Promotion of Wind Energy Technology in Sweden

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Master's program in Environmental Science 120 hp
Promotion of Wind Energy Technology in Sweden, Autumn 2017

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Content

Abstract:

The main aim of this investigation is to identify barriers against, and opportunities for increase of the share of wind energy in the overall energy mix of Sweden. The selected research question examines the factors required for Sweden to increase its share of wind energy from todays 12.2% to 20% in 2025? The report would present and evaluate different strategies which could enhance the installed wind power capacity in Sweden from a current 12.2% to 20% by year 2025.A combination of both explanatory and exploratory techniques has been adopted. Innovation system and learning theory is selected as a theoretical frame allowing analysis of the concept of innovation.

A strategy that might prove to be fruitful to increase the share of wind power in Sweden is for the government to introduce tax exemptions to companies and corporations willing to minimize greenhouse gas emissions by switching to 100% renewable energy. It will certainly reduce the carbon footprint of Sweden. In addition, all of the already installed wind turbines can be upgraded one MW each. 38.5% of this increase (i.e. 3000 MWs) will take place via upgrading the existing 3000 wind turbines whereas the remaining 61.5% (i.e. 4800 MWs) will be installed in the form of 600 new wind turbines. From a critical perspective, the cost of an individual wind turbine has decreased 35 – 40 % since 2009 and is expected to drop further. It is important to point out that we can recycle 95% of the components of a wind turbine once it completes its life cycle whereas, a nuclear power plant takes much more time and finances to be decommissioned upon the completion of its life span. Finally, the selected research question is both realistic and achievable provided proper time, energy, technical expertise and financial resources are directed towards achieving this goal.

Keywords: Sustainable Development Goals (SDGs), Clean energy technology, Vestas, Wind turbines and Vattenfall

Introduction

Industrialization turned the 19th century into an era of coal. Economic progress and development further transformed the 20th century into an era of oil (Brown 2012). However, with the advent of the 21st century, the concept of Sustainable Development and green economy started to flourish. It is generally referred to as an era of renewable energy technologies (RET). A report from Intergovernmental Panel on Climate Change (IPCC) confirms that the fossil fuel based generation of electricity is responsible for a large part of emission of greenhouse gases (GHGs) into the earth's atmosphere. These anthropogenic emissions have given birth to climate change (IPCC 2011). A constant supply of energy is believed to be the backbone for all progress and development that has taken place so far. A sustainable reliance on clean energy will help in achieving Sustainable Development Goal number 7 (i.e. affordable and clean energy) (United Nations 2017). Among all the sources of power generation, renewable sources are the most preferred, as they are cost competitive to conventional sources of power generation. In fact, the cost of electricity produced through renewable resources is approximately the same in more than 30 countries, compared to the electricity produced from conventional sources (Griffin 2017). Besides cost competitiveness, renewable sources are environment friendly as they produce less harmful waste emissions in comparison to their counterparts.

Wind energy can be a sustainable substitute to nuclear power when it comes to electricity generation (England 2017). From a financial perspective, the installation of a wind farm requires maintenance & functioning cost whereas, a nuclear power plant requires maintenance cost, functioning cost, expenses to take extreme safety measures and an additional cost to deal with waste (Clark 2012). Since the beginning of the industrial era around 1850, humans have been relying extensively on fossil fuels for electricity production. This has added a lot of carbon dioxide, and other greenhouse gases emission into our atmosphere (IPCC 2011). This disturbance is without doubt responsible for the ongoing climate change (European Commission 2017). As a result, the global average temperature has started to rise. At present, it is about 0.85 degree Celsius higher than it was before the advent of industrialization (European Commission 2017). The concept of Sustainable Development was introduced in 1986 to mitigate climate change. A key strategy adopted to address this challenge was to invest large sum in clean energy sector over decades.

The government of Sweden can achieve a carbon neutral future by increasing the share of renewable energy in the overall energy mix (United Nations 2017). Sustainable Development Goal 13 “climate action” is directly related to the promotion of renewable energy. The expansion of clean energy technologies at a broader scale is crucial to sustain economic growth in future especially for a highly industrialized country like Sweden. In this research project, Sweden is selected as case studies to identify factors that are important for developing and increasing renewable energy sources focusing on wind energy. The Minister for International Development Cooperation and Climate in Sweden recently signed “*Swedish Climate Law*” which binds all the incoming governments to achieve the target of *net zero emissions* by 2045 (The Government of Sweden 2017). This thesis analyzes the possibilities to increase the share of wind energy in the overall energy mix of Sweden. In terms of energy policy making, it could then be utilized to reduce reliance on nuclear power for electricity generation. Sweden generates around 12.2% of its total electricity from wind energy technology. It points out the fact that the wind power as a technology is mature and the required skills and knowledge are available to implement the research question. A possible hindrance in the promotion of wind power can be the lack of awareness among masses concerning the knowledge and need of windpower as a clean source of electricity production. It then leads to masses developing resistance against the installation of wind turbines in close proximity of residential areas.

1.1. Research Problem & Aim of the Study:

The main aim of this investigation is to identify barriers against, and opportunities for increase of the share of wind energy in the overall energy mix of Sweden.

1.2. Research Question

What is required for Sweden to increase its share of wind energy from todays 12.2% to 20% in 2025? It can also be referred to as a 20:2025 goal (Kingsley 2013).

Theoretical Framework

Innovation system and learning is a theory that focus on effective interaction among all stakeholders involved in the process of innovation. Innovation does not happen in isolation. It is based on effective interaction between multiple stakeholders that works in harmony with each other. This interaction then leads to transfer of knowledge between the involved stakeholders. The concept of learning resides at the center of innovation theory. Another extremely important point when it comes to applying innovation theory is to define the boundaries of the system. Defining the limits enables the researcher to focus on a selected system and to understand its core elements that are involved in the process of innovation. It also helps the researcher in studying relationships that exists between the identified elements in a selected system. As a result, researcher can then generate more concrete results that would otherwise be missed in case of a system with vague boundaries. In the process of innovation, learning is of two types, first and foremost is learning by searching that is a quest to find new knowledge. Second type of learning is referred to as learning by doing. It takes place at the manufacturing level and focuses on enhancing production skills. The innovation system and learning theory has played a major role when it comes to analyzing the development of wind energy technology in the Netherlands and in Denmark.

From an investment point of view, it is always feasible to diversify the portfolio when it comes to power generation. A project with a combination of wind turbines and solar photovoltaics would attract more investors due to diversity than a project based on a single clean source. A possible explanation for this behavior could be that some investors like to invest money in technologies at an early stage of development whereas others prefer to invest in a clean technology source more mature than the rest (Wüstenhagen and Menichetti 2012).

