MSc Program
Environmental Technology & International Affairs

Paying back our Balance: Can Advantages in renewable Energy play a leading Role in offsetting anthropogenic Sources for Climate change

A Master's Thesis submitted for the degree of
"Master of Science"

supervised by
em. Univ.-Prof. Dr. Günther Brauner

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Vienna, 01.06.2017

Affidavit

I, **STEFANIE VALCHEVA**, hereby declare

1. that I am the sole author of the present Master's Thesis, "PAYING BACK OUR BALANCE. CAN ADVANCES IN RENEWABLE ENERGY PLAY A LEADING ROLE IN OFFSETTING ANTHROPOGENIC SOURCES OF CLIMATE CHANGE", 62 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted this Master's Thesis as an examination paper in any form in Austria or abroad.

Vienna, 01.06.2017

Signature

Abstract

The overwhelming majority of climate scientists agree that human activities, especially the combustion of fossil fuels, such as coal, oil, and gas, increasingly contribute to the change of the climate currently observed. Moreover, they are confident that global temperatures will continue to rise for decades to come posing a threat to flora, fauna, and humankind. Anthropogenic greenhouse gas emissions are currently higher than ever and the largest single source of global emissions is the energy sector. Therefore, one of the most effective ways to combat human-induced climate change is through the application of alternative sources of energy, such as solar, wind, and hydro power. The European Union had recognised this and requested in 2009 its member states to develop National Renewable Energy Action Plans (NREAP) explaining how each country expects to reach its legally binding 2020 target. The overall EU target for renewable energy use by the year 2020 is 20%. The paper looks closely into the potential and objectives of three European countries – Norway, Spain, and Cyprus - investigating their individual strategies for reaching their commitments. Notwithstanding the apparent moderate progression in efficiency technology and cost effectiveness, renewable energies have the potential to mitigate greenhouse gas emissions, thus counterbalancing anthropogenic changes to the global climate, contributing to social and economic development and moving each country toward a clean energy future.

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List of Abbreviations

AC	Alternating Current
AGU	American Geophysical Union
AMS	American Meteorological Society
CH4	Methane
CFCs	Chlorofluorocarbons
CO_2	Carbon Dioxide
CHP	Combined Heat and Power
CIE	Cyprus Institute of Energy
CERA	Cyprus Regulatory Authority
EEA	European Economic Area (EU + Iceland, Lichtenstein, and Norway)
EGS	Enhanced Geothermal Systems
EU	European Union
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GGEAT	Greenhouse Gas Emission Allowance Trading
GW	Gigawatt
IPCC	The Intergovernmental Panel on Climate Change
ktoe	Kilotonne of oil equivalent
N_2O	Nitrous oxide
NREAP	National Renewable Energy Action
PV	Photovoltaics
REP	Renewable Energy Plan
RE	Renewable Energy
RES	Renewable Energy Sources
Rpm	Revolutions per minute
SF_6	Sulfur hexafluoride
TWh	Terawatt-hours
UNFCCC	United Nations Framework on Climate Change
WEC	Wave Energy Converter

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Furthermore, I must also express my very profound gratitude to my family for providing me with unfailing, never ending support and continuous encouragement throughout all my years of study, as well as, through the process of researching and writing this thesis. This accomplishment would not have been possible without them. Thank you.

Last but not least, thank you to Michael without whom this all would not have worked out in the first place.

Introduction

Considered by the world's leading scientific community as one of the greatest challenges of our time, climate change represents a catastrophic threat to the human civilization. Researchers continue to provide scientific evidence that human activities are, indeed, causing changes in the Earth's temperature, atmosphere, in the amounts of greenhouse gases, aerosols, and cloudiness. According to the 2014 IPCC report on Climate Change, anthropogenic greenhouse gas emissions are currently higher than ever and have been increasing since the pre-industrial era, driven largely by economic and population growth. Scientists are calling for drastic measures in order to reduce greenhouse gas emissions, and urge countries and their policymakers to take immediate steps towards adopting specific targets for climate change mitigation.

In order to be able to radically tackle the emissions of greenhouse gases, it is evident that the primary target should be the energy sector, as it is the largest single source of global emissions. Since the 1850^{s}, the use of fossil fuels has increased and demand for energy to meet basic human needs is constantly rising. The crisis caused by overuse of fossil fuels is changing the natural balance of the planet. Therefore, scientists strongly encourage the application and further development of alternative sources of energy. Besides having the potential to mitigate climate change, renewable energy technologies—such as solar power, wind power, hydroelectricity, biomass and biofuels for transportation—can provide wider benefits. If applied and implemented properly, these technologies can contribute to social and economic development and a secure energy supply, as well as reduce negative impacts on the environment and health. Decreased dependence on fossil fuels aside, renewable energies offer a way to diversity global power supply and have the potential to move each country toward a clean energy future.

Research Objectives

This thesis seeks to shed light on the following research question: **Can the advances in renewable energy play a leading role in offsetting anthropogenic sources for climate change?**

In order to answer the central question, the paper will investigate and provide the reader with a more nuanced and objective picture of the holy grail of the climate change debate, as well as, on the observed climate change effects, their possible causes and consequences.

Renewable energy is expected to change the energy business as we know it. It is therefore essential to not only understand it but also to observe recent developments, which underpin the progress and application of these technologies and their potential to deliver a sustainable future.

Structure and Methodology

The first part of the thesis will concentrate on explaining the concept about climate change. Global warming is a fact, but what are the different opinions on what's causing the rise of the temperature and who can be held responsible? After a thorough literature review, several hypotheses will be presented and discussed. It is essential to note that the temperature change itself is not the most severe effect of the changing climate. Alteration in precipitation patterns and sea levels are expected to have a much greater impact than the increased temperatures alone. Thus, the scientific research on climate change involves far more than simply changes in the temperature of the surface. Climate change has already had observable effects on the environment as a whole; before focusing on some of the world's most pressing environmental challenges, the author will elaborate on the impacts of climate change on humans (health implications), the society (climate change refugees), and the economy.

Scientists are confident that global temperatures will continue to rise for decades to come and therefore insist for urgent action to combat climate change. Arguably, one of the most effective ways is through the application of alternative sources of energy. Therefore, the second part of the thesis is devoted to several different types of renewable energies, such as solar, wind, marine and hydro power, and the key benefits of their application. Moreover, the author will evaluate different factors, such as performance, energy efficiency, finance, safety, pollution, etc. for meeting consumer's needs, as well as environmental concerns.

The third part of the thesis will present several case studies based on the National Renewable Energy Action Plan 2010 (NREAP) under Directive 2009/28/EC of the European Parliament and of the Council. Individual EU and EEA states have different available resources and their own unique energy markets. Furthermore, depending on their geographic location, each country has different needs that should be taken into an account, e.g. a southern European country like Cyprus require specific architectural design, as well as increased energy consumption in order to cool buildings and households during summertime. Reversed is the situation in a northern European county such as Norway – enormous energy consumption to warm households in the colder months. Central European countries, on the other hand, must be able to provide for both.

This means that these countries will have to follow distinctive paths when it comes to meeting their obligations under the Renewable Energy Directive, including their legally binding 2020 targets. The control of European energy consumption and the increased use of energy from renewable sources, together with energy savings and increased energy efficiency, represent substantial parts of the package of measures needed to reduce greenhouse gas emissions and thus comply with the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC). Those components also play an important part in promoting the security of energy supply, technological development and innovation, providing opportunities for employment and regional development. In order to reduce greenhouse gas emissions within the European community and reduce its dependence on energy imports, the development of energy from renewable sources should be closely linked to increased energy efficiency.

The case studies on three European countries – Norway, Spain, and Cyprus will look into the potentials, strategies and objectives on how each of them is planning on reaching the individual commitments for 2020. By applying a mix of different renewables technologies and policy measures on local, regional, and national level, it is aimed at reducing the manmade sources for climate change.

The author of the thesis will utilize both quantitative and qualitative techniques when conducting research. In quantitative research, an investigator relies on numerical data

and qualitative research emphasizes words, rather than quantification in the collection and analysis of data[1]. The needed data and information will be gathered primarily through secondary sources: textbooks, environmental treaties, journal articles, and case studies. Furthermore, a literature study of magazines and legitimate Internet sources regarding the chain of recent events that have happened and are in the process of happening will be conducted to provide current theoretical framework for the study.

Part I: Climate Change

Earth's climate is a product of interactions between sunlight, the atmosphere, and the oceans. There is a climate change when alteration of long-term weather pattern of a region occurs. An example is through temperature change, changes in wind pattern and average temperature[2]. The result may affect one region or a large area. A change of energy within the Earth's atmosphere also causes climatic change. It is then spread around the world through ocean currents as well as weather patterns and the wind thus affecting different region's climate. Other contributing causes of climate change are natural processes like variations in the sun's intensity or volcanic eruptions, human activities such as cutting and burning trees (deforestation) and emission of greenhouse gasses (GHG)[3]. Greenhouse gasses, such as CO_2, CH_4, N_2O, CFC, SF_6, are group of compounds which are able to trap heat in the atmosphere, thus keeping the Earth's surface warmer[4]. An increase in the amount of GHG in the atmosphere magnifies the greenhouse effect which is creating global warming and consequently a change of the climate. Even though CO_2 is the primary GHG emitted through human activity and the most important contributor to the change of the climate, emission reduction efforts and measures should not focus on carbon dioxide only, since the rest of the gases are generally much stronger climate forcing agents than CO_2. For example, nitrous oxide (N_2O) has 300 times the global warming potential compared to CO_2, therefore, it is important despite lower concentrations.

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[1] Charles, et al. 2002.
[2] Lazarus, Richard J. *"Super wicked problems and climate change: Restraining the present to liberate the future."* Cornell L. Rev. 94 (2008), 1153.
[3] Ibid., 1153.
[4] Allison, Ian. 2010. *"The science of climate change: questions and answers."* Canberra: Australian Academy of Science.

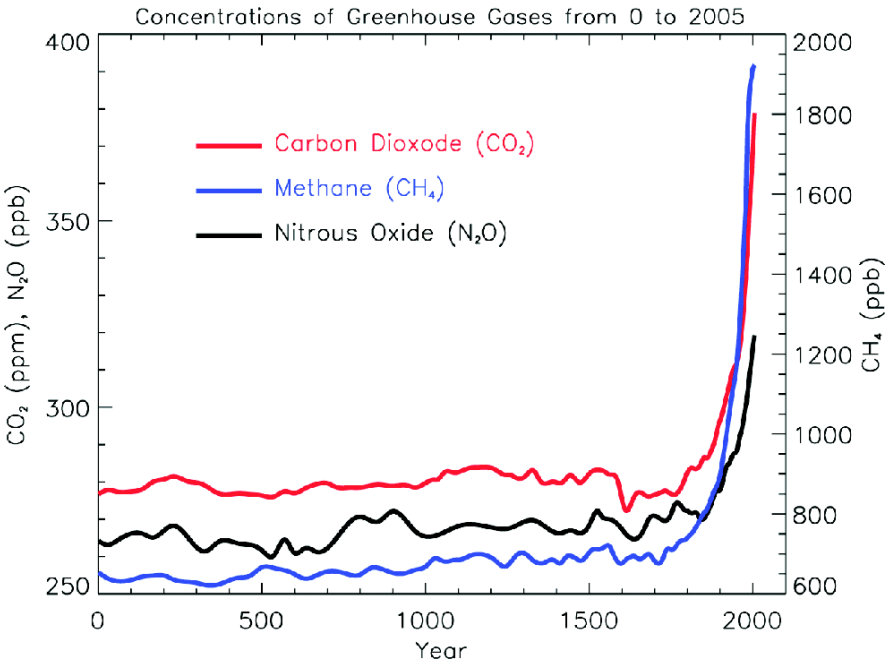

Figure 1: Greenhouse gas concentrations for 2,000 years. Data retrieved during analysis of air bubbles trapped in Antarctic ice cores.[5]

Methane

In addition to that, the different emissions of greenhouse gases from the agricultural sector or factories also lead to a steady rise in temperature thus emitting either of the greenhouse gases. One of the greenhouse gases that causes rise in temperature is methane (CH_4). In the fields where agricultural practices occur, there is usually bacteria which breaks down and decomposes organic matter under conditions where there is starved oxygen. The decomposition produces methane in the air. Another source of methane in the agricultural sector is when the livestock population is increased and concentrated; methane is released from the herbivorous animals specifically in their intestines[6]. Therefore, scientists increasingly insist for a dietary change and a reduction in meat consumption, or at least for red meat to be substituted by poultry due to their minimal methane release (see figure below). Lastly, another source of methane in the agricultural sector is the clathrate. The ice crystal structure contains large amount of methane to form a compound called clathrate. Clathrate

[5] Division on Earth and Life Studies. 2012. "Climate Change: Evidence, Impacts, and Choices." National Research Council. *The National Academics Press*. p. 7
[6] Croitor, Roman, and Jean Philippe Brugal. 2010. "Ecological and Evolutionary Dynamics of the Carnivore Community in Europe during the Last 3 Million Years." *Quaternary International* 212 (2): 98–108.

when emitted, it releases methane which causes a rise in temperature. Release of methane in the air causes greenhouse effect hence leading to a steady rise in temperature.

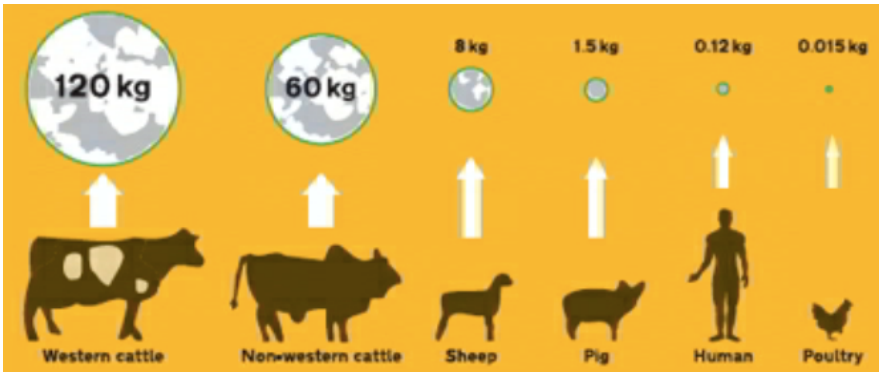

Figure 2: Methane emission per animal / human per year.[7]

Aerosols

The atmosphere also contains aerosols that alter the temperature of the Earth in many different ways as well. The two major ways in which they do that is by absorbing or scattering the radiation of the sun. The clouds can also be altered by the aerosols where their chemical and physical properties are changed. The clouds cool the air and the surface of the Earth by scattering the solar radiation and rays. This is contrary to the aerosol sprays where they absorb the sunlight rays, warming up directly the air hence the rise in temperature of the Earth. The parties that propel the release of the colossal amounts of aerosols in the air are: in the farming sector, animal waste applied in the production of biomass, in the production of power and electricity[8]. The burning of biomass results into production of various organic droplets. Additionally, in the transport sector, the emissions from the exhaust of the various machinery leads to an increased production of pollutants. The pollutants that are generated can either be aerosols or the pollutants emitted in the air are later transformed to form aerosols in which the conversion occurs due to various chemical reactions[9].

