Czech University of Life Science Prague

Faculty of Economics and Management

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Diploma Thesis

Optimization of energy production using renewable in Sweden

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DIPLOMA THESIS ASSIGNMENT

Bc. Giri Prasad Kandel

Economics and Management

Thesis title

Optimization of energy production using renewable in Sweden

Objectives of thesis

The aim of the study is:
*To analyze the potential energy economics in Sweden by renewable sources
*Specifically, to create an optimal energy mix for Sweden
*To know performance and future prospects of renewable energy sources and their position on the Swedish economy
*To review the main factors and to find the ideal energy mix for Sweden.
*To analyze the future situation of renewable energy source and impact on the economy specifically focus on Electricity.

Methodology

*Comparison method: with Norway and Germany

*Statistical data analysis(Regression, time series analysis) using SAS/Excel

*Econometric analysis: Time series(1990-present) analysis and prognosis

*Linear programming method

The proposed extent of the thesis

60 pages

Keywords

Energy consumption, Optimization methods, Renewable energy resources, Wind energy generation, Solar power generation,

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Optimization of energy production using renewable in Sweden

Declaration

I declare that I have worked on my diploma thesis titled "Optimization of energy production using renewables in Sweden" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the diploma thesis, I declare that the thesis does not disrupt copyrights of any third person.

In Prague on 29th March 2019 ………………………….

Giri Prasad Kandel

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Optimalizace výroby energie za využití obnovitelných zdrojů ve Švédsku

Optimization of energy production using renewables in Sweden

Abstrakt

Tato práce se zabývá optimalizací výroby energie s využitím obnovitelných zdrojů ve Švédsku. Zaměřuje se na období od roku 1995 do roku 2015 a toto rozmezí bylo zvoleno proto, že během něj došlo v oblasti obnovitelných zdrojů k velmi výraznému rozvoji. Hlavním cílem tohoto výzkumu je prokázat, že emise CO2 a HDP jsou ve významně protikladném vztahu. Energie je klíčová pro ekonomický rozvoj, ale růst moderní světové populace, který vyžaduje více energie získané z předvídatelných vyčerpatelných zdrojů, zvyšování ceny energií a obavy o životní prostředí, představuje riziko pro udržitelný ekonomický růst. Naproti tomu přechod na obnovitelnou energii získávanou z přirozeně doplňovaných zdrojů podporuje energetickou bezpečnost a také reaguje na problémy jako jsou globální oteplování a změna klimatu. Tato práce si klade za cíl odhalit vliv a základní vztahy v oblasti obnovitelné energie. Také popisuje emise CO2 a růst HDP s pomocí různých obnovitelných zdrojů energie. S využitím simplexového algoritmu zjišťuje problém minimalizace nákladů, což přispívá k nalezení optimálního řešení. Výsledky mluví ve prospěch pozitivního vlivu obnovitelné energie obecně, stejně jako jednotlivých druhů, zejména vodní, jaderné, větrné a solární energie a dalších, na hrubý domácí produkt na obyvatele ve Švédsku. Nicméně vodní energie vykazuje nejvyšší vliv na ekonomický růst ve srovnání s ostatními typy obnovitelné energie ve Švédsku. V neposlední řadě diplomová práce optimalizuje současný mix obnovitelných zdrojů energie pomocí lineárního programování a doporučuje optimální poměr pečlivě vybraných zdrojů energie jak z ekonomického, tak environmentálního hlediska.

Klíčová slova: Švédsko, obnovitelné zdroje energie, výroba energie ve Švédsku, optimalizace, vodní energie, jaderná energie, výroba větrné energie, výroba solární energie, lineární programování, simplexový algoritmus, Kayova rovnice, emise CO2, růst HDP

Optimization of energy production using renewable in Sweden

Abstract

This paper deals with the Optimization of energy production using renewables in Sweden. It examines from 1995 to 2015, and this period has been chosen because on this period the development of renewable energy sources is very significant. The core objective of the research is to prove that, CO2e emissions and GDP has significant opposite relationship. Energy is vital to economic progress, but the modern universal population increase that demands more energy produced from predictable exhaustible resources, an energy price expansion, and environmental fears, risks sustainable economic growth. However, switching to renewable energy twisted from naturally restocked resources encourages energy security, similarly addressing matters such as global warming and climate change. This paper aims at discovering the influence and fundamental relation among renewable energy. Also, this paper tells about CO2e emissions and GDP growths with the help of different renewable energy resources. The simplex method has been used to find out the cost minimization problem which tells us to figure out the optimal solution. The results provide support for a positive influence of renewable energy overall, as well as by type, specifically hydropower, Nuclear energy, wind power, solar energy, and others on gross domestic product per capita in Sweden. Even so, Hydroelectricity shows the highest influence on economic growth among the rest of renewable energy types in Sweden. Last but not in the least, the diploma thesis optimizes the current renewable energy mix by using linear programming and recommends the optimal ratio of the carefully chosen energy sources both from an economic perspective and an environmental perspective.

Keywords: Sweden, Renewable energy resources, Energy Production Sweden, Optimization, Hydroelectricity, Nuclear energy, Wind energy generation, Solar power generation, Linear programming , Simplex method, Kaya Identity, CO2 emissions, GDP growth

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List of abbreviation

SWEA -Swedish Wind Energy Association

SWPTC-Swedish Wind Power Technology Centre

RES-Renewable Sources

GHG-Green House Gas

IRENA-International Renewable Energy Agency

WEC-World Energy Council

NREL-National Renewable Energy Laboratory

IEA-International Energy Agency

USAID-United States Agency for International Development

LNG-Liquefied Natural Gas

LPG- Liquefied Petroleum Gas

WNA-World Nuclear Association

IHA-International Hydropower Association

SEA -Swedish Energy Association

EROI-Energy Return on Investment

CCS- Carbon Capture and Storage

TW: Terawatt

TWh: Terawatt hours

GW: Gigawatt

GWh: Gigawatt hours

1. Introduction:

Energy is the central to supportable development in the 21st century. In this new Era Energy is the most valuable things. For different purpose you must need the energy. It can be in different forms. It has vital impact as an environmental, social, and economic which its influence on climate, reduction of the poverty, industrial production and agricultural throughout and efficiency and environmental and health of human beings. To Develop policies of a sustainable energy conversion is one of the most significant tasks of the twenty-first century. The choices of this generation that will make in the coming years about energy will determine the how and what world future generations will get. Energy is the sustainable production and presence using way of it will determine the future of energy and capability of it to grow or run out or be a sustain. If the slow growth of energy demand while the efficiency of energy is growing up means that share of the renewable energies is necessary. While improving the developing countries in the Energy production and consumption there must be the challenge about important of energy. To handle all those situations, it will require an active proposal of all sectors including energy production, transportation, building, industry and agriculture as well as the scientific association, the Government, local community and different consumers (Rubner, 1982).

Renewable energies are strappingly well-thought-out as very potential and ecologically superior to fossil fuel energy in terms of tumbling CO2 vindication and effective application of energy resources. Since the rapid increasing in the world population the demand on the limited fossil fuels, renewable energy becomes more relevant as part of future solution to the energy. Huge increases in the manufacturing company as depending on the fossils and crude oil makes the world to think about new implementation on the energy. Many researchers and ecologist found that the renewable energy sources could afford as much as half of the world energy demand by the year of 2050. Renewable energy is now comprised in coast-to-coast policies, with goals for it to be a considerable proportion of stimulated energy within the imminent decades. Many policies have been discovered with associated to renewable energy as a national target to accomplish in the several economics are implemented to meet international treaties such as UN framework convention on the climate variation (Prof.Havrland Bohumil, 2011). A wide-ranging overview, an introduction to Renewable Energy discovers how we can utilize the sun, wind, biomass, geothermal properties, and water to create and generate more supportable energy. As a multidisciplinary tactic, the study participates environmental, economic, social, biological, apart from political policies and engineering problems related to renewable energy. The value on the renewable resources is not neglected. It describes the essentials of energy, counting the allocation of energy, as well as the boundaries of natural resources. Preliminary with solar power, the dissertation exemplifies how energy from the sun is shifted and deposited; used for heating, cooling, and lighting; composed and intense; and transformed into energy (Nelson, 2011).

The paper will precisely focus on the Renewable energy resources as a wind power as a front and followed by Bioenergy includes Biofuel and geothermal heat pump or ground sources heat pumps (GSHP), hydro, ocean energy tidal energy. Describing packing as a billion-dollar clue, the paperback debates the problems of storing energy and bounces an overview of innovative technologies from flywheels to batteries. Similarly, it observes institutional matters such as environmental protocols, encouragements, set-up, and societal outlays and welfares. More specifically the paper will discuss others various sources of energy with the further references of reading, formulas, methods, case studies, and all-embracing use of statistical figures and diagrams.

1.1 Background of study:

The Swedish government of energy policies have also encouraged the use of renewable energy. Green electricity certification is one of the best examples. To be suitable and eligible, electricity must come from variety of sources such as wind, solar, geothermal or wave power; biofuels or small-scale hydroelectric plants. Main electricity vendors are required to buy some amount of green electricity as part of their ordinary supply, despite the fact power producers collect authorization and certificate for the renewable electricity they produce. In the meantime, from 1996 Swedes have been able to choose their own power supplier and about companies selling their energy to the Swedish government or Swedish energy providers. Sweden has a low emission rate which is about 80 percent of total electricity production in Sweden comes from mainly nuclear and hydroelectric power (Sweden Sverige, 2018). But according to the latest news, Sweden decide to decrease the amount of nuclear energy and spend on wind energy because nuclear energy is quite expensive than other renewable energy. Sweden currently has three nuclear plants with eight nuclear reactors in commercial activities and in the market operation, nonetheless, nuclear power ruins a topic that makes the division in political parties in Sweden. About 11 percent of the electricity comes from wind power (Sweden Sverige, 2018).

1.2 Aim of the study:

a. To analyse the potential energy economics in Sweden by renewable sources.
b. To know performance and prospects of renewable energy sources and their position on Swedish economy.
c. To review the main factors and to find the ideal energy mix for the Sweden.
d. To analyse future situation of renewable energy sources and impact on the economy.
e. To figure out the ideal renewable energy mix.

1.3 Motivation of study:

I was always thinking about the future demand of energy sources. Technology has been developed and growing up but at the same time demand of energy is increasing and increasing. While I was studying environmental science and even in general life it has been seen the impact of non-renewable energy sources in the human life. The impact of crude oil to the environment by producing large amount of carbon dioxide and related harmful gases which decreasing the atmospheric layer thinner and thinner. Nevertheless, Carbon dioxide has no direct upshot on ozone, unlike CFCs and HFCs. Higher levels of carbon dioxide, though, do have an indirect consequence on the ozone layer in the stratosphere. But then again near the poles and in the superior stratosphere, CO_2 is increasing the amount of ozone by avoiding nitrogen oxide from contravention it down. If it keeps going continuously the life of human and age of earth will no longer exist because it will damage atmospheric layer and many diseases will appear which will damage the humankind life. So, if we want to save the earth and our life, we have got to do something by taking seriously. And one more thing to be notice is the crude oil is decreasing and there will be shortage of energy. To fulfil and survive we must think differently, and which is renewable energy sources. It avoids the environmental effect and will be cheaper to use and main feature is its recyclable. For the renewable energy most of the developed and developing countries having huge investment and research. While I was researching about some good example of it and I found Sweden has doing well on it. Sweden has a rich stock and supply of moving water and biomass, which pays to the country's high share of renewable energy. Hydropower and bioenergy are the topmost renewable sources in Sweden. Hydropower generally for electricity production and bioenergy for heating system. And they have quite well production from solar power system and wind energy. This all makes me to do more research in this country and contribute at least some research. This is the motivation for myself which will be implemented in my home country Nepal.

2 Objectives and Methodology:

2.1 Objectives of the thesis:

Main objective of my research is to learn the different form of alternative energy sources accessible for future and to figure out the potential energy sources in the Sweden. And, I am focusing to understand important factors for contribution in influential if alternative energy should be used on beside. Sweden is one of the good examples to follow for the future sustainable development in energy sector, so I am more interested to understand vital role for the country economy by renewable energy sources. Furthermore, to analyse and predict future affect in the environment by non-renewable sources and role played by renewable energy sources. Sweden has high strategic plan and the target is 100 percent renewable electricity production by 2040 so one of main objectives is to understand how it will work effectively and it can be a good motivation for other developing countries to follow -up. Last but not least is to understand the main circumstances of CO2e emissions using kaya identity. In the last three-four decades the amount of CO2e is increasing all over the world which affect daily human life and environment, so my research will help to understand the how bad effect of non-renewable energy in the daily life of human beings and to the environment.

2.2 Methodology:

I have been used several ways to clarify and understand my research. Some of the major are as follows:

2.2.1 Comparison method: with Norway and Germany

This method will help to understand how neighbours are growing up and what is the future role of Sweden to compete in the market by renewable energy sources. I have been compared with the production of renewable energy, consumption of renewable energy, kaya identity which told us about CO2 emissions in the certain criteria. Also, in comparison method, there has been compared the latest development and energy policy and strategic plan in each country. In comparative analysis data will be analyse among Norway with Sweden and Germany with Sweden. Production of renewable energy will be comparing in between these two countries. Mainly comparison will be done in the production, consumption and installed capacity of each country in last two decades. Data will be taken from 1995-2015, since this is the most appropriate period to analysis for future prediction as well.

2.2.2 Statistical data analysis:

If we are satisfied of estimation of our hypothesis, it as well necessary to evaluate the model efficiency and quality. We always interested in an economic variable, what really affects to the acknowledgements that's why we can get good result. Statistical analysis will be done via application excel, where CO_2 emissions will be dependent variable and four different independent variables. Independent variables are GDP, however is also connected with different factors, population of the country, Energy intensity and carbon intensity. In statistical analysis data will be taken from 1995-2015 so analysis could be very effective, and it could talk about past procedure and it makes easier to estimate the future prediction. In statistical analysis, the production mix of renewable energy and cost efficiency will be calculated which will help to figure out which sources more productive and less costs efficient.

2.2.3 Kaya identity (Greenhouse gas emissions)

Last method will be kaya identity. The Kaya identity tells the greenhouse gas (GHG) emissions to energy use, economic progress and population growth. Consequently, it can be functional to crumble GHG emissions with respect to the latter relations. In kaya identity will focus on the three different state which are obviously Sweden and Sweden will be compared with complex progressive Nordic countries Norway and West European country Germany. I have been chosen those countries because both of them are huge country and the strategic plan of those countries are similar to Sweden and Germany has huge impact on EU and is the leading country in the EU. While, Norway has huge resources of renewable energy sources for example hydro, solar and wind energy. So, the kaya identity will discover and figure out the relation of country economy and CO_2 emissions.

2.2.4 Linear programming

Linear programming is a mathematical modelling technique in which a linear function is maximized or minimized when subjected to various constructions. This technique has been very suitable for supervisory quantitative choices in business preparation and development, in industrial engineering, and—to a lesser extent—in the social and physical sciences.

The solution and explanation of a linear programming problem diminishes to discovery the optimum value it can be the largest or smallest, depending on the problem of the linear appearance or expression also known as the objective function

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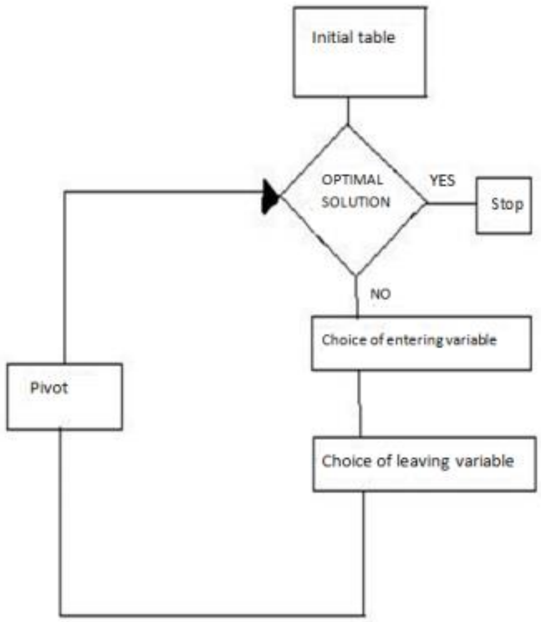
$$f = c_1 x_1 + \dots + c_n x_n$$

subject to a set of limitations stated as inequalities:



2.3 Hypothesis:

H1: More energy consumption per capita supports economic growth of Sweden

H2: Renewable sources of energy such as Hydro power, nuclear power plant is less harmful to the life of human being compared to a non-renewable source of energy such as coal (in point of view from CO2 emission)

H3: Increase in share of renewable energy impact on greenhouse gas emissions and climate change.

3 Literature review

3.1 Exigency of Renewable energy:

3.1.1 Global Warming and Globalization:

This globalized world in which we attain the affluence and growth. In this spectacular growth, however, the global warming or climate change problem unseen behind has extremely exposed the survival of the human environment. Many debates have been going on the environment change due to Globalization. It has positive rumors but on same time it affecting to the other part which has been hidden or peoples are not caring about that part. Since last decade this some non-profitable organization are focusing and disusing about the linkage between environment and liberalization and globalization. We must rely on the forces of globalization and the global cooperative dynamisms of people to challenge such a disaster and to fortification the welfares of our following generations.

Along with economic globalization, manufacturing and industrial production and free trade between countries in the world have settled to a very progressive stage; however, the impairment to the environment, as well as the massive impact of climate change, makes us to retake the excessive crisis of human existence waiting behind of the globalization into justification. The developing countries like China and India in the Asia and Brazil in South America has enormous impact on global economy and in the environment as well. They are producing many goods using natural resources, and which makes the global warming, deforestation and other natural disaster. Those countries are only one of the examples but even Developed countries are doing the same way to dismiss the environment. Currently, the atmosphere is gradually roasting with the build-up of the greenhouse gases (GHG), all kinds of environment change wonder such as floods increasing temperatures and expanding sea-levels convey impacts to the entire world. According to my experience in Czech Republic (2018 summer) the weather is strange because of three climate change. In the mid of June and July weather should hot and temperature should be above 20 degrees Celsius but sometimes in the evening its gradually decreasing to less than 10 degrees Celsius which is unbelieve and inhabitants feels already frigid winter. Climate change is not only closely connected with people's daily practices, but also affect the production of people's food, predominantly the most common crops, rice and wheat food. If the harsh weather causes crop failures, the world's increasing populace will very possibly suffer from scarcity.

The worldwide scale, interconnectedness, and economic concentration of current human movement are historically unparalleled, as are numerous of the subsequent environmental and societal deviations. These universal changes basically stimulus patterns of anthropological health, intercontinental health care, and civic health activities. They found a syndrome, not a set of isolated changes, that replicates the interconnected compressions, stresses, and rigidities arising from an excessively large world population, the universal and progressively systemic ecological influence of many economic activities, suburbanization, the banquet of consumerism, and the broadening gap of income inequality between rich and poor both within and between countries.

Since last couple of decades, international connectivity has enlarged on several frontages, counting the movement or flow of information, movements of folks, trading and an exchanging pattern, the flow of investment and capital, monitoring and controlling systems, and cultural and ethnic distribution. These exponential increases in demographic, economic, commercial, and environmental catalogues have been considered an Excessive Quickening. Strangely, the resulting environmental effects are now shifting foremost tackles of the Earth system (Anthony J. McMichael, 2013).

3.1.2 Societal fluctuations and economic activity:

In distinct aspects of globalization impact population health including the augmented appearance of new infectious diseases, viruses and harmful bugs. Adversative world-wide influences on healthiness, such as rising the price of food and lengthy assortments of some communicable diseases. Future global health goals must be better combined with the essential stimuli of scarcity, unfairness, illiteracy, variation and climate change, the way of land-use patterns, and food anxiety on health. Nevertheless, apprehension for human health is not yet near that centre but must start to think deeply on this stage (Anthony J. McMichael, 2013). This echoes the ongoing misunderstanding of what health means and the domination of a slender, clinically based opinion that apparently does not consider the central need, in improving population strength, to report the reduced fit between conservational, ecological and sociocultural circumstances and elementary humanoid biologic and psychosomatic requirements.

3.1.3 Environmental and ecologic changes:

Climate modification encouraged by human actions, for instance, is owed to the worldwide accumulated additional of greenhouse emissions. Main deterrence of healthiness difficulties rising from such worldwide ecological and sociodemographic deviations hence needs a synchronized universal strategy. Some of these examples can explain an environmental and ecologic change in the earth that will gradually influence the world's health sector (Anthony J. McMichael, 2013). Foremost, the influenceable virus will increase in the world especially in South and East Asia because of the huge population and the careless of ecological and health sector. It might affect the African country as well in the same level or higher. The danger rises with population growth. Another could be the problems with the sea food because of overfishing, nutrition pollution, warming and acidification which directly affects the human health and aquatic ecosystem (R.M. Harrison, 2003). Those few examples even explain the future food security human health and environmental problems created by globalization overpopulation and careless in the environment protection.

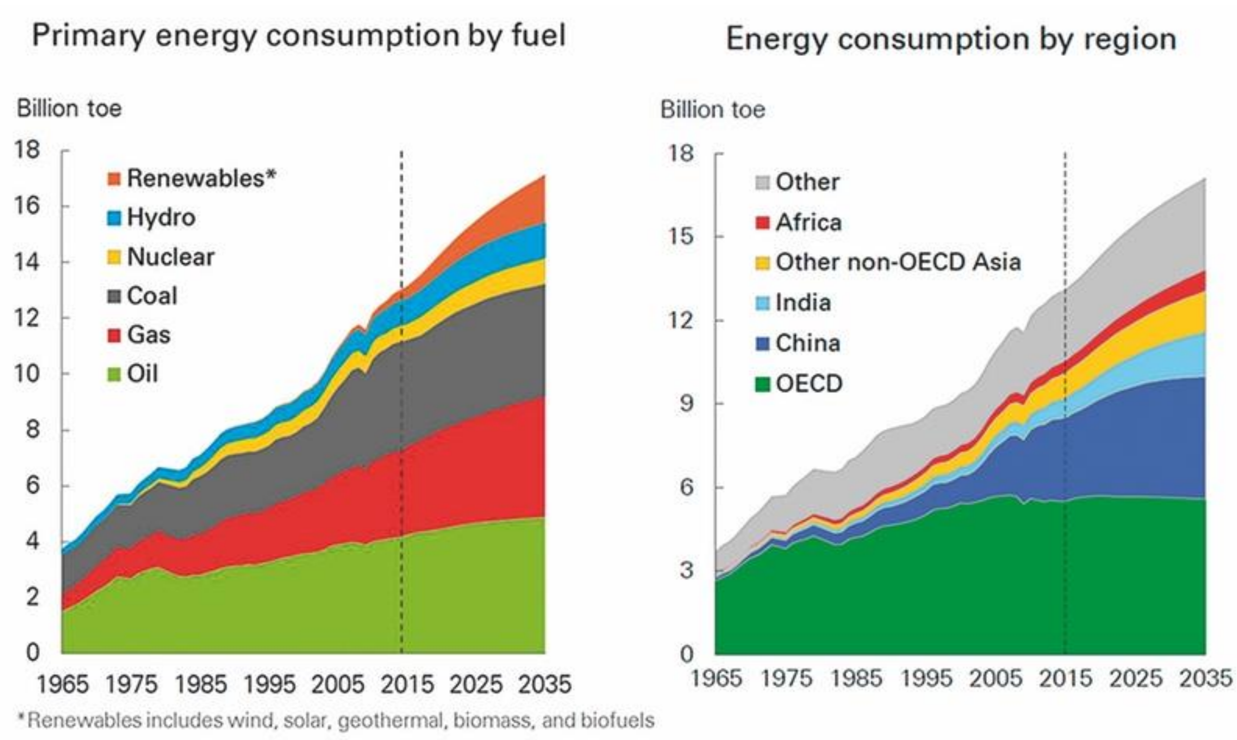
3.2 Ending of the fossil fuel Era:

The world's energy market is still dominated by fossil fuels. The sustainable and renewable energy sources are still unclear and that seems relatively expensive and the way longer than the coals and oils. Therefore, the developing countries that strongly believe and focus on the fossil fuels so that can accomplish the energy demand of their country economy. The Paris climate deal is, hypothetically, an imperative first step on the way to addressing climate change. But some of the headings have been enthusiastically exaggerated, saying the agreement symbols the "end of the fossil fuel era." That's unpleasantly premature. Oil, gas, and coal still make up about 86 percent of the world's energy stock, a fraction that has hardly shifted since 1997. Until that drops suddenly, we can't really announce the termination of the fossil fuel era:

3.2.1 World energy consumption sources by region:

Worldwide consumption of primary energy grew powerfully in 2017. As per latest data consumption of energy led by natural gas and renewables, with coal's share of the energy mix enduring to decline. Primary energy consumption progress is an average of 2.2% in 2017, up from 1.2 % last year and the fastest since 2013. By fuel, natural gas accounted for the largest increase in energy consumption, followed by renewables and then oil.