With reference to this report, innovation theory can help in identifying factors that causes friction in the promotion of wind energy technology in Sweden. Once identified, the friction creating factors would then be eliminated with the help of examples from other countries within Europe that have higher installed wind power capacity than Sweden.

Another important theoretical concept is NIMBY (Not In My BackYard). The idea of NIMBY is quite well-grounded when it comes to highlighting problematic issues especially in case of infrastructure projects like construction of nuclear and conventional waste facilities close to a residential area, construction of a wind farm close to a residential area, drilling for oil in offshore areas and the construction of railroads and roads in forests (Wolsink 2000). It is important to understand that innovation system and learning is a process that fosters research and knowledge creation and leads to the development of new technologies. On the contrary, NIMBY is a concept that prevents issues to occur in present that might become a social problem in future. Thus, there is a high chance that both of the already spoken concepts might act in the opposite direction on a same issue.

2.1 Pros & Cons of Wind Energy and comparison with other sources of power production:

According to the European Wind Energy Association (EWEA), a key advantage of wind energy technology is that a wind turbine does not emit any greenhouse gas during power generation. The average break even point for a modern wind turbine, where it has produced the same amount of energy that was consumed for its construction and installation, is six months. During the whole life span of a wind turbine, which is estimated to be around 20 – 25 years, each turbine produce 80 times more electricity than it has consumed. Wind turbines also consume less water in comparison to nuclear power plants and produce no hazardous waste at the end of the cycle (EWEA 2017). After the decommissioning of a wind turbine, most of the components can be recycled for example ferrous high alloy, ferrous metal, aluminium and aluminium alloys, copper, zinc, magnesium, batteries and blades can be easily recycled up to 95% (Andersern et al. 2014). Thus, a positive environmental impact in terms of power production with very low GHGs emission, and almost no waste provides wind energy technology with a competitive advantage over fossil and nuclear power production. From a financial and operational perspective, the installation of wind turbines in large numbers is a fair and square deal as the cost of installation; decommissioning and electrical infrastructure of a wind turbine is inversely related to the number of installed wind turbines (i.e. if one factor increases the counter factor decreases (Hofmann and Spertad 2014). From a critical perspective, wind turbines have a positive environmental impact since a turbine neutralizes its carbon footprint, consumes less water than nuclear and fossil based power plants and all components of a turbine can be recycled up to 95% upon the completion of life span (EWEA 2017).

Innovation theory through the generation of knowledge helps us to understand that wind farms are more reasonable to pursue than either fossil fuel or nuclear based power plants. Conventional power plants emit greenhouse gases into atmosphere which stays there for at least 100 years (Clark 2012) for example, carbon dioxide which stays in atmosphere for 20 – 200 years, methane for 12 years, nitrous oxide 114 years and chlorofloro carbons (CFCs) which can stay from less than a year to many thousands of years (Clark 2012). When compared with wind power, nuclear technology releases waste which needs to be safely buried for more than100,000 years (Rose 2011). A typical nuclear power plant roughly consumes 400 gallons of water to produce a megawatt of electricity (Henry 2017). To handle the nuclear waste in a safe manner, the Government of Sweden has taken an important step by introducing a law which enables the nuclear power plant operators to pay a surcharge of 0.04 SEK per Kwh of nuclear power. It is collected in a government fund referred to as "Nuclear Waste Fund". The fund had a financial standing of SEK 60 billion by the end of 2016 (SKB 2017). The financial resource from nuclear waste fund is directed to decommission nuclear power plants and safely manage the nuclear waste in Sweden. As per the standard operating procedures, a nuclear power plant is required to be decommissioned once it completes its life span. However, the decommissioning operation cannot be initiated before a year due to high levels of radiation.

With reference to the concept of NIMBY, wind power also has limitations (i) wind might not blow all the time (ii) wind farms have relatively small time span of operation when compared with either fossil fuel or nuclear power plants that works for a relatively longer time span (e.g. 40 years for a nuclear power plant) (SKB 2005) (iii) Another common disadvantage of wind energy deployment is noise pollution. Wind turbines normally generate two types of noises **(i)** mechanical noise **(ii)** aerodynamic noise. Mechanical noise is generated due to the interaction between different parts of wind turbines and aerodynamic noise is generated as a result of interaction of blades with air. Proper insulation has improved the design of wind turbines over period of time and has minimized mechanical noise up to a certain extent for commercial scale wind farms. Another commonly known disadvantage of wind turbines is bird and bat mortality. It depends a lot on other factors like weather, specific site (depending upon if the wind turbines are installed in the migration route of birds and bats), direction and strength of local winds and finally, the design characteristics of wind turbines. It is important to mention here that scientific studies have not yet reflected any serious threat to either biodiversity or human health due to the installation of large scale wind turbines (Anshelm and Simon 2016).

In Sweden, the main development in the sector of hydropower as a clean source started in 1940 and the reliance on the construction of hydropower plants lasted till 1970. After that, the reliance was shifted from hydropower plants to the construction of nuclear power plants. A key reason of the shift was to protect the rivers. Most of the hydropower plants with large output capacity are located in Norrland (i.e. the North of Sweden). Altogether, there are 9 major rivers in Sweden that represents a collective installed hydropower capacity of 13,000 MWs (around 80%) of the total installed hydropower capacity in the country. It is important to mention here that river lule alv in Norrland has 15 hydropower plants with a cumulative installed capacity of 4366 MWs. On yearly basis, all of the 15 hydropower plants on river lule alv produce around 14.6 GWh of electricity (Flood 2014). Norrland is amongst the most sparsely populated regions in Europe and it has a threshold of 12.5 inhabitants per square kilometers (Gloersen et al. 2005). It might possibly be true that the presence of large rivers and low population density has enabled the then administrations to mitigate NIMBY with reference to the construction of large hydropower plants in Norrland, Sweden.

Generally speaking, wind energy minimizes the reliance on fossil fuels for electricity generation, thus facilitates in reducing the greenhouse gases emission. An excessive reliance on fossil fuels is an immediate cause for climate change which is already costing over a trillion dollars to global socio-economic system as a whole. As per an article published in Harvard Business Review, current emission scenario is not good for financial system and the value at risk ranges between USD 2 trillion to USD 25 trillion on per annum basis (Winston 2016). In this particular case, wind energy would serve as a sustainable alternative to nuclear power. Moreover, it would open a new window of opportunity in terms of employment generation and establishing new industry / sector to replace conventional sources of electricity generation. Finally, wind power generated 1.1 million jobs in 2015 at global level due to a very strong installation trend. Same trend can occur in Sweden too when it comes to job creation however, more fiscal and human resources are needed to be channalized in this direction to transform the desired goal into reality (IRENA 2016).

