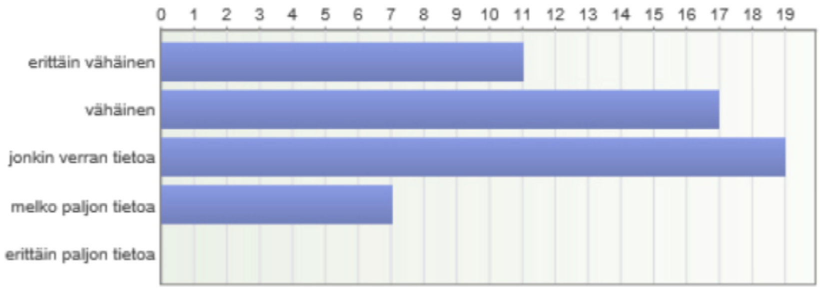
6. Asumismuoto

Vastaajien määrä: 54



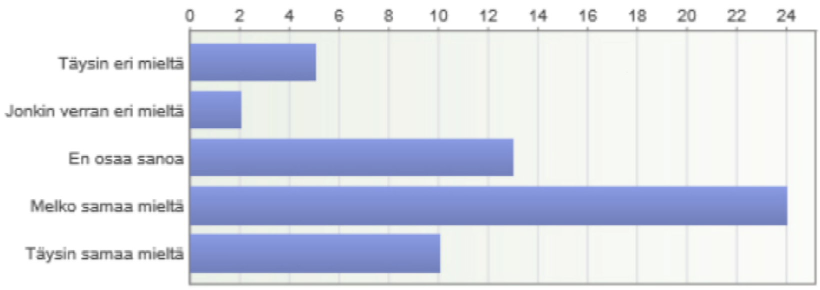
7. Kuinka arvioisit tietämystäsi aurinkoenergian hyödyntämisestä sähköntuotannossa?

Vastaajien määrä: 54



8. Aurinkosähkön omatuotanto kiinnostaa minua

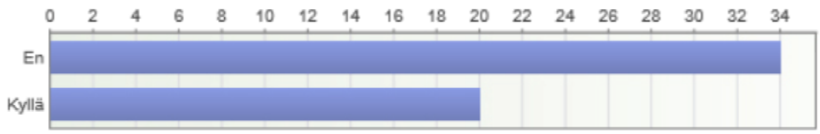
Vastaajien määrä: 54



J. Residence, Level of knowledge, Solar PV micro production interests me

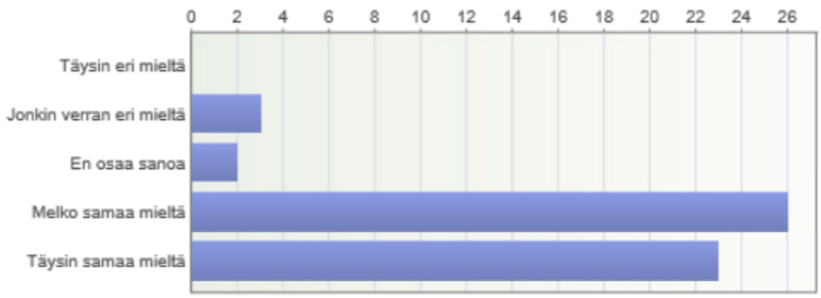
9. Olen harkinnut aurinkosähköjärjestelmän hankkimista

Vastaajien määrä: 54



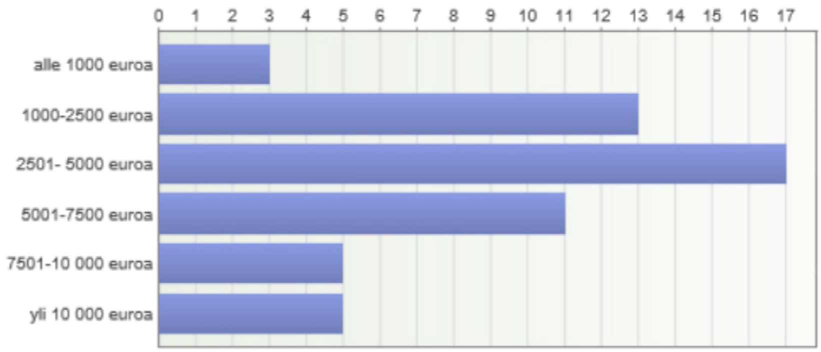
10. Tiedän asumiseni sähkönkulutuksestani aiheutuvat vuosittaiset kokonaiskustannukset

Vastaajien määrä: 54



11. Kuinka paljon arvioisit oman aurinkosähkön tuotantojärjestelmän kokonaiskustannukseksi asunnossasi?

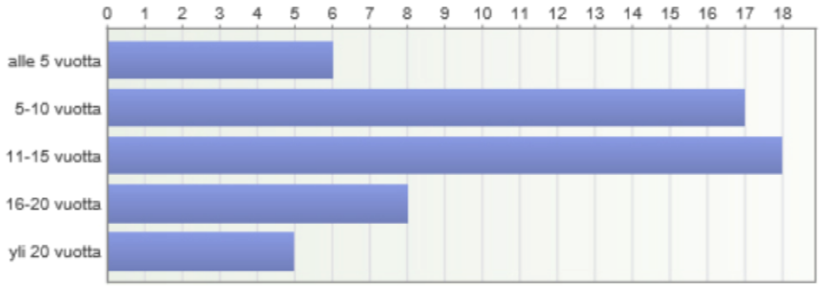
Vastaajien määrä: 54



K. I have thought of acquiring a PV system, Awareness of the costs of electricity,Estimated price of a PV system

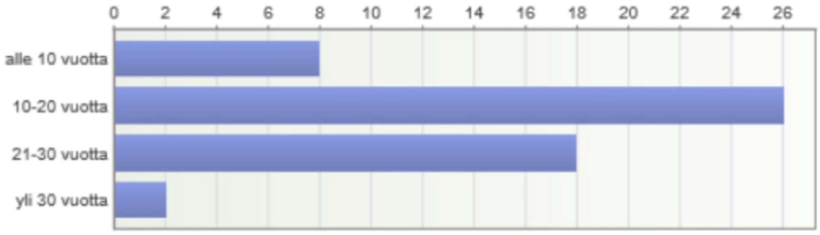
12. Minkä arvelisit asuntosi aurinkosähköjärjestelmän takaisinmaksuajaksi? (järjestelmän kokonaiskustannus huoltoineen verrattuna ostosähkön hintaan vuosien saatossa)

Vastaajien määrä: 54



13. Minkä arvioisit aurinkosähköjärjestelmän käyttöiäksi?

Vastaajien määrä: 54



L. Payback time, Working life of a PV system

14. Näkemyksiä aurinkosähkön omatuotannosta 1= Täysin eri mieltä, 2= Jokseenkin eri mieltä, 3= Ei samaa eikä eri mieltä, 4= Jokseenkin samaa mieltä, 5= Täysin samaa mieltä

Vastaajien määrä: 54

	1	2	3	4	5	Yhteensä	Keskiarvo
Aurinkosähkön omatuotanto on ympäristöystävällistä	2	0	4	17	31	54	4,39
Aurinkosähkön omatuotanto on kokonaiskustannuksiltaan Suomessa taloudellisesti kannattamatonta verrattuna ostosähköön	5	10	25	11	3	54	2,94
Aurinkosähkön omatuotannosta on vaikeaa löytää tietoa	0	11	21	16	6	54	3,31
Aurinkosähköjärjestelmän hankinta on hankala prosessi	0	11	25	13	5	54	3,22
Aurinkosähköjärjestelmä pilaa maiseman	15	19	13	5	2	54	2,26
Aurinkosähköjärjestelmä talon katolla kertoo talon omistajan vastuullisemmasta suhtautumisesta ympäristöasioihin	3	2	9	26	14	54	3,85
Yhteensä	25	53	97	88	61	324	3,33

15. Kuinka tärkeitä seuraavat asiat ovat sinulle? 1= Ei lainkaan tärkeää, 2= Ei kovin tärkeää, 3= Melko tärkeää, 4= Tärkeää, 5= Erittäin tärkeää

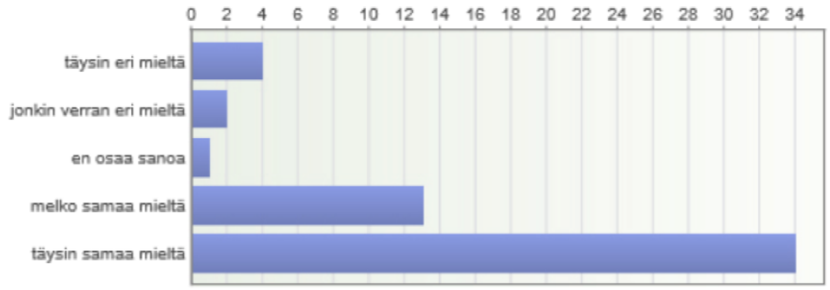
Vastaajien määrä: 54

	1	2	3	4	5	Yhteensä	Keskiarvo
Sähkön hinta	0	1	6	19	28	54	4,37
Sähkön tasainen hinta tulevaisuudessa	0	1	5	26	22	54	4,28
Tuotetun sähkön ympäristöystävällisyys	0	4	10	22	18	54	4
Tuotetun sähkön kotimaisuus	0	4	8	25	16	53	4
Sähköliittymän käyttöönoton helppous	0	5	12	19	18	54	3,93
Sähköliittymän luotettavuus	0	0	1	17	36	54	4,65
Energian säästäminen	0	0	8	17	28	53	4,38
Suomen energiaomavaraisuus	0	0	8	25	21	54	4,24
Yhteensä	0	15	58	170	187	430	4,23

16. Uusiutuvia luonnonvaroja tulisi hyödyntää mahdollisimman paljon

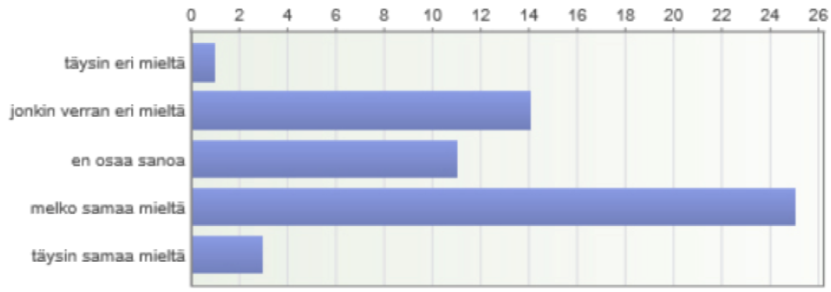
Vastaajien määrä: 54

M. Views on solar PV production, How important the following things are to you?



17. Teen omalta osaltani tarpeeksi edistääkseni kestävää kehitystä

Vastaajien määrä: 54



N. Renewable resources should be used as much as possible, I contribute enough to support sustainable development