Production of Energy and Environmental Protection as a Prerequisite for Sustainable Development

Diana Baus

How does access to this work benefit you? Let us know!

Follow this and additional works at: http://academicworks.cuny.edu/gc_etds

Part of the Business and Corporate Communications Commons, Business Law, Public Responsibility, and Ethics Commons, Environmental Studies Commons, Growth and Development Commons, Health Economics Commons, and the Regional Economics Commons

Recommended Citation

Baus, Diana, "Production of Energy and Environmental Protection as a Prerequisite for Sustainable Development" (2017). CUNY Academic Works.
http://academicworks.cuny.edu/gc_etds/1907

This Thesis is brought to you by CUNY Academic Works. It has been accepted for inclusion in All Graduate Works by Year: Dissertations, Theses, and Capstone Projects by an authorized administrator of CUNY Academic Works. For more information, please contact deposit@gc.cuny.edu.
PRODUCTION OF ENERGY AND ENVIRONMENTAL PROTECTION AS A PREREQUISITE FOR SUSTAINABLE DEVELOPMENT

by

DIANA BAUS

A master’s thesis submitted to the Graduate faculty in Liberal Studies in partial fulfillment of the requirements for the degree of Master of Arts, The City University of New York

2017
Production of Energy and Environmental Protection as a Prerequisite for Sustainable Development

by

Diana Baus

The manuscript has been read and accepted for the Graduate Faculty in Liberal Studies in satisfaction of the thesis requirements for the degree of Master of Arts.

____________________  ________________________________
Date  Sophia Perdikaris
Thesis advisor

____________________  ________________________________
Date  Elizabeth Macaulay-Lewis
Acting Executive Officer

THE CITY UNIVERSITY OF NEW YORK
ABSTRACT

Production of Energy and Environmental Protection as a Prerequisite for Sustainable Development

by

Diana Baus

Advisor: Sophia Perdikaris

This paper explains why renewable energy is a prerequisite for sustainable development. The development of renewable energy sources is important because renewable energy sources have a very important role in reducing emissions of carbon dioxide (CO₂) into the atmosphere, eradicate poverty and increase the employment rate. In the first section the paper introduces renewable energy sources. The focus is on the function of solar energy, wind power, biomass, geothermal energy, and hydroelectric energy and their implementation globally. The second part of the paper elaborates on the economic, political, and social aspects for the development of renewable energy sources. The main aspect of economic and political reasons is employment growth and the rise of democracy in developed and undeveloped countries. Employment for each renewable source is analyzed. The social benefit of renewable energy deployment is crucial for the well-being of humanity. Further on, the third section explains discusses renewable energy as a prerequisite for the sustainable development. The focus is on global leaders who have already deployed renewable energy and its technologies. Positive versus negative characteristics of renewable energy are listed, and the impact of green companies on renewable energy deployment is examined.
PREFACE

Renewable energy sources can be divided into two main categories: traditional renewable energy sources, such as biomass and large hydropower plants, and the so-called "new renewable sources", such as solar energy, wind energy, geothermal energy, and so on. Renewable energy sources provide 18% of the total world energy (Lund 6), but most of that energy derives from traditional use of biomass for cooking and heating. Therefore, when we exclude conventional renewable energy sources, it turns out that the so-called "new energy sources" produce only 2.4% of total world energy (Aswathanarayana et al. 1). That share in future should be significantly increased because the lack of fossil fuels is becoming more evident, and their harmful impact has significantly increased in the last few decades. The Sun provides the Earth with 15,000 times more energy than the mankind in this stage is able to consume, yet despite that some people on Earth are freezing. This shows that renewable sources could and must be used more efficiently, and that we should not worry about the future when fossil fuels will be entirely exploited.

The development of renewable energy sources is important because renewable energy sources have a very important role in reducing emissions of carbon dioxide (CO₂) into the atmosphere. The reduction of CO₂ emissions into the atmosphere became a goal of the countries that are members of the European Union and other signatories of the UN Climate Change Paris Agreement (Framework Convention on Climate Change), which was signed by 194 nations in 2015, but only ratified by 117. Increase in the share of renewable energy sources increases energy system sustainability. It also helps in improving the delivery of energy security by reducing dependence on imported energy resources and electricity. It is expected that renewable
energy sources will become economically competitive with conventional energy sources in the medium to long term.

The most interesting renewable energy sources are solar energy, wind energy, water energy and bioenergy. Solar radiation is the main driver of most renewable energy sources, but there are several sources that do not originate from it. These are the geothermal energy and energy that can be obtained from the tides. Renewable energy sources are abundant in the nature, but currently they are very inaccessible due to the very high cost of investment, so people are still forced to use more non-renewable energy sources.

The process of acceptance of new technologies is very slow. The main problem for the installation of new plants is their starting price, which raises the price of gained energy in the first few years to the level of non-profitability compared to other commercially available sources of energy. A large share of the production of energy from renewable sources is the result of environmental awareness of the population, which despite the initial non-profitability install facilities for the production of clean energy. Cleanliness of renewable energy sources is the main argument of proponents of such energy sources as well as energy independence.

In this thesis, I will focus on the production of energy and environmental protection as a prerequisite for the sustainable development. This paper will discuss different forms of renewable energy sources and it will examine main economic, social and political reasons for the development of renewable sources. It will also address disadvantages and negative aspects of implementation of renewable energy sources. Finally, the paper will be concluded with a section that talks about renewable sources as prerequisites for sustainable development.
# Table of contents

## INTRODUCTION

## 1. RENEWABLE ENERGY SOURCES

1.1. Solar Energy
   - 1.1.1. Photovoltaic Cells
   - 1.1.2. Concentrated Solar Power (CSP)

1.2. Wind Power
   - 1.2.1. Wind energy from ancient time until today
   - 1.2.2. Benefits and disadvantages of wind energy

1.3. Biomass
   - 1.3.1. Biomass from the forestry waste
   - 1.3.2. Biomass from the non-wood plants
   - 1.3.3. Pros and cons of biomass energy

1.4. Geothermal Energy
   - 1.4.1. Production of electrical energy from geothermal sources and its benefits

1.5. Hydroelectric Energy
   - 1.5.1. Wave Energy
   - 1.5.2. Tidal Energy

## 2. MAIN ECONOMIC, POLITICAL, AND SOCIAL ASPECTS FOR THE DEVELOPMENT OF RENEWABLE SOURCES

2.1. Economic and Political Reasons for the Development of Renewable Sources
   - 2.1.1. Employment in Solar Photovoltaic Sector
   - 2.1.2. Employment in Liquid Biofuels Sectors
   - 2.1.3. Employment in Wind Sector
   - 2.1.4. Employment in Hydropower
   - 2.1.5. Policy Mix for the Deployment of RE

2.2. Social Reasons for the Development of Renewable Sources
3. RENEWABLE ENERGY AS A PREREQUISITE FOR THE SUSTAINABLE DEVELOPMENT

3.1. Places where renewable energy is deployed 39
3.2. Positive vs. negative characteristics of renewable energy 40
3.3. Green companies and their impact on renewable energy deployment 42