2.2. How to increase financial investment for the promotion of wind energy technology in Sweden

A low scenario with reference to 2030 is 8.8 GWs of installed wind power capacity whereas a high case with reference to installed wind power by 2030 is 20 GWs respectively (Ho and Pineda 2015). A key question which arises at this point is to divert more financial resources to make the transition from nuclear to wind power more profitable and sustainable. A key way for the Government would be to issue more green bonds which will ensure the channelization of financial resources for the promotion of wind energy technology in Sweden. It can prove to be a brief and profitable window of opportunity for the Government of Sweden in both short and long run. A report published by International Energy Agency (IEA) reflects that implementing strategies to mitigate climate change can unlock financial opportunities of worth USD 19 trillion. Likewise, implementing Paris Climate Agreement can unlock financial opportunities of worth USD 13.5 trillion or more before 2050 (Figueres et al. 2017). Sweden can certainly harvest the financial benefits of clean energy technologies by upscaling the installed wind power capacity to sustainably replace nuclear power in the country. It will not only provide a safe future for the current and future generations but will enable the Government to achieve its 2045 climate goal in true letter and spirit (Government offices of Sweden 2017).

By following the footsteps of Denmark, Sweden can certainly harvest similar financial benefits too. A key idea when it comes to the promotion of wind energy technology in Sweden is to have a fund similar to “Nuclear waste fund” but with a reverse mechanism in place. The proposed fund can be named as “Wind Energy Promotion fund”. The national Government of Sweden can pay a subsidy 0.04 SEK per kwh of wind energy which can then be collected in the proposed Wind Energy promotion fund. An alternate would be to pay 0.02 SEK per kwh and ask the sector of wind energy to raise another 0.02 SEK per kwh on matching grant basis. Similarly, another idea is to motivate pension funds to invest more finances in the sector of wind energy in Sweden. The Government of Sweden can guarantee secure investment and appropriate financial returns in order to enhance the confidence of the pension fund investors.

2.3 Financial Pro's & Con's:

Alecta is just an example in this regard. It is the fifth largest pension fund in Europe and had invested SEK 770 billion at the end of 2016. However, out of this invested SEK 770 billion, only SEK 7 billion were invested in the form of green bonds. Thus, a mere 0.9% of the total invested money was invested in the promotion of clean energy technologies (Alecta 2017, pg. 21). The national Government of Sweden can play an active role here by motivating financial advisors at Alecta to invest more fiscal resource in sector of wind energy in Sweden. It will certainly give a sustainable push to wind energy sector in Sweden. Likewise, Fourth Swedish National Pension Fund (i.e. Fjärde AP-Fonden AP4) had a total financial worth of 347 billion kronor on 30th June, 2017(Fjärde AP Fonden 2017) however, only a mere 4.4 billion kronor (i.e. around 4400 million sek or 1.3% of the total financial worth) were issued in the form of green bonds (Sustainability and Corporate Governance Report 2015/2016). Again, the Government of Sweden can certainly motivate the investors at AP4 too to invest more money in the sector of wind energy technology in Sweden. If the national government would successfully motivate the already spoken stakeholders to invest large sums in the sector of wind energy technology in Sweden, it can certainly open a new window of opportunity for the national Government. The least the national government can do in this regard is to ensure a safe investment and an appropriate financial return on the invested sum. On the contrary, lack of investment will certainly restrain the growth of the sector of wind power in Sweden. It will also decrease the confidence of cleantech companies that will negatively impact an overall growth and innovation in Sweden. It is important to mention here that Denmark on average earns over 50 billion DKK (i.e. around USD 9 billion) as revenue on per annum basis through the exports from the sector of wind power(Denmark.Dk (website) 2017). With proper investment of financial and physical resources, so can be the case for Sweden too.

2.4. How other countries in Europe have improved public opinion about wind turbines:

Policy makers have adopted different creative approaches to resolve the issue of NIMBY in creative manner in numerous countries across Europe. In order to minimize public resistance against wind turbines, the state of Bavaria in Germany has introduced a rule referred to as "10H rule" where wind turbines are not allowed to be installed closer to other buildings than at a distance which is 10 times the height of the wind turbine (Morris 2016). It is important to mention here that Germany has an installed wind power capacity of 45 GWs which is the third largest in the world (REVE 2016). Germany and Denmark are two neighboring countries of Sweden and both have a large wind power capacity. The core factor behind the success of wind power in Germany and Denmark is cooperative ownership where the public in general gets the opportunity to participate in the process of power generation from wind turbines (Anshelm and Simon 2016). In the Netherlands people showed to be least bothered from the noise of a nearby wind turbine, if they had a financial stake in the installed wind turbine (Bell 2016). Similarly, research in Spain and United Kingdom (UK) show that public opinion about wind turbine improves once the turbines go online (Busby 2012).France imposed taxes on wind farms to earn revenue so that more social benefits could be offered to communities with wind farms. Likewise, in Spain wind farm developers invest money in local economy to create employment and to give a financial boom to the local economy which will eventually benefit the masses in general living in that particular area with wind farms. In United Kingdom, the wind farm developers offer a certain amount of money on per annum basis or per megawatt of installed capacity which is then spend on local projects for community development (Cowell et al. 2011). In recent years, Italy has observed an exponential growth in the installed wind power capacity in some of the least developed areas of the country. In some cases, the installed turbines have introduced economic progress in municipalities suffering from a tight financial situation. This has certainly improved public opinion towards the installation of wind turbines in least developed parts of Italy (Cavicchioli and Garofalo 2015). Thus, if energy policy makers in Sweden will opt for cooperative ownership with community benefits where public will have the opportunity to participate in the process of power generation through wind turbines and company responsible to operate wind farms would invest in local economy, there are ample chances that this will certainly increase the social acceptance factor of wind turbines in both short and long term basis in Sweden.

Research Method - Case Study

The main aim of this investigation is to identify barriers against, and opportunities for increase of the share of wind energy in the overall energy mix of Sweden. In order to increase the validity of the case study, multiple sources like governmental reports, academic books, policy briefs, newspapers and scientific journals have been considered for data collection and case description. The focus of data collection was to identify factors that could then reduce the friction when it comes to the expansion of wind power in Sweden. The data was collected through online libraries and search engines. A combination of both exploratory and explanatory research techniques has been applied to identify factors that would then allow the sector of wind power to facilitate the Swedish Government to reduce its reliance on nuclear power.