[7] NASA's Goddard Institute for Space Science & https://www.worldfuturecouncil.org/how-does-agriculture-contribute-to-climate-change/
[8] Maher et al. 2010. "Global Connections between Aeolian Dust, Climate and Ocean Biogeochemistry at the Present Day and at the Last Glacial Maximum." *Earth-Science Reviews*.
[9] Ibid.

Sunspots

Elimination of the sunspots also increases the rise of average temperature of the Earth. Sunspots are darker, cooler areas on the surface of the sun in a region called the photosphere. The photosphere has a temperature of 5,800 K and sunspots have temperatures of about 3,800 K. Some studies show that sunspot activity has doubled in the last century. The apparent result down here on Earth is that the sun shines brighter by about 0.1 percent now compared to 100 years ago[10]. The plasma of the hot solar is blocked by the dark spots. Faculae, the part surrounding the dark spots, emit more solar radiation and are more powerful. Hence, there is generally a rise in temperature of the Earth.

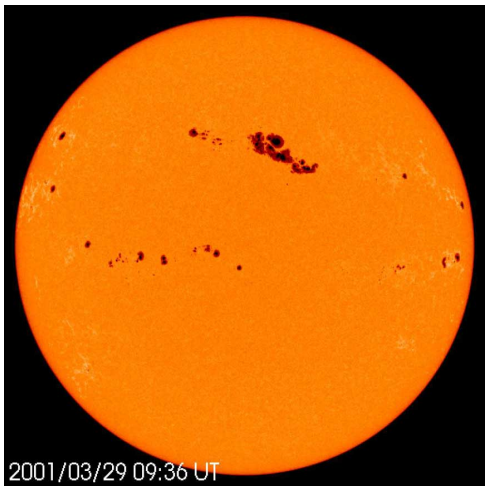

Figure 3: Sunspots.[11]

However, scientists also admit that they have a lot to learn about natural phenomena like sunspots and solar wind (wind coming from the sun and influencing galactic rays which may affect e.g. the cloud cover of the Earth). Some sceptics of the theory about man-made climate change insist global warming is caused namely by these natural variations in the sun's output and perceive any form of control and regulation of carbon emissions as pointless attempt with rather negative consequences for the global economy.

[10] E/The Environmental Magazine. *"The Role of Sunspots and Solar Winds in Climate Change."*
[11] NASA. 2003. https://www.nasa.gov/centers/goddard/news/topstory/2003/0313irradiance.html

1. Scientific Opinions and Hypotheses

National and international scientific groups have issued statements both detailing and summarizing the current state of scientific knowledge on the Earth's climate. To start with, the American Geophysical Union (AGU) says that the Earth's climate is changing as a result of human activities[12]. It continues to expound that there is increased emission of carbon dioxide (CO_2) and greenhouse gasses (GHG) from the beginning of Industrial Revolution. From years 1000 to 1800, the atmospheric carbon dioxide (CO_2) averaged 280 ppm. But since the beginning of the Industrial Revolution in 1800, the level of atmospheric carbon dioxide (CO_2) has risen from about 280 ppm to about 390 ppm in 2011, a 40% increase[13]. These gasses are the main causes of the increased surface warming over the past 150 years[14]. While there are doubts of impacts to be experienced, there are no suspicions that could make results of climate change insignificant. Additionally, surprise outcomes may cause even further dramatic changes than expected.

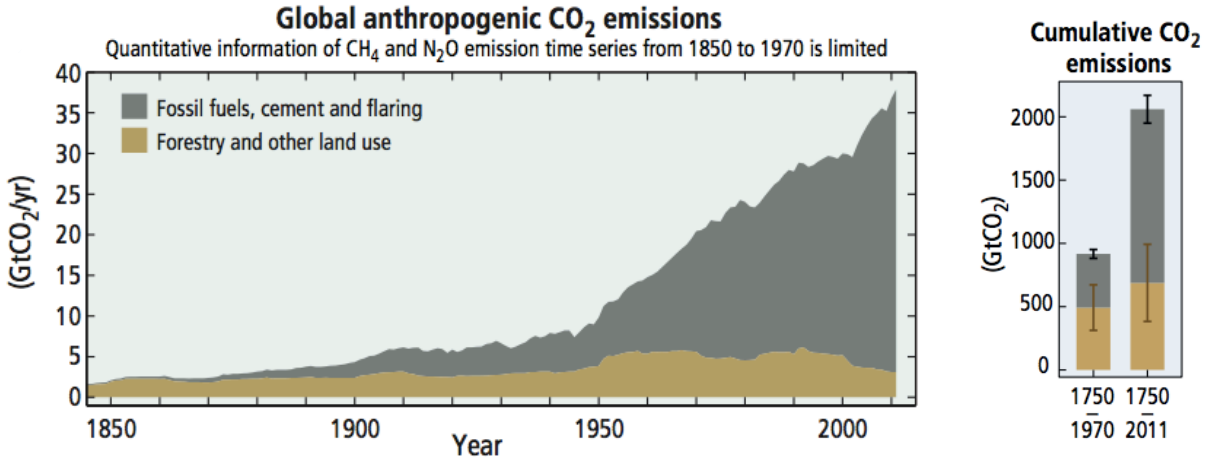

Figure 4: Global anthropogenic CO2 emissions from forestry and other land use as well as from burning of fossil fuel, cement production and flaring.[15]

Another scientific organization that has declared its position on global warming is the Geological Society of London. In its report, it states that for the past century there has

[12] Intergovernmental Panel on Climate Change. 2014. *"Climate Change 2014–Impacts, Adaptation and Vulnerability: Regional Aspects."* Cambridge University Press, 13.
[13] Timberlake, Karen & Timberlake William. 2014. *"Basic Chemistry".* Pearson New International Edition. p 95
[14] Ibid., 15.
[15] IPCC. 2014: "*Climate Change 2014: Synthesis Report".*

been an increase in the growth of human population leading to further increase in utilization of resources[16]. This has raised the rate at which gasses like methane (CH_4) and carbon dioxide (CO_2) from the burning of fossils, cement production, agriculture, and deforestation are emitted in the atmosphere. It further adds to the evidence from geological records which are in agreement with the physics that explains the effects of addition of large amounts of carbon dioxide (CO_2) to the atmosphere warms the world with a probability of leading to floods on the low-lying costs rising sea levels and change in rainfall patterns[17]. Geological Society of London is worried that the Earth's climate will warm further because of the further increase in human population thus posing a great challenge to the condition. This means that an increase in human population will lead to an increase in the climate change. Earlier before the increase in human population, an increase in sea level had a slight effect on Homo sapiens[18]. This will be contrary to the state at the moment because we have an increased population in the coastal cities at the moment especially if climate change could happen suddenly. Equally, climate change makes some areas to experience less precipitation which leads to drought. There will be a large scale result of human migration due to both increasing drought and rising seas.

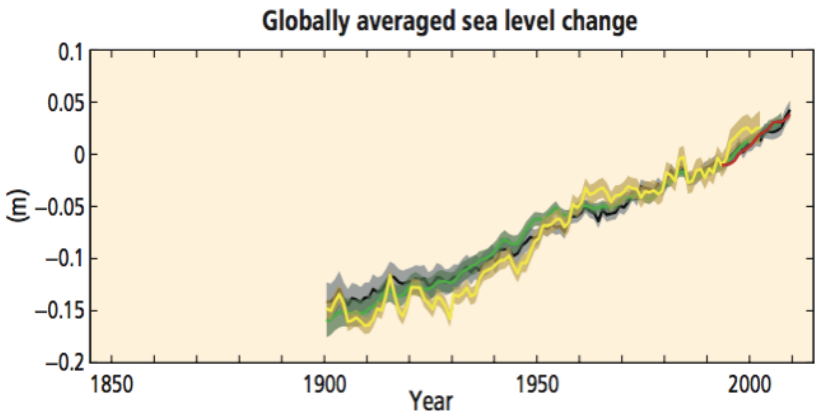

Figure 5: Annually and globally averaged sea level change.[19]

In addition to those two scientific organizations is American Meteorological Society (AMS) which also came out with its opinion on climatic change. It is highlighted in the

[16] Ibid., 16.
[17] Ibid., 17.
[18] Ibid. 19.
[19] IPCC. 2014: "*Climate Change 2014: Synthesis Report.*"

statement adopted by its Council in 2012 and stated about the availability of evidence on climate change which is mainly caused by human activities[20]. It continues explaining that the available scientific evidence is based on reliable research and that the climate change being experienced at the moment will be irreversible for years to come as more greenhouse gasses is continuously released to the atmosphere. Furthermore, this continuous climatic change will increase stress and risks to human societies, ecosystems, economies and wildlife in the course of the 21st century and more decades to come making it crucial that the society has to respond to climate change[21].

2. Impacts of Climate Change

2.1. Humans

The continuous change in climate has resulted into permanent alterations to the normal livelihood of the humans, who are not only affected health-wise but also minimizing their lifespan[22]. There are various implications of climate change, and they include effects on health, food consumed, water, energy sources, weather, and the loss of biodiversity.

The major implication of climate change is the health of humans, which will deteriorate over time as climate change continues[23]. Human health dwells best under suitable conditions. Through increasing change of the climate, the survival conditions are affected and thus affecting the health of humans. This could be through the depletion of the Ozone layer and the evolution of resistant diseases. For this reason, climate change results in high mortality rates that are caused by resistant diseases and heat waves problems due to increased temperatures. On the other hand, change of the climate also affects the food consumed and causes water pollution thus, resulting into high malnutrition cases and the infection of body organs.

[20] Oreskes, Naomi. 2004. "The scientific consensus on climate change." *Science* 306 (5702), 1686.
[21] Ibid., 1686.
[22] Adelman, Sam, and Mary Robinson. 2014. *"Human health and change in Climate: The impact of climate change on the dominant discourse."* Human Rights and Climate Change, 159-180.
[23] Ibid

In addition, research has indicated that climate changes may lead to increased effect on human mental health[24]. The fact that individuals may lose their homes and assets through floods and storms may be a cause of post-traumatic stress, thus affecting their mental health. In conclusion, the increasing effects of climate change will result in health problems, the loss of biodiversity, and natural resources that humans depend on. Therefore, the survival of humans requires a proper ecological system with proper climatic conditions.

2.2. Society

Climate change has led to high rise in temperature, a low humidity and low precipitation level, leading to no rain forming clouds hence desertification of a place. Prolonged droughts in area have led to people suffering and lacking the basic human needs such as clean water and food. Thus, people are forced to leave their homeland and end up becoming climate change refugees. What is more, climate change may also cause natural disasters and calamities such as floods and hurricane sandy. Such calamity leads to destruction of personal property, such as housing, in a large scale of land which evidently leads to displacement of people seeking shelter somewhere else.

2.3. Economy

Climate change is also a propelling factor in the loss of productivity in the agricultural sector, transport sector and business sector. The high temperatures brought about by the climate may hinder certain crops that need favourable cool and wet conditions for proper growth to maturity and high yielding[25]. Harvesting and planting of such crops is also inhibited. Also loss of productivity is experienced in the transportation sector and business sector where extreme weather conditions can inhibit and hinder the daily work and jobs taken by people. This therefore results to loss of the economy impacted by the climate change.

Climate change also leads to government incurring costs on refugees, security and migration funds needed. Climate change leads to drought on a large scale area and

[24] Ibid
[25] Sakata et al. 2010

people. Prolonged drought in an area leads to migration of people to a place with more conducive environmental conditions and this might be seeking refuge in another country. The country which has received immigrants will have to incur costs on developing security around the borders of the nation and also the nation would have also had to incur costs on funding the people on feeding programs.

Climate change leads to destruction of various natural plants and also natural habitation. The natural ecosystems that have been destroyed are valuable factors in the economy. The high rise in temperature and increase in the percentage of carbon in the atmosphere has enhanced the devastation of plants hence reduction on exportation products thus the state or nation is prone to economic losses due to drop in profits.

3. Current Issues

3.1. Climate Change and Russia

Russia experiences imbalance rainfall among other weather phenomena in the form of drought, floods, rapid frosts, heat waves, heavy snowfalls, and tornados. These events pose a great impact on the country's economy. This is in accordance to the research report in 2013 which came out with a suggestion that, without sufficient actions to adjust agriculture to climate change that leads to a decrease in yields, the cost of the produce will increase from RUB 109 billion 2020 to 121 billion in 2050[26]. Also, the melting of permafrost (the thick subsurface layer of soil that remains below freezing point throughout the year) in the northern region of Russia, a result of climate change, leads to infrastructure issues and a need for construction of pipelines, gas, and roads. While the greater part of northern Russia is entirely rural, it produces about 75 percent of Russia's oil and about 90 percent of natural gas[27]. Therefore, even if this melting does not affect a greater part of Russia's population, this continuous melting of the permafrost will affect Russia's ability to extract. Russia's annual expenditure on

[26] Stern, Nicholas. 2014. *"What is the economics of climate change?"* World Economics-Henley On Thames. 7 (2), 2.
[27] Ibid., 3.

maintenance of the pipelines has increased gradually from 1.9 billion in 2010, and it is expected to increase more in future as the universal temperature rises[28].

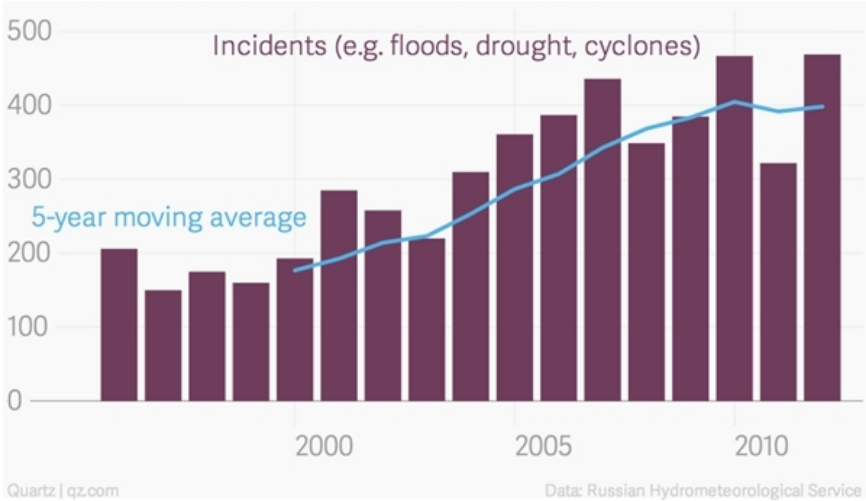

Figure 6: Dangerous extreme weather on the rise in Russia.[29]

There are also suggestions that climate change and the increase in temperature will have some positive impacts on Russia. These benefits are anticipated to come from the Arctic region. The melting of the Arctic's sea ice will lead to improvement in the navigation of sea lanes[30]. In addition to that, an increase in global temperature will reduce the cost of supplying heat to people who live in isolated regions. Others hold that an increase in temperature rising through climate change will impact positively on Russia's agriculture. Research by Illinois University suggests that climate change will result in an increase in Russia's arable land by 40 to 70 percent[31]. Despite the fact that this may sound promising, the existing agricultural system of Russia may not be able to take advantages of these promising gains.

[28] Ibid., 4.
[29] Tekeeva, Khalimat. 2016. *"Wildfires in Russia: Much Worse Than You Could Imagine"*
[30] Ibid., 5.
[31] Ibid., 5.

3.2. Climate Change and China

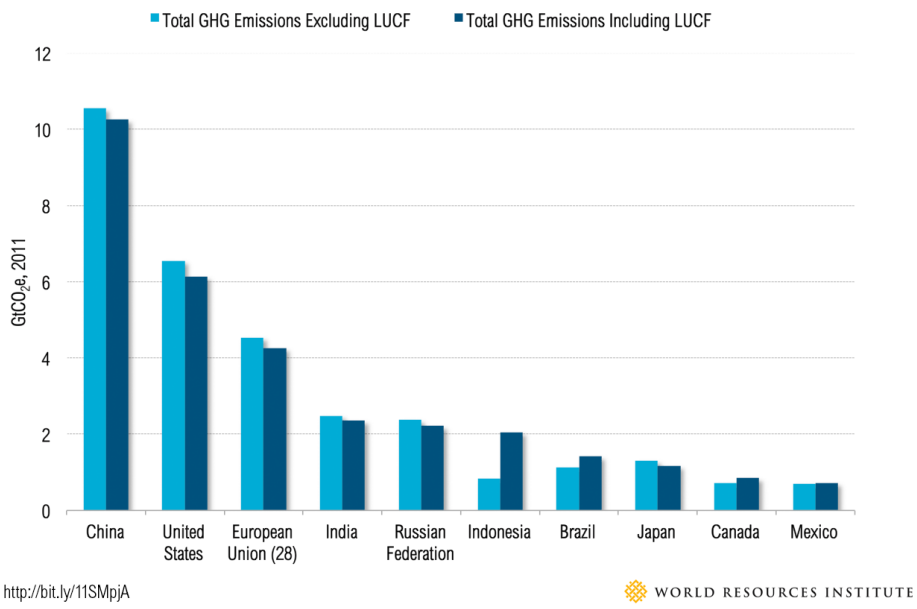

Figure 7: Top 10 Emitters. According to data, 10 countries produce around 70 percent of global GHG emissions in 2011. LUCF refers to emissions stemming from land use change and forestry.[32]

Currently, China is the largest emitter of GHGs in the world. This has led to a rise in international pressure since the early 1900s[33]. The country has begun experiencing challenges on its environment which has pushed it to take cautions to fight the challenge brought by climate change. According to a report released in 2011 by China's scientists, it is most probable that in the future, this climate change would cause significant impacts on water resources, ecosystem, agriculture and China's coastal zones[34]. China has started experiencing an increase in flooding, decline in agricultural output and droughts. This has attracted different stakeholder's attention who point out that apart from affecting the environment, climate change also poses a major threat to mankind. Members of the international community have appealed to each and every one to stand together to safeguard the home of humankind as the climate change has become a threat to it. Predicted future effects of climate change may make China take more severe actions[35]. Some of the predictions state that the

[32] http://cait.wri.org/historical
[33] Nordhaus, William D. 2007. "A review of the Stern review on the economics of climate change." *Journal of economic literature* 45 (3), 686.
[34] Ibid., 687.
[35] Ibid., 690.

amount of rainfall will continue decreasing in northern China resulting to a scarcity of fresh water. Contrary, it is predicted that there will be an increase in the rainfall intensity in the southern China which will lead to more rigorous flooding shortly[36]. It is further expected that the intensity of China's heat will increase because of climate change. Important to note is that the country's authority is already taking enormous actions against it by e.g. implementation of renewable energy sources. In fact, in 2015, China was the biggest investor in RES worldwide.

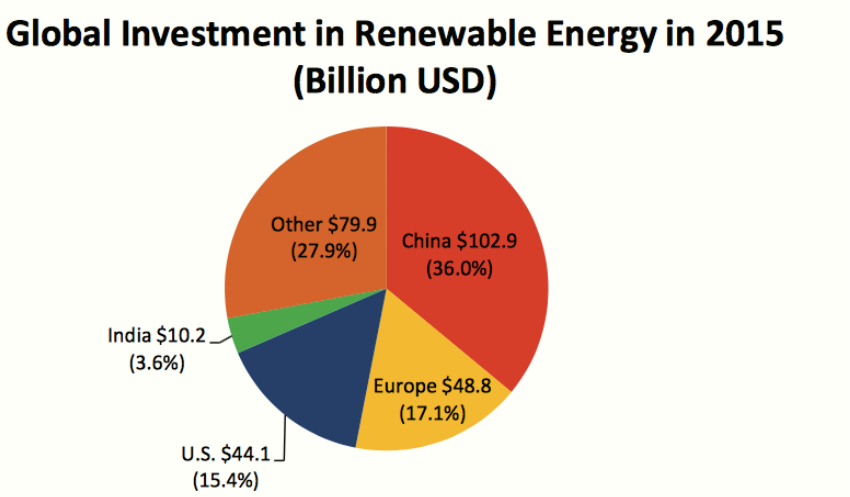

Figure 8: Global investment in renewable energy.[37]

3.3. Climate Change and India

Climate change is a complex problem facing India today. India experiences an increase in ocean temperature, rising sea level and widespread melting of ice and snow[38]. This has led to rising in conditions affecting agriculture which include glacial runoff, precipitation, and temperature. Agriculture is the backbone of Indian economy. Thus it will be affected by the fluctuations in rainfall patterns. Climate change can cause a huge biodiversity loss, and the effect will be felt equally by individual species and their ecosystem[39]. Overwhelming effects on many animals' habitats and plants as

[36] Ibid., 692.
[37] Bloomberg New Energy Finance. 2016. "Global Trends in Renewable Energy Investment"
[38] Walther, Gian-Reto, et al. 2002. "Ecological responses to recent climate change." *Nature* 416 (6879), 389.
[39] Ibid., 396.

a result of climate change are expected to send existing plant and animal species to extinction.

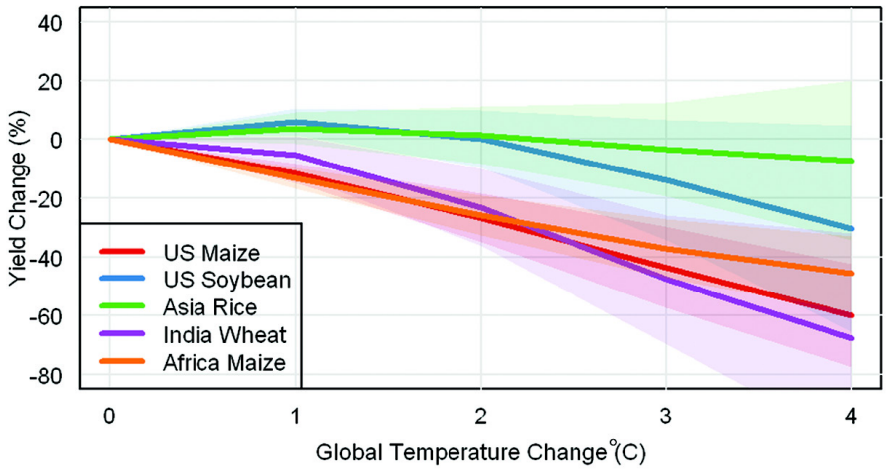

Figure 9: Loss of crop yields per degree warming. The expected impacts on crop yield are from both warming and CO_2 increases, assuming no crop adaptation.[40]

4. Conclusion

Since many systems are tied to the climate, its change can affect a lot of related aspects of where and how plants, animals, and people live, health risks, availability of water and food production. Some climate change sceptics admit that there is, indeed, human contribution, nevertheless, insist that it is rather insignificant and could not possibly be assigned as the main reason for the warming of the climate. And admittedly, the Earth's climate has fluctuations. What they seem to ignore, however, is not the fact that the climate is changing, this of course has happened before. It is rather about the rate of change. Flora and fauna cannot evolve and adapt at this rate whereas previously that had thousands of years to. Scientist and researchers around the globe are urging countries to start the implementation of renewable energy technologies, asserting their potential to initially mitigate and in the long term even offset, the anthropogenic sources for climate change.

[40] National Research Council. 2011. *"Climate Stabilization Targets: Emissions, Concentrations, and Impacts over Decades to Millennia".* p. 161. Washington, DC: The National Academies Press.

Part II: Renewable Energy

1. Solar Energy

Solar energy, as a renewable source of infinite clean energy, has the potential to meet ever-increasing energy demand in the world. Unlike fossil and other sources of energy, this energy is free, non-polluting, and inexhaustible. The rising concern of energy crisis, environmental impact of energy production technologies, and the lack of energy availability and security issues are steering the world towards the adoption of renewable energy sources[41]. As a renewable energy variant, solar energy can help in mitigating energy crisis of the future. Solar energy is harnessed in the form of heat and light from the sun using state-of-the-art technologies including solar cells, solar heating, solar architecture, and artificial photosynthesis. It is a clean form of renewable energy, which offers an inexhaustible source of energy at cheap cost. The potential of solar energy to replace environmentally detrimental sources of energy is the driving force behind the research and innovation of solar-based systems[42]. Apart from initial setup cost, solar energy does not include large operating or conversion cost. Anybody can own a solar energy conversion plant to meet home and industrial energy requirement. Poor energy conversion efficiency is the leading cause for solar energy not being a popular source of energy. However, with the proliferation of technology including nanotechnology, biotechnology and natural and physical science, the efficiency of conversion of solar energy into electric, light or heat energy is rapid increasing to yield a cost-effective and globally scalable source of clean energy[43].

1.1. Technology behind Solar Energy

Where does it come from?

Solar energy comes entirely from the sun. However, it comes to usable form in many ways. To speak in a broad sense, all the forms of energy in the world are supported by solar energy. For example, biomass and fossil fuels comes from plants and animal's relics, which used solar energy to grow and store energy. The wind energy that causes

[41] Foster Robert, et al. 2010. *"Solar energy"*. 1st arg. Boca Raton: CRC Press.
[42] Crabtree, George and Nathan Lewis. 2007. "Solar Energy Conversion". *Physics Today* 60 (3): p 37.
[43] Nathan S. Lewis. 2007. "Toward Cost-Effective Solar Energy Use". *Science* 315, (5813): 798-801.

windmill or wind turbine to flow comes because of temperature difference between adjacent areas in the environment, created by the sun. The amount of solar energy strikes the Earth surface is vast; scientists measured that the total amount of energy reserved in the Earth is the equivalent to only 20-days of sunshine[44].

The sun produces solar energy from the fusion reaction that takes place inside its core constantly[45]. It produces heat and light energy and contains other forms of energies including X-ray, cosmic ray, and electromagnetic waves as well.

How It is Produced and Harnessed?

Solar energy harnessing has been an ancient venture. People are trying to exploit solar energy from very old time. The basic idea of production and harnessing solar energy lies in the capture and the conversion of solar energy into some usable form. There are two forms for capturing solar energy - active and passive systems. In active system of solar energy harness, some means of capturing sunlight is used, which is then converted into other forms of energy. For example, the photovoltaic cell is used to capture sunlight and convert it into electric energy. On the other hand, the passive system does not convert solar energy rather simply design facilities and materials to make use of solar energy in the form for light, heat, or wind. For example, placing and orienting a house in a special direction to facilitate heating and thermal exposure to sun.

[44] ucsusa.org. 2007. *"How Solar Energy Works".* Union of Concerned Scientists.
[45] Solar Energy Facts. 2012. *"Where Does Solar Energy Come From?"*. Blog. Solar Energy Facts. http://solarenergyfactsblog.com/where-does-solar-energy-come-from/

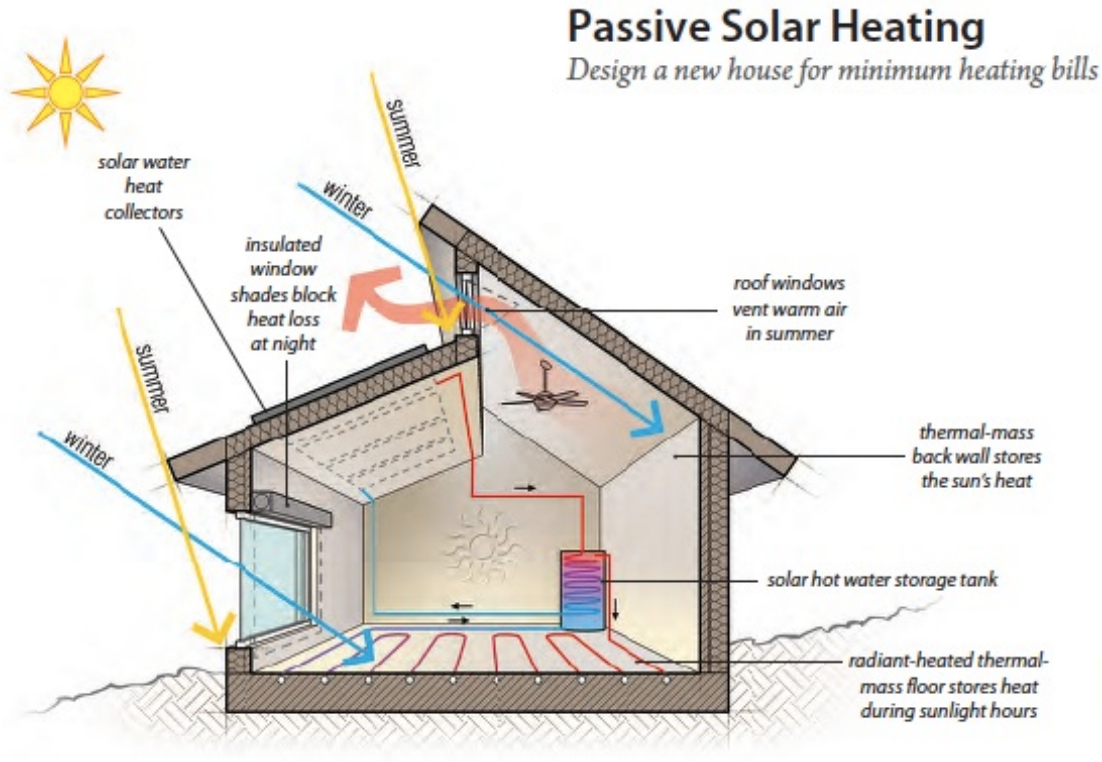

Figure 10: Example for passive solar heating.[46]

What Materials and Installation Methods Are Used?

As active solar energy harness technique, photovoltaic cells are mainly used. These cells are made of silicon; when sunlight hits the surface of photovoltaic cell, it frees up electron by imparting photon energy to them[47]. These free electrons generate direct current, which is then stored to a battery and converted into alternating current for use[48].

[46] Masia, Seth. 2014. "Passive Solar Heating". Solar Today. http://solartoday.org/2014/04/passive-solar-heating/
[47] Karolis Kiela. 2012. *"Photovoltaic cells"*. Science – Future of Lithuania 4 no. 1: 52-62.
[48] Chetan S. Solanki. 2011. "*Solar Photovoltaics*". 1st arg. S. l. : Prentice-Hall of India.

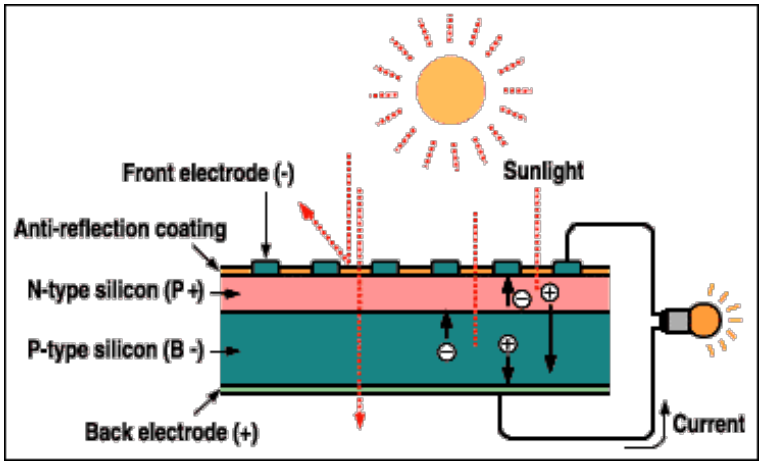

Figure 11: Principle of a solar cell.[49]

Another active solar harness technique includes thermal collector, which is consisted of a series of heat-absorbing panels and tubes to circulate heat through water and used to warm up building.

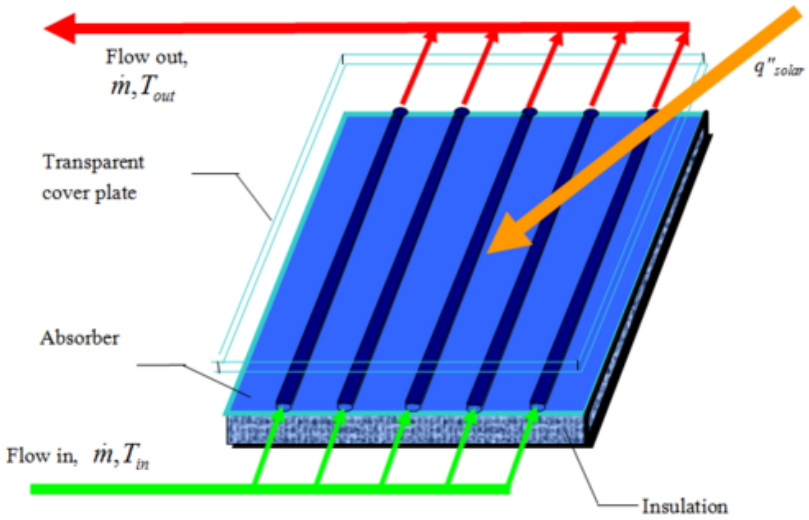

Figure 12: Typical construction of solar thermal collector.[50]

On the other hand, solar concentration system that uses arrays of mirrors arranged in a series of long parabolic troughs to reinforce sunlight and focus on a heat collection

[49] "How solar cells work". http://solar-power-systems.blogspot.co.at/2011/01/how-solar-cells-work.html
[50] "Solar thermal energy collectors". https://www.thermalfluidscentral.org/encyclopedia/index.php/Solar_thermal_energy_collectors

system[51]. The heat collection system heats water or fluids to generate steam, which can be used for different purposes.

Figure 13: Solar thermal vs. PV.[52]

Passive harness techniques are based on design and orientation of construction or materials in a way to absorb direct sunlight and provide necessary heat, light, or wind energy. Such techniques are very helpful in preserving solar energy and saving electricity bills.

1.2. Advantages and Disadvantages

Cost Benefits

Solar energy is one of the cheapest energy sources available now. The cost of solar energy system may vary for different techniques, purposes, and systems. Solar energy may be used for electricity production, heating, cooling, or ventilation purposes. Modern homes are equipped with different solar energy systems ranging from photovoltaic array to solar concentration system. It is obvious that the operational

[51] Mondol et al. 2015. *"Large scale water lens for solar concentration".* Optics Express 23, no.11.
[52] "Differences Between Solar Photovoltaic and Solar Thermal". 2017. http://www.greenmatch.co.uk/blog/2016/04/differences-between-solar-photovoltaics-and-solar-thermal

cost of solar energy system is trifle because sunlight is free for all in all countries. For electricity generation, solar energy system consumes $0.10 for each kilowatt of energy production, whereas the installation cost of solar panel for each watt of electricity is $10 on average[53]. On the other hand, the cost of solar thermal energy system for heating system may cost from $5,000 to $7,500 for a typical home[54]. However, apart from low operational cost, solar systems include minimum maintenance cost. It is the cheapest energy system of that the world could avail. The production cost of solar energy is pretty low. Typically, $10 USD is enough for per watt production. It does not require any fuel or material for energy conversion.

1.3. Benefits in Environmental and Social Impacts

Solar energy is one of the cleanest forms of renewable energy. It does not emit greenhouse gas, does not create fumes, heat, or noise, and disposes zero waste. Solar energy system offers a sustainable energy sources with no environmental impact or toxic emissions. Environmental impact of solar energy systems is almost none; solar energy system can be implemented on the rooftop or on the backyard of a facility without requiring any land acquisition or habit loss. It does not interfere with the environment or society. No hazardous material is associated with the production of solar power. It operates quietly and does not give off anything to the environment. Large-scale solar energy systems may be implemented in desert or no-man's land because it needs minimum human operators or local supply to generate electric power. On top of that, solar energy systems can be installed in agricultural lands, roadsides or any sun exposed areas[55].

On the hand, solar energy systems ensure positive social impact by generating clean energy; it respects human rights of workers because it does not require laborious work from the worker, it ensures community rights are not violated and stakeholder's interests are not neglected through its commitment to safe and environmentally energy clean generation process. Solar energy systems ensure safety and security for

[53] Solar Power Authority. 2012. *"How Much Do Solar Panels Cost to Install*?". Solar Power Authority.
[54] Southface.org. 2015. *"Solar Thermal Costs, Paybacks and Maintenance".* Southface Energy Institute.
[55] Ucsusa. 2015. "How Solar Energy Works". Union of Concerned Scientists.

workers as well as for common people. It can be generated on site, which reduces transmission hazard. The planning, designing and implementation of solar energy systems create large employment opportunities and help the society reduce unemployment problem. The economic impact of solar energy system is highly influential to the society. Being clean in nature, the energy does not need extensive measures to deal with environmental pollution and hence the economic gain can be realized in terms of social prosperity. By maintaining environmental cleanliness, solar energy system improves health of community people and reduces the health-related costs and complications. Furthermore, by reducing the oil dependence solar energy system strengthens economic condition of the country.

Disadvantages

One major demerit of solar energy is that it is dependent on the availability of the sun. Solar energy cannot be produced at large scale in countries where sunlight is inconsistent or low. Based on the availability of the sunlight, the volume energy production varies over a wide range, which can create energy unbalance in the grid. Another problem of solar energy is that the solar panels harvesting use cultivating lands, which reduces crop production significantly[56]. Again, the initial investment is high in solar energy harvesting plants, while the energy efficiency is comparatively low (about 20%)[57].

1.4. Example of Country: Germany

Germany sets a role model in solar energy generation and use; about 7% of the country's net electricity generation comes from solar resources. It is the second leading country in solar energy generation, produces 1.2 GW of electricity generation from solar resources, after China[58]. It is among the top countries amongst the world's top PV installer. The country sets a target of installing and producing 2.5 GW of electrical energy from solar resource by the year 2050. The country meets 35% of its

[56] Ollhoff, Jim. 2010. *"Solar power".* 1st arg. Edina, MN: ABDO Pub.
[57] Richard, Martin. 2016. "First Solar's Cells Break Efficiency Record." Sustainable Energy: *MIT Technology Review*.
[58] Harry Wirth. 2017. *"Recent Facts about Photovoltaics in Germany".* Photovoltaic Modules, Systems and Reliabilit. Fraunhofer ISE.

energy demand from solar energy[59]. Integrating innovation with the solar energy technology, the country has been storing about 41% of its total solar energy production for local usage since 2016. All other countries across the world can take example of Germany and go for solar energy as their primary source of electricity.

1.5. Conclusion

Solar energy system is an emerging technology, which is a prospective source of alternative energy. It is a clean form of energy, which is sustainable, inexhaustible and cheap. However, the technology of processing and transferring solar energy is not efficient and up to the mark. The storage and conversion efficiency is not good, which put limits to wide adoption of solar energy as an alternative source to fossil fuel sources. For smaller facility with moderate demand of energy, solar energy system is highly preferable over other forms of energy resources. However, modern researches are focusing on finding ways to improve solar energy efficiency and implement it widely as a viable source of energy worldwide because of its sustainability and cleanliness.

2. Wind Energy

In the contemporary globe, calls have been rife on the usage of clean energy sources like solar, biogas, and water bodies. Wind energy falls under the clean energy sources since it involves harnessing of wind to draw power. As such, wind energy can be described as the mechanism by which wind is utilized to produce electricity. Wind turbines are used to convert kinetic energy drawn from the wind into mechanical energy. Then mechanical energy is converted into electricity via a generator. At this state i.e. mechanical power, it can still be used to perform certain tasks like pumping water among others. As elucidated by environmental research, combustions of fossil fuels, which is the principal means of generating power across the globe, has a direct relation to climate change. In a move to prevent climate change, industries have been encouraged to adopt the clean energy sources like wind. Therefore, this part of the thesis will strive to underline the aspects surrounding wind energy including the

[59] Michel Jeffrey. 2016. *"Germany sets a new solar storage record".* EnergyPost.eu.

technology involved, merits and demerits, and countries that have adopted the technology.

2.1. Technology behind Wind Energy

As the wind blows past the wind turbines, the blades arrest kinetic energy and hence rotate. The action converts the kinetic energy into mechanical power. The rotation normally turns a shaft enjoined to the gearbox that in turn heightens the rotation speed by a factor of about 100. In the process, a generator rotates to generate electrical power. The wind towers can be approximately 80 meters or more. Furthermore, wind measurements are obtained to ensure the turbine is exposed to the strongest winds and angle in order to maximize the power captured.

Onshore Wind Energy

In onshore wind energy, turbines are set on land to harvest moving air that is used to generate electrical power. They are mostly located in farms among other regions that tend to experience higher rates of wind. Wind turbines function on a simple principle i.e. the wind energy turns around two or three propeller-like blades around a rotor. On the hand, the rotor that is joined to the main shaft gyrates a generator to generate electricity. There exist many different designs of horizontal-axis wind turbines. However, the commonest turbine has three blades, pitch or stall- regulated and a horizontal axis equipment that operates at almost-fixed rotational speed. Other concepts include the gearless “direct drive” turbines constituting of adjustable speed generators. The turbines normally begin to generate electrical power when the wind speeds are typically three to five meters per second (m/s). Maximum power can be obtained at 15m/s and cuts-out at roughly 25m/s.

Figure 14: Onshore Wind Energy Harvesting.[60]

The two commonest mechanisms of regulating power output obtained from the rotor blades include pitch and stall control. In pitch control, the rotor blades' angle is regulated via the control system that has inbuilt braking aspects as the blades start to be static when fully feathered. In stall control, the integral aerodynamic aspects of the blade determine the output power. The rotor blade's thickness and twist vary in such a manner that turbulence happens on the rear side of the blade when the wind speed is too high. In that regard, the turbulence indicates that the blade is less efficient thus minimizing output power when the speed is high. The machines also consist of a braking system that halts the turbines when it is necessary. Apart from controlling the output, the turbines can be either variable fixed speed.

Typical contemporary wind turbines consist of the following major parts:

- Blades – though there are several configurations, most turbines consist of three blades. The blades are made of fiberglass-supported epoxy resin or polyester. Nonetheless, new materials like carbon fiber are being utilized to take into consideration the strength-to-weight ratio required by the ever enlarging blades. Laminated wood can also be used.

[60] Photograph: Graeme Robertson for the Guardian. 2012. https://www.theguardian.com/environment/2012/sep/25/climate-change-windpower

- Rotor hub – the hub and rotor assembly rotates at 10 to 25 revolutions per minute (rpm) contingent on the turbine design and size.
- Nacelle – it is the turbine's main structure and houses the main constituents of the turbine.
- Gearbox – it is designed to convert high-torque, low-speed rotation of the rotor to a high-speed rotation typically 1500 rpm.
- Generator – used to convert the mechanical power into electrical power. A typical generator functions at 690V and provides 3-phase AC.
- Controller – used to observe the turbine while collecting operational data.
- Transformer – it is used to step up power from the generator to a value that is determined by the grid requirements[61].

Offshore Wind Energy

This entails the utilization of wind farms built offshore, normally on the continental shelf, to harvest wind power in order to generate electrical power.

Figure 15: Offshore Wind Energy Harvesting. Princess Amalia Wind Farm in the North Sea.[62]

[61] International Renewable Energy Agency. 2012. *"Renewaiesble Energy Technologies: Cost Analysis Series: Wind Power"*. Vol. 1.
[62] Photograph: Ad Meskens. ZME Scienece. 2016. http://www.zmescience.com/science/news-science/offshore-wind-cost-07072016/

Wind energy has faced several constraints over the years with the most prominent one being gaining consent for wind farms. However, with an adequate regulatory environment, the offshore wind farms could offer the solution as they allow large turbines to be constructed in high wind speed regions. Therefore, even though offshore wind energy is an expensive undertaking as compared to the onshore, the long-term projections are good. Initially, the offshore wind turbines were founded on the onshore machines. The offshore machines require further corrosion protection among other reinforcements to counter the adverse marine environment[63].

The offshore machines are primarily made of three kinds of foundation i.e. the single-pile, gravity, or multi-pile structures. The choice of foundation is influenced by sea-bed conditions, prospected costs, and water depth. Moreover, floating support structures are currently being researched.

2.2. Advantages and Disadvantages

One of the key benefit of this energy source entails the environmental aspects. In other words, it is a clean fuel source that does not have any detrimental impacts on the atmosphere unlike the combustion of fossil fuels. Furthermore, the wind turbines do not release atmospheric gasses that heighten health risks like asthma or even lead to greenhouse gasses or acid rains. In fact, as per the Wind Vision Report, utilization of wind energy can minimize the greenhouse gas discharges by roughly 14 percent thus prevent climate change. Apart from that, wind energy is a safe activity. This is because unlike other sources of energy, wind power does not require water. In the contemporary globe, water is continuously becoming a scarce commodity in some regions; hence, wind power ensures water is conserved[64]. It is also safer than nuclear energy, which has health risks in the short and long terms. Wind energy is also inexhaustible. As such, the future aspects of the activity remains intact. In other words, wind energy does not face the risk of being exhausted in the near future. The inception of offshore harvesting makes it even more stable. Another merit regards the cost. Wind energy is a cost-effective venture with one of the lowest prices in power generation.

[63] Ibid.
[64] U.S. Dept. of Energy. n.d. *"Advantages and Challenges of Wind Energy*".

As compared to other sources of energy like hydro and fossil fuels, wind energy is rather inefficient. For instance, the theoretical maximum power extracted by a turbine rotor is approximately 59.3 percent; a factor known as the Bitz limit. In that regard, the wind turbine can only extract a percentage of the total available wind. Considering the other factors like vibrations, bearing, and friction losses and also the rotor and generator efficiencies, the available efficiency could be around 35.5 percent. Wind energy is also a fluctuating aspect; hence, not reliable in terms of performance. The available wind potential tends to shift annually[65].

2.3. Example of Country: China

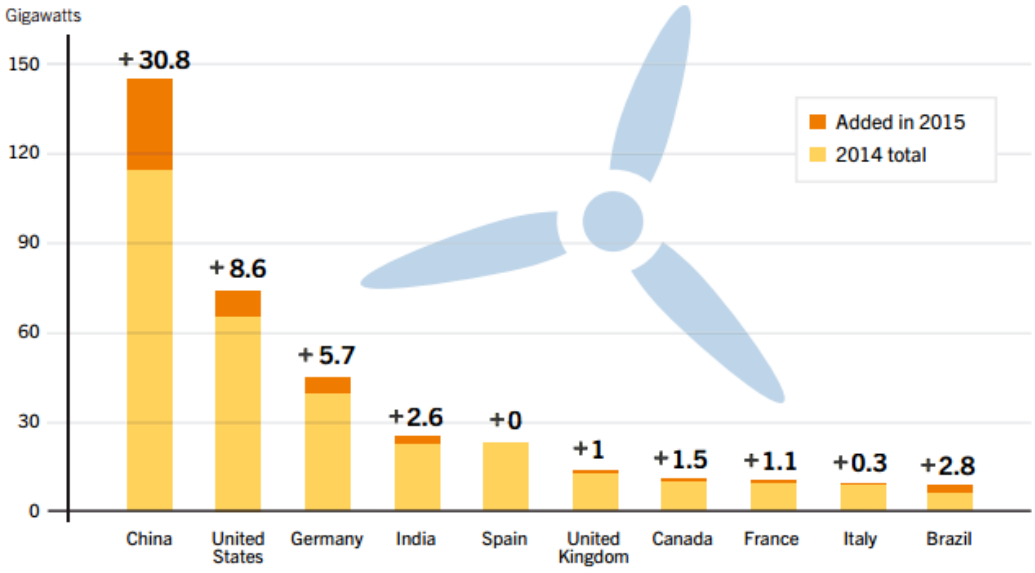

Figure 16: Wind Power Cumulative Capacity and Annual Additions by Country.[66]

China is one of the most prominent users of wind energy across the globe. In 2013 alone, the country installed 16.089MW, which is a rise of 3.130MW from 2012. By the end of 2013, the total installed capacity was at 91.413MW. The top four regions with the highest total connected capacity in 2013 were Inner Mongolia with 20270MW, Hebei with 8500MW, Gansu with 7100MW, and Shandong with roughly 7000MW[67]. The total installed capacity of wind power has increased over the years in China. For

[65] Ibid.
[66] REN21, Renewables 2016 Global Status Report.
[67] Li Junfen, et al. 2014. *"China Wind Power Review and Outlook.":* pp 1-36

instance, it was approximately 1200.MW in 2008, 2580.5MW in 2009, 6236.4MW in 2011, and 9141.3MW in 2013. In that regard, installed capacity increased over the years making China one of the most prominent utilizers of wind energy[68]. However, wind energy is not the only renewable energy source utilized in the country[69]. The country has also invested on other areas like solar.

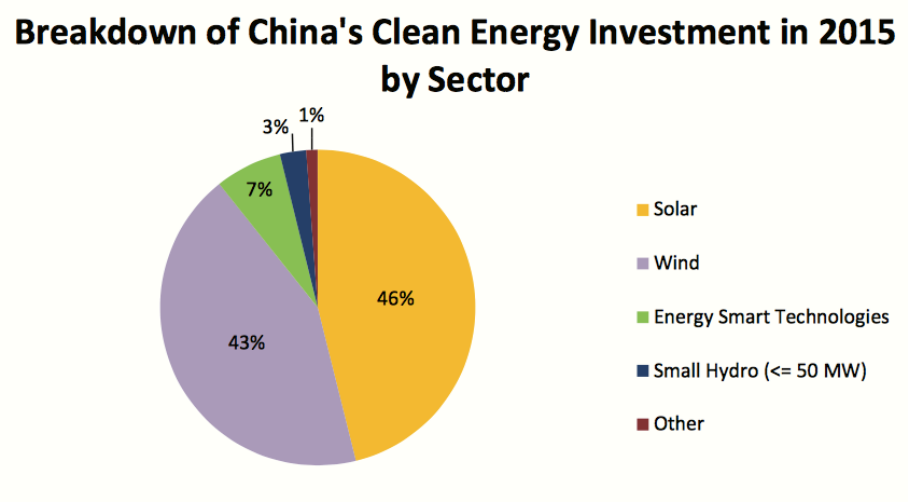

Figure 17: Breakdown of China's 2015 Renewable Energy Investments.[70]

2.4. Conclusion

Wind energy continues to evolve in many countries across the globe. The calls for cleaner energy sources as a means of combating climate change have implored many to seek the renewable sources like wind energy. This technology entails harvesting the wind to drive turbines that gyrate generators to convert kinetic energy into mechanical and then electrical power. Unlike other sources of energy, wind power is cost-effective and does not pollute the environment. However, the efficiency levels are quite low as compared to hydro, nuclear, or solar power. Nonetheless, it is an inexhaustible source whose prospects look good, especially as offshore technologies

[68] Hunter, John. 2017. "Harnessing Breezes for Electricity."
[69] Ibid
[70] Macdonald, Jennifer. 2015. *"Clean Energy Defies Fossil Fuel Price Crash To Attract Record $329bn Global Investment In 2015."* Bloomberg New Energy Finance. https://data.bloomberglp.com/bnef/sites/4/2016/01/BNEF-2015-Annual-Investment-Numbers-FINAL.pdf

continue to increase. The offshore wind energy is more efficient and reliable as compared to the onshore technologies though they are much expensive. Taking China as an example, the global utilization of wind energy continues to increase as evidenced by the statistics mentioned above. Therefore, wind energy has a high potential regarding growth in the energy sector, precisely renewable energy sources.

3. Marine and Hydropower

The ocean has for a long time been a source of energy that has been ignored. Estimates indicate that only 0.1% of the energy that come from ocean waves could is capable of meeting the energy needs of the world. Currently, there are different technologies aimed at meeting this potential. There are also other technologies being investigated and are at different stages of development including marine and tidal energy. Hydropower is generally used in the context of generating electricity from water power. Industrialist William Armstrong was the first industrialist to build a hydro-electric power station in the UK and since them, it has become an appealing source of energy. Hydropower and ocean energy has however not become very common due to the capital costs involved. Its multidisciplinary nature that involves geology, hydraulics, hydrology, and structural, electrical and civil engineering has meant that it poses some of the greatest challenges to engineering projects.

3.1. Technology behind Marine and Hydropower

Waves crushing on rivers and beaches through sloping valleys are forces of nature. There is no doubt moving water is powerful especially among those who have swam against river currents or stood on the path of breaking waves. Technologies behind the production of energy in water enables in harnessing the might of moving water that is used in homes and commercial places. Hydrokinetic technologies are known to produce renewable electricity by harnessing the kinetic energy of water bodies with the energy being as a result of the motion of the water.

To generate energy from currents and waves, technologies known as hydrokinetic conversion devices are developed. These technologies are characterized either as rotating devices or wave energy converters (WECs). These devices are still being

developed and are expected to be improved in the coming years. Currently, there is expectation that turbine arrays and wave parks will be developed in the industry to deliver clean and renewable energy for commercial purposes.

Wave Energy Devices

WECs are designed to uses the movement of two or more bodies. A displacer is one of the bodies and pressure is exerted on it by waves[71]. The reactor is the second body and moves relative to the displacer. Despite there being various configurations and designs of WECs, the four common ones include:

Overtopping device

The overtopping device can also be described as a floating reservoir and is formed when waves hits the walls of the device. The reservoir then develops a level of water that is higher than that of the surrounding that is used to turn turbines when water moves out through the lower section and flows into the sea[72].

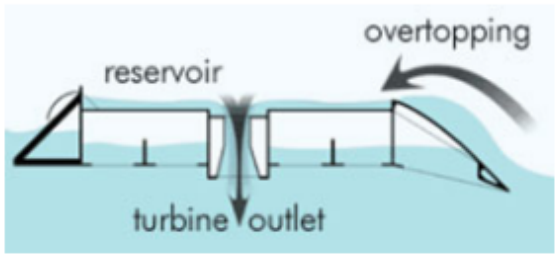

Figure 18: Overtopping Wave Energy Converter.[73]

Point Absorber

The point absorber utilizes energy from all paths at a particular point by taking advantage of the vertical motion of waves to act as a pump that pressurizes internal fluid or sea water which driver the turbine[74]. The point absorber has various

[71] Union Of Concerned Scientists. 2017. *"How Hydrokinetic Energy Works"*
[72] Union Of Concerned Scientists. 2017. *"How Hydrokinetic Energy Works"*
[73] Ibid.
[74] Ibid.

configurations with one being the hose pump point absorber that has a surface-floating buoy that is laid on the floor of the sea.

Figure 19: A Point Absorber Wave Energy Converter.[75]

Generation of electricity by point observers can be maximized through the energy capture and device-wave resonance.

Attenuator

This is also referred to as the heave-surge devices. The long and jointed structures floating is positioned in a parallel manner to the direction of the wave and power is generated by the movement of the waves. The movement of the waves sets each section of the device in motion against the other segment. Their relative motion that is focused at the joints between each segment is used to put pressure on the pistons that compress fluids by using a motor which in turn drives the generator.

[75] Ibid

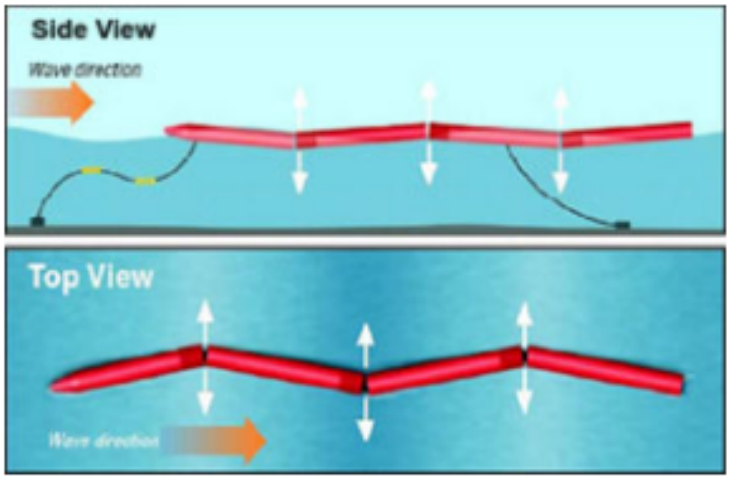

Figure 20: Attenuator.[76]

Rotating Devices

As a rotating device passes across a rotor, the kinetic energy of flowing water such as that of an ocean or river is captured. As the current turns, the water also turns and creates energy that is then converted to electricity. Most rotational devices designs are similar to those of wind turbines and are widely used. This similarity in their designs has helped in fastening of technological development of turbines used in water.

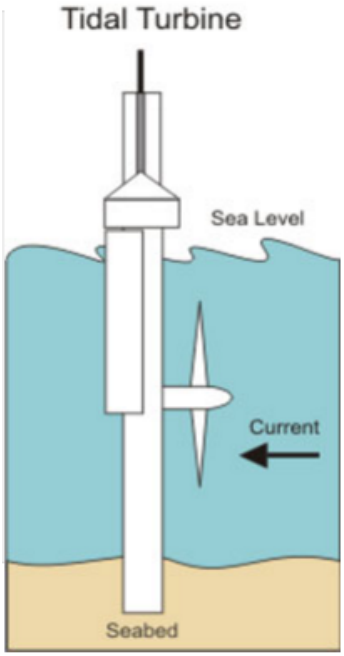

Figure 21: Horizontal Axis hydrokinetic rotating device.[77]

[76] Ibid
[77] Ibid

3.2. Advantages and Disadvantages

Efficient and Reliable

Marine and hydropower is considered and efficient and reliable source of energy[78]. As long as there us an adequate supply of water, hydroelectricity production can be constant and can be relied upon by the economy of a country.

Renewable and Clean

Marine and hydropower are clean sources of energy. Fossil fuels do not have to be burnt to produce electricity. Thus, there are no harmful emission that pollute the environment. Water is a renewable source of energy that cannot run out and its use helps in the conservation of a non-renewable source of energy.

Flexibility

Hydroelectric dams are flexible because they can meet the energy demands of a population in real-time[79]. Whether high or low volume are required, engineers can always alter the intake of water to decrease or increase the flow of water into the dam thus generating the desired amount of electricity.

Economical

Once the initial hydroelectric equipment has been constructed, it is economical to produce hydroelectric power. Hydroelectric power is also not vulnerable to the fluctuation costs of fossil fuel; hence they provide a stable economy with predictable energy prices.

Environmental Impact

One major disadvantage of marine and hydropower is its impact on the aquatic life. The turbines that are placed in the water act as a wall for both the wildlife and aquatic life that live within the water[80]. Species such as fish can get harmed leading to their migration up and down the stream. Plants are also harmed making nutrients not to

[78] Cutler J Cleveland. 2009. *"Concise Encyclopedia Of History Of Energy"* 1st ed. San Diego, California: Elsevier.
[79] Ibid., 150
[80] Ibid., 155

reach the aquatic life. Habitats are also likely to be destroyed during the construction and operation of the turbines.

Expensive

Marine and hydropower plants are expensive to build. Such stations require extensive engineering, planning and construction before they can start producing power. The financial resources required to realize such projects are usually huge and has been the major stumbling block in the exploitation of this clean source of energy.

3.3. Example of Country: Brazil

Brazil's approach to hydropower is rather different from other countries. The country relies on large power plants rather than the smaller dams that are common in most countries. Almost 80% of energy generated and consumed and Brazil come from hydro plants. Brazil is ranked third in hydropower potential in the world. It is only China and Russia that have the highest hydropower potential. Hydroelectric energy produces 75 million KW all over Brazil with 158 plants in operation, with some under construction[81]. The hydropower plant on the Parana river known as Itaipu used to be the largest plant in the World until the Three Gorges plant in China took over as the largest hydropower plant. Brazil's geography is perfect for hydroelectric production. The large rivers, high precipitation levels and elevation changes make it suitable for hydropower generation[82]. This is the reason why there are large hydropower plants in Brazzil such as Belo Monte, Tucurui, Ilha Solteira and Sao Luiz dos Tapajos.

3.4. Conclusion

The increased carbon emissions due to the use of non-renewable sources has prompted nations to revert to renewable sources of energy. Marine and hydropower have become the most attractive sources of energy. Various technologies have been developed to produce electricity from rivers and oceans. Overtopping device, attenuator, wave energy devices and rotating devices are some of the technologies

[81] Wagner, Hermann-Josef, and Jyotirmay Mathur. 2011. *"Introduction to Hydro Energy Systems Basics, Technology and Operation"*. Berlin: Springer, p 16
[82] Ibid., 18

that are used to produce electricity. Hydropower has various advantages that make it suitable for the future of electricity production. Hydroelectricity is clean, renewable and flexible. However, it risks the life of aquatic life and wildlife. Construction of hydropower plants are also expensive to construct because they a lot of planning and financial resources to actualize. Brazil is one of the largest producers of hydropower with some of the largest power plants. The country's large rivers and high precipitation levels make it the best. Other countries should follow the footsteps of China, Russia and Brazil to ensure clean energy and reduce global warming.

Part III: Case Studies

1. Norway

1.1. Norwegian Energy Sector

The Kingdom of Norway is a monarchy state comprising of the western segment of the Scandinavian Peninsula, the island of Svalbard in Archipelago and the island of Jan Mayen. The Norwegian territory covers a total land area of about 385,252 km^2 and has a total population of about 5,258,317 people based on the January 2015 population estimates[83]. It is the third largest energy producer and exporter in the world after Russia and Saudi Arabia and is also a strong advocator of climate change and mitigation. Norway has an ambitious target to reduce its global emission levels for greenhouse gasses by up to 30% of the levels it produced in 1990 by 2020. It has also targeted to become a carbon-free country by 2050. To meet the 2020 greenhouse gas cut will require that the country's electricity supply system and the energy levels used in the buildings are carbon-free. With the large revenues derived from the petroleum products sales, it is estimated that Norway is well-placed to invest sufficiently in developing new solutions to a low-carbon future.

[83] Blindheim, Bernt. 2014. *"A Missing Link? The Case of Norway and Sweden: Does Increased Renewable energy Production Impact Domestic Greenhouse Gas Emissions?"* Energy Policy 77: 207-215.

1.2. Norway's National Renewable Energy Policy

Norway is looking forward to developing an economy which is run purely on non-carbon energy (clean energy/ renewable energy) by 2050. A short-term plan to reduce its greenhouse gas emission by 30% of the total emission produced in 1990 comprises the major component of its policy plan and development in the path to achieving its 2050 goals. As the European Union records, hydropower comprises the largest share of the clean energy produced in Norway, accounting for 99% of the total amounts of energy produced in the region annually[84]. Figure 22 shows the energy production by type.

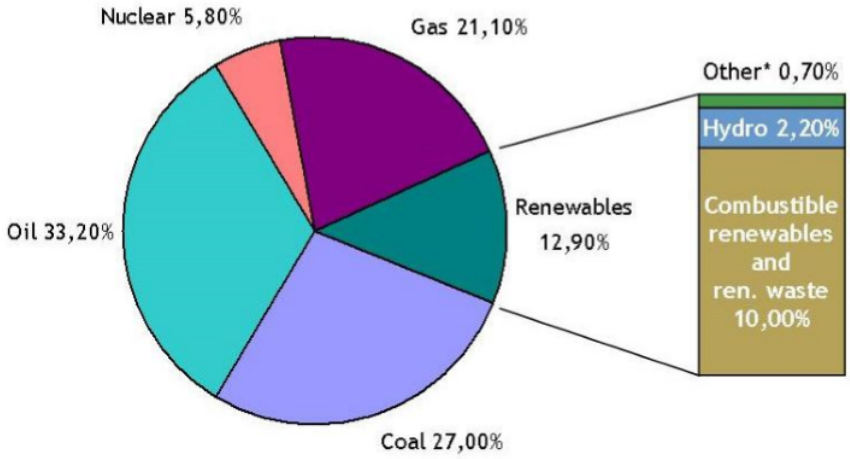

Figure 22: Norwegian energy production by sector 2013.[85]

Compared to other non-clean energy sources, the renewable energy sector comprises a smaller proportion of the total energy production in the country (Hydro being the largest).

Other renewable energy sources of the country include solar, wind and biomass[86]. Figure 23 shows the production levels of the renewable energy in Norway in 2010. The average annual growth is estimated at 2.3%. The current policy is driven by the

[84] European Parliament. 2009. *"Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the Promotion of the Use of Energy from Renewable Sources and Amending and Subsequently Repealing Directives 2001/77/EC and 2003/30/EC."* Official Journal of the European Union 5.

[85] Gonzalez, David, Aygün Kilinc, and Nicole Weidmann. 2011. *"Renewable Energy development hydropower in Norway."* Proc. Int. Finance and Economics.

[86] European Parliament. 2009. "Directive 2009/28/EC of the European Parliament and of the Council of 23April 2009 on the Promotion of the Use of Energy from Renewable Sources and Amending and Subsequently Repealing Directives 2001/77/EC and 2003/30/EC."

knowledge that current objectives on environmental conservation and developments determine the levels of energy cuts to be achieved in the vision 2020 and 2050 respectively. The short and medium-term policies on renewable energy focus on increased exploitation of renewable energy sources. Second is the countrywide reduction in energy consumption levels by developing more flexible energy systems. The third aspect of the policy focuses on the distribution of power production as well as the gasified power plants which are associated with no emissions[87].

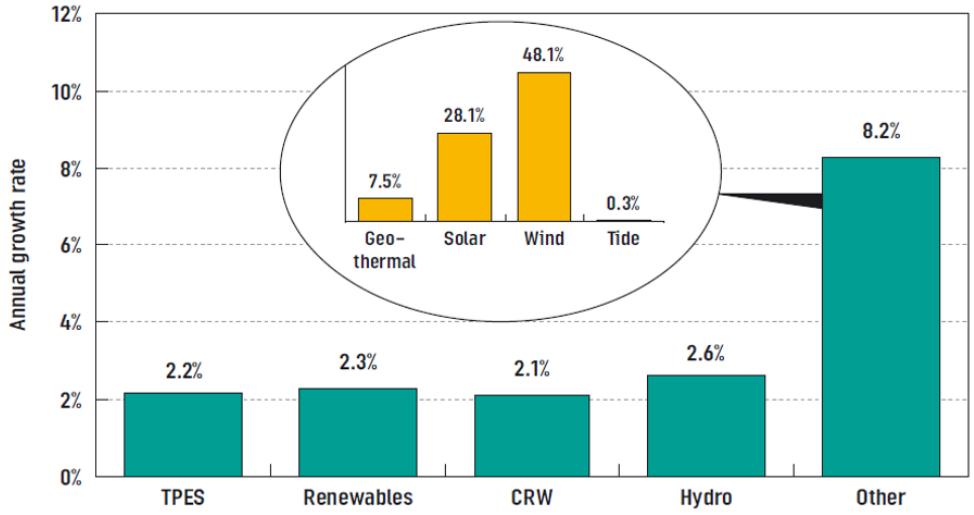

Figure 23: Norwegian renewable energy production 2010.[88]

1.3. Expected Energy Consumption Trends 2010-2020

Energy consumption levels and trends in Norway remain high despite the attempts to cut it down. In 2013, buildings consumed 78 TWh with the household sector using up to 46TWh and the tertiary sector 32 TWh. This shows a consistent increment of 6 TWh in households' energy consumption, up from 42 TWh in 2000 representing about 20% annual increase. The major household energy consumer is electricity, constituting 81% in residential use and 79% in tertiary. However, the climate corrected data on energy use registered a decrease by 1% annually between 2000 and 2013[89].

[87] Ibid., 17
[88] Gonzalez, et all. 2011. "Renewable Energy development hydropower in Norway." Proc. Int. Finance and Economics. 2011.
[89] Blindheim, Bernt. 2014. *"A Missing Link? The Case of Norway and Sweden: Does Increased Renewable Energy Production Impact Domestic Greenhouse Gas Emissions?"* Energy Policy 77: pp 207-215.

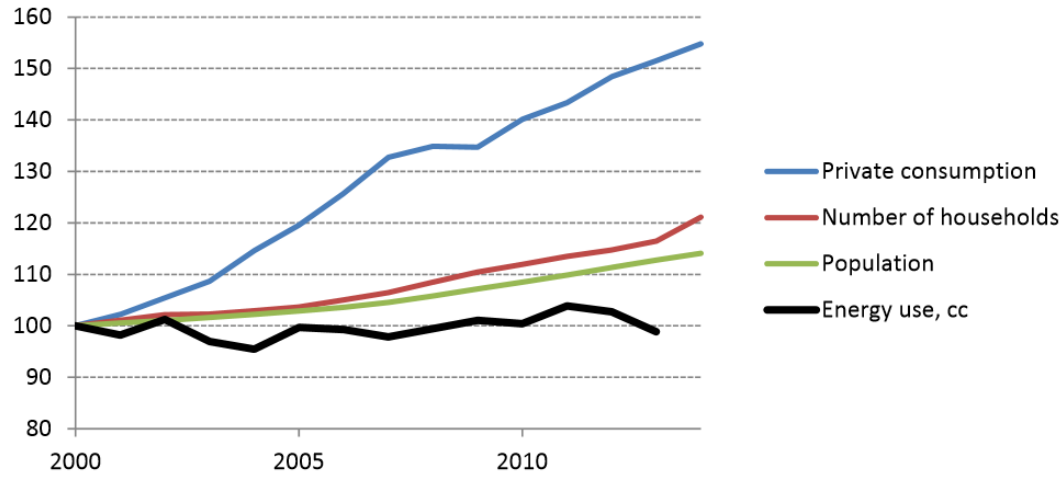

Figure 24: Energy Consumption trends in Norway 2000-2015. [90]

Since 2000, there has been a consistent rise in the energy consumption as portrayed in the graph in figure 24. With the policy plans in place, the consumption levels are projected to reduce considerably and hit the projected targets by 2050. The annual reduction in energy consumption is forecasted as 0.6% per capita, 0.9% per every household, 1.3% per area, and about 2.6% per private goods produced in the country[91].

1.4. Renewable Energy Targets

The Republic of Norway has committed to achieving a national renewable energy target of up to 67.5% as directed in the 2009/28/EC Directive.[92] By 2010, total production of renewable energy amounted to about 61%, and this is projected to increase to 67.5% by 2020 following the estimated growths in production and consumptions for renewable energy[93]. Further production of renewable electricity is expected. However, due to climate change, serious concerns are raised about the future state of the hydrological cycle. Table 1 shows the overall national targets for

[90] Institute for Energy Technology. 2015. Energy Efficiency Trends and Policies in Norway. Kjeller: Institute for energy technology.
[91] European Parliament. 2009. "Directive 2009/28/EC of the European Parliament and of the Council of 23April 2009 on the Promotion of the Use of Energy from Renewable Sources and Amending and Subsequently Repealing Directives 2001/77/EC and 2003/30/EC." Official Journal of the European Union 5.
[92] Ibid., 23
[93] Blindheim, Bernt. pp 207-215.

energy share derived from the renewable sources and the projected gross consumptions for 2005 to 2020.

Table 1: National overall target for the share of energy from renewable sources in gross final consumption of energy in 2005 and 2020 in Norway[94]

(a) The share of energy from the renewable sources regarding the final gross consumption in 2005	60.1%
(b) Energy targets from renewable sources regarding the final gross consumption by 2020	67.5%
(c) The expected total adjusted energy consumption levels by 2020	21,483
(d) The expected amounts of energy produced from renewable sources in correspondence with the 2020 levels.	14, 501

1.5. Sectorial Targets

Sectorial plans on renewable energy consumption and production are projected from the 2010 figures and are estimated to reduce consistently as the country nears the 2020 and 2050 renewable energy targets respectively. Figures 24 and 25 show the trends in sectorial and consumption respectively.

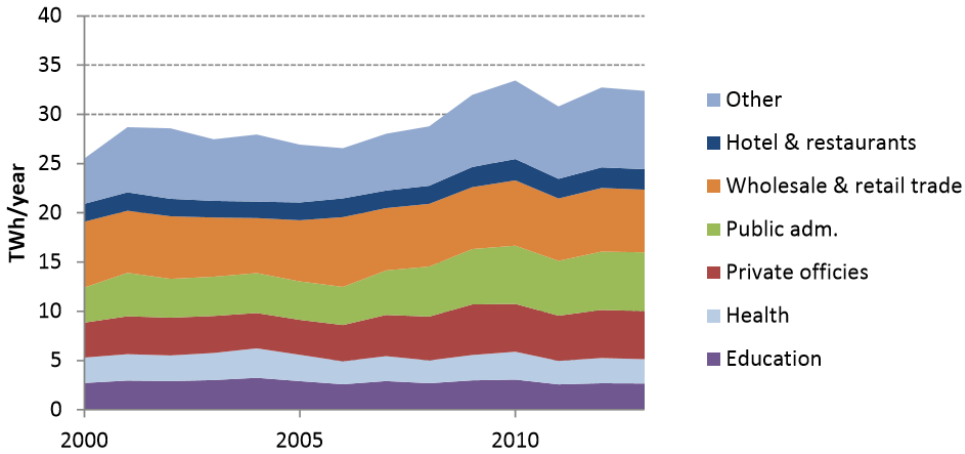

Figure 25: Norwegian sectorial energy targets. [95]

[94] NREAP Norway, p. 13
[95] Institute for Energy Technology. 2015. *"Energy Efficiency Trends and Policies in Norway"*. Kjeller: Institute for energy technology.

According to the Norwegian renewable energy policy plans, the improvements in production trends and reduction in consumption trends are supposed to be projected from the figures 23 and 25 above. Despite these anticipated reductions, a lot of unexpected occurrences are anticipated following the climate instabilities. For instance, in 2010, a lot of energy was high due to the very cold weather registered at the time leading to the high use of non-renewable energies for home heating[96]. However, more renewable energy sources have been installed since to enable the country to meet its planned production levels.

1.6. Measures for Achieving the Targets

The government of Norway has devised various strategic measures to help achieve the renewable energy targets. The key guiding document is the Kyoto Protocol. The onset of the measures to cut down climate gas emissions in Norway can be traced to the period 1991 following the passing of the Energy Act. The act introduced a clear distinction between the market for power production and the functions of the national monopolies[97]. Notably, the act permits the customers at various levels to select corresponding supplies that would minimize climate gas emissions. Also, in January 2005, the Norwegian government signed into force, a law which defined an allowance for greenhouse gas emissions trading and aligned this law to the Norwegian Emission Trading System[98]. Consequently, in congruence with the EU emission trading systems, the country has laid down measures to stimulate this industry, not covered under the CO_2 tax regimes. The main aim of this approach is to reduce the climate gas emissions.

As Buen observes, the primary objective of the Norwegian government in its attempt to reduce GHGs emission is to reduce the use of carbon mineral oils for home heating by a whopping 25%. This goal was to be achieved during the first commitment period of 1996 – 2000 in accordance with the guidelines of the directives of the Kyoto

[96] Ibid., p 22
[97] Kirkpatrick, Colin et al. 2011. *"Trade Sustainability Impact Assessment (SIA) on the Comprehensive Economic and Trade Agreement (CETA) between the EU and Canada: Final report."* Econ Papers.
[98] Buen, Jorund. 2006. "Danish and Norwegian Wind Industry: The Relationship between Policyinstruments, Innovation and Diffusion." *Energy policy* 34 (18): 3887-3897.

Protocols (2008-2012)[99]. In a bid to achieve these targets, the Norwegian government developed a natural-gas-fired plant fitted with technology to reduce CO_2 emissions. The natural-gas-fired plants work in coordination with the CLIMIT program to meet the required levels of CO_2 emissions by 2020 and consequently achieve a free-CO_2 producing state in 2050[100].

In conjunction with the measures illustrated above, the government of Norway has also presented a policy to expand natural gas in the domestic sector. The policy also focuses on increasing the country's energy sector to hydrogen sources besides increasing the provision of electricity through increased installations across the Norwegian continental shelf. The policy describes the green certificate market which considers the environmental protection, security of the supply and demand for the renewable energies and developing the acceptable standards for developing and managing the renewable gas resources in the Republic of Norway[101]. Following these developments, the Norwegian government launched another strategy to help it meet its clean energy plans. In this strategy, all hydrogen-related activities would manage and financed on a common platform[102]. In addition to these, there are renewed focus to increase renewable energy production, and the protection of the sources enabled by the development of various acts. Such include the water resources act, the energy act, the watercourse regulation act, the industrial licensing act, etc. These acts and regulations ensure that the sources are well-protected and made much more sustainable for prospects.