Figure 3 1 World energy consumption sources by region



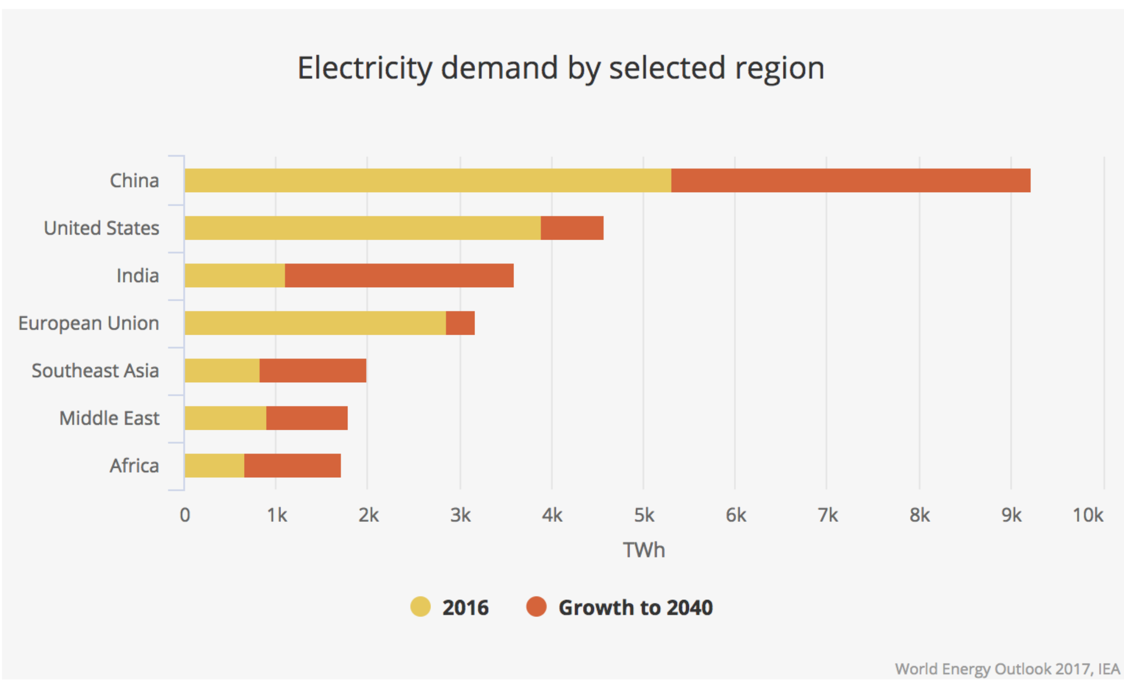
Sources: Weltenergieverbrauch – Erwartunge (30 July 2018)

In 1995, more than 20 years ago, Shell presented a scenario in the "Energy in the 21st Century - Considerations for the Development of World Energy Consumption" (Czakainski, 2018)study of how global energy supply might last. Some important basic propensities are shown qualitatively and quantitatively. For example, energy consumption is increasing, the system is becoming more varied and flexibility and power are strongly connected with wealth. Driven by quickly growing energy consumption, the Shell study recognized global economic development and, in specific, the increasing number of people on Earth. For the year 2030, a consumption of about 24 billion tons of crude oil corresponding has been estimated. As early as 1995, rising CO 2 emissions were a matter of fear. Oil, coal, and gas consumption were originally expected to increase expressively but peaked around 2020 (Md. Rabiul Islam, 2018). Crowning oil was a significant keyword at that time. Coal and gas were expected to grow powerfully until the 1940s. At the same time, the energy system should spread significantly in the upcoming. Wind and biomass were well-thought-out the great expectation. Calculated was a rapid increase in renewable energy; By 2030, they should rapidly asylum half of the energy demand.

3.2.2 World Energy demand by selected reason:

In the below chat which shows the demand of electricity in different continent or sub-continent. It also indicates that developing countries are demanding more energy than developed and least develop region. This might be because of the huge companies and factories are moving to the developing region. In the developed region only, service sector is increasing while industrial sector is growing and moving to developing region.

Figure 3 2 Energy demand by selected reason



Sources: World Economic Forum

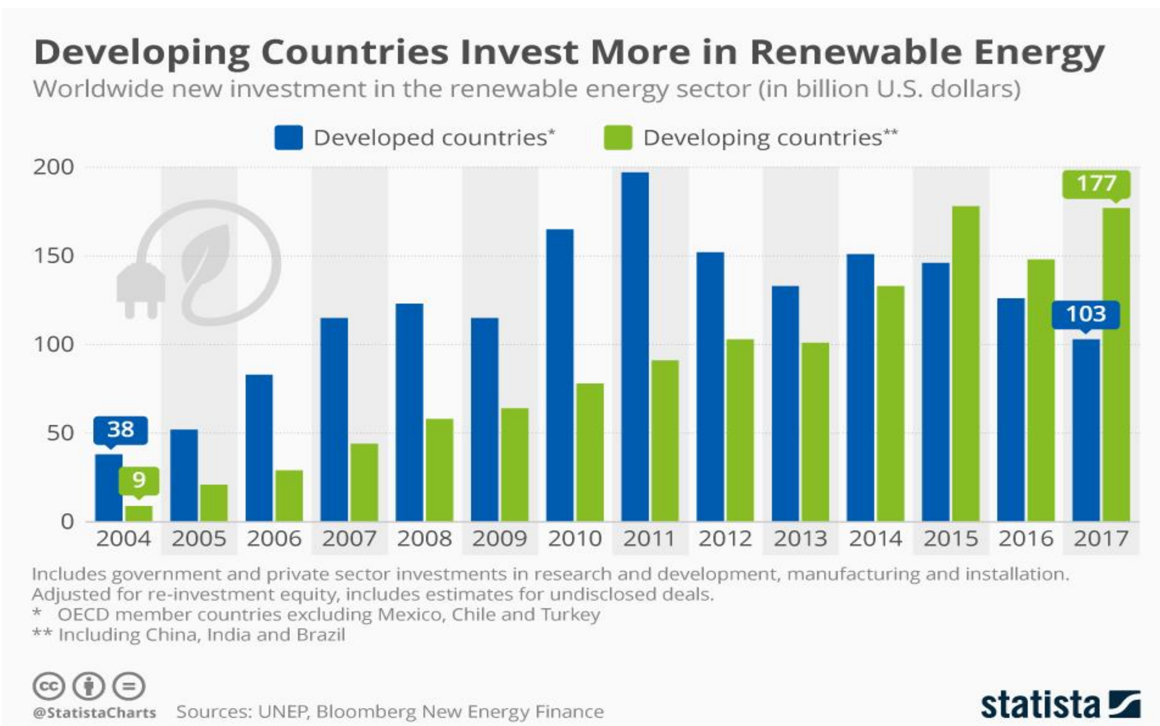
China is one of the largest countries for the demand of energy now and in future. Followed by USA and India are the 2nd and 3rd largest countries by demand side in 2016 but in future India seems 2nd largest instead of USA. However, the progress in middle eastern and African countries are recognisable as well. But the progress in EU looks bad than other region in future but the one of the biggest hopes is European Union since it has progressive deplanement in new technology. Renewable energy is a universal miracle on the upturn. For the conceivable upcoming, its progress is set to flash. But we must certify that improvement is made in the right way. Our primacies and pronouncements now will govern how future civilizations advantage.

3.3 Renewables energy as the scenarios for contemporary and future Energy source:

The difficulties of the energy in coming decades or in future mentioned earlier, focused in the developing countries, especially in the Asian countries have demonstrated experience on how to relief and motivate for a successful illustration of the renewable energy to meet their upgoing energy trend or requirement. These contributions are based on rather on small hydro-power stations or biomass or geothermal power plant or any others solar systems. The 2nd richest country in the Hydropower is Nepal which is in South Asia has more hydro power and resources to cover almost East-south Asian countries. But the way of growing on this country is non -effectible. They might change the way of production or management or the new and long-lasting technical stuffs. As a mathematically more than 90%of the country's energy generation capacity can be done by hydro. Hydropower plays a typically momentous role in Nepal's economic future since of the gauge of its possible. Nepal has many small streams that produce an enormous amount of hydro for that state or region. After the long research, Nepal has 40,000 megawatts of hydro generation by volume which is quite enough (USAID, 2018). And this amount is a lot for the country itself and they can export to the neighbour's country and generate and grow up the economy. If this potential capacity used properly, it may perhaps smoothly meet Nepal's demand and create a surplus that could be exported to neighbouring countries in South Asia. Since they have more trading partner with two giant countries like China and India, there is the only way to compete and increase the partner is from the hydro. Nevertheless, the deficiency of admission to steady, network-abounding electricity is a crucial restraint to economic growth and an interference to dropping scarcity and deficiency.

Furthermore, several developing nations such as Brazil, India, Indonesia, China, and South Africa have been committed to doing volunteered themselves for the targets to meet energy criteria through renewable energy resources. If we more focus on Brazil, it is Latin America's main and largest renewable energy market. As a comparison in the world, Brazil has the highest hydro capacity as well. According to Brazil's government expectation and assurance to renewable energy is still solid and sustained investment is projected in the wind, solar, and hydropower capacity development and progress. This country generates about 76% of its electricity from its renewable sources (export.gov, 2017). The major sources of energy for Brazil and Latin American countries is wind and hydropower and followed by the solar system which makes the expansion of energy over Brazil and Latin America for the investment framework.

Figure 3 3 Developing countries and Renewable Energy

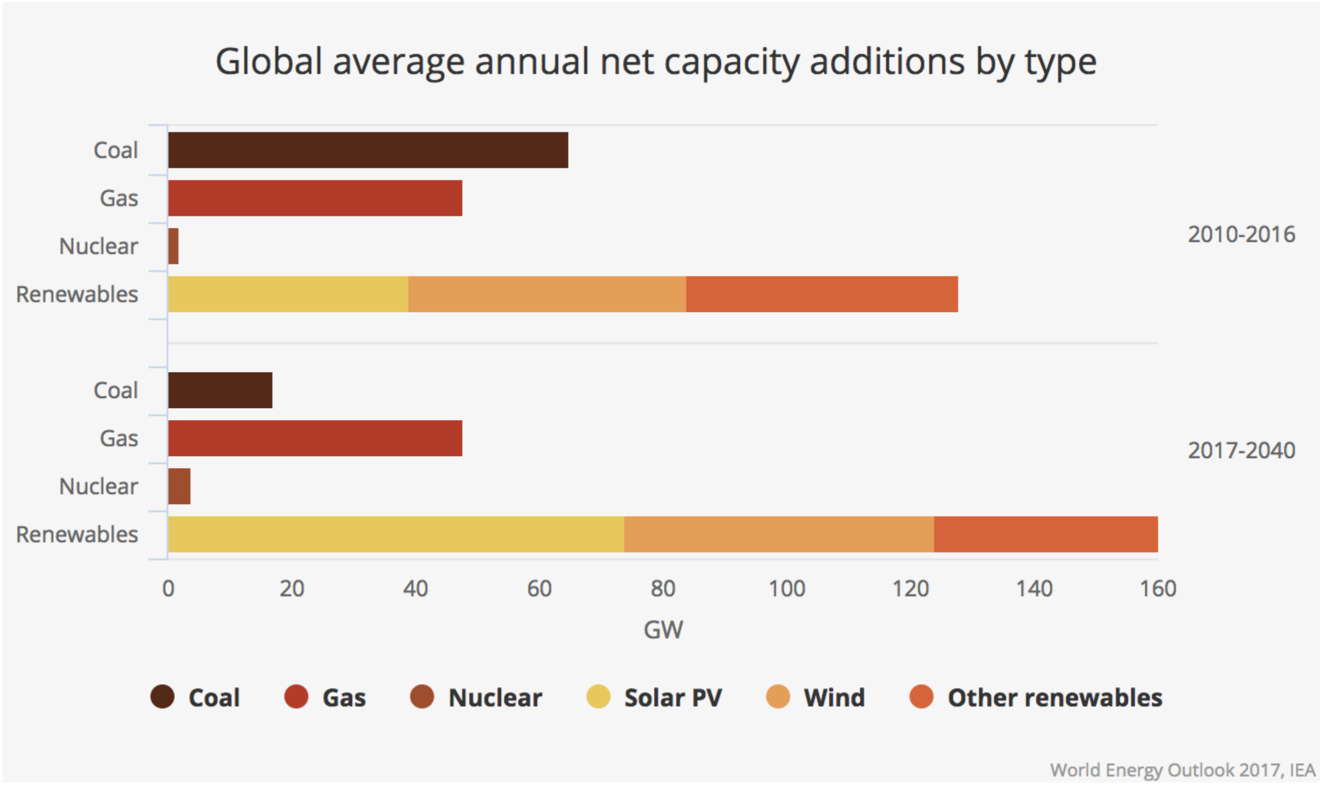


Sources: https://www.statista.com/chart/13491/worldwide-new-investment-in-the-renewable-energy-sector/

3.4 Expansions in Renewable Energy - Current Movements & Future Predictions:

During the entire recent age, mankind has used fossil fuels to fulfill its energy necessities and to do the daily business. Coal, oil and natural gas have struck homes and motorized technology for centuries, powerful development frontward. But as human progress and advance fast-tracked, the unsustainability of such energy converted superficial (Tyler, 2018). Comprehensive fuel supplies depreciated, and the atmosphere became more and more polluted and created the unexpected diseases that affect the human being and all kind of animals in daily life. The thought and differently search for renewable sources of energy initiated, to warrant a maintainable future or sustainable future of the energy (Tulsi Tanti, 2018). Currently, our progress and civilization stand at a life-threatening stage. We are on the end of espousing clean energy at a scale never seen previously. But for renewable power to continue its rapid spread and an improvement, the right pronouncements need to be taken to fulfill the coming centuries and so on for the energy sources.

Figure 3 4 Global average annual net capacity additions by type



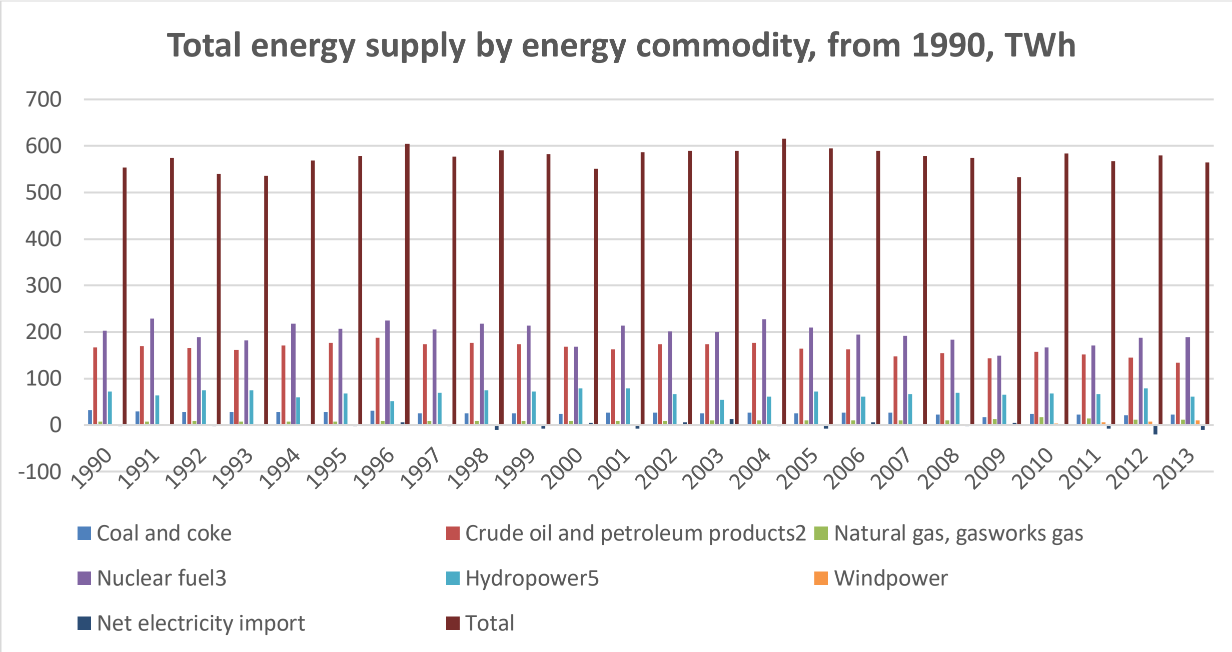
sources: World Economic Forum

Whenever the clean energy made highlighted scenario on the global prospects of energy stability and the large calculable, the questions were raised how to continue with it. In every level, an unstable policy for future energy concepts and the fulfilment of it by diverse ways. There were lack of concept and lack of funding to immediate update the concepts of renewable energy but few years later its dramatically changes and all governments, policies and scientist are focusing on it. This day the fifth largest renewable energy is producing by electricity. In 2016, there were about 160GW of clean energy provided or supplied globally. This is increased by 10% according to 2015, but the cost is still somehow seeming expensive because of lack of technology and lack of funding and so on. Solar system was applied since long time, but it was not that much effective as now it is, and solar power boosting the biggest renewable energy sources followed by wind energy and hydro power, which gives more or less about 15% (Tulsi Tanti, 2018). As my research from internet it was the first year in the history that made a solar capacity out shined any further energy creating technology. Coal and gas are still the effective sources of energy and it's not seems easy to replace by others, but the developing technology made everything changes so we should consider that in future the energy will be supplied by sustainable and renewable source rather than natural gas and coal.

3.4.1 Expansions in Renewable Energy - Current Movements & Future Predictions in Sweden:

Power system in Sweden is an integrated part of the Nordic one and there is continual energy exchange among the nations. Energy is operated in a coordinated European energy market and the corporal transmission capacity is via cables (Ahmad Vasel, 2019). This capacity is predictable to intensification. In Sweden, Nuclear power and hydropower has over 80 percent of electricity production while wind power and other energy produce under 20 percent. Hydropower is being one of the most important sources in the Sweden.

Figure 3 5 Total energy supply by energy commodity



Source: own calculation (data taken from Swedish Energy Agency and Statistics Sweden.)

As we can see here in the chart, from 1990 to 2013 total supply of energy has been being fluctuation. In 1996 total supply has been made by 605 TWh and it has been up and down till 2004 but we can see significant supply of energy in 2004 by 615TWh. If we compare total supply from last two decades, it shows it decrease in this period. But comparing only renewable energy sources its sensationally increase in last decade.

3.5 The Economics of Non-renewable energy sources:

Before focusing on the renewable energy sources, it is necessary to understand major impact and fact of non-renewable energy sources. Once we got understand why we are observing, or why we want to move forward by replacing what we are consuming, this makes more sense and understandable of renewable energy sources. So, I decided to explain in brief about non-renewable energy sources in the world and looked for statistics and impact of it in the society before entering to the main research point which is renewable energy sources and its impact to the economy of Sweden.

Non- renewable energy comes from the sources which will run out in future and we cannot generate in lifetimes or many times. Non – renewable energy resources are mainly Fossil fuels: coal, petroleum and natural gas. The main element of Non- renewable energy sources contains the carbon. For this reason, also called it Carboniferous period. All fossils fuels are formed by same way contains with carbon (Tushar K. Ghosh, 2009). Since many years ago the dead plants, animals and others were crushed under the pressure of seabed. Dregs and rocks piled on the top of them, which create huge pressure and heat under the ground. On that environment the plant and animal remain eventually turned into the fossil’s fuels like Natural gas, coal and petroleum. That makes today, there is huge subversive pouches of these non-renewable sources of energy entirely over the world. It has many advantages and disadvantages of it. Fossils fuels are the most valuable sources of energy on these days, they can be stored for long time shipped in different part of the world (Ajit Kumar Verma, 2015). However, the burning fuels are the harmful for the environment because they release enormous particles that can pollute the water, air and the land. Since all those fuels contain carbon which is the most harmful for the Biosphere and atmosphere. Carbon dioxide is a gas that retains heat in the Earth’s atmosphere, a procedure called the “greenhouse effect.” The greenhouse effect is essential to life on Earth but relies on a composed carbon economical (Morse, 2013).

The four key non-renewable energy sources are:

a) Crude oil (petroleum)
b) Natural gas
c) Coal
d) Uranium (nuclear energy)

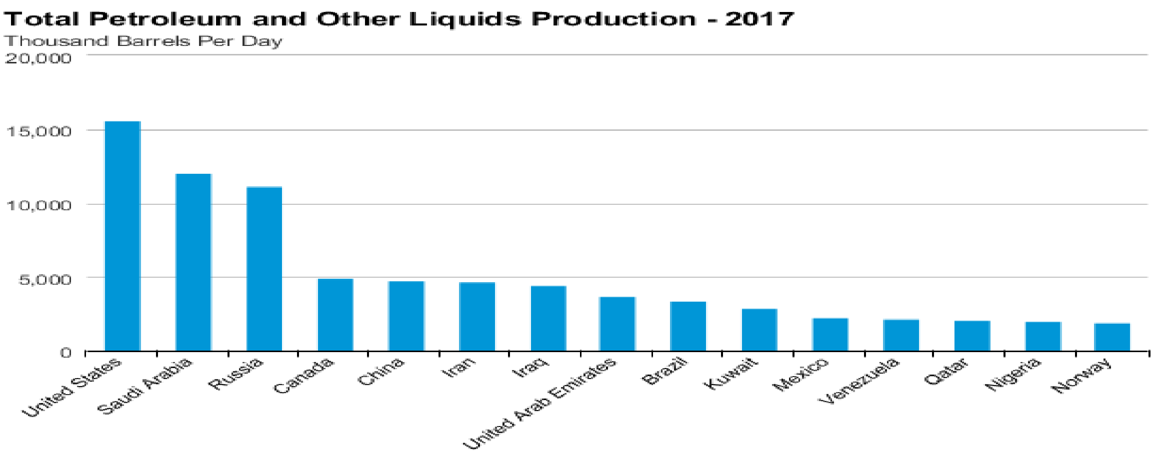
3.5.1 Crude oil (Petroleum):

Crude oil is a combination of hydrocarbons which is formed by flowers, suburbs, plants and animals that existed millions of ages since. Crude oil is a fossil fuel, which exits in the form of liquid in the underground in the tiny spaces within rocks and near to surface of the sands. Petroleum goods are fuels thru from crude oil and additional hydrocarbons exact in natural gas. Petroleum products can correspondingly be made as of coal, natural gas, and biomass. After crude oil is removed from the minced, it is sent to a factory wherever different fragments of the crude oil are detached into serviceable fuel products (U.S. Energy Information Administration, 2018). These petroleum products consist of gasoline, concentrations such as diesel fuel and boiler oil, jet fuel, petrochemical feedstocks, honeycombs, waxes, greasing oils and many others.

3.5.1.1 Production of Crude oil in the world:

As per latest data about petroleum and other liquids production which is shown in the below chart. To measure unit has been used known as thousands of barrels per day.

Figure 3 6 Petroleum and other liquids productions



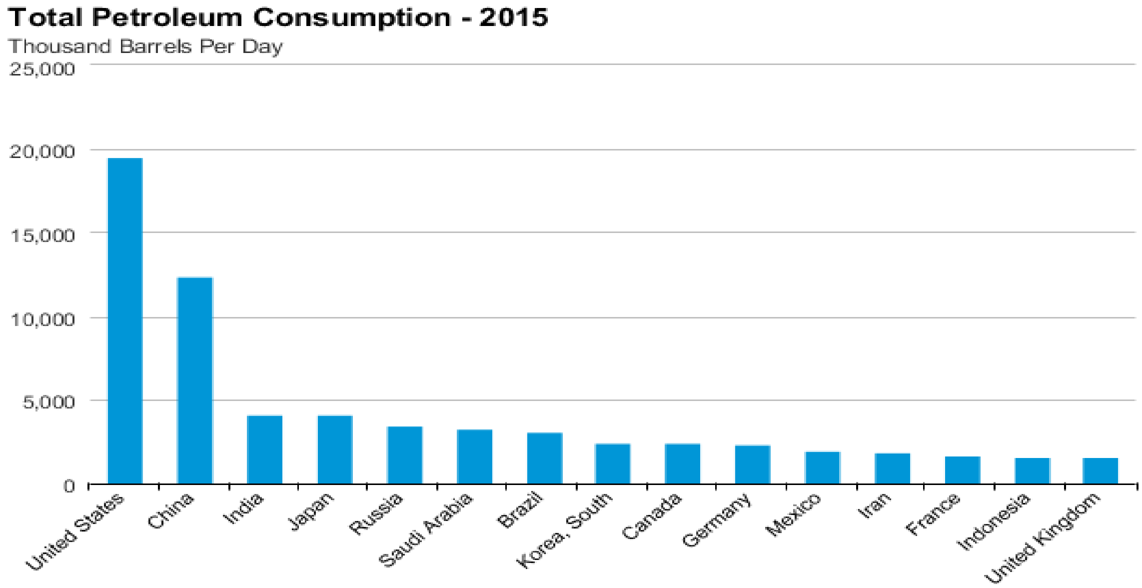
Source: Total Crude oil and Other Liquids Production 2017 (https://www.eia.gov/beta/international/index.php?view=production)

According to 2017 the United states is the highest country to produce petroleum products and followed by Saudi Arabia and Russia. USA has produced more than 15000 Barrels per day and around 12500 and 12000 Barrels followed by Saudi Arabia and Russia corresponding. We cannot see the Sweden in the above top fifteen list which could be motivation to them to increase in non-renewable energy sources.

3.5.1.2 Consumption of Crude oil in the world:

While talking about consumption of crude oil in the world seems decreasing because of increasing amount of renewable energy sources. For the consumption mostly economically, big countries are in the front. For example, United states is second highest country in case of economy, but they are still highest country to consumed of more crude oil. And rapidly increasing emerging countries like China, India are in list of 2nd and 3rd highest countries to consume more crude oil in the world.

Figure 3 7 Consumption of Crude oil in the world



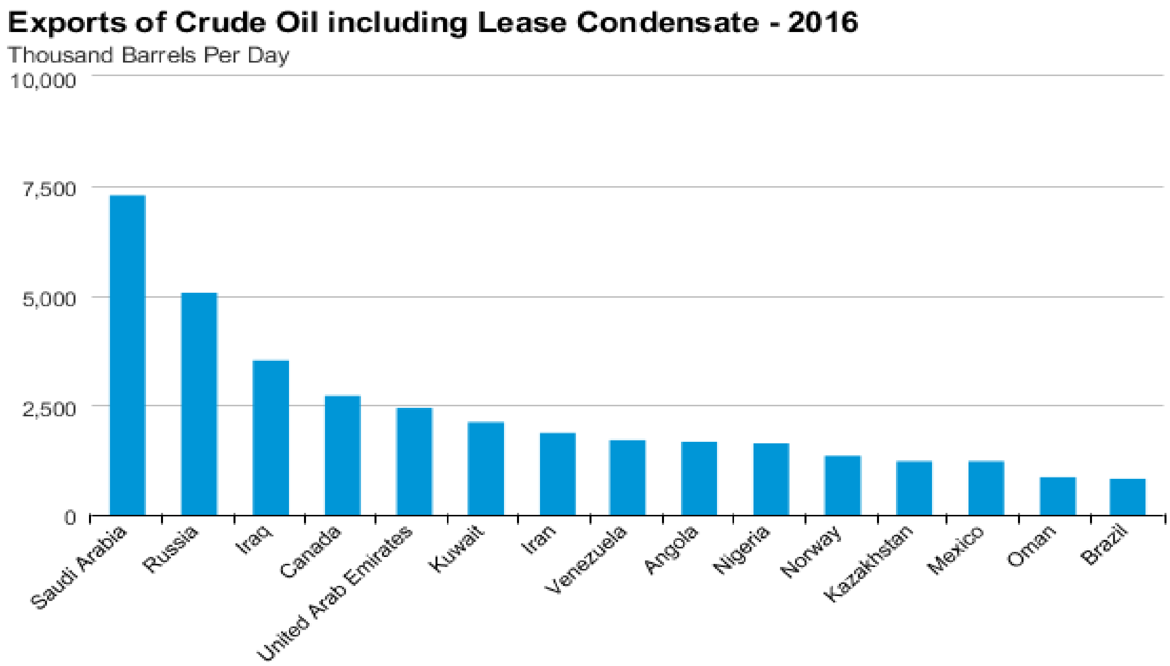
Source: Total Crude oil and Other Liquids Production – 2017 (https://www.eia.gov/beta/international/index.php?view=production)

Same as production United states is the country has highest consumption followed by China and India. United states Consumed more than produce and same a s China and India. United states consumed around 19000 Barrels per day.

3.5.1.3 Exports of Crude oil in the world:

As it is known that middle east countries are rich in oil and gas likewise, they should have highest share on the market of in terms of export to the third countries. Saudi Arabia is also known as land-based economy which means the economy of the nation is handled by natural resources given by nature in the nation which is used for the development of the nation and trade between third nations or third parties. Also, Russia is rich in the crude oil and others natural energy resources. Russia is 2nd highest exporter after Saudi Arabia in the world but in the Europe continent it might be the highest or competing with Norway. However, the demand is increasing even though renewable energy resources are implemented this is because of enormous increase in the industry which needs oil for the functioning and mainly vehicles are increasing and increasing but still needs oil to function it.

Figure 3 8 Exports of Crude oil in the world



Source: Total Crude oil and Other Liquids Production – 2017 (https://www.eia.gov/beta/international/index.php?view=production)

For the Exports and imports of Crude oil Saudi Arabia is in the top list and followed by Russia Iraq and Canada and UAE correspondingly. For most of the Middle east and Asian country Saudi Arabia exports and for the Europe Russia does and for the American countries Canada is in the Top list. But there is a lot country in the middle east which exports enormous amount of petroleum in the entire world.

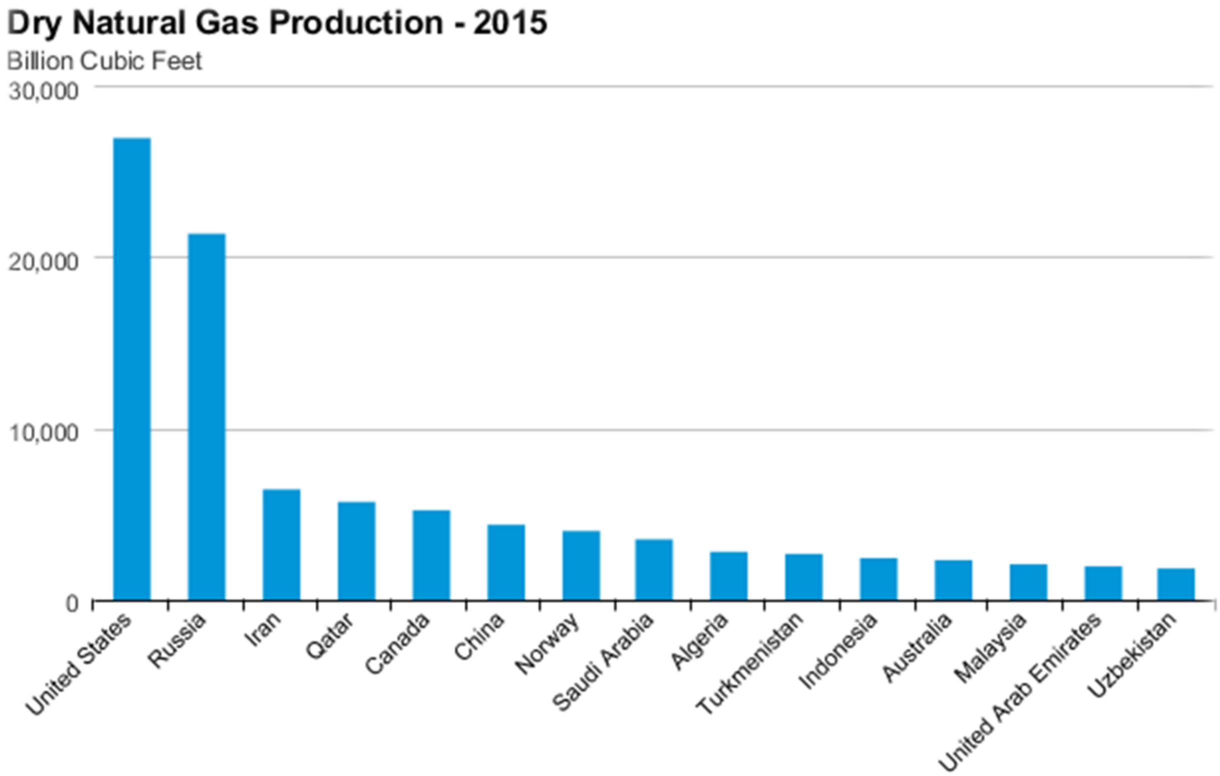
3.5.2 Natural gas:

Natural gas ensues bottomless under the earth's surface. Natural gas contains mainly of methane, a compound with one carbon atom and four hydrogen atoms. Methane also represents by CH_4 according to chemical formula. Natural gas similarly comprises minor quantities of hydrocarbon gas liquids and nonhydrocarbon gases. Mostly, we use natural gas as a fuel, burning oil and to make materials and many chemicals also included some medicines. Commonly including varying amounts of other advanced alkanes, and occasionally a small ratio of carbon dioxide, nitrogen, hydrogen sulphide, or helium and others atoms. Lots of years ago, the ruins of plants and animals (diatoms) decomposed and assembled up in dense layers, sometimes mixed with gravel, sand and sediment. Over time, these layers were suppressed under sand, silt, and rock. By huge pressure and heat changed the organic material into the petroleum products, coal and others natural gases (U.S. Energy Information Administration, 2018). Natural gas used as a source of energy since long time for machinery equipment, heating, cooking, and electricity generation. The most important in this century it is mainly used as a fuel for vehicles and as a chemical feedstock in the production of plastics and other commercially vital biological compounds.

3.5.2.1 Production of Natural gas in the world:

The international gas trade has been rising and rising from last 5 decades. Subsequently, the first LNG exports initiated, from Alaska and Algeria, and the first pipelines were constructed, from the Netherlands to bordering states in Europe. Currently, 30% of designed gas is operated crosswise national limitations, two-thirds by tube and the outstanding third as LNG. Top gas exporters are Russia, Norway, Qatar, Australia, and, progressively, the United States. Wide-reaching trade, specifically in LNG, will remain to grow in terms of both the volume and the number of exporting and importing states.

Figure 3 9 Production of Natural gas in the world



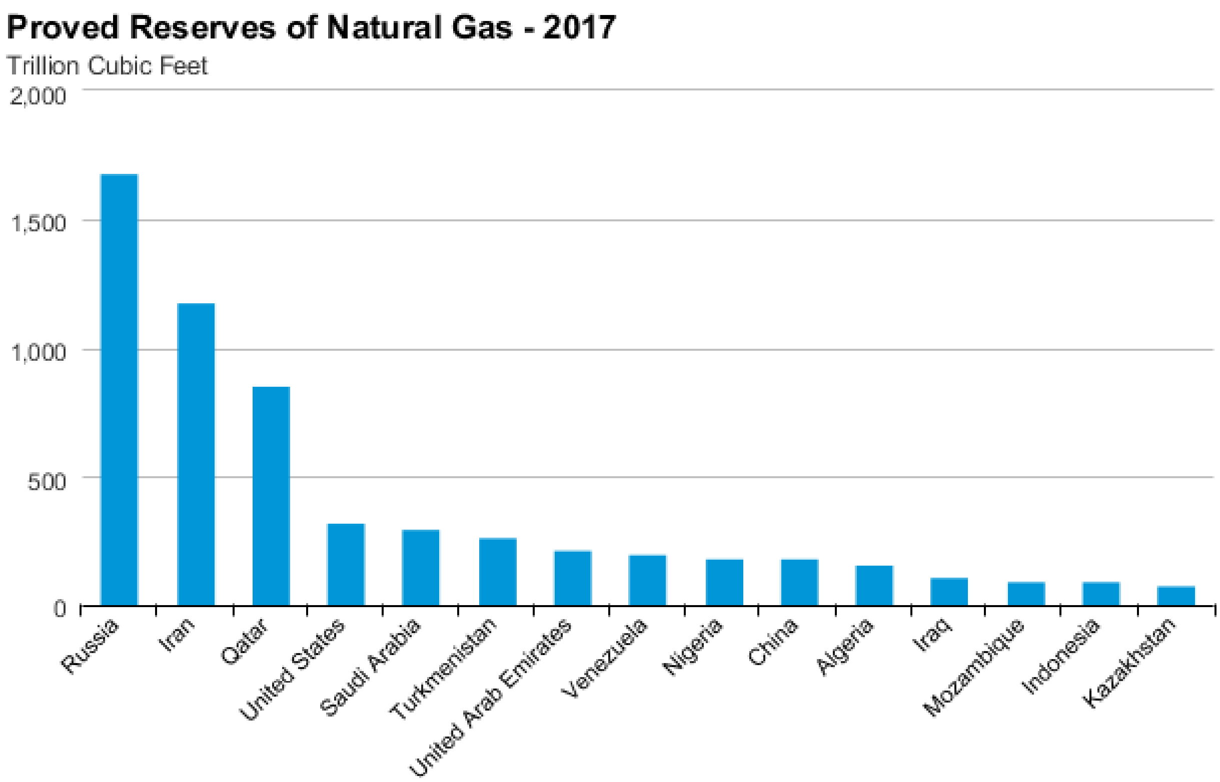
Source: Total natural gas and Other Liquids Production – 2017 (https://www.eia.gov/beta/international/)

United stated still seems on the top position to produce the natural gas in the world. Russia is the second most important countries to produce natural gas in the world and 1st in the Europe continent and in the east countries Iran, Quarter are the other countries to help the world by producing the higher amount of natural gases. Central Asian countries like Turkmenistan and Uzbekistan are on the top 15 list. According to EIA Research the United states is in the top list since 1980s and they are producing around 26000 billion cubic feet.

3.5.2.2 Reserve and capacity of Natural gas in the world:

Approximately 80% of the world's total established natural gas reserves are in ten main countries. Russia at the most the list, property around a neighbourhood of world's total gas reserves, surveyed by Iran and Qatar in the Middle East.

Figure 3 10 Reserve and capacity of Natural gas in the world



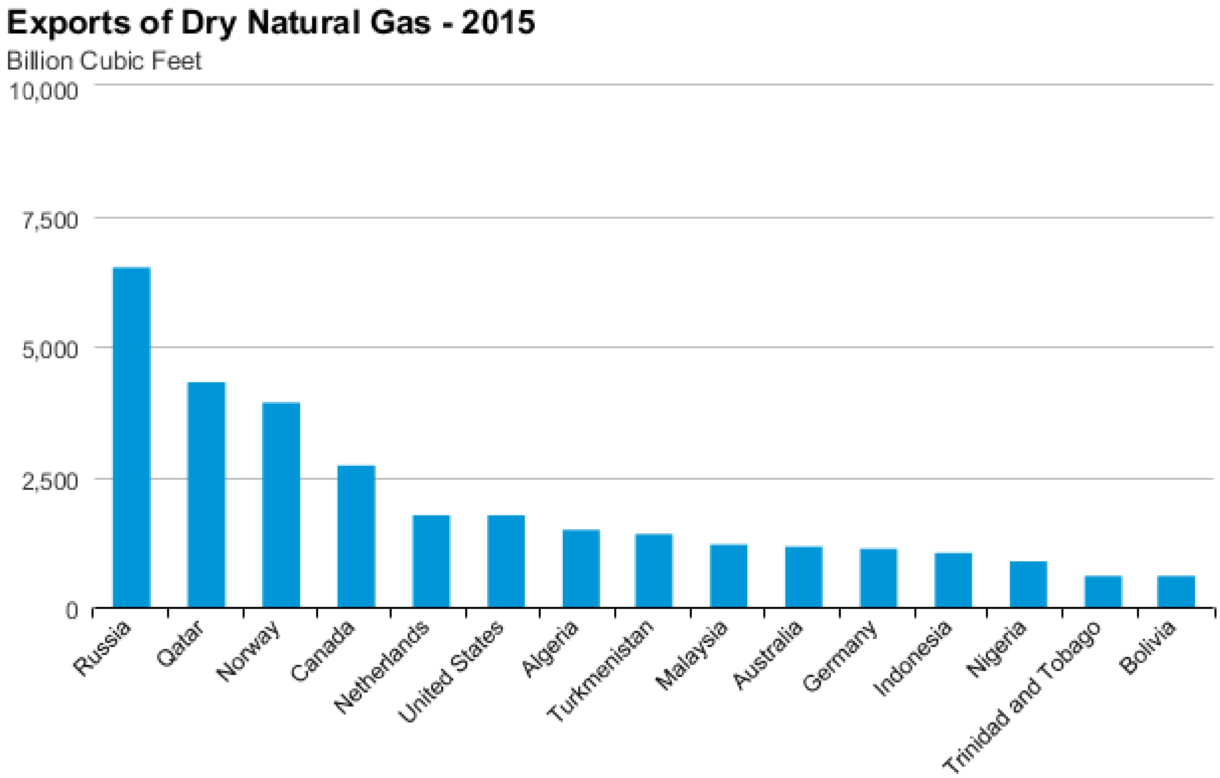
Source: Total natural gas and Other Liquids Production – 2017(https://www.eia.gov/beta/international/)

In the reserve and capacity Russia is the country which has uppermost reserve of natural gases in the world. They have approximately 1650 Trillion Cubic feet and in the second followed by Iran. Iran has capacity about 1200 Trillion Cubic feet. So, on trailed by Quarter having reserve around 900 Trillion Cubic feet and United states is in the 4th list of preserving the natural gas in the world. Nigeria is in the middle of top 15 countries having reserve so having Natural gases.

3.5.2.3 Exports of Natural gas in the world:

Natural gas is an adaptable, clean-burning, and effective fuel that is used in an extensive diversity of tenders. In the 19th and early 20th eras, natural gas was castoff mainly for highway and construction striking, providing what was acknowledged as Gaslight. Nowadays, upgraded circulation of gas has made imaginable an extensive diversity of uses in households, businesses, industries, and power plants. According to 2015, exports of natural gas in the world is leading by Russia and followed by Qatar.

Figure 3 11 Exports of Natural gas in the world



Sources: Total natural gas and Other Liquids Production – 2017
(https://www.eia.gov/beta/international/)

Rendering to 2015 Russia exports about 6000Billion Cubic feet of natural gas to the entire world and tracked by Quarter about 4000 Billion Cubic feet. Since the Nordic European countries Norway is in the top list and in the 3rd list by world to exports the Natural gases. Conferring to many reports shows middle east countries have more Natural gases but, in this list. Qatar is only in the top list for exports of Natural gases. United states are somewhere in the middle of the list by exporting the natural gases.

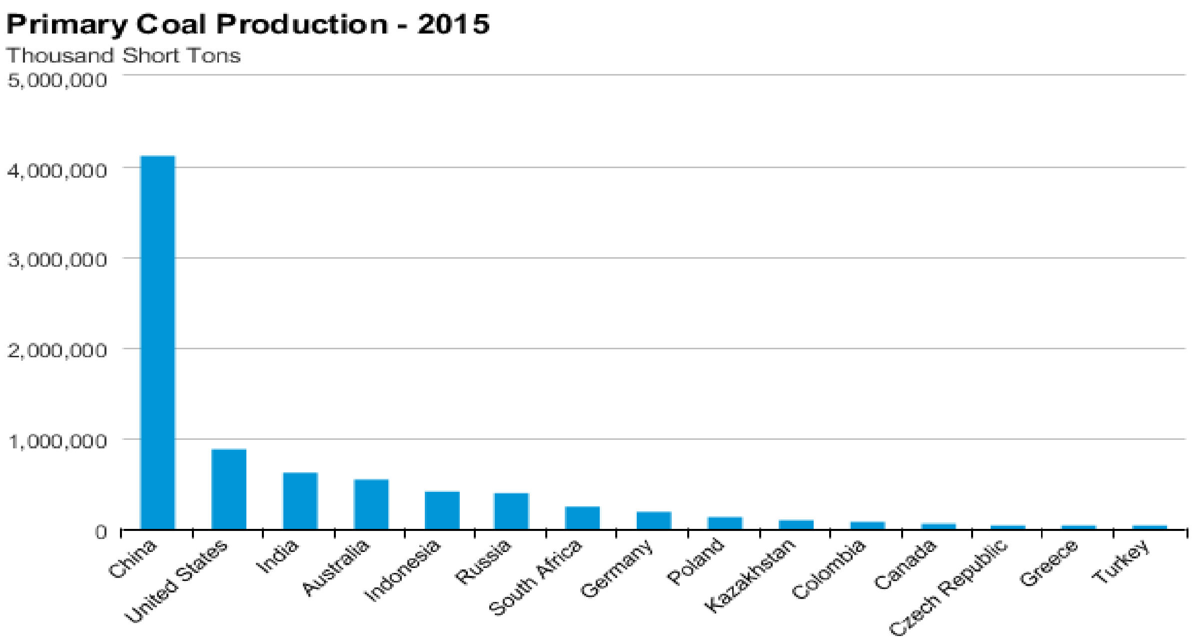
3.5.3 Coal:

Current life is unimaginable without electrical energy. For many reasons as It lights houses, buildings, streets, make available domestic and industrial heat, and powers most stuffs used in households, offices and technology in factories. Enlightening access to electricity international is perilous to lessening deficiency. And comes out coal, it plays a dynamic role in electricity generation universal. Coal-fuelled power plants presently fuel 37% of total electricity and, in some countries, coal fuels a higher fraction of electricity. Coal formed from plants that were concealed millions of years ago. Because of high-temperature, high-pressure environments underground changed the plants physically and chemically, formed coal.

3.5.3.1 Production of coal in the world:

To leading Countries in Coal production, China is the topmost coal producer while the United States comes in next. Further major coal producers are India and Australia. Five states, namely China, the United States, Russia, India, and Japan accounted for over 75% of global coal consumption.

Figure 3 12 Production of coal in the world



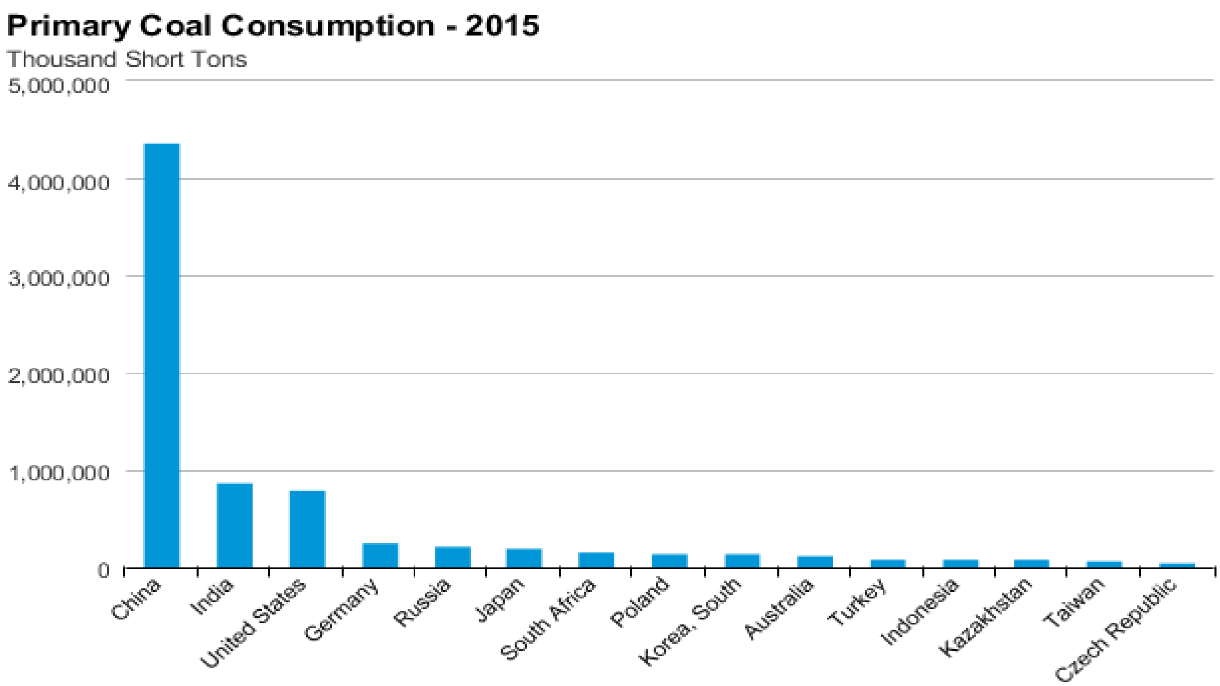
Sources: Total coal and Other Liquids Production – 2017 (https://www.eia.gov/beta/international/)

In the survey from 2015, the primary coal production in China is the highest country to produce in the world. China produce around 4100000 thousand short tons. United stated is in the 2nd position to produce coal as a non-renewable energy source. Followed by India, Australia and Indonesia. Czech Republic is in the top 15 list to produce Coal.