CONCLUSION 44

BIBLIOGRAPHY 46
# Table of figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1</td>
<td>Proved Reserves at End 2008</td>
<td>1</td>
</tr>
<tr>
<td>Figure 2</td>
<td>CO₂ Concentration Profiles for the Baseline, ACT and BLUEMap Scenarios</td>
<td>3</td>
</tr>
<tr>
<td>Figure 3</td>
<td>Growth of Renewable Power Generation in the BLUEMap Scenario, 2000-2050</td>
<td>4</td>
</tr>
<tr>
<td>Figure 4</td>
<td>Absorption of sunlight through PV cells</td>
<td>7</td>
</tr>
<tr>
<td>Figure 5</td>
<td>Use of wind energy compared to the other energy sources</td>
<td>8</td>
</tr>
<tr>
<td>Figure 6</td>
<td>Ancient Persian Windmill, medieval windmill and modern windmill</td>
<td>9</td>
</tr>
<tr>
<td>Figure 7</td>
<td>Short rotation crops</td>
<td>13</td>
</tr>
<tr>
<td>Figure 8</td>
<td>Algae biofuel</td>
<td>14</td>
</tr>
<tr>
<td>Figure 9</td>
<td>Temperatures in the Earth</td>
<td>16</td>
</tr>
<tr>
<td>Figure 10</td>
<td>Principle of transformation of geothermal energy to electrical energy</td>
<td>17</td>
</tr>
<tr>
<td>Figure 11</td>
<td>Hydroelectric power plants: Transformation of hydro energy to the electrical energy</td>
<td>20</td>
</tr>
<tr>
<td>Figure 12</td>
<td>Use of tidal vs. wave energy in the world</td>
<td>23</td>
</tr>
<tr>
<td>Figure 13</td>
<td>Framework for Analyzing the Socio-economic Effects of Large Scale RE Development</td>
<td>25</td>
</tr>
<tr>
<td>Figure 14</td>
<td>Renewable energy employment in selected countries and regions</td>
<td>28</td>
</tr>
<tr>
<td>Figure 15</td>
<td>Employment in Large Hydropower by Country in 2015</td>
<td>32</td>
</tr>
<tr>
<td>Figure 16</td>
<td>Renewable Energy Benefits by 2030</td>
<td>36</td>
</tr>
<tr>
<td>Figure 17</td>
<td>Sustainable Development Goals According to their Priority</td>
<td>38</td>
</tr>
</tbody>
</table>
Table 1. Top ten countries in installed wind power capacity 10
Table 2. Top 10 Geothermal Countries 18
Table 3. Hydroelectric Power generation by country, 2012 19
Table 4. Renewable Energy Employment by Technology 30
1. **RENEWABLE ENERGY SOURCES**

Renewable energy resources are self-sustaining energy resources that can be found in the nature and used for an infinite period of time. Use of fossil fuels brought us to an unacceptable position in ecology. “Each country has to figure out its own energy portfolio, consistent with its endowment of energy resources, and employing technologies, which are economically viable and socially equitable, and have minimum adverse impacts” (Aswathanarayana et al. 1). However, studies showed that very soon at this rate of consumption, all stocks of non-renewable fuel will be exhausted. Therefore, the current situation in the field of ecology requires investments in renewable sources of energy production, because as the studies show on Figure 1, our oil reserves are sufficient for 40 years, 65 years for natural gas and 220 years for coal exploitation at the current pace.

*Figure 1. Proved reserves at end 2008 in thousand million barrels. Source: Statistical Review of World Energy*
The book *Green Energy Technology, Economics and Policy* by Aswathanarayana et al., explains that the rise of the temperature to 2ºC by 2050 is regarded as a serious issue which could cause great losses in agriculture all over the world. The rise of the temperature in India by 1ºC proved with the gross loss of USD 20 billion. Renewable resources, such as solar, wind, geothermal, biomass and hydro energy are inexhaustible. It is just important to capture that energy and transformed it either to electrical energy, hydrogen and clean transportation fuels.

Changes in energy economy “are sought to be accomplished through greater energy efficiency, greater use of renewable and nuclear power, CO₂ Capture and Storage (CCS) on a massive scale, and development of carbon-free transport” (Aswathanarayana et al. 1). Green energy is seen as an investment in people and their health as it is free of carbon dioxide. Nowadays, when the benefits are known, it is unknown how to drop its price.

With the economic crisis of 2008, rich and poor countries were forced to find a solution to get out of recession and adopted Renewable Energy Technologies (RETs), because it was expected to be job-generating but also inexhaustible industry which benefits the environment. (Aswathanarayana et al. 1) It is duty of each country to decide which technologies will be used and how will they be integrated in national policy respectfully to the national social and economic circumstances. Energy technologies are easily developing due to “technology improvements and marketing penetration” (Aswathanarayana et al. 2).

Some countries as China and Denmark have already introduced green technology. In 2008, China as a largest producer of solar panels and wind turbines, created 1.12 million new jobs and became a super power for development of renewable energy technologies. Denmark reduced carbon-economy and in that way reduced emission of gases by 14%. However, usage of energy reminded the same. Denmark became European leader in green energy consumption.
Most used way of green energy is wind power and biomass, which produce 30% of Denmark’s overall electricity, and allows them to export 11% of energy technology. Denmark, for relatively small country, raised its GDP for 40% with the usage of green energy, which had a positive impact on the socio-economic situation in the country.

Renewable energy resources are the resources for the future, “for the simple reason that, unlike the fossil fuels, they do not get depleted when used” (Aswathanarayana et al. 7). Scientists predict two possibilities about the renewable energy consumption till 2050. First assumption in the ACT Map scenario (Figure 2) is that increase of renewable energy will be 35%, and second, in the BLUE Map scenario (Figure 3), 45%. “Up to 2020, bulk of renewable energy production will come from biomass and wind. After 2020, solar power production will become significant. Hydro will grow continuously till 2050…” (Aswathanarayana et al. 8)

![CO2 concentration profiles for the Baseline, ACT and BLUE Map scenarios. Source: Green Technology, Economics and Policy by Aswathanarayana, U. et al.](image)
Urban areas contain 50% of the overall population. That means that cities will have to find a way how will they deliver renewable energy to the citizens. For the cities with the low latitude and lot of sunshine, solar panels could be the solution. Cities located close to the sea could trap tides energy and wind energy, and for these cities close to the forests could be suitable for energy from biomass.

1.1. Solar Energy

Sun is the closest star and the major source of energy on the Earth. It can produce 15 times more energy than the humans can consume. Moreover, if it is used in the right way it allows humans to rely on it once the fossil fuels will be used. Solar energy is not used to its maximum due to the fact that some people still lack of general necessities. Sun energy is free and can be used everywhere where the sun shines, even though some electricity can be produced.
when it is cloudy. (Aswathanarayana et al. 21) Among many positive characteristics, it is important to mention that solar collectors (photovoltaic cells) are very easily installed and have no moving parts.

1.1.1. Photovoltaic Cells

The development of photovoltaic cells began in 1839 when the French physicist A.H. Becquerel realized that the current between two electrodes in the electrolyte increases during exposure of electrodes. The same effect on solid body (selenium) was noticed by W. G. Adams and R. E. Day in 1877. Thanks to that cognition the device for measuring the intensity of light was developed soon. Immediately afterwards, the researchers turned to solving the problem of using photovoltaic cells as commercial sources of electric energy. With the use of solar cells, solar energy is directly converted into electric energy. Photovoltaic cells can be used as independent or additional sources of energy. They are used as independent sources of energy, in the area that is not connected to electricity network, mostly in mountains regions or on the vessels. Otherwise, they can be used together with the electricity network for the economic consumption of electricity.

The principle in which PV cell work is when solar radiation shines photovoltaic cell energy given to electrons releases them and pushes them to the cell surface causing imbalance in the number of electrons between the upper and lower side of the cell. Then cells connected with the wire will allow current to flow. All cells are connected into the plants and with the help of device which tracks the angle of Sun rays, they turn toward the solar radiation. Electrical energy from the PV cells can be used for lighting, for household appliances, or stored in batteries. (Aswathanarayana et al.30) However from the early development, PV cells found its function in
the facilities such as lighthouses, airports, research platform at sea, residential and industrial buildings.