3.1 Installed Wind Power Capacity in Sweden since 1982:

It is a commonly known fact that the number of installed wind turbines is directly proportional to the installed capacity and the production of electricity in Gigawatt hours. For example, in 1982 in Sweden, the number of installed wind turbine was 1, so the installed capacity was 3 Megawatts. On the other hand, the number of installed wind turbines in year 2000 in Sweden was 527, so the installed wind capacity grew to 241 MWs, which resulted in the production of 447 GWs of electricity. Following the same trend, the number of installed wind turbines skyrocketed to 1166 in year 2008, so the installed wind capacity also grew to 1090 MWs. It resulted in an electricity production of 2001 GWs in year 2008. Finally, the number of installed wind turbines escalated to 2961 in year 2014 which represented an installed capacity of 5097 MWs (i.e. 5.097 GW). Collectively, it produced 11,234 GWs of electricity. (Swedish Energy Agency 2017).

3.2 Electricity Production Capacity in Megawatts (1996 - 2014):

Sweden has relied upon number of different resources for the sake of electricity production. Hydropower is the largest source to produce electricity in Sweden since 1996, followed by nuclear power as the second largest source. However, the installed capacity for nuclear power has decreased gradually from 1996 to 2014. This trend is not quite sharp however it is still appreciate-able. The share of other thermal power sources (including district heating, CHP industry & gas turbine) has increased during last 19 years and as a result, it was the third most utilized source of electricity generation. On the contrary, the share of wind power escalated from 105 Megawatts in 1996 to over 5 Gigawatts in 2014 followed by solar power that increased from 16 megawatts in 2011 to 79 megawatts in 2014 (Swedish Energy Agency 2017)

3.3 Sweden as a Case Study

Assuming that Energy Authority in Sweden decides to install 20 wind turbines, each with an output capacity of 8 MWs (i.e. more or less of the same size as of the under-construction offshore Horns Reserv III project in Denmark) on the East coast of Sweden, it would enhance the installed wind power capacity up to 160 MWs (20 turbines x 8 MWs capacity each) (4C Offshore website 2018). As a result, the installed wind capacity of 160 MWs would generate 58,400 MWs or 58.4 GWs (i.e. 160 MWs x 365 Days = 58,400 MWs) on annual basis. The Energy Authority can then take the next step to install 580 wind turbines (each with an output capacity of 8 MWs) for the sake of green electricity generation. An installation of wind turbines on the East coast will help Sweden in improving knowledge and production skills with reference to the deployment of wind turbines and power generation in off-shore areas. Collectively, the installation of 600 wind turbines would then enhance the installed wind power capacity up to 4800 megawatts (i.e. 4.8 GWs) on daily basis. As a result of this increase, an additional 1,752,000 megawatts (i.e. 1752 gigawatts) of wind power would be added to the total energy mix on annual basis (i.e. 600 turbines x 8 MWs output capacity x 365 days = 1752 gigawatts / annum). Let's assume, that 552 GWs are subjected to line losses, uncertainties and other anomalies generated during the process of electricity transfer from wind farm to end user, even then 1200 GWs (i.e. 1.2 TWh) of wind power would be there to satisfy the electricity demand of different sectors on annual basis. This learning process would certainly promote collaboration and sharing of knowledge between different industries in Sweden. It would also help in improving the skills relevant to the deployment of wind power in off-shore areas of Sweden. In the long run, the innovation process and learning experience of offshore deployment of wind farms might help Sweden in earning revenue through the export of this technology.

According to the annual report 2015 of Svenska Kraftnät, the annual domestic electricity consumption in Sweden was 140 terawatt hours in year 2014 (Svenska Kraftnät 2014). The installed wind capacity in Sweden for year 2015 was 6000 Megawatts (MWs), whereas, the generated electricity through wind turbines was over 15000 gigawatt hours. The wind power contributed 12.2% in the total energy mix in year 2015. The development of wind energy in Sweden started in year 1991 but the trend remained static till 2001. However, in the following years there was an exponential growth when the installed capacity reached its pinnacle of over 6 GWs in 2015 (International Energy Agency 2015)

In order to increase the current generational capacity of wind energy from 12.2% to 20%, an additional generational capacity of 4 - 5 gigawatts should be installed. It is important to mention here that a commercial scale wind turbine with 2 MWs generational capacity cost between USD 3 – 4 million (Wind Industry 2017).

Table 1: The table given below reflects that a commercial scale wind turbine with an output capacity of 2 MWs costs around USD 3 – 4 million. Keeping the price of a 2 MWs wind turbine as constant, a turbine with an output capacity of 8MWs would cost USD 12 – 16 million.

Wind Turbine Capacity	**Cost (including installation)**
Commercial Scale 2 MWs	USD 3 – 4 million
Commercial Scale 8 MWs	USD 12 – 16 million

Table 2: The price of installation 600 wind turbines each with the generational capacity of 8 MWs would roughly cost between USD 7.2 – 9.6 billion.

Number of Wind Turbines with 8 MWs as output capacity	**Cost (including installation)**
1 wind Turbine	USD 12 – 16 million
10 wind turbines	USD 120 – 160 million
100 wind turbines	USD 1.2 – 1.6 billion
300 wind turbines	USD 3.6 – 4.8 billion
600 wind turbines	USD 7.2 – 9.6 billion

The price quoted here is just a rough estimation and the price in field (i.e. in business as usual) may vary accordingly. The combined installed capacity of 600 wind turbines would be 4.8 GWs. Energy policy makers in Sweden can choose to install over 0.533 GWs of wind power on per annum basis from year 2017 onwards (roughly around 66 wind turbines each year), so by the end of year 2025, a total of 4.8 GWs of installed capacity would be added to the already installed wind power in Sweden.

Again, innovation theory and learning process helps to understand that both land-based and offshore wind farms would be feasible for Sweden. Oceans and seas have a high wind speed around noon that makes them more desirable for the sake of electricity generation during peak hours (Anderson 2013). On the contrary, it is relatively easier to transfer generated electricity via an onshore wind farm. An offshore wind farm is also more vulnerable to rough and tough conditions of sea or ocean especially when it comes to storms. Therefore, it requires an additional maintenance cost to function smoothly which means it puts an extra financial load on the company that operates an offshore wind farm. Both offshore and onshore wind farms can better satisfy the peak demand of electricity and are a viable alternative to nuclear power. It is environment friendly in terms of operations, financially feasible in terms of installation & electricity production and finally, the technology has matured significantly over period of time.