1.7. Assessment

The strength of the Norwegian renewable energy policies, like any other policy, lies on how well they are focused and implemented[103]. Consequently, the Norwegian government has, in consistency with the policy frameworks, developed clear paths

[99] Ibid., 3889
[100] Christensen, Toke et al. 2013. *"Country-Specific Factors for the Development of Household Smart Grid Solutions: Comparison of the Electricity Systems, Energy Policies and Smart Grid R&D and Demonstration Projects in Spain, Norway and Denmark"*. SmartGrids, pp 1-31
[101] Ibid., 15
[102] Ibid., 17
[103] Biesbroek, G. Robbert, 2010. "Europe Adapts to Climate Change: Comparing National Adaptation Strategies." *Global environmental change* 20 (3): pp 440-450.

defined by the acts to ensure that the energy sources are protected even as they are exploited for the national good. The effectiveness of the strategies put in place by the government of Norway depends on their management and implementation. Climate change is a very dynamic phenomenon which is characterized by the occurrence of many unpredictable natural phenomena[104].

The government of Norway has established strong coordination effort between the research community and the policy implementation systems to aid information exchange for better policies implementation. As a result, there are research and development activities ongoing in to develop proper and adequate information regarding the renewable energy needs, consumption patterns, and development requirements. Demonstration projects are often established to precede the actual implementations to ensure success. Also, the development of regulatory frameworks which are driven purely on the basis of the safety standards helps to ensure that the policies are implemented effectively. These steps are made to ensure that the planned approaches are geared towards reaching the set objectives.

1.8. Conclusion

Norway has a great potential of renewable energy aided by abundant hydro, wind and solar among other clean energy sources. The country's plans to achieve 100% clean energy state is feasible as evident from the policy outline. The policies on renewable energy are robust in terms of focus and the measures laid down to achieve them. Although clean energy is more expensive than the other ones, the Norwegian abundance of capital resources derived from the sale of oil and petroleum products is an additional advantage. Based on the assessment of the planned approaches outlined above, the feasibility of these plans is guaranteed. However, the government needs to put in appropriate measures to deal with the external, environmental factors such as extreme climate events, e.g. prolonged droughts which may affect production from hydro sources.

[104] Ibid., 445

2. Spain

2.1. Spanish Energy Sector

Spain's energy sector is extremely complex and therefore, it is undergoing significant changes. The recent economic slump exerted strain on consumption, particularly hydrocarbons and the generation of primary energy such as renewable energy. Nonetheless, the average demand for energy has barely evolved. Therefore, the Directive 2009/28/EC was adopted to encourage the use of renewable energy and estimates that European Union (EU) nations to target 20% share of energy from renewable sources, while 10% target for energy from renewable sources by 2020[105]. To Spain, this means that renewable sources must contribute 20% of the final energy used and contribute 10% from renewable sources in its transport sector. Much as the National Renewable Energy Action Plan (NREAP) complies with the Directive, Spain has begun its Renewable Energy Plan (REP). This is in a bid to adhere to the stipulated targets in the Directive for 2020 and indicative path for that year. Again the approval of REP will be done in 2020 so as to allow time for further suggestions concerning the NREAP.

2.2. Spain's National Renewable Energy Policy

Spain's national renewable policy has developed based on European nations' standards. However, it offers certain responses to major issues that are Spain's energy policy has faced from several years. Therefore, Spain's national renewable energy policy is characterized by significant energy in terms of gross domestic product (GDP) unlike other European nations[106]. Spain consumes more energy. Again, if compared with those countries that have related industrial systems and economic growth, Spain's energy consumption is much higher. This condition is a result of a number of variables and hence, it is reversible instead the impact of energy accumulation, that is, intensive economic development. Attempts have been made in to ensure efficient energy to address this pattern, which has put Spain on convergence with the mean of European nations with respect to energy intensity, a direction that Spain has followed for some years.

[105] Spain's National Renewable Energy Action Plan (NREAP) 2011-2020, p. 6

Spain is also characterized by a considerable reliance on energy. The scarce deposits of fossil fuel have contributed to a high reliance on energy in this country. This significant reliance implies increased risks for generation procedures, including those associated with efficient energy supply and volatile global market prices. [107] Furthermore, the energy policy in Spain is associated with the high degree of greenhouse gasses mainly as a result of considerable development in electricity production and transport demands in the previous decades. Therefore, to address these issues, Spain's energy policy have focused on increasing the competitive advantage of its economy; security of energy supply; and sustainable environmental, social and economic development.

2.3. Expected Energy Consumption Trends 2010-2020

Spain's expected energy consumption are based on the Directive 2009/28/EC. However, the inadequacy of efficiency measures from 2010 leads to a significant growth in the demand for primary as well as final gross energy at a rate of approximately 2% yearly[108]. But when integrated with an increase in GDP it is likely to generate an accumulated intensity of primary energy by about 5% in 2020. With a focus on the impacts of energy saving and efficiency takes into account Spain's gross final consumption for transport, heating, cooling and electricity. Furthermore, Spain's expected energy consumption for 2010 to 2020 is determined by additional energy efficiency scenario and the reference scenario as laid out in the Directive2009/28/EC[109].

2.4. Renewable Energy Targets

The national renewable energy targets depend on the gross final consumption in 2005 and 2010. For instance, in 2005 energy from renewable sources was about 8.7%, while the energy targeted from renewable sources in 2020 was 20%. Therefore, the expected national energy consumption in 2020 is 97,041, which means that expected

[107] Spain's National Renewable Energy Action Plan (NREAP) 2011-2020, p. 118
[108] Ibid., 14
[109] Ibid., 14

energy from renewable sources is about 19,408. This is obtained by multiplying targeted from renewable sources in 2020 by the expected national energy consumption in 2020. When it comes to sectoral targets, the key variables include energy used in heating, cooling, electricity, and transportation. Hence, to get the renewable energy used in heating and cooling, it is necessary to divide the gross final energy use by renewable sources used in cooling and heating by gross final consumption of energy for heating and cooling.

With respect to energy used in transportation, final energy from renewable sources utilized in transport is divided by energy such as petrol, diesel, biofuel consumed in transport. Based on the sectoral renewable energy targets, transport is main consumers accounting for 40% of the final consumption and followed by industry at 30%[110]. Nonetheless, demand for energy in these sectors has declined, which can be attributed to economic expansion and other sectors especially service and residential sectors.

2.5. Measures for Achieving the Targets

Spain has developed a structure for standardizing, simplifying and unifying administrative processes to authorize the renewable energy installation and simple alerts. This measure targets public administrations and it is important when it comes to easing administrative problems related to authorizing installation of renewable energy source plants. In the area of electricity generation, there is effective planning for electricity supply for marine programs while taking into consideration the progress of the administrative process. The measure of electricity supply intends to remove hindrances that influence the installation of marine projects. In electricity generation, there is also the proper management of energy demand in order to facilitate the involvement of consumers. In particular, better management of electricity is done to increase capacity for integrating renewable energy into electricity structures.

In the area of thermal renewable energy, several measures have been adopted for example; there is a renewable heat incentive system (ICAREN), which intended to

[110] Ibid., 9

generate about 709 ktoe and targets public administration. Additionally, there is a Renewal Thermal Installation measure for certifying and confirming the inclusion of renewable thermal energy in gross consumption as well as the credibility of statistical transfers [111]. In hydrogen sector, incentives are given to replace, maintain and rehabilitate hydrogen plants generating 10 MW and purpose to enhance generation capacity of installations about to end their usefulness.

In the geothermal field, aid and risk programs have been developed to help in the evaluation of geothermal projects. These programs aim at promoting the developments of geothermal projects. Another measure in this area is certification and training initiatives in various fields of geothermal projects. Certification and training measures aimed at increasing quality of geothermal energy.

Spain has adopted a number of measures in the solar sector. For example, there are measures involved in encouraging desalination facilities. These facilities help in establishing new solar technologies. Moreover, in the wind field, Spain has instituted a technical procedure to help aero-generators use the grid. In turn, this measure enables greater wind integration in electricity structure. Moreover, in wind sector there is a measure concerned with repowering wind farms; this is useful in recognizing obsolete technologies and maximize them with wind systems. The technical requirements of renewable energy are standards should be fulfilled by all plants. Observance of these requirements is a must as they are part of the Royal Decrees.

[111] Ibid., 22

Table 2. Measures for achieving renewable energy targets in Spain[112]

Type of measure	Result	Target group	Start and end date
Development of a structure	Reduce administrative problems		2010-2020
Planning of electricity supply	Eliminate challenges that effect development of marine renewable energy	State administration	2011-2020
ICAREN	Financial	Generate 709 ktoe	2012-2020
Incentives to install, modernize or replace hydrogenic plant equipment	Enhance installed hydrogenic capacity	Public administration	Not defined
Aid and risk initiatives	Promote project developments	Investors	2011-2020
Strategies to promote desalination	Help establish of new utilization of solar technologies	Research centers, public administration, and developers	2011-2020

[112] Ibid

2.6. Assessments

In Spain, it is compulsory that the contribution of every renewable energy source must fulfill the 2020 targets. Much as hydroelectric energy is an efficient technology, is not fully tapped to meet the compatibility requirements of environmental sustainability and quality of water bodies. Moreover, hydroelectric is useful when it comes to the security of energy supply and diversification. The 2020 targets emphasize on projects in the administrative phases, therefore, estimated energy performed to install hydroelectric tools in government infrastructures is not currently used while the installed capacity is about 40 to 60 MW yearly[113]. Essentially, the annual growth of hydroelectric is projected to increase irrespective of the applicable decrees. In 2020, the total installed hydroelectric power will be around 16,662 MW. However, this is not inclusive of pure pumping capacity.

The geothermal power sector relies on available resources within Spain. Hence, this calls for putting for research in renewable resources. Nonetheless, processing licenses and various phases of research before the implementation of geothermal power takes about 5 years and 3 more years for actual implementation to begin. As such, there is a program for developing high-temperature geothermal power. The potential of geothermal energy in Spain is considerably reliant on available geothermal resources including projects related to aquifers and enhanced geothermal systems (EGS). At the moment, EGS are in the development phase with a number of projects in progress. Nevertheless, development progress in future will allow the functioning of demonstration plants. Besides EGS, there are high-temperature aquifers fractured regions with anomalous geothermal components[114]. When it comes to renewable energy from geothermal power, there are different heat pumps and the number has been increasing steadily as demonstrated below.

[113] Bowyer, C. and Kretschmer, B., 2010. Anticipated Indirect land use change associated with expanded use of biofuels and bioliquids in the EU–an analysis of the national renewable energy action plans. IIEP (March 2011), p 8
[114] Ibid., 9

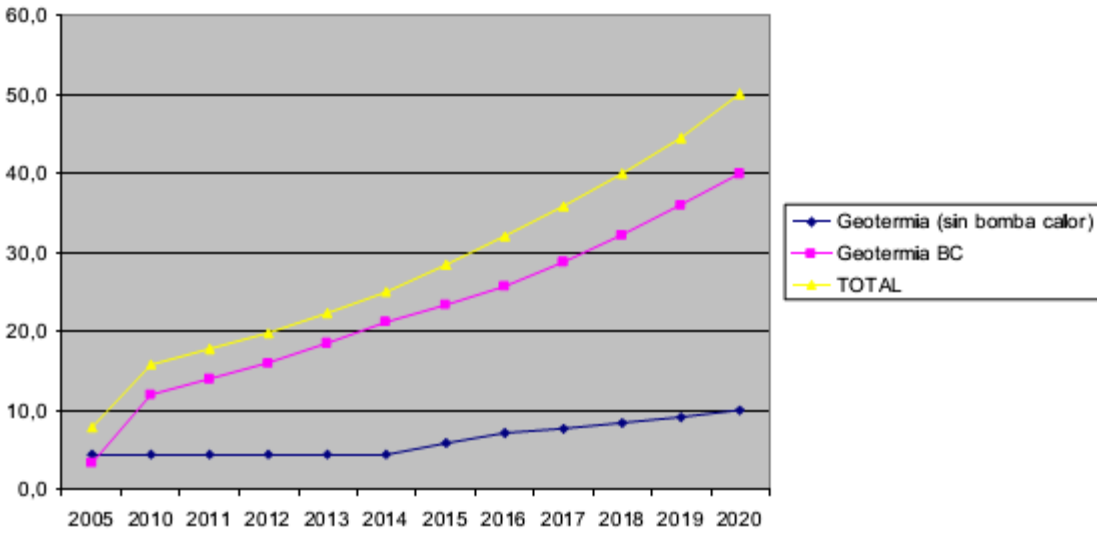

Figure 26: Number of heat pumps for geothermal in Spain (2005-2020).

Based on the Directive 200/28/EC geothermal, aerothermal and hydrothermal energy generated by heat pumps is renewable. But since it requires additional energy, heat pumps that produce energy greater that primary energy is considered. Nonetheless, the Directive does not specify the amount of energy captured by heat pumps. It is estimated that for solar photovoltaic energy to meet the 2020 targets, it has to generate about 14,316 GW while the capacity for 2011 to 2020 is roughly 4,346 MW[115]. For that reason, the focus has been on the current structure to provide quotas as well as tariffs for installation. The estimated energy is computed on the theory that 67% of the installations are in building while 33% in monitored regions this was done with careful attention on areas with the significant sun. The forecasted contribution of photovoltaic energy to fulfill 2020 targets is 15,353 GWh while capacity growth is estimated to be 4,447 MW[116].

[115] Ibid., 144
[116] Ibid., 145

3. Cyprus

3.1. Cypriot Energy Sector

Across Europe, Cyprus is one of the nations with the high cost of electricity. This is because of significant dependence on liquid fuel to generate energy. Nevertheless, a remarkable transition is imminent on its energy sector. While renewable sources have been developed, their cost has reduced considerably. In the meantime, there are increasing concerns regarding greenhouse gasses demonstrating rigid European Union laws. Renewable energy sources present Cyprus the opportunity to cut down costs and environmental effect of energy generation. Following the recent economic inflation, using renewable energy can assist Cyprus to minimize the importation of fuels, reinforce trade balance and create job opportunities. The efficacy of solar heaters can be replicated for photovoltaic systems. The country has embarked on achieving a higher percentage of renewable energy, a milestone that assists in assessing maximum investment in the energy sector. Renewable energy sources will be important in the roadmap to 2020. Additionally, energy planning model utilized in the measurement of benefits of renewable energy based on several conditions is managed by the Cyprus government, especially the Ministry of Commerce, Industry, and Tourism[117]. The energy model is used as a platform for evaluating potential energy policies and numerous energy pathways while helping determine technical, economic, and penetration of renewables and further enhance energy generation through renewable energy sources.

3.2. Cyprus' National Renewable Energy Policy

In Cyprus, the national energy renewable policy is developed by the Ministry of Commerce, Industry, and Tourism and other agencies, including Cyprus Energy Regulatory Authority and the Electricity Authority of Cyprus and the Transmission. Therefore, the Ministry determines Cyprus' renewable energy needs and requirements from global agreements while describing the primary axes for regulating renewable energy targets to be adopted. Furthermore, the country's renewable energy policy

[117] Ministry of Tourism and Trade. Subdirectorate-General for International Relations in the Energy Sector State Secretariat for Energy.

highlights the social aspect of energy. Cyprus national renewable energy policy relies on different dimensions including the following ones.