Maintenance costs for photovoltaic system are minimal, because there are no moving parts therefore damages are not likely to occur. Per year consumers costs are around 0.5% of the capital investment. (Aswathanarayana et al. 24) Mostly costs of maintenance relate to washing modules of dust and dirt. Life expectancy is on average 35 years. (Aswathanarayana et al. 24) Another benefit is that PV cells work quietly, being able to supply electricity to one household but to the entire neighborhood as well. It is used for “direct supply of solar heat to buildings and industrial process, and provides up to 40% of global energy, and for production of solar hydrogen which can be used as fuel” (Aswathanarayana et al.21).

However, solar energy is expensive, in terms of cost for the kWh of electrical energy, which is US cents 20 to 40, comparing to electricity derived from the fossil fuels which is relatively cheap US cents 3 to 5. (Aswathanarayana et al. 21) Another lack of solar energy is that there is no power supply during the night. Nevertheless, solar energy is the fastest growing among the other green energy resources and it is believed that its consumption in the following years will grow significantly. In the developed economies, such as North America, emerging economies, such as China and India, until 2050, “CSP (Concentrated Solar Power) will grow strongly” (Aswathanarayana et al. 22). The same prediction follows for the equatorial counties of Latin America and Africa.
1.1.2. Concentrated Solar Power (CSP)

Concentrated solar power system collects solar energy through the mirrors placed on the surface and transforms it into the electrical energy. For its work, system needs plenty of sunshine, land and water. The collected heat powers a steam turbine which drives a generator. CSP system does not transfer solar energy into electrical energy directly, but first into the thermal energy. “In other words, it can store heat in various forms, and release power as and

Figure4: Absorption of sunlight through the PV cells. Source: Solar Energy Diagrams, Barth B.
when needed” (Aswathanarayana et al. 27). therefore, CSP plants can be used for thermal heating or cooling of buildings. Estimation showed that the whole USA territory could be provided with the electricity from CSP plants on the area of hundred square meters. When the expected shortages of fossil fuel occur, CSP plants are expected to be an attractive solution as they can serve in few different ways.

1.2. Wind Power

Wind energy is the most developed source of renewable energy. It is growing annually for 20% to 30%. “Wind power is expected to provide 12% of the global electricity by 2050, thereby avoiding annually 2.8 gigatonnes of emissions of CO₂ equivalent. This would need an investment of USD 3.2 trillion during 2010-2050” (Aswathanarayana et al. 11). Wind energy demand a lot of forecasting of local winds in order to put the wind farms in use.

![Figure 5. Use of wind energy compared to the other energy sources. Source: Renewable Energy and Jobs: Annual Report for 2016. International Renewable Energy Agency.](image-url)
1.2.1. **Wind energy from ancient times until today**

Throughout the history wind power had a great importance in the maritime development, which enabled international relations among the continents. Ancient Egyptians used the favorable winds to move vessels downstream and upstream the Nile. Wind energy opened doors to mechanism but also made geographical expeditions possible. First historical evidences of humans using energy of wind to obtain mechanical energy are dating from ancient Persia, 2000 years BC. More specifically, it was a simple windmill with the horizontal blades on which were placed the sails and caught the wind. In that way mill could process the grain. Moreover, windmills had a function of water pumps and soil watering.

Windmills greatly developed during the medieval age. Many scientists worked on their development, and with the time they were more and more incorporated into the factories. With the start of industrial revolution in the 19\(^{th}\) century, number of wind mills dropped five times. In 1970s, with the first energy crisis in Denmark and US, number of windmills started growing again.

*Figure 6. shows ancient Persian windmill, medieval windmill and modern windmill.*  
*Source: Wind as a source of alternative energy.*
The trend of transferring wind energy to electrical energy spread throughout western countries such as Great Britain, Netherlands, Sweden and Germany. Nowadays, wind energy industry is very strong. Countries are supported by their government with tariffs and fiscal incentives. Market with wind energy turbines is growing and until now it successfully spread to Asia and South Europe. “There are wind farms in about 40 countries in the world, with thirteen of them having a capacity of 1000 MW of installed capacity” (Aswathanarayana et al. 13). In 1980s California and Denmark were only markets for wind turbines, until 1990s when Germany entered followed by Spain causing the great boom in the wind energy industry. Today Germany is the leading country in production of electric energy from wind energy, making almost one third of world’s overall wind energy production. Successful use of wind in Germany is the result of governmental incentives that are supporting installment of new capacities. Table below shows top ten countries with the wind capacity.

<table>
<thead>
<tr>
<th>Country</th>
<th>MW</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>22,247</td>
<td>23.6</td>
</tr>
<tr>
<td>United States</td>
<td>16,818</td>
<td>17.9</td>
</tr>
<tr>
<td>Spain</td>
<td>15,145</td>
<td>16.1</td>
</tr>
<tr>
<td>India</td>
<td>8,000</td>
<td>8.5</td>
</tr>
<tr>
<td>China</td>
<td>6,050</td>
<td>6.4</td>
</tr>
<tr>
<td>Denmark</td>
<td>3,125</td>
<td>3.3</td>
</tr>
<tr>
<td>Italy</td>
<td>2,726</td>
<td>2.9</td>
</tr>
<tr>
<td>France</td>
<td>2,454</td>
<td>2.6</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>2,389</td>
<td>2.5</td>
</tr>
<tr>
<td>Portugal</td>
<td>2,150</td>
<td>2.3</td>
</tr>
<tr>
<td>Rest of the world</td>
<td>13,018</td>
<td>13.8</td>
</tr>
<tr>
<td>Total top ten</td>
<td>81,104</td>
<td>86.2</td>
</tr>
<tr>
<td>Global total</td>
<td>94,122</td>
<td></td>
</tr>
</tbody>
</table>

(Source: Energy Technology Perspectives, 2008, p. 347)

Table 1. Top ten countries in installed wind power capacity. Source: Green Technology, Economics and Policy by Aswathanarayana, U. et al.
1.2.2. Benefits and disadvantages of wind energy

There are many positive characteristics of the wind power. Among the most important ones is that it does not emit carbon dioxide. They do not run of fuel but on wind energy which is free. In that way they are desirable alternative to fossil fuels because they do not pollute the environment. Wind farms also have a positive impact on lowering the wind power in the areas that are exposed to powerful wind blowing. The best suitable place for wind farms are hills and shores on the open oceans. However, people prefer this area to be free from “aesthetic pollution” and to serve as tourist attractions. Another challenge is noise that wind plants produce. Noise can be aerodynamic, which comes from the blades, and mechanical, which is produced when the rotating parts move. However, new designs bring enormous improvement regarding the noise. Variations of wind, from tornado to light breeze, ask for technical improvements regarding how to protect wind plants from strong wind and use the maximal power from the light breeze. Otherwise, expenses of maintenance have to be added to the price of the electricity. Regarding the environment, wind plants impose threat to migratory birds, but that can be avoided by placing wind plants out of birds’ routes.

1.3. Biomass

Biomass is naturally produced energy that supplies energy for more then 1.6 billion people. For India itself energy from bio fuels provides heating for over then 668 million people. (Aswathanarayana et al.29) It is produced from natural wastes which come from the agriculture, industry, forests and landfill gases. (Aswathanarayana et al.29) Biomass can be of plant or animal origin. Biomass produced from plant waste can be a product of wood (waste from forestry and wood industry, fast-growing trees, waste wood and wood that occurs as a by-product
in the agriculture) or non-wood plants (by-products and waste of crop production and the biomass obtained by the cultivation of oilseeds, algae and grasses). Biomass of animal origin constitutes of waste and residues from livestock.

