Czech University of Life Sciences Prague

Faculty of Economics and Management

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Bachelor Thesis

The Future of Electricity in All Areas of Industry

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BACHELOR THESIS ASSIGNMENT

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Business Administration

Thesis title

The Future of Electricity in All Areas of Industry

Objectives of thesis

The objective of this work is to evaluate the possibility of a complete transition of countries' economies to renewable sources, as well as the economic contribution of countries to the production of electricity from renewable sources.
In the course of the analysis, the author strives for the objective, to answer the question – is it possible to switch to electricity using renewable sources and what economic benefits should this transition bring?

Methodology

The division of the work into a theoretical and practical parts will take place in such a way that the author, using analysis, analogy, and concretization, explains that renewable power sources will be able to generate sufficient electrical power, avoiding interaction with minerals.

In the practical part, the author will use the inductive and deductive methods of conclusion. As a result, the author offers an economic model, in the form of certain graphs, where the answer is given – both the possibility of this transition and the economic benefits between countries.

The proposed extent of the thesis

30-40 pages

Keywords

Renewable sources, electricity, sufficient capacity, economic benefits

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Recommended information sources

BOYLE, G. *Renewable energy : [power for a sustainable future].* Oxford: Oxford University Press, 2004. ISBN 0-19-926178-4.

JENKINS, R O. *Environmental regulation in the new global economy : the impact on industry and competitiveness.* Northampton: EDWARD ELGAR, 2002. ISBN 1-84376-845-3.

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SOLARI, G. *Wind science and engineering : origins, developments, fundamentals and advancements.* Springer: Cham, 2019. ISBN 978-3-030-18814-6.

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Declaration

I declare that I have worked on my bachelor thesis titled " The Future of Electricity in All Areas of Industry" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the bachelor thesis, I declare that the thesis does not break any copyrights.

In Prague on 15.03.2023 _____

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The Future of Electricity in All Areas of Industry

Abstract

The ultimate goal of this thesis is the possibility of a complete transition as well as the economic benefit of countries when generating electricity using non-traditional - renewable sources. A large number of different enterprises, transport, and appliances operate at the expense of minerals such as oil, gas, and coal. Every day mineral reserves are losing their total volume, so our world needs to learn how to introduce a renewable source to get a sufficient volume energy that will maintain vital qualities on our planet. In the course of the analysis, the author strives for the main goal, to answer the question - is it possible to switch to electricity using renewable sources and what economic benefits should this transition bring?

Keywords: Renewable sources, electricity, sufficient capacity, economic benefits.

Budoucnost elektřiny ve všech oblastech průmyslu

Abstrakt

Konečným cílem této práce je možnost úplné transformace a také ekonomický přínos zemí při výrobě elektřiny pomocí netradičních obnovitelných zdrojů. Velké množství různých podniků, dopravy a spotřebičů pracuje na úkor nerostů, jako je ropa, plyn a uhlí. Každý den nerostné zásoby ztrácejí svůj celkový objem, takže náš svět se musí naučit, jak zavést obnovitelný zdroj, aby získal dostatečný objem energie, která bude udržovat životně důležité vlastnosti na naší planetě. V průběhu analýzy se autor snaží o hlavní cíl, odpovědět na otázku-je možné přejít na elektřinu pomocí obnovitelných zdrojů a jaké ekonomické výhody by měl tento přechod přinést?

Klíčová slova: obnovitelné zdroje, elektřina, dostatečná kapacita, ekonomické přínosy.

Table of content

List of Figures

List of tables

List of abbreviations

BNEF	Bloomberg New Energy Finance
CCS	Carbon capture and storage
RES	Renewable energy sources
GW	Gigawatt

GP	Gross product
IRENA	International Renewable Energy Agency
KW	Kilowatt
kWh	Kilowatt-hour
kWh/m2	Kilowatt hours per square metre
NOAA	National Oceanic and Atmospheric Administration
PV	Photovoltaic
USD	United States Dollar
$/kW-hr	US dollar per kilowatt-hour

1 Introduction

Every day, engineers from almost all countries of our world are developing more units of the product that work with the help of electricity. Humanity is trying to switch to electronic products, and we are happy to welcome this in our daily lives. For centuries, a person has been using a certain kind of energy. The initial energy of a person needed for everyday life was firewood, after which a person learned to extract coal, and subsequently a natural combustible liquid called oil. Comparing ancient and modern man, we can observe the picture of evolