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Solar Energy: Jobs and Technology
- Learning from Developments in Norway and Germany 2001-2015

MSc in Innovation and Entrepreneurship

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Summary:

The thesis investigates three trends in the development of jobs in the PV industry in Norway; one growth from 2001-2010 (trend 1), followed by a rapid decline in 2010/2011 (trend 2), and then a growth again in 2011-2014 (trend 3).

By studying the variables of the technology and other resources of the firms, the market and the industry, in addition to the surrounding governmental regulations, incentives, and the culture, the strategic advantages of a nation may be found. Three theories from a strategic tripod; the resource-based view, the industry-based view and the institution-based view, will form the structure of the thesis, and will seek to uncover the mentioned trends of study. In addition, a comparison will be made with Germany. This makes it possible to analyze the job creation in the PV industry in Norway, in addition to find explanations for the development.

There was no single-factor conclusion. All of the three variables were necessary and could partly explain all of the three trends. By this, the importance of the combined effects of the three variables of the strategy tripod became clear. I found that, for trend 1, the industry- and resource-based views were found to be important, especially the growing global market, competence and contracts with suppliers. Trend 2, was mainly explained by the institution- and industry-based view, where the Chinese government's aid to its own PV manufacturers over flooded the market, resulting in a price war. The rapid decline compared to Germany could be a result of the lack of differentiation in Norway. Trend 3 showed primarily to be a result of the resource-based view, namely, a new technology focus and uniqueness, but also the industry- and institution-based view, with more focus on a concentrated part of the value chain and a high community spirit.

Keywords for the library: Photovoltaic, PV, solar cells, job creation, technology innovation, renewables, energy, resources, industry, institutions, Norway, Germany, competitive advantage, strategy

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ABSTRACT

The number of jobs in Norway has shown a decrease during the last couple of years, mainly triggered by the falling price of oil and gas (SSB, 2015). Due to this, much competence and knowledge has been set free. One sector, in particular, has been growing almost nonstop globally, and has become a challenger to the prominent position of the oil and gas industry. In 2015, renewable energy sources was the most invested energy source, growing past fossil fuels for the first time (UNEP and Bloomberg, 2016). Of this, solar energy gave the biggest contribution. In 2006, Norway was the biggest producer in the world of wafers (IEA PVPS Norway, 2006). This is a part of the value chain of photovoltaics (PVs), also known as solar cells. PV production in Norway has led to a growth in the number of jobs, but in 2010, the country witnessed a sharp decline.

Today, Norway's job creation in the PV industry is on its way up again, and the hope is that it again can facilitate jobs in order to make use of the free competence and knowledge in the country. In order to do so, one needs to learn from the past. So, what can explain the job creation development in the PV industry in Norway? Several papers and theses have addressed this question, but they are not up to date, and lack discussion of recent developments (Koesah, 2013; Klitkou and Godoe, 2013). In addition, some have focused solely on production and silicon PVs (Hanson, J., 2006), while the aspect of other technologies and the question of job creation is less prevalent in the literature. It may also be useful to compare the development with another country that has been important for the PV emergence, and that has had a more "normal" energy mix, compared with hydropower in Norway. This may uncover learning that has not previously been considered. Germany was chosen for this purpose.

My contribution to this field is to discuss and compare the PV industry's contribution in generating jobs in Norway and in Germany, learning from the past to find possible strategies for the future. This will be conducted with a mixed method approach. The discussion is seen in light of three different aspects, namely the companies' PV technology, the market/industry, and thirdly, in light of the surrounding environment of culture and governmental regulations and incentives. The three aspects are analyzed utilizing a strategy tripod tool of Peng et al. (2009)

that contains: Barney’s (1995) resource-based view, Porter’s (1980) industry-based view, and Scott (2008) and North’s (1990) institution-based view, respectively.

This approach shows a complex picture, where each of the three views, point at both individual and jointly combined explanations for the ups and downs of the job creation in the PV industry, and also between the two countries. My thesis claims that there are three historical trends in the Norwegian development of jobs created from the PV industry, one growth (trend 1), followed by a rapid decline (trend 2), and then growth again (trend 3). The three trends are compared with the German development, and together with the strategy tripod, the development in Norway is discussed. The first trend revealed to, mainly, be a result of prior R&D knowledge, silicon production, metallurgic competence from other industries, a growing market and contracts with foreign suppliers. The second trend reflects, among other underlying explanations, the Chinese government’s incentives, resulting in a price war in the PV market, as the main reason for the decline. The third trend showed mainly to be a result of focus on quality, innovation and a different technology, in addition to experience from a concentrated part of the value chain and community spirit. These explanations goes to show that each of the tripod parts alone, do not serve sufficient explanations. All of the three parts of the tripod, in addition to its combined effects, are necessary for an adequate conclusion of the development of PV jobs in Norway. At the end, the result shows several implications for the future job creation in the PV industry in Norway.

PREFACE

This thesis marks the end of a two-year Master of Science in Innovation and Entrepreneurship offered by Bergen University College and the University of Oslo. It has been a desire to write the thesis based on my educational background, both the natural and social sciences.

I would like to thank my supervisors, Åge Garnes and Tom Skauge at the Bergen University College, for their patience and valuable time spent on guiding me through the vast field of theories and research on the matter. The constructive advice and many discussions on the design and subject of the thesis have helped me and been a great inspiration.

I would also like to thank Dhayalan Velauthapillai, an acknowledged PV researcher at Bergen University College. His superior knowledge on PV technology has been helpful in regards to my learning, and has served as great guidance through the gathering of technological data for the thesis.

I would further like to thank the interviewees for their valuable time spent answering my questions. Alf Bjørseth, an expert with extensive knowledge dating back to the emergence of the PV industry in Norway, and Erik Stensrud Marstein, an expert in particularly PV R&D and collaborations.

Hanne Sjøvold Hansen

Bergen, May 2016

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1. Introduction

1.1. Background

Sieferle (1990) claimed that the social framework of man's society may function, only if large amounts of energy is mobilized. The world's growing demand for energy (IEA, 2015a) has led to the development of a range of technologies for harvesting energy. Whether oil, gas, wave power or other energy sources are utilized, the sun has originally been the energy contributor for that source, set away from a small fraction (Guinan and Ribas, 2002). In an attempt to find more sustainable energy sources, the focus the last few years, or even decades, has developed in the way of renewables. This is evident when the annual renewable energy capacity installed in 2015 was more than half of the entire energy capacity installation in the world, and the most invested energy source was renewable energy (UNEP and Bloomberg, 2016). Some of these technologies utilize the sun directly. These are solar thermal energy, which exploits the heat from the sun, solar fuels, that make chemical use of chemical reactions, and last, solar cells, also known as photovoltaics (PV), that utilize the sun to make electricity.

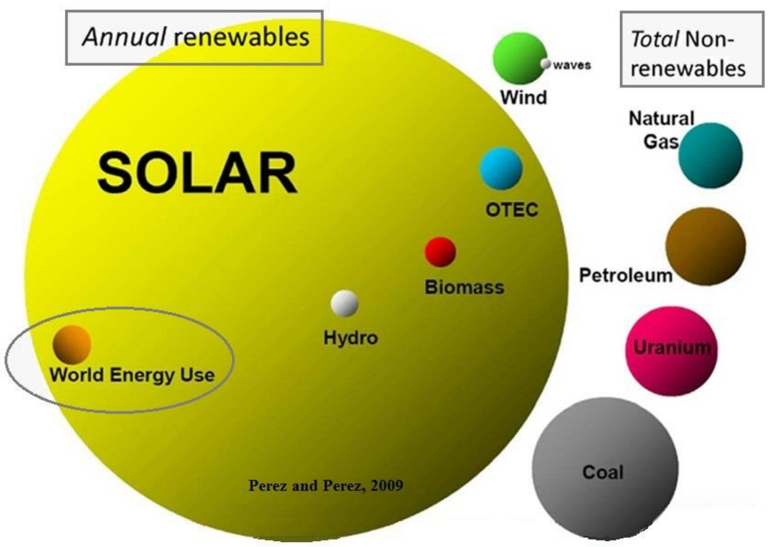


FIGURE 1: THE ANNUAL ENERGY POTENTIAL OF RENEWABLES COMPARED TO THE KNOWN RESERVES OF THE FINITE ENERGY OF NONRENEWABLE ENERGY SOURCES, PRESENTED FIGURATIVELY. THE ORANGE "PLANET" TO THE LEFT IN THE FIGURE, THAT IS CIRCLED, SHOWS THE ENERGY USE OF THE WORLD IN 2009. (SOURCE: EDITED VERSION OF PEREZ AND PEREZ, 2009).

Based on effective installed capacity, solar energy has the potential to be the largest environmentally friendly energy source by 2020, because solar radiation is the most available source around the world (Smets et al., 2015). Comparing the annual energy potential from the sun with other energy sources corresponds with this (see figure 1). The annual energy available from the sun exceeds the finite energy available from uranium, oil and gas. It is not completely correct to call the latter sources finite, but compared to renewables, the regeneration of these sources is of such a long timeframe that they may be seen as finite. Figure 1 demonstrates the sun's superior advantages with regards to annual availability compared to the other energy sources, both finite and renewables.

My thesis focuses on the electricity generating solar source, namely the PV. The PV energy might qualify for all the three dimensions in the Triple bottom line: Economic, social and environmental (Carson et al., 2015:191), which is outlined in the debate on corporate social responsibility. In this thesis, the environmental part of PVs should be clear, and reading from the recent developments in the jointly set goals of zero net emissions by the midcentury in COP21 in Paris in 2015 (UNEP and Bloomberg, 2016), there is a social and economic commitment to climate change. This leads to new opportunities for generating jobs in Norway, where the social and economic dimensions of the Triple bottom line would be applied, again, resulting in a strategy for environmental change. This measure should be considered, bearing in mind the decline in the number of jobs in Norway the last couple of years, due to the changes in the oil and gas industry.

Jobs in the PV industry can range from manufacturing of materials to operation and maintenance of the main grid. This thesis however, focuses on jobs from manufacturing of materials, cells and modules, while the rest of the value chain will play a role in the discussion. The focus is on the production part, because this is the part that is, to some extent, independent of whether or not the sales and market grow in the specific country that is studied.

The production shares of PVs have shifted from the Asia Pacific region and the US, to prominence in Europe and the Asia Pacific region until 2005, before China became the market leader (Smets et al., 2015). Two countries that were leading in each their period, during the European era of dominance, were Norway and Germany (Alstadheim, 2000; IEA PVPS Norway, 2006). Comparing Norway, one of the smallest countries in Europe, with Germany, one of the biggest, may show learnings. Large countries may often be more subject to institutional and market factors, due to the greater impact, both positive and negative. In addition, Germany has had a different energy mix, where fossil electricity has been dominant, while Norway depends on hydropower.

In both Norway and Germany, the PV industry has experienced unstable and fluctuating progress. Based on the recent numbers on PV investment, where PVs are most invested among the renewables (UNEP and Bloomberg, 2016), in addition to the historical shift in production shares, it is not expected that it will stabilize yet. The research questions in my thesis try to uncover this fluctuation, and find possible explanations and understandings:

How has the number of jobs in the PV industry in Norway developed from 2001-2015? How can we explain this development? What can we learn from the past and from mirroring the Norwegian development with that of Germany?

1.2. THESIS BUILD-UP

Chapter 2 deals with the theory of the dependent variable of jobs, in addition to three chosen variables, that is presented successively. For the purpose of the thesis, the theories are summed up and operationalized at the end of chapter 2. The research method, design and objects are presented in chapter 3, before the results and discussion are presented in chapter 4. The discussion is divided in regards to the three theories. First, the technologies are investigated with the resource-based view, second, the market and industry are studied with the industry-based view, and at last, the governmental regulations and incentives, in addition to culture, are studied by using the institution-based view. A table of summary presents the results at the end of each subchapter. This table is based on relatively constructed terms, only meant for comparison between the different variables. Subchapter 4.3 sums up these three parts, in addition to looking at the results in a new way. Following this, subchapters 4.4 and 4.5 represent future outlooks and recommendations based on the historic development of jobs, and imply new theoretical recommendations, respectively. Finally, in chapter 5, a conclusion is presented, and further research is implied in chapter 6.

2. THEORY

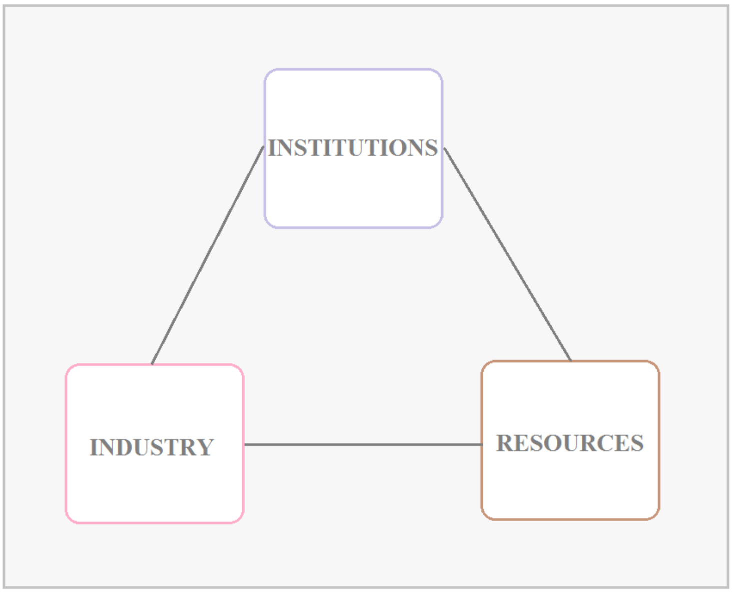


FIGURE 2: EDITED VERSION OF PENG ET AL.'S (2009) STRATEGY TRIPOD.

It is a belief that the dependent variable of the number of jobs in the PV industry will be influenced by strategies conducted by the surroundings, whether it is the firm, the government or the market. The theory build-up of the variables of the thesis is based on figure 2, so that each part is sufficiently covered. The reason for the three chosen variables was a result of the theory collection. In the field of strategy, there is a vast variety of fields that have been and are being investigated from various perspectives; SWOT analysis and PESTEL analysis, are some examples.

From the beginning of the writing process of the thesis, the PV technology was in focus. This was chosen from the understanding that the PV technology has had a central role in Norway, due to knowledge, competence and experience from the metallurgic industry and from early research and development (R&D) on the subject (Kitkou and Godoe, 2012). One important strategy theory that includes technology, when investigating the competitiveness of firms, is the resource-based view of Barney (1995). It also became clear that Porter's (1980) industry-based view had been an important starting point for Barney's resource-based view. Finally, a tripod (Peng et al., 2009) became clear in the literature (see figure 2), after many years of defining institutions (Scott, 2008; North, 1990). Therefore, the institution-based view was also chosen. Choosing only one of these may show deficiencies, where the different views have revealed shortcomings of the others (Barney, 1995; Peng et al., 2009). To be able to cover most of the relevant subjects for the development of jobs in Norway, all of these theories are reviewed. The three theories are discussed and operationalized in the following subchapters, before they are gathered into one tool towards the end of the theory chapter. First, however, the dependent variable of the development of jobs in the PV industry needs to be defined.

2.1 Jobs

This thesis investigates the development in the number of jobs in the PV industry in Norway, with the aim of uncovering improvements and lessons for future development. PV is predicted to be one of the biggest electricity providers by 2050 (IEA, 2014). This will probably be an important factor to consider when developing strategy at the firm level, and when developing the strategy of the whole Norwegian PV industry, in order to create jobs.

A job is something most people, in most parts of the world, can relate themselves to. It can be considered a necessity or a luxury, but it is clear that jobs create a circulation of money, contributing to the development of an economy in a society. The more people that have jobs, the more people are able to pay for products and services from other people that are working. This is known as division of labor, where some workers specialize in particular products or services, while other workers specialize in other products or services (Arntzen, 2009). This is what the economy is built on, and it shows a virtuous circle where the whole system benefits from a growing work force (Reich, 2014).

Regarding the growing demand for energy worldwide, opportunities for creating jobs within this sector, are many. However, jobs within the renewable energy sector possess an especially unique opportunity to fulfill the Triple bottom line. The Triple bottom line comprises the social, economic and environmental dimensions (Carson et. al., 2015). The environmental part of the PV as an energy source and product may be clear, and reading from recent developments in the jointly set goals in Paris in 2015, there is social and economic commitment to climate change, affecting the choice of energy sources in the years to come. Job creation in this sector may prove to be sustainable, and should be a possible strategy for Norway.

Jobs in the PV sector cover a range of fields, from the production of metals and other raw materials, the production of contacts and wires, and the production of machines that produce these former mentioned parts, to the sale and administration, installation and maintenance of PVs. This shows a complex and diverse sector, even when several parts have not been mentioned. An attempt to gather important parts of this sector in to one value chain can be seen in figure 3.

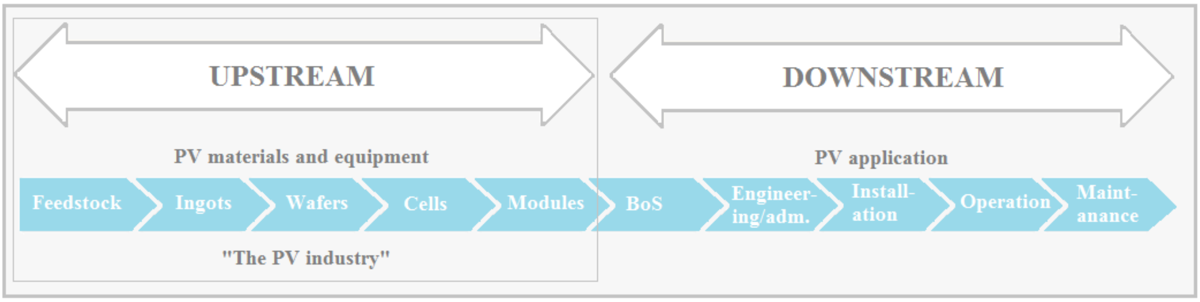


FIGURE 3: THE PV SECTOR PRESENTED IN A POSSIBLE REPRESENTATION OF A VALUE CHAIN. FOR THIS THESIS, THE IN THEORETICAL RELATIVE, TERMS "UPSTREAM" AND "DOWNSTREAM" ARE DEDICATED TO EACH HALF. THE UPSTREAM PART IS THEREBY DEFINED, AND REPRESENTS THE DEPENDENT VARIABLE OF THE JOBS IN THE PV INDUSTRY FOR THIS THESIS.

The use of the terms "upstream" and "downstream" are relative, but are chosen to represent this division for the purpose of the discussion in this thesis. The "upstream" part of the value chain is characterized as *the PV industry* in my thesis, while the entire value chain is called the PV sector. This comes from Hill and Jones (2013), where a sector is defined as a group of closely related industries. My definition of the PV industry offers jobs in the production of raw material, ingots, wafers, cells and modules (squared in figure 3). The manufacturing part, or the upstream part, of the value chain is the part of the sector where Norway, mostly, has been participating, historically, and is therefore the natural choice for the further investigation. For the purpose of this thesis, the diverse PV value chain is therefore defined as a sector, while a chosen smaller portion of it, the upstream part, is defined as the PV industry. By this, the boundaries of the chosen dependent variable have been defined.

Gary Higgins has claimed that the right manufacturing industries contribute more to the economy than other sectors are able to do in a developed economy (Heskett, 2012). However, these jobs are normally easier to "steal" by other companies or countries, and they can be termed tradable jobs. The jobs in the defined PV industry in this thesis are examples of tradable jobs. The tradeable jobs may add more value per employee (Spence and Hlatshwayo, 2011), and by being closer to the product, strategies towards research and innovation may be easier to implement, adding even more value to the industry. This makes it an important task for the national economy to keep manufacturing jobs within the country.

The importance of jobs in the PV manufacturing industry in regards to value added should now be clear. The number of jobs in the PV industry is the dependent variable in the two countries, and three variables, with accompanying strategy theory, seek to discover this development. It is the belief that the strategy of a firm or a nation, will influence competitiveness, and by that, the ability of job creation. Following this, the theory to investigate this job creation is presented. The first part deals with the technology of PV, to understand the actual product of which the jobs create. The accompanying resource-based view of Barney (1995) follows in the next subchapter. The theory of the surroundings is covered by the industry-based view of Porter (1980) and the institutional-based view of Scott (2008) and North (1990), in that order. A historical analysis is intended to reveal the explanations for this development. The focus is from the Norwegian point of view, where the German situation seeks to help explain further.

2.2 PV TECHNOLOGY

Energy is defined as the capability to do work, and it is a quantity that can change from one form to another, but it is assumed that it never is consumed in any way. That is, energy is always conserved (Chang and Overby, 2011). One important aspect when converting energy to another form is the conversion degree to the desired form. When a person is pushing a box on the floor, from one side of the room to the other, chemical energy stored in the person is converted in to kinetic energy to do the actual pushing, but some energy is lost in the form of heat between the floor and the box, as well. The degree to which energy is converted to the desired form can be calculated by dividing the actual energy output, in the form of the desired energy form, by the energy input. This results in the term *efficiency*, which is an important term within PVs, as we will see.

The sun is the Earth's primary energy source (Chang and Overby, 2011). The electromagnetic radiation from the sun includes energies with wavelengths ranging from approximately 0.3 to 3 µm (Lillestøl et al., 2006). The radiation from the sun contributes to an energy of 230 W/m^2 on average around the Earth. This energy can be utilized indirectly and directly. The direct conversion is important for this thesis, where there are three different approaches, namely; converting it into energy in the form of heat, chemical fuel or electricity. The focus in this thesis is on solar energy converted into electricity.

The photoelectric effect is defined as the ejection of electrons from a material that is exposed to light with at least a certain minimum frequency (Chang and Overby, 2011). This utilization of light particles, also called photons, can generate current or voltage, thus giving rise to the phenomenon of the photovoltaic (PV) effect. This can happen in numerous ways, where the use of semiconductors is the abundant method. A semiconductor is a material that with increasing temperature increases its electric conductivity (Atkins et al., 2010). A semiconductor utilizes a band gap (see figure 4). This band gap represents the energy difference between the valence

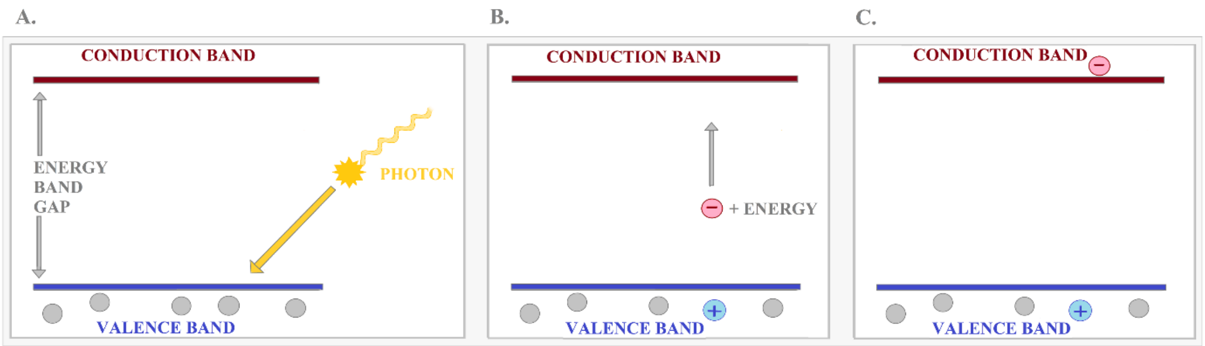


FIGURE 4: A) THE ENERGY BAND GAP IN A SEMICONUCTOR IS PRESENTED, WHERE THE VALENCE BAND CONTAINS THE ELECTRONS. A PHOTON WITH ENERGY IS APPROACHING. B) THE PHOTON HITS ONE OF THE ELECTRONS, AND THE ENERGY IS SUFFICIENT TO KICK IT OUT OF THE VALENCE BAND, LEAVING A POSITIVE LOADED HOLE. C) WITH ENOUGH ENERGY, THE ELECTRON CAN ENTER THE CONDUCTION BAND, AND CONTRIBUTE TO THE FLOW OF ELECTRONS, ALSO KNOWN AS ELECTRICITY.

band (the band where the outer electrons are) and the conduction band. For a photon to give rise to an electron moving from the valence band to the conduction band, it must have, at least, the same amount of energy that the band gap consists of. When this is fulfilled for the semiconductors, the photon's energy gives rise to the formation of free carriers or excitons (see figure 4 B), depending on whether the absorbing material is inorganic or organic, respectively (Jayawardena et al., 2013). The band gap enables a situation where the excited free carriers or excitons obtain a longer time period in the conduction band before they recombine to their original state in the valence band, thus making the probability of utilizing their energy to make current in the conduction band much higher. The band gap also represents the radiation energy that a material can utilize to make electricity, because smaller energy amounts will go directly through the material and larger energy amounts will, among other cases, give rise to electrons ending up in other energy bands that are not controlled, thus creating thermal energy. Due to this phenomenon, the material's band gap represents the material's possibilities and limitations.

As can be seen, the PVs are mainly based upon the utilization of semiconductors. This is further explained in the following subchapters, where the division is made upon generations. These generations represent different goals and different ways of utilizing materials. The distinction between these generations is not necessarily apparent, and the grouping is not consistent. While some researchers divide the generations by inorganic, organic and hybrid (a mix of organic and inorganic) PVs (Babu et al., 2014), other researchers divide the generations based on a chronological and problem-solving manner (Smets et al., 2015; Jayawardena et al., 2013). Because this thesis investigates a development over time, the latter definition of the different PV technological generations is the chosen one. In each subchapter is a description of some of the most common technologies produced or researched. The 3rd and 4th generations are gathered in the same subchapter because there are disagreements regarding what is what, and if there even exists a 4th generation. I have chosen to include it due to the importance of covering all of the aspects in the PV technology.

2.2.1 1ST GENERATION

Crystalline silicon is the most widely used semiconductor in PVs (Office of Energy Efficiency and Renewable Energy, 2013), and is regarded as the traditional component in the 1st generation (1G) of PVs. Germanium is also used as a semiconductor, but to a less extent (NTNU, n.a.). A crystalline material has an ordered structure that can be divided into several, repeating geometries. The opposite of a crystalline material would be an amorphous material, which does not have a repeating structure. Silicon in its pure crystalline form has a structure like diamond.

Crystalline silicon wafers are often divided in two groups, namely polycrystalline silicon (p-Si) and monocrystalline silicon (mono-Si). The first mentioned type consists of several crystals, while the last mentioned only consists of one crystal, just as the names imply. p-Si has shown to transform around 21% of the energy from solar radiation, into electricity. Mono-Si is more effective and can transform almost 26% of the energy into electricity (Fraunhofer ISE, 2016:24), but in turn, the production of these cells requires a lot more energy. This is due to the need for cleaner feedstock materials, better control and energy during production, which in turn gives perfect structures without dislocations or grain boundaries.

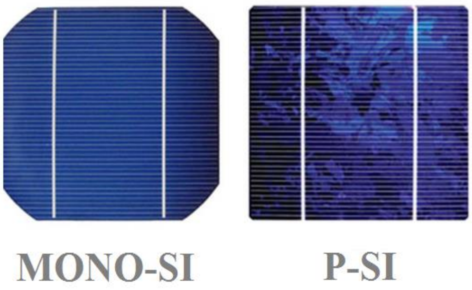


FIGURE 5: MONO-SI CELLS, WITH A UNIFORM COLOR, COMPARED TO THE VARYING COLORS IN P-SI, AS A RESULT OF SEVERAL CRYSTALS. THE LINES THAT MAY BE SEEN ON THE WAFERS, ARE WIRES. EDITED VERSION OF SOLAR CLOSET, 2015.

The product, either it is mono-Si or p-Si, originate from a production of solar grade silicon, also known as feedstock. This needs to be properly pure, depending on either of the two groups. After this, an ingot is produced, which is a block of pure silicon. Last, the wafers are cut out of this, which can be seen as thin slices of silicon. The p-Si wafers are blueish in color, with visible crystals, while the mono-Si wafers have a uniform color, which corresponds to one crystal (see figure 5).

2.2.2 2ND GENERATION

Development of the 2nd generation (2G) of PV began due to the wish to produce PVs at a lower cost, but in return, they have lower efficiency. The 2G PV focused on using less material, and less energy for production, lowering cost per watt and the time needed for the PV to generate the same amount of energy (Jayawardena et al., 2013). The result became thin films. They are created by a random nucleation process where atoms or molecules are condensed, or react on a substrate (Chopra et al., 2004). The active part of the thin films is the semiconductor. The semiconductors in thin films are mainly based on amorphous silicon (a-Si), Cadmium Telluride (CdTe), Copper Indium Selenide (CIS) and Copper Indium Gallium Selenide (CIGS).

The III-V technology has the highest conversion efficiency of the thin films. Examples of this combination include gallium arsenide (GaAs), indium arsenide (InAs), indium phosphide (InP), gallium phosphide (GaP) and gallium indium arsenide (GaInAs) (Smets et al., 2015). This technology and production is very expensive and is mainly used in space applications, but they are also being used in some applications on Earth. In Australia, a solar farm where sunlight is concentrated towards a small plate with GaAs, results in an efficiency of more than 35% (Wesoff, 2008).

a-Si, that is silicon that does not have an ordered structure on a molecular level, can be used in PVs. A problem with a-Si thin films is the loss in efficiency from around 16% to 13% after early use, mainly due to the light-induced degradation caused by recombination of free carriers (Smets et al., 2015). Crystalline silicon can also be used in thin films, making it possible to take advantage of the high efficiency of 1G and flexibility, and hopefully the low cost, of 2G (Smets et al., 2015).

CIGS and CdTe belongs to a group called chalcogenide PVs. CdTe PVs is currently the thin film with the lowest cost per watt (Smets et al., 2015), with a lab record of 19.6%, while the module CdTe record is 16.1%. A limitation for CdTe is that tellurium is a rare material. The largest limitation of CdTe PVs, however, is the toxic and environmental impact of cadmium. New materials that can replace cadmium are therefore being studied.

The CIGS thin film PV has reached the highest efficiencies of the thin film technologies, which is above 20% (Smets et al., 2015), but with the dependency on the very rare material of indium, CIGS PVs have upscaling and potentially economic limitations. In Madrid, a research group is trying to find a substitution for the rare materials made of indium (Bjørk, 2016). Their answer to this is the use of tin-, titanium- and gallium-oxides.

2.2.3 3RD AND 4TH GENERATIONS

With 3rd generation (3G) PVs, the goal is to utilize a larger part of the radiation from the sun, thus giving higher efficiency pr. m^2, and to lower the cost of production at the same time (Jayawardena et al., 2013). 3G PVs are also based on semiconductors. The semiconductor can transport the exited electrons or excitons, but there also needs to be something to absorb the photon energy in the first place. So what other materials can be semiconductors? Titanium dioxide, TiO_2, nanoparticles is an example that can be used as a semiconductor. From this, the 3G of PVs are comprised of the utilization of, among other, quantum dots, nanocrystalline films, perovskite, spectral conversion and multi-junction, including organic materials (polymers) and dye-sensitized solar cells (DSSC). Jayawardena et al. (2013) also include 4^{th} generation (4G) PVs in the division of PV generations, which aims at taking advantage of the low cost and flexibility of thin films, in addition to the stability of inorganic nanostructures. Whether or not the 3G and 4G should be divided in two or not has been, and is still being, discussed in the literature. For the purpose of this thesis, the two generations are reviewed together.

The DSSC is an example of a 3G PV. The original thought behind these PVs was to learn from nature, where trees and leaves take advantage of the sunlight in order to make chemical energy, by the use of chlorophylls (Sire, 2009). The semiconductor in DSSC is based on TiO_2 nanoparticles. The major drawback of DSSC is its weather dependency, where low temperatures and high temperatures can damage the PV, but it is in return a relatively cheap technology to produce. Research is currently focusing on solving the damage caused by temperature changes, and finding dyes that can utilize a larger fragment of the electromagnetic spectrum from the sun.

Another technology that actually takes advantage of a larger fragment of the solar light, is PV based on quantum dots. Quantum dots of varying size absorb radiation with altering wavelengths. These PVs do not have the drawbacks of wearing from temperature changes that the DSSC has. Quantum dots are spherical particles made up of a semiconducting material, with a diameter in the order of 2-10 nm (Sigma Aldrich, n.a.). These PVs can even be altered so that not only does the varying size of the quantum dots increase efficiency, but each dot can utilize photon energies that are higher than it would normally need to excite an electron, and then send the rest-photon energy to another dot to be utilized (Smets et al., 2015). It is a hope that quantum dot PVs can reach an efficiency of up to 50% (Sire, 2009), but they are, however, not commercially available yet.

Organic PVs developed due to the wish to produce larger volumes faster and at lower costs, compared to 1G (Kalowekamo and Baker, 2009). These PVs are defined as organic if the absorbing layer is made up of only organic material (Notarianni et al., 2013), causing the current to be dependent on the creation of excitons. The problem with these PVs is the lifetime, problems with largescale production and power conversion efficiency.

From this research, perovskite PV is under development. Perovskite is a mineral that has shown a great growth in efficiency in PVs since its beginning, and is a promising PV (Smets et al., 2015). Perovskite in PVs can be based on two positively charged molecules, one organic and one inorganic, and a third molecule that is negatively charged. Lead is usually used in the high performing PVs, but due to its toxicity, new materials are being investigated to replace it. Another problem with this technology is the fast degradation due to damp and/or ultraviolet radiation.

2.2.4 Summing up the technology theory

The 1G is the most abundant PV technology, and is usually based on a silicon semiconductor. The 1G technology is divided in two groups, namely p-Si and mono-Si. The first mentioned is cheaper to produce, and has an efficiency of up to 22%. The mono-Si PVs are more expensive and energy consuming in production, but the efficiency can reach almost 26%. Due to the relatively high cost and material rigidity of both, p-Si and mono-Si, the 2G was developed. This is a cheap substitute, but has lower efficiency, and some of the raw materials of different kinds are rare and some are even toxic, making a need to find substitute materials for many productions of 2G. The development of 3G and 4G technologies was a result of the need to produce PVs with higher efficiencies, but as a result, the PVs are very expensive, or are still at the R&D stage. Some materials used in 3G and 4G are also toxic or rare, making it necessary to find substitutes. For the purpose of the thesis, the two generations of 3G and 4G are discussed under one, due to the disagreements concerning the actual existence of 4G.

From the overview above, I argue that PV technology is of vast extent, ranging from several types of materials, with their own advantages and disadvantages, making the choice of production or R&D, difficult. The technology may be anticipated as an important choice for a company to consider in its strategy work. As point of departure for the discussion in this thesis, is the understanding of the quantity and variation of PV energy sources, in addition to the four concepts of technology generations, seen in the light of efficiency, cost of production and toxicity. These generations form the basis of the questions asked from the theory of Barney (1995), where the technology can be considered as a resource of the firm. This theory will be reviewed in the following part.

2.3 THE RESOURCE-BASED VIEW

In 1984, Wernerfelt introduced the importance of investigating the resources of the firm, where not just the product is in focus. Resources were broadly defined as everything regarded as a strength or a weakness in the firm. Barney (1991) believed that there were far more theories regarding *external* factors, such as those presented by Porter (1980), for example, and wanted to draw attention to a simple approach investigating the *internal* factors of a firm, and lay the foundation on resources and capabilities. His definition of resources and capabilities included "all of the financial, physical, human, and organizational assets used by a firm to develop, manufacture, and deliver products or services to its customers" (Barney, 1995:50). Barney (1995) divided the resource-based theory in four aspects: value, rarity, imitability and organization (VRIO). This is a tool that can be utilized to look at the resources and capabilities in a firm, and determine whether or not it is valuable, rare, imitable, and whether or not the firm is organized in a way that utilizes its resources in the best possible way and that increases profitability. The theory is built in a sequential manner, where each of the four parts in the VRIO tool are asked in the order described by the name (see figure 6).

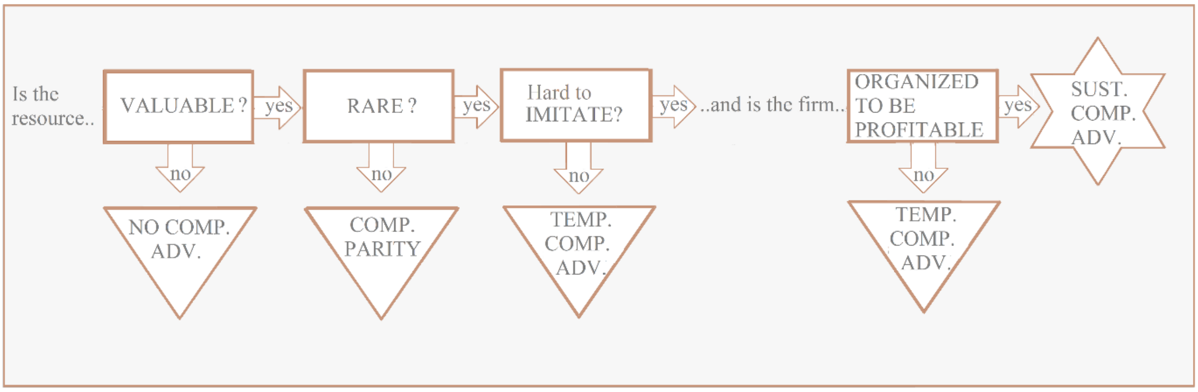


FIGURE 6: AN EDITED MODEL OF THE VRIO TOOL DESIGNED BY ROTHAERMAL (2012). A SEQUENTIAL QUESTION FORM, WHERE THE COMPETITIVENESS OF A FIRM IS INVESTIGATED.

2.3.1 VALUE

Is the resource valuable? The first question addresses the value of the resource or capability. Barney (1995) states that value is closely linked to a firm's use of resources to exploit opportunities and threats, where the competitive environment is of great importance. If the resource can not be said to exploit an environmental opportunity and/or neutralize a threat, thus being valuable, no competitive advantage exists for the firm. The value must be evaluated constantly to make sure it is up to date on the competition. The question of value is the first consideration, and emphasizes that a resource needs to be valuable to even be considered by the next parts of the tool.

2.3.2 RARENESS

The next part deals with the rareness of the resources. Is the resource of investigation, rare? If a resource is not rare, it can easily be comparable to other valuable resources from other firms, creating a competitive parity. In this context, rareness means that only a few firms hold control of the resource. If this is the case, the next question is asked.

2.3.3 IMITABILITY

This question deals with the imitability of the resource. Is the resource hard to imitate? When a resource is valuable, rare, but not hard to imitate, a temporary competitive advantage exists. According to Barney (1995), imitation happens in two ways, either by duplicating or by substituting. Duplicating occurs when a firm builds its competitive advantage around the same resource as another firm, while substituting occurs when a firm does the same only with resources that are not identical, but have the same strategic implications and are no more expensive to develop. Substituting was the last piece of the resource-based view in 1991, when Barney called it VRIS, but revised it in 1995 to be a part of the imitability aspect. It is of great interest for a firm to have resources that are hard to imitate. Hard to imitate leads to cost disadvantages for other firms to develop, produce or sell the resource. Cost disadvantages can originate from historic events, various minor decisions and/or social factors/tacit knowledge. If this is the case, the last question concerning the firm's organization is asked.

2.3.4 ORGANIZATION

Is the firm organized to exploit the resources and capabilities, and in that way be profitable? If no, it is still just a temporary competitive advantage. Answering yes to the question implies that the internal resources and capabilities are utilized in such way that the firm is better equipped to survive, meaning that the firm has a sustainable competitive advantage. According to Barney (1995), this can be said to be the case when the resource is valuable, rare, imitable, and the firm is organized to be profitable. To exploit the resources and capabilities the firm must, according to Barney (1995), among others, evaluate its future strategy for possible new market entrance, lower the risk by introducing control systems, or build a report or communication system throughout the firm.

2.3.5 SUMMING UP THE RESOURCE-BASED VIEW

Barney (1995) has presented a tool with four sequential parts that deals with value, rareness, imitability and organization. For each of the four parts, a question is asked. The more questions that have "yes" as an answer, the better is the competitive advantage of the firm (see figure 6). This is a simple and versatile tool for the investigation of the technology, and the knowledge and competence within a firm, hence defined as resources. It has been shown that one may use the fourth question of the tool to investigate the firm. By this, it would be possible to use the resource-based perspective for investigation of the individual firms. On the other hand, due to time constraints, and a tilted investigation if only some of the companies are studied, this is not done. Therefore, the first three questions of value, rareness and imitability will form the resource-based view in the thesis. A more generalized investigation of the firms is however the subject of study in the next theory, namely, the industry-based view.

2.4 THE INDUSTRY-BASED VIEW

The industry-based view is built on the importance of the surrounding environment in which the firm is placed (Porter, 1980), where an industry is defined as a group of companies offering products or services that satisfy the same customer need (Hill and Jones, 2013). In this, the competitive strategy is of great importance. At that time, Porter (1980) was of the opinion that the competitive strategy theories were more focused on big companies that worked in a broad manner, in several industries. This eventually led to a loss of information that could characterize one particular industry and the firms in this industry. Porter's book from 1980 presents several analysis tools that may be used for analyzing the firm's own position, its competitors, and the industry as a whole.

Porter (1980) presents four key factors to do a good competitive analysis, namely the ethical principles of the employees, the firm's strengths and weaknesses, the possibilities and threats in the industry, and the society's expectation. The first two are internal and the second two are external factors. This led to the well-known Five Force model, which investigates a firm's competitors and rivalry in this market: the buyers, the suppliers, potential new firms that can compete, and substitutes. According to Hill and Jones (2013), Andrew Grove, the former CEO of Intel, expanded the Five Force model into a Six Force model (see figure 7). The intention behind this

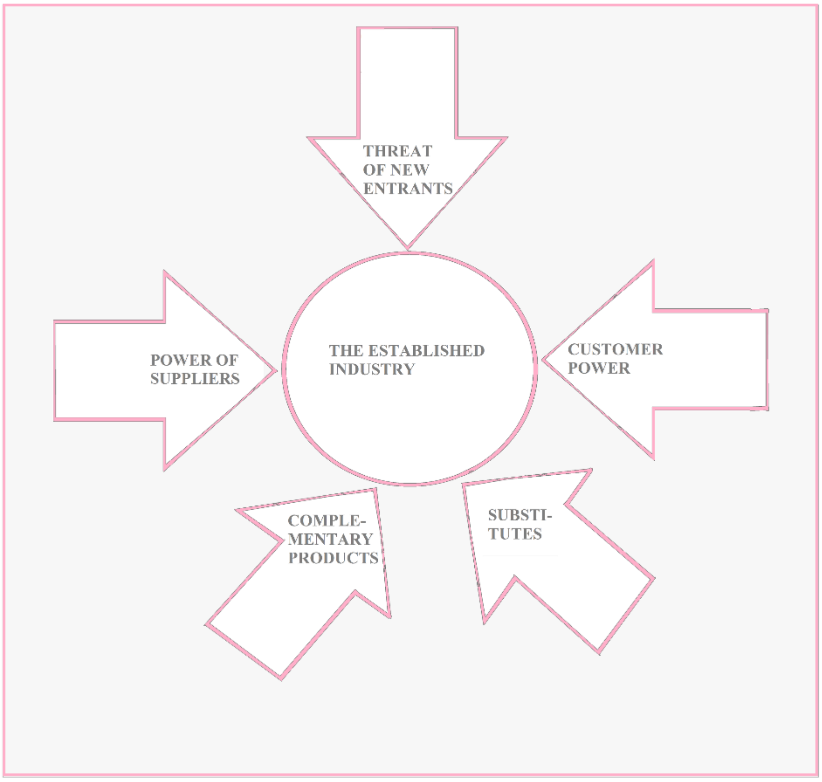


FIGURE 7: A REPRESENTATION OF THE SIX FORCE MODEL. THE ESTABLISHED INDUSTRY WITH ITS FIRMS IS THE CENTER, WHILE FIVE OTHER FORCES OF CUSTOMERS, NEW ENTRANTS, SUPPLIERS, SUBSTITUTES AND COMPLEMANATRY PRODUCTS SURROUND IT.

model is to measure the strength of each of the forces, which gives an indication of potential opportunities, and potential threats (Porter, 1980).

2.4.1 RIVALRY AMONG ESTABLISHED FIRMS IN THE INDUSTRY

The mainspring of the Six Force model is the competitive struggle for market share among established firms in the same industry. This struggle occurs in numerous ways, for example service pricing or quality alteration, PR, commercials, etc. (Framnes et al., 2014). For the firms in the industry, a low degree of competition often results in the opportunity for firms to increase prices and reduce spending on competitive strategy costs. The opposite, when there is a high degree of competition in an industry, the firms can experience lower profitability due to more price competition or more investment in competitive strategies. To investigate the situation in an established industry, one often looks at the competitive structure, industry demand, cost conditions and exit barriers (Hill and Jones, 2013).

The competitive structure tells something about the number of firms and the division of market share. A consolidated industry, is made up of a few, or even just one, big company, and it is characterized by an even strategy competition where the prices are regulated to be profitable. However, when companies try to take market share from each other, the result is often intense rivalry. The opposite would be a fragmented industry where several smaller companies are part of an intense strategy competition, and where the entry barrier is low. As a result, prices are kept down to keep or expand market shares, which leads to an unfavorable industry for many of the participants.

Industry demand determines what customers the companies would fight over, and directing attention to new customer groups or additional sales to existing customers, are strategies that could increase profit without increasing rivalry. This means that an increased industry demand results in opportunities, while a decreased industry demand results in threats. Another factor that can create threats in an industry, is increased cost conditions. High fixed costs will create rivalry between firms to keep the sales quantum as high as possible, leading to possible price wars and eventually less profit. Threats can also occur due to high exit barriers, which is the last factor that determines the rivalry in an industry. Exit barriers include emotional, economic and strategic elements. This may include pride, task specific assets or promises to customers making it difficult to exit parts of the industry. High exit barriers can often result in companies being locked in an industry that is not profitable for them.

2.4.2 Risk of new entrants

The potential competitors may be new start-ups, or a competitor may be an established company from another industry looking to diversify its business areas. The risk of entry by these potential new competitors is determined by several additional factors, namely: customer switching costs, governmental regulations, absolute cost advantages, economies of scale and brand loyalty (Hill and Jones, 2013).

Customer switching costs relates to the economic, energy and time consuming costs that customers must face when switching from one company's product or service, to another company. Higher switching costs result in higher entry barriers for new entrants. The same often goes for government, which is also linked to higher entry barriers, making the competition in the established industry smaller. High absolute cost advantages for established firms also increase the entry barrier. Absolute cost advantages can originate from a longtime acquired experience from materials, workers, storage, production, etc., or from winning better trust from investors based on a longer period of service. Economies of scale also show that established companies are capable of lowering costs because they can spread advertising costs and fixed costs over a larger production volume, buy cheaper feedstock due to large batches, and standardize mass-production of their products. Brand royalty is the last strategy established companies might utilize in order to higher the risk of entry for potential competitors. Consistent advertising, patent protection, high quality and after-sales service are some examples of measures companies can implement to build brand royalty (Hill and Jones, 2013).

2.4.3 Bargaining power of customers

The competitive situation in an industry or market is greatly affected by the buyers. These buyers may be the end-users, next-in-line manufacturers, or retailers. The factors that contribute to the competitive force are the relative size and number of firms between the buyer and seller side, switching costs, price transparency, and the ability of vertical integration.

A buyer group that consist of a few, large companies will have great power over a group of many, small sellers, and vice versa. A large company will have better impetus to threaten to switch to another company, thus having more power. In order to do so, however, the switching costs should be relatively low. A company in the center of the industry (the sellers), trying to keep its market share, would benefit from raising its switching costs in order to prevent competitors from stealing its customers. Another factor is price transparency, which shows the degree to which a customer can compare the prices from each seller, and what they actually get for that price. The last factor is the possibility for a customer to go through with up-stream vertical integration with an acquisition, or with contracts, which is also independent on the size of that firm.

2.4.4 Bargaining power of suppliers

Just as the customers could retain power by being few and large, the same goes for suppliers. A large and rare supplier makes it difficult to bargain over price, and custom-made products are difficult to find. The suppliers are most powerful when there are few substitutes, when the established industry is not capable of threatening to enter the supplier part of the value chain, and when suppliers can threaten to enter the established industry. Enhancing the switching costs in the established industry, acquiring or entering contracts, are attempts to prevent the bargaining power of the suppliers.

2.4.5 Substitutes

The companies that make up this group are those that focus on other products or services, but at the same time can provide the same or similar customer needs. This force can lower the price the other industry can take for its products. If there are many substitutes to choose from, this makes the competitive force high.

2.4.6 Complementary product

The complementary products make up the products that could raise the value of the products in the industry, thus a large choice of adequate complements could make an industry more profitable, and lower the competitive force in that way. If the supply of complementary products is low, this could result in lower profit in the established industry, increasing the competitive force.

2.4.7 SUMMING UP THE INDUSTRY-BASED VIEW

The industry-based view of Porter (1980) is based on the direct surrounding environment in which the firm is placed. Porter presented a Five Force model, which was later extended to a Six Force model (see figure 7). The established industry is the subject of investigation, and may be fragmented or consolidated, based on the number of firms. This, in addition to the demand and exit barriers, influences the competitive nature of the industry.

In addition, the five other forces affect competitiveness. The first, namely the risk of new entrants is dependent on switching costs, branding, economies of scale and governmental regulations. The second and third, which is the bargaining power of customers and suppliers, respectively, affect the industry based on the number and size of the customers and suppliers, switching costs, and possibilities of integration. The fourth, namely, the substitutes' power, depends on the competitiveness of that particular industry, and may lower the value of the industry under investigation. The last force is complementary products, which are regarded as products that may raise the value of another product. For the purpose of the thesis, all of the forces are studied to some extent. However, due time constraints, complementary products are discussed in brief.

2.5 THE INSTITUTION-BASED VIEW

As shown above, the internal factors, such as the technology and the organization, can be investigated using the resource-based view, and the external competition and market, in addition to some internal firm related factors, can be investigated by the industry-based view, but they do not cover the entire context surrounding the firm (Peng et al., 2009). This has been a critique of the two strategic management theories. Narayanan and Fahey (2005) criticized the industry-based view for ignoring history and institutions in its attempt to describe today's situation. Brouthers et al. (2008) claimed that a valuable, rare and hard to imitate resource could be the quite opposite when presented in an entirely different market and context.

In 1997, Oliver suggested a comparison of institutions and resources to find sustainable competitiveness, while Peng et al. (2009) presented the institution-based view as a third leg, in addition to the resource-based view and the industry-based view, making a tripod in strategic management (see figure 2). However, institutional theory is not new. From around 1850 to 1920, the institutional approaches dominated political science (Scott, 2008:5). The definition of an institution has varied over the years, and within different scientific fields.

An institution may be referred to as the "rules of the game" (Peng et al., 2009). Reich (2013) has indeed said that the free market that exists, to varying degree, is controlled by the rules of the game, namely the laws, regulations and rules given by the government. There are however, several definitions of institutions (Eriksson-Zetterquist et al., 2014:247), mainly based on different scientific fields. While political scientists emphasize the above mentioned rules of the game, anthropologists highlight the cultural and historic effects of the institutions.

2.5.1 Three pillars of institution: Regulative, cultural-cognitive and normative

Scott (2008:48) has been of the belief that institutions may be comprised of all of these aspects, moving "from the conscious to the unconscious, from legally enforced to the taken for granted" (Hoffman, 1997:36, referred in Scott, 2008:50). Scott made a distinction between regulative, normative and cultural-cognitive institutions, which would represent the three supportive pillars of institutions. The regulative pillar includes laws and regulations, which are often results of the society's lack of faith or trust in establishments. The normative pillar comprises the values and expectations that people see in regards to what is righteous, which may be overlapping the emotional exit barriers mentioned for the established industry in Porter's (1980) industry-based view. The cultural-cognitive pillar includes the things that are subject to the common perception of what makes sense. These three supportive pillars are prerequisites that an organization needs to achieve in order to be accepted (Carson et al., 2015).

2.5.2 TWO INSTITUTIONAL PARTS: FORMAL AND INFORMAL

Scott's (2008) three pillars do have connection with earlier definitions that seek to comprise the different views on institutions as well. North (1990) divides institutions in two, namely, the formal and the informal. The former includes rules, regulations and laws, while the latter includes culture, norms and ethics. Peng et al. (2009) claims that there is an overlap between North and Scott, that results in the regulative being a part of the formal institutions, and the normative and cultural-cognitive being a part of the informal institutions (see figure 8).

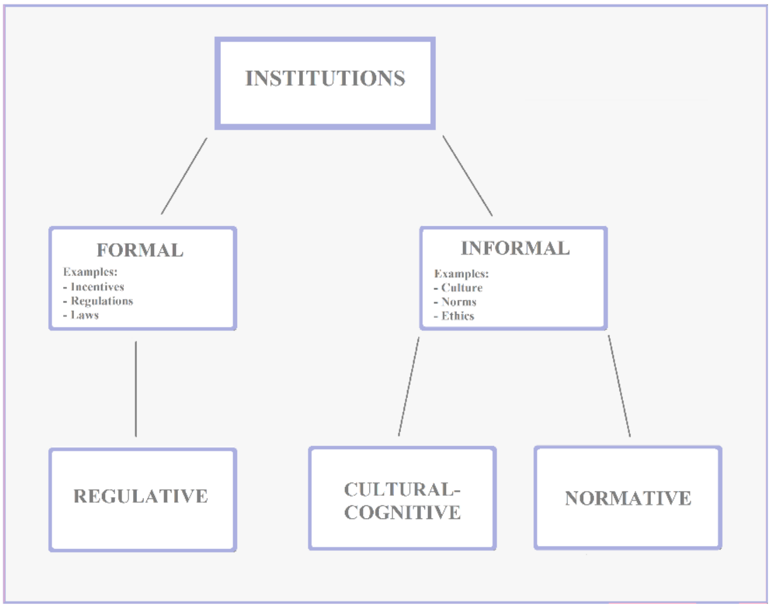


FIGURE 8: INSTITUTIONAL THEORY. BASED ON NORTH (1990) AND SCOTT (2008).

Even though institutions are a result of human activities, it does not necessarily mean that institutions emerge through deliberate action (DiMaggio and Powell, 1999, referred to in Eriksson-Zetterquist et al., 2014:247). According to Peng et al. (2009) two statements play significant roles in the emergence of institutions. The first proposition states that the managers and firms make their strategic decisions within the formal and informal restrictions that are given in an institutional framework. The second proposition states that formal and informal institutions play together to reduce uncertainty, give rise to legitimacy, and guide the managers and firms. When the formal institutions fail to do so, the informal institutions step in. For example, there were less formal institutional regulation in China until 1996, but the unique informal collectivism substituted the need for it (Peng and Health, 1996). This shows the importance of the institution as a tool, where it can reduce uncertainty, give guidelines and create order, in both the formal and the informal way.

2.5.3 SUMMING UP THE INSTITUTION-BASED VIEW

As the discussion and figure 8 show, there are different views and definitions of institutions. Scott (2008) emphasized the three pillars, namely the regulative, normative and cultural-cognitive factors. Peng et al. (2009) links North's (1990) two divisions, of formal and informal institutions to these three pillars, where the cultural-cognitive and normative is part of the informal, while the regulative is part of the formal institutions. For the purpose of this thesis, all of these aspects may be important and would be interesting to investigate. However, due to time constraints, and limitations regarding the data available, a choice needed to be made based on what could be possible to achieve. The emphasis is therefore placed on an extended version of the formal institution perspective. The extended version includes both negatively and positively associated factors, namely regulations and rules, as well as incentives. This has been added to the formal part in figure 8. Incentives may encourage activities with punishments or rewards (Hanson, R., 2013). The belief is that the incentives may have been an equally important factor for the PV industry. The focus of the formal institutions will, because of time constraints, be on governmental factors, even though companies may be important for this as well. In addition, some minor parts deal with culture and ethics from the informal institutions.

2.6 SUMMARY OF THEORY

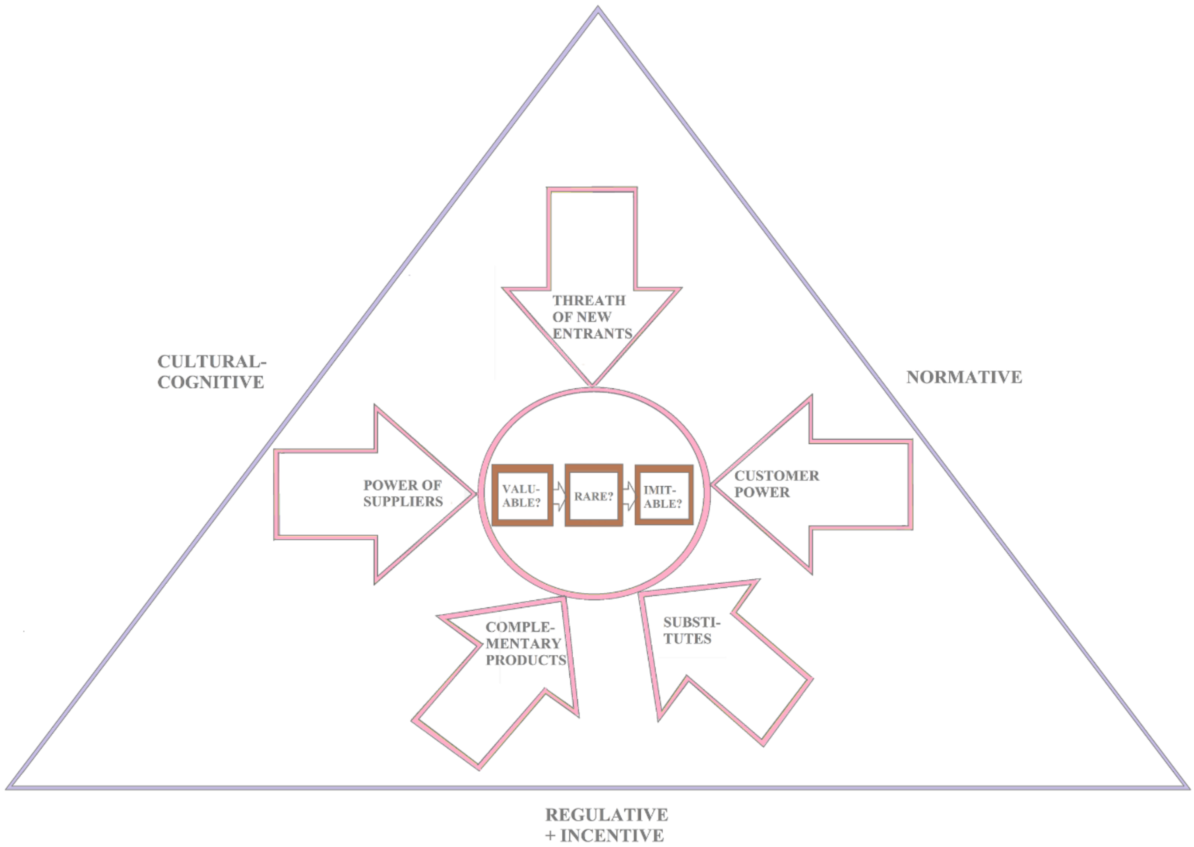


FIGURE 9: THE CHOSEN PARTS OF THE TRIPOD PRESENTED IN REGARDS TO DIMENSIONS. THE RESOURCE-BASED VIEW REPRESENT THE DIMENSION OF A FIRM IN THE ESTABLISHED INDUSTRY, WICH IS A PART OF THE INDUSTRY-BASED VIEW, IN ADDITION TO THE SURROUNDING SECTOR. THE REGULATIONS, INCENTIVES, CULTURAL-COGNITIVE AND NORMATIVE LEVEL, REPRESENTS THE INSTITUTION-BASED VIEW.

In this thesis, the PV industry's creation of jobs needs to be investigated in multiple dimensions, in order to find the explanations for the development on the national level. The discussion is therefore dependent on a theory that covers all, or most of these dimensions. This shows the need for exploring a range of levels, from the micro level to the macro level. Figure 9 shows a new representation of the strategy tripod, which could be seen in figure 2.

The three theories that has been presented, enable a discussion from the firm level, to the governmental level, and this is reflected throughout the thesis. Even though the theories are applicable to all of these levels, and some explanations may be located in several levels, the focus of this thesis is on the national level, namely, the job creation in the PV industry in Norway.

The four generations of PV technology have been revised in order to further investigate technology in the discussion with the first three parts of the resource-based view of Barney (1995), namely, the value, rarity and imitability (see figure 6). The industry is studied with a widely applied theory, namely Porter's (1980) competition strategy, which is also known as the industry-based view. Here, 5 forces are of particularly interest, namely the established industry, new entrant, customers, suppliers and substitutes (see figure 7). Finally, an extended version of the formal, or the regulative, part of the institution-based view investigates the surrounding governmental regulations and incentives, in addition to the culture and the ethics from the informal part, to a minor extent. This is done by Scott (2008) and North's (1990) institution-based view (see figure 8). These three views corresponds to the strategy tripod presented by Peng et al. (2009). An analysis diagram presents these theories in regards to the investigation of the chosen dependent variable of jobs in the PV industry (see figure 10). This makes up the basis and structure of the thesis. The brown color represents the resource- based view, the pink color represents the industry-based view, and the purple color represents the institution-based view, throughout the thesis.

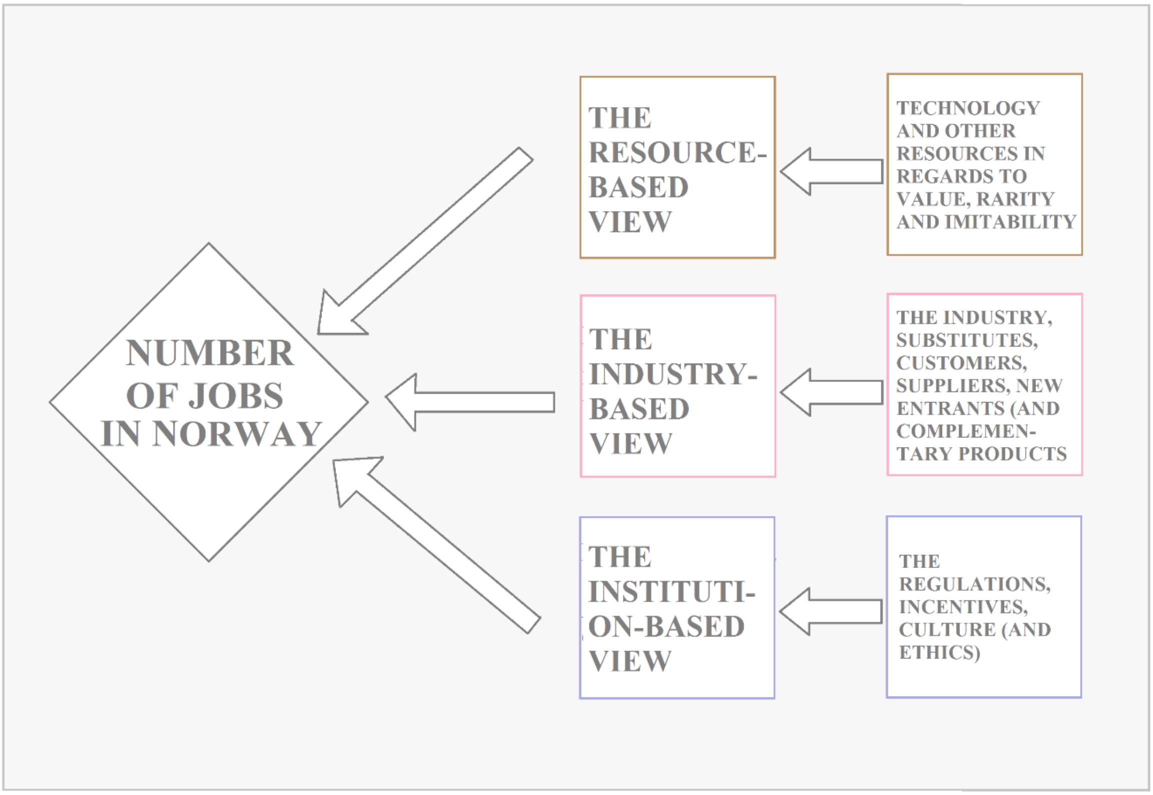


FIGURE 10: THE THESIS UTILIZES THREE VARIABLES; THE TECHNOLOGY, THE INDUSTRY AND MARKET, AND THE REGULATIONS, INCENTIVES AND CULTURE, IN ORDER TO UNCOVER THE EXPLANATIONS FOR THE DEVELOPMENT FOR THE DEPENDENT VARIABLE, NAMELY THE NUMBER OF JOBS. THE BROWN COLOR WILL REPRESENT THE RESOURCE, THE PINK WILL REPRESENT THE INDUSTRY AND THE PURPLE WILL REPRESENT THE INSTITUTIONS.

3 RESEARCH METHOD

In this part, the methods used for the data gathering are presented. The assumptions, and following decisions, are elaborated through a discussion on the purpose of the thesis. Blaikie (2009:10) views the three types of questions that all research questions can be reduced to as "what", "why" and "how". I use these questions for the structure of this chapter, where three questions, based on the above mentioned, are asked in order to cover the background for the methods chosen. The questions are as follows: What is being researched? Why is this research important? How can this be researched?

3.1 WHAT IS BEING RESEARCHED?

The focus in the thesis is on the development of number of jobs in the PV industry in Norway, ranging from feedstock, ingot and wafer production, to cell and module production. This is in other words, the dependent variable, and is therefore the focus of the study. To research the explanations for the dependent variable, I was in need of some variables that could help explain this development, and the chosen factors were the technology/competence, the market/industry and the regulations/incentives/culture. These factors needs to be researched as well.

As stated earlier, Germany is used as a comparison to the Norwegian development. The reason for this was a wish to find the explanations that may be difficult to discover when only one case is studied. Using Germany as a mirror to find (unexpected) factors that may have contributed to the development, could be informative. Especially when Germany show differences in size and energy mix. Germany's development in the number of jobs, and in the three aspects, are by that, also subject for research to some extent.

3.2 Why is this research important?

Since the current unemployment rate, per 1000 citizens, in Norway is at its highest level since 1993 (SSB, 2016), there is a strong desire to decrease this figure. A number of industries may facilitate this situation, but one strategy could be to learn from the market. The major group making up the high unemployment today, originates from the oil and gas industry, which has seen a declining tendency in both investment and production the last few years compared in percentage against renewables (UNEP and Bloomberg, 2016), while wind and solar have had the opposite development. Norway has been one of the largest producers of parts of the PV value chain in the past, and several companies are still in operation. This is in contrast with many other European countries, including Germany, making Norway a rare, and even unusual, case. Investigating the explanations for this, in addition to finding possible improvements, may lead to a better understanding of a further growth in the number of jobs in Norway.

3.3 How can this be researched?

Epistemology is the philosophy of how to find the truth, reality or existence (Easterby-Smith et al., 2015). At each end of the epistemological continuum, two extremes exist. Positivism and social constructionism. The positivist view refers to a way of thinking where the truth is something that exists, independently (Easterby-Smith et al., 2015), whether or not it is discovered by a researcher (Alvarez et al., 2013). This truth is discovered by using, what has been understood as, objective methods, based on independence of what is being observed, value-freedom from the object being studied, causality, hypothesis and deduction (Easterby-Smith et al., 2015). The positivist view is the basis of the quantitative method. At the opposite side of the continuum, social constructionism is found, which refers to a philosophical way of thinking where the participating research object and/or the researcher creates the truth (Easterby-Smith et al., 2015; Alvarez et al., 2013), thus contributing with subjective methods. The researcher being a part of the observation, being driven by value, finding general understandings, and activities where data collection induce new ideas characterize such methods. Social constructionism is the basis of qualitative methods. The epistemology continuum from positivism to social constructionism means that scientists can utilize a range of different philosophies and methods.

3.3.1 CHOICE OF METHOD AND RESEARCH DESIGN

The different methods of choice, based on the epistemological philosophies, consists of a large collection. Case study, survey, archive study, historical analysis, experiment, etc., are only a handful of the possibilities. Historically, these methods have been linked to different approaches, namely, explorative, descriptive and explanatory. According to Yin (2014), however, all study types can be used for each approach. The aspects, that one should rather consider when choosing the approach, is what type of research question one has, the control requirements of the events being studied, and the focus on timeline. Yin (2014) argues that when the goal is to find the explanation for "why" or "how" the present circumstances and phenomenon occur, without the need of control of the objects being studied, the case study method is a good tool. For the purpose of my thesis, the job creation in the PV industry in Norway is the main case, with the case of Germany being less emphasized.

Due to the data and theory needed to present the vast field of the development of jobs, the technology production in the PV industry, the market and the regulations and incentives, in Norway and Germany, many disciplines are encountered. I have chosen the use of several methods, both quantitative and qualitative. In other words, I will take advantage of the method of triangulation (Easterby-Smith et al., 2015:54). The aim of triangulation is to collect several, diverse perspectives through different methods (Grønmo, 2004:55). The strategic decisions for a triangulating method are clarified in the following discussion.

The quantitative method in this thesis makes up the data gathering for the first research question, namely: "How has the number of jobs in the PV industry developed?" This means that the dependent variable, the job development, is constructed by a quantitative method. In addition, there is an underlying research question for the explanation of the development as well, namely: "How has the number in production/market developed?" This leads to some aspects of the explanatory variables being subject to the quantitative research method as well, namely the technology production, and the installed capacity for the market. This will be number collection, leading to a statistical representation of the data. A code form is constructed in advance of the data gathering, in order to secure data that may be compared, both between the two countries and between the different years (Grønmo, 2004:201). This quantitative approach is descriptive, which corresponds to an inductive research strategy (Blaikie, 2009:105).

The qualitative method makes up the data collection for the second research question, namely: "How can we explain the development of the number of jobs in the PV industry?" This question calls for data sources that can "look back in time". This may be possible to attain from texts, movies, reports, persons, etc. As a result of the discovery of a collection of historical reports, which is made clear in the following sections, I chose to conduct a text analysis. In a qualitative text analysis it is important to find texts that represents what is being researched (Grønmo, 2004:189), and in this case, texts that may be comparable for both countries. This makes up the main data source in the thesis, but other sources may supplement. Interviews give explanations for the development, and may give some prediction for further development. In addition, some similar scientific papers are used, which as a result leads to a meta-analysis. The text analysis is explorative, descriptive and explanatory, which results in both an inductive and a deductive research strategy, while the interviews are explanatory and predictive, which are considered as deductive research strategies (Blaikie, 2009:105).

In addition to the importance of placement in the epistemological continuum, as the discussion of quantitative and qualitative shows, the emphasis on societal conditions is important. Generally, in social sciences, a division is made according to three analytical perspectives, namely the perspective of space, the perspective of time, and the perspective of levels (Grønmo, 2004:377). For this thesis, the perspective of time will be important to mark, but the two others are also a part of the thesis. For the perspective of levels, as was mentioned in chapter 2.6, the main focus is on the national level, even though it is necessary to review several other levels as well, to find explanations for the development. The two other perspectives are dealt with in the following part.

The perspective of space stresses the importance of the relation of similarities and differences between different places (Grønmo, 2004:384). Here, Norway and Germany may be understood as two different "spaces". As we have seen, Germany was chosen as the comparing country because of the dissimilar energy mix, which is more common than Norway's unique dominance of hydropower, in addition to the size of the country, and the governmental incentives towards an energy shift. The quantitative and qualitative data is collected, to a sufficient degree, for Germany as well. The perspective of space deals with, among others, the comparative study, which opens up for the comparison of the development in the two countries. In a classic case-oriented comparative study, Ragin (1989:45) states there are three important factors to consider. First, similarities, or other characteristics, should be investigated. Second, the similarities or characteristics that are found, need to be causally relevant to the case. Third, a general explanation is served, based on the similarities and characteristics. This method is both inductive, because the researcher determines the theory used for the found characteristics, and deductive, because this theory serves as a guide in the investigation. Because Norway is the main case, and Germany is used as a comparative source, only a semi-comparative study, or a testing case study, is conducted.

Before a comparison is conducted however, the efforts in regards to investigating the historic timeframe should be conducted (Ragin, 1989). The timeline-perspective stresses the importance of the relation of stability and change (Grønmo, 2004:384). The realization of the necessity to view the data collected as a timeline in this thesis, is important. One can divide the perspective of time into longitudinal and cross-section studies. It is impractical to investigate the situation at only one point of time, if the goal is to learn from a past development (Grønmo, 2004:377). The history needs to be researched in order to see the change, which Blaikie (2009:105) emphasizes with the link between the retroductive research strategy and the change purpose of the research. From Yin (2014:150), this corresponds with the analytical approach of a time series, which is possible to conduct if the events over time have been traced in detail. This method is usually used when the observed trend can be compared with another rival trend, which is the case in this thesis, thus the focus is a longitudinal study. However, in my thesis the time line is also divided in several groups or trends, making it possible to view each trend as an individual case, thus a form of a cross-section study is conducted. This makes it possible for pattern matching between Norway and Germany, which is the one of the most desirable analytical approaches in case study, according to Yin (2014:143). However, the main focus is a longitudinal timeline study, where the entire development is important for the complete understanding.

Seen as a whole, I conduct a testing case, both qualitative and quantitative, with emphasis on a longitudinal timeline, with the focus on the national level, and with statistical gathering, text analysis, some meta-analysis and with supplementary interviews, as research methods. This makes up an example of a mixed method, where I will conduct the research through triangulation. The chosen objects of study for this mixed method are presented in the following part.

3.3.2 CHOICE OF RESEARCH OBJECTS

The goal for the choice of relevant texts and papers was to find sources that had been written with the same background for the two countries, making the comparison much more straight forward. The chosen papers for this purpose were reports presented by one of the International Energy Agency's (IEA) programs, namely the Photovoltaic Power Systems (PVPS) program. IEA is an independent organization that aims at contributing to clean, secure and affordable energy for its 29 member countries (IEA, n.a.). The PVPS program was established in 1993. It aims at increasing collaboration to enhance PVs position in society's energy transition towards renewable energy sources (IEA PVPS, n.a.). Over the years from 2001 to 2015, annual reports, with altering authors, have been presented, that summarize the highlights from each of the 29 members. In addition, a thorough National Survey Report of PV Power Applications for each country is presented almost every year. These reports are structured in almost the same manner for each year, with only small variations in the topics under review. These national and annual reports, for Norway and Germany, form the major data sources for the thesis. The reports were used for the gathering of numbers concerning jobs, production of different technologies, historical facts about competition and market, and governmental regulations and incentives. A list of the reports are provided in table 1.

TABLE 1: LIST OF REPORTS FROM IEA PVPS

TYPE OF REPORT	YEAR	AUTHOR
IEA PVPS ANNUAL REPORT	2000-2015	IEA PVPS
IEA PVPS NATIONAL SURVEY REPORT OF PV POWER APPLICATIONS IN NORWAY	2002	Jonas Sandgren
	2003	Fritjof Salvesen
	2006-2010	Fritjof Salvesen and Lars Bugge
	2011-2012	Lars Bugge
	2013-2014	Øystein Holm
IEA PVPS NATIONAL SURVEY REPORT OF PV POWER APPLICATIONS IN GERMANY	2002-2003	Frank Stubenrauchage
	2006-2008, 2010, 2012-2013	Lothar Wissing
	2014	Georg Altenhöfer-Pflaum

For the purpose of the thesis and easy recognition, the authors' names are not used, and are henceforth termed "IEA PVPS Annual" + the applicable year. For the same reason as the annual reports, the national reports are termed "IEA PVPS" + Norway/Germany + the applicable year.

Due to the lack of some numbers, for the statistical data gathering for Germany, I looked for additional sources of data. The PVPS reports presented Fact Sheets of the leading manufacturers in Germany from German Trade and Invest (GTAI) several times. It therefore seemed reasonable to choose this data source for the statistical data of Germany. GTAI is an agency of the Federal Republic of Germany that deals with inward investments and foreign trading (GTAI, n.a.). The information available on their website and upon request is aimed at German companies that want to expand abroad, and foreign companies that want to enter the German market. The Fact Sheets that are used, are partly available on their website, but some years are missing. GTAI was therefore contacted via mail to gain access to all of the fact sheets. Only the years from 2004-2015 were available. The reports will be named "GTAI" + the applicable year, throughout the thesis. The fact sheets from the last month available of that particular year was always chosen, in order to make it comparable to the IEA PVPS reports.

My research process and my search for data are concentrated around text data. During the analysis of these data, I recognized missing or incomplete explanations for parts of the development and decided to supplement with two expert interviews. The personal interviewees were Erik Stensrud Marstein and Alf Bjørseth.

Erik Stensrud Marstein is the center director of the Norwegian Research Center for Solar Cell Technology, and he is the Deputy Head of Department at Ife (Institute for Energy Technology) (Ife, n.a.), where he has been since 2003 (Marstein, n.a.). He has been working in the solar industry for almost 15 years, and therefore has vast experience in the technology and research areas in particular, and in the market and political areas. This experience and knowledge is of great interest for supplementing information from all of the variables in the thesis. Marstein was presented with the outline of the thesis via mail, and agreed to participate in an interview. Due to time and geographical issues, the semi-structured interview with respondent Marstein was conducted over the phone, with a recorder that was used in consensus with Marstein. The interview was later transcribed. Throughout the thesis, this interview will be referred to as: "Marstein, 2016".

Alf Bjørseth was the head of research at Hydro in the 1980s, and in the beginning of the 1990s, the CTO of Elkem (SNL, 2012). In 1994, he was one of the entrepreneurs that started ScanWafer, in addition to three other solar cell and module production companies. These companies merged into REC in 2000, where Bjørseth became the President and CEO (Scatec, n.a.). In 2005, he sold the rest of his share in REC and upon retirement from REC, became head of Scatec, which he founded in 1989. He has since established several companies, among others Scatec Solar and Norsun. Bjørseth's experience from the emergence of the PV industry in Norway, and his knowledge from the industry's point of view, in all of the variables in this thesis, makes him an important supplementary source of information. Bjørseth was presented with the outline of the thesis via mail, and agreed to a written interview, with a follow-up written interview. A structured interview, in other words. Throughout the thesis, this interview will be referred to as: "Bjørseth, 2016".

The two interviews of Bjørseth and Marstein were conducted in Norwegian. The interview guide can be found in appendices A and B. The research conducted is identifiable, and has been submitted to the Data Protection Official for Research (NSD) with the project number: 48512.

TABLE 2: RESEARCH OBJECTS

NAME	METHOD	QUANTITATIVE / QUALITATIVE	PURPOSE	RESEARCH STRATEGY	DATE
IEA PVPS REPORTS 2001-2015 (MAIN SOURCE)	Text analysis	Quantitative / Qualitative	Explorative and descriptive / Explanatory	Inductive / Deductive	2/8/16-4/25/16
GTAI FACT SHEETS	Text analysis	Quantitative	Descriptive	Inductive	2/24/16-2/29/16
ERIK S. MARSTEIN	Interview	Qualitative	Explanatory / Predictive	Deductive	3/29/16
ALF BJØRSETH	Interview	Qualitative	Explanatory / Predictive	Deductive	4/7/16 and 4/25/16

Table 2 represents the data sources for the thesis, where the IEA PVPS reports are the main sources, while the expert interviews are supplementary sources. In addition, several other individual texts and papers are used. The advantages and disadvantages of this particular mixed method, and reasons for this choice are reviewed in the following section.

3.3.3 ADVANTAGES AND DISADVANTAGES OF THE CHOSEN RESEARCH METHODS AND OBJECTS

When conducting a research, two words are important to be aware of; validity and reliability. Validity, or authenticity, is the extent to which the research actually can represent what has been chosen to be described (Easterby-Smith et al., 2015:343). The number of jobs is the chosen subject that is being described, while the three aspects of technology, market/industry and regulations/incentives are chosen to represent the subject that needs to be described. The three aspects may well lack some factors, but they were chosen based on some highly acknowledged theories, in the belief that they strengthen the validity of the thesis. Reliability, or accuracy, is the consistency of a measurement, and is measured as the repetitive nature of the data measured. Each of the research methods and data sources are viewed with regard to validity and reliability in the discussion of advantages and disadvantages.

For the gathering of numbers for the statistical part, the text analysis as a tool is excellent. The chosen reports have a repetitive nature, preserved retrospect and are publically available, increasing the reliability. In addition, they were chosen because of the authority represented by, especially IEA, and because the information that may be retrieved comprises several parts of variables chosen in this thesis, thus increasing the validity. This shows several advantages for the gathering of the qualitative part, as well. Furthermore, the benefit of text analysis is the researcher's ability to experience the past through another author or authors' write-ups. The data from the PVPS and GTAI's reports can be regarded as time capsules. The researcher then becomes familiar with the actual circumstances at that particular point of time. This excludes the memory disadvantages that comes with many other data sources, such as interviews. Text analysis does not necessarily mean that the data source is a printed text, it may as well be a movie, a commercial, a picture or graffiti art (McKee, 2003). This makes the text analysis a versatile tool.

There are however some disadvantages using the method of text analysis that must be mentioned. These texts may be a result of a particular author's thoughts and opinion. Only one or two author(s) accounted for explanations for the development for a particular year, increasing the possibility of error and decreasing the reliability. This is a disadvantage of the text analysis, seen from the positivist approach. However, this is difficult to avoid. Many sources of data, especially in the social sciences, will cause to undergo subjective factors (Hammersley and Atkinson, 1987). An advantage, in addition to the mentioned ones in the above paragraph is however, that changing authors throughout the period wrote the reports. Similar concerns, as for the subjectivity, could be raised towards the relationship between the researcher and the source of data. The researcher may also affect what information is outlined as most important, which Hammersley and Atkinson (1987) argues is impossible to avoid. In this thesis, I will seek to keep the influence at a minimum by remaining close to the theory presented in chapter 2.

In addition, it is important to mark that the reports and sheets from PVPS and GTAI are missing for some years, which affects the validity, and the results from these must therefore be seen in regards to this. There is also a disadvantage using the GTAI fact sheets in that they only represent leading manufacturers. However, Germany only demonstrates a different development compared with Norway, and the actual numbers are not important. Thus, the number of firms represented on these fact sheets (approximately 50) is sufficient to represent the development.

An attempt to supplement this data source, and thus reduce the error risk, was the decision to use two expert interviews. The interview is the most important source in a case study (Yin, 2014:110). The interviewee, as a research object, provides data that has been subject to years of experience and reflection. The memory disadvantage has already been mentioned, but in addition, there may be a problem with reliability for the interview gathering seen as one data source. Every interview is unique in its own way, resulting in altering emphasis. A structured interview is therefore a strategy. Interview guides were made in the belief that a prior structure of data gathering increases the reliability of a case study (Yin, 2014:84). The interview with Bjørseth was conducted in that way, while Marstein's interview was conducted as a semi-structured interview. This does therefore decrease the reliability to some extent. However, considering the interviewees' extensive knowledge and experience on the subject, it is the hope that their agreements or disagreements on my research questions, serve as highly regarded indicators of the development. This increases the validity. The interview could both serve as an informative and clarifying source, and an idea generating source and source of new information. The former is the strategy for this thesis.

As we have seen, the main disadvantages of the data sources in this thesis, seen standing alone, is the author or interviewees' subjective opinions, which may give meaning and explanations for certain events. This also affects the validity, in the form of selection bias, when the researcher chose the research objects (Collier and Mahoney, 1996), and the individual sources may decrease the reliability. Because several authors wrote the chosen reports, the interviews supplement this information, and further supplementary data is gathered from a range of texts and papers, in addition to the mirroring beside Germany, this approach can be viewed as a mixed method, and triangulation, as we have seen. Yin (2014:119) claims that a major strength of the case study is the opportunity to use several sources of data, enhancing the reliability. The triangulation may improve the drawbacks of the text analysis and interviews alone, increasing the reliability, and give the most objective historic timeline possible. The triangulation seeks to gather data from several sources, comparing them and giving a probabilistic answer to the research question, based on these data sources. Because this may be considered a more positivist approach, it may therefore make the individual text analysis and the interviews less subjective, and less subject to conclusions based on only a few situations. As a whole, this helps increase the validity.

Due to the inclusion of many research methods, both in the quantitative and qualitative approaches, some pitfalls may appear (Ragin, 1989) because of the differences in epistemological philosophies in the vast majority of research methods spread out on the continuum. To prevent these pitfalls, the theory is used to a greater extent, as a framework. In other words, the theory is a safety net. The strategy tripod therefore represents the backbone of this thesis.

The text analysis forms the basis of the results, giving the explorative, descriptive and explanatory results. The interviewees then serve with their explanatory and predictive data, showing the subjective explanation for the development, why it is the way it is, and future prospects, acting like a testing case against the main data source.

4. RESULTS AND DISCUSSION

The reviewed theory and method form the basis for the discussion of the results. First, in subchapter 4.1, the research question and results concerning the actual development of the number of jobs in the defined PV industry in Norway are presented. Following this, subchapter 4.1.1 compares the Norwegian development with the German development. Chapter 4.2 seeks to find the explanations for this development, thus answering the second research question, based on the three views of Barney (1995), Porter (1980) and North (1990) / Scott (2008).

4.1 HOW HAS THE NUMBER OF JOBS IN THE PV INDUSTRY IN NORWAY DEVELOPED?

As the title of this subchapter implies, the first part of the research question in my thesis is studied here, namely: *How has the number of jobs in the PV industry in Norway developed from 2001-2015?* The number of jobs is seen from the defined PV industry: from feedstock, wafer and ingot production, to cell and module production.

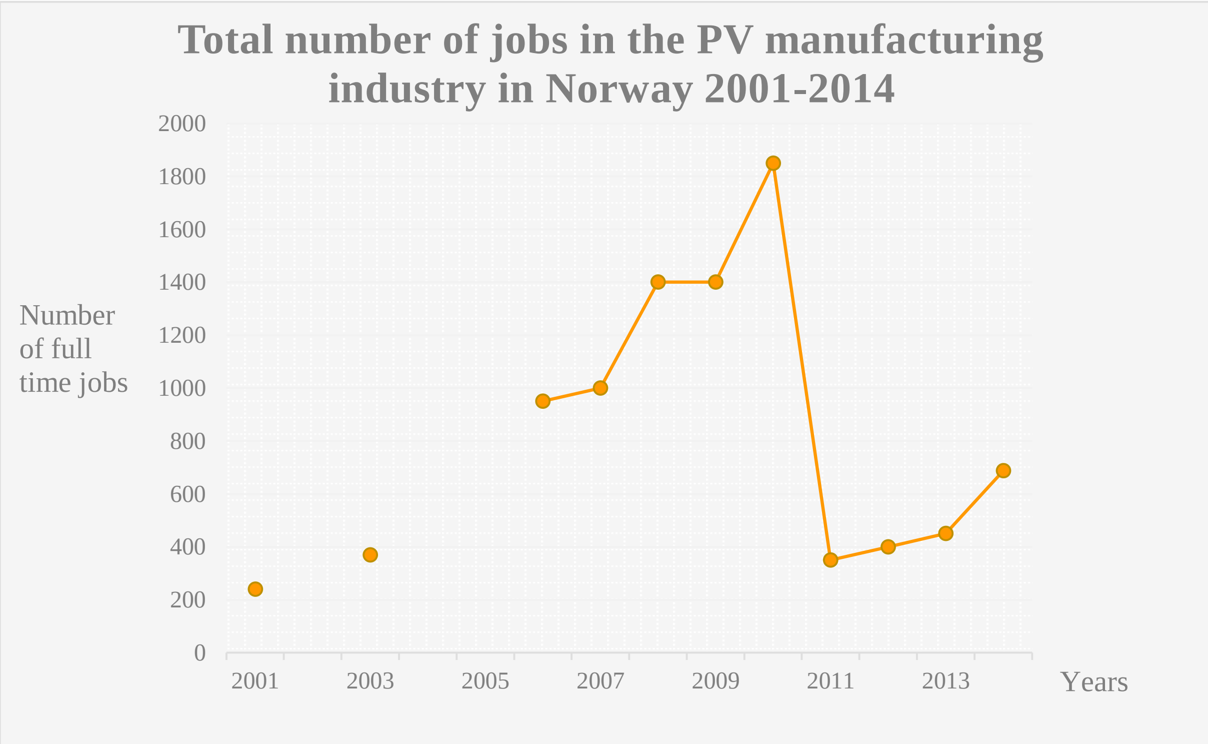
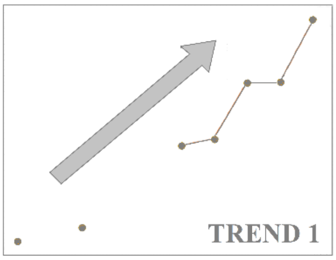
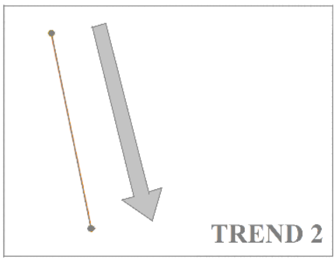


FIGURE 11: THE DEVELOPMENT OF THE NUMBER OF JOBS IN THE PV INDUSTRY IN NORWAY FROM 2001 TO 2014. FEEDSTOCK, WAFER, INGOTS, CELLS AND MODULES ARE INCLUDED. SOURCE: IEA PVPS NORWAY 2001-2014

As can be seen from figure 11, Norway has had a fluctuating evolution of the jobs in the PV manufacturing industry. Examining the number of jobs from the PV industry in Norway, shows in particular three trends (Trend 1, Trend 2 and Trend 3). It is important to remember, throughout the discussion, that these trends are a part of a continuum, and are therefore subject to, and a result of, strategy executions both before and during the actual timeframe of the trend. The trends are examined historically below.

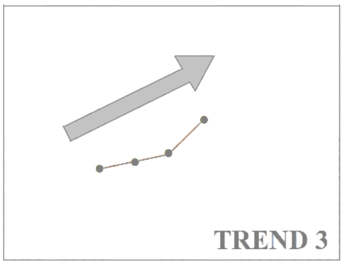


Trend 1 shows the growth from 2001 to 2010, when there was a general optimism reported in the media from that time (Haugstad, 2006). The industry however, started to evolve as early as 1992, when Hydro had to lay off around 150 employees in Glomfjord in Meløy (Haugstad, 2006). Reidar Langmo was hired in a company owned by Meløy and Hydro to create jobs in the region again. Langmo knew Bjørseth from before, and they agreed to work together with some ideas. In 1996, the building of the first factory of ScanWafer had started, after the company had been established in 1994 (IEA PVPS Norway, 2003). REC was a result of a fusion of ScanWafer, Fornybar Energi (founded 1996) and SolEnergy (Haugstad, 2006). In 2002, REC became the first solar energy company to have its own feedstock production, due to a joint venture with an American company. In addition, REC had production of modules at ScanModule in Sweden with REC thus covering everything from feedstock to module production (IEA PVPS Norway, 2006). Elkem Solar was founded in 2001 (IEA PVPS Annual, 2006), and started building its factory for energy efficient solar silicon feedstock in Kristiansand in 2009. Before this, Elkem had been producing silicon for many years, where some of it ended up as solar grade silicon for PVs. From 2005 and until 2010, several other PV manufacturing companies emerged, namely Norsun, Innotech Solar, Fesil Sunergy and EnSol. The latter two did not get the chance to produce much, most likely due to the unfortunate timing towards the year of 2010. Norsun and REC started to plan building more production facilities in Singapore towards the top year of 2010 (Nortrade, 2009; Ceccaroli, 2012).



Trend 2 shows the fall in the number of jobs in the Norwegian PV industry that is rapidly declining from 2010 to the beginning of 2012. The decline for REC started in 2010, when REC ScanModule in Sweden closed (IEA PVPS Norway, 2010). This is not a part of the overview of the above figure, but it indicates the beginning of the decline for REC. By the end of 2011, REC permanently closed the cell and three p-Si production facilities in Norway, and temporarily closed more than half the p-Si factories. In the spring of 2012, the rest of the p-Si and all of the mono-Si production sites were also permanently closed (IEA PVPS Norway, 2013). In the beginning of 2011, China International Bluestar became the full owner of Elkem (IEA PVPS Norway, 2011), thus Elkem Solar was no longer a Norwegian company, even though the production facilities were kept in

Norway. China International Bluestar also bought REC Solar in 2015 (Hirth, 2016a). In 2012, Elkem Solar and Norsun had to lay off employees temporarily. In addition, Norsun had to lay off people permanently (IEA PVPS Norway, 2012).



Trend 3 shows the number of jobs, again, starting to grow. The growth period is from 2012 to 2014, where 2014 is currently the last available data for Norway. In 2013, the temporarily laid off employees at Norsun got their job back, and a new company, namely Norwegian Crystals bought the old REC facility in Glomfjord, planning to produce mono-Si (IEA PVPS Norway, 2013). EnSol is still operating, even though no commercial production is operational (EnSol, n.a). Elkem Solar started producing some amounts of their new solar grade silicon for a period in 2012/2013 (IEA PVPS Norway, 2013), but it was not until 2014 that the production at Elkem Solar's facility in Kristiansand ran at full capacity (IEA PVPS Norway, 2014). There was no cell or module production in Norway in this period, but the number of employees in the PV *installation* industry is included for this period because the numbers are presented together in the reports. Regarding the small number of actual annual installations in Norway, however, this number is expected to be very small, making this contribution negligible.

4.1.1 Comparing the development of jobs in Norway and Germany

The three trends make up the three ups and downs in the number of jobs in the PV industry in Norway between 2001 and 2014. These trends would need to be compared with the chosen comparison country as well, before the explanations for the development are reviewed. The strength of comparative studies (Ragin, 1989) led to choice of a country that would have similar development, thus it needed to be sufficiently alike. On the other hand, the country needed to be sufficiently different, in order learn from it. Several European countries have had a growth in the use of PVs, though one country in particular experienced an early and rapid market growth, and that is Germany. In addition, this country is different in the mix of energy sources, and has, as can be seen in figure 12, a different development in the number of jobs the last few years. However, both Norway and Germany, at one point, have been one of the biggest producers in the PV industry, which will soon be clear. Therefore, the part of the research question that deals with comparing Germany's development in the number of jobs with Norway, will be conducted here.

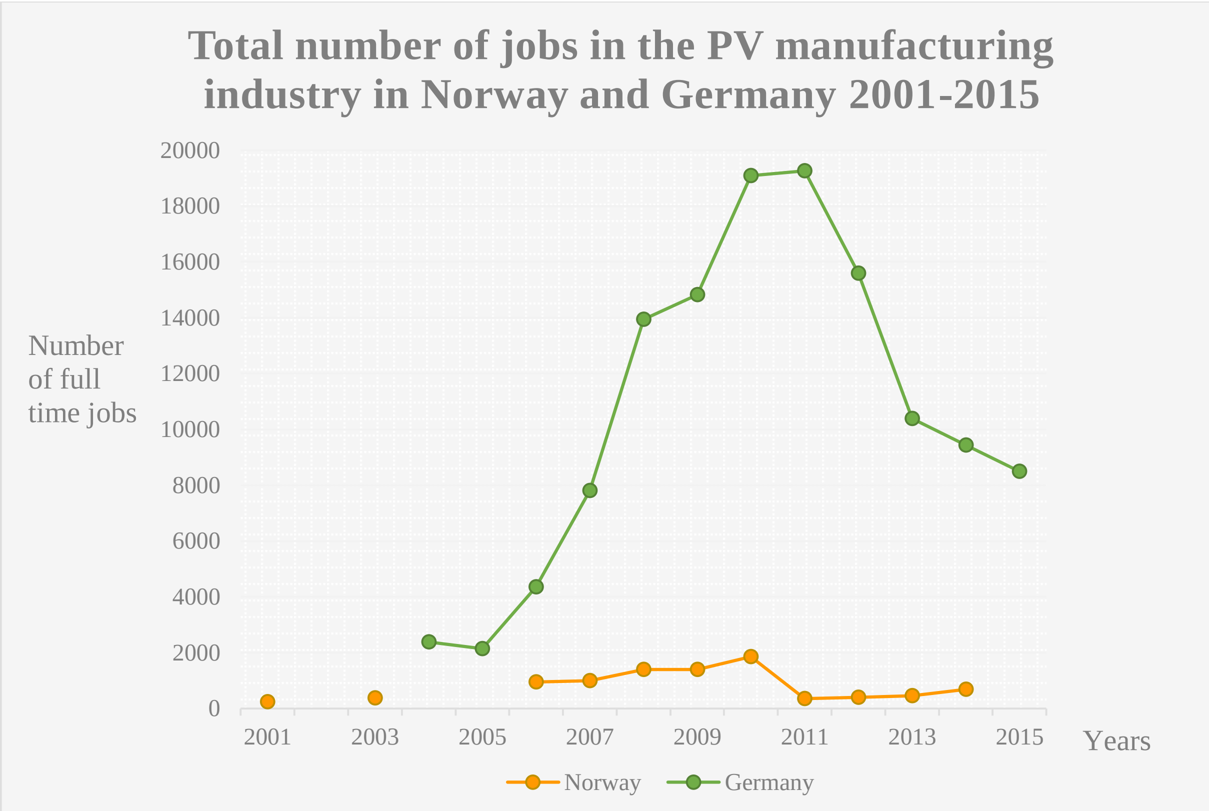


FIGURE 12: THE NUMBER OF JOBS PER YEAR FROM 2001-2015 IN GERMANY (GREEN) VERSUS IN NORWAY (ORANGE). SOURCE: IEA PVPS NORWAY 2001-2014, IEA PVPS ANNUAL 2004-2015 AND GTAI 2004-2015.

Does the German development show the same three trends as the Norwegian? What are the similarities and differences? The number of jobs in Germany is presented in the same confined PV industry as presented for Norway, namely feedstock, ingot, wafer, cell and module (see figure 12). Both Norway and Germany have been active in production of other equipment for PVs, as well. These production numbers are not included however, in an attempt to reduce the number of variables, and due to the wish to concentrate on the industry where Norway once was the biggest.

Figure 12, clearly shows that the German PV industry is of a much larger quantity than the Norwegian, which should be expected due to the difference in the number of people living in Germany. This difference is however, expected to be even more distinct because the numbers from Germany's development in figure 12 only represent the leading manufacturers, as mentioned in chapter 3.3.3. Even though this is the case, the number of firms represented is high, and this graph only attempts to represent a development, where the actual numbers are less important. By making a secondary axis on figure 12, a new graph shows a figure where a comparison of the trends is easier, and where this mentioned error is of less importance (see figure 13).

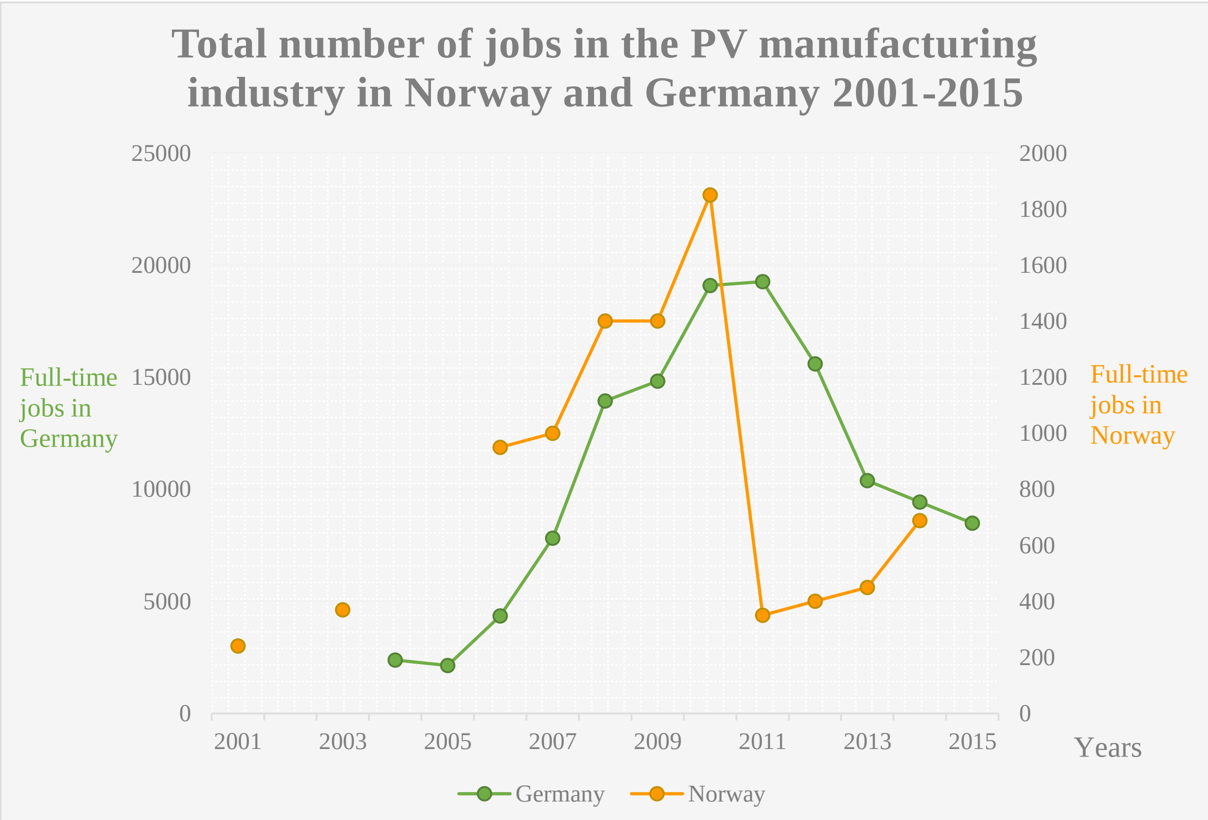


FIGURE 13: A COMPARABLE REPRESENTATION OF THE JOB DEVELOPMENT IN THE PV INDUSTRY IN NORWAY (ORANGE) AND GERMANY (GREEN). SOURCE: IEA PVPS NORWAY 2001-2014, IEA PVPS ANNUAL 2004-2015 AND GTAI 2004-2015

Further, figure 13 will make the basis of the comparison of the two countries in regards to the three trends.

Compared trend 1: The growing trend shows many similarities for the years that data are available. This growth sustained until 2010 for Norway, and until 2011 for Germany. During this time, many new and exciting measures and actions were undertaken, and the newspapers showed an optimism for the industry. In 2000, Alf Bjørseth stated that they were going to be the biggest producer of silicon wafers, and grow past Bayer Solar from Germany, which was the biggest in the world at the time (Alstadheim, 2000). REC had become the biggest producer of silicon and wafers in 2006 (IEA PVPS Norway, 2006). This shows that both Norway and Germany played a big role in the production of PV components between 2000 and 2010.

Compared trend 2: Both Norway and Germany experienced a turning point in 2010-2011, where a decline in the number of jobs is visible. The Norwegian job crisis in the PV industry was more dramatic in regards to figure 13. Germany also had a slight decline, but it was much slower, which did not start until 2011. Two of the leading PV manufacturers in Germany (Q-Cells and Bosch Solar) had to change their business, by being acquired by an Asian company and giving up on silicon cell production, respectively (IEA PVPS Germany, 2013). Trend 2 thereby shows some similarities between the countries, in the way that a decline was visible, but there were also differences, both in the actual year of the decline starting, and in the degree of the decline.

Compared trend 3: The decline continues in Germany until 2015, which is the last available data (see figure 13). In 2013, 40 companies was active in the PV industry, in comparison with the 62 companies in 2008 (IEA PVPS Germany, 2013). In Norway, however, a new turning point is visible. Several Norwegian PV producers have emerged and grown the last few years, resulting in jobs for its citizens. Elkem Solar, NorSun and Norwegian Crystals are now expanding their production in Norway, while in Germany, the opposite is happening.

The presented three trends make up the principle of the organized discussion in each subchapter, and leads to the discussion of possible explanations for the development. Highlighting the similarities and differences between Germany and Norway can contribute to learning and improvement in Norway's PV industry, and may also contribute to other industries. So what can explain these similarities and differences? Each of the following subchapters represent one of the three views, namely the resources, the industry and the institutions, and are presented in a historic timeline from the three trends in the following sections. This will shed light on the development of jobs.

4.2 How can we explain this development?

As the figures in chapter 4.1 suggest, the PV market and industry in Norway and Germany has seen some major changes in the number of jobs through the years, and it does not seem to be stabilizing yet. The explanations for this development and the three trends is revised in the following part. This does by that investigate the second research question, as the title of the subchapter implies, namely: *How can we explain this development?* During the discussion, the German situation is compared to the Norwegian, making the mirroring clear, in addition the learnings from the past become clear. By that, the last research question is also addressed: *What can we learn from the past and from mirroring the Norwegian development with that of Germany?*

The three explanatory variables from the strategy tripod will now seek to find these explanations. In the following section, chapter 4.2.1, the technology and other resources are reviewed, using the resource-based view in order to find possible explanations for the development. Following this discussion, chapter 4.2.2, the market/industry is reviewed using the industry-based view. And finally, in chapter 4.2.3, the culture and governmental regulations/incentives are investigated with the institution-based view.

4.2.1 Investigating the technology with the resource-based view

The general technological factors can be evaluated using Barney's (1995) resource-based view. Between the different technology generations, and even within the generation groups, it may be shown that the products vary in value, rareness, and imitability.

Mono-Si can contribute to a higher efficiency pr. m^2, than can p-Si, and has the ability to neutralize the threat of p-Si to an extent. Thus, it seems to be more valuable. The production degree of mono-Si has historically been below that of p-Si (Fraunhofer ISE, 2016:17), making it rarer, as well. Due to the costly production of mono-Si, making production more favorable in locations where water for cooling is in abundance and where the electricity costs are low, PVs based on this technology can be harder to imitate. Based on these arguments, the mono-Si technology has a temporarily competitive advantage over p-Si for companies with access to the mentioned resources, from Barney (1995). However, the p-Si PVs may be more favorable due to a lower price.

Because the efficiency of 2G is lower than the other generations, it is less valuable. Based on the theory of Barney (1995) and figure 6, this leads to the assumption that 2G PVs may not have any competitive advantage over 1G from the first question. However, this is dependent on the customer's choice, because the low cost for the customers and flexibility of the cell can increase the value. Because smaller amounts of 2G PVs are produced, than that of 1G, these PVs are rarer. The production is relatively easy and cheap, thus it is not a difficult technology to imitate. The question of imitability depends on the material that is used. This makes the production mostly dependent on the access to feedstock, and the toxic effects on the environment and human life, which have been stated to be the drawbacks on many of the 2G technologies. Without finding substitutes, the 2G may therefore lose competitive advantage in regards to the 1G PVs.

3G and 4G PVs have (or are aiming at) the highest efficiency pr. m^2, making it capable of neutralizing the threat of the other generations, thus it may be regarded as the most valuable. It is also the technology that is produced to the smallest extent. This makes the 3G and 4G PVs rare. Due to the cost of producing them, they are harder to imitate. In addition, there is a shortage of many of the vital materials, or there are toxic disadvantages to some of the materials used in this technology, making it important to find new substitutes. This makes the technology much harder to imitate, unless a company manages to find a good substitute material, and a cheaper production method. Based on this, and according to the resource-based view, 3G and 4G PVs will have a temporarily competitive advantage over 1G and 2G PVs, if the drawbacks are improved. Due to the vast possibilities in material choice, the rarity within 3G and 4G may be more spread as well, decreasing the parity. Knowing that many of these technologies are still at the R&D stage, this progress may be interesting to observe.

Is it possible to use the production of the technology as an indicator for jobs? Norway has been able to provide jobs for thousands of citizens the last decades, due to the oil and gas industry, and it has resulted in great profit for many and for the country as a whole. This has been based on an increase in oil and gas production and an increase in oil and gas prices. These two combined have been the major forces that have driven the continuing investment in the industry. However, the production of crude oil peaked around 2001 and gas production peaked around 2004 (Government, 2012). Maintaining the industry has been driven by the increase in prices alone since then. Just as can be argued using the price and the production of oil and gas as variables that can explain the number of jobs in the industry, the production and price of PVs can also be indicative of the number of jobs in the same industry. While prices have decreased in the PV industry worldwide, the production and market has increased even more. Knowing the major decrease in jobs that the oil and gas industry is facing today, should show that the production is one important variable that determines the number of jobs. In addition, the growing tendency in the production of PVs for Norway is a promising development for the creation of future jobs. So how has the production of PVs evolved?

The worldwide focus on production of the different technological generations has been shifting. In the 1980s, mono-Si was actually the most produced technology, even though the total PV production was only a small fraction of today's production quantum (Fraunhofer ISE, 2016:18-19). This changed to increasing focus in the direction of 2G towards the end of the 1980s, when 1G again started to grow. By the beginning of 2000, p-Si was the most produced PV material in the world. What is the situation in Norway?

In Norway, the focus on production has mainly been on 1G of PVs, and that is the reason why this is the only technology generation that is presented in figure 14. The division has been made within the 1G group instead, namely on p-Si and mono-Si. As stated earlier, p-Si is less expensive to produce due to a lower necessity for pure silicon. REC started producing p-Si. NorSun and Norwegian Crystals, the main wafer and ingot producers in Norway today, are focusing on mono-Si, which is visible from figure 14.

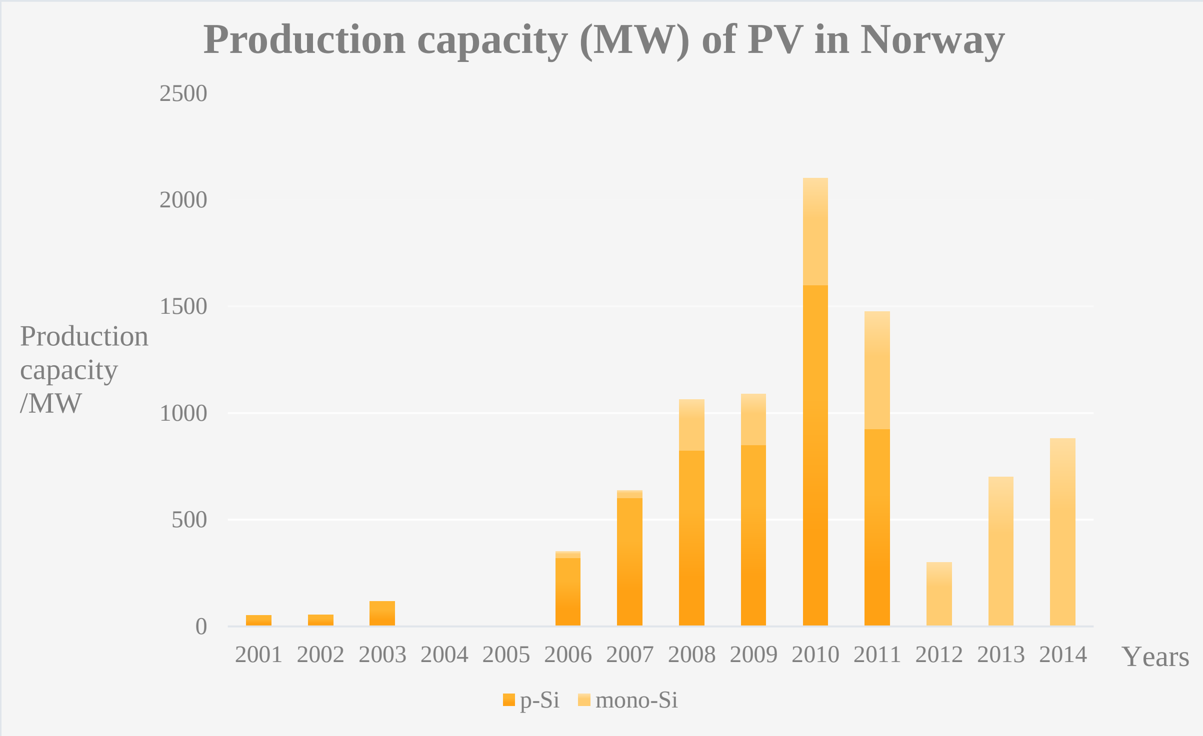


FIGURE 14: THE PRODUCTION OF PV IN NORWAY FROM 1999 TO 2014 (SOME YEARS HAVE LACKING DATA, AND ARE THEREFORE NOT INCLUDED). ONLY 1G TECHNOLOGY HAS BEEN PRODUCED, AND THE DIVISION FOR EACH YEAR, THUS SHOW WHETHER P-SI OR MONO-SI HAS BEEN USED. MONO-SI HAS APPARENTLY BEEN GROWING THE LAST YEARS. (SILICON FEEDSTOCK IS NOT INCLUDED, THE NUMBERS ARE ONLY AVAILABLE FOR A FEW YEARS)

Due to the lack of correlating entities, and that it is difficult to distinguish between mono-Si and p-Si for feedstock production, because clean enough solar silicon can be used for both p-Si and mono-Si, Elkem's production is not included in figure 14. The number of employees at Elkem Solar is included in figures 11-13, however. The production of PV in Norway for the year of 2014 is therefore likely to be higher, when the new factory of Elkem Solar ran at full capacity. In addition, in reality, there would also be a visible production of p-Si, if Elkem's number had been available. In 2016, part of the old REC plant at Herøya is expected to be up and running with Elkem Solar, increasing the production even more. The production will be silicon ingots, based on silicon feedstock from Elkem Solar's own production (Elkem, 2016). This will further increase the number of employees and the production in Norway, mainly towards p-Si (Marstein, 2016).

It is now clear that Norway's production showed similar tendencies as the number of jobs, and that the focus has been on 1G, but what has Germany focused on?

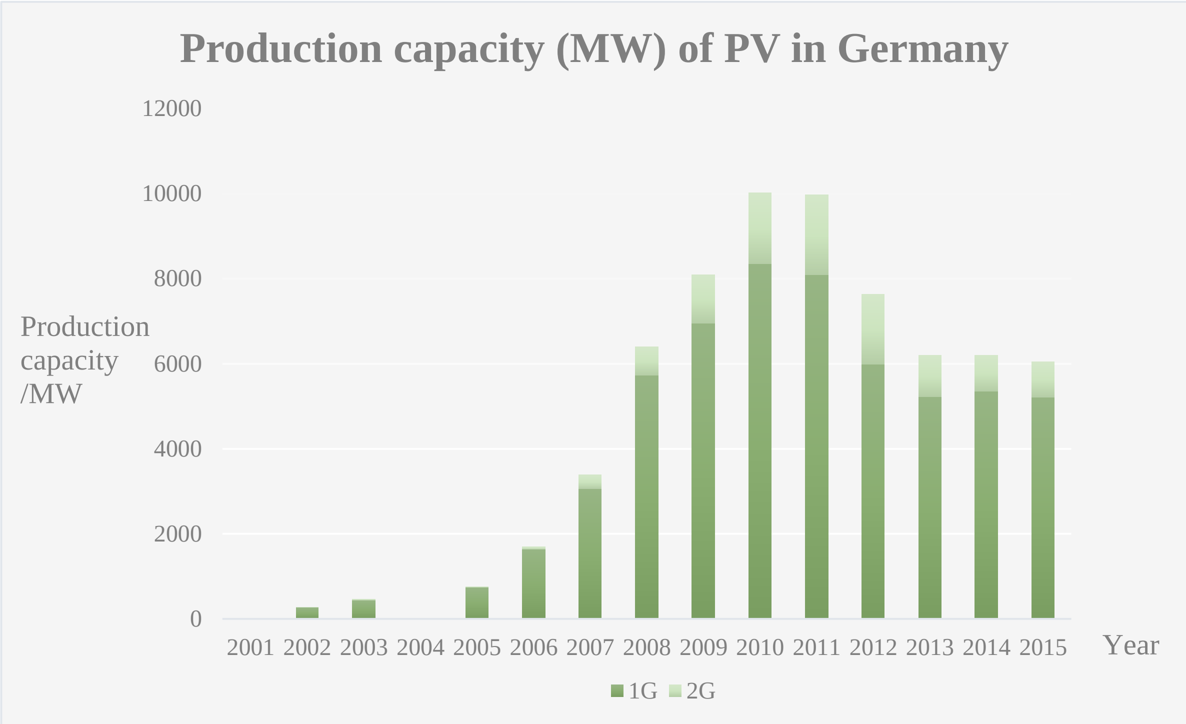
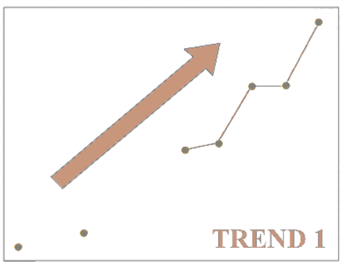


FIGURE 15: THE PRODUCTION CAPACITY OF PV IN GERMANY FROM 2001 TO 2015 (WHERE YEARS WITH LACKING DATA ARE OMITTED). IN GERMANY, BOTH 1G AND 2G HAVE BEEN PRODUCED, AND BOTH TECHNOLOGIES HAVE SEEN A DECREASE THE LAST YEARS. (FOR COMPARISON WITH NORWAY, FEEDSTOCK IS NOT INCLUDED). SOURCE: GTAI 2004-2015 AND IEA PVPS GERMANY 2002-2014.

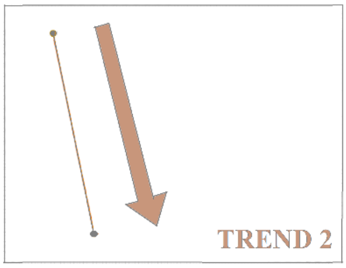
From figure 15, one may see that Germany has produced both 1G and 2G. Both the production capacity of 1G and 2G grew until 2010 and 2011, and slowly decreased in the following years. In 1G, the production of wafers, cells and modules are included, and 2G represents the thin film production. The development is comparable to the number of jobs in Germany (see figure 12-13), where the two peak years are 2010 and 2011, which are almost the same. There is a minor increase in the number of jobs from 2010 to 2011, and there is a minor decrease in the production capacity from 2010 to 2011. Due to some errors that could arise, mainly the mentioned representation of only leading manufacturers in chapter 3.3.3, these differences are not reviewed further.



The resemblance between Norway and Germany for the period of the growing number of jobs from 2000 to 2010-2011, is that production in the two countries was growing as well. The focus of both countries was the 1G technology, as was also the case for production in the rest of the world at that time, as we have seen. The choice of the 1G technology, and thereby the dominant use of silicon, has been said to originate from the previously constructed knowledge and experience base from the use of silicon in electronics (Goetzberger et al., 2003, referred in Hanson, J., 2006). Had another technology generation been the dominant, it is difficult to say whether Norway and Germany would have grown as much, or as little, as they did. However, this choice of technology may have been a possible explanation for the growth in Norway and Germany during this period. Norway had, as mentioned a company that had been producing silicon for years, namely Elkem.

After Hydro had to lay off production workers at several facilities, for instance the aluminum production in Årdal in 2007, the factory in Glomfjord in the 1990s and the factory at Herøya in 2001, a lot of metallurgic experience and competence was set free (Kagge, 2004). These workers then had to find work at other facilities. The production of silicon is a similar field to the field they had been working in before, namely the metallurgical field. This made it easy to adapt to this new industry. This experience and knowledge was therefore essential for the beginning of the PV industry in Norway. From Barney (1995), this resource made the Norwegian companies less imitable, increasing the temporary competitive advantage. This, together with the dominant 1G technology, especially p-Si may have had an influence on the development, regarding the metallurgic competence. Without these resources, the buildup of the p-Si production facilities would have taken much longer, and may not have started in the first place. Marstein (2016) states that the highly skilled workers at the factories have been very important, and that this expertise is one of the competitive advantages the Norwegian companies possess. These resources were therefore important and valuable for the early growth in the beginning of the PV industry in Norway, and are still today.

From 2003 to 2008, solar silicon was deficit (Mehta, 2014). This made the production of 1G PVs more expensive, thus, the end-product was also expensive. From 2008 to 2009, the growth stagnated somewhat in Norway, but not in Germany. The raw material deficiency of p-Si could be an explanation for this. In Germany, the 2G producers could take advantage of this deficiency. As stated, 2G thin films made of a-Si needs less material, making the production less costly than the production of 1G. In a period of expensive raw materials, this would therefore be a competitive advantage. From 2005 to 2012, the production of 2G grew in Germany, leading the country to take advantage of the raw material deficiency with the production of other generations, resulting in more steady growth, both in production and in the number of jobs.



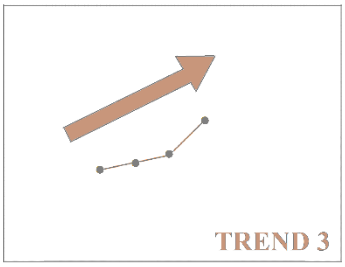
As stated, trend 2 shows one important factor, in particular, that showed a dissimilar development in the two countries. That factor would be that there is no apparent decline in 2010, in contrast with the Norwegian development, which experienced a rapid decline. From Barney's (1995) resource-based view, the technology strategy, and thus a firm's choice of PV generation, may be an explaining factor for the difference in decline.

Germany produced both 1G and 2G technology, as shown in figure 15. The production capacity of this generation increased from 2005 to 2012. Could this have made an impact on the number of jobs? As figure 15 shows, the 1G technology decreased first, while the decrease of the 2G technology was one year later, holding the industry up. This could indicate that it was the 1G technology that was threatened the most, making this a less valuable technology, in addition, the 1G may have scored low on the question of rarity from Barney (1995), resulting in parity between the producers of 1G. These two factor would have increased the competitive advantage of 2G. In 2013, however, both the production of 1G and 2G declined in Germany, and the number of jobs decreased further. This shows that both these technology generations in Germany had lost competitive advantage from the resource-based view, making it harder to keep the jobs within the country. The 2G technology can therefore show to have slowed down the decline, but it did not stop it. However, this differentiation of technology generations could show to make the industry more stable in regards to price fluctuation, raw material deficiencies, etc., and the 2G technology can therefore be an explanation for the slow decline in Germany compared to Norway.

Drawing a parallel between the 1G versus 2G in Germany, and the p-Si versus mono-Si in Norway, in the period from 2010 to the beginning of 2012, indicates some similarities. The focus on 1G, and especially p-Si in Norway, may have contributed to the decline in both countries. As the 2G in Germany slowed down the decline, so did the mono-Si in Norway. The decline in production was mainly visible for the p-Si producers in Norway. The Chinese producers had found cheap ways to produce a lot of p-Si (Bjørseth, 2016; Marstein, 2016). REC had to shut down, first its p-Si factories, and in 2012, the mono-Si factories had to close. Norsun however, managed to get through by terminating some employees, and continued to produce mono-Si through the slump. Even though the price was decreasing and the production decreasing for mono-Si as well, in 2012, this technology was still a relatively difficult and costly business. Could REC have avoided shutting down everything if more of the production had been focused on mono-Si?

Alf Bjørseth has stated that Norway would be much better suited to producing mono-Si PVs because of the low electricity costs in the country and the abundant water resources for cooling (Stokkan, 2015). Focusing more on this, could have saved Norway from the rapid decline. Bjørseth (2016) claims that the Chinese manufacturers initially had trouble competing with quality and price on the mono-Si production. This made the mono-Si production less vulnerable to the decline, which may be proven by the shutdown of p-Si production in Norway first (see figure 14). In retrospect, it was stated that the Norwegian PV industry should have taken advantage of its dominant position in order to develop more complex and less imitative technologies. REC was accused of lack of innovation and uniqueness in its wafer, cell and module technology (Ceccaroli, 2012). An opposite strategy would have led to a temporary competitive advantage, from Barney (1995) (see figure 6). The ongoing focus on p-Si, a weak p-Si lock-in of some sort, could therefore have been a contributing factor for the rapid decline.

Another explanation could be the lack of focus on quality, innovation and technological edge, as Bjørseth (2016) states, namely that the companies that carried the opposite strategy “and managed to retain this head start, managed to survive and still do. Although for these, as well, it has been a tough period with rapidly falling prices.” This shows the importance of quality and innovation focus, and indicates the possibility of a more stable industry in Norway if this had been better during this period.



Norway has mainly focused on producing mono-Si after the decline in 2010-2011. Based on the discussion above, for trend 2, and the discussed competitive advantage of mono-Si in Norway, this increased focus towards mono-Si may explain the recent growth in the Norwegian industry, compared to the further decay in Germany. Bjørseth (2016) does partly support this explanation, in addition to more experience in the actual production. This experience results in higher efficiency and tacit knowledge that increases the competitive advantage. According to IEA PVPS Germany (2014), only the efficient producers may produce without loss in the situation that exists today. This further substantiate the possibility of resources being an explanation for the growth we see in Norway today.

For Germany's part, it could be that it is the production of p-Si that is decreasing, and that mono-Si may be increasing. This is however, not possible to state, due to lack of data on this part. It may however, be a possible explanation for the difference between the two countries.

So what can help explain the lack of growth in Germany? The technology generation choice could be an explanation for the ongoing decline in Germany. The production of 2G decreased in the years after 2012. From a technology generation standpoint, Germany's investment into 2G could therefore be a reason why growth in the number of jobs in the country has not become a reality again. This can be an argument when coupling it with the fact that 2G technology has not yet attained the larger portion of the market, with only 10% in 2014 (REN21, 2015:62), and Marstein (2016) has stated that the US's extensive focus on 2G has resulted in a tilted industry. Most companies focusing on 2G have struggled to attain a low enough price, when knowing that the efficiency is lower than 1G. Even though the 2G could have been a contributing factor and saved Germany from a rapid decline in 2011, it may also explain the lasting decline.

4.2.1.1 Summing up the discussion of resources

The possible explanations for the three trends in regards to the resource-based view are summarized in the following paragraphs. A simple overview of the impact of the resources can be seen in table 3.

Trend 1: As stated, the PV industry in Norway took advantage of the competent workforce from Hydro's old metallurgic industry. This can be one explanation for the growth in the PV industry from 2000 to 2010. In addition, the already established silicon production may have contributed to the growth due to the dominance of 1G at the time, and especially p-Si. Germany's steady growth compared to Norway, especially in 2008 and 2009, could be explained by the growing focus on 2G as well as 1G, making a differentiation.

Trend 2: The rapid decline for Norway versus the slow decline for Germany may point to a technology explanation that may be more complex. Germany produced both 1G and 2G, and it was mainly the 1G that decreased during the first couple of years, while there was a delay for the 2G decline. This may show a slow decline due to a technology generation differentiation. Therefore, the rapid decline in Norway could be explained by a lack of technology generation differentiation. However, the lack of differentiation within 1G could also be a reason, namely, the weak p-Si lock-in. Bjørseth (2016) does state that Norway had a competitive advantage with the production of mono-Si, and that this could have showed to slow down the decline, if it had not been for the focus on p-Si. Lack of innovation, quality and uniqueness of the PV products were also mentioned as factors for the decline in Norway.

Trend 3: The shift from p-Si to mono-Si represents an explanation for the growth in Norway. In addition, the experience and efficiency in production has increased, making the Norwegian producers attain tacit knowledge of the mono-Si production. This is a competitive advantage. The ongoing decline versus the growth can be explained by Germany's choice to produce 2G, which has not grown past 1G yet.

TABLE 3: THE INFLUENCE OF TECHNOLOGY ON THE DEVELOPMENT OF NUMBER OF JOBS

(NONE, MINOR, MEDIUM, STRONG)

	NORWAY	GERMANY
TREND 1	Medium/Strong	Minor
TREND 2	Medium	Medium
TREND 3	Strong	Minor

Table 3 shows four terms that represent the degree of impact of the resources; from none, to minor, to medium to strong. These are intended for relative comparison between the different trends and the different theoretical views of the thesis. The impact on Germany needs to be seen in regards to the emphasis laid on the case of this country, meaning that the degree of impact is only presented to show the similarities and dissimilarities with Norway.

The resource-based theory of Barney (1995) has helped reveal some important influential aspects with the technology, as can be seen from table 3, showing the importance of the technology for the development of number of jobs in the PV industry. Table 3 also uncovers some potentially unexplained or not sufficiently explained trends from the resource-based view. The resource (the technology and competence) is therefore an important factor, but it is not a sufficient explanation. The market is the actual buyers of the technology, and may be just as important. The market and structure of the industry are therefore investigated to find a sufficient answer to the development of jobs.

4.2.2 INVESTIGATING THE MARKET WITH THE INDUSTRY-BASED VIEW

Before the PV industry is investigated, the surrounding industries, also known as the substitutes, and the customers, in the form of end-users, are investigated, in order to give an overview PV condition.

The renewable energy market is comprised of a range of technologies, for instance wind power, wave power, bioenergy, geothermal energy, solar heat, hydropower, etc. The development of this market has shown a growing tendency, and in 2015, renewable energy accounted for 53.6% of the annual new power generating capacity installed (UNEP and Bloomberg, 2016), even when large hydro power was left out, making it bigger than oil and gas for the first time. Of this, the PV market comprised a share of 41.8%, with wind taking first place with 46.3% of the installed capacity in renewables in 2015. This makes wind the biggest substitute competitor, and this, as well as the others, may well have affected the development of PVs in the past, but due to time constrains, a thorough discussion on historical impact of these substitutes is not included. Nuclear power is another energy source that can be classified as environmentally friendly, and a substitute, but this source is not considered a renewable energy source.

Even though the global installation has grown past fossil energy sources the last year, it has not always been this easy. In several countries, the solar market and other renewable markets as well, have had to struggle with competition and opposition from the utility companies. This has slowed the growth of the renewable energy market. The already established utility companies have mostly focused on other energy sources and many have worked hard to diminish solar power. In several European countries there have been powerful utility companies trying to work against the growth in the solar energy market. This is of course not incomprehensible when the top 20 utility companies in 2008 were worth 1 trillion EUROS, and by 2013 were only worth less than half of that (The Economist, 2013), with renewable energy sources to blame. When people started buying solar panels for their houses and companies, being able to produce their own electricity for some hours a day, meant a loss in revenue for the utility companies. The energy provided from the utility companies can therefore be regarded as a substitute for solar energy, and has been a major competitor.

This picture, however, is complex. Some utilities have also bought solar farms, contributing to the development of solar energy as a whole, and giving more green energy to their customers. This could have been a strategy to try to slow down the customers want to buy their own green energy source. Meanwhile, other utility companies have had to pay private residential producers for the excess electricity they provide the grid.

Every one of the above mentioned energy sources and technologies can be regarded as substitutes for PV, and would, based on Porter's industry-based theory, increase the competitive landscape for the established PV industry. The accident in Fukushima in 2011 did however affect the global market for nuclear power, and did provide better terms for PV, and all of the other renewables, as an energy sources (Buchan, 2012). Reading from the report from UNEP and Bloomberg (2016), the fact that solar is the most invested of the renewables, and has been since 2010, makes it possible that the renewable substitutes lose power over solar in the near future. The increased investment in renewable as a whole, compared to fossil energy, makes solar gain power over these sources as well. The global solar industry is therefore, predicted to have better competitive advantage from Porter's industry-based view.

We have now seen the present global picture of the market for renewable energy sources, and that PV obviously is an important and a growing part of this picture. Even though the historic discussion of the competitive landscape from the substitutes was not prioritized, the present situation has shown that the substitutes may have less power over the global PVs today, from the industry-based view. How has the bargaining power of customers been evolving?

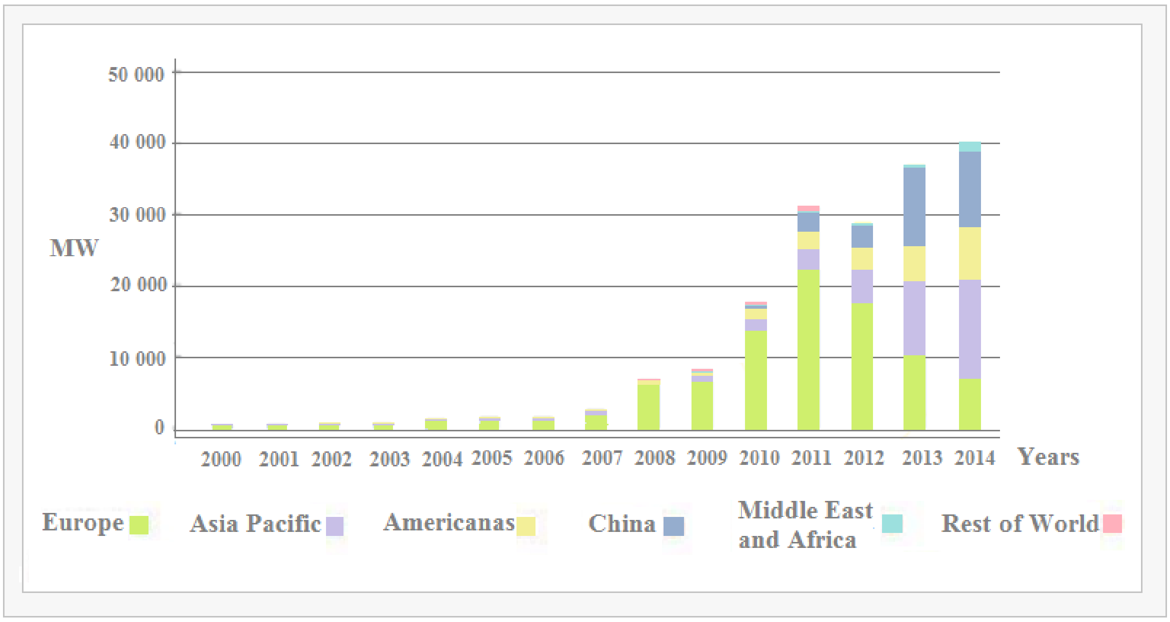
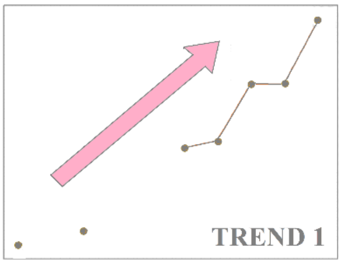


FIGURE 16: INSTALLED PV CAPACITY FROM 2000-2014. EUROPE, ASIAN PACIFIC, AMERICA, CHINA, MIDDLE EAST AND THE REST OF THE WORLD. EDITED VERSION OF FIGURE 2 IN SOLARPOWER EUROPE, 2015.

As can be seen from figure 16, the PV market has shifted from Europe to Asia the last couple of years. The over-all world PV market has been growing almost non-stop since 2000, with the exception of 2012. From 2000 and until 2012, Europe was the biggest market for PVs. In 2011, 74% of the world's PV installation happened in Europe, while in 2014, this number had dropped to around 18% (Smets et al., 2015). From 2013, Asia grew massively, and has now by far the biggest customer base of PVs, and is still growing. This is due to both a drop in the European market, and a growth in the Asian market. This development shows that the end-users, or customers, of PVs have shifted. This background knowledge of the worldwide customers forms the basis of the further discussion of the three trends.



The special market development in Germany was one of the reasons this country was chosen to compare with Norway. In Germany, the market has been greatly affected by several energy source acts and benefits. In 2000, the Renewable Energy Sources Act (EEG) started, and gave the citizens the ability to buy PVs and benefit from feed-in tariffs for every kWh fed in to the grid (IEA PVPS Germany, 2002). This was in addition to the 100 000 Roof Solar Power Programme. The EEG lowered the feed-in tariffs successively to 2003 (IEA PVPS Annual, 2014), mainly because of a new government, financial downturn and the introduction of the Euro. In 2004, the feed in tariff was raised, and then successively lowered again, and has been revised several times, in order to keep the pressure on innovation and development in the manufacturing companies. Energiewende has become a word to describe Germany's transition to the use of renewable energy sources (Lang and Lang, n.a.). The will to change the country's energy use was a result of the energy mix at that time. Germany's energy sources have mainly been comprised of fossil fuel, nuclear and hydro power, in descending order. These governmental incentives towards the renewable market made it possible for Germany to test different renewable technologies. Rainer Baake, a minister of Germany, stated that bioenergy counters the environmental and food production aspect, hydro power is already fully expanded, and geothermal energy was difficult to make use of in Germany, which makes wind power and PV the winners in the country (Osmundsen, 2016).

This increase in market, due to governmental incentives, has been of great importance for the development of an industry. The governmental market incentives have secured, to an extent, customers for PV producers. When Energiewende started, PV was not profitable, but making it accessible for private residential customers, commercial operation and industry to buy it, made it profitable for a manufacturing industry to unfold (Drevon, 2011; Hanson, J., 2016). Germany became the biggest market, making the need for more PV production apparent, thus, Germany could take advantage of this by creating factories and jobs within the country in the production part of the value chain as well. It shows that it is not sufficient to subsidize just the R&D, there must be a market there to show the way. In other words, there must exist a market pull, not just a technology push. Therefore, the incentives towards the market affected production, and may well be the reason for Germany's achievement in creating jobs for its citizens from 2000 to 2011.

Norway did not focus on market incentives, and could not show to increasing numbers in companies due to a market growth within the country, like Germany. The production in Norway was, however, growing. Why could this be? Of course, the global market growth also benefitted the emergence of a Norwegian PV industry. In 2007, 53% of REC's PV wafers were sold to Asia, where Japan was the biggest customer, while 47% were sold in Europe, where most of it ended up in Germany (IEA PVPS Norway, 2007). This goes to show that the growing market in Germany, also benefitted Norway.

Other factors played a significant role as well. When producing PVs an important aspect is the access to raw materials. From 2003 and until 2008, raw material of silicon was deficit (Mehta, 2014). As we saw in chapter 4.2.1, Germany started to produce 2G, needing less silicon during this period. Norway had a different solution. Companies in Norway had to collaborate, and Elkem and ScanWafer formed a jointly owned company, Solar Silicon (Ruud and Larsen Mosvold, 2005, referred in Koesah, 2013). In addition, Elkem and REC entered contracts with partners in the US in this period. This was to make sure they had all the material they needed. Bjørseth (2016) claims that contracts with foreign suppliers of solar silicon feedstock "was crucial for the growth of REC at that time", in order to have a secure supply. From Porter (1980) this shows the importance of securing contracts and lowering the bargaining power of the suppliers, which would give the Norwegian producers a competitive advantage compared to the other producers. This looks like a good strategy, reading from the production capacity growing during the entire time, until 2010 (see figure 14), and it may well be the determining factor for the growth in Norway.

As we have seen, the growing market, and thereby the lowering of rivalry within the established industry, in addition to the stabilizing of the suppliers, resulted in better competitive conditions for the emergence of the Norwegian PV industry, from Porter (1980). The following discussion is comprised of the established industry and its susceptibility of new entrants through the years of trend 1.

After Germany had contributed to a growth in the PV market, it resulted in a growing tendency for European *production* as a whole. We saw earlier, that there had been a geographical shift in the market, but the shift in production is just as visible through the years. In figure 17, the two are compared for the period 2000 to 2012. The geographical origins of the PV manufacturers have shifted from the Asia Pacific region and America during 2000 to 2006, to Europe in 2007 and 2008, to Asia and especially China from 2008 (Smets et al., 2015). This has affected the prices and the amount PVs produced. Why did the production shift from Europe and Germany, to China?

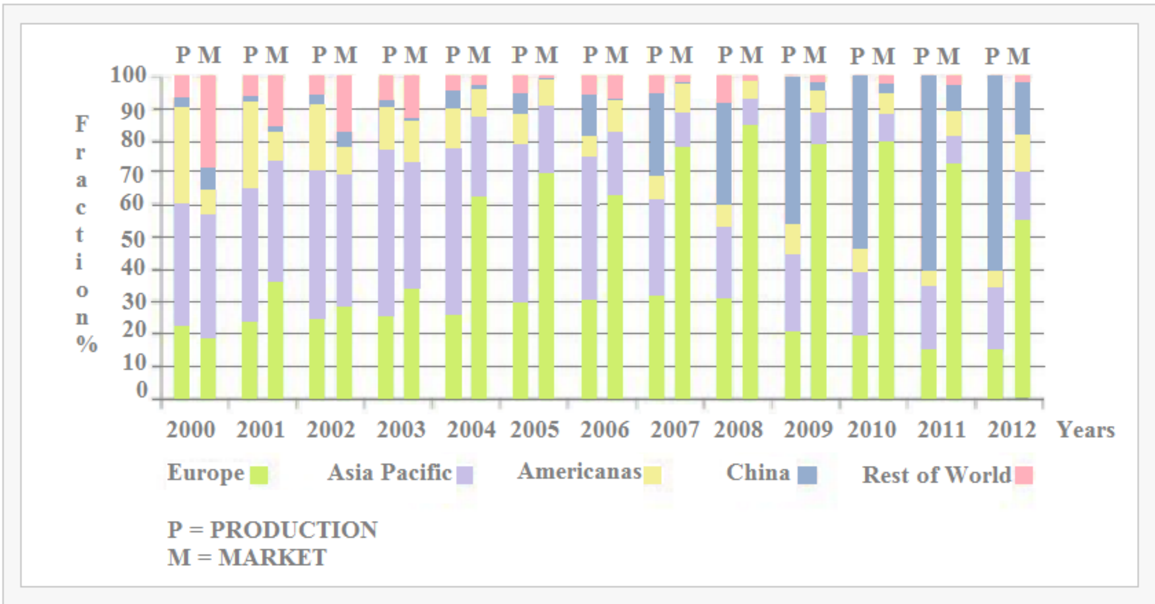
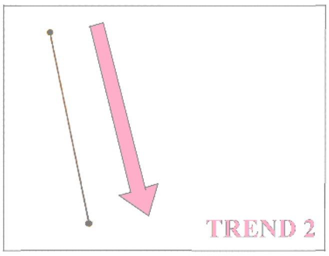


FIGURE 17: THE PRODUCTION (P) OF PVS AND MARKET (M) OF PVS SEEN IN PERCENTAGE OF THE GEOGRAPHICAL ORIGINS. SOURCE: EDITED VERSION OF SMETS ET AL., 2015.

China started to concentrate public funding towards building its own PV manufacturing industry around 2004 (Puttaswamy and Ali, 2015). The focus was mainly on p-Si PVs. This resulted in a resurgence of new Chinese companies. As the Chinese manufacturers developed standardized production lines, and as the export increased, they managed to intensify the competition even more when economies of scale became a possibility for them. After years where Europe was the biggest producer of PVs, Asia, and especially China grew vastly after

2008. According to Porter's industry-based view, an unstable and shifting industry like this often corresponds well with a fragmented industry, where no company has the entire power to establish a definite price on the product. In order for other companies to become important actors, as the Chinese manufacturers quickly became, the industry most likely had low entry barriers, which corresponds well with a fragmented industry. The lowering of the price can be seen as a price war (IEA PVPS Germany, 2014), and could have lowered the entry barriers even more, making the once powerful manufacturers in Europe, Asia Pacific and America, lose more power. However, China as a country became increasingly powerful, giving their companies the ability to determine a low price, due to production subsidies. This can therefore, towards 2010, be regarded as a fragmented industry, with one particularly powerful and growing country.



In March 2011, the spot price of p-Si was at its highest point, but during the year, it decreased by approximately 70% (IEA PVPS Norway, 2011). The primary cause is claimed to be the rapid increase in production from the Chinese manufacturers, over flooding the market, compared to the earlier situation. The entire production capacity of the world was around 60-70 GW, while the actual market was around 40 GW in 2013 (IEA PVPS Germany, 2013). The main and direct cause for decline of the other PV producing countries was the rapid growth of the Chinese manufacturers. From Porter (1980) one could see that the low entry barriers did make it possible for new companies to enter the industry. This again led to low prices, that the customer wanted, reading from figure 16, where the market was growing until 2011, increasing the bargaining power of the customer as well.

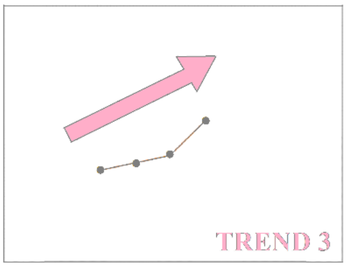
In addition to this main cause for a decline in Norway and Germany, other underlying factors could have affected the decline further. One contributing factor could be the world economic crisis in 2008 and 2009. This did actually affect the production of PVs in Germany (IEA PVPS Germany, 2011). The other explanations could be that the fragmented industry and the not so big market, yet, had resulted in production that may not have reached economies of scale. This may have lowered the abilities to withstand a large competitor, from Porter (1980), thus giving the Chinese subsidized producers a head start to this opportunity.

So why did the decline affect Norway more than it did Germany in 2010 and 2011, based on the market and industry? The mentioned Fukushima accident influenced Germany more than it did Norway, in regards to future strategy choices for energy sources. Germany had several nuclear power reactors, and had in 2010 decided to extend the lifetime of these. After the accident in 2011, however, this decision was reversed, and the reactors that had been shut down for service did not start up again, in addition to the phase out of the production of the remaining reactors by 2022 (Buchan, 2012). The government could by that, have affected the energy production by subsidizing more towards PV, among others. The German PV market did actually boost in 2011. The main reason for this has, however, been stated to be the low cell and module prices, and that the government announced that the feed-in tariff for PV customers would decrease further in 2012 (IEA PVPS Germany, 2011). They have announced the lowering of the subsidies several times, in an attempt to make the manufacturers sustainable alone. This could be one of the explanations for the prolonging of the number of jobs and production in Germany, compared to the decline in Norway, in 2011.

Another explanation for the rapid decline in the number of jobs and production in Norway, compared to the slow decline in Germany, could be the difference in the number of companies in the two countries. This difference may be seen in figure 12, where the absolute number of jobs is presented. Norway was more vulnerable due to a small number of companies within the country. A company going bankrupt or relocating to another country would be more obvious to the overall situation in a country with only a few establishments in the industry. RECs move-out was of course an important factor for the visible decline, in addition to Elkem Solar having to lay off employees temporarily in 2012, as well some smaller companies that went bankrupt (IEA PVPS Norway, 2012). This shows the impact the number of firms can have on a development, where more companies can lead to a more secure development of the number of jobs, seen as one. Of course, there will be companies that may go bankrupt, and companies that have to lay off many employees. For them this is drastic, but seen as a whole system, the impact is less drastic. In Germany, the risk was differentiated throughout a number of companies. In 2011, the number of PV producing companies in Germany was around 70 (IEA PVPS Germany, 2011), making the risk of decline being distributed on more than ten times more distinctive companies, compared to Norway. This may indeed be an explanation for the slow decline in Germany and the rapid decline in Norway.

As seen, the number of companies may have resulted in Norway being more susceptible for a decline, and in chapter 4.2.1 it was stated that REC was the one with the largest decline in Norway, going from being the largest PV company to shutting down all of the facilities in Norway. Why was REC, especially, more susceptible to this? As discussed in chapter 4.2.1, REC was mainly focused on p-Si, but another explanation may have been the company's focus on establishment in Singapore (Ceccaroli, 2012). In 2005, REC decided to build a wafer, cell and module factory in Singapore. A lot of money was invested in this new factory, and many Norwegian workers went over to teach the employees their knowledge and competence. This has, seen in retrospect, led to REC surviving the sudden price reduction, and may have contributed to an even bigger growth in the PV market. However, seen in the light of the Norwegian workforce at that time, this was not a positive strategy, where much of the competitive advantage of REC in Norway were lost.

Comparing the number of jobs and the production capacity in Norway, it shows that the production capacity decreased by a smaller factor than the number of jobs, from 2010 to 2011. It is even more obvious when knowing that in the graph showing jobs (figure 11), the surviving company Elkem Solar is included, while in the production graph (figure 14), Elkem is left out due the lack of correlating production numbers. Investigating the numbers of the actual production from this year shows that the production did not increase either. This development is more similar to the German development, where the decline happened in 2011-2012. Why did so many lose their jobs in Norway, when the production was still going? This could just be a strategy to cut down expenses, and therefore lay off workers, before a total closure happens. In order for such a strategy to be conducted, from Porter (1980), the competition must have been high, resulting in a price competition, with terminating people, and eventually overproduction to compensate for the loss in revenue. The mentioned fragmented industry, with low entry barriers, thereby created a situation where the Norwegian producers had to choose a strategy to keep up the production and lay off employees. This represents a picture of tough times for many PV manufacturers in this period.



In 2001 and until 2010 the PV production industry consisted mostly of numerous smaller companies, which comprised the mentioned fragmented industry. Today, this is still the case. There exists more than 5 000 PV manufacturers around the world (ENF Solar, 2016). In 2013, the EU and China decided on a Minimum Import Price (MIP) in an attempt for Europe to stop the over-subsidies and resulting price dumping of PVs from China (Fuhs, 2015). Reading from the MIP, a PV trade stop between the US and China, and the low price of PVs, the industry is still characterized by a price war, but the still growing market makes the industry more desirable. It may well be that the Chinese manufacturers have an advantage when the market in China now is the biggest, making the MIP and trade stop with the US, less important for them. The price of p-Si is again increasing, and the reason for it is the growing market in China, and the Chinese government's statement that the installation subsidies will decline in the nearest future (Hill, 2016). This shows China's superior power, both over the market and the industry, just as the rest of the discussions in this subchapter have shown.

There has however, been some problems for the Chinese manufacturers. Michael Hvitfeldt stated that the Chinese solar panels that were installed in great quantity in Denmark during 2011 and 2012, would show to have flaws in a few years (Nilsen, 2016a). Hvitfeldt himself, installed solar panels on his own roof, and has already found efficiency and crack deficiencies. He says that, even though the price reduction, due to the Asian manufacturers taking over the market, was great for the market increase, the quality of the solar panels is causing the lifetime of the panels to decrease sufficiently. This could indeed be a branding strategy for the European producers, but according to Marstein (2016): "When we today witness what many factories in Taiwan and China are capable of producing, it does not stand back compared to the products from factories in Japan or Europe." This leads to the understanding that the competition has toughened, not just on pricing, but on quality as well. The competitive environment in today's established industry is now comprised of actors that seeks to lower the price, increase the quality and quantity, resulting in a tough environment, and thus an even more competitive industry.

The price and quality war is an explanation for the decline in the PV jobs in Germany, but why is the number of jobs in Norway increasing? Norway does have some advantages over other competitors in the established industry, for instance China, and that is clean energy during production of PVs, in addition to production technologies that consume less energy. In addition, just as the small number of companies in Norway could be a contributing factor for the rapid decline in 2010-2011, it may also be a contributing factor to the growth, namely that a growth can be more visible among a small number. This shows a possibility of "luck" being a contributor for the growth we see in Norway today. However, other industry factors may be well as important, as we will see now.

A strategy to avoid or control the fluctuation in the market due to price and quality wars, for instance, could be to spread across several parts of the value chain, or vertical integration. In the beginning of PV production in Norway, several parts of the value chain were exploited by the companies. REC specialized in p-Si production (IEA PVPS Norway, 2011), from feedstock silicon and wafers to cells and modules, but only wafers and cells were produced in Norway (IEA PVPS Norway, 2006). After the company closed down its cell production in 2011, most of the jobs in REC were moved out of Norway. The headquarter is still located in Oslo, but as Reich (2013) put it: "[W]here the company's headquarter lays is less and less important in this global economy", resulting in a decreased number of jobs. After the move-out, there was only one more cell and module producer in Norway, namely Innotech Solar.

Today, when Innotech is no longer in operation, this contributes to one of the differences in PV production between Norway and Germany. Germany has covered almost the entire value chain, including feedstock, wafers, ingots, cell and module production, inverters, etc. There are companies that possess the whole, or several parts of the value chain, and there are companies that focus on only one part, also in Germany, but the country as a whole has been differentiated throughout several parts of the value chain (IEA PVPS Germany, 2002-2014). This may be a good strategy concerning the nature of the PV industry during the last decades.

After the decline, Norway has almost exclusively concentrated its production around feedstock, wafers and ingots. Norwegian Crystals are focusing their production around ingots and blocks, the part of the process that they say can have competitive advantage in Norway (Ivar Blekastad, COO of Norwegian Crystals, mail, 10/29/15 and 1/21/16). The rest of the production, namely wafers, cells and modules, is conducted through contract manufacturing in Asia and Europe. Norsun and Elkem Solar are also focusing around a small portion of the value chain, where it has been discussed earlier in chapter 4.1 that Elkem has been owned by China International Bluestar since 2011. The fact that a Chinese owned company can produce in Norway, could show that this part actually is competitive to do in Norway. Concentrating the organization of the firm around one part can make the company's operation more susceptible to fluctuation and changes, but may also give opportunities in the form of more flexibility due to less tied up resources and assets, in addition to less bureaucratic costs (Hill and Jones, 2013). This may be a reason for the Norwegian industry still growing, giving jobs to more people, namely that the country has found the part of the value chain that can have competitive advantage in this country.

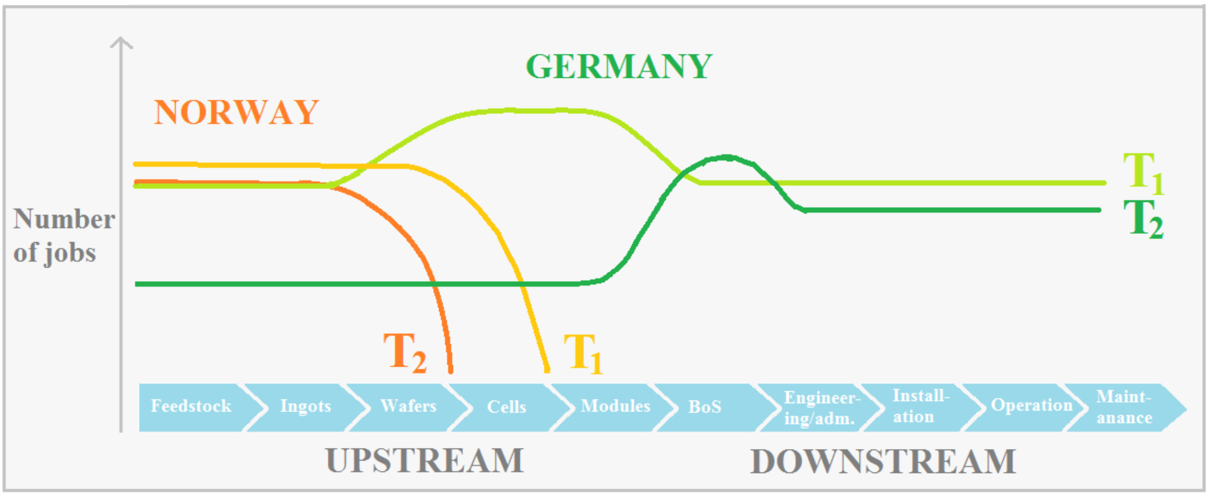


FIGURE 18: ONE REPRESENTATION OF THE PV VALUE CHAIN, WHERE THE DIVISION IS MADE BETWEEN UPSTREAM ACTIVITIES, NAMELY PV MATERIAL AND EQUIPMENT PRODUCTION, AND DOWNSTREAM ACTIVITIES, NAMELY PV APPLICATIONS. THE GRAPHS SHOW AN OVER-SIMPLIFIED REPRESENTATION OF THE NUMBER OF JOBS IN THE PV SECTOR IN NORWAY (ORANGE) AND GERMANY (GREEN) IN REGRADS TO THE VALUE CHAIN, AT TWO SPECIFIC TIMES, NAMELY IN THE BEGINNING OF THE 2000S AND TODAY. T1 (LIGHT COLOR) VERSUS T2 (DARK COLOR), RESPECTIVELY. IT IS IMPORTANT TO MARK THAT THE GRAPH IS ONLY A REPRESENTATION OF THE INFORMATION FROM IEA PVPS NORWAY AND GERMANY, AND THE REPORT OF UNEP AND BLOOMBERG, 2016. IT IS NOT BASED ON ACTUAL NUMBERS.

IEA's (2015c) report stated that all countries in Europe have experienced a decrease in the number of jobs in the PV sector from 2011 to 2014, except for the UK. This report deals with the entire value chain from the upstream activities like feedstock production, cells and modules, to the downstream activities like administration, installation and maintenance. Germany is no exception to this decrease, but from 2013 to 2014, the number of jobs in the entire PV sector actually increased in the country (GTAI, 2014). Knowing that the PV manufacturing industry at that time, was still decreasing, from figure 12 and 13, this increase should therefore be expected to originate from another part of the value chain.

During 2000s, Germany's focus in the PV sector has been on cell and module production, which has given the biggest contribution to the production capacity (IEA PVPS Germany, 2001-2015). In 2014, however, Balance of System (BoS), which is production of contact, switches, circuits, etc. for the PVs, gave the biggest contribution to the PV sector (IEA, 2015c). This development can be seen in figure 18. Has Germany realized that the production of the other parts can not attain competitive advantage in developed countries? IEA's (2015c) report actually states that Europe should focus the future job creation to the downstream part of the value chain (see figure 18). This should absolutely be a strategy in the years to come to create more jobs in Norway, as well. Bjørseth (2016) and Marstein (2016) also point the finger on installation and operation of solar farms in other countries, as a possible further growth of jobs in Norway. "Although I am very fond of the metallurgists, we have a lot of supplementary expertise all over Norway, who definitely need to contribute as well" (Marstein, 2016). Scatec Solar is an example that has already proven this fruitful.

The ongoing decline in the PV industry, defined in this thesis, in Germany can therefore be a result of the jobs being moved to BoS production, and to installation and service on PVs. Both Norway and Germany have shown to be interested in being a part of and benefitting from the PV market that is growing globally, but Germany has had a local PV market to consider as well. Germany has had the opportunity to move the production to parts of the value chain that they believe are more profitable, making the number of jobs decrease in the investigated part of the PV industry. They may believe that BoS and downstream activities are more favorable activities. This may be due to the volatile nature of the PV industry through the years, or past experience in China taking over industry jobs, for instance in magnesium and rare earth element production (Bjørseth, 2016). As was stated in chapter 2.1, the jobs in the defined PV industry may be viewed as tradable. This knowledge and experience may be the reason that we see an ongoing decline in the PV industry in Germany today, whilst not in Norway.

It may well be more profitable, just like IEA (2015c) suggests, but Norway has not had the possibility to move the jobs towards upstream activities due to a minor market at this point of time. PVs off-grid has been the main use in Norway (IEA PVPS Norway, 2010), mostly for cabins out of reach of the main grid. This is no guarantee for a future growth in the use of grid-connected PVs. The important impact the PV market has had on the PV industry in Germany needs to be deliberated. Considering the market pull, as well as the technology push, and by that not only subsidizing R&D, but also the market, as Germany did at an early stage, should be something the Norwegian PV market and industry should learn from Germany.

Mainly three things have stopped or slowed down the market growth in Norway, namely the low energy prices, high technology costs and minor subsidies (WWF and Accenture, 2016). In addition, Germany can be said to have a larger will to change due to the energy mix. Germany has been a big producer of electricity from fossil fuel, making the need to be more environmental friendly grow with the international demands. In Norway, we produce electricity mostly from hydropower.

A new strategy proposed by the oil and energy minister of Norway, Tord Lien, aims at lowering or removing the renewable electricity certificates (Sysla Grønn, 2016a) that facilitates the building of new renewable energy sources in Norway and Sweden, by giving the energy producers the ability to sell clean energy certificates (Fornybar, n.a.). This would weaken the market pull for PVs in Norway in the short run, which is the opposite strategy of what Germany started out with. Removing these certificates may lead to less renewable energy sources being built, increasing the energy price in Norway, and producing less renewable energy for the rest of Europe. For Europe as a whole, this will give less contribution to the decrease in greenhouse emissions, and it will make the Norwegian energy utilities more profitable. The latter shows the competitive force of substitutes from the industry-based view. These two aspect can however, lead to the opposite consequence of what was expected with the phase out of the renewable electricity certificates, in the long run. Less environmental friendly energy production and electricity that is more expensive will lead to elimination of one of the three mentioned things that has slowed down the market growth in Norway. This can lead to a situation where the consumers may be more willing to install PVs to create their own electricity at a lower cost.

In addition to the difference in energy mix, and will to utilize other renewable energy sources, between these two countries today, the timing is different. When the market in Germany grew, it was one of the first countries to really commit and succeed in the PV sector, making their own contribution to the market play a superior role. This led to new opportunities for German PV manufacturers to emerge as well. Norway is too late and too small to make this type of contribution to the overall PV market today.

A growth in the Norwegian market is expected, however. The mentioned renewable electricity certificates are, even though decided to phase out in 2021, still a possible market incentive for the growth of PVs in Norway, up to that time. The same goes for incentives towards new buildings where the energy consumption goes below the normal technical norms (IEA PVPS Annual, 2015). Several parts of Norway are now working towards an increase in the number of installed solar panels on rooftops. Enova, a public enterprise that seeks to promote environmentally friendly energy consumption in Norway, has been subsidizing the PV costs for residents since 2015. Oslo subsidizes up to 40% of the cost of PVs (Nilsen, 2016b). Christian Michelsen Research and Greenstat have calculated an expected growth in solar energy use for electricity until 2050, when it is expected to be one of the main contributors to decentralized electricity (ZeVision, n.a.). A growth in the market in Norway can contribute to a growth in the industry, especially if Norwegian producers are considered as the first choice. This makes it even more important to consider the case of keeping workplace within the country, and that is one reason why Germany is an example to learn from.

4.2.2.1 Summing up the discussion of the industry

The three trends will now be summarized in regards to the industry-based view, and the correlating table 4 seeks to give a simple overview of the impact of this part.

From trend 1, it is probable that Germany's early approach with subsidizing the market, resulted in a growth in the PV industry as well, both for Norway and Germany. Germany quickly became an important actor, in both the industry and the market. In Norway, the growth of the PV manufacturing jobs, seen from the view of Porter (1980), was most likely a result of the growing customer demand, and the control of suppliers. Contracts and collaboration, and later acquisition, of foreign suppliers, were important strategy choices. This led to a secure supply of feedstock for the Norwegian producers, giving them the competitive advantage they needed to grow. However, there has been a shift in the geographical origin of the PV producers several times from 2000. In the beginning, Asia Pacific and America were the biggest producers, before Germany took over. In 2008, China became the biggest producer. This showed an unstable and fragmented market, susceptible to entrance of new companies.

Trend 2 showed that this fragmented industry became subject to a situation where China could enter as a new competitor, and it resulted in customers with more bargaining power. The price war and overproduction caused by the new Chinese producers, is said to be the principal reason for the decline in the PV industry for other manufacturers, like Norway and Germany. However, the financial crisis may have been a contributing factor for the decrease as well.

Norway's decline was much steeper than Germany's, and one explanation for this could be the Fukushima accident, which caused Germany to try to phase out nuclear power in the country, making the effort to produce more and install more PVs, a possible strategy. Since Norway did not have any nuclear reactors, this did not affect Norway that much. In addition, Norway was a country with a much smaller number of PV companies, making it more susceptible to change.

From trend 3, the European solar market has changed and the PV sector in Europe is now more concerned with downstream activities (engineering, administration, installation, maintenance, etc.). Looking at only the defined PV industry in Germany, it was visible from figures 12-13 that this has been declining, and this can be due to a gradually downstream movement in the value chain. Germany has experienced several other declining manufacturing industries due to Chinese competition, and may be moving downstream due to this.

The growth in Norway could be a result of the flexible and low bureaucratic costs the chosen part of the value chain offers, whereas the German industry focuses on several parts. Each of the Norwegian companies are now concentrating the production on smaller parts, stating that they have found what can attain competitive advantage in Norway. However, firms such as

Scatec Solar are moving further down the value chain by installing PVs in developing countries. Moving downstream within Norway may also be possible regarding the development of the market in Norway today, which is still marginal, but nonetheless, growing. This may show new possibilities for the future, and will be discussed later.

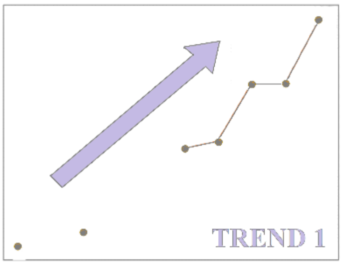
TABLE 4: THE INFLUENCE OF INDUSTRY AND MARKET ON THE DEVELOPMENT OF NUMBER OF JOBS
(NONE, MINOR, MEDIUM, STRONG)

	NORWAY	GERMANY
TREND 1	Strong	Medium/Strong
TREND 2	Strong	Strong
TREND 3	Medium	Medium

Table 4 shows four terms that represent the degree of impact of the industry; from none, to minor, to medium to strong. These are intended for relative comparison between the different trends and the different theoretical views of the thesis. The impact on Germany needs to be seen in regards to the emphasis laid on the case of this country, meaning that the degree of impact is only presented to show the similarities and dissimilarities with Norway.

As table 4 shows, the impact from the industry are characterized to be about the same degree between the countries. However, the actual explanations for trend 1 and 3 are dissimilar for the two countries, as we have seen. Trend 2, on the other hand, is most likely a result of the entrance of the Chinese manufacturers. Just as table 4 explains, some of the trends are now described to a fuller extent than table 3 could do, but still there are parts that are lacking. The entrance of the Chinese manufacturers was defined as part of the industry-based view due to the fact that it directly impacted the rest of the PV producers by its entrance. However, the entrance was possible due to an underlying reason, namely the Chinese government's incentives, which is a part of the institution-based view. The decision to discuss this within the industry-based view was a desire to see the development from Norway's (and Germany's) point of view. Therefore, only the institutions that originate from Norway and Germany are reviewed in the next subchapter.

4.2.3 INVESTIGATING THE INSTITUTIONS WITH THE INSTITUTION-BASED VIEW



There have existed several R&D projects and formal collaboration programs, which may be viewed as incentives (see figure 8). These have contributed to the industry development in Norway. After the oil crisis in the 1970s, the Norwegian government invested in R&D on PVs, among other renewables (Klitkou and Godoe, 2013). This may have been essential for the development of a PV industry later. Several collaborations and R&D programs were established in the following years, contributing to a possible growth in the future. The Norwegian Solar Energy Society was established in 1981 to facilitate a growth in the knowledge and the use of solar energy in Norway (The Norwegian Solar Energy Society, 2015). RENERGI was a research program funding R&D activity in the renewable energy sector in Norway. This program funded in total 2 billion NOK from 2004 to 2012 (RCN, n.a.). From 2003 to 2006, the Nordic PV project was active. This initiative tested the power production of PVs in the Nordic countries. From 2007-2011, the follow-up of the Nordic PV project was established, given the name the Nordic Centre of Excellence PV. The goal of this program was to strengthen the PV industry. In 2007, Ife was funded with 31 MNOK by the Nanomat program from the Research Council of Norway (RCN). This was a funding aiming at developing PVs that were more effective, by the use of nanotechnology (Sire, 2009).

As shown, several R&D projects, programs and collaborations have been active in Norway, before and during the growth of the PV industry. Knowledge and competence was already in place, making an entrance into this industry possible. Further focus on increasing the knowledge, in R&D, was a sign of commitment. The public funding towards PV R&D was at a steady state during the 1990s and the first half of the 2000s, but after 2005, a clear growth became visible (Klitkou and Godoe, 2013). This public focus on the PV R&D may have contributed to the growth of the industry.

The establishment of the Norwegian Research Centre for Solar Cell Technology in 2009, has been a unifying factor in increasing the collaboration between the R&D institutions and the companies (IEA PVPS Norway, 2013). In addition, it has been an important actor for focusing R&D towards some jointly agreed goals and work packages in technology development. The

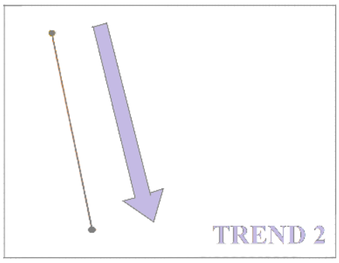
RCN funded and gave this center the status of researching environmentally friendly energy. Before 2009, RCN alone, and through its projects, was the main source of public funding in the PV field, but with the establishment of this center, some funding was earmarked to more collaboration between industry and research (IEA PVPS Norway, 2012). The center has a duration from 2009 to 2017, with a budget of around 340 MNOK (The Norwegian Research Centre for Solar Cell Technology, n.a.). The main goal of this center has been to jointly obtain international leading knowledge and competence (The Norwegian Research Centre for Solar Cell Technology, 2014). It has resulted in 14 partners, of which four are research institutions (NTNU, Ife, Sintef and the University of Oslo). It is understandable that a collaboration between actors that have different strategies due to the altering proximity to the research and to the industry, it will present problems for where on this continuum the center should be placed. The chosen placement has however showed to be fruitful, and Marstein (2016) has stated: "I would say that for absolutely all of our Norwegian business partners, the center has had a very important role to play. The tools, methods and infrastructure that have been built up, would not have become a reality without the center's funding, and business partners would not have been able to do what they do now, in innovation projects". This indicates the center's importance in developing of the Norwegian PV industry.

Some R&D institutions and PV collaborations have been across borders, involving Germany as well. IEA have set some rules before countries can become members (29 countries today) (IEA, n.a.), making the members strive to be more environmentally friendly. IEA's established the PVPS program in 1993, and today it seeks to increase the collaborative efforts in PV R&D. This can be regarded as a formal institution. In addition to this collaboration, there have been several other similar collaborations across borders in Europe, but also around the world, such as the International Solar Energy Agency, and in the Nordic countries; the Nordic PV project. The research collaborations and projects also effect the focus towards developing the PV industry, both by facilitating the exchange of knowledge and experience, and by allocating funding.

In addition to R&D collaborations, a positive culture, an informal institution, has been important for the growth in the PV industry in Germany (IEA PVPS Germany, 2002). For Germany, the great increase in PV installation in the country have boosted a positive vibe, creating a culture that seeks to be more environmental friendly. The 100 000 Roofs Solar Power Programme and the EEG, that seek at benefitting energy consumers that chose environmental friendly sources, thus increasing the market, sturdily influenced the PV producers as well (IEA PVPS Annual, 2004). These incentives were a part of the formal institutions for the PV market, but led to a reputation and culture among the buyers that favored the local companies. Thus the culture, also known as an informal institution from Peng et al. (2009) (see figure 8), enhanced the production of PVs. "[T]he EEG strongly influenced and gave new impact to suppliers of silicon feedstock, silicon wafers, solar cell- and module producers as well as manufacturers of production equipment and other PV components or systems" (IEA PVPS Annual, 2004). According to the GTAI (2005), the local producers had an advantage compared to the foreign producers, due to the governmental incentives to these local producers. This shows an institution, in the form of a market incentive, affecting the culture in the industry in the same country.

Industry incentives have also been important in Germany. According to Grau et al. (2011) there are three factors that are important to consider when investigating the German PV manufacturing regulations. First, Germany offers reduced interest loans. Banks on the national level offers so called Entrepreneur Loan and Special Program Loan, that aim at investment project financing, and banks on state level focus on loans with low interest rate to mainly startups. Second, Germany has had two important sources of incentives and grants for industries. The Investment Allowance Act and the Joint Task program, both focusing on manufacturing industries and some service industries, supporting them by tax-free payments and non-repayable grants in cash. Third and last, Germany has offered public guarantees. Companies lacking securities can apply for public guarantees in order to facilitate innovative companies to start up.

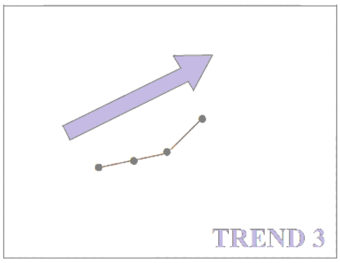
In Norway, some incentives contribute to the startup of new companies as well. Solenergi AS in Koppang got funds due to their geographic location (Parmann, 1984), which was also the case with Norsun. In 2006, Norsun was granted 30 MNOK in district aimed investment (DN, 2013b). Several other PV firms established in rural locations as well, benefitting from the Regional Development Fund and from Hydro (Tvedt, 2013; Klitkou and Godoe, 2013). This could show a strategy that many PV companies pursue, namely to go out in the districts in order to get more funding, and to build jobs for the local community, often in areas that may have experienced closures before, like the areas of the former factories of Hydro. This may have been an important contribution for the development of the PV industry in Norway from the beginning, based on the locations of most of the PV factories.



Even though some incentives may have been fruitful for the growth, some regulations may have resulted in the decline in Norway. According to Bjørseth (DN, 2013a), the capital tax in Norway has stopped further PV industry growth and job creation in the country. He stated that this tax was hostile towards private industrial companies, and that it slowed down entrepreneurship. This statement came after he had started several of the PV companies. The finance minister at that time agreed with the fact that the tax could affect businesses in their start-up phase, and pointed at possibilities of increasing the basic allowance (bunnfradrag). Today, the tax rate has been lowered, down to 0.85%, but Bjørseth (2016) states that this is still unbeneficial for new startups, especially considering when this must be paid even though there is no profit. This tax may have contributed to fewer PV industrial companies from starting, and may be an explanation for the rapid decline in 2011.

Marstein (2016) has raised concerns regarding too little incentives focused towards industry growth in Norway, as well. Due to better incentives elsewhere, he says: "we have seen several good ideas from Norway that have been established abroad, for instance in Germany, which is not even among the cheapest countries." Even though, some incentives for establishments in remote areas are available, as earlier mentioned, Norway should have been more industry-friendly with better incentives. This is of great importance for a build-up of a sustainable PV industry. Bjørseth and Marstein's critique could point to measures that would have slowed down the decline, and even led to more increase in the number of jobs in the future.

The already discussed subsidies from the Chinese government to its PV manufacturers greatly influenced the PV jobs in Norway and Germany (see chapter 4.2.2). These subsidies were deliberate measures, and can be categorized under formal institutions. The Norwegian government could have done the same, in order to keep the industry going. Ole Enger, a former director of REC, has however, stated: "If we only had competed with Europeans and Americans, we would have managed very well. The Chinese are in a different league. You compete with a combination of Chinese companies and the Chinese government. If we had realized it sooner, we would have invested less in Norway" (Drevon, 2011). This statement goes to show, once again, the superior power of China, making it possible that it was actually nothing that could have prevented a decline from happening, even though some measures could have prevented the *rapid* decrease in Norway.



Despite the ongoing effort in institutions aimed at the PV sector, it does not necessarily show an increase in the use of these measures in Europe. As we have seen from UNEP and Bloomberg (2016), the annual installation of renewable energy has surpassed the fossil energy sources. This report also states that the renewable energy investment worldwide reached its highest point in 2015, exceeding the old record from 2011 (UNEP and Bloomberg, 2016). In this, R&D, industry and market directed investments are included. About 56.3% of the renewable investment went to solar, making this the most invested renewable technology in 2015. The biggest contributor to this growth however, was China, responsible for more than one third of the investment. The investments in Europe however, decreased even more in 2015, making the decline an ongoing trend since 2011. This may be an explanation for the ongoing decline in Germany.

Even though a decline in investment in renewables in Europe is visible, Norway has still been focusing on R&D. In 2013, ENERGIX was established as the new research program to fund clean and renewable energy projects. ENERGIX focuses on technology and social sciences. In 2015, the program decided to fund energy projects that aimed at a much higher level than other projects (RCN, 2016). Three projects were chosen to get funding from the ENERGIX program in January 2016. Two of the projects are directed at improving the PV technology or the PV production. According to Marstein (2016), Norway has many projects that aim at a higher level, but he does emphasize that most of these projects do not live to see the day. It would however, be interesting to follow some of these projects into the future, in case they actually do succeed.

The Solar Cluster was established in Norway in 2013 (Solenergiklyngen, 2016), and is managed by Ife and Oslo Renewable Energy and Environment Cluster. The Solar Cluster aims at establishing enduring structures and knowledge, in order to strengthen the industry and increase the market share in the growing, global market. This may be expanded. In March 2016, Arena, a Norwegian innovation cluster program that seeks to facilitate immature clusters, received the project proposal and application for an Arena Solar cluster (Hirth, 2016b). The RCN, SIVA and Innovation Norway finances and supports the Arena program (Norwegian Innovation Cluster, n.a.). The goal of the new solar program will be to make a name of the Norwegian solar industry, including R&D, manufacturing, installation in both Norway and abroad, and grid connection.

In 2016, the government presented the first energy policy paper in 17 years, which investigates a strategy for further focus on climate and environmental friendly energy sources, but at the same time facilitating an efficient and secure energy supply (Government, 2016). The PV industry was not given a lot of focus, however, a part from establishing the fact that Norway has high competence, competitive energy prices and automated production. Prior to this energy policy paper, the Norwegian government proposed the startup of Fornybar AS, a fund with 20 billion NOK that will invest in companies that make use of or produce renewable energy (Bergen Venstre, 2016). During the spring of 2016, a revised arrangement and final location of the establishment will be clear. This could indeed benefit the PV industry.

The mentioned formal institutions like Fornybar AS, the Solar Cluster, ENERGIX, as well as the former mentioned Norwegian Research Centre for Solar Cell Technology, are all aiming at contributing to an increased focus towards renewable energy sources and the buildup of a Norwegian industry around it. In addition, there existed several R&D projects at universities, and at Sintef and Ife, resulting in future competence and knowledge in the PV field. This focus may have contributed to the further growth of the industry in Norway. Bjørseth (2016) even goes to say that this may be one of the reasons for the difference in Norway and Germany, where Norway has invested more in innovations in R&D. The public funding from the RCN to the PV field was at its highest point in 2010-2012 (IEA PVPS Norway, 2001-2014), in addition to what was earmarked the Norwegian Research Centre for Solar Cell Technology from 2009 to 2017. This makes the focus on this industry from the government, even during a labor and production decline, stand still, which could be an explanation for the growth already starting in

2012. The funding after 2012 is however, difficult to track, due to distribution through several of the mentioned projects and centers after this year. It is however, claimed that the number from the RCN has been decreasing annually (IEA PVPS Annual, 2012-2015). Maybe the number of jobs within R&D will better indicate this development?

The number of jobs in the R&D institutions, not including R&D within the companies, decreased from 2013 to 2014 (IEA PVPS Norway, 2012-2014). In 2010, the number reached its highest point of 80 employees, and it stayed there until 2013, but in 2014, the number had decreased to 62, despite the growth in employees in the rest of the PV industry. The numbers for 2015 and 2016 are not available. This can be an important factor for the future of the Norwegian PV industry. The decrease in the R&D sector correlates poorly with a picture of a future growth in the industry, especially regarding the development of new technologies within 1G and other generations. It is however important to note that these numbers do not take the R&D inside the companies into account.

The mentioned projects that have influenced the Norwegian PV industry can be categorized as formal institutions, but there may have been some informal institutions in the growth of the PV industry as well, especially in the form of Scott's (2008) normative pillar (see figure 8). Norway has been a typical country where the community spirit has been high, and the former closure of Hydro's factories in the areas, may have contributed to a will to get through the tough times. This community culture may have been a big contributor to the growth in the PV industry today as well (Bjørseth, 2016). In this industry there are many people who are willing to "walk up extremely steep hills" in order to reach the goal (Marstein, 2016).

An attempt to make the European producers sustainable was the introduction of the MIP (Fuhs, 2015), as was presented in chapter 4.2.2. The goal was to better the competitive conditions for European producers, by stop supporting the massive Chinese subsidies to its own PV producers, and the resulting price dumping. This regulation would benefit the European producers by securing a bigger market in Europe for European products, but resulted in critics from a range of fields. It has been stated that this regulation, in many ways, only favor the module producers in Europe (Fuhs, 2015), and in 2015 a review of whether to keep it or not started (Cuff, 2015).

Many wafer, ingot and cell producers had been exporting to China, in order to produce the PV module at a lower price, and then sell these modules at a low price, but due to the MIP, these Chinese module producers lost market share in Europe and it has been shown that it slowed down the European market for these producers. It would however, force them to sell to the European module producers, which was the goal in the first place. The picture is, in other words, complex. Seen from figure 13, it is not clear whether the MIP is the main cause, but Germany experienced a slowing down of the decline in 2013 and the years after, and Norway experienced a more rapid incline. Marstein (2016) does say that there is a possibility of the MIP being one explanatory factor for the improved growth in Norway, but he does specify that this is only based on assumptions.

In 2013, the government in China decided to give tax rebate for PV manufacturers until 2015, to support them in a troubling time. This is an example of a direct governmental regulation to support the manufacturers and the industry in the country, where up to 50% of the tax could be paid back to the manufacturers (Meza, 2013). The tax rebate was established after the production of PVs had grown to overcapacity, and export and import trouble continued with the USA and the EU. This led to the Chinese manufacturer increasing their debt. By this, the assumption that the MIP bettered the conditions for Norway and Germany is strengthened, and assumptions made of China being superior (see discussion of trend 3 in chapter 4.2.2) may show weaknesses.

The first proposition in Peng et al. (2009) give rise to the topic of corporate social responsibility and ethics (see figure 8). A firm bases its strategies on the rules and norms it is a part of, but it can also choose to defy these rules and norms. A discussion about this can be based on the knowledge that Chinese PV manufacturers use more energy and have a higher carbon footprint than European manufacturers (Yue et al., 2014). When the production energy originates from polluting sources, this must be considered in the equation. Elkem Solar uses mostly hydro power, in addition to cutting energy spending by 75% compared to traditional silicon production (Elkem, 2013). The Norwegian company Dynatec has also been researching a new method that cuts the energy spending by up to 90% (NHO, 2015). While from an economic standpoint, it can seem best to move the production to China, it is not necessary the best strategic decision based on the environment. The norms a firm should follow to contribute as little as possible to climate changes, does indeed make up an institutional framework. Firms that break these norms can lose competitive advantage over other firms if these environmental norms show to become more important in the years to come, especially after the goals set at the United Nations Climate Change Conference in Paris in November 2015. This agreement, between an expected record high number of countries (Sysla Grønn, 2016b), may be a very important formal institution that results in deployment of even more renewable energy sources in the years to come. The environmental aspect, therefore, does at this point provide an advantage for the Norwegian and German PV manufacturers, and for the generation of jobs in these countries.

At the same time, in 2011, the EU set a long-term goal in reducing the greenhouse gas emission by 85-90% from the 1990-level by 2050 (EC, n.a.), just as Germany had the year before (Hanson, S., 2010). This led the member countries to an ambitious commitment, and may have led to a positive culture among the PV producers. These informal institutions are however difficult to place within the impact they may have had on the development of jobs.

4.2.3.1 SUMMING UP THE DISCUSSION OF INSTITUTIONS

The three trends are summarized in regards to the institution-based view, and an attempt to represent the impact of this part may be seen in table 5.

My data showed that, for trend 1, some loans and incentives have given startup companies several benefits in Germany, and that the incentives towards the market increased the opportunities for PV producers, as we saw in chapter 4.2.2. The latter is considered as a market/customer pull in this thesis, and not investigated directly under the institution part. The production incentives have been the focus of this part.

Incentives towards the producers in Norway have also been important, to some extent. However, this has mainly evolved around district-aimed incentives, and in much lesser degree than in Germany. A part from this, many formal institutions, and mainly R&D projects, within Norway, within Germany, across the Nordic countries, European countries, and around the world have contributed to a growth and further development in the PV industry in both countries. It is however, difficult to point the finger at some particularly important projects. However, the early R&D projects on PV in Norway after the oil crisis, is claimed to have been important for the growth

For trend 2, Bjørseth (2016) focused the attention on the capital tax, which may have contributed to the companies being less profitable. In general, it is however, difficult to blame the government for this decrease (Bjørseth, 2016). On the other hand, Marstein (2016) also claimed that the incentives in Norway have resulted in ideas leaving the country in an attempt to start in a place that is more industry-friendly, for instance in Germany. This may have made the decline more noticeable in Norway compared to Germany.

Investigation of trend 3 showed that the MIP could be an explanation for the slowdown in Germany’s decrease in the number of jobs, in addition to the additional increase in Norway. In Europe, the investment in renewables had decreased annually since 2011. This is partly the reason for Germany’s ongoing decline in the number of jobs in the PV industry. Trend 3 did, however, go to show that the investment globally had increased, and was at an all-time high. China was the biggest contributor to this. This would give China more power.

Today, Norway may have some competitive advantage over China, however. Norway can contribute with cleaner energy when producing the PVs, in addition to minor energy consuming production technologies, making it a more environmentally friendly choice. The ongoing focus on R&D, and the collaborating R&D and industry projects may have increased the growth in Norway. The recent decline in the number of jobs in R&D however, may show to have a bad influence in the future. Until then, the high community spirit in Norway, may have contributed to the ongoing growth, and persistence in the PV industry. See table 5 for a guiding summary.

TABLE 5: THE INFLUENCE OF INSTITUTIONS ON THE DEVELOPMENT OF NUMBER OF JOBS

(NONE, MINOR, MEDIUM, STRONG)

	NORWAY	GERMANY
TREND 1	Medium	Strong
TREND 2	Minor/Medium	Minor/Medium
TREND 3	Medium	Minor/Medium

Table 5 shows four terms that represent the degree of impact of the institutions; from none, to minor, to medium to strong. These are intended for relative comparison between the different trends and the different theoretical views of the thesis. The impact on Germany needs to be seen in regards to the emphasis laid on the case of this country, meaning that the degree of impact is only presented to show the similarities and dissimilarities with Norway.

Table 5 summarizes the institution-based view in a simple way. The three trends have now been explained to a fuller extent, and will be investigated together in the following subchapter.

4.3 SUMMARY + A NEW LOOK AT THE RESULTS AND DISCUSSION

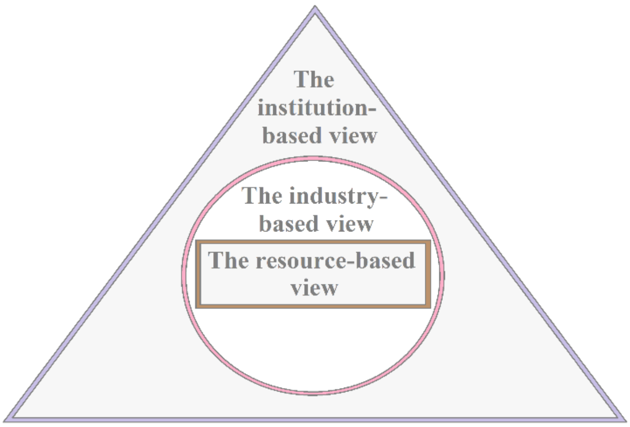
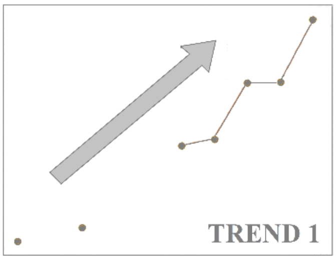


FIGURE 19: A SIMPLER REPRESENTATION OF FIGURE 9. THE COMBINED EFFECTS OF THE THREE CHOSEN ASPECTS OF RESOURCES, INDUSTRY AND INSTITUTIONS MAY BE UNDERSTOOD FROM THIS REPRESENTATION.

The division of the three discussion subchapters are based on the three aspects of technology, market/industry and institutions. This was a division chosen because the original thought of this thesis was to investigate the technological contribution to the development. I have shown that the market/industry and institutions relevant factors have contributed an equally big part, if not more, to this development in Norway and Germany. The thesis therefore continued to look at these two aspects as well. In this way of building up the thesis, each aspect has been thoroughly studied, and many topics have been covered. In this execution, however, some of the institutions were organized under the market chapter due to the direct influence on this part, some R&D institutions were mentioned under the technology discussion, as well as the institution discussion, and some industry-related factors were discussed in the institution-based chapter, etc. This shows an overlapping and a correlation between some of the investigated factors, and may demonstrate that figure 9, which is presented in a simpler form in figure 19, may be a better representation of the strategy tripod seen in figure 2, for this thesis. In other words, there exists a risk of omitting important combined effects when carrying out the study the way it has been done.

Germany is a good example to see the correlation between the three aspects of technology, market/industry and institutions. In the beginning of the PV development in Germany, the government gave incentives to the customers of PVs, which in other words will say that the market was affected by formal institutions. This led to a market pull, and an opportunity for PV manufacturers to startup. With a decreasing feed-in tariff through the years, these German manufactures had to focus on product innovation and production innovation in order to keep the market going, leading to a technology development. This shows the importance of investigating the correlation between these factors as well, not just separately. The three variables chosen to describe the dependent variable are in other words not independent. Therefore, in this part, the three aspects are summarized, and they will be studied in combination, for each of the three trends, looking for correlation factors and new insight for the development.



From table 3, 4 and 5 we saw that trend 1 was mainly a result of the explanations from the industry-based view, followed by the explanations from the resource-based view and the institution-based view, for Norway's part. The growing market, especially from Japan and Germany, and with that, low entry barriers opened up doors for new companies to emerge. This made it possible for Norway to be a part of this growing industry. In addition, Norway had invested in R&D projects as far back as the oil crisis in the 1970s, resulting in early knowledge with PVs. After several R&D collaborations, within the country, across borders in Europe and in the rest of the world, more competence was shared. The technology of 1G may have contributed to the growth in both countries. This was possible due to the dominant 1G technology, which has been claimed to originate from the already constructed knowledge and experience base from the use of silicon in electronics worldwide (Goetzberger et al., 2003, referred in Hanson, J., 2006).

The use of p-Si in the beginning, however, may have been a result of the large market for this technology, where, among others, Germany had been a huge contributor. The German government's timing of the market incentives may have resulted in the choice of p-Si, where the p-Si was the technology that was developed most, in both efficiency and cost at that time. If these market incentives had been conducted at a different point of time, we could have seen another dominant technology today. This shows the correlation between institutions and market, in addition to timing, in the choice of technology, and may have enabled for a growth in both countries.

This technology made it even easier for an entrance of new companies, easing the way in for Norway, due to the competence and knowledge from the metallurgic industry, and from silicon production, in addition to less costly energy prices. Furthermore, public incentives in areas subject to earlier factory closures and rural districts from the government and from Hydro. The already mentioned R&D projects from many years prior to 2000, resulted in direct knowledge and competence in the PV field. All of these factors show Norway's advantages for an entrance in to the PV industry and for growth. The *fast* growth however, was primarily a result of the companies' contracts and acquisitions of foreign suppliers of silicon, creating a secure supply, which was an important strategic advantage in times of silicon deficiencies. This shows the importance of all of the three theories of the strategy tripod, in particular the industry-based view.

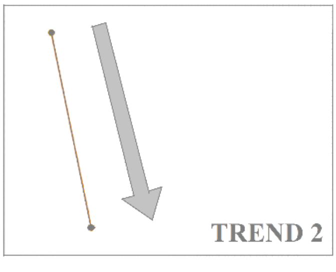


Table 3, 4 and 5 showed that trend 2 could mainly be explained by the industry-based view, second, by the resource-based view, and last, to a minor/medium extent, by the institution-based view. For trend 2, the main reason for the decline in both countries, was the rapid expansion of Chinese manufacturers. The Chinese government's incentives and loans to its producers resulted in artificially low prices and extreme price wars. Many PV producers, not only in Norway and Germany, experienced tough times in this period.

The Chinese government's incentives have primarily been discussed under the industry-based view, because this is the part that directly influenced the Norwegian producers, and that is the reason for the importance of this theory for trend 2. However, the decision could have been to discuss it under the institution-based view, due to the importance of incentives for this development. This again, goes to show the correlation between the entities in the strategy tripod.

The rapid decline in the number of jobs in Norway, compared to Germany, could be a result of lack of innovation, quality, and the choice of technology, namely 1G, and of that, p-Si, which resulted in a weak p-Si lock-in. This technology was at one point necessary for Norway to enter the industry and market, but it may have showed a less dramatic decline if p-Si gradually had been replaced by mono-Si at an earlier stage. This can be stated due to the ongoing production of mono-Si through the slump. Even though this production was negatively affected as well, this was only to a small degree and at a slower pace, compared to the p-Si decline. In addition, it could have been a strategy to produce several technological generations, as Germany did with 1G and 2G, differentiating the risk on several products.

Not only did Germany differentiate in technology, but also in several parts of the value chain, and among a large number of companies. This made the country more resistant towards changes in the market and industry, resulting in a slow decline in the number of jobs, in contrast with Norway. This shows a learning from the German development. Norway had few (although some large) companies, where REC used a lot of resources building a factory in Singapore. This may have troubled the outcome for the Norwegian company of REC, and for the outcome of the industry in the country in this period, seen together, due to the small number of firms.

The capital gain may be a reason for the slow-down of the growth of jobs in the PV industry in Norway, and even the reversing, especially for new establishments (Bjørseth, 2016). In addition, too few industry-aimed incentives may have resulted in companies establishing in other countries instead. Marstein (2016) wish for a Norwegian government that is more industry friendly. These institutions, and lack thereof, may have been contributing factors to a decline in Norway.

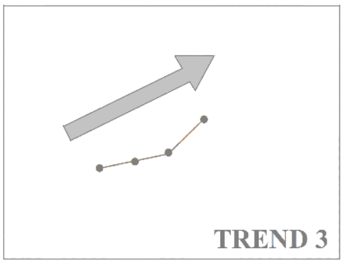


Table 3, 4 and 5 summarized the impact for trend 3, and showed that the resource-based view presented the primary explanation for the new growth in Norway, while the industry- and institution-based view served explanations that were of a medium degree. My data revealed that the growth in the Norwegian industry today is mainly a result of a shift towards mono-Si and more experience in production. The less costly electricity and abundance of water for cooling, increases the competitive advantage of producing mono-Si in the Norway, as well as making the product more environmentally friendly. In addition, a concentration around a small and competitive advantageous part of the value chain, and the introduction of the MIP, may explain a further growth.

The PV R&D funding was growing through the slump/trend 2, and may have been important for the growth we see today, where there must be expected a delay in the effect of such a strategy towards R&D. The decrease in the number of jobs in the PV R&D area in 2013 and 2014 is therefore not promising for the future. The internal R&D in the companies may however have increased, but this is difficult to say anything specific about, without access to their numbers.

R&D within the companies, in addition to the access of knowledge and expertise that the research institutions possess, could be of great importance for the companies, and thus a good strategy in order to reach this goal. This shows a link between the resources of the firm and the institutions. From the early 2000s, R&D on PVs focused mainly on silicon, which were the most funded projects. 1G has also been the most produced, but in the R&D sector, other generations have gained focus as well. In 2009, The Norwegian Research Centre for Solar Cell Technology was established, a collaboration between PV companies and research institutions. This collaboration has been focusing on fulfilling specific work packages: mainly on silicon production, silicon characterization, silicon cells and module improvements. In other words, the focus has mainly been on 1G, but one of the work packages has been to research and develop new generations of materials for PV. This center has been an important institution, and according to Marstein (2016), all of the Norwegian companies currently participating in the center have been working in at least one innovation project based on, among other things, knowledge and competence from the center, in parallel with the center. This indicates the center's importance in innovations in R&D in the PV industry in Norway. This technological development is essential for gaining competitive advantage and profitability, says Bjørseth (2016). This formal institution has been important, and may be a vital factor in the technology choice in Norway now, and in the future, thus influencing the resources of the firm.

Another factor that may serve to explain the growth in Norway is the new market incentives in Norway. Many of them were mentioned in chapter 4.2.2. These incentives may be defined under the formal institutions, but they affect the industry and market. In addition, they may affect the informal institution, which now will be made clear. In Norway, the installation in the residential market quadrupled from 2014 to 2015, albeit only a minor quantum (Multiconsult, n.a.). This may well be an explanation for the ongoing growth in the number of jobs in the PV industry in Norway. Learning from the past in Germany, Enova started their first incentives towards PVs on residential homes. This act shows similarities with the EEG and 100 000 Roof Solar Power Programme in Germany, which has resulted in PV comprising approximately 6% of the annual gross electricity generation (IEA PVPS Annual, 2015). These market incentives could indeed contribute to a positive culture around PVs in the country, thus be an informal institution that encourages the Norwegian industry to grow even further. The positive culture in Norway, may be an explanation for the growth in the number of jobs in the country, and may contribute to further growth.

Why has Germany not seen the same growth? We have already seen the jobs move downstream in Germany, but other factors may contribute as well. In recent years, it can be seen that the several European governments' will to keep the market going was decreasing. The drop in the European market can be partly seen due to a decline in subsidies to customers, and even anti-subsidies, in some European countries. Spain, for instance, had to lower its subsidies in 2008, when the financial crisis struck the country (Fillon, 2015). In 2015, the government introduced a tax where PV users had to pay, not only for the electricity from the PVs that were transported to the grid, but also the consumed fraction of the electricity produced from the PV in the residents (Tsagas, 2015). The incentives towards customers of solar cells have decreased in Germany. The market, as we have seen, has also decreased in Germany, making it possible that a negative culture has emerged.

In addition to the decrease in incentives in Germany, the prices of PVs have grown in Europe. This is a result of the introduction of the MIP. Many discussions have evolved around the question of whether or not to keep the MIP (Fuhs, 2015), especially when knowing that Germany aims at lowering their emissions drastically by 2050. When the customers had to pay a higher price for the PVs in order to support their local producers, the market slowed down drastically. Just as the local PV producers could have benefitted from a positive culture towards local customers before, the MIP could have contributed to a negative culture due to high prices. These negative actions towards the German PV market would then result in fewer customers for the local producers, leading to a decline in the number of jobs, exactly as the ongoing development in Germany goes to show.

From this, it has been stated that Norway do have some advantages over Germany today, seen in light of a positive culture. Bjørseth (2016) claims that Norway might have some competitive advantage over Germany in innovation in the PV industry. In addition, community spirit is still going strong in Norway. This may be a mixed result of the market situation in the countries and prior experience. Germany has a significant PV market, even though decreasing, making it possible to move the jobs to a more secure part of the value chain, namely downstream. Here it may be more difficult for the Chinese to take over. Germany has also had to deal with Chinese taking over many industries in the past, such as the mentioned magnesium and rare element production in chapter 4.2.2, and may now be moving away from this. Norway has not had the possibility to move the jobs downstream, and a high community spirit may therefore have resulted in the ongoing growth today.

4.3.1 Summary of the discussion

The main explanations for the growth in trend 1 in Norway were a growth in the market due to market incentives in many European countries, among others Germany, and the Norwegian contracts with foreign silicon suppliers (see figure 20 below). In addition, Norway had the knowledge and competence from the metallurgic industry, silicon production and from early R&D at some institutions, making the market dominance of p-Si technology at that time, an advantage. Finally, district aimed incentives from the government and from Hydro helped the build-up of factories, and collaborating R&D between institutions and industry, resulted in innovation.

The primary reason for the decline in trend 2 has been claimed to be the Chinese government's incentives and loans to its own PV manufacturers, leading the way to over-production and rapid price fall (see figure 20 below). Some factors have also been reviewed, that may have contributed to the decline. The weak p-Si lock-in, not enough focus on quality, uniqueness and innovation, in addition to the fragmented industry, globally, may have eased the way in for a new entrant, such as China. The lack of differentiation in technology generation, and within 1G, in addition to lack of differentiation in the number of firms in Norway, showed two distinct differences with Germany. This may have been the reason for the *rapid* decline. The financial crisis, an unfavorable capital tax and too few incentives for industry building in Norway, have been mentioned to contribute to the decline as well.

When it comes to trend 3, a focus on a less imitable technology, in the form of mono-Si, that Norway has several years of experience from producing, has been mentioned to be an important explanation for the growth today. With this, it has been possible to focus on quality, innovation and competence, which may partly be a result of the many R&D collaborations. The concentrated part of the value chain, with contract manufacturing, is another strength. In addition, the environmentally friendly production is a competitive advantage, and the MIP may have improved the conditions for manufacturers, especially regarding the Chinese government's recent need to give tax rebates. The Norwegian community spirit may have contributed as well, in regards to not giving up, which became clear from the dissimilar situation in Germany. This is summarized in figure 20.

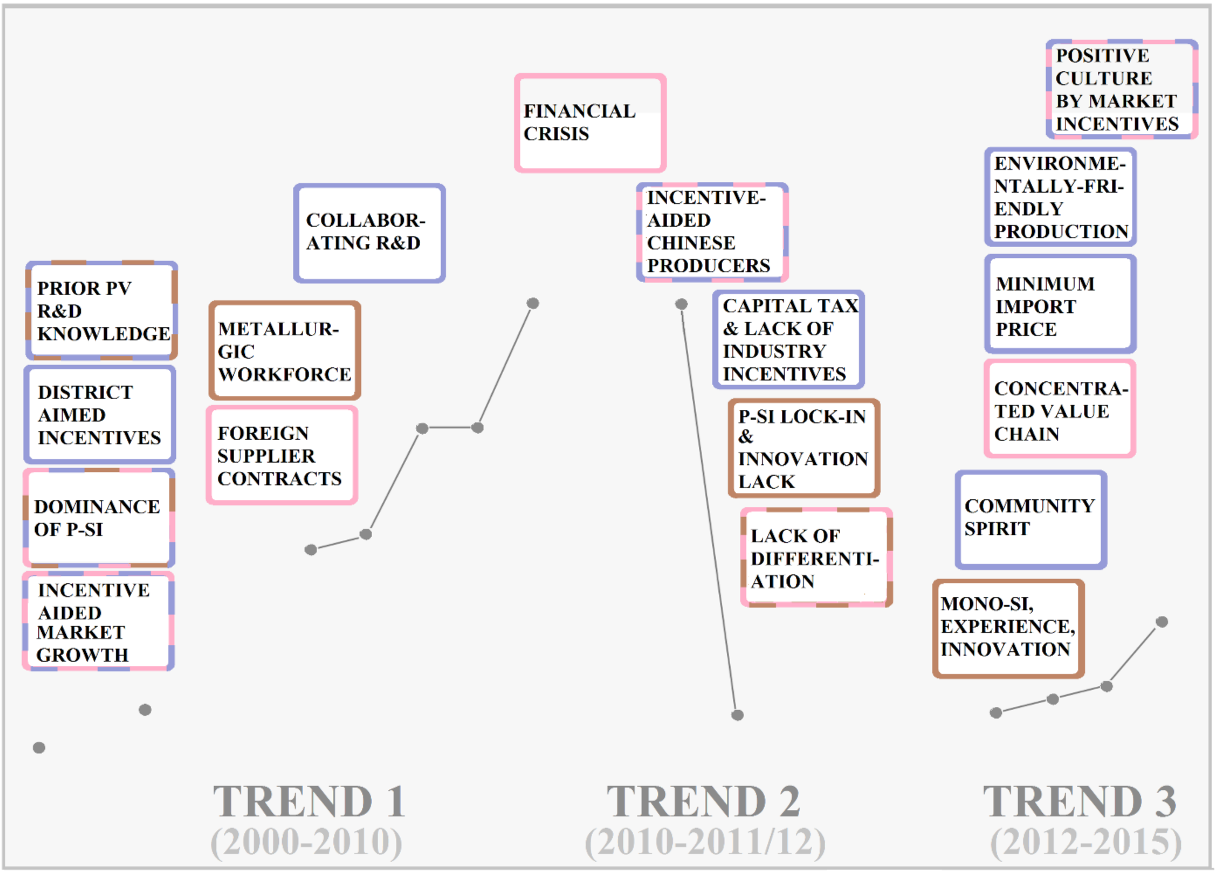


FIGURE 20: A SUMMARY OF THE RESULTS AND DISCUSSIONS. THE DEVELOPMENT OF THE NUMBER OF JOBS IS THE GRAPH THAT IS PRESENTED, WHERE IT HAS BEEN DIVIDED CONCERNING THE THREE TRENDS IN AN ATTEMPT TO VISUALIZE THE RESULTS. THE BROWN COLOR REPRESENTS THE RESOURCES, THE PINK REPRESNTS THE INDUSTRY, WHILE THE PURPLE REPRESENTS THE INSTITUTIONS. SOME BOXES HAVE SEVERAL COLORS, MEANING THE RESULTS ORIGINATE FROM COMBINED EFFECTS FROM THE PARTICLUAR SOURCES.

4.4 POLICY IMPLICATIONS AND FUTURE OUTLOOKS FOR THE PV INDUSTRY IN NORWAY

In this part, the historic development and possible explanations that have been studied in this thesis, will be reviewed in regards to future development outlooks and recommendations for further strategy implementations. This will also address the last of the research questions: *What can we learn from the past and from mirroring the Norwegian development with that of Germany?* We have already found learnings from the past and from mirroring with Germany, in regards to understanding the actual development. However, in this part, these learnings will be seen in regards to the future. First the market, some complementary products and possible new entrants will be revised. Following this, the possibilities of institution-aimed technology steering, and how this may be done in regards to the technology generation focus from today's situation, is discussed.

The market, at one stage, will reach a point where sales stagnate. This can happen due to a superior substitute technology taking over the market, or it can happen due to a PV saturated market. The first mentioned eventually leads to the death of PVs. The last mentioned is more complex, because it is dependent on how many areas of use one can find. The use of PVs has traditionally evolved around ground- and roof-mounted installations, but there are several other markets as well. A relatively new market is the utilization of the rest of the surfaces of the buildings, also known as building integrated PV. Other usage areas of PVs are small personal, electronic devices, security and traffic surveillance. This has been a part of the market already, but with increased efficiency, several other devices can be utilized better by PVs. In 2016, France started building a 1000 km road covered in solar cells (Nilsen, 2016c). Several researchers try to send electricity made from PVs in space, through microwaves, down to earth (Government, 2016). Finding new usages and markets will of course prolong the lifetime, increase the profit for the PV manufacturers and create more jobs. Today, the life cycle of the use of PVs is around 20 years, giving the possibility of a market for renewal and replacement as well.

Last year, the battery pack presented by Elon Musk, harvested great attention worldwide. The batteries can distribute the electricity to the peak hours in the evening on a sunny day, and it can give an even electricity flow for the household on a cloudy day. The use of battery packs along with PVs is not a new idea, however. Batteries have been sold as a complementary product for decades, especially in the off-grid market that is made up of cabins this has been of great value. One of the new features of the battery is that it can store a lot more energy than before, and Musk's battery is an effort to make these batteries more popular (Plumer, 2015). The growth in popularity of a complementary product does make the other product more popular as well, according to Hill and Jones (2013) (see figure 7). By integrating a good battery technology with PVs, the market for PVs can grow even more, creating jobs for even more people. Norway may serve as a large battery itself for the European continent, by utilizing the regulative advantages of hydropower (Langberg, 2016). This does however call for a better infrastructure.

From the industry-based view, the strategy for Norway in the following years should be to embrace new markets and complementary products, in order to increase profits and job creation in the Norwegian PV industry. This may be a strategy for further building of the value chain in Norway. But what about new entrants in to this industry?

The price war, may also point in the direction of expanding the value chain. Learning from the past has always been a strategy to follow, and may be important in the years to come. The energy market is changing, and many new, emerging countries are in need of fast rollout of energy sources. PV is one of the growing energy sources, as we have seen. China has showed to be powerful in this industry, due to its incentives from the government, and because of its size. Knowing that China was the biggest contributor to the global renewable investment in 2015, in addition to the country's great market growth and industry growth, Norway and Germany should keep on paying close attention to this country, in addition to other emerging countries. India, for instance, is emerging, and may be an important competitor in the years to come (IEA, 2015a), especially considering the population size of India. It is difficult to compete with these countries when it comes to price. Innovation and uniqueness should be key factors in the production facilities in Norway, as it has been the last few years. However, IEA (2015c) went as far as advising the European countries to focus on creating jobs in the installation part of the PV sector, instead of the production part. This may be possible in Norway as well (see figure 18), as we have seen the market growing the last couple of years. In addition, the mentioned Scatec Solar is a perfect example of a company that utilizes the possibilities of PV markets in emerging countries.

We saw that Germany increased its industry by increasing the market, not only by creating a positive culture, but also by actually creating customers of a relatively small market at that time. Norway is too small, and too late to do this with the same impact, but it is still possible for the government to steer the choice of technology. The small market in Norway today may be an unused resource that can be utilized in direction steering the technology development. By utilizing formal institutions in the form of incentives towards technology specific PVs in the growing Norwegian market, a door towards technology development can show to open. Focusing R&D towards a specific technology could contribute to a development like this, if the government follows. A growth of a new, industrialized, and superior 3G or 4G PV could lead to other countries starting to develop this technology as well, increasing the market further. If Norway manages to stay at the forefront in the production, it can lead to a promising future for

Norway's PV industry. Bjørseth (2016) specifies that a radical innovative PV technology can be difficult to penetrate into the established PV market today. Marstein (2016) agrees with this. However, a collaborative strategy like the above mentioned, could show to ease this entry. After all, the market is generally acknowledged to be one of the biggest contributors to innovation (Klitkou and Godoe, 2013), and several examples of penetrating an established market, or disruption, has been proved before (Tushman and Rosenkopf, 1992, and Bower and Christensen, 1995).

By aiding the known power of the market pull, this could be a possible strategy to help the industry in Norway in the right direction for future production, making Norway a leading manufacturer in the future. This calls for a clear and well thought out technology choice, in addition to more R&D towards new technology generations. Combining this technology push with the market pull, could be an important factor for Norway to learn from Germany's past development.

In order to take charge in the technology generation production it will be important to get out of the 1G lock-in. As was claimed for trend 1, the choice of the 1G technology, may have been a result of the prior knowledge from other industries, which in turn, may have been a result of a path dependency. The 1G technology has historically been the most invested and produced PV in the world, and in Norway, and still is today. The historical focus on subsidizing and funding 1G PVs can be an explanation for the ongoing focus on this technology as well. It can create a type of lock-in and path dependency where the wish to keep producing this technology, in order to avoid having invested in a technology that is not oriented for the future market, is evident. This is also known as sunk cost, and should in general not be a part of a future strategy choice. Of course the aspect of a mature and commercially ready technology or not must be considered, but this lock-in could prevent these new technologies from developing and also affect the government in their future subsidizing decisions, making it a bad spiral for the development of new technology. This can however lead the way to future strategies for Norway. A strategy for the Norwegian companies and government could therefore be to break out of this spiral and focus even more on 3G and 4G, in order to be ready for a technology change and to create more jobs, especially in the R&D sector at this point of time.

From the discussion of the various PV technology generations it can be stated that the collection of 3G and 4G PVs have the best competitive advantage, based on the resource-based view of Barney (1995). Jayawardena et al. (2013) has however, stated that even though 3G is a promising and successful technology, it has failed to be competitive on the cost pr. watt with previous generations, mainly due to the further need of improvement. 4G was therefore, introduced to lower this cost, but also this generation needs further improvement. In addition to this, China produces over 90% of the world's rare earth metals, and does by that control the price and supply (Bjørk, 2016). This makes it crucial for other PV producers to find materials that could substitute these rare materials in 3G and 4G. Greater efforts towards research and developments of new materials should therefore be considered as a strategy. This means that, whether a distinction is made between 3G and 4G or not, the research on these technologies need to be maintained, and makes it even more important, in order to find a radical technology that can challenge or take over the 1G dominated industry and market.

This focus towards 3G and 4G R&D may already be a part of the strategy for the future of PV in Norway. NTNU and Ife are two of the research institutions that are a part of the Norwegian Research Centre for Solar Cell Technology. These institutions have several research groups that are aiming at developing more efficient PVs. NTNU has developed a material that is made of a graphene wafer with GaAs templates. This material is flexible, thus expanding the use of PVs further (NTNU, 2012). Ife has been researching a 3G silicon PV that tries to utilize more of the solar radiation (Marstein et al., 2008). 3G and 4G could show to have better competitive advantages for a company that manages to find a good and relatively cheap way to produce it. The mentioned company EnSol in Norway may be one of these. EnSol was started around 2010, and has been developing a thin film technology in the 4G segment. The company aims at starting commercial operation during 2016 (EnSol, n.a.). This would be interesting to follow in order to make Norway more focused towards 3G and 4G technology, which will be more competitive according to the resource-based view, and may give rise to more jobs in the future.

Further R&D on 1G is also important, because it is vital to note that this technology is the far biggest technology on the market today. After the massive decline in the price of 1G PVs during this period, Marstein stated that there is almost no more room for cost reduction improvements (Quale, 2014). The efficiency is the part that needs to be further developed, in addition to installation costs, in order to improve the PVs, and make them more market attractive. Bettering the efficiency would give rise for smaller areas to produce more electricity, lowering the payback time for the customers in that way. This strategy would increase the production, and hence the number of jobs, making it crucial for companies to find cheaper ways to increase the efficiency in the years to come.

If the 1G production is to be continued, the question concerning the choice between p-Si and mono-Si arises. Should the mono-Si benefits regarding perfection and better efficiency be the most important factor for the future of production, or should the easy scale-up of p-Si be the most important? p-Si is easy to produce in large quantities at once, while mono-Si has a limitation before breaking due to the grain boundaries etc. (Stokkan, 2015). As we have seen, Bjørseth (2016) claims that mono-Si could be a contributing factor for the growth we see today, where Norway has had some environmental and economic advantages for mono-Si production, in addition to tacit knowledge from long experience. This makes it a valuable, rare and less imitable resource. On the other hand, Marstein (2016) is of the opinion that Norway needs to keep the focus on both technologies within 1G, in order to differentiate and to produce what the market wants. In addition, Marstein points to the fact that these technologies are linked, meaning that one can learn from one of the two, to improve the other one.

"Despite the fact that R&D investment is essential to enhance enterprise competitiveness, there exists additional barriers, or forms of market failure, which results in businesses generally investing less in R&D than what is the economical optimal." (NOU 2012: 9, 135). This statement shows that companies are generally more focused on their current product portfolio, and less concerned with future developments. If this is the case for the PV industry in Norway and Germany as well, it will indicate a potential for improvement. When it comes to innovations within R&D, both within companies and publicly, "Norway should be much clearer on what Norway actually is going to pursue" (Marstein, 2016). This would result in predictability and security for the R&D institutions and the industry, something that Bjørseth (2016) agrees will be important for the future development in the Norwegian industry. This would also make the funding more efficient, and may make it easier for companies and institutions to actually pursue an innovative goal.

Whether or not Norway focuses on both mono-Si and p-Si within 1G, or just one, the question that follows is: Will the Norwegian PV industry keep producing and incrementally innovate 1G solar cells, or will radical and new generations of PV technologies thrive to see the day as well? This is a question for the future, but the answer should be a part of today's strategy choices for the established, and possibly emerging, companies. Marstein (2016) has stated that Norway possess a high competence within the metallurgic industry, that we today, have a lot of experience within the 1G technology, and that there are still many things to improve with these silicon cells. This calls for a further commitment to the 1G technology. But that does not mean it is unthinkable to work with other technologies as well. Pursuing, and even expanding, the R&D efforts on new technologies can be very important. Bjørseth (2016) says: "We need to innovate in order to have a competitive advantage." The market may shift one day, and Norway should be ready to take part in the PV industry in the future as well.

A lesson from the past may be to take advantage of the competent workforce that has been set free from the oil and gas industry today. As was discussed in chapter 4.2.1 the metallurgical workers from Hydro's former factories could be implemented in the new PV industry at the time. It has been claimed that this knowledge and competence may have eased the way in for Norway as a PV producer. The workers from the oil and gas industry are of considerable numbers, with a lot of varying competence, making it even more interesting to look at possibilities for implementing this resource into the PV industry today. This degree of variation may lead to new technology innovations, which again could result in a strengthening of the uniqueness in the PV technology produced in Norway, increasing the competitive advantage.

4.5 THEORETICAL IMPLICATIONS

In a case study, where there is a combination of quantitative and qualitative data, and there is a focus on one case, such as the PV industry in Norway in this thesis, it will be difficult to generalize the findings to other cases (Yin, 2014). In these studies, theory testing or generation is more common (Easterby-Smith et al., 2015). The theory has been tested on a longitudinal, partly comparative, and partly level-based case.

The theoretical strategy tripod of Peng et al. (2009), which included Porter (1980), Barney (1995) and North (1990)/Scott (2008) showed three distinct views on the competitive strategies (see figure 2). The distinctiveness is however, not that obvious. As early as 1980, Porter implied that resources in the firm were important in the strategy for competitiveness. Barney (1995) stressed the importance of the surroundings as well. The introduction of the tripod was therefore not a surprise, in the way of new thoughts, but the equal positioning against each other, as three entities in a strategy tool, was new.

A further development of this tripod would be to present it as one entity (as seen in figure 9). Even though, the focus in this thesis was on the national level, each of the levels of the theory needed to be investigated, in terms of technology, knowledge, companies, surrounding sector and countries. There is a connection between these levels. In this way, as figure 9 shows, it could be regarded as representing different levels, where there is an equally big contribution to each level, from each level. This way of studying a specific object seen in the context of restrictions and possibilities, is not new, however. In marketing there exists a representation of the entire market system, which ranges from the micro system in the center, to the surrounding public system, and last, to the macro system (Framnes et al., 2014). This shows a complex structure that develops in regards to changes in the three parts, which again will influence the other parts.

This dimensional representation in marketing was therefore an inspiration for a similar representation within the field of strategy. In this thesis, the tripod as one, dimensional entity has been tested. The resources may be a result of the surroundings, and the surroundings may implement strategies based on the resources. To see this as an example from the thesis, this became clear in regards to the competent workforce from other industries, and the path dependency of the 1G choice, respectively. A dimension representation of the tripod may therefore be presented. This does however, call for further research in testing the theory against other industries as well, in order to increase the strength of this strategy theory.

The thesis has tested the theory and found that the theory represented as a tripod by Peng et al. (2009), do serve as a good guidance in finding data within the three entities. It did also serve as a good tool for the investigation of jobs in the PV industry, resulting in findings that, together, serve to represent the development. However, the realization of the connections and overlap between the entities, in addition to the transitions in levels, in this thesis, may also serve to be represented as one entity with several dimensions. In regards to investigating job creation, this could therefore show to be a new representation of the theory of the tripod, showing the importance of the combined effects, and effects on different levels.

5. CONCLUSION

My first research question was: *How has the number of jobs in the PV industry in Norway developed?* As the discussion has shown, the development of the jobs in the PV industry in Norway has shown in particular, three main trends. A growing start (trend 1), followed by a rapid decline (trend 2), and a more recent growth again (trend 3). Comparing Norway with Germany have been informative, where the similarities often functioned as a verifying case, and the differences pointed at not previously considered explanations. In addition, the chosen aspects of the strategy tripod: the resources, industry and institutions, from a national level, guided the way for several explanations for the development in the three trends. Further, several combined factors from the theories have led the way to important reasons that have influenced the development of jobs in the PV industry. This goes to answer the next research questions: *How can we explain this development? What can we learn from the past and from mirroring the Norwegian development with that of Germany?*

For trend 1, the growing market, due to Germany, among others, represented low entry barriers, resulting in a possible emergence of a Norwegian PV industry. The competence and knowledge from a former metallurgic industry, from silicon production and from early PV R&D were a good combination with the p-Si dominance at that time. In addition, district-aimed incentives were important for growth. The relatively rapid growth, however, showed to be a result of the contracts with foreign suppliers. For trend 1, both the resource- and the institution-based view were important for finding explanations for the growth, but the industry-based view was particularly essential.

Trend 2 showed a rapid decline in Norway. The Chinese government's subsidies and loans to its companies took advantage of the fragmented industry, and this was presented as the primary reason for this development. A weak p-Si lock-in, with resulting lack of innovation, quality and uniqueness, capital tax, lack of industry-aimed incentives, and the financial crisis were also mentioned as explanations. The reason for the rapid decline in Norway, compared to Germany was claimed to be because of a lack of differentiation in technology generation, and within 1G, and the number of firms. For trend 2, the industry-based view revealed the primary reason for the decline, but the resource-based view was also important.

For trend 3, a focus on a less imitable technology, in the form of mono-Si, that Norway has several years of experience from producing, is claimed to be an essential explanation for the growth we see today. With this, it has been possible to focus on quality, innovation, competence and efficiency in production, which may also be a result of R&D collaborations. The Norwegian community spirit may have contributed as well, in regards to not giving up, as Germany may have done due to former experiences in loss of tradable jobs and the possibility of moving downstream in the value chain. These mentioned factors may be why Norway is growing, and Germany is not. The concentrated part of the value chain, with contracts with foreign suppliers and customers, is another strength. In addition to this, the MIP may have improved the conditions for manufacturers. From trend 3 it was clear that the industry- and the institution-based views showed some explanations for the recent growth, but that the resource-based view presented the primary explanation.

Together, the three theories of the strategy tripod has been able to uncover the explanations for the development of the number of jobs in the PV industry in Norway, where the case of Germany has helped reveal more explanations within the strategy tripod.

The third and last part of the research questions did also open up for a discussion on taking learning from the past and from Germany in order to better the conditions for job creation in the PV industry in the future for Norway. The tripod tool has shown that today, the market is characterized by a predominance of 1G PVs, but we have also seen that this has been shifting due to an unstable industry through the years. Even though it has been claimed that penetrating the industry with a new technological generation may be difficult in the relatively mature market today, it is not unthinkable. Several examples from other industries have shown this possible. This makes it very important for the Norwegian PV industry to focus on other technologies than 1G as well. The lack of a PV market in Norway could be a unique possibility. Expanding the market in Norway, may create jobs in the downstream part of the value chain, but it may also create possibilities for incentive-aided technology development, in favor of new 3G and 4G technologies, in addition to complementary products. In this aspect, the possibility of a free and competent workforce, originating from another industry, such as the oil and gas industry, may show fruitful.

Throughout the writing of the thesis, it became clear that the resources, the industry and the institutions, are partly dependent, and that they comprise a complex picture of the development. The tripod that is utilized in the discussion showed to be more cohesive than was first anticipated. A more united representation of the theories is presented, where the dimensions and levels are clearer, as well. This representation is more consistent with the complex and dependent variables shown in the thesis.

6. FURTHER RESEARCH

From the new theory implication, for the dimension representation of the strategy tripod, it is recommended that the tool needs to be investigated in the light of other industries as well. This is necessary due to this thesis not investigating a representative selection, where only one industry and mainly one nation is in focus. In order for the three theories presented as a tool of dimensions to become a possible versatile and functioning tool, it needs to be tested in other situations as well.

Furthermore, the strategy tripod presented in dimensions, needs to be tested for all of the parts, not only the ones that were chosen for this thesis. The organization of the firm from the resource-based view, the complementary products of the industry-based view, and several portions of the informal part of the institution-based view, are sections of the theories that were omitted due to time constraints. Testing the new tool with all of these parts is necessary, in addition to investigating the jobs in the Norwegian PV industry with these omitted parts. This may reveal new explanations that has not yet been uncovered in this thesis. Investigating Germany to a fuller extent, than was done in the thesis, may also show to find more explanations.

At last, it is proposed that new research should be conducted to study the development in the future. This thesis can be regarded as a follow-up of former studies on the matter, even though new aspects were covered as well. This resulted in new learnings, especially for the recent development, which is of most importance for strategy choices in the near future. I therefore recommend a study that investigates the creation of jobs in the Norwegian PV industry at a later point of time, seeking to find new developments and new policy implications.

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APPENDIX A: INTERVIEW GUIDE FOR ALF BJØRSETH

(I have decided to present the original interview guide, which is written in Norwegian. This was a choice based on the wish to avoid dissimilar understandings of the questions when translated into English)

INTERVJU

Antall arbeidsplasser som følge av solcelleproduksjon i Norge og Tyskland hadde en nokså lik utvikling fra 2000 fram til 2010, der det var en stor vekst, men litt humpete (figur 13). I 2010-2011 opplevde begge land en knekk, og antall arbeidsplasser har ikke kommet opp på samme nivå igjen foreløpig. Norge opplevde en rask nedgang fra 2010. Vekst i arbeidsplasser kom raskt opp igjen etter nedgangen i Norge, og startet allerede i 2012. Tyskland opplevde en langsom nedgang fra 2010. Veksten i Tyskland har til nå uteblitt. Men hvorfor hadde man havnet i denne situasjonen, hvilke hendelser kan forklare utviklingen, hva burde vært gjort annerledes, hva skjer nå, og hva burde skje nå? Dette er spørsmålene som ønskes besvart i dette spørreskjemaet.

Guiden er delt i tre deler, først en del om teknologi og marked, så en del om offentlige reguleringer og insentiver, og til slutt en avsluttende del med tilleggsmuligheter. Innenfor hver del er spørsmålene fordelt ut fra fortid, nåtid eller framtid. Alle spørsmålene bør bli sett i lys av grafen som viser endringen av arbeidsplasser innen solceller.

DEL 1: TEKNOLOGI OG MARKED

FORTID

1. REC vokste seg stor ganske raskt, ved fusjon i Norge og overtakelse av utenlandske firma. Også langtidsprodusent av silisium, Elkem, inngikk avtale med et amerikansk firma for produksjon av silisium til solceller. Var RECs og Elkems fot innenfor produksjon i utlandet avgjørende for at de kunne vokse så mye? Eller var den allerede opparbeidede kunnskapen og kompetansen rundt silisium i Norge viktigere?

2. Konkurransebildet for produsentene har endret seg fra japansk/amerikansk til europeisk til kinesisk dominans på verdensbasis. Kina sin solcelleproduksjon begynte å vokse betraktelig allerede i 2004, da offentlig støtte i landet hadde økt betydelig. I tillegg var det mangel på silisium rundt 2005-2009, og deretter en påfølgende overproduksjon av solceller. Hvordan har disse konkurransefaktorene påvirket mulighetene for norske bedrifter å starte opp og fortsette i denne industrien fra 2000 til 2010, med tanke på priskrig, kvalitetskrig, etterspørsel, osv.? Hvilke konkurransestrategier burde norske solcellebedrifter ha satset på, sett i ettertid, for å hindre at Kinas konkurransekraft skulle øke så mye?

3. Kan høye utgangsbarrierer (emosjonelle utgangsbarrierer som følge av stolthet med å ha skapt en ny norsk industri eller økonomiske utgangsbarrierer som følge av f.eks. investering i maskiner og bygninger) for å gå ut av industrien, ha hindret at den norske solcelleindustrien døde helt ut rundt 2010-2011?

4. Produksjon av monokrystallinsk silisium kan sies å være mer verdifullt, sjeldent og vanskeligere å imitere enn multikrystallinsk silisium, særlig i Norge grunnet tilgang til kjølevann og billig og miljøvennlig vannkraft. Kunne man ha unngått utflyttingen av arbeidsplasser til Asia hvis man hadde satset mer på monokrystallinsk silisium med en gang? Eller var multikrystallinsk silisium «den uunnværlig inngangsbilletten» til solcelleindustrien for Norge?

NÅTID

5. Vil dere si at teknologiskiftet fra en overvekt av produksjon av multikrystallinsk silisium, til monokrystallinsk silisium er en av grunnene til at man igjen ser en økning av arbeidsplasser i Norge? Hvorfor, eller hvorfor ikke?

6. 3.generasjons (3G) og eventuelt 4.generasjon (4G) solceller, ser teoretisk ut til å kunne skape de beste konkurransefordelene (høy verdi, sjelden og vanskelig å imitere) for et firma som finner en god produksjonsmetode. Foreløpig har 1G fått mest støtte. Tror dere mer satsing på produksjon av nyere generasjoner kan skape enda flere arbeidsplasser i Norge? Er tiden inne nå, eller bør vi vente på at teknologien blir mer moden først?

7. I Norge har bedriftene gått bort fra å produsere flere deler av verdikjeden, og fokuserer nå på silisium (råmaterialer, wafere, ingots, osv.), mens i Tyskland finnes det flere selskaper som inngår i store deler av verdikjeden, med produksjon av råmaterialer, celler, moduler, invertere, osv. Hva tror dere er hovedgrunnen til at norske bedrifter har valgt å ikke bygge verdikjeden videre, etter at REC og Innotech Solar la ned produksjon i Norge, og eventuelt hvorfor fortsetter man med det i Tyskland?

FRAMTID

8. Er det noen forskningsprosjekter, eller liknende, som ser svært lovende ut for framtidig solcelleproduksjon i Norge?

9. De kinesiske myndighetenes subsidier og skatteletter til landets solcelleprodusenter skapte overproduksjon, som førte til at det ble mindre lønnsomt å produsere andre steder, og i 2009 ble Kina den største produsenten av solceller. Dette kan nok sies å være hovedgrunnen til nedgangen både i Norge og Tyskland. Hva bør man i Norge gjøre for å forhindre en liknende situasjon som følge av andre oppblomstrende land, for eksempel Brasil, India, Sør-Afrika?

DEL 2: STATLIGE REGULERINGER OG INSENTIVER

FORTID

10. Hvilke norske, statlige reguleringer og insentiver var avgjørende for vekst innen produksjon fram til 2010? Kunne noen reguleringer eller insentiver ha hindret den store nedgangen?

11. Hva har samarbeidsprogram som The Norwegian Research Centre for Solar Cell Technology, IEAs Photovoltaic Power Systems Programme, og liknende, betydd for utviklingen og satsingen på produksjon i Norge og Tyskland?

NÅTID OG FRAMTID

12. Hva må spesifikt skje, med tanke på lover, reguleringer, insentiver, samarbeid, osv., for at Norge nå skal satse mer på produksjon av nyere og mer innovativ solcelleteknologi (både ny generasjon og innenfor silisium)?

DEL 3: OPPSUMMERING OG TILLEGGSFAKTORER

13. Er det andre faktorer som bør nevnes som avgjørende for veksten av produksjon i Norge fram til 2010? Og hva med nedgangen etter 2010?

14. Er det andre faktorer som har spilt en stor rolle for at norsk solcelleproduksjon igjen kan bidra med et voksende antall arbeidsplasser?

15. Basert på situasjonen i dag, hvordan tror dere den videre utviklingen kommer til å se ut?

16. Er det andre faktorer som dere mener det bør bli fokusert mer på for å øke antall arbeidsplasser i årene framover?

OPPFØLGINGSINTERVJU

a. Dere mener at produksjon i utlandet var avgjørende for veksten man opplevde fram mot 2010. Og at den metallurgiske kunnskapen og kompetansen man hadde fra før i Norge, var mindre viktig. Hvis dere ser denne kunnskapen og kompetanse for seg selv. Vil dere si at den hadde betydning allikevel, med tanke på at man kunne øke produksjonen som følge av arbeidernes allerede opparbeidede kunnskap? Kan dette ha vært et konkurransefortrinn i forhold til andre land? (Refererer til spørsmål nr. 1 i det tidligere skjemaet)

b. Bjørseth har en gang uttalt at formueskatten bremser solcelleindustrien i Norge. Er det blitt gjort endringer her, som dere mener har bedret situasjonen?

c. Hva tror dere er den største grunnen til at Norge igjen ser en økende grad av produksjon og arbeidsplasser innen produksjon, mens Tyskland fortsatt synker? Har Tyskland gitt opp denne delen av solbransjen, og «gitt» den til Asia, og heller beveget seg mer mot service, vedlikehold og installasjon? Hvorfor fortsetter Norge i så fall (*i tillegg* til å utvide mer mot f.eks. den delen av verdikjeden der Scatec Solar befinner seg)? Har det noe med stolthet, vilje og dugnadsånd å gjøre?

d. Dere sier at barrierene for å komme med disruptiv teknologi begynner å bli høye, etter hvert som markedet og industrien modnes. Tror dere 1.generasjon eller silisium vil fortsette å være markedslederen på grunn av dette? Er det da sikrere for Norge å drive med inkrementell, eller stegvis, innovasjon innen 1G/silisium? Eller mener dere det bør foregå forskning innen mer radikal innovasjon også? (Refererer til spørsmål nr. 6 i det tidligere skjemaet)

APPENDIX B: INTERVIEW GUIDE FOR ERIK S. MARSTEIN

(I have decided to present the original interview guide, which is written in Norwegian. This was a choice based on the wish to prevent dissimilar understandings of the questions when translated into English)

DEL 1: TEKNOLOGI OG FORSKNING

1. I Norge har fokuset vært på 1G opp gjennom årene, særlig innen produksjon. I 2012 skrev regjeringen i et dokument (NOU) at FoU ofte blir nedprioritert i bedriftene i forhold til hva som egentlig er samfunnsnyttig forsvarlig. Det er vel også 1G som har fått mest statsstøtte til forskning. Burde dette ideelt sett ha vært mer fordelt på andre teknologier også (2G, 3G, 4G)?

2. Hva er det generelle synet på insentivene som har blitt gitt til forskning på solceller opp gjennom årene? Har det stimulert til forskning på mer innovativ teknologi, eller kunne det ha vært mer effektivt?

3. En av disse virkemidlene som startet i 2009 er The Norwegian Research Centre for Solar Cell Technology, der du er senterdirektør. Har dette vært en viktig bidragsyter for å øke innovasjon i industrien? Hvor viktig har dette senteret vært for utvikling av ny teknologi/produksjon/osv.?

4. Innenfor 1G finner man mono- og multikrystallinsk silisium. Produksjon av monokrystallinsk silisium kan sies å være mer verdifullt, sjeldent og vanskeligere å imitere enn multikrystallinsk silisium, og der har Alf Bjørseth en gang uttalt at Norge stiller sterkt grunnet tilgang til kjølevann og billig og miljøvennlig vannkraft. Kunne man ha unngått utflyttingen av arbeidsplasser til Asia hvis man hadde satset mer på monokrystallinsk silisium med en gang? Eller var multikrystallinsk silisium «den uunnværlig inngangsbilletten» til solcelleindustrien for Norge?

5. Og hvordan er fokuset innenfor forskning i Norge mellom disse to teknologiene i dag?

6. Både Norge og Tyskland har vært mest fokusert på 1G solceller, men i Tyskland så man også en økning innen produksjon av 2G fram til 2012. 2G er mindre verdifullt (avhengig av material), lettere å imitere, og sjeldnere enn 1G i markedet. Mener du at 2G burde vært mer utnyttet også i Norge?

7. 3G og eventuelt 4G solceller, ser teoretisk ut til å kunne skape de beste konkurransefordelene (høy verdi, sjelden og vanskelig å imitere) for en bedrift som finner en god nok og billig nok produksjonsmetode. Har vi forutsetning for å lykkes med 3G og 4G i Norge, ut fra kompetanse i forskningsmiljøene? Er tiden inne nå, eller bør vi vente på at teknologien blir mer moden først?

8. Hvordan ligger Norge an i forhold til andre land når det gjelder forskning på nye generasjoner av solceller?

DEL 2: SAMARBEID, MARKED OG OFFENTLIGE REGULERINGER/INSENTIVER

9. Jobber forskningsinstitusjonene i Norge hovedsakelig mot norsk industri eller er det også mye samarbeid med utenlandsk industri? (Hvis mot utenlandsk, hvorfor?)

10. I årsrapporten for The Norwegian Research Centre for Solar Cell Technology for 2014 står det at dere har kunnskap og ekspertise innen flere deler av verdikjeden, selv om man innen produksjon nesten utelukkende driver med silisium råmaterialer, wafere, ingots, etter at REC og Innotech la ned i Norge. Bør vi benytte denne kunnskapen og bygge ut verdikjeden innen produksjon videre igjen? (Celler, moduler). Er det noe spesifikt innen forskningen her?

11. Er de offentlige insentivene som gis til forskning innen solceller en viktig bidragsyter til å skape arbeidsplasser lengre inn i framtiden? Er denne støtten effektiv nok i dag?

12. Hva kan forbedres for å skape arbeidsplasser?

13. Har minimum import price (MIP) endret forholdene for norske produsenter?

14. Er det noen samarbeidsprogram som har betydd mye for Europa eller hele verden som helhet?

15. Er det andre faktorer man bør fokusere på for å øke samhandling mellom forskningen og industri innen solceller i Norge i dag?

16. Hvorfor vil du fortsette i denne bransjen?