1.3.1. Biomass from the forestry waste

Biomass from the forestry waste is the organic matter created in the forest ecosystem, consisting of trees and shrubs used for mechanical and chemical processing, and for thermal heating used as firewood. An intensive cultivation of fast-growing tree species such as willow, poplar, alder, birch, acacia and others can accelerate the production of biomass. This process is known as the "culture of short rotation" or "intense culture of short rotation ". Short rotation crops (SRC) such as willows and poplars are used for production of heat and electricity. These plants are rejuvenated from shoots that are growing from the stump or roots. High density of planting will allow cutting every two to five years. Short rotation crops are a great solution for the soils that have been abandoned, where agricultural production is not profitable or are unsuitable for cultivation of valuable forest species. The main function of this type of culture is the production of biomass as a renewable and environmentally friendly energy source. In addition they can be an alternative in the poor habitats for diversification of agricultural land, offer the possibility of environmentally advanced ways of water and soil purification, and also serve to bind increasing amounts of atmospheric carbon.
1.3.2. Biomass from the non-wood plants

Algal Biofuels

During the photosynthesis green plants, such as algae, produce cyanobacteria that can convert 10% of sun energy into biomass. (Aswathanarayana et al. 32) “The rate is 5% for algae, and 1% for corn and sugar cane.” (Aswathanarayana et al. 32) Each cell of algae is able to produce chemical mix that contains fuel that can be used for cars and trucks. That fuel is carbon free and non-toxic. Cultivation of algae is the best in closed systems that allow sunlight and nutrients, as well as CO₂ as a bioreactor. Until now, since 2011, Californian company Sapphire Energy have had produced one million gallons of biodiesel and jet fuel. (Aswathanarayana et al. 32)
Ethanol

Ethanol is another biofuel produced of livestock. Brazil is the largest producer of ethanol from sugar cane, while in Europe and United States ethanol is produced from the oil seeds. (Aswathanarayana et al. 33) Brazil got an incentive to use sugar sane because of low sugar prices, and by now saved around USD 40 billion in foreign exchange using the mixture of ethanol and gasoline to run cars. (Aswathanarayana et al. 33)

1.3.3. Pros and cons of biomass energy

In contrast to other sources of green energy, biomass power can be turned on and off, depending on when is needed or not. When the biomass fuel burn it produces particles SO₃ and
NOx which are harmful for the environment. (Aswathanarayana et al.29) However, emission of particles is in a much smaller amount when comparing to the burning of fossil fuels. Biomass fuels are biodiesel, ethanol, methanol, dimethyl ether, FT diesel, hydrogen, and bio-oil and bio-methane. (Aswathanarayana et al.30) Biomass energy has two drawbacks; “the demand for bio-fuels has led to deforestation, and the deterioration of wetlands and peat soils, and thereby, increased the CO2 emissions and food prices“(Aswathanarayana et al.30). An example, on increased price of food, is corn which price grew as its use for biodiesel increased. Another negative characteristic is that when biomass in not available, it has to be transported and transportation costs are high.

The main goal is to increase the use of biomass for energy production in economic competitive and sustainable manner with the least impact on the environment. Research and development projects should also develop new ways of obtaining bio-fuels, as well as new equipment and methods for producing, handling and use of bio-fuels. Increasing the use of biomass leads to the reduction of greenhouse gas emissions, better maintenance of forests, and security of energy supply and increasing the productivity of forests.

Biomass has the highest potential among all the other green energy sources. Until now it has been the highest contributor to green energy, but still it has been used inefficiently for domestic purposes. Research on biofuel on algae and other plant is continuously in the progress and it is believed that by 2050, use of biomass will be four times higher.

1.4. Geothermal Energy

Geothermal energy is a thermal energy that is created under the Earth's surface, in its crust, due to the slow decay of radioactive elements, chemical reactions or friction in the
movement of tectonic plates. Earth can produce inexhaustible amount of energy, therefore it is considered to be a renewable energy source. When going in the depth of the Earth, its crust is consists of melted rocks and its temperature rises close to 1250 °C. Tectonic movements cause the leakage of magma which when reaches the surface creates a new upper layer of crust. However, magma can create volcanoes and stay in side of the pool. Depending on the depth of the whole, magma needs at least half a million years or longer to cool down. Since the process of cooling is long and magma has a high temperature gradient, volcanoes are suitable to be sources of geothermal energy.

![Temperatures in the Earth](image)

*Figure 9. Temperatures in the Earth. Source: Colorado Geological Survey.*

Geothermal energy potential is enormous and incomparable to the amount of energy that can be produces from fossil oils. Geothermal resources are ranging from the shallows to deep thermal water reservoirs that can be brought up on the surface and used in everyday life. In the nature, geothermal energy comes in the form of volcanoes, hot water springs and geysers
Geothermal energy throughout the history was consumed for warm medicine baths, but nowadays exploitation of geothermal energy is directed towards the process of obtaining electricity, household heating and industrial plants. Furthermore, geothermal energy can be used for other purposes such as the production of paper, milk pasteurization, swimming pools, in the process of drying wood and wool, planning livestock, and for many other purposes (DiPippo 6).

1.4.1. Production of electrical energy from geothermal sources and its benefits

Production of electrical energy from geothermal sources has no harmful impact on the environment because it uses hot water and steam from the earth to run the generator, so there is no burning of fossil fuels, only water steam. When cold water is pumped on hot rocks that are near the surface, the hot steam comes out at the high pressure and drives the generator. Today there are three different types of geothermal plant in use, these are: plants that work on the principle of dry steam, flash steam and binary cycle. The most affordable are plants that work on dry steam principle.

![Geothermal Power Plant Diagram](image)

*Figure 10. The principle of transformation of geothermal energy to electric energy. Source: A Student’s Guide to Global Climate Change.*
Geothermal energy has an advantage to be of a large magnitude, “the heat stored in the earth is estimated to be 100,000 times more than the world’s annual energy use.” (Aswathanarayana 46) It is also available throughout the whole year and production costs are not high. Moreover, production of electrical energy from geothermal sources is completely carbon free. Drawback is that change in the reservoir pressures can trigger low magnitude earthquakes. Also, geothermal energy is not transportable and it can be used just in the area nearby the source. Today, United States are the top users of the geothermal energy (Figure 11), with the highest concentration of geothermal plants in the west. In the US, geothermal energy is the third biggest source of electrical energy after the hydro energy and biomass.

Table 2. Top 10 Geothermal Countries. Source: ThinkGeoEnergy Research, GEA, IG.
1.5. Hydroelectric Energy

The movement of water in the nature is caused by solar energy. It gives the energy to watercourses (rivers and streams) and waves, which was for centuries used to obtain mechanical work in the mills. The first hydropower plants in the world were built in 1876 in Germany and were used to supply aristocratic mansions with the electricity. Today hydropower is used only for the generation of the electricity. When hydropower energy is compared to the other renewable energy sources used for electricity generation, hydropower is the only one that is used in a significant proportion. Some countries, especially Sweden, Switzerland and Norway, obtain most of their electricity from hydropower (Aswathanarayana 39). Nowadays, hydropower makes 90% of all renewable energy sources (Aswathanarayana 39). It is also among the cheapest ways of producing electricity (Aswathanarayana 39).

Hydroelectric power plants are power plants in which the potential energy of water goes through the turbine and convert into mechanical (kinetic) energy, which is in an electric generator used to produce electricity. Exploitation of water potential energy is economically competitive production of electricity comparing to fossil and nuclear fuels, so it is the most important renewable energy source (representing 97% of the energy produced by all renewable sources).