3.4 Promotion of Wind Energy Technology is a must for a Sustainable Sweden:

The first and the foremost hindrance is the strong presence of nuclear power with an overall capacity of 9.5 GWs. The installed nuclear power capacity has gradually decreased over years from 10.05 GWs in 1996 to 9.53 GWs in 2014 (Swedish Energy Agency 2014). As per a framework agreement that took place between Swedish Social Democratic Party, the Moderate Party, the Swedish Green Party, the Centre Party and the Christian Democrats, four more nuclear reactors will be decommissioned by 2020 and Sweden will generate all of its electricity from clean energy sources by 2040 (The Government of Sweden 2017). It is important to consider wind power as a sustainable alternative to nuclear power and therefore focus of energy policy should on the expansion on wind energy technology to decommission the remaining nuclear power plants in Sweden. The Government of Denmark prioritized wind power over nuclear power and thus imposed a ban on the use of nuclear power to generate electricity (International Energy Agency 2014).

From an economical perspective, the cost of a wind turbine has decreased 30 – 40 % during last 8 years. Prices are further expected to decrease another 35% in case of offshore wind and 26% in case of onshore wind in the coming 8 years. (Reuters 2016). As a result, wind energy technology is more financially feasible than nuclear power since its price is expected to decrease sharply plus it is environment friendly and requires fewer expenses to function as there is no hazardous waste to deal with. It is important to mention here that China has a cumulative installed wind power capacity of over 145 GWs. Likewise, Germany has a total installed wind power capacity of 44.9 GWs, Spain has over 23 GWs of installed wind power capacity and India has installed over 25 GWs of wind power by the end of year 2016 (Global Wind Energy Council 2016). In comparison, Sweden has a total installed wind power capacity of 6.5 GWs and it is still a very large per capita capacity as the total population is slightly over 10 million (SCB 2018) .

From an environmental perspective, Sweden plans to achieve net zero emissions by 2045 and to achieve this ambitious goal, it plans to reduce its greenhouse gases emission 63% by 2030 and 75% by 2040. These percentages are compared against the emission levels of 1990 and are only for the sectors that follows the regulations of European Union (EU) (The Government of Sweden 2017). A key strategy to reduce the greenhouse gases emission from these sectors is to satisfy their electricity demand through clean energy resources. To do so, the Government of Sweden can choose to increase the number of installed wind turbines to enhance the share of wind energy in the overall energy mix from a current 12.2% to 20% by 2025.

As already spoken, the construction of hydropower plants was the most popular mean to produce clean electricity during 1940 – 70 in Sweden. With an increased knowledge about the impacts of large hydropower plants on rivers, came in the movement to protect rivers. Thus from 1970 onwards, construction of nuclear power plants were prioritized over hydropower plants. Today, it is a known fact that it is extremely expensive and risky to safely manage and store nuclear waste. Due to this strong reason, no one wants a nuclear waste storage facility near a residential area. Likewise today, wind power is a sustainable alternative to nuclear source of power production. As discussed earlier, wind power produces no hazardous waste, it’s extremely price competitive, consume less to no water in its operations, create jobs and up to 95% of its components can be recycled once a wind turbine completes its life cycle. If this information is communicated to masses that wind power is good for the environment, safe for society and fosters economic growth simultaneously and energy policy makers would also prioritize wind power over other conventional sources of power production, there is a high possibility that public behavior towards wind turbines would change positively. It is important to mention here that oil was once considered a useless resource as it would reduce the worth of land for agricultural practices (Robbins 1986). However, with the passage of time and the development of technology and infrastructure, oil is now one of the most important commodities to sustain economic growth. It is quite clear that masses behavior towards oil changed with the passage of time and the development of technology. It is the same for wind power too as before 1973 offshore and onshore wind farms were a dream for Denmark now it is a reality that generates a lion's share of electricity for the country. Similarly, as already discussed that masses behavior towards wind turbines improved in United Kingdom and Spain once wind turbines started producing power.

It is also a known fact that when it comes to values and initiating a project, the governing body briefly prioritizes economic growth and job creation over all other values. Thus, a clean power generation project with an ability to create jobs and giving a boost to economic growth in a particular area will have a higher chance of implementation than a project with a moderate or low positive impact. Moreover, project planners and those responsible for the execution can perform the implementation in a manner as to minimize its likely impact on surrounding environment (Newell and Matti 2017).

Comparison with Denmark

Denmark has reduced greenhouse gases emissions up to 30% since 1990 and aims to a reduction with 40% by 2020. In 2013, the export of wind energy technology contributed 6.5 billion Euros to Danish economy. By 2030, the country aims to phase out coal based power plants and by 2050, all of the sectors including electricity, heat, industry and transport would be powered by renewable resources. In 2015, the installed wind capacity in Denmark was 5.072 GWs and the figure was 4.9 GWs a year before (Annual Report 2015). By calculating the difference, it can be concluded that a total of 175 MWs of wind power was installed in 2015.

Again in 2015, the Government of Denmark provided a subsidy of DKK 8 billion to renewable energy sector and it was DKK 1.1 billion more than the subsidy offered during last year. The total installed capacity for solar photovoltaic stood at 783 Megawatts (MWs) in year 2015. The installed solar photovoltaic capacity in year 2014 was 609 Megawatts (MWs), respectively (Annual Report 2015). It can be concluded, that a total of 174 MWs was added to the already installed solar photovoltaic capacity in year 2015**.**

The development of wind energy in Sweden is relatively slow than in comparison to Denmark, Germany and Spain (Nilsson et al. 2004). In 2013, the total installed wind power capacity was 4.47 GWs and it reached to an install capacity of 5.42 GWs with an addition of 0.95 GWs in 2014 (The Royal Swedish Academy of Engineering Sciences 2016). In 2014, the major share of electricity was produced from hydro power (i.e. 42%) and the least share was generated from solar power (i.e. 0.06%). Likewise, nuclear power contributed 41% and wind power contributed 8% during the same year. There is a direct need to reverse this energy policy trend as focus should be more on generation of electricity through wind farms. Wind energy technology has matured over the period of time and if proper resources are applied, it can minimize the reliance on nuclear power.

The installed wind power capacity of Sweden is higher than Denmark but its geographical area and population size is much larger. As a result, the final share of wind power in the overall energy mix of Sweden is fairly less than in comparison to Denmark. Another prominent difference that exits between the two is that Denmark aims to install wind turbines with higher output capacities. So, more electricity could be generated from the existing infrastructure.

Similarly, Denmark provides large subsidies to green energy sector and therefore it's natural that a greater availability of funds would definitely promote innovation and efficiency in the field of wind energy technology. The cost of an individual wind turbine has dropped 35 – 40 % since 2009 thus, from a critical perspective it is financially reasonable to prefer wind energy over nuclear power, as it is environment friendly and produces no hazardous waste to deal with in a later phase (Chestney 2016). It is important to mention here that Sweden has geographical space that could be channalized to install wind turbines and the sector of wind energy technology is mature too. A key problem in the promotion of wind power is the public resistance towards the installation of wind turbines and it can be mitigated through the implementation of 10H rule, provision of jobs to people in communities with wind farms, upgrading the already installed wind turbines, increasing subsidies to clean energy sector and the reinvestment of revenue from wind farms in municipal social programs. All of these factors will certainly create a soft public opinion towards wind farms in municipalities across Sweden.

Besides wind power, the percentage of solar power in the overall energy mix should be increased too. For example in year 2014, only 0.06% of total electricity was produced through solar power whereas none was produced a year before. Energy policy makers can plan to enhance the share of solar energy in the overall energy mix for example, a strategy to generate up to 3% of electricity through solar photovoltaic cells. It is equally important to mention here that the geographical location of Sweden might not be ideal for the installation of solar photovoltaic (PV) panels due to low sunlight, but even a minor share of 3% electricity from solar PV might create a significant difference.

During 2006 – 2016, the installed capacity of wind power in Sweden has increased from 571 Megawatts (MWs) in 2006 to 6520 Megawatts (MWs) in year 2016. This shows an 11.4 times increase in the overall installed capacity of wind power during last 11 years. The total production capacity of wind power in Sweden was 6.52 GWs (i.e. 6,520 MWs) at the end of year 2016**.** On the other hand, the installed wind power capacity in Denmark increased from 3136 MWs in 2006 to 5290 MWs in 2016. An increase of 2154 MWs took place over the span of 11 years in the total installed capacity in Denmark (Windpower website 2017). During the last decade (i.e. 2005 – 2016), wind energy reflected an exponential growth in terms of electricity consumption at national level in Denmark.

Table 3: The percentage of electricity consumed in Denmark generated through wind turbines has increased from 19% in 2005 to 38% in 2016.	
Year	**Share in terms of electricity consumption**
2005	19%
2006	17%
2007	20%
2008	19%
2009	19%
2010	22%
2011	28%
2012	30%
2013	33%
2014	39%
2015	42%
2016	38%

A key Danish strategy that Sweden can replicate is to opt for wind turbines which have higher output capacities and thus can generate more electricity in terms of gigawatts. As mentioned earlier, one such example is a turbine with output capacity of 8 MWs and a rotor diameter of 164 meters respectively. The turbine has been produced by Vestas. A single wind turbine with output capacity of 8 MWs per day can generate 2920 MWs (i.e 2.92 GWs) on per annum basis. Let's say that if 0.92 GWs is lost in terms of line losses, even then a single turbine would generate 2 GWs on per annum basis. Thus, it can be concluded that a single wind turbine with an output capacity of 8 MWs would facilitate the energy authority to generate 2 GWs on per annum basis. With basic mathematical calculation, it can be projected that the installation of 100 such turbines would produce 292 GWs on per annum basis. Assuming the line losses to be 92 GWs, the final output would be 200 GWs on annual basis. Installation of 300 wind turbines with an individual output capacity of 8 MWs would produce 2400 MWs on daily basis and 876 GWs on annual basis. Assuming the line losses to be 276 GWs, the final output would be 600 GWs. Finally, installation of 600 wind turbines each with an output capacity of 8 MWs would generate 4800 MWs on daily basis and 1752 GWS on annual basis. Again after subjecting the line losses, the final output would be 1200 GWs, respectively. Thus, an installation of 600 wind turbines, each with an output of 8 MWs would produce 1.2 terawatt hours of clean electricity on annual basis.

Discussion

The primary goal of this research is to identify factors which would increase the share of wind energy in Sweden from the present percentage of 12.2% to 20% by 2025. Therefore, different factors like upgradation of already installed wind turbines, installation of turbines with larger output capacities, more subsidies to wind energy sector, a strong political will to reduce reliance on nuclear power and expenses on handling of nuclear waste and Government's right to allow the installation of wind turbines rather than municipalities will be discussed.

A constant supply of electricity plays an important role in the development of any country. However, once a country attains a certain socioeconomic status, it has to sort out ways to make its progress more eco-friendly. Sweden is a highly industrialized country where more than 40% of electricity is generated through water resource, another 40% is generated through nuclear power plants, 12 % is generated through wind turbines and finally 8 % is generated through solar and other thermal energy sources. It is important for the energy authority in Sweden to prioritize wind power over nuclear technology. The most crucial issue with nuclear power plants is that nuclear waste is complex and expensive to handle and is also dangerous from social and environmental perspective. Wind farms on the other hand provides an eco-friendly alternative where the electricity is generated at a price competitive level and the disadvantages / issues are minor to tackle in comparison to nuclear based power plants.

It was equally interesting to know that lack of interaction between the involved stakeholders and reluctance to share the generated knowledge were the key reasons why wind energy sector did not establish much in Netherlands. Another crucial factor was the lack of investment subsidies from the then Dutch government to companies involved in the purchase of wind turbines. On the contrary, there existed a close relationship between the research institutes, turbine producers and turbine owners in Denmark that lead to the massive success of wind energy sector in Denmark. Moreover, the Danish government played an extremely important role from the very beginning as it introduced investment subsidies in 1979 that made the purchase of Danish wind turbines far attractive than others. As a result, Denmark exported around 2000 wind turbines to the state of California in 1985 that helped the country to gain knowledge by constructing wind turbines.

From 1988, wind energy technology made a gradual shift from learning by doing approach to a more research oriented sector in Denmark (Kamp et al. 2004).

Opponents to wind power are generally in favor of wind power however, are against the installation of wind turbines in areas close to their residence. Thus, in order to increase the installed wind power capacity of any place it is important to promote open and honest collaboration between utilities, wind power developers, public bodies and masses in general. It is also true that the support of wind power is normally high in countries that already have high installed wind power capacity. So another way to increase installed wind power capacity in any particular area is to install one turbine at a time and simultaneously keep on improving the public opinion and attitude through mutual collaboration and learning (Wolsink 2000).