3.5.3.2 Consumption, reserve and capacity of coal in the world:

This is a frightening movement since regardless of growing global consciousness of the hazards of global warming due to greenhouse gas emissions, some key economies are incapable to substitute their coal-based energy with less carbon-intensive energies. Truly, coal is mostly used for electricity production, by means of two-thirds of world consumption working to electricity production; this quantity intensification to three-quarters if China and India, which conventionally have more extensive uses, are excepted; the rest of consumption goes to industry mainly steel production. Coal ruins the greatest polluting source of energy: it normally produces twice as much CO_2 as natural gas, its main competitor.

Figure 3 13 Primary coal consumption by countries



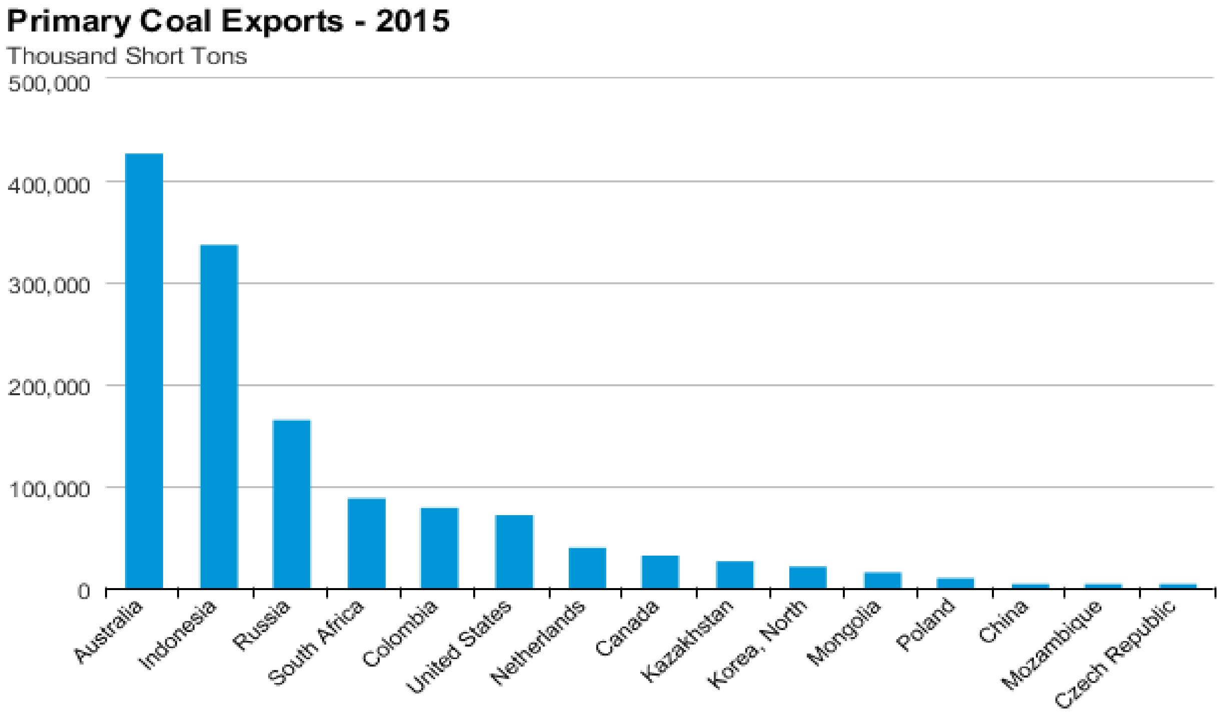
sources: Total coal and Other Liquids Production – 2017 (https://www.eia.gov/beta/international/)

As one of the biggest countries in the world always in the front line for the consumption because of population and need to the normal. So as China is in the top to consumed coal fuel. China consume more than they produce means that they must import some amount coal from foreign country. Another big country like India and United states are just behind of china. by amount they have enormous difference using the renewable sources. Czech Republic is in the top 15th of the list. Since Czech have many developing factories it will be increase in the amount of coal consumption. By the reserve capacity United State is in the top by 251000 million shots tons.

3.5.3.3 Exports of coal in the world:

Coal can be transported to demand centres very fast, securely and simply by ship and rail or via any other transportation. A huge quantity of suppliers is dynamic in the international coal market, certifying a competitive and effective market. Coal markets currently are very dynamic: a variability of assets is traded; new value indexes have been twisted for diverse qualities in diverse areas and a growing amount of broadside trading is the captivating place. It is traded all over the world, per coal shipped massive reserves by the ocean to reach markets. Overall international trade in coal touched 1333.5 Mt in 2015/16; even though this is an important amount of coal it accounts for about 18% of total coal consumed. Built on data from the International Energy Agency, since 2000 worldwide coal trade has augmented by 105 %.

Figure 3 14 Primary coal exports



Sources: Total coal and Other Liquids Production - 2017 (https://www.eia.gov/beta/international/)

Primary exports of coal by 2015, Australia exports about 425,000 Thousand short Tons and about 350,000 Thousand short tons by Indonesia. And followed by South Africa, Colombia and united states. China is in the 14yh largest country to exports and Czech Republic is in the 15th largest country to exports coal according 2015 statistics.

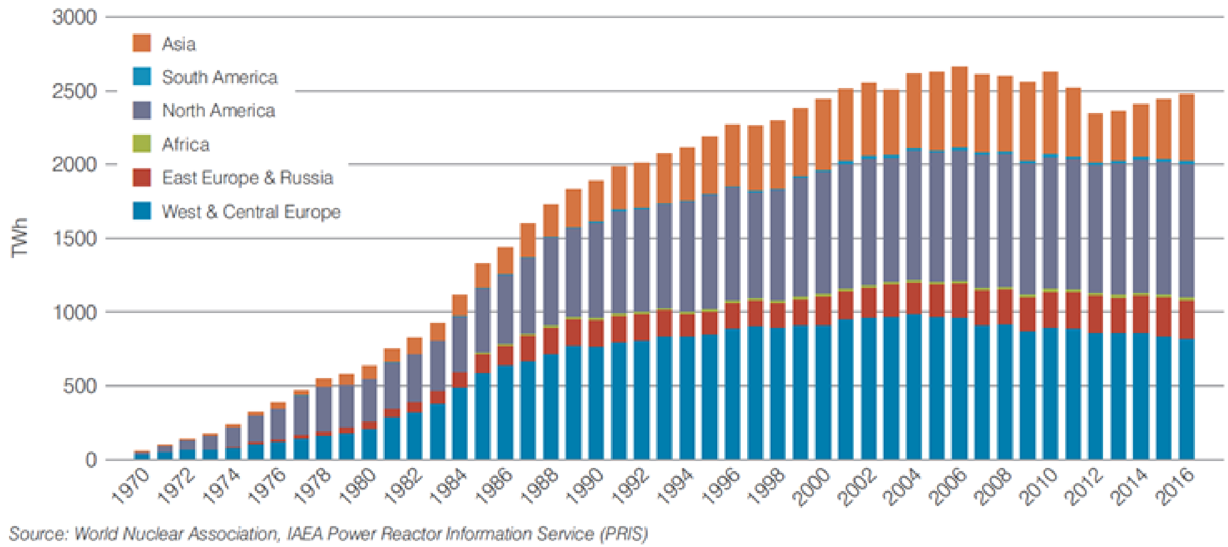
3.5.4 Nuclear Energy (Uranium):

The rudimentary fuel for a nuclear power apparatus is uranium – a heavy metal able to release plentiful concerted energy. Uranium arises naturally in the Earth's crust and is slightly radioactive. Uranium is the only an element with a naturally-occurring fissile isotope in the universes. Most of the uranium castoff in nuclear reactors can be recycled. It occurs in most rocks in concentrations of two to four parts per million and is as mutual in the Earth's crust as tin, tungsten and molybdenum and about forty times as common as silver. Existence of relatively solubility, it is also found in the oceans, at an average concentration of three portions per billion. There are several locations in diverse chunks of the world where it happens in economically-recoverable absorptions. When mined, it produces an assorted uranium oxide product, U_3O_8. Uraninite, or pitchblende, is the utmost communal uranium mineral. Natural uranium formed by mixture of isotopes, together with a small proportion of one that is fissile – willingly able to fission to yield massively supplementary energy than any incineration procedure.

3.5.4.1 Production of Nuclear energy in the world:

From one place to another 11% of the world's electricity is produced by nearby 450 nuclear power devices. About 60 more reactors are under creation, equivalent to 16% of prevailing volume, while an additional 150-160 are planned, equivalent to approximately half of existing volume. In 2016 nuclear plants supplied 2477 TWh of electricity, up from 2441 TWh in 2015 (World Nuclear Association, April 2018). This is the quarter uninterrupted year that global nuclear generation has ascended, with output 130 TWh higher than in 2012.

Figure 3 15 Production of Nuclear energy in the world



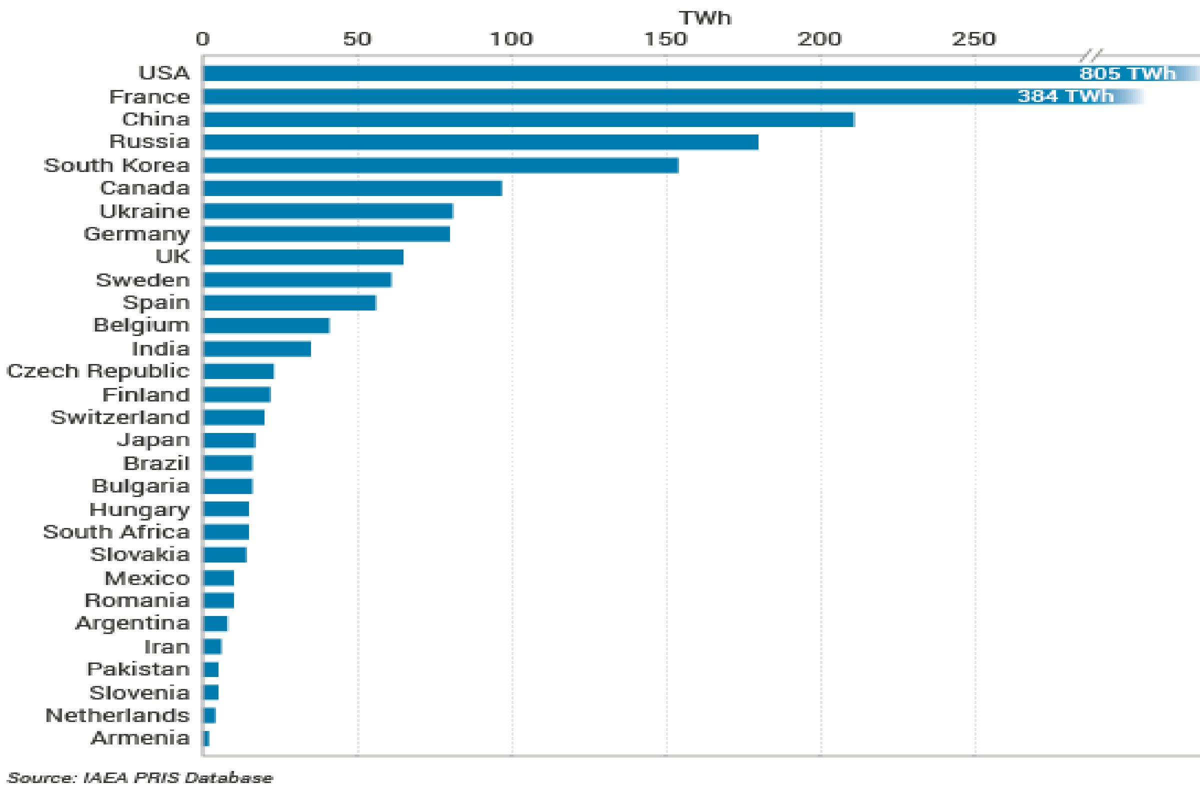
Source: Nuclear Power in the World Today, 2018 (http://www.world-nuclear.org/information-library/current-and-future-generation/nuclear-power-in-the-world-today.aspx)

Since data from 1970, the nuclear energy has been increasing rapidly in the West and central Europe and in American countries. In the Asian countries like China, India, Pakistan and other countries implementing the nuclear energy as a different reason. In the chart below, we can see the list of the countries having nuclear power.

3.5.4.2 Nuclear Generation by Country 2016:

Nuclear power positions need momentous investment to construct, nonetheless, their comparatively low running costs over a long functioning life make them one of the most cost-effective least-carbon technologies. Nuclear power has one of the lowest carbon footpaths of any energy source. Most of carbon dioxide productions accompanying with nuclear power stations rise throughout construction and fuel processing, not in the time of electricity generation. Below chart express the amount of energy or electricity generated by top countries in the world.

Figure 3 16 Nuclear Generation by Country



Source: Nuclear Power in the World Today,2018 (http://www.world-nuclear.org/information-library/current-and-future-generation/nuclear-power-in-the-world-today.aspx)

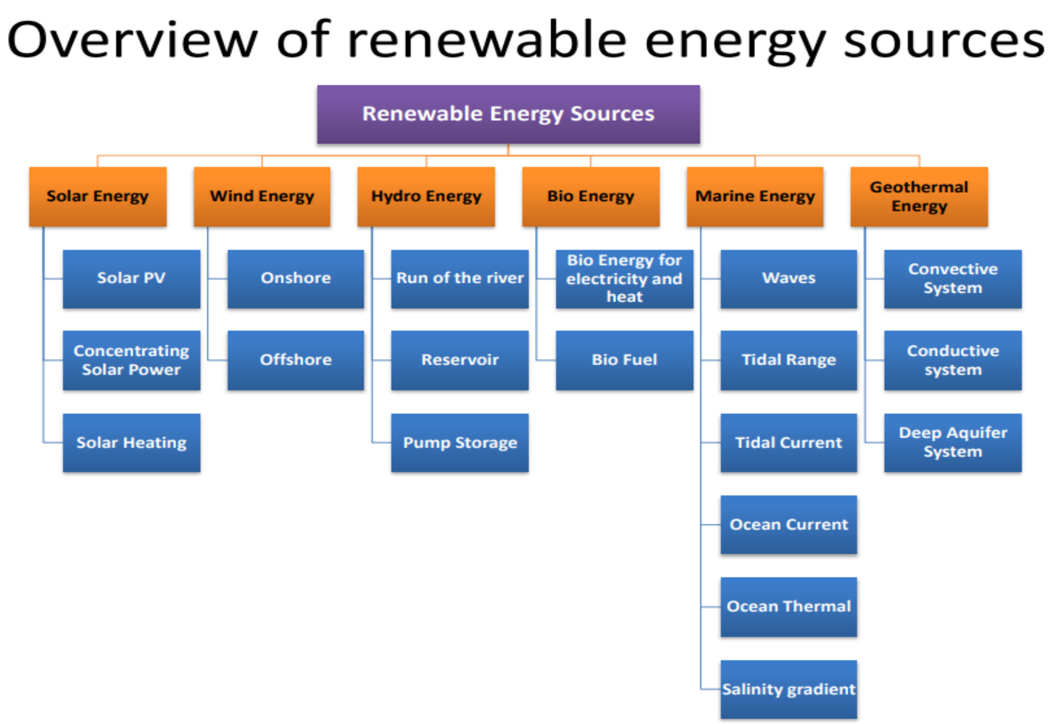
Sixteen countries hinge on nuclear power for at slightest one-quarter of their energy. France becomes about three-quarters of its electricity from nuclear energy; Hungary, Slovakia and Ukraine get more than half from nuclear, whilst Belgium, Czech Republic, Finland, Sweden, Switzerland and Slovenia get one-third or more. South Korea and Bulgaria normally get more than 30% of their electricity from nuclear, whereas in the USA, UK, Spain, Romania and Russia about one-fifth of electricity is from nuclear (World Nuclear Association, April 2018). Japan is rummage-sale to trusting on nuclear power for more than one-quarter of its electricity and is predictable to reappearance to someplace near that level.

After all, we can see Sweden has quite huge impact in the world by producing Nuclear energy. But others natural gases, coal, and petroleum is all imported by neighbours like Norway and EU. This all makes Sweden to develop to renewable energy sources.

3.6 The Economics of Renewable energy sources:

Superior use of renewable energy is seen as a crucial element of any move to contest of climate changes and is being antagonistically endorsed as such by the new United State government and by other administrations (Solomon, 2008). Thus far there is a little economic investigation of renewable energy. Without new storing technologies that can stun this intermittency, abundant of the decarbonization of the economy will have to originate from nuclear, carbon imprisonment and storage and energy competence (Almas Heshmati, 2015). Nuclear and carbon imprisonment are not without their problems. New energy storage technologies could significantly upsurge the character of renewables, but none are present in vision. The overview of the renewable energy sources as shown in the chart.

Figure 3 17 Renewable energy sources



Sources: Developments in Renewable Energy - Current Trends & Future Prospects

3.6.1 Hydro energy:

Great conservative hydropower projects at this time provide the widely held of renewable electric power generation. With nearly 1,100 gigawatts (GW) of comprehensive capacity, according to latest survey hydropower produced an estimated 4,100 terawatt hours (TWh) of the 24,659 TWh total global electricity (C2ES, 2017). As a country wise United States is the third-largest producer of hydropower after China and Brazil. In the year 2011, a plentiful damper than average year in the U.S. Northwest, the United States generated about 7.9% of its total electricity from hydropower (C2ES, 2017). Hydropower functioning costs are relatively lower than other renewable sources and especially hydropower generates little to no greenhouse gas emissions. Hydropower has not much bad influence on nature, but it has one major environmental influence which is a dam and blocks barrier to create a reservoir or distract water to a hydropower plant fluctuation the ecological nature of ecosystem and physical distinguishing of the river. It might change the direction and it could affect the river system. Water power imprisonments the energy of sprightly water in rivers, streams, and waves to produce and generate electricity. Conventional hydropower plants can be built in rivers with no water storage also called as “run-of-the-river” or in conjunction with basins that accumulate water, which can be used or recycled on an as-needed basis. As water flows downstream, it is directed or conducted down through a pipe or other intake assembly in a dam. The continue flowing water turns the blades of a turbine and that generate electricity in the powerhouse, positioned around the base of the dam according to mechanics. Since it has continuous flows means it produces electricity continuously. If water has on high speed, so that produce faster and more precisely. Mostly for this case, we can generate even in the small stream but only things must settle down according to water flow.

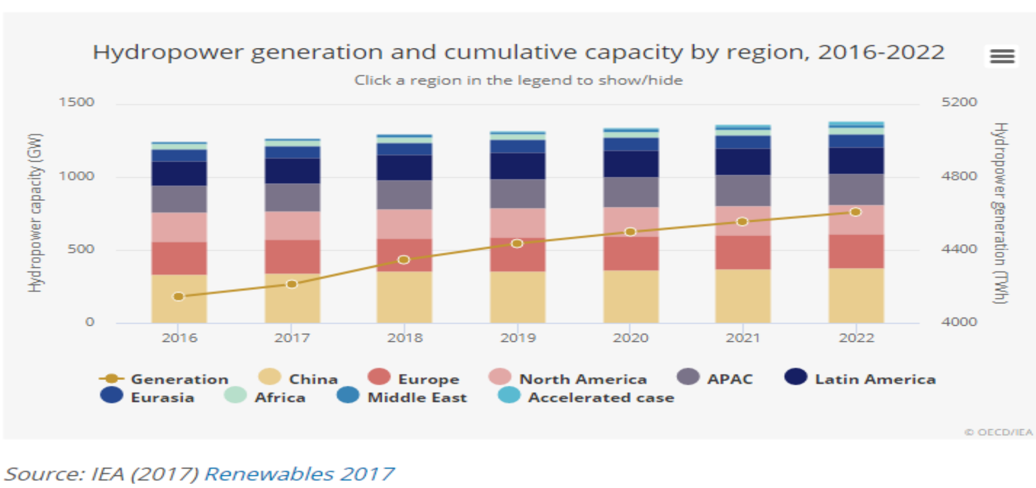
Minor hydropower projects, generally less than 10 megawatts (MW), and micro-hydro power (less than 1 MW) are less costly to develop and have a minor ecological influence than large conventional hydropower projects. As a record in 2016, the overall amount of small hydro mounted worldwide was 78 GW. China had the largest share in the small hydropower and is about 51 percent. China, Italy, Japan, Norway and the United States are the top five small hydro nations by installed capacity. Many other countries have renewable energy goals that include the expansion of small hydro projects. Since less costly and easier to produce for small countryside it has becoming most attractive to produce the renewable energy. Part of the hydropower is called Hydrokinetic electric power which including wave and tidal power, is a form of unconventional hydropower that captures energy from waves or currents and does not necessitate dam construction for reservoir. In 2011, a 254 MW tidal power plant in South Korea initiated operation, replication the global capacity to 527 MW. By the end of 2016, global capacity was about 536 MW which is very positive sign for the future development. And another type of hydro power energy called

Pumped storage hydropower plants which use low-cost electricity and characteristically overnight throughout periods of low demand to pump water from a lower-lying storing reservoir to a storage reservoir situated directly above the powerhouse for future use during periods of peak electricity demand. Granting economically worthwhile, but this strategy is not well-thought-out renewable because it uses additional electricity than it generates.

3.6.1.1 Hydropower generation and collective capacity by region:

Hydropower is the prime and largest source of renewable energy in the world, making about 17% of the world's energy power from over 1 200 GW of installed capacity. Annual net capacity progress has decelerated in topical years, due to fewer great project's existence established in China and Brazil. Nevertheless, cumulative capacity is still predictable to upsurge by a supplementary 119 GW by 2022 (International Energy Agency, 2017). China is to be expected to raise at a slower step than in the past but would still account for over 40% of the net progress, tracked by accompaniments from other markets in Asia, Latin America, and Africa. Hydropower is predictable to continue the world's largest source of renewable energy generation by 2022 and will play a critical part in decarbonizing the power system and refining system elasticity. Progressive developments can be expected in market sections that can subsidize to this litheness such as restoration of existing hydro plant and pumped storing missions.

Figure 3 18Hydropower generation and capacity by region



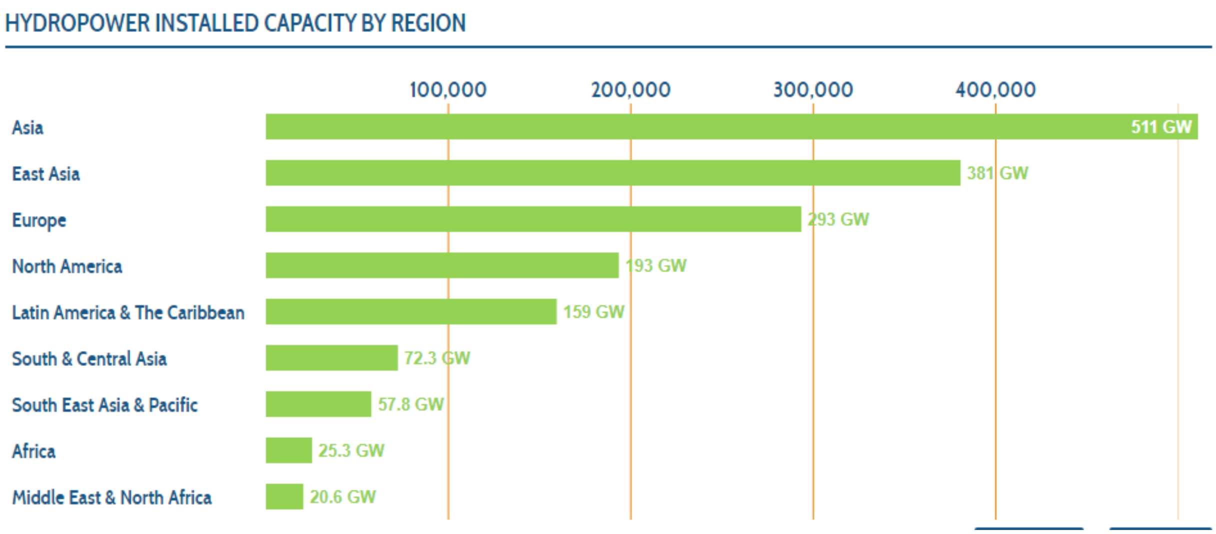
Source: IEA (2017) Renewables 2017

Hydropower is a developed technology, so far it remains to progress. Reservoir hydropower plants and pump storage plants are mainly well-matched to if system flexibility, while run-of-the river hydropower plants are themselves adjustable conferring to current or periodic weather circumstances.

3.6.1.2 Hydropower generation and installed capacity by region:

Hydropower is the top leading renewable source for electricity generation internationally, supplying 71% of all renewable electricity. Accomplishment 1,064 GW of installed capacity in 2016, it produced 16.4% of the world's electricity through altogether sources.

Figure 3 19 Hydropower generation and installed capacity by region



Source: World Energy Council 1016 https://www.worldenergy.org/data/resources/resource/hydropower/

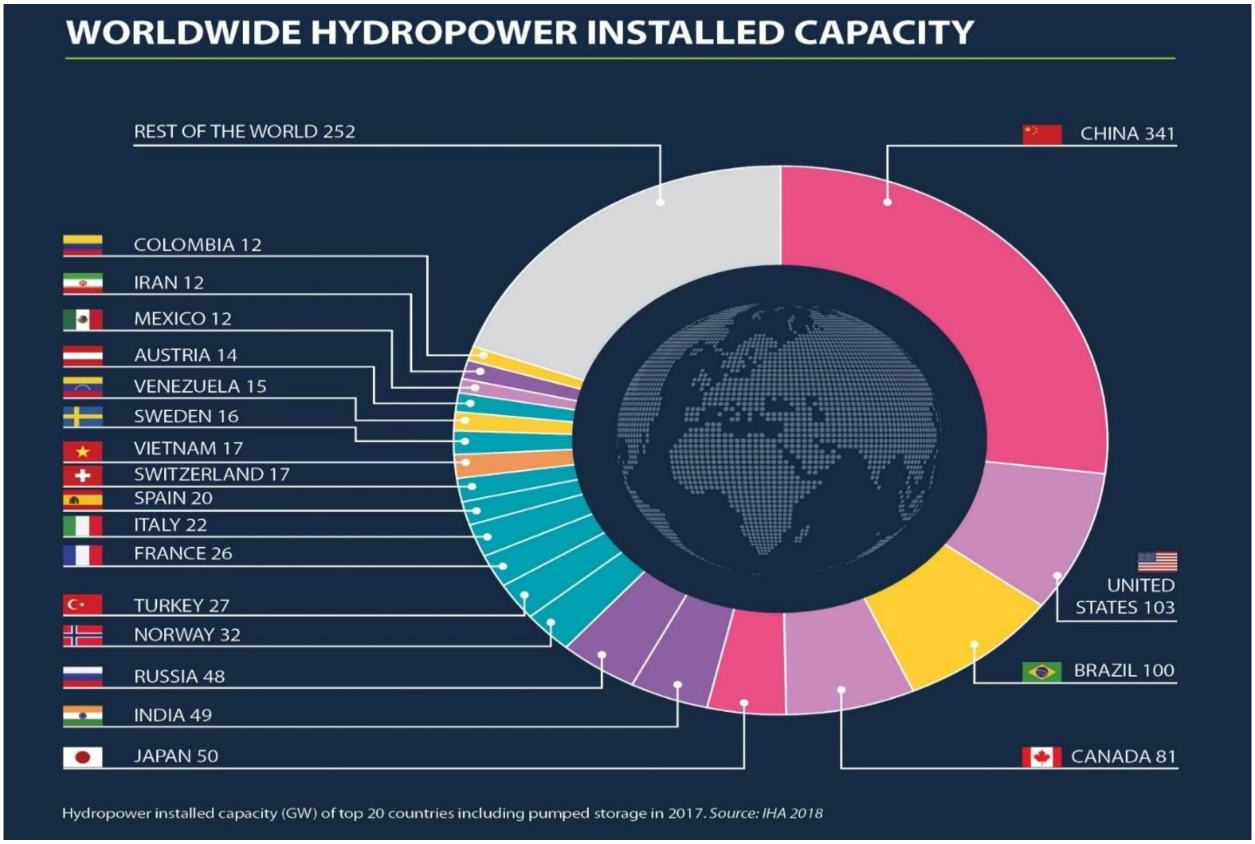
In the 21st century hydro or water power or energy is frequently considered as 'gross theoretical capacity', also explained as the capacity of hydro energy generation. If all-natural water flows delimited as many 100% effective turbines as imaginable, 'technically utilizable capacity', the portion of gross hypothetical capacity probable inside the limits of recent technology, besides 'economically exploitable capacity', the possible volume in the central of the limitations of current technology and limited economic situations (World energy council, 2016).

Mainly there are three different natures of hydropower stations: 'run of river', where the electricity is produced through the regular flow of a river'; 'reservoir', where influence is generated through the throughout or release of deposited water; and 'pumped storage', where warehoused water or stored water is recycled by pumping it posterior up to a sophisticated reservoir to be released yet again.

3.6.1.3 Global hydropower installed capacity:

Hydropower is the one of the most flexible and reliable of the renewable energy resources, accomplished of meeting baseload electricity necessities as well as, per pumped storage technology, meeting peak and unpredicted demand due to scarcities or the use of alternating power sources. There are many prospects for hydropower expansion through the world and even though there is no strong agreement, estimations specify the accessibility of approximately 10,000 TWh/year of unutilized hydropower possible globally (International Energy Agency, 2017).

Figure 3 20 Global hydropower installed capacity



Source: International Hydropower Association,2017

The latest record 4,185 terawatt hours (TWh) in electricity was produced from hydropower according to report of 2017, which avoiding roughly 4 billion tons of greenhouse gases as well as destructive poisons. Global hydropower installed capacity representation to 1,267 gigawatts (GW) in 2017, which also including 153 GW of pumped storage. Throughout the year, 21.9 GW of capacity was further added including 3.2 GW of pumped storage. Hydropower development in East Asia and the Pacific, with 9.8 GW of capacity added in 2017 is the fastest growth and followed by South America by 4.1 GW, and South and Central Asia produce about 3.3 GW, while whole Europe does produce by 2.3 GW, and Africa by 1.9 GW and North and Central America by 0.5 GW. By the end of 2017, World largest producer of hydropower is china and china accumulated for approximately half of worldwide added installed capacity, at 9.1 GW. And the record is followed by south American country Brazil which is 3.4 GW, and India accumulated 1.9 GW, and Portugal do 1.1 GW and by Southern African nation Angola 1.0 GW (International Hydropower Association, 14 May 2018).

WORLD

	Total installed capacity including pumped storage (MW)	Pumped storage (MW)	Generation (TWh)
TOTAL	1,266,955	153,041	4,185

Source: International Hydropower Association,2018

As global capacity in hydropower is rapidly increasing year by year which is very constructive news for the world as a renewable energy resource. Accumulated installed capacity in the world is 1,266,995 MW leading by china and trailed by Brazil, India and Portugal. Even developing countries give the impression by growing and generating quite good amount. About 153,041 MW of energy produce by pumped storage hydropower.

3.6.2 Hydropower production in Sweden:

The overall amount of hydropower plants in Sweden is 2 057 of which 1 615 have already installed capacity of maximum 10 MW. Total capacity is 16 197 MW of which 1 050 MW is small hydro means capacity of plants less than 10 MW (World Energy Council 2018, 2018). Inclusively, the total number of electricity production is 66 TWh throughout an ordinary year 4.6 TWh of which is produced in SHP. As per as the BlueAGE study allotted by ESHA in 2001, Sweden is in the fifth place in energy persuasive in small hydropower in Europe. Sweden follow to being in the fifth position is Italy, France, Germany, and Spain. The structure of new innovative hydro plants has basically concluded, on behalf of environmental and political reflections. Forthcoming movement is expected to be very largely curbed to the innovative modernization and restoration of remaining volume. Since most of the European countries are developed on the large capacity of hydropower but still there is huge potential for small and medium size of hydropower in Sweden. According to BlueAGE study demonstrations a Swedish potential of almost 2 TWh in progression existing plants and building new-fangled plants pleasing into account economic, technical and most important environmental restrictions.

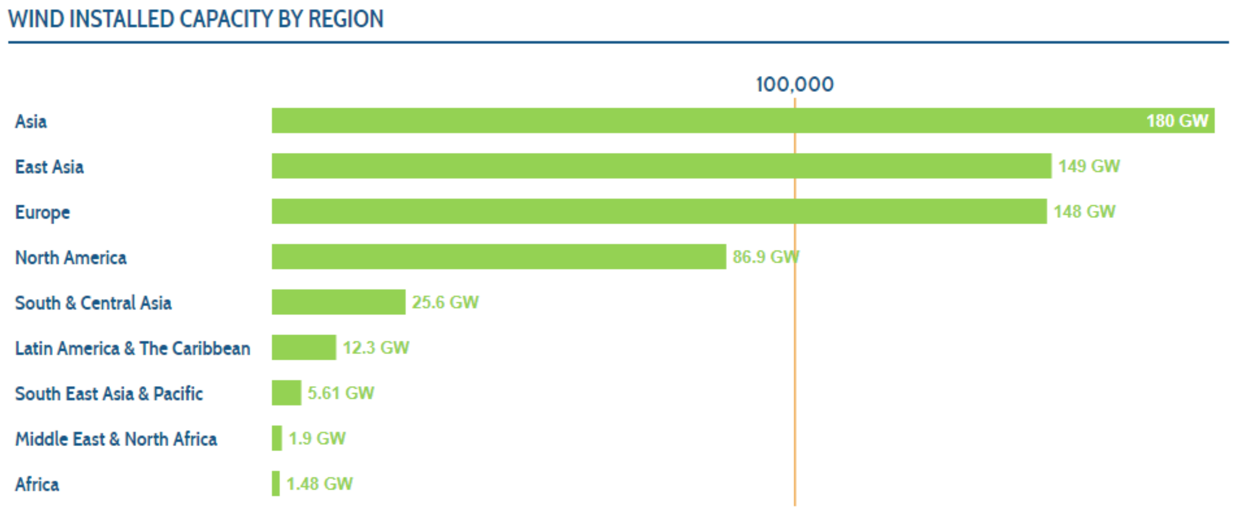
3.6.3 Wind Energy

Wind energy is existing effectively all over the place on the Earth, nevertheless there are widespread dissimilarities in wind strength, reliability and consistency. Wind energy is a form of solar energy. Wind energy defines the procedure via which wind is used to generate electricity. Wind turbines change the kinetic energy in the wind into mechanical energy. A generator can convert mechanical power into electricity power or electric form of energy.

3.6.3.1 Wind energy production in the world

According to the world energy resources from 2015 estimate and suggests that there is 1 million GW of wind energy accessible on the Earth, and if only 1% of this land was operated properly at reachable effectiveness this would happen to meet global electricity demand. Even though (World Energy Council, 2016)maximum wind energy is formerly gotten onshore, offshore wind farms are becoming more common and popular as a greater resource area with less environmental influence. At the end of the year 2015, world wind power generation capacity has reached 435 GW, around 7% of overall global power generation capacity. Global wind power generation was about to 950 TWh in 2015, approximately 4% of total global power generation. The market power of wind can be divided into large wind called as onshore which is 422 GW, around 210,000 machines, and small wind onshore less than 1 GW installed finish 2015, more than 800,000 machines, and offshore (around 12 GW installed end 2015, around 4,000 machines). Mostly large onshore and offshore wind turbines are settled in a wind park. In the world, the largest wind parks exceed 1 GW in sizes, such as Gansu Wind Farm which is located in China, Muppandal Wind Park which is in India or Alta Wind Energy Center in the USA. Talking about installed capacity by country China has the largest wind energy installed capacity with 145 GW and in the 2nd position the United States with 73 GW, followed by Germany 45 GW, India 25 GW, Spain 23 GW, and the UK 14 GW (World Energy Council, 2016). If we focused on regional production of wind energy in the world Asia region has the most capacity by 329GW and followed by Europe with 148GW and north America with 86.9GW. Middle east and African countries do not have significant capacity yet, but they are growing up.

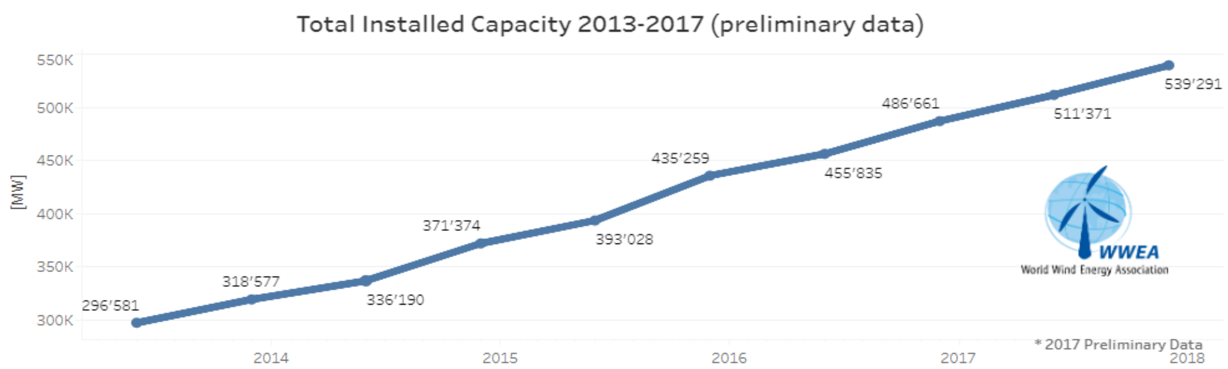
Figure 3 21 Wind installed capacity by region



Source: World Energy Council 2016 (https://www.worldenergy.org/data/resources/resource/wind/)

In the Europe and North America wind energy power has been developed significantly and growing up faster with high priority among the renewable energy resources. According to end of the year 2017 overall capacity of all wind turbines installed worldwide reached 539'291 Megawatt (World Wind Energy Association WWEA, 2018), according to preliminary statistics published by World Wind Energy Association.

Figure 3 22 World Wind Energy Association



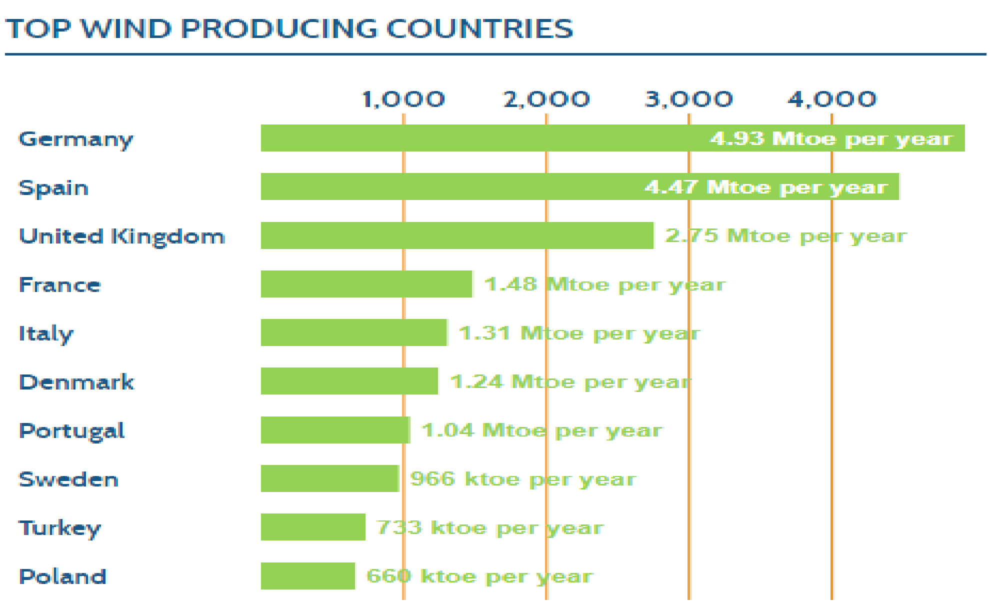
Sources: World Wind Energy Association 2017 (http://wwindea.org/blog/2018/02/12/2017-statistics/)

Since 2013 the capacity has been enormously increasing in the world and reached approximately 540GW which is added by 52.6GW in the year 2017.

3.6.3.2 Wind energy production in Sweden

Sweden targets for 2030 renewable energy will likely be met in 2021 ensuing predictable flow in wind power connections, trade body Swedish Wind Energy Association (SWEA) has projected. In 2017 Sweden set a new renewable energy target of 46.4Wh/year by 2030 which is rising from 28.4TWh/year by 2020. Sweden had 6,691MW of wind power already installed by the end of the year 2017, accounting for an assessed 17.2TWh of yearly energy production, as per SWEA accounts. Sweden expected 815.5MW of wind power capacity by the end of 2018, the SWEA guesswork, with an overall output from wind power rising to a projected 19.8TWH/year. All together joint announcement with Gustav Melin, CEO of clean energy organization Svebio, Charlotte Unger Larson, SWEA CEO, wrote: "The quick enlargement means that the 2030 goal will be stretched by 2021 – nine years in advance (Richard, 2018)." Nevertheless, the duo recommended that the up-to-date proposal of Sweden's scheme of electrical documentation, joint with neighbouring country Norway that would distress the economic ability of remaining power constructors. In the chart below, we can see the top wind producing countries in the Europe and Sweden is in the top 8 by 9066 Ktoe per year.

Figure 3 23 Top wind producing countries



Sources: World Energy Council 2016 (https://www.worldenergy.org/data/resources/region/europe/wind/)

The new wind energy installations in 2012 obligated a capacity of 755 MW. The target is to upsurge renewable generation by 25 TWh related to the level in 2002 by 2020. A key fragment of wind power research sponsored by the Swedish Energy Agency is approved out in the research agendas Vindforsk III, Vindval, and the Swedish Wind Power Technology Centre (SWPTC). Technical program Vindforsk III runs from 2009–2012 and has overall finance of about 80 million SEK which is 9.3 million EUR or 12.3 million USD. Vindval is an information program that focused on studying and research on the environmental paraphernalia of wind power. Vindval runs from 2009–2012 with a budget of 35 million SEK which is equal to 4.1 million EUR or 5.4 million USD. The SWPTC at Chalmers Institute of Technology runs as of 2010–2014 and has a total financial budget of 100 million SEK which is equal to 11.6 million EUR or 15.4 million USD (World Energy Council, 2018). The centre concentrations on the comprehensive project of an optimum wind turbine, which takes the collaboration between all mechanisms into an explanation.

3.7 Renewable energy policies in Sweden:

The Kingdom of Sweden encourages renewable electricity through out by three mains as a quota system, tax regulation mechanisms and a subsidy scheme. In Sweden, tax exemptions are the main encouragements to support renewable heating. The main encouragement for renewable energy use in transport is a tax exemption for biofuels (Intelligent Energy Europe, 2014). Regarding policies endorsing the progress, installation and use of RES-installations, there is a contribution for research and development in the field of wind energy. Sweden encourages renewable energy through various incentives, the most significant of them being the quota system, which is constructed on a certificate trading system. Additionally, tax regulation mechanisms and a subsidy scheme have been introduced as well (Vågerö, 2019/01/17).

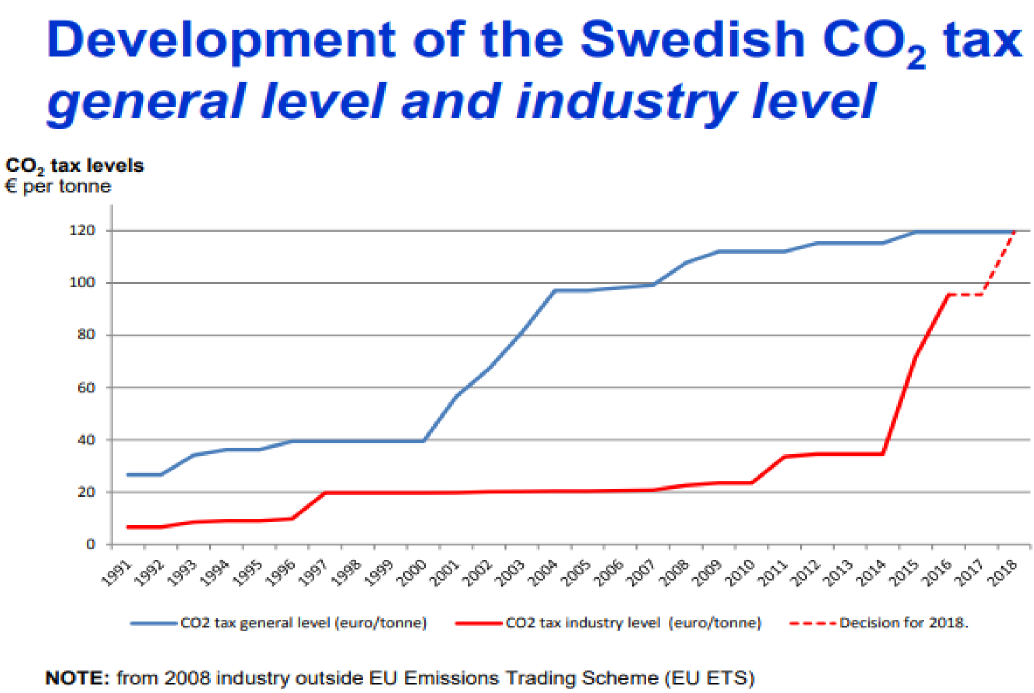
Quota system is the main and utmost incentive for the use of renewable energy sources is a quota system in terms of quota requirements and a certificate trading system. The Electricity Certificates Act accommodates energy suppliers to demonstrate that a certain quota of the electricity supplied by them was produced from renewable energy sources. Energy suppliers intend to make available this indication by offering tradable certificates assigned to the fabricators or producers of electricity as of renewable sources.

Tax regulation mechanisms which deals with electricity generated from wind energy is qualified for tax freedoms containing in a decrease of the real estate tax as well-defined in the Act on the Federal Real Estate Tax. Electricity formed in electricity generators with a capacity below than 50 kW is not taxable. In circumstance of electricity generated from wind, wave and solar this capacity boundary is sophisticated as authorized by the Energy Tax Act (World Energy Council, 2016). Subsidy: Sweden also grants subsidies for photovoltaic installations which is very helpful.

3.7.1 Swedish Energy and CO2 taxation:

CO2 tax is based on fossil carbon content of fuels, which was announced in 1991, laterally with remaining energy tax. Portion of main over-all tax reform, CO2 tax achieves cost effective emission bargains. Mainly divided into two levels of CO2 tax for heating fuels, per ton CO2 – high for households and service (27 € in 1991; 119 € in 2016) and low for sectors at hazard of carbon leakage likewise industry, agriculture and heat production in combined heat and power plants (Ministry of Finance Sweden, 2016).

Figure 3 24 Swedish Energy and taxation



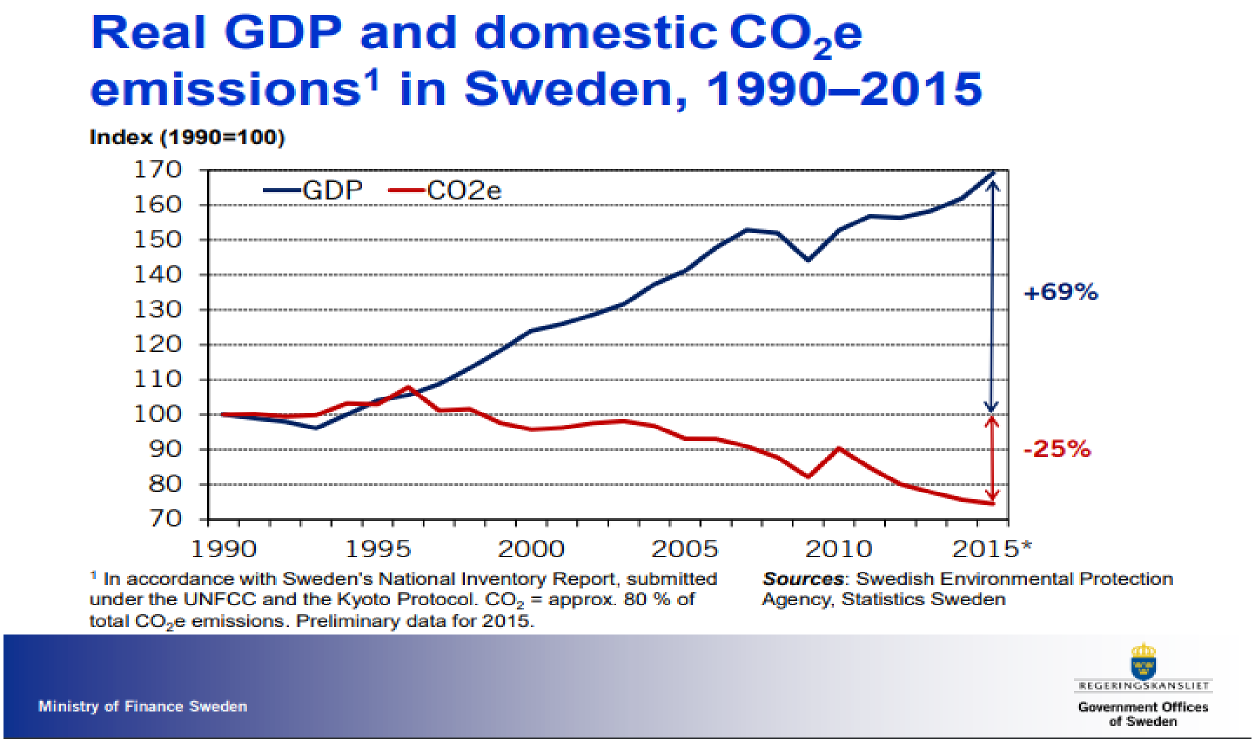
Source: Ministry of Finance, Government of Sweden,2018

As we can see in the above chart, Swedish Carbon-dioxide taxation in the 2 different level as a general level which is households and in the industry level. In 1991, in general level CO2 tax levels is around 25 Euro per ton and now a days in 2018 it is about 120 Euro per ton. If we look at the industry level is around 5 euro per ton in 1991 and now a days is equal to general level which is 120 Euro per ton.

3.7.2 Relation between GDP and domestic CO2e emissions in Sweden:

Country GDP has indirect relationship with CO2e emissions. If country has more renewable energy sources means more consumption. If the consumption increase the GDP of country increase as well. In the other hand while energy is producing via renewable energy sources the is definitely low amount of CO2 emissions. This is how the how explain and it shows GDP and CO2e emissions have indirect and opposite relation.

Figure 3 25 Relation between GDP and domestic CO2e emissions in Sweden



source: Swedish Environmental Protection Agency, Statistics Sweden,2016

As we can see in the above chart from 1990 till 2015 GDP has been growing up by +69% and at the same time reduction in CO2e is by -25%. This indirect relationship shows that reduction in CO2e increase the GDP of the nation. There might be different reason to control CO2e but one of the major reasons is development in renewable energy sources. In 2009 there is an exception case so both were decreased because of well-known financial crisis happened.

4 Empirical analysis:

To analyse the result different tools have been used. Comparative analysis shows that how Sweden progress rather than other countries and kaya identity shows the development of renewable energy sources and statistical analysis shows how significant it is to the development of country economy. Also, analysis has been done about the optimization of production in the Sweden.

4.1 Model of specification:

In this field, certain procedures were used. This chapter explains in detail the procedure approved in incoming at the implication of this research work. Research decision is the frame work of examining a research problem. In other way, it refers to the methods used in collecting data which are to be used in studying and analysing a survey problem. Data collection on its own implicates a range of activities from the individuals in the library mining information from volume of materials accessible as favours to this work. In this section, we follow our objective additional by specifying our model. The model is to verify the consumption of more renewable energy which makes CO_2 emissions decrease and GDP increase in the Sweden.

4.2 Justification of the Model:

In this section, methods of data collection were used in the collection of data from different official webpages. The use of data was chosen for this study because it considered being the most appropriate method for the needed material at the tiniest amount of time. Though this has been chosen amongst other instrument of data collection for this revision because of some additional advantage it has over further methods.

4.3 Method of Evaluation:

Some statistical econometric tests will be used to calculate the regression; this include coefficient of multiple determinant R^2 which measures the magnitude to which the explanatory variables explain the variation in the dependent variable. The F statistic measures the overall significance; the beta coefficients measures the relative significant of each of the independent variable t-statistic.

4.4 Research approach:

The approach used in this study is basically gotten from secondary foundation and sources. This is observed as the plan structure and strategy of investigation comprehended to obtain answers to research problems. It guarantees that the required data are collected and that they are precise.

However, the secondary data used in this study was obtained mainly from the Swedish Energy Association, World Energy Council, World Economic Forum, International energy agencies, OECD data World Bank, IRENA.

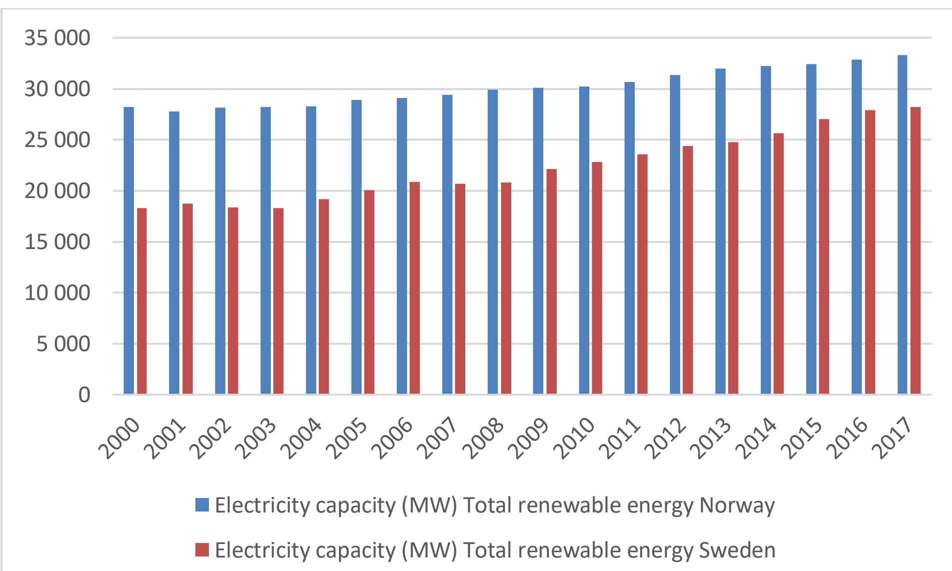
4.5 Comparative analysis:

In comparative analysis data will be analyse among Norway with Sweden and Germany with Sweden. Production of renewable energy will be comparing in between these two countries. Mainly comparison will be done in the production and installed capacity of the countries in last decades.

4.5.1 Renewable electricity capacity in Sweden and Norway:

Below chart help to compare two giant countries for the renewable energy sources. The Nordic countries are well known for the renewable energy development in the Europe.

Figure 4 1 Renewable electricity capacity in Sweden and Norway



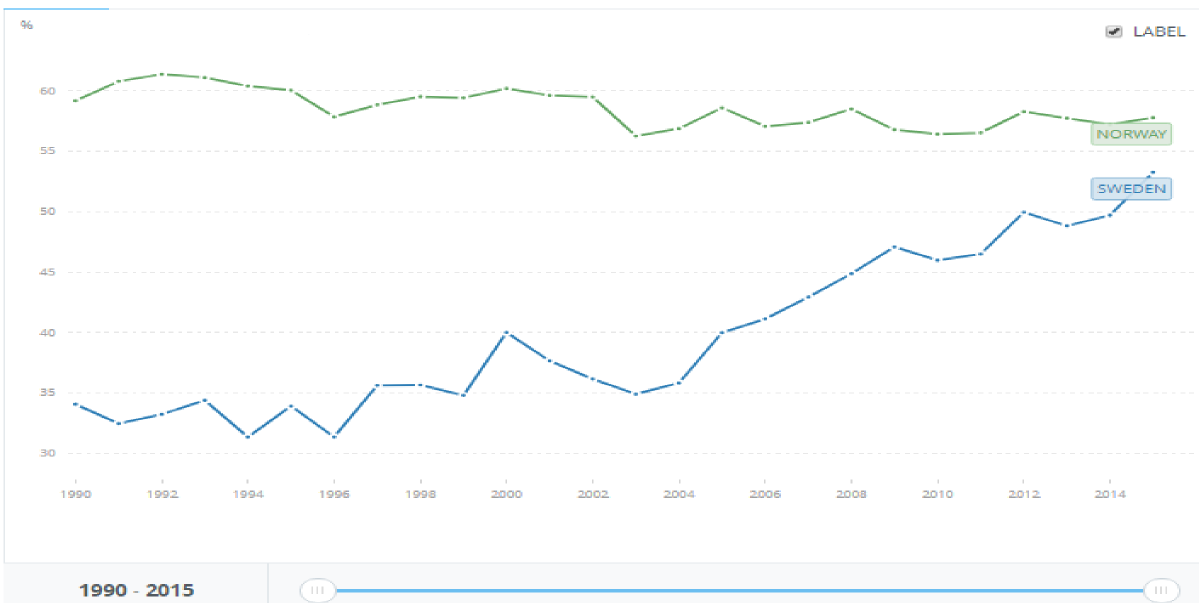
Selected indicators: Electricity capacity (MW).
Selected technologies: Renewable hydropower.
Selected countries and areas: Norway; Sweden.
Selected years: 2000; 2001; 2002; 2003; 2004; 2005; 2006; 2007; 2008; 2009; 2010; 2011; 2012; 2013; 2014; 2015; 2016; 2017.
Source: Own calculation
Data taken from: IRENA (2018), Renewable Energy Statistics 2018, The International Renewable Energy Agency, Abu Dhabi.

From the above chart we can compare in between Sweden and Norway. Data has been taken from 2000 till 2017. As we can see in the chart Norway has comparatively high capacity than Sweden. In the year 2000 Norway has 28193MW electricity while Sweden has 18282MW electricity capacity. Since then both countries developing their capacity by different ways. Norway and Sweden have straight strategic plan that makes those two countries are in the top of the ranking in the Europe by renewable energy sources. As per latest data in 2017 both countries have high capacity than year 2000. In 2017 Norway has 33283MW electricity capacity and in the same year 2017 Sweden has 28218MW. They are even cooperating for further development of renewable energy resources. In this 17-year period Sweden developed around by 10000MW while Norway increased by 5000MW. So, this development shows that Sweden is growing rapidly in renewable energy resources in comparison to Norway and even other countries.

4.5.2 Renewable energy consumption (% of total final energy consumption)

The graph clearly expresses the final consumption of the energy from renewable sources. It also shows the developing trend from 1990 to 2015.

Figure 4 2 Renewable energy consumption in Sweden and Norway



Source: Own calculation (data taken from The World Bank)

The above trend shows the total consumption of renewable energy in Norway and Sweden. In the above green line shows the consumption of renewable energy in the Norway and the below blue line shows the consumption of renewable energy in Sweden. Comparison made as per data from 1990 till 2015, whereas Norway has comparatively high consumption of renewable energy resources but in fact Sweden shows the huge development in this period. As we can see in 1990, Norway using about 59.174% of energy from renewable sources and in 2015 is decreased by about 2 and became 57.772%. In another side talking about Sweden, they were consuming 34.062% in 1990 and now we can see enormous development which makes 53.248% by 2015. As we can compare easily that how Sweden has been competitively increased their value in the world through renewable energy sources. And, they have quite good strategic plan that makes country very competitive in the international market.

4.5.3 The Norwegian and Swedish RES commitments and plans

The Norwegian assurance is to rise the RES share from 58.2% in 2005 to 67.5% by 2020. The Swedish commitment is to increase the RES share from 39.8% in 2005 to 49.0% by 2020 shows the details of the Norwegian and Swedish RES action strategies. Conferring to the strategies, improvement must be informed to the EU every 2 years.

Table 4 1 The Norwegian and Swedish RES commitments and plans

		2005 (base year)		2011		2020	
		Consumption(TWh)	Renewable share,%	Consumption(TWh)	Renewable share,%	Consumption(TWh)	Renewable share,%
Norway	Heating abd coolong	51	33.3	51	37.2	50	43.2
	Electricity	125	97	126	103.3	127	113.6
	Transport	47	1.2	52	4.6	57	10
	Gross final	**230**	**60.1**	**240**	**62.6**	**250**	**67.5**
Sweden	Heating abd coolong	153	53.7	171	57.6	197	62.1
	Electricity	151	50.9	152	55.7	155	62.9
	Transport	87	4	90	8.1	94	13.8
	Gross final	**401**	**39.7**	**423**	**44.2**	**456**	**50.2**

Source: own calculation in excel (data and info of combined figures from Government Offices of Sweden, Tables 1 and 3; Ministry of Petroleum and Energy, 2012a)

Note that the 2020 goal in the Swedish RES plan is higher than the official RES commitment of 49.0%. Sweden already has 53% of energy from renewable. The Norwegian 2020 target matches the official obligation. There are some clear variances among these two state RES strategies. The Swedish plan accepts significantly sophisticated development in total energy consumption than the Norwegian plan. The Norwegian ratio target in the heating and cooling sector is ambitious; though, enlarged consumption is not projected. These policy demonstrations that phasing out fossil fuels by growing renewable energy use is a crucial subject in this sector. The renewable share is still expected to increase, indicating that large amounts of renewable energy will be introduced in this sector.

4.5.4 Kaya identity (Greenhouse gas emissions)

The Kaya Identity is a well-known tool in environmental literature. The Kaya identity was invented by Japanese energy economist Yoichi Kaya. Kaya claims that the main drivers of greenhouse gas emissions change can be divided into main three factors:

a) Welfare changes
b) Energy Intensity changes
c) Carbon Intensity changes.

Welfare is defined in terms of GDP; Energy Intensity denotes the amount of energy expended to create one unit of welfare; and Carbon Intensity denotes GHG emissions per unit of energy consumption.

Developed countries typically use less energy per unit of welfare than less-developed countries or developing countries, and low Carbon Intensity indicates a high share of renewables in the total energy mix. The Kaya Identity exemplifies that once welfare rises, changes in Energy Intensity and Carbon Intensity must higher than compensate for the volume of development if emissions drops are the objective. A country's Kaya Identity figures place it in a welfare-, energy- and emissions situation and highlight which influences are the most thought-provoking in terms of dropping GHG emissions. Successive studies have recurrently separated welfare into two factors:

a) population
b) GDP per capita.

The Kaya Identity can be denoted as shown below.

$$CO_2 = \text{Population} \times \text{GDP per capita} \times \text{E/GDP (Energy Intensity)} \times CO_2\text{/E (Carbon Intensity)}$$

OR

{\display style F=P\times {\frac {G}{P}} \times {\frac {E}{G}}\times {\frac {F}{E}}} Where:

F is global CO2 emissions from human sources

P is global population

G is world GDP

E is global energy consumption

G/P is the GDP per capita

E/G is the energy intensity of the GDP

F/E is the carbon footprint of energy

4.5.4.1 Kaya identity (Greenhouse gas emissions assessment of Sweden and Norway)

Greenhouse gas emissions calculation of Sweden and Norway are comparing to figure out their progress and effective implementation of the commitment made by themselves.

Table 4 2 Greenhouse gas emissions assessment of Sweden and Norway

index (reference year = 100)	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Sweden																				
CO_2 emissions	120	108	110	108	100	98	101	104	100	94	90	86	82	78	88	81	75	72	72	71
Population	103	103	103	103	104	104	104	105	105	106	106	107	108	109	110	110	111	112	113	114
GDP per population (GDP per capita)	102	105	109	114	119	121	123	125	130	133	139	142	141	132	139	141	140	141	143	147
Energy intensity (TPES/GDP)	104	98	96	90	82	85	86	82	81	78	72	70	69	67	71	67	68	66	63	57
Carbon intensity: ESCII (CO_2/TPES)	110	102	102	101	99	92	92	97	90	86	84	81	78	81	82	77	71	69	70	74
Norway																				
CO_2 emissions	118	124	130	136	116	120	118	128	130	126	129	131	129	130	137	132	129	128	129	134
Population	103	104	104	105	106	106	107	108	108	109	110	111	112	114	115	117	118	120	121	122
GDP per population (GDP per capita)	122	128	131	132	136	138	139	139	144	147	149	152	151	146	145	145	147	147	148	149
Energy intensity (TPES/GDP)	86	86	88	90	87	87	80	86	81	80	79	78	90	89	96	78	81	88	74	77
Carbon intensity: ESCII (CO_2/TPES)	109	108	109	108	93	94	100	99	103	99	100	100	84	87	85	99	92	83	98	95

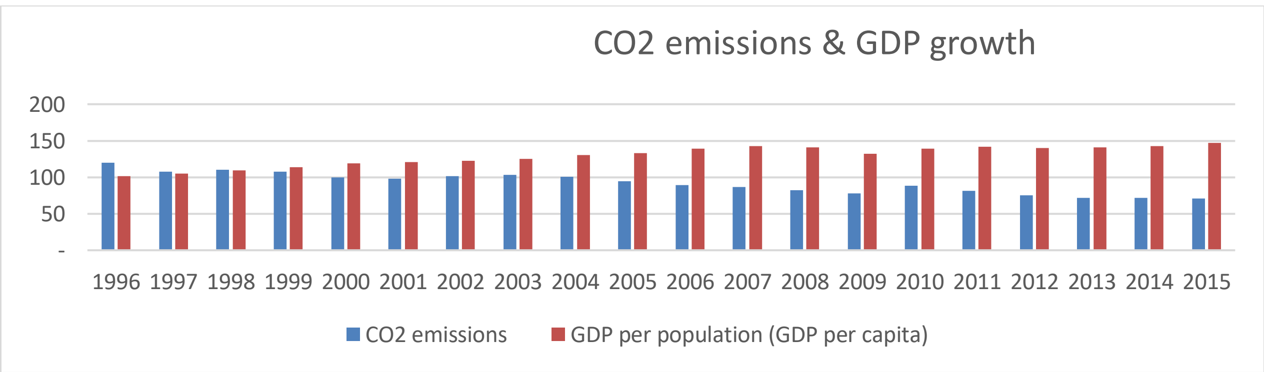
Source: Own calculations (data taken from: CO2 Emissions from Fuel Combustion (2017 Edition), OECD/IEA, Paris.)

Table 4 3 Units of different variables of Kaya identity

	Energy consumption	Emission	GDP/Capita	Energy intensity	Carbon Intensity
Unit:	**GWh**	**Kton**	**$**	**KWh/$**	**Kg/KWh**

By prominent the forthcoming changes in population (P), economic production (G/P), energy intensity (E/G), and carbon efficiency (F/E), it is conceivable to make a knowledgeable prognosis of imminent carbon emissions (F). Apparently, the population is significant as, in the nonappearance of whatever else, more people means more energy consumption. Likewise, economic production measured by GDP per capita plays a vital role, as a superior economy means superior consumption of energy. The energy intensity term is where technology originates in. As we progress new energy technologies or advance the effectiveness of current energy technology, we assume that it will take less energy to upsurge our GDP by and the supplementary dollar, i.e., we should see a deterioration in energy concentration. Last, but positively not least, is the carbon efficiency. As we progress and more and more switch over to renewable energy sources and non-fossil fuel created energy substitutes and advance the carbon efficiency of remaining fossil fuel sources, we can suppose a failure in this quantity as well, i.e., less carbon produced per unit of energy construction. In the above table the main highlighted field which is CO2 emissions is calculated with the help of kaya identity. As per kaya identity if we compare GDP growth year by year made CO2 emissions is going down. Nonetheless in 2009 GDP and CO2 both are decreased because of financial crisis. And after comparing with another country Norway has less effect because Sweden economy is more affected than Norway economy via renewable energy sources. Long 20 years of statistics shows that CO2 emissions is downward in both countries but in Sweden the number is downward rapidly which shows there is effective energy sources from renewable energy.

Figure 4 3 CO2 emissions and GDP growth

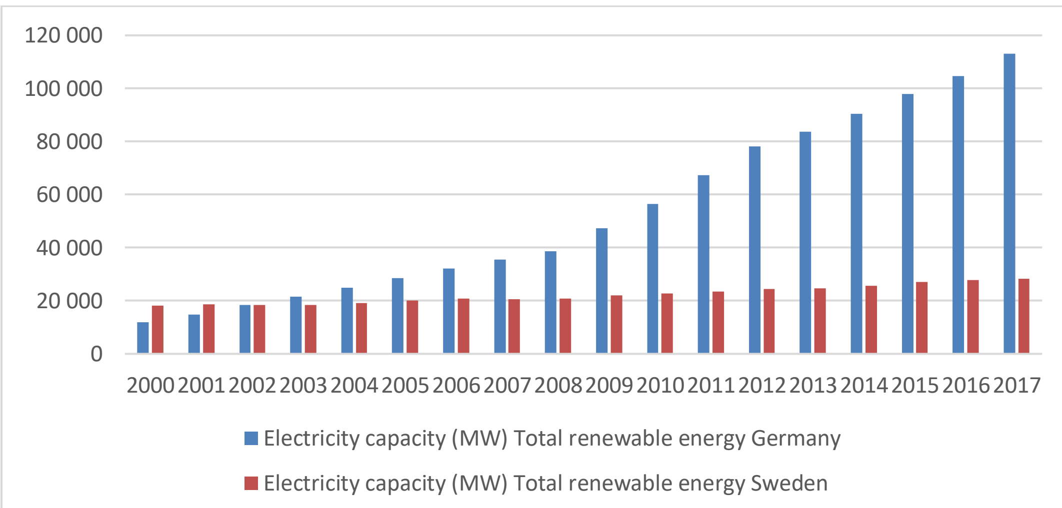


Sources: Own calculation (based on above table)

In the beginning of 1995/96 GDP of the Sweden and CO2 emissions are comparatively similar because on that time mostly energy comes from non-renewable energy sources likewise coal, gas, oil and so on. But time by time renewable energy production has been increase and that made consumption of it increased but that make less consumption of energy from non-renewable sources also are the key factors of CO2 emissions. Lastly, the conclusion is more renewable energy production/ consumption means less CO2e emissions and more consumption of energy also increase in GDP. In a cross-way increase in GDP also refers to the CO2e emissions decrease in case of Sweden via kaya identity proved by year and year.

4.5.5 Renewable electricity capacity in Sweden and Germany

Figure 4 4 Electricity capacity in Sweden and Germany



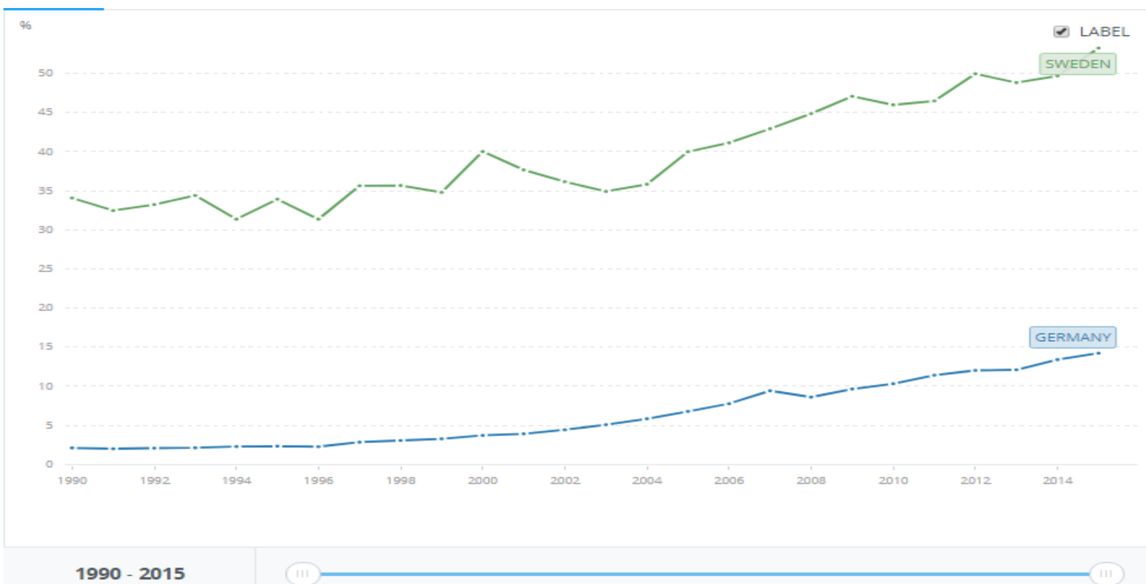
Selected indicators: Electricity capacity (MW).
Selected technologies: Renewable hydropower.
Selected countries and areas: Germany; Sweden.
Selected years: 2000; 2001; 2002; 2003; 2004; 2005; 2006; 2007; 2008; 2009; 2010; 2011; 2012; 2013; 2014; 2015; 2016; 2017.
Source: Own calculation
Data taken from: IRENA (2018), Renewable Energy Statistics 2018, The International Renewable Energy Agency, Abu Dhabi.

The above chart shows the electricity capacity in Sweden and Norway. As I mention already about Sweden in the above chart while comparing with Germany Sweden has lower capacity. It might be the reason that Germany is huge country in comparison with the Sweden. As it is clear that, in the beginning of 2000 Sweden had more capacity than Germany until 2002.But right after 2003 the Germany increased dramatically their electricity capacity. As per latest data from 2017 Germany made their capacity 113,061MW while Sweden running with 28,218MW in 2017. Nevertheless, it is obvious that Germany is huge country and they have more capacity.

4.5.6 Renewable energy consumption (% of total final energy consumption):

From point of view of capacity Germany lead but in point of view of consumption of renewable energy sources Sweden consumed much more than Germany. While we consider data from 1990 till 2015 Germany consumed about 2-3% of total electricity from renewable resources and by 2015 it increases and made it about 14% which is not a huge difference. At the same time Sweden had 35% in 1990 and now it is 53%. As we easily can distinguish how Sweden develop their consumption of renewable energy resources.

Figure 4 5 Renewable energy consumption in Sweden and Germany



Source: Own calculation (data taken from The World Bank)

In the European Union, Sweden is one of the good examples to follow. Sweden ministry announced that by 2040 Sweden will be using 100% energy from renewable energy resources.

4.5.7 Kaya identity (Greenhouse gas emissions)

The Kaya Identity is a well-known tool in environmental literature. The Kaya identity was invented by Japanese energy economist Yoichi Kaya. Kaya claims that the main drivers of greenhouse gas emissions change can be divided into main three factors:

d) Welfare changes

e) Energy Intensity changes

f) Carbon Intensity changes.

Welfare is defined in terms of GDP; Energy Intensity denotes the amount of energy expended to create one unit of welfare; and Carbon Intensity denotes GHG emissions per unit of energy consumption.

Developed countries typically use less energy per unit of welfare than less-developed countries or developing countries, and low Carbon Intensity indicates a high share of renewables in the total energy mix. The Kaya Identity exemplifies that once welfare rises, changes in Energy Intensity and Carbon Intensity must higher than compensate for the volume of development if emissions drops are the objective. A country's Kaya Identity figures place it in a welfare-, energy- and emissions situation and highlight which influences are the most thought-provoking in terms of dropping GHG emissions. Successive studies have recurrently separated welfare into two factors:

c) population
d) GDP per capita.

The Kaya Identity can be denoted as shown below.

$$CO_2 = \text{Population} \times \text{GDP per capita} \times \text{E/GDP (Energy Intensity)} \times CO_2/\text{E (Carbon Intensity)}$$

OR

{\display style F=P\times {\frac {G}{P}} \times {\frac {E}{G}}\times {\frac {F}{E}}} Where:

F is global CO2 emissions from human sources

P is global population

G is world GDP

E is global energy consumption

G/P is the GDP per capita

E/G is the energy intensity of the GDP

F/E is the carbon footprint of energy

4.5.7.1 Kaya identity (Greenhouse gas emissions assessment of Sweden and Germany)

Below Kaya identity table shows the intensification of GPD, population, energy intensity and backward carbon intensity. Carbon intensity is decreasing in the period of 1995-2015 because increasing trend of energy consumption from renewable energy sources. As chart explain in the beginning of the 1995/96 Germany has less carbon emissions than the Sweden. But eventually Sweden develop their advance technology and moved for the renewable energy resources. By connecting with GDP and CO2 emissions, CO2 emissions has indirect relationship with GDP. If GDP growth is increasing from renewable energy resources means emissions of carbon goes down which is totally preferable with the nature.

Table 4 4 Greenhouse gas emissions assessment of Sweden and Germany

index (reference year = 100)	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Sweden																				
CO_2 emissions	120	108	110	108	100	98	101	104	100	94	90	86	82	78	88	81	75	72	72	71
Population	103	103	103	103	104	104	104	105	105	106	106	107	108	109	110	110	111	112	113	114
GDP per population (GDP per capita)	102	105	109	114	119	121	123	125	130	133	139	142	141	132	139	141	140	141	143	147
Energy intensity (TPES/GDP)	104	98	96	90	82	85	86	82	81	78	72	70	69	67	71	67	68	66	63	57
Carbon intensity: ESCII (CO_2/TPES)	110	102	102	101	99	92	92	97	90	86	84	81	78	81	82	77	71	69	70	74
Germany																				
CO_2 emissions	94	91	90	87	86	88	87	87	86	84	85	82	82	77	81	78	79	81	77	78
Population	103	103	103	103	103	103	103	103	103	102	102	102	102	101	101	101	101	102	102	103
GDP per population (GDP per capita)	109	111	113	115	118	120	120	120	121	122	127	131	133	126	132	136	137	137	139	140
Energy intensity (TPES/GDP)	89	86	84	81	79	80	78	78	78	77	76	70	70	69	70	64	64	65	62	61
Carbon intensity: ESCII (CO_2/TPES)	95	93	92	91	90	90	90	91	89	87	86	87	87	87	87	88	90	90	88	89

Source: Own calculations (data taken from: CO2 Emissions from Fuel Combustion (2017 Edition), OECD/IEA, Paris.)

	Energy consumption	Emission	GDP/Capita	Energy intensity	Carbon Intensity
Unit:	**GWh**	**Kton**	**$**	**KWh/$**	**Kg/KWh**

Above mention units are used for the measurement of the different variable. Energy consumption is measured in Gigawatt hours while CO2 emission is measured in Kilotons and GDP in USD. In comparatively Sweden has low emissions than Germany that point us Sweden has more consumption of renewable than Germany. Even though in the beginning of this research Germany was better but in the sources of renewable energy. As a conclusion of this part Sweden has more consumption than Germany in different way.

4.6 Optimization of the current energy mix with linear programming

Linear programming is a mathematical modelling technique in which a linear function is maximized or minimized when subjected to various constructions. This technique has been very suitable for supervisory quantitative choices in business preparation and development, in industrial engineering, and—to a lesser extent—in the social and physical sciences.

The solution and explanation of a linear programming problem diminishes to discovery the optimum value it can be the largest or smallest, depending on the problem of the linear appearance or expression also known as the objective function

$$f = c_1 x_1 + \ldots + c_n x_n$$

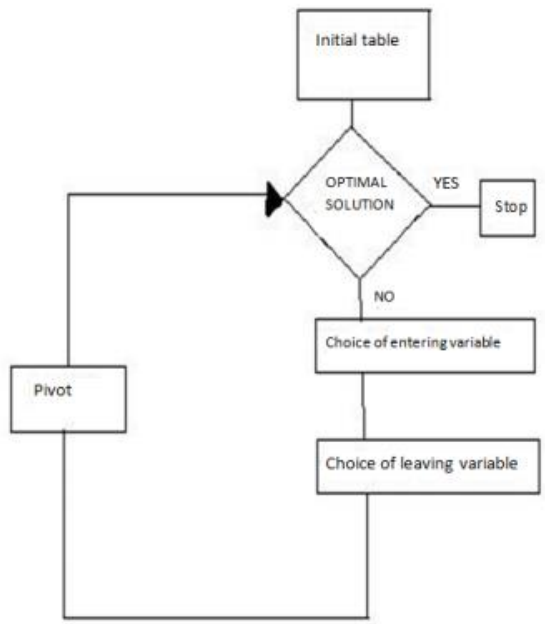
subject to a set of limitations stated as inequalities:

$$\begin{aligned} a_{11} x_1 + \ldots + a_{1n} x_n &\leq b_1 \\ &\vdots \\ a_{m1} x_1 + \ldots + a_{mn} x_n &\leq b_m \text{ with } \forall x_i \geq 0. \end{aligned}$$

The a's, b's, and c's are coefficients determined by the dimensions, needs, costs, profits, and further necessities and boundaries of the problem. The straightforward assumption in the application of this method is that the several relations between demand and obtainability are linear; that is, none of the xi is upstretched to a power other than 1. In order to get the solution to this problem, it is necessary to find the solution of the system of linear inequalities which means, the set of n values of the variables xi that concurrently satisfies all the inequalities. The objective function is then estimated by substituting the values of the xi in the equation that defines f.

For the purpose of the optimal energy mix creation, simplex method in linear programming tool is going to be used. Simplex method is the most suitable method for finding optimal solution for the given problem.

Table 4 5 optimal solution



source: (Montreal, n.d.)

Linear programming or linear optimization is a mathematical programming created by the American mathematic George Dantzig in 1947. This is fundamentally a study of systems of inequalities and their resolutions, then it comes to improving results under circumstances determined by a system of inequalities.

4.6.1 Simplex method

The Simplex method is an approach to determining linear programming models by hand using slack variables, tableaus, and pivot variables as a means to result the optimal solution of an optimization problem. In my research minimization of cost would be calculated. In the equation following variables are represents,

Selected sources,

a= cost of hydropower electricity

b= cost of Nuclear power electricity

c= cost of Solar power electricity

d= cost of wind electricity

e= cost of biomass electricity

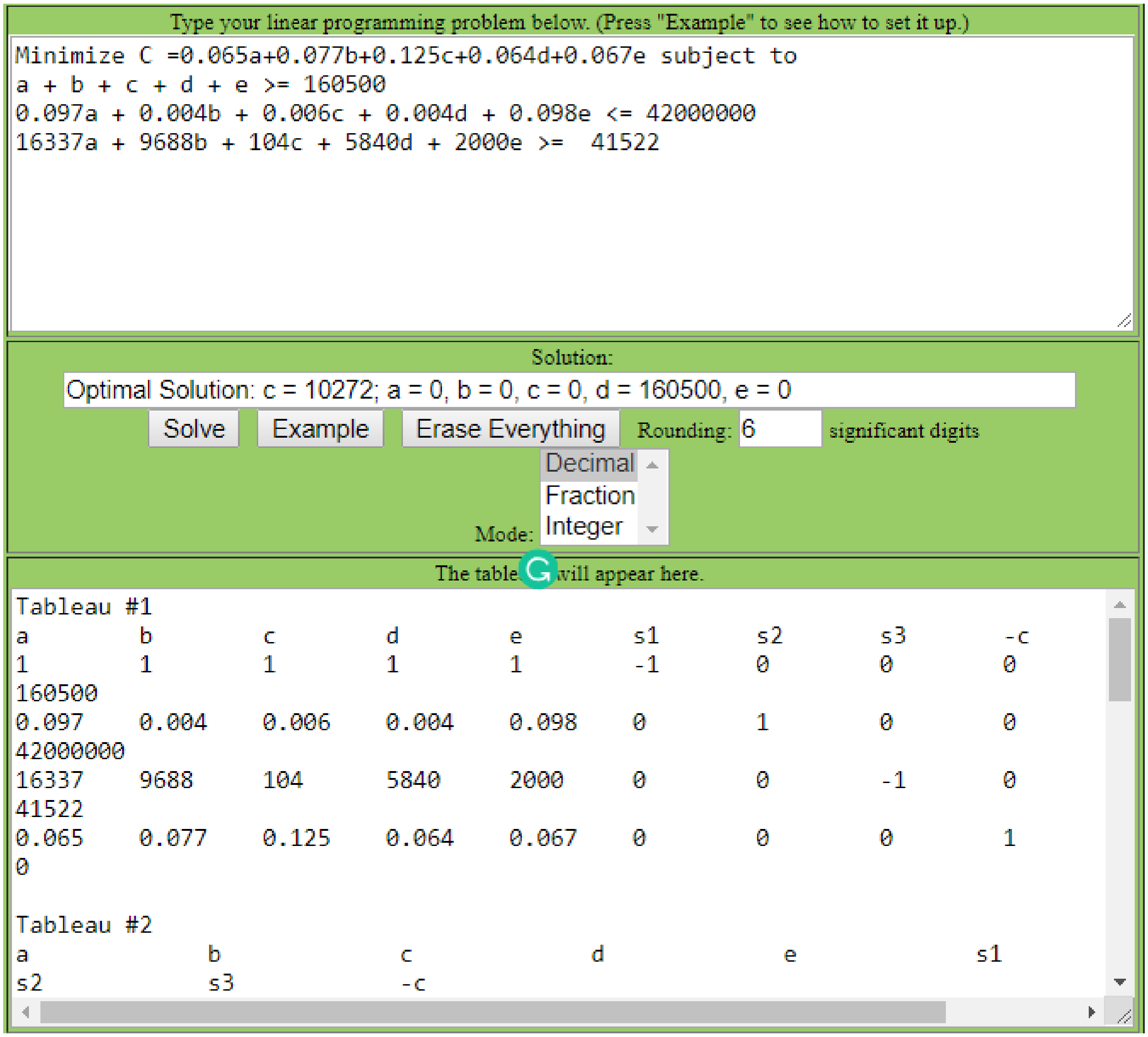
The basic objective function of the linear model specifies that the basic objective is to create an energy mix with a view to minimizing the cost of producing energy from selected renewable energy sources. Among the limitations also CO_2 emissions were included, with the aim that the amount of emissions produced from selected sources was less than the total amount of emissions produced in the Sweden. The measurement of cost is in unit of Eur/MWh. The data are taken from official website of Swedish energy association. The full version of databases has been attached in the below appendix also.

Optimization equations

$$\text{Minimize } C = 0.065a+0.077b+0.125c+0.064d+0.067e \text{ subject to} \qquad [I]$$
$$a + b + c + d + e >= 160500 \text{ (electricity consumption)}$$
$$0.097a + 0.004b + 0.006c + 0.004d + 0.098e <= 42000000 \text{ (emissions)}$$
$$16337a + 9688b + 104c + 5840d + 2000e >= 41522 \text{ (installed output)}$$

The equations chosen for the optimization problem undoubtedly proves that the core objective of the linear programme is to figure out such renewable energy mix, which would significantly lower costs of electricity generation, composed with the inferior amount of emissions produced throughout this generation.

Table 4 6/7/8 optimal solution



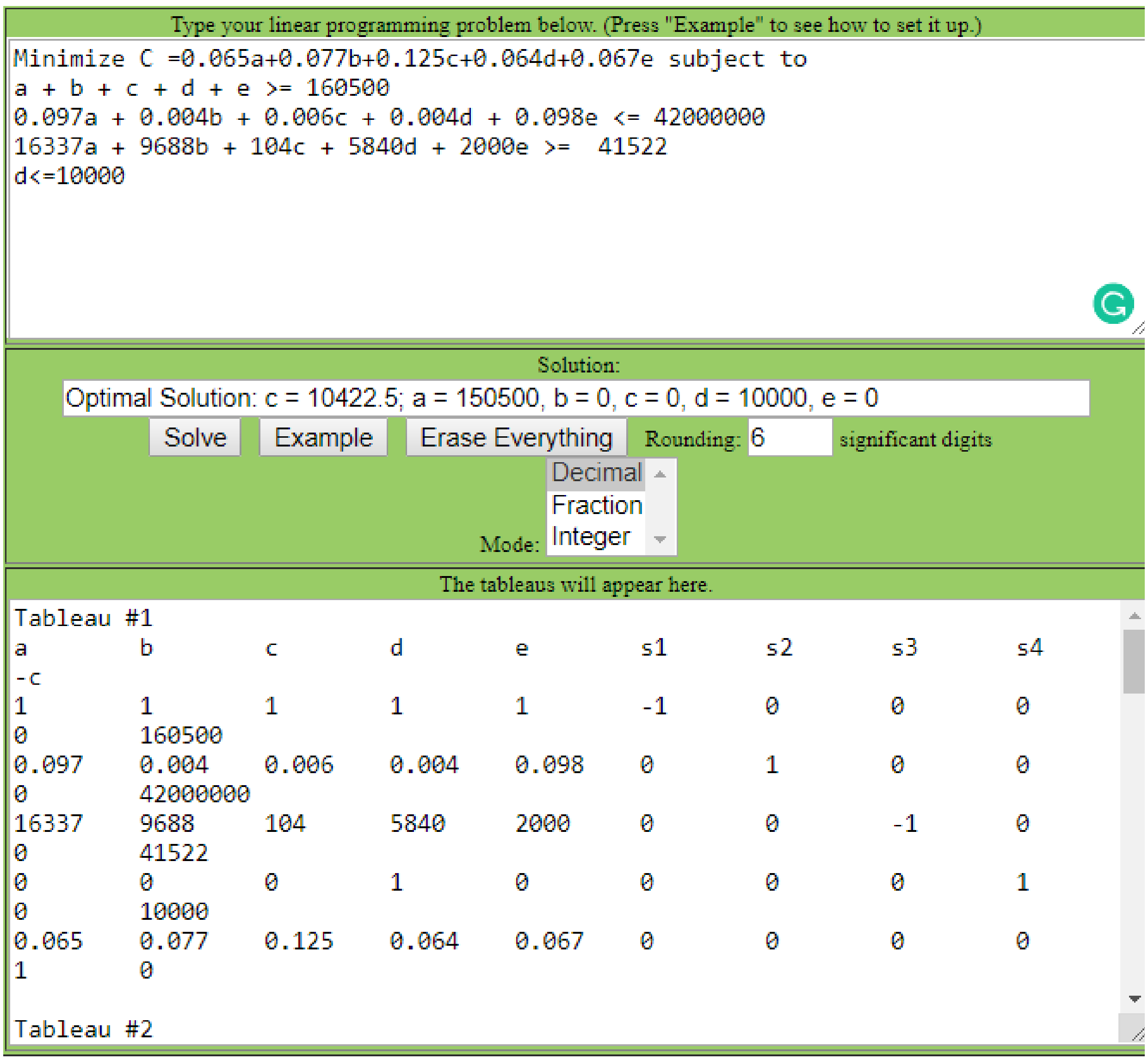
In the first proposed scenario, the linear programme proposed an optimal solution in a way of using only wind power plants with total energy generation 160500 MWh, and total costs of 10272 EUR/MWh. This scenario could be the best for cost minimization but it just include biomass energy which is not optimal in practical life or in case of Sweden. In practice, such energy mix is not applicable in Sweden conditions. The proposed optimal energy mix should encompass renewable energy resources in order to ensure the decrease of the amount of emissions unconfined in the air from electricity generation. Therefore, in the next step, wind power plants production is reproached in order to give the programme possibilities to use also other energy sources in the optimal mix formation.

Minimize C = 0.065a+0.077b+0.125c+0.064d+0.067e subject to [II]

a + b + c + d + e >= 160500 (electricity consumption)

0.097a + 0.004b + 0.006c + 0.004d + 0.098e <= 42000000 (emissions)

16337a + 9688b + 104c + 5840d + 2000e >= 41522 (installed output)
d<=10000
Table 4 7



The reproached value was given to the limit for the wind electricity by maximum 10,000MGh and it shows that hydro power should be produced in amount of 150,500GWh. Such equation is not clearly optimal since they have 2nd highest energy by Nuclear power. As per latest data hydro power cannot produce more than 16,337MWh but it is also clear that in Sweden can increase in the production of hydro power to fulfil their strategic plan about 100% electricity from renewable energy. So, to find the more optimal solution it is better to increase the capacity of hydro. Then to find the better solution it is necessary to reproach the value of hydro.

Minimize C =0.065a+0.077b+0.125c+0.064d+0.067e subject to [III]

a + b + c + d + e >= 160500

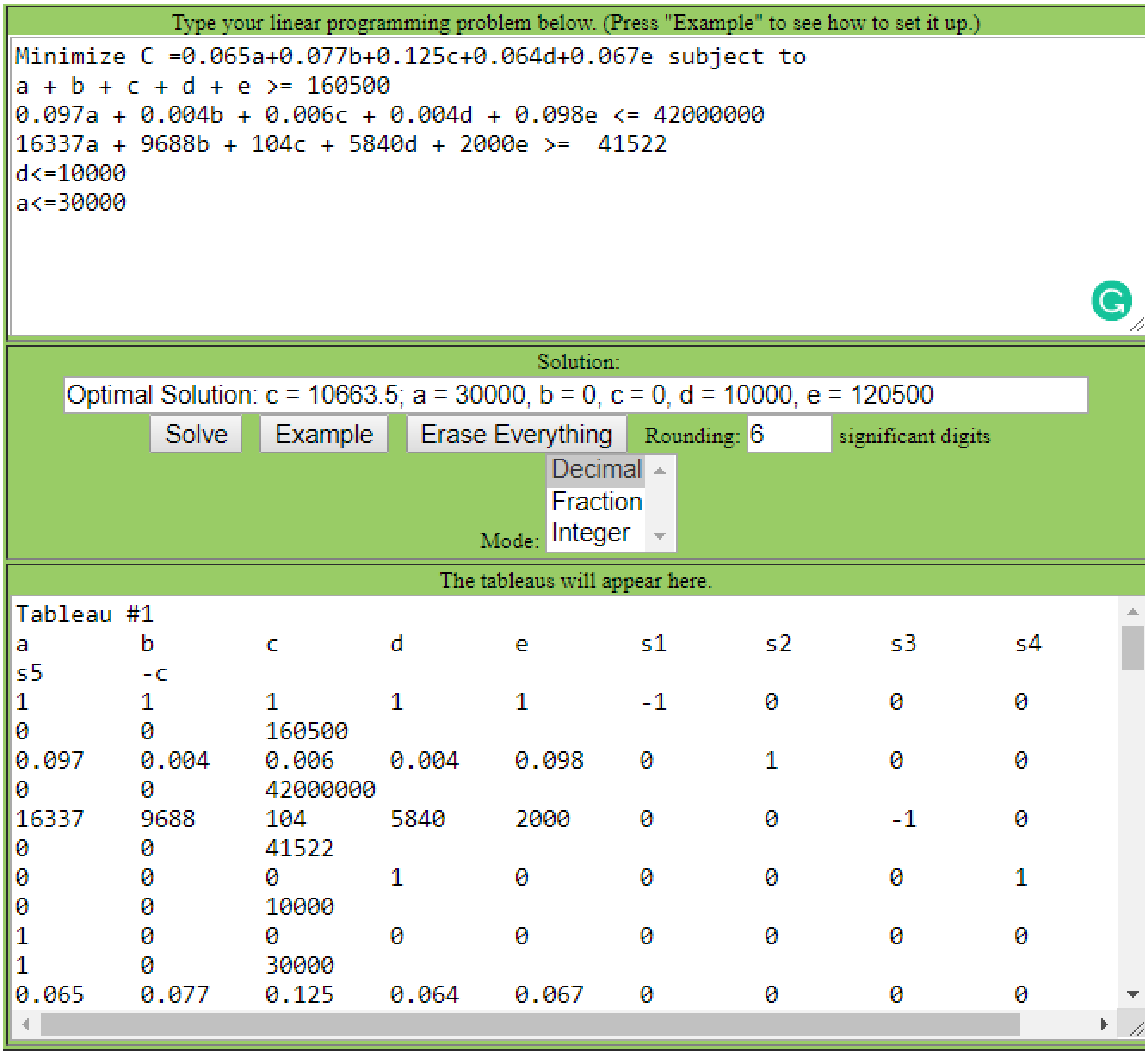
0.097a + 0.004b + 0.006c + 0.004d + 0.098e <= 42000000

16337a + 9688b + 104c + 5840d + 2000e >= 41522

d<=10000

a<=30000

Table 4 8

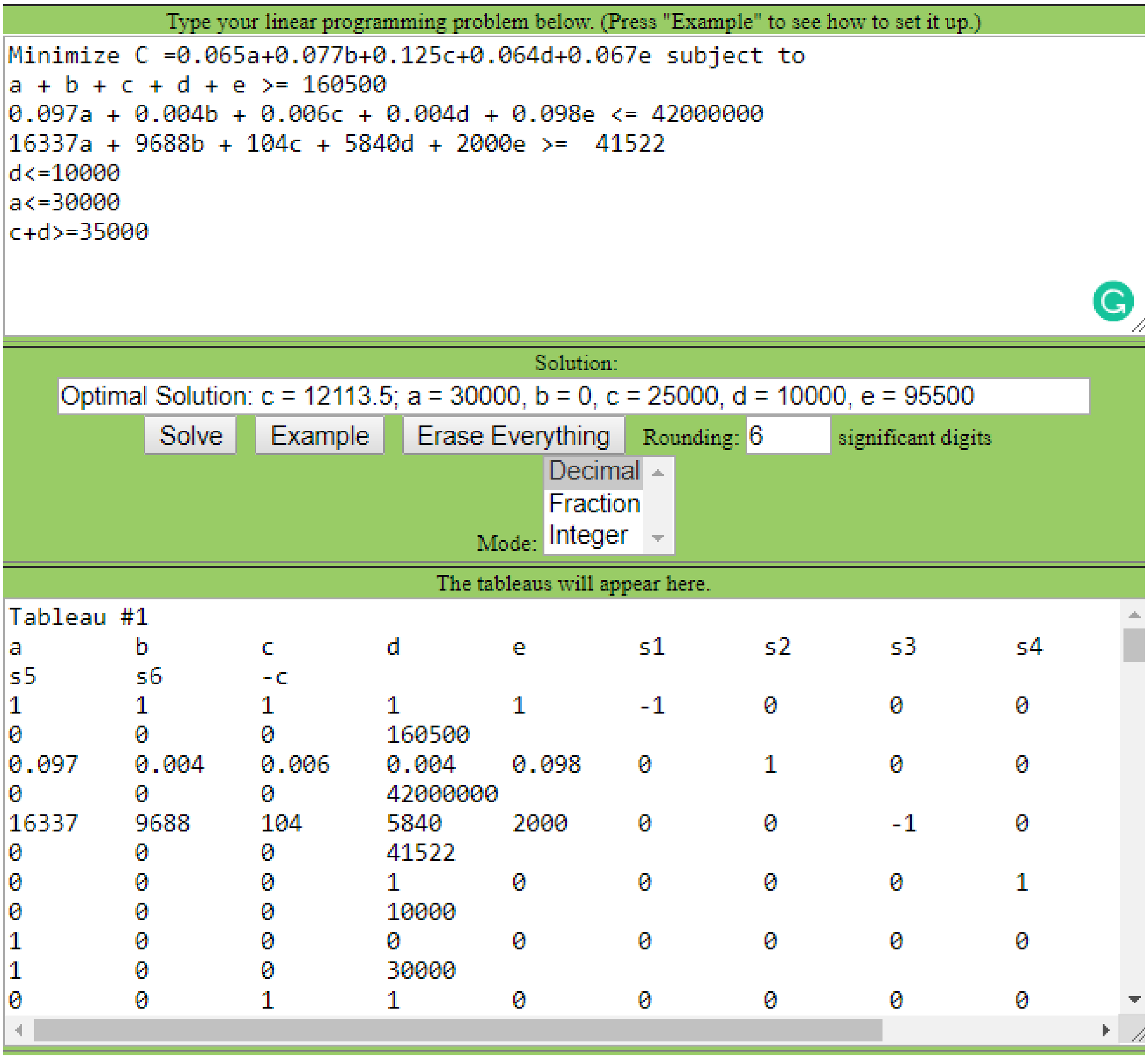


While increase in the amount of hydro to linear programme shows the maximum for production of Biomass energy. Well, in Sweden electricity from Biomass has significant amount but as per above result which is not optimal since it shows two main coefficients nuclear and solar out from the energy mix which is not thinkable for Sweden. In this case it is necessary to reproach new conditions here we can include all energy sources. In this case it is necessary to include nuclear power plant and hydro power to get the optimal solution.

Minimize C =0.065a+0.077b+0.125c+0.064d+0.067e subject to [IV]
a + b + c + d + e >= 160500
0.097a + 0.004b + 0.006c + 0.004d + 0.098e <= 42000000
16337a + 9688b + 104c + 5840d + 2000e >= 41522
d<=10000
a<=30000
c+d>=35000

To take solar and nuclear in the energy mix the amount of wind energy and solar energy has been increasing in an addition form to the 35000MWh.

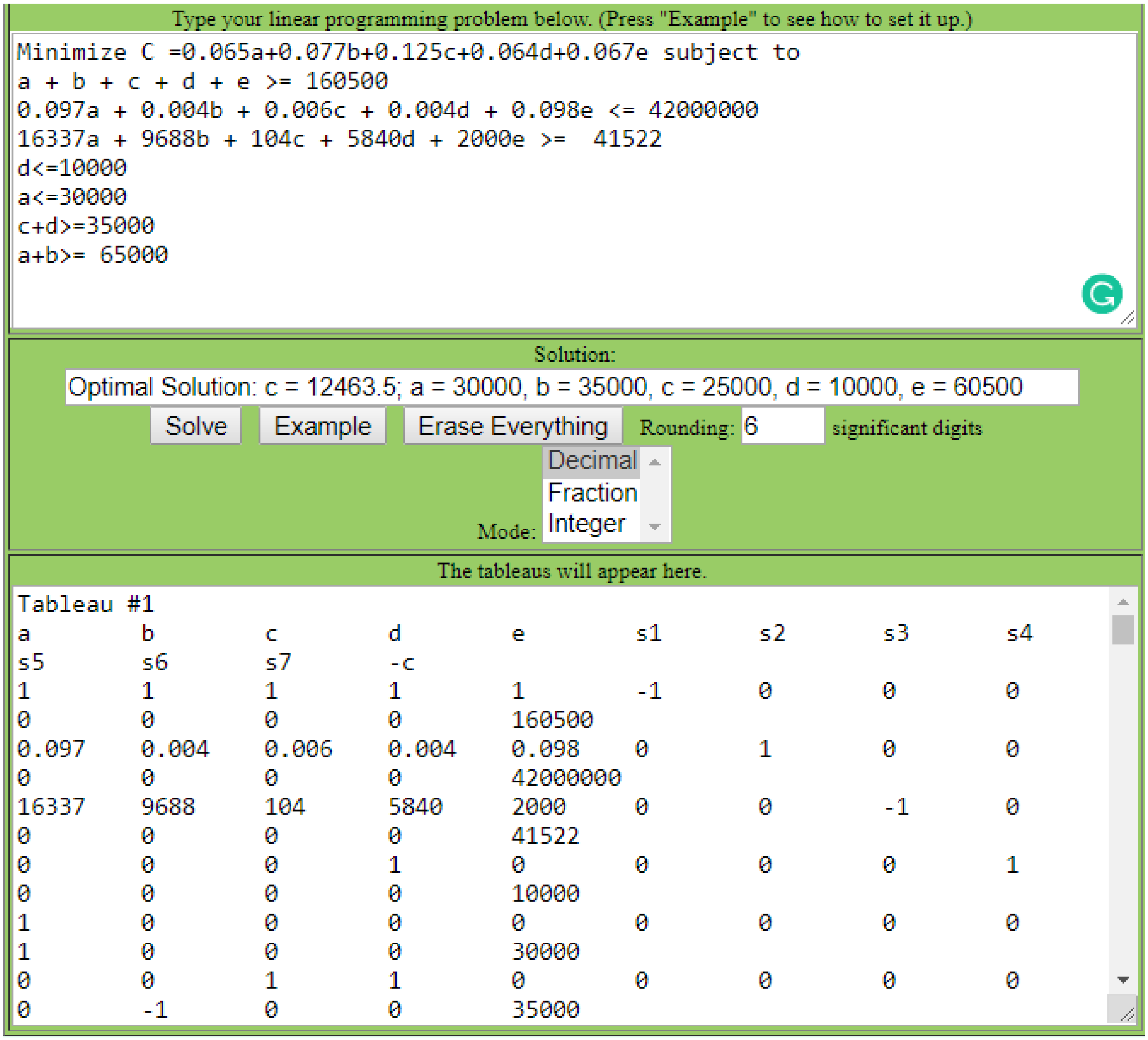
Table 4 9



This step remained the same level for hydropower and purposed wind power plant. While combined amount of 35,000MWh to the solar and wind power, it gives 95,500MWh to the solar and 25,000MWh to wind energy, since wind power plant has been set up for 10,000MWh. If the consideration of wind made nothing, the result shows same as a first step which is already not optimal solution. This purpose focus on Biomass energy however it did not include Nuclear power plant. As not included Nuclear power in the energy mix it is not optimal solution because Sweden has very significant amount of energy from Nuclear power plant. Sweden has three operative nuclear power plants, with ten operational nuclear reactors, which produce approximately 35-40% of the country's electricity. So, to include nuclear power plant in the it is necessary to reproach the conditions. Meanwhile Hydropower and Nuclear energy has huge significant role in the Swedish energy sector then it, we cannot exclude from the energy mix. In the meantime, it seems without inclusion of hydropower and Nuclear power, the Swedish energy cannot show the optimal solution. In the next step, a consideration has been made about Nuclear power plant and Hydropower to include all main energy sources in the renewable energy mix.

$$\text{Minimize } C = 0.065a+0.077b+0.125c+0.064d+0.067e \text{ subject to} \qquad [V]$$
$$a + b + c + d + e >= 160500$$
$$0.097a + 0.004b + 0.006c + 0.004d + 0.098e <= 42000000$$
$$16337a + 9688b + 104c + 5840d + 2000e >= 41522$$
$$d<=10000$$
$$a<=30000$$
$$c+d>=35000$$
$$a+b>= 65000$$

Table 4 10

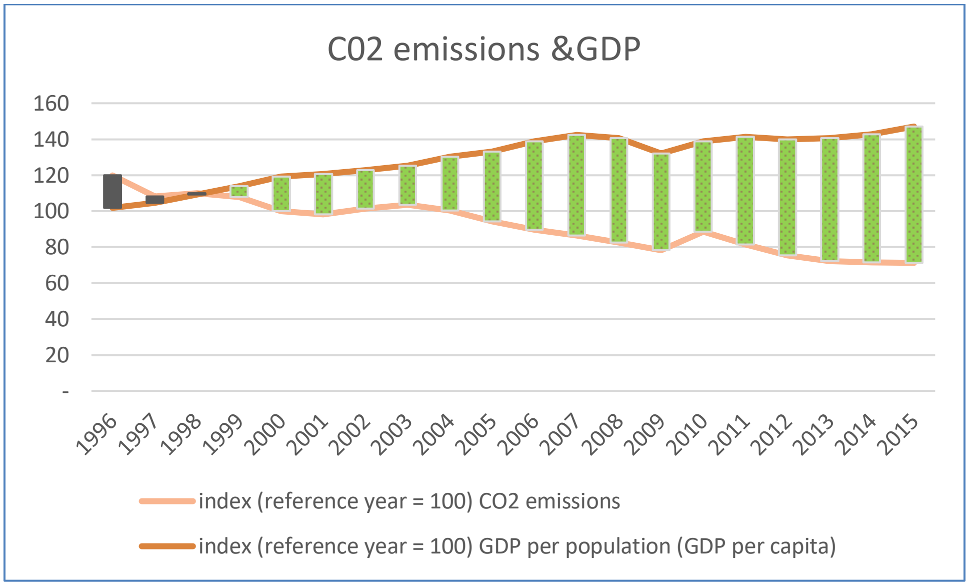


The optimal energy mix in this variant include all energy while some of the coefficient has been made constant to include all coefficients. Previous solution does not purpose the nuclear energy however in this solution, if Hydropower can produce 120,000MWh then the ability of Nuclear power could be 80,000MWh. The production of wind power remains the same as purposed in the 2nd equation and it suggest increasing the production of Biomass to make more cost efficient and optimal solution.

5 Presentation and analysis of result:

The government of Sweden in 2016 with most of the political parties, determined very crucial agreement on long-term energy policy. The arrangement involves of a roadmap for a revolution of the energy system as a target to reach 100% renewable electricity production latest by 2040. Also, with objectives to be net zero GHG emissions by 2045.

Figure 5 1 C02 emissions and GDP



Source: Own calculation based on data from empirical analysis

As per empirical analysis shows that it's not easy to achieve but if the growth goes little in high range there is not chance to not happen. Since the carbon tax was executed in 1991, the economy has grown up by 75% although the country's emissions decayed by 26% (Gray, 2018) (Government of Sweden, 2018). Hydropower is the major renewable electricity source in Sweden, trailed by wind and biomass. Not much upsurge in hydropower generation is expected, and also decided to close two nuclear reactors by 2020. Subsequently 2000, wind power has enlarged from 240 MW to 6 520 MW in 2017, conceded 10% of generation and is expected to increase much more.

6 Summary of finding and Discussion:

Constructionline of hydro, solar, biomass, wind or nuclear plants produces an insignificant carbon footprint in comparison with reserves from avoiding fossil fuels like coal, gas, oil and so on. It is happening in the market that, non-renewable energy producers complain and sometimes argue that nuclear, wind, hydro or solar power have a hidden carbon footprint, due to their production procedure and construction. Nuclear power is twice as good as coal, with the energy implanted in the power plant and fuel compensating 5% of its total output, equivalent to an EROI of 20:1., whereas EROI refers to Energy Return on Investment. Such as wind and solar perform even well, at 2% and 4% respectively, equivalent to EROIs of 44:1 and 26:1. If we more focus on the carbon emissions my research finds that the footprint of nuclear, wind and solar are much lower than coal and gas with CCS, as well as hydro or bioenergy, whereas CCS refers to carbon capture and storage, Also, my research found that decrease in carbon emission has direct opposite relation with the GDP growth of the nation. To reduce the carbon emissions, we must use renewable energy sources, Furthermore, if we have more manufacturing companies and factories or so on means we need more energy. Such as consuming more energy demands more production. And consumption has a direct relationship with the GDP of the nation. So more renewable energy consumption increases the GDP of the states. In the other hand, we are using the energy from non-renewable sources definitely decrease the amount of fossils fuels and mainly decreases the number of carbon emissions. It is true that renewable energy resources also produce carbon while manufacturing and construction of the power plant, however, this amount is comparatively low with the non-renewable energy sources. Progressively less energy will be accounted to produce solar modules, due to technological advancement and a modification on the road to less energy concentrated technology alternatives. At the same time, the global environment variation, the determination will diminish the CO_2 emissions per unit of electricity.

7 Conclusion and Recommendations:

The core aim of the thesis was to analyse the current energy mix from the economic and environmental standpoint. The result could be a good example to follow by other EU member states and the rest of the world. Based on the empirical analysis, it was supposed that the recent energy mix may be enhanced from the country economic side, and certainly have to be optimized from the environmental perspective. The optimized resolutions were projected by the use of the linear programming tool, and it demonstrates biomass energy as renewable as energy resources. Such energy mix meets the vision and conception of Sweden and transfers mainly on renewable resources that have the least emissions which are recommended as Biomass energy. There won't be any mistake to expect that even the technological level of the use of renewable resources will surpass in a few years, which will mechanically raise the installed renewable capacity and will be able to supplementary diminish the consumption of fossil fuels also means low GHG emissions. This thesis specified three research hypotheses: H1: More energy consumption per capita supports the economic growth of Sweden. H2: Renewable sources of energy such as Hydropower, the nuclear power plant is less harmful to the life of the human being compared to a non-renewable source of energy such as coal (in point of view from CO2 emission). H3: Increase in share of renewable energy impact on greenhouse gas emissions and climate change. For the first hypothesis, comparison analysis with Germany and Norway proves that an increase in the consumption of renewable energy source also increases the economy of the nation. In that comparison chart justify how Sweden grow their GDP along with energy sustainable development. Talking about the 2nd hypothesis, the kaya identify proves that the CO2 emissions level from renewable energy sources. As we know that CO2 contain carbon and carbon is harmful to human, animal and to the environment. While the decrease in CO2 emissions means an increase in RES. For the 3rd hypothesis, the creation of optimal energy models of energy mix answer. Meanwhile, the planned mix endorses the cheapest energy resources, the lower cost of producing electricity will be sufficiently replicated in the last price of electricity, which will also be lower. It also recommends the optimal solution for future perspectives of energy mainly from RES. The growing capacity of energy from renewable sources will not only help Sweden to happen its 100% renewable electricity and greenhouse gas emission targets but also emphasize the revolution into a sustainable economy. In the meantime, it has encouraging influences on the safety of energy supply and the incapacitating of the dependence on energy importations.

As recommendations, shall be summarized there should be constant growth rates, specifically with respect to the electricity sector. And support schemes in overall replicate and are implanted in an exact nationwide approach and involvement. Variety of technologies should be renovated and extended with new technology. About the Grid Issues, there is still a large lack of guaranteed admittance for RES importance communication, market strategy, grid advancement & optimization. Further encouragements for the strengthening of circulation grids, clear long-term policy instructions and goals for grid optimization and implementation with a strong collaboration between users and the RES industry is needed. Correspondingly, given the inter-relations among energy reserves, greenhouse gas emission drops and renewable energy, a binding goal for energy saving is crucial for sustainable energy forthcoming. However, the implementation of energy reserves has to be on the way in order to sustenance the timely fulfilment of the obligatory RES goals. For sustainable development of energy Renewable energy sources is the only way to go through since fossil fuels are harmful to the climate change and it is the era of fossil fuels ending.

8 Appendix:

8.1 Total energy supply commodity

Table 4 7 Total energy supply commodity

Total energy supply by energy commodity, from 1970, TWh

	Biomass[1]	Coal and coke	Crude oil and petroleum products[2]	Natural gas, gasworks gas	Other fuels	Nuclear fuel[3]	Primary heat[4]	Hydropower[5]	Wind power	Net electricity import
1970	43	18	336	0.0	0	0	0.0	41	0.0	4.0
1971	40	17	311	0.0	0	0	0.0	52	0.0	2.0
1972	40	17	317	0.0	0	4	0.0	54	0.0	1.0
1973	42	19	328	0.0	0	7	0.0	60	0.0	1.0
1974	44	21	292	0.0	0	6	0.0	57	0.0	3.0
1975	44	22	289	0.0	0	36	0.0	58	0.0	1.0
1976	43	21	317	0.0	0	48	0.0	55	0.0	2.0
1977	41	17	314	0.0	0	60	0.0	54	0.0	-2.0
1978	45	18	297	0.0	0	71	0.0	58	0.0	-1.0
1979	47	21	305	0.0	0	64	0.0	61	0.0	2.0
1980	48	19	275	0.0	0	76	1.0	59	0.0	1.0
1981	50	17	254	0.0	0	114	1.0	60	0.0	-3.0
1982	48	19	235	0.0	0	117	1.0	55	0.0	3.0
1983	52	25	202	0.0	2	124	0.7	64	0.0	4.9
1984	58	29	191	0.0	2	152	1.9	68	0.0	0.4
1985	61	36	200	0.8	3	173	3.2	71	0.0	-1.5
1986	61	35	200	2.3	4	202	5.3	61	0.0	-4.7
1987	61	34	196	3.2	4	200	6.9	72	0.0	-4.2
1988	63	32	196	4.0	4	207	6.9	70	0.0	-2.6
1989	62	31	189	5.4	5	196	6.8	72	0.0	-0.5
1990	61	32	168	6.7	5	202	7.1	73	0.0	-1.8
1991	64	29	170	7.2	7	228	7.4	63	0.0	-1.3
1992	65	28	165	8.1	7	188	6.9	74	0.0	-2.2
1993	68	28	161	8.0	7	182	7.2	75	0.0	-0.6
1994	72	28	171	7.9	7	217	6.9	59	0.1	0.3
1995	77	28	176	7.9	7	207	7.0	68	0.1	-1.7
1996	81	31	188	8.5	7	224	6.9	52	0.1	6.1
1997	83	26	174	8.4	7	206	6.1	69	0.2	-2.7
1998	82	25	176	8.7	9	218	7.4	75	0.3	-10.7
1999	83	25	174	8.3	7	213	7.5	72	0.4	-7.5
2000	84	24	168	8.1	7	168	7.5	79	0.5	4.7
2001	86	26	163	9.2	8	214	7.6	79	0.5	-7.3
2002	91	26	174	9.3	9	201	7.7	66	0.6	5.4
2003	96	26	174	10.3	10	200	6.6	53	0.6	12.8
2004	96	27	177	10.3	12	227	6.7	61	0.9	-2.1
2005	105	25	164	9.8	9	210	6.2	72	0.9	-7.4
2006	109	27	163	10.2	13	194	5.8	62	1.0	6.1
2007	113	26	148	10.5	14	191	5.8	66	1.4	1.3
2008	115	23	154	9.6	14	184	5.7	69	2.0	-2.0
2009	119	17	143	12.8	13	149	5.2	66	2.5	4.7
2010	128	24	157	17.2	14	166	5.4	67	3.5	2.1
2011	123	23	151	14	14	171	5	67	6	-7
2012	129	21	145	11.8	13	188	5.8	79	7.2	-19.6
2013	129	22	134	11	14	189	4	61	10	-10

Source: Swedish Energy Agency and Statistics Sweden.

Note: [1] Other fuels are included in biomass prior to 1983.

[2] International aviation included until 1989.

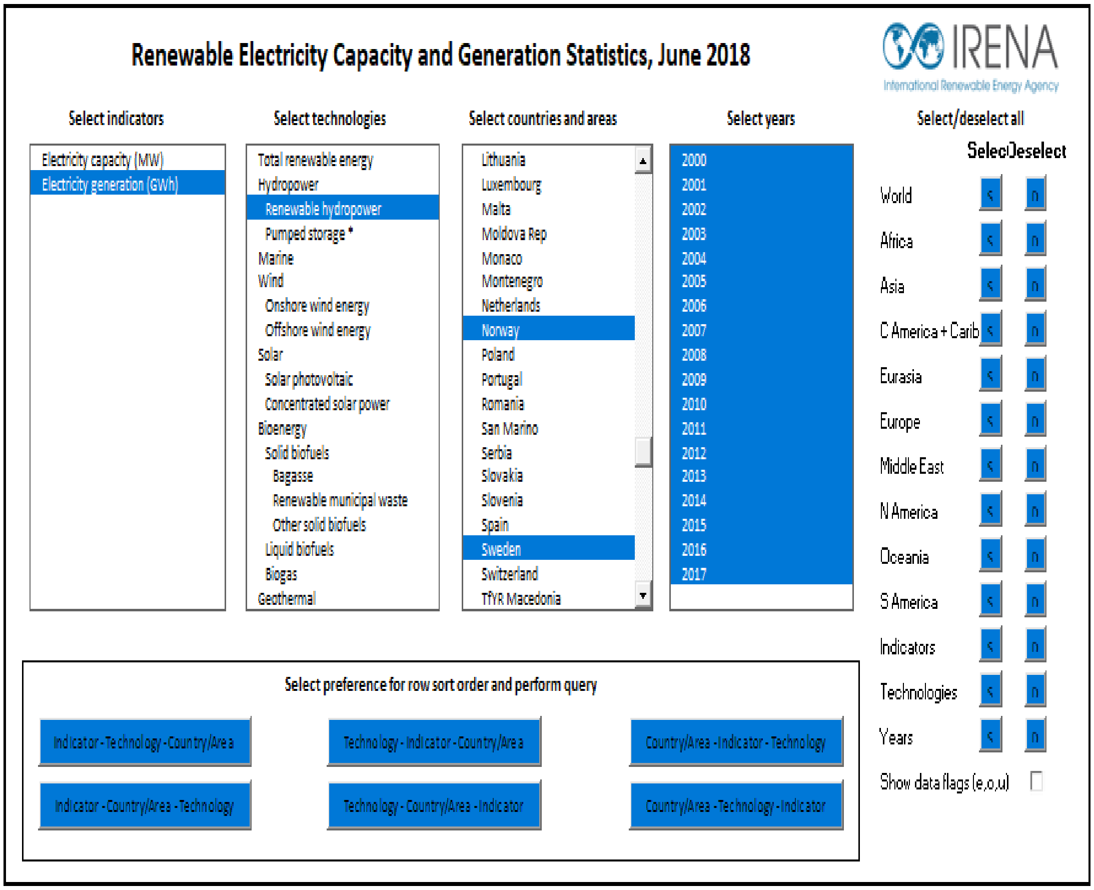
[3] Nuclear fuel is reported gross, i.e. as supplied nuclear fuel energy, in accordance with UNECE guidelines.

[4] Heat pumps in district heating plants.

[5] Including windpower until 1989

8.2 Renewable electricity capacity and generation

Table 4 8 Renewable electricity capacity and generation statistics



* Note: Pumped storage is included under the "Hydropower" category but not in the "Total renewable energy". Generation from mixed plants is split between hydropower and pumped storage as appropriate.

8.3 Renewable energy production mix

Table 4 9 Renewable energy production mix

Renewable Energy Production mix (http://www.tsp-data-portal.org/all-datasets)							
	a	b	c	d	e	f	h
Year/Sources	Hydro	Nuclear	Biodiesel	Biomass ar	Solar, Tide	Wind Elec	Total
1994	58.50800058	210.6000021	-	2.283	0.001	0.072	271.464
1995	67.42100066	201.3272747	-	2.424	0.001	0.099	271.2723
1996	51.2226005	213.8181839	-	2.192	0.001	0.144	267.3778
1997	68.36500067	201.3090929	-	2.835	0.001	0.203	272.7131
1998	74.25000073	211.8303051	-	3.042	0.001	0.317	289.4403
1999	70.9740007	210.6939415	-	2.882	0.001	0.358	284.9089
2000	77.79800077	165.0000016	-	4.342	0.001	0.457	247.598
2001	78.26900077	207.5878808	0.0298994	4.021	0.002	0.482	290.3918
2002	65.69600065	196.0757595	0.0298994	4.439	0.002	0.608	266.8507
2003	53.00500052	194.0727292	0.0398658	4.836	0.002	0.679	252.6346
2004	59.52200059	227.8123356	0.0996645	7.9990001	0.002	0.85	296.285
2005	72.07500071	210.8384566	0.0996645	8.3570001	0.002	0.936	292.3081
2006	61.1060006	197.1331232	0.4983226	9.3550001	0.002	0.987	269.0814
2007	65.49700064	194.950911	1.0963096	10.656	0.003	1.43	273.6332
2008	68.37800067	185.8662746	1.3953032	11.225	0.004	1.996	268.8646
2009	65.19300064	151.633153	1.744129	12.209	0.007	2.485	233.2713
2010	65.73400065	168.8804562	1.9932903	13.397	0.009	3.502	253.5157
2011	65.77000065	176.0558502	2.4916128	11.883	0.011	6.0830001	262.2945
2012	78.14300077	186.2848503	2.8705234	11.64	0.019	7.1650001	286.1224
2013	60.9660006	193.101214	3.1952551	11.97325	0.0319922	9.1604034	278.4281
2014	60.6620006	188.765818	2.884419	11.97325	0.0580898	10.161881	274.5055
Cost E/MWh	**65**	**77**			**125**	**64**	**331**

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