![Hydroelectric power plants](image)

*Figure 11. Hydroelectric power plants: Transformation of hydro energy to the electrical energy.*
*Source: Battery and Energy Technologies, Electropedia.*

Hydropower can be obtained from the ground water courses (rivers, streams, canals, etc.), from the waves and tide. Land headwaters originate from water circulation in the nature. Their energy comes from the sun. Sea waves, those that are caused by weather conditions, also derive from the solar energy. Waves that occur due to the effects of the Earth’s crust, such as volcanoes or earthquakes, have devastating effects, therefore, are not suitable for use. In contrast to waves, the energy of tides comes from the gravitational effects of celestial bodies, namely the interaction of the Moon and the Earth.
However hydropower still significantly lags behind in its production. The reason for this lies in the fact that the exploitation of hydropower has also important technical and natural limits. The main limitation is the requirement for the existence of an abundant source of water throughout the year, because the storage electrical energy is expensive and very harmful to the environment. In order to avoid fluctuations in the water levels at certain locations, it is necessary to build dams and reservoirs. The construction of reservoirs often requires immersion of large parts of the valley, and sometimes the whole village. The raising level of groundwater around reservoirs could have an impact on the wildlife too.

Another impact is the change in relationship of sedimentation and erosion in the river bed. It all points out the fact that hydropower is not completely harmless to the environment. Earthquakes also impose a danger; therefore, some areas require an additional seismic protection. Hydropower is unlike the other renewable energy sources; there is no problem with the lack of necessary technology, but the problem is a lack of the required location. Many of the best locations around the world have already been in use. Despite some disadvantages of hydro energy, its impact on the environment is still much lower when comparing to use of fossil fuels.

1.5.1. Wave Energy

Wave energy is a transformed solar energy caused by winds, which are the result of differences in the air pressure that occur due to different heat amounts of certain parts of the surface. Steady winds cause permanent surge on particular areas and those are the places on which it is possible to exploit their energy to power the turbine conveniently. One of the ways is for a wave to enter the room and squeeze the air out of it. The air drives a turbine, which can then trigger the generator. When the wave comes out of the room, the air enters the room through
a passage that is normally closed. Another way to use vertical motion of waves (up - down) is for
the movement of piston within the cylinder. The piston can also trigger the generator. Most
systems that use energy waves are of a small power, but they can be used for generating smaller
lighthouses.

In the present time, there is a huge interest for an exploitation of the energy of waves.
This form of energy production has not been developed yet even though there are a number of
technical solutions for the development of that type of energy resource. Nevertheless, only in the
United Kingdom, there are more than 350 patents with different solutions (Aswathanarayana 41).
The conversion of wave energy into electricity could be of an interest to islands that are far away
from the shore and where it is expensive to connect them to distant conventional power plants
with long lines. Volatility of waves requires the storage of energy. Ocean currents are huge
sources of energy, but no effective solutions have been introduced yet. The production of
electricity based on the differences in temperature of the sea at different depth levels is also
possible.

1.5.2. Tidal Energy

Using the tides to generate electricity is related to a limited number of areas on Earth
where there are large variations in sea level during high and low tide. The facility has several
power plants with this mode, and few countries plants to build these plants in areas with a large
difference of tides in the amount of 8 to 10 meters. These hydroelectric power plants are of high
powers and they are able to produce significant amounts of electricity. In seas where there is no
difference between high and low tides, there are no conditions for the construction of such power
plants. Tidal power is classified as a form of hydropower by which the sea movement is caused
by the lunar or fall and rise in the sea level, which is used for transformation into electricity and other forms of energy. So far, there are no major commercial exploitations of this energy, but its potential is not small. Tidal power has the potential to create electricity in certain parts of the world, that is, where the tides are extremely emphasized. Sea tides are more predictable than wind energy and solar energy. This method of electricity production cannot cover the world's needs, but it can make a major contribution to renewable sources. The difference in the height of the tides varies depending on a geographic location, but usually it is estimated to be between 4.5-12.5 meters (Aswathanarayana 42). For example, the amplitudes of the tides in the Mediterranean Sea are 10 centimeters and in the Atlantic, Pacific and Indian Ocean, they range on average between 6-8 meters (Aswathanarayana 42). In certain locations of the shore of western France and in the southwestern part of the United Kingdom, the amplitude reaches even over 12 meters (Aswathanarayana 42). On the Atlantic coast of Western Europe, the time between two tides is 12 hours and 25 minutes, and on the shores of Indochina only one tide in 24 hours occurs (Aswathanarayana 42). For an efficient production, a minimum height of 7 meters is required. It is estimated that in the world, there are about 40 sites suitable for the installation of tidal power plants (Aswathanarayana 42).

Figure 12. Use of tidal vs. wave energy in the world. Source: Energy without carbon; Graphs-Tidal Energy
2. **MAIN ECONOMIC, POLITICAL, AND SOCIAL ASPECTS FOR THE DEVELOPMENT OF RENEWABLE SOURCES**

Adoption of Kyoto Protocol in 1997, as an international agreement associated to the United Nations Framework Convention on Climate Change, countries committed to participate in the reduction of the emission. “Recognizing that developed countries are principally responsible for the current high levels of GHG emissions in the atmosphere as a result of more than 150 years of industrial activity, the Protocol places a heavier burden on developed nations under the principle of ‘common but differentiated responsibilities’” (UNFCCC 1).

Nowadays renewable energy has become the main concern of the social and economic development. The main question about the renewable energy is how to implement it hundred percent in the society. There are two important aspects that must be considered for the implementation and successful use of renewable energy. First, “wise economic decisions are needed for the questions of the use of non-renewable energy sources, pollution and global warming” (Kopsakanagas-Savolainen and Svento vii). There is a strong incentive to understand the energy market and the new economic theory which is grounded on the consumer not just having a passive role but to be active and optimizing users of the energy. Currently, renewable energy sources provide world's demand with 15-20% of energy. (Akella et al. 1) “The supply is dominated by traditional biomass, mostly fuel wood used for cooking and heating, especially in developing countries in Africa, Asia and Latin America” (Akella et al.1). The rest of the renewable energy sources contribute to the world’s energy demand with 2%. Many policy makers, in the countries with low income economies, see the renewable energy as an opportunity for higher income, expansion of the job market, improved contribution to industry and trade development.
Second, social benefits that come from the implementation of the renewable energy are the most important reasons for its development. However, to obtain these goals society needs to implement certain technology changes on national and international level.

2.1. Economic and Political Reasons for the Development of Renewable Sources

Smart economic decision making regarding the use of renewable energy became the main concern in economic and societal spheres. “Our homes and real estate are all the time more and more dependent on electricity. Electricity bills take a growing share of the budgets of household and firms, and this development creates new needs for smart usage of electricity” (Kopsakanagas-Savolainen and Svento 7). Renewable energy increases global economy. Economic progress always contributes the social improvements and reduces the poverty. “As populations expand, living standards improve and consumption rises, total demand for energy is expected to increase by 21% by 2030” (Ferroukhi et al. 13).

Targets that were set up to minimize the greenhouse gas emission, pushed policy makers around the world to find other solutions. Changes in investments for infrastructure and energy sectors increased the growth across the economy. Impact of the energy sector has a wide range of benefits; from job creation to the environmental conservation. Making the energy supply more cost effective, reliable, secure and environmentally sustainable thus contributes to the long-term resilience of economic development. “The deployment of renewable energy technologies has seen remarkable growth in recent decades, supported by enabling policies and steep cost reductions. Improved energy security, fewer adverse climate change impacts and broader energy access are widely viewed as motivations for this increase” (Ferroukhi at al.13).

The use of renewable energy creates a wide range of economic benefits. The main benefit is the job creation because its keeps economy healthy and running. “When more people are working, the benefits extend beyond the income earned from those jobs. Benefits occur when
workers spend part of their income in the local economy, generating spin-off benefits known as the 'multiplier effect’” (Ferroukhi et al. 14). International Renewable Energy Agency states that use of renewable energy can create much more jobs when its compared to what conventional energy systems offer. The number of jobs depends on stages of production, moreover, how much production is carried out in the certain region and if technologies are manufactured locally.

The cost of investment in the new technologies is effective because it will save more money that would be spent on fossil fuel and power bills. The study area seeks for the new ways of energy, to give a wide spectrum of possibilities. Energy supply diversity on the market strengths overall economy, because there are more ways to increase the revenue. “A number of scenario studies have investigated the potential contribution of renewable resources to global energy supplies, indicating that in the second half of the 21st century their contribution might range from the present figure of nearly 20% to more than 50% with the right policies in place” (Ferroukhi et al.14). The strength of renewable energy is unquestionable because it meets the energy demand of the world many times. In the last 30 years, the substantial drop in the cost of solar and wind technologies increased the likelihood for the transition to renewable energy. Nevertheless, all the other support mechanisms for the support of the renewable energy evolved, what makes it clear that future will incline toward renewable sources. However, nowadays due to the constant fluctuations in the price of oil and gas, that process of integration of renewable energy is slowing down.

Among other impacts, renewable energy will affect GDP. The growth of GDP “will depend on the economic structure of the country, the costs of alternative energy sources (e.g. fossil fuel prices, energy technology costs), and whether the equipment and required services are imported or sourced locally” (Ferroukhi et al. 14). The profitability of the investment in the
renewable energy will be increased if the technologies are produced locally. Studies suggest that until 2030 “employment could increase anywhere from a few thousand to over a million” (Ferroukhi et al. 14). Worldwide, income per capita is positively correlated with the energy use per capita and both are strongly linked with the economic growth.

In 2015, 8.1 million people were employed in renewable energy industry. From that number 1.3 million was employed in hydropower sector because it is the largest and it can accommodate many workers. “Renewable energy markets and employment continued to be shaped by favorable policy frameworks in several countries, regional shifts in deployment and increased labor productivity” (Ferroukhi et al. 5).

![Figure 14. Renewable energy employment in selected countries and regions. Source: Renewable Energy and Jobs: Annual Report for 2016. International Renewable Energy Agency.](image-url)
It is on the country to propose the policy frameworks that would create the employment. The examples are Indian and Brazilian frameworks where Indian government focused sharply on solar energy and Brazilian created employment through the wind energy. United States invest a lot in the creation of employment in solar energy industry. Asian renewable energy market continuously grows and sells technology and lower price than it did before. More importantly, policies work in its favor of its deployment, therefore, in the last few years; Asian employment increased greatly comparing to European. “Increased demand in Asian markets created employment opportunities in the installation segment of the value chain, and fostered domestic equipment manufacturing in some countries” (Ferroukhi 5).

China and Japan became very successful producers of solar PV equipment production of solar PV equipment and due to excessive labor productivity, in 2015 employment grew drastically. However, Brazil faced different experience in the production of feedstock bio fuel. Increased mechanization decreased the labor requirement not just in Brazil, but in China too. Chinese wind manufacturers introduced technology with the greater automation which decreased the number of the employers in the sector. “In the United States, for example, renewable energy jobs increased by around 6%, while employment in oil and gas extraction (and support activities) contracted by 18%” (Ferroukhi 5). China followed the same trend with the employment of 3.5 million people, which exceed the 2.6 million that were employed by the oil and gas sectors. The table below summarizes the job findings in the different renewable energy sectors in 2015.
Employment in the solar PV has increased with the decreased cost of solar PV technology. “Globally, solar PV installations in 2015 were 20% larger than in the previous year, with China, Japan, and the United States in the lead” (Ferroukhi 8). That made solar PV the largest renewable energy employer in 2015. International Renewable Energy Agency estimated that solar PV employed around 2.8 million people and achieved growth of 11% compared to the previous year. The world’s leader in the employment is China with the contribution of 1.7 million jobs in 2015. However, China also holds a first place in manufacturing as well as in installations. Closely behind China are Japan and United States. Thanks to the low tariffs both countries experienced employment up to 28%. (Ferroukhi 8) European Union did not mark any increase in the employment because of the decrease in the manufacturing and relaying on Asian
market. Shift in the employment in Asia targets Bangladesh and India for the spread of the market.

2.1.2. Employment in Liquid Biofuels Sector

Employment in liquid biofuels continues to decline annually, with the decline of 6% in 2015, due to the rapid mechanization in countries like United States, Brazil and Indonesia. In contrast, the situation on European labor market is much better. Positive growth of jobs was also marked in East Asian countries like Thailand and Malaysia. However, among the strongest world’s powers are Brazil, and markets in South America, among the highest one is in Argentina and Columbia.

2.1.3. Employment in Wind Sector

Wind energy recorded the highest employment in Germany, United States and China. New installations secured the increase in global employment for 1.1 million people. Germany and Untied States developed the industry on the coast where off shore winds blow. “Wind employment in the United States rose by 20% to 88,000 jobs, as new capacity additions grew by two-thirds over 2014 Brazil saw strong gains, with an estimated 41,000 wind jobs in 2015, up 14%. The EU added about 10,000 wind jobs during 2014 (up about 4%)” (Ferroukhi 15). Brazil and India try to take over the same tactic as the EU countries did. However, today China is the highest employer, where among the strongest ten wind companies, keeps five Chinese, like Ming Yang and United Power.

2.1.4. Employment in Hydropower

Hydropower industry in Germany, United States and Brazil increased in labor by 13% in 2015. (Ferroukhi 9) International Renewable Energy Agency finds it difficult to track the employment and with that the deployment of the industry, because there are many small
hydropower plants that employ workers informally. Large hydropower plants annually employ up to 1.3 million people. The figure below shows the world’s highest employers by the country.

![Graph showing employment in large hydropower plants by country in 2015](image)


### 2.1.5. Policy Mix for the Deployment of Renewable Energy

Policy makers around the world accepted renewable energy as an opportunity to increase the potential benefits out of it deployment. Many policies are implemented to stimulate the development of the domestic industry. Increase of the domestic industry encourages the “investment and technology transfer, strengthening capabilities, promoting education and
training, as well as research and innovation greatly affects value creation.” (Ferroukhi 14) For each country it is crucial how policy mix will look like, because it will set up country’s conditions and priorities. The most important target is to closely involve stakeholders from different industries because they are the key for the economic growth. “Policies should be designed as part of a holistic framework that is consistent with and supports a well-defined national strategy” (Ferroukhi 15). Policy mix has to be strongly linked to the economic long term plan and ensure that stability is achieved at the every step of the renewable energy deployment. Moreover, policy mix needs to be tailored according to the country’s weak and strong points, considering each local area and its potential for development.

For the success of the policy mix it is important to measure development, firms’ capabilities and workers’ skills. That would mean that with the deployment of renewables, industries will have to educate and train their workers, measure the quality of the programs and cooperate with other industries. “Cooperation and cohesive action between the private and public sectors, industry associations and international organizations can help ensure the success of such policies” (Ferroukhi 17). Certain activities focusing on research and development can help defining issues and help to maximize value creation. “To create an enabling environment for research and innovation, supporting measures can include funding, building competence and human capital, facilitating knowledge diffusion and developing infrastructure” (Ferroukhi 17).

There are a number of tools with different scope and capabilities, which measure the impact that renewable energy has on socio-economic development. The selected tool should be chosen regarding to the human and financial sources available. That will supply government with the data which will give a conclusion if the energy deployment was successful or not. Data collection should be collected during the longer period of time and consist of targeted
information and statistical surveys. Well collected data gives the ability to be compared on national and international level. Moreover, with the good data collection country can easily see if the policy mix needs to be improved or dismissed.

2.2. Social Reasons for the Development of Renewable Sources

Renewable energy deployment has an ability to change poor communities and alleviate the poverty. The most important segment in the process of introducing green energy to the community is education of people. Education facilitates the process of implementation of green energy, but also develops awareness about the individual responsibility for the environment. It also raises the knowledge about the waste pollution and health issues that are the product of excessive consumption. Moreover, “the involvement and participation of people and responsibility for duties of the community will be strengthened” (Wiesmeth and Gold 16).

In the 1970s, when renewable energy entered the market, many Western countries were suspicious about its outcome and what would be impacts on the people. “With regard to nuclear, some were afraid of the consequences of such technology in terms of security and ownership” (Lund 12). People questioned how community will be affected with the radioactive waste and what impact will it have on the quality of their life. However, local communities have an important role in choosing the right renewable energy sources, because they have ownership of the local area. It is important to enroll them in the discussion because cases from Denmark in 1970s, during the time of crisis proved it to be an important issue where communities like to “have their own renewable sources of energy instead depending on nuclear or imported fossil fuels” (Lund 12). This is a process of Choice Awareness, which drive people to create a life that
is worth living according to their individual and societal point of view. The consensus between local communities and the government helps in creating suitable democratic infrastructure (Lund 12). “The suitable democratic infrastructure may improve the awareness of choice and thereby, in general, create better living conditions” (Lund 12). Choice Awareness theory claims that suitable democratic infrastructure will raise the awareness of possibilities and improve the living conditions.

However, the complete implementation of renewable energy requires the enforcement of wider responsibilities for the outcome of decisions and their impacts. That would require changes in legal and institutional levels. “Some necessary changes in the legal framework start from the proposition that an environment adequate for health and well-being is essential for all human beings including future generations” (UN 4). Without the community participation and support, the law itself cannot be implemented. “It principally needs community knowledge and support, which entails greater public participation in the decisions that affect the environment. This is best secured by decentralizing the management of resources upon which local communities defend, and giving these communities an effective say over the use of these resources” (UN 4).

Large-scale projects, such as building of the new energy plants, will need to provide free access to information and a range of experts who will participate in the project and be able to inform the public. “When the environmental impact of a proposed project is particularly high, public scrutiny of the case should be mandatory and, wherever feasible, the decision should be subject to prior public approval, perhaps by referendum” (UN 5).
3. RENEWABLE ENERGY AS A PREREQUISITE FOR THE SUSTAINABLE DEVELOPMENT

Among sustainable development goals, energy is one of the most essential. As it was said before, green energy has a positive impact on the economy; therefore it is a crucial for sustainable development and poverty alleviation. United Nation research data shows that in 2015 almost 2.8 million people have no access to the energy services and over 1.1 million people live without electricity. “Furthermore, around 4.3 million people are dying prematurely every year due to indoor pollution resulting from cooking and heating with unsustainable fuels” (United Nations 1). Therefore, the global goal is to find sustainable sources that would be able to meet necessities and demand on a global level, but also to have harmless impact on the environment.
Since 1992, United Nations highlighted the issues of excessive energy consumption non-renewable resources that have harmful impact on human health, environment and Earth’s atmosphere. Energy goals that will were listed in the Agenda 21, committed countries to undertake political, economic and social measures. Countries faced the complex challenges and for the first time faced the importance of using renewable energy resources. Agenda 21 was not implemented until the 9th Sustainable Development Commission, where countries agreed to give a strong emphasis on the development and implementation of more efficient technologies, which will help in expansion of sustainable energy development.

In 2002 at the World Summit on Sustainable Development, in The Johannesburg Plan of Implementation, renewable energy was addressed as a prerequisite for the sustainable development. The Johannesburg Plan called for the global action that would give a special attention to: the access of affordable an economically, socially and environmentally acceptable energy services; recognition of renewable energy deployment as a way to diminish poverty issue on the global level. Further, the need for new technologies that will hurry the process was emphasized. Moreover, the plan was to diversify the energy supply “by developing advanced, cleaner, more efficient and cost-effective energy technologies; combine a range of energy technologies, including advanced and cleaner fossil fuel technologies to meet the growing need for energy services; accelerate the development, dissemination and deployment of affordable and cleaner energy efficiency and energy conservation technologies” (United Nations 3).

In 2011, United Nations Secretary General Ban Ki-moon put the deadline on Sustainable Energy for All to be conducted by 2030. He asked for three major objective to be fulfilled; “ensuring universal energy access to modern energy services, doubling the global rate of improvement in energy efficiency and doubling the share of renewable energy use in global
energy” (United Nations 3). In 2014, UN General Assembly included renewable energy as a self standing goal on energy. “SDG #7 calls to ‘ensure access to affordable, reliable, sustainable and modern energy for all’” (United Nations 3). As of 2015 renewable energy deployment became the most discussable topic and an issue of non-deferrable nature. The weight is placed on governments, civil society, and the private sector. Together they should ensure that each country achieve the goal of deployment of renewable energy as well as security for poor and forcibly displaced people.

![Figure 17. Sustainable Development Goals According to their Priority. Source: The Socio Economic Benefits of Solar Energy, International Renewable Energy Agency.](image)

By 2030, renewable energy should eradicate energy monopoly which was set up by country's leading energy companies. Until today 1.1 billion people do not have access to electricity and around 2.8 rely on wood or other solid fuels which is used for cooking and heating. (United Nations 5) nevertheless, there is a great number of people who are forcibly
displaced from their homes because they were affected by natural disasters or war. With the deployment of renewable energy refugee camps would be able to offer a decent life to more then 125 million people. “With a huge shortage in funding as well as limited policies and practice on sustainable -and clean energy provision within the humanitarian community, current energy practices in camps are often dirty, inefficient, polluting, unsafe for the users, and damaging to the surrounding environment.” (United Nations 7) The lack of energy is tightly connected to the lack of education. United Nations studies suggest that refugee children are five times more likely to drop off the school when compared to non-refugee children. “Only 50% have access to primary education, compared with a global level of more than 90 per cent. Only 1% of refugee youth go to university” (United Nations 5). More than 80% of refugees live without or with the limited amount electricity for lighting, cooking and powering. The issue of heating is the main cause of illnesses and death among young children and women. Moreover reports from Burkina Faso show that violence against women is present in the unlit neighborhoods. Renewable energy would bring safety and sustainability to these environments. “With clean, sustainable fuel, or fuel-efficient technologies, refugees can cook meals and avert the malnutrition and ill-health that may occur when using open and polluting fires” (United Nations 5).

3.1. Places where renewable energy is deployed

Among the first countries who adopted renewable energy is Denmark. Before 1973, Denmark supplied whole energy for the electricity production from the fossil fuels, but the crisis in the same year caught it unprepared for the sudden rise of prices. In the next 30 years Denmark managed to stabilize its energy production by efficiency improvements in supply and energy conservation. “The renewable energy share of the primary energy supply has increased from
around zero in 1972 to 16 percent in 2007, and a wind power production has become equal to a 20 percent share of the electricity demand.” (Lund 2) Furthermore, since 1997, Denmark has become self-supplying with the oil and natural gas from the North Sea, which will not be able to supply Denmark for a long period; therefore, it will have to switch to 100 percent renewable resources. (Lund 2) By 2014 Denmark became the country with one of the strongest renewable energy production.