As mentioned earlier, Sweden has generated 12.2% of its electricity through wind farms in the previous year. However, energy authorities can achieve more electrical output through the installation of windmills with higher output capacity or by upgrading the already installed ones. The geographical location of Sweden enables it to have different wind speeds at different levels. In the northern Sweden, at the height of 49 meters over the Bothnian sea, the average offshore wind speed is 7 - 7.5 meters per second whereas, the average offshore wind speed over the Baltic sea at the elevation of 49 meters is 8 - 8.5 meters per second. An average wind speed over the southern Sweden is 5.5 - 6.5 meters per second whereas, the average wind speed over the northern Sweden is 4.5 - 5.5 meters per second (Söderberg and Bergström 2008). It is projected in this report that with proper policy making and financial input, the installed wind power capacity can be increased up to 20% by year 2025.

The already installed wind capacity in Sweden at the end of 2016 was 6,520 MWs which represented 12.2% of the electrical output in the total energy mix. The total installed capacity including all sources of power generation in Sweden was 39,549 MWs at the end of year 2014. With simple mathematical calculations, it can be concluded that, if 6520 MWs makes 12.2% of already installed wind capacity in 2016, then the total installed capacity for Sweden at the end of 2016 would be 53,443 MWs ((6520/12.2)*100 = 53,443 MWs). This figure includes all sources of electricity generation in Sweden. It is important to note here that it is just estimation and actual figure for total installed capacity might vary.

The 20% of 53,443 MWs would be 10,687 MWs (i.e. (20/100)*53443=10,687). As per the expected outcome of this project report, the installed wind capacity would be raised up to 4800 MWs through the installation of 600 wind turbines each with an output capacity of 8 MWs. So the total installed wind capacity would be 11,320 MWs (i.e. 6,520 + 4800 = 11320 MWs). The figure is 633 MWs more than the targeted 20%, however, line losses and power loss during transmission is a common factor, so even if 633 MWs would be lost due to line losses and other anomalies during transmission, even then the energy authority would be able to raise the bar for wind power from 12.2% to 20% by year 2025.

From a social perspective and to mitigate the effects of NIMBY, it would be convenient for the Government of Sweden to install wind turbines in areas which are not so densely populated. A possible location for the expansion of wind energy is the northern part of Sweden. The government might have to construct roads, if it hasn't already, to facilitate the establishment and the maintainence of wind farms. It will facilitate the administration to address public concerns regarding wind turbines in a sustainable manner. As spoken earlier, the installation of wind farms in the northern region of Sweden will certainly offer cooperative ownership with community benefits to local masses which will certainly create employment and give boom to local economy. It will create a favorable public opinion plus will generate revenue for the local government as well. It is important to understand here that the presence of a wind turbine which can be recycled once it completes its life cycle is much safer than the presence of a nuclear power with nuclear waste meant to stay for the coming 100,000 years. Moreover, rural areas across the Sweden can easily be utilized to install wind turbines with higher output capacities in comparison to ones installed in close proximity of urban areas. A turbine with a higher output capacity will lead to more production of electricity and thus a larger share of clean energy in the overall energy mix of Sweden. The development of physical infrastructure plus the production and the installation of wind turbines will promote economic progress and create jobs for masses in Sweden

From a political perspective, the municipalities have the authority to veto and nullify the installation of wind turbines in their respective areas. As a result, several municipalities have vetoed the installation of 350 wind turbines during last 3 years (Sverige Radio 2017). Let's assume that each turbine had an output capacity of 3 MWs, it means that the current Government of Sweden missed the opportunity to install over a Gigawatt of wind energy in its tenure. The price of a certificate to operate a power plant in Sweden has also sharply decreased since 2003 (Sverige Radio 2017). This reduction in price plus the government's ambition to install 1000 wind turbines by 2020 will certainly expand the share of wind energy in the overall energy mix in coming years (Nohrstedt 2017).

There exist a big contrast between Sweden and Denmark. Sweden is a fairly large country regarding its area, and the population size is almost twice as large as in Denmark (Heleniak T et al. 2016). The per capita energy consumption for both countries is roughly equal, but the total energy consumption for Sweden is twice as large as Denmark's, due to the doubled population size (The World Bank 2015). In Denmark, the sources of power generation are quite diversified. Wind power is certainly the largest, and has an installed capacity of 5.25 Gigawatts (GWs). It is followed by natural gas with 2.15 GWs, coal with 1.6 GWs, biomass with 1.5 GWs, solar photovoltaics with 851 megawatts (MWs), oil with 685 MWs, waste with 351 MWs, biogas with 112 MWs, hydropower with 7 MWs and other sources with an overall install capacity of 26 MWs respectively (Energi net 2017). In Sweden, hydropower with an installed capacity of 16 GWs is the largest source of power production. It is followed by nuclear power with an installed capacity of 9.5 GWs, other thermal energy with 8.3 GWs, Wind power with over 5.4 GWs and finally solar photovoltaic with an overall installed capacity of 79 MWs respectively (Byman 2016).

According to SKB, the financial worth of nuclear power programme in Sweden is SEK 141 billion. Till date, SEK 43 billion has already been utilized for the promotion of nuclear power and the safe management of nuclear waste while the remaining funds of worth SEK 98 billion will be utilized from 2018 onwards (SKB 2017). The financial figure of SEK 98 billion (i.e. around 9.8 billion euros) is too big of an amount which if channelized for the promotion of wind power can easily help Sweden to be nuclear power free country. In comparison, the neighboring country of Denmark has a more active sector of wind power production due to a more responsive subsidization program for renewable energy sector on annual basis. It also has turbines with higher output capacities than in comparison to Sweden. For this thesis project, a total of 11 years (i.e. 2006 – 2016) is considered as a time frame for data collection

From the perspective of Sustainable Development, the expansion of wind power from 12.2% to 20% will yield social, economic and environmental benefits for Sweden. First and foremost is that the installation of 600 wind turbines would give a boost to wind industry. It would create more jobs, promote research and development and would enhance technical ability when it comes to the power generation and deployment of wind turbines in off-shore areas. From the perspective of aesthetics, installation of wind turbines would increase the attractiveness of natural landscapes. In certain cases, population might think the opposite too. From the point of view of environment, it would provide a sustainable alternative to nuclear power which is good for Sweden in both short and long term. The installed nuclear power at the end of year 2014 was 9,528 MWs. Thus, if the wind power capacity is increased up to 4800 MWs as projected in this report, it would neutralize the reliance on nuclear power somewhere between 40% to 50% (i.e. 9528 – 4800 = 4,728 MWs). From an energy policy maker's point of view, it would be a complete win – win situation. From a social perspective, it would create more awareness among people on the issue of green electricity generation through wind turbines. All these steps would create a sustainable present and future for Sweden and its inhabitants.