Competitiveness

To ensure the competitiveness of its energy markets, Cyprus has liberalized these markets with the goal of enhancing the efficiency of the local economy, as well as improved service delivery. It has also improved its energy infrastructures and development of renewable sources of energy in accordance with spatial planning[118]. Moreover, to attain competitiveness, the country has invested in the energy industry on the basis of effective resource use. It has also gone a step further to simplify energy license processes.

Environmental Protection

To ensure environmental sustainability and protection, Cyprus encourages its citizens to use renewable energy to greatly cut down pollution and emissions of greenhouse gasses. In the transport industry, the nation encourages the use of biofuels instead of petrol. Moreover, Cyprus promotes high energy efficiency and heat generation in various sectors and huge commercial plants[119].

Security of Energy

To attain security of energy, Cyprus has diversified its renewable sources of energy through a strategic objective of introducing natural gas. Again, it has increased energy supply focusing on research of its fossil fuel. In a bid to promote the security of energy, Cyprus also maximizes efficient use of renewable energy with the purpose of substituting energy with other sources, such as imported ones. Competitiveness, environmental protection, and security of energy have been converted into particular measurable based on the 2020 binding goals for Cyprus, when it comes to consumption, reducing greenhouse gasses by 5% from 2005, especially for groups outside the Greenhouse Gas Emission Allowance Trading (GGEAT).

[118] Ministry of Tourism and Trade. Subdirectorate-General for International Relations in the Energy Sector State Secretariat for Energy 11/05/111.
[119] Ibid.

3.3. Expected Energy Consumption 2010-2020

The expected energy consumption in Cyprus in 2010-2020 targets has been computed through the creation of an energy model for Cyprus. Forecasts on energy usage in Cyprus are anchored on the European Commission National Renewable Energy Action Plan for 2020[120]. It is with help of this model that energy utilization is computed based on the core fields of activity, such as agriculture, industry, domestic consumption, tertiary sector, and transport. However, it has to factor in certified forecasts when it comes to macroeconomic indices and fuel costs. The model also computes the share of energy utilization putting into consideration the cost of technology, the infiltration of various technologies, technical skills, and other variables that impede the level of diffusion in Cyprus[121].

Moreover, the model utilizes certified data on the energy balance for 2005-2009 as the base. Here, the effect of the economic crisis on the energy sector is considered as well. Nonetheless, it adjusts the aggregate savings prospect between the reference scenario and energy efficiency scenario for the period 2010-2020.

In reality, the reference situation undertakes that no extra energy redeemable measures will be executed after 2010 for the primary and final consumption at a state and regional level, except for those adopted legally by 2010. In 2010, for instance, the aggregate energy consumption reached 1,909 ktoe. However, by 2020, the aggregate energy consumption will have reached 2,240 ktoe. The observable gradual increase since 2010 until 2020 can be characterized by increased energy consumption. This is also pegged on the increase in private transport because of a dilapidated public transport.

3.4. Renewable Energy Targets

According to the EU Directive 2009/28/EC, member nations of the EU has an obligation to formulate and present the European Commission and National Renewable Action Plans (NREAPs) highlighting pathway that enables them to realize

[120] Cyprus National Renewable Energy Action Plan
[121] Ibid.

the 2020 renewable energy, energy proficiency, and HCH cut targets. In this respect, Cyprus 2020 renewable energy targets are as follows. The country's overall target stands at 13%. This is the share of energy created from renewable sources in the collective aggregate consumption. Out of this, heating and cooling are represented by 23.5% of the heat usage met by renewable sources[122]. The country's 2020 electricity target stands at 16%. This will be released by energy from renewable energy. However, transport will account for 5% which will be generated from renewable sources[123]. In meeting these targets, Cyprus is involved in creating an institutional and administrative scaffold to underpin deployment of renewable energy sources (RES). There are also research and development measures to underpin renewables.

3.5. Measures for Achieving the Targets

Cyprus has adopted various measures to attain its renewable energy targets. For instance, Cyprus Institute of Energy (CIE) that was formed in 2000 does not only promote but also develops the utilization of renewable energy sources within the nation. As such, the Institute actively takes part in the global programs associated with renewable energy sources, collaborates with other related institutes globally, conducts research, provides technical assistance, and fosters the use of new and efficient energy technologies.

Another regulatory measure is the Cyprus Regulatory Authority (CERA), as an independent body, it safeguards consumers' interests, ensures reliability and quality of electricity, environmental protection, ensures reliability quality and energy, and promotes the use of renewable energy sources. Furthermore, there is the Combined Heat and Power Law. This law provides Cyprus with a legal structure to create and implement programs, particularly those that promote energy generation via integrated generation from renewable sources of energy. The special rate measures that target investors, particularly those that generate energy using renewable energy sources. This measure enhances renewable energy sources. In this case, special incentives are given to every technology.

[122] Cyprus National Renewable Energy Action Plan
[123] Ibid

Electricity Authority of Cyprus is also a measure that requires purchasing renewable energy electricity. Nonetheless, this is only applicable if the investors produce energy using renewable energy sources. Legal frameworks have also been put in place to determine the adoption of planning policy to install wind farms, turbines, photovoltaic structures. In particular, this measure is important when it comes to determining areas that allow installation of renewable sources of energy. In addition, this measure promotes environmental protection, especially in sensitive regions.

There is also Circular 3 of 2008 that was issued by the Minister of Interior and specifies assessment benchmarks for all applications while determining locations that are licensed to install renewable energy sources plants. Circular 3 has contributed to the remarkable decrease in evaluation and approval time for grants, especially from small-scale photovoltaic structures.

Additionally, the application rates for a significantly small wind farm, biomass, and photovoltaic power plants. This measure purposes at reducing investment expenses, as well as non-inhibitive processes, for extremely small renewable energy sources. It also promotes scattered and small renewable energy plants. The institution of Cyprus Energy Agency supported by the European Commission encourages the use of renewable energy. Other measures put in place to help Cyprus its renewable energy targets include campaigns, seminars, and events.

Table 3. Measures to attain renewable energy targets in Cyprus[124]

Measure	Type of measure	Results	Target
CERA	regulatory	Promote the use of renewable sources of energy across Cyprus	Investors and electricity consumers
Combined Heat and Power Law	regulatory	Provides Cyprus a legal structure to create and institute renewable energy sources	

[124] Ibid

CIE	regulatory	Promote and develop the utilization of renewable energy sources within the nation	The people of Cyprus
Special rates for renewable energy	Financial	Increase renewable energy	Investors
Electricity Authority of Cyprus	Regulatory	Enhance renewable energy sources	Investors
Legal structures	Regulatory	Environmental protection and selection of areas suitable or renewable energy sources	All the people of Cyprus
Circular 3 of 2008	Regulatory	Considerable decrease time needed to approve photovoltaic structures	Investors
Application rates	Financial	Encourage interspersed for small-scale renewable energy source plants	Investors
Cyprus Energy Agency	Soft type	Promote the use of renewable energy	All the people of Cyprus
Seminars, campaign, and events	Soft type	Encourage the use of renewable sources of energy	All the people of Cyprus

3.6. Assessments

It is evident that to meet the targets, it is necessary to take into consideration every renewable energy technology. Therefore, to achieve the 2020 target estimates expected for every renewable energy technology and trajectory for shares from renewable sources like concentrated solar power, photovoltaic, biogas and so forth. However, these sources should be in line with the sustainability laws stipulated in

Directive 2009/28/C [125]. This directive requires Cyprus to implement a national renewable plan to set out national goals to share renewable energy used in cooling, heating, electricity, and transport. But again, it is of great importance that other policies associated with energy efficiency are integrated to attain the national targets. Based on the Directive 2004/8/C, Cyprus has a strategy of developing as well as the promotion of efficient cogeneration. To meet efficient cogeneration, Cyprus has promoted funding small-scale renewable energy plants, zero-rating cogeneration among others [126]. The nation has also enacted a law that promotes the use of renewable energy in combined heat and power (CHP) because as stipulated by the Directive energy used in biogas, generation is essential. Therefore, based on the estimated contribution of every renewable energy technology and indicative trajectory for renewable sources in 2010-2020, in 2010 total energy consumption was 77.66 out of which biomass in the household was about 6.69 Ktoe. In 2011, the total was 81.32 that can be attributed to reduce the use of electricity and use renewable energy from heat pumps. Basically, data shows that contribution of each energy technology in Cyprus is increasing steadily since 2010 to 2020 as demonstrated in the table below.

Table 4. Estimated contribution of each renewable energy source to meet Cypriot 2020 targets in GWh/a [127]

	YEAR											
Renewable energy source	2005	2010	2011	2012	2013	2014	2015	2016	2917	2018	2019	2010
Solar	41.27	59.02	61.50	64.59	68.15	71.67	75.14	78.43	81.63	84.71	87.66	90.47
Solid biomass	4.2	18.30	19.24	20.36	21.63	22.92	24.20	25.45	26.67	27.87	29.03	30.16
RE from heat pumps	0	0.34	0.58	0.82	1.08	1.34	1.61	1.88	2.16	2.43	2.71	2.97
Total	45.47	77.66	81.32	85.77	90.86	95.93	100.95	105.76	110.46	115.01	119.39	123.60

[125] Beurskens, et al. 2011. "Renewable energy projections as published in the national renewable energy action plans of the European member states." Energy Centre of the Netherlands.
[126] Ibid.
[127] Cyprus NREAP

Conclusion

Climate change is a natural phenomenon in which the weather patterns on Earth are altered significantly over the course of time and for an extended period of time (decades to millions of years) which can be caused by natural factors or man-made factors. Climate change has occurred over the years resulting in advancements and recessions in glaciers of the globe, but in recent times it has become a real concern among scientists who keep insisting that this time it is primarily attributed to human activity and that its spread and advancement is proceeding at an unprecedented pace, unlike what has been witnessed or contemplated before. The main driving force of the climate change is global warming which is a steady rise in the surface temperatures on Earth resulting in negative effects such as melting snow caps, increased sea levels and prolonged drought, all of which have prompted scientists and governments to institute mitigation measures such as development of alternative, renewable and clean sources of energy such as hydrogen fuels, solar energy and wind energy[128]. These mitigation measures and areas form the substance of discussion in the last section.

Renewable energies have been recommended by scientists and scholars as the way to go in mitigating and possibly reversing the effects of global warming due to their minimal carbon footprint and energy consumption. Some of these methods include; solar energy, wind energy, hydrogen fuel, and hydroelectric power. Every one of these methods does not involve the emission of carbon dioxide into the atmosphere and thus is recommended as a potential means of replacement for the traditional alternatives such as coal, which have been the biggest culprits in the global warming phenomenon.

However, despite their apparent use in the reduction of global warming, these methods are relatively new and have not been extensively studied like the traditional mainstream methodologies of power production, as a matter of fact, they only became a real concern and alternative when scientists sounded the alarm on global warming. Wind energy is best utilized as an alternative in areas where there is plenty of rapidly flowing wind, such as deserts. This, however, does not mean that it is for communities

[128] Climate.nasa.gov. *"Climate Change: How do we Know?"*

that dwell in the deserts but rather, they are best located in deserts or places with sufficient winds to turn the turbines. Wind farms can be large, often taking up several hectares of land and thus are optimally located out of residential zones. They use wind energy to turn turbines and thus produce electricity.

In Egypt, several studies have been conducted on its feasibility of harnessing various forms of energy, wind included and they have found that it is indeed possible and feasible to do so, as a matter of fact, it has been done already and the country aims at increasing renewable energy contribution to 20% of the grid. The wind turbines are effective at converting energy into electricity and they rank higher than coal plants, whereas coal plants convert about 29% of the coal to electricity, wind farms concert approximately 45% of the wind that passes through their blades into electric energy which can soar to almost 50% at peak efficiency. However, it is mandatory to note that wind energy production is highly location specific and studies have to be conducted to determine its effectiveness in a place and thus the potential success, in fact, the efficiency numbers given here could vary widely on various site[129].

Solar power is the second alternative and has great rewards and flexibility. This method would help reduce climate change by alleviating the reliability on fossil fuels and thus facilitating the transition to clean energy. To defectively use this method, there must be sufficient and intense sunlight, upwards of 6 hours a day. Additionally, the solar option is flexible in that it can be mounted on rooftops as opposed to wind farms that must be established on an independent site. Using the previous example, Egypt has been able to successfully implement solar energy projects that should contribute 2.2% to the national grid by 2022. This works for the country due to its 9-11 hours of intense sunlight daily. Such projects have stalled and failed countries such as the Netherlands that can have less than 3 hours of uninterrupted sunlight on any given day.

[129] Elshazley, Rawya Mostafa. 2011. *"Feasibility of Concentrated Solar Power Under Egyptian Condition*." Germany: KfW Entwicklungsbank.

From this discussion, it is evident that countries are embarking on short and longer strategies of implementing renewable sources of energy[130]. For example, in Egypt there was need to invest in renewable energy so that it can mitigate the load on fossil fuels and ultimately replace them in the event that it became necessary. Urban population is Egypt have ballooned with corresponding increase in energy demands, Egypt alone saw a 5.6% increase in the energy consumption in the year 2014[131]. This can be unsettling when looked at from the bigger perspective in terms of urban areas worldwide there seems to be a growing spree as global population rises.

From this standpoint, it is clear that the innovations and investments in renewable energy are fuelled by the need to curb global warming and climate change and at the same time, to complement fossil fuels in catering for the rapidly growing global population's energy demands.

As much there have been rapid advances in the field of alternative energy sources, there have been failures, and ultimately, lessons to be learned. One of the biggest lessons that have been brought out is the need to conduct adequate scientific research to substantiate the implementation of renewable energy projects[132]. A clear example is the Netherlands where the government went to great lengths to promote the solar energy programs, for example by providing free panels to households and greatly subsiding the cost of solar panels, only for it abandon the project later due to infeasibility as mentioned in the former section. However, despite the apparent slow progression of technology in efficiency and cost effectiveness in the fields of renewable energies, these technologies will help offset the manmade changes to the global climate. In their infancy, they are already contributing significantly and with the promising research and developments in the fields such as hydrogen fuels and tidal energy, their contribution is likely to become significant and noticeable. However, just like the chlorofluorocarbons (CFCs) menace[133], it shall take some years to see the improvements[134].

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[130] Hsu, Shi-Ling. 2011. *"The Case for a Carbon Tax: Getting Past Our Hang-ups to Effective Climate."*
[131] Khalil, Shaaban. 2007. Cairo International Conference on High Energy Physics. New York.
[132] Ucsusa.org. *"Tropical Deforestation and Global Warming."*
[133] *The Montreal Protocol 1987, which is considered successful, banned the use of CFCs, main chemicals causing ozone depletion; parties have achieved their obligations.*
[134] Vagen, Zax. 2016. *"Cost Effective Renewable Energy for the home, Coffee and Solar Power".* Seattle: Amazon Digital Services LLC.

The current global world has encountered a consistent change of climate conditions, which is proved to worsen as time progresses. Research and development in the areas of different renewable energy technologies has picked momentum and has seen vast improvements over the past decades. Additionally, countries have realised the need for alternative energy and instituted strategies to make it a possibility. It is this will power and scientific research that shall help in the flourishing of the renewable sources industries and their ultimate leading role in offsetting the anthropogenic source for global warming. The extent of the future impact of climate change is ultimately determined by economic, technological and policy choices that will be made today.

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