Nowadays, Norway produces more than 99% of electric energy from hydropower. It also has a potential to develop wind power and wave power. Norway is one of the countries that incline to the 100% renewable energy production. In the wind power sector China reached 31% of global production. Wind plants are positioned along the long Chinese coast, where 45% of new capacity was added in 2014. (Wilson 2) Unites States and Germany also successfully use wind power for the production of electricity. Wave energy is adopted worldwide but highest production is achieved in Portugal and Australia, while South Korea appears on the top of the list for use of tidal energy. Germany is the global leader of solar energy production and makes a quarter of the world’s capacity. The largest geothermal sources are placed in United States, in California. However, El Salvador, Kenya, Iceland and Costa Rica use geothermal geysers for 15% of their electricity production. Lastly, Brazil is the largest user of biomass, producing 28% of total amount of electricity from it.

3.2. Positive vs. negative characteristics of renewable energy

People become more and more influenced and educated by media about the benefits of renewable energy and harmfulness of fossil fuels. Often unexpected cost fluctuations of fossil fuels make people unsatisfied and uncertain about price stability. Renewable energy is dependent on infrastructure and price of natural sources is not likely to inflate. Moreover, renewable
resources are sustainable and continua, what gives a positive notion and reliability. Comparing to the fossil fuels, sources cannot run dry and installations do not have to be removed ever, what is unlike to oil platforms that have to be removed once they are exhausted.

However, people favor renewable energy mostly because of the large scale job creation and environmental protection. Low footprint of carbon dioxide and less pollution make people want to accept it in their community. Another benefit is the worldwide job in the planning, infrastructure, governmental institutions, on the field, etc. Technologies are initially expensive but in the long run they end up being cheaper as they do not require high maintenance.

Disapproval of renewable energy is very common in countries with the low GDP. Because of the already built fossil fuel plants and experienced work with coal, the price of renewable installations is perceived as extremely high and unnecessary. Therefore, undeveloped countries will use what they already have established and what is cheaper. Nevertheless, a weak side of renewable energy sources is that they are vulnerable to the extreme climate conditions. Resources depend mostly on the sun and wind for the production of energy, which can be disturbed by long periods of rain and low winds. In the unfavorable weather conditions nonexistent production of electricity will force people to lower the consumption, in other words consumption would be very limited. Nowadays, the question is if the climate change in certain areas during the long period of time will make renewable energy plants useless.

Another weak point is the low quantity of energy that renewable sources can produce in the short period of time. Low quantity of energy comparing to what we are used to spend on a daily base, would mean that consumption must be lowered. For a large amount of electricity solar panels and wind plants have to occupy large amount of space. For wind farms the best
option is to be placed on hills, but many times it evokes negative opinion from the communities who want to keep nature untouched. Studies suggest that people’s rejection of renewable energy comes from the lack of concern about the energy because they enjoy abundance of electricity daily.

3.3. **Green companies and their impact on renewable energy deployment**

Many large companies launch sustainability initiatives to increase their supply chains, use eco-friendly waste disposal as well as recycled and small packaging. “New technologies like electric cars, affordable solar panels, environmentally-friendly cleaning products, and energy-efficient devices are making it possible for businesses of all sizes to create value for customers who want to ‘go green’” (Kear 2). Consumers show interest for companies that care about the environment and want to diminish pollution. For large and small companies “going green” does not mean just the reputation on the market but also saving significant amount of money. Today one of the most significant steps toward the environmental protection and reduction of carbon dioxide is made by automotive company Tesla.

Tesla started as an energy innovation company with the critical target of producing a car that will be 100% percent emission free. Tesla’s cars promote renewable energy sources as company works tightly with other renewable partners around the world. (TESLA 2) Tesla’s cars run on the lithium-ion battery that charge itself through the solar panels. Tesla cooperates closely with TreeHouse to sell Powerwall; a “home battery that is charged with electricity generated by solar panels or from the utility grid” (TreeHouse 1). Another Tesla’s partners are Fronius and SolarEdge. Tesla partnered with these PV companies “to make a joint development of a PV storage and backup power solution for the world residential solar market” (TESLA 4).
Among other large companies that promote green energy are Toyota, Siemens, DONG Energy and Panasonic. Together with Tesla, they are on the list of top 200 carbon free companies, in the world. Each company “must have a market capitalization of more than $1 billion and generate 10 percent of their revenues from clean sources” (Holder 1). All of these companies received 90 percent of their income from clean energy. China contributed the list with 66 companies, United States with 40, Japan with 20, Germany with 8 and India and Canada with 5. The list of top 200 companies excludes companies that utilize oil and gas and also if they exploit or force labor of minors. In the competition of 2015, companies that engaged in “negative climate lobbying or profit from tropical deforestation” were also excluded. (Holder 2) “The Clean 200 nearly tripled the performance of its fossil fuel reserve-heavy counterpart over the past 10 years, showing that clean energy companies are providing concrete and measurable rewards to investors…the outstanding performance of this list shows that the notion that investors must sacrifice returns when investing in clean energy is outdated” (Holder 2).

As clean energy investment showed as very profitable and appealing. The use of renewable sources will improve its technologies and lower their costs. That will cause a lot of problems to companies that run on carbon. Therefore, since carbon companies are still in a greater number and cheaper for develop and undeveloped countries, they keep monopoly and have support from the government. Strong incentives from the international organizations and nongovernmental organizations, together with the spread of knowledge about the environmental issues and its possible protection, will force countries to incorporate renewable energy into the long term plan, change the infrastructure, give an opportunity for education to everyone and accept sustainable development as a whole.
CONCLUSION

This paper focused on renewable energy sources. They exist in the nature in the abundance and are zero emission. Some of them have been already in use for a long period of time. These sources are biomass and hydropower. The other renewable energy sources are slowly progressing to in the market. These energy sources are: solar energy, wind energy and geothermal energy. Renewable energy sources are still not reachable for many undeveloped countries. However, with their installments undeveloped countries would benefit from many social and economic changes. Many countries still try to eradicate poverty and hunger, but it is impossible because without the energy sources that are sustainable people cannot live in healthy and decent conditions. Monopoly of carbon industries is temporarily unbreakable because their products are cheaper and available in abundance. Renewable energy sources do not produce a big quantity of energy, which could force consumers to spend the energy reasonably. Thinking about the energy consumption would make consumers active participants in the cycle consumption, considering that at the moment they passively consume as much as they want.

Another positive outcome of renewable energy which leads to sustainability is that green energy rise countries economy. Economic development is best presented by the growth in the employment and long term saving as maintenance costs are almost non-existent. However, installments and costs of the technologies in the beginning of the process can be high and that is the main reason why people reject renewable sources. Today, among two hundred biggest renewable energy companies; Tesla, Toyota and Siemens proved that green product is attractive on the market but also helps industries to save money.
United Nations categorized renewable energy as a priority sustainable development goal, among twenty-one others. Until 2030, the world should implement renewable energy and lower statistics on carbon emission drastically. Sustainable development that will be carried out until 2030 is impossible without renewable energy deployment because the lack of energy and pollution are obstacles to other twenty sustainable development goals. Renewable energy is closely linked to our existence and therefore is a prerequisite for sustainable development.
BIBLIOGRAPHY

BOOKS:


**ARTICLES:**


Holder, Michael “Tesla, Toyota and Vestas ranked among world’s top green companies”. The Guardian. 2016.