5.1 Analytical Findings:

It is commonly known that innovation always takes place within systems formed by different actors and organizations (Kamp et al. 2004). All of the involved stakeholders does a lot of communication and thus each then contribute to innovation and learning. Normally, a technology is developed in a laboratory and is then tested in field. During the test phase, data is collected which is then communicated to laboratory to improve the designed technology further. The process is repeated quite often to a point where it becomes rational with respect to social, environmental and financial aspects to prefer the developed technology over the existing one. A primary reason for the success of wind power sector in Denmark was the close collaboration between all of the involved stakeholders where government provided enough subsidies from the very beginning, laboratories worked as a team with manufacturers of turbines and operating team provided correct feedback to remove the identified hindrances. The received feedback was then used to improve the designed wind power technology in laboratory. A transparent and honest communication right from the start certainly removed all the frictions which then lead to the sustainable growth of wind power sector in Denmark. Unfortunately, the same factors that triggered growth in the sector of wind power in Denmark were ignored by Netherlands. Consequently today, wind power plays a limited role when it comes to total energy mix in Netherlands.

With reference to innovation theory and its application to enhance the installed capacity of wind power in Sweden, it is important for the wind turbine manufacturers to develop effective communication channels with authorities in municipalities, laboratories to improve the existing technology, receiving sustainable feedback from the operational base and to certainly invest in municipal social programs in the areas selected for the installation of wind turbines. This will facilitate the turbine owners in the transfer of knowledge that would then help them in overcoming the existing obstacles in the promotion of wind power in Sweden. A commonly known obstacle is a fear among masses in residential areas that choose to see an installed wind turbine in close proximity as a potential threat and a source of noise pollution. This phenomenon is commonly referred to as "not in my backyard (NIMBY)". It is important to mention here that several countries across Europe with certainly higher installed wind power capacity than Sweden have resolved NIMBY issue with various innovative solutions producing sustainable benefits for people, local economy and environment.

As spoken earlier, policy makers in countries like Germany and Denmark have resolved NIMBY problem by giving people the opportunity to participate in the process of power generation from wind turbines. An introduction of 10H rule in Bavaria, Germany is certainly a right step in the right direction to mitigate NIMBY issue and to increase the installed wind power capacity. Similarly, as already discussed, research has revealed that people would be least bothered by the installation of a wind turbine, if they would have a financial stake in the installed wind turbine. Denmark has mitigated NIMBY issue by upgrading its already installed wind turbines. As a result, Denmark today has 20% less installed wind turbines than it had in 2001 however, it's wind power generational ability has soared two-fold during the same time span (State of green 2018). Other researches have shown in UK and Spain that opinion of masses gradually improves once a wind farm goes online.

In the case of Sweden, a close relationship between the authorities of municipalities and wind turbine manufacturers would facilitate the transfer of knowledge that can certainly introduce a sustainable change and reduce ambiguities as the former currently has the right to reject the installation of a wind turbine in its proximity. As a consequence, municipalities across Sweden have rejected the installation of 354 wind turbines during last three years (Springborg 2017). In addition to developing better communications with the authorities of municipalities, the turbine manufacturers can also work closely with residents as well. An important and effective way to accomplish this task is to opt for *learning by interacting strategy*. In this case, the turbine owners would interact frequently with users of electricity (i.e. masses). It will allow them to know their reservations concerning wind turbines and thus to effectively resolve them on priority basis with the help of innovation system and learning. This public preference along with investment in municipal social programs will act as a bottom-to-top approach to develop soft corner at municipal level when it comes to the installation of wind turbines in municipalities. Wind turbine manufacturers are already implementing the aforementioned strategies in Spain and UK, where the turbine developers prioritize locals for employment and also invest money in local social benefit programs. This increases the benefits of installed wind turbines two-fold, first it is an environment friendly source to generate electricity and up to 95% of the components of a turbine can be recycled at the end of life span. Secondly, the installed turbines then lead to an improved quality of life due to an increase in financial investment in social programs and employment creation for locals. As a result, overall installed wind power capacity increases and the designed project then satisfies social, economic and environmental aspects of sustainable development.

Summing it all, a wind farm proposal with an aim to invest returns in municipal social programs, ensuring employment for local masses, an implementation of 10H rule and an effective communication between all stakeholders might be observed more positively and appreciated by both authorities and residents. Finally, the identified points are both realistic and achievable in terms of implementation provided proper time, energy, technical expertise and financial resources are directed towards achieving this goal.

5.1.1 Indicators concerning Sustainable Development:

The indicators considered by the European Union when it comes to sustainable development, climate change and energy are *greenhouse gas emissions, primary energy consumption, global surface average temperature, GHG intensity of energy consumption, energy dependence, consumption of renewables, electricity generation from renewables and share of renewable energy in transport* respectively (European Commission 2017)**.** These indicators can further guide the energy policy makers in Sweden to focus on factors which could promote Sustainable Development in the country. It is important to mention here that there exist an inverse relationship between the renewable energy promotion and climate change. Climate change is a result of an increase in GHGs concentration in our atmosphere, majority of which has been emitted due to the generation of electricity from fossil fuel resources. Thus, when renewable resources are used on a large scale for the sake of power generation, the emission of GHGs is minimized significantly. This reduction makes renewable resources eco-friendly and more suitable for the sustainable management of power sector in both present and future.

Another important factor is to produce energy efficient electrical appliances to reduce electricity consumption. As the consumption would be minimized, the requirement to produce electricity would naturally decrease too. It would also be environment friendly and financially efficient from a policy maker's point of view. First, the production of energy efficient electrical appliances would lead to research and development in electrical appliances sector which would stimulate economic growth in that particular field. Secondly, when the energy efficient electrical appliances would be purchased and used by consumers, it would lead to a decrease in an overall energy consumption which is good for the environment. As mentioned earlier, there exist an inverse relationship between energy efficiency and power generation.

Acknowledgement:

I am extremely thankful to my supervisor Monica Hammer for her constant support, guidance and prompt replies to my queries. I feel blessed to have her as my supervisor as she provided me the room to work in my own way. Without her backing, this research work would not have been possible for me and I am sure one cannot desire for a better or amicable supervisor.

I am also thankful to Patrik Dinnetz for his positive feedback, patience and guidance during the research work.

I am highly indebted to Sweden; it's government, Tornado AB and Swedes for giving me the opportunity to study in Södertörns Högskola.

Finally, I would like to dedicate this thesis to my family for the support, affection and love I have received throughout my life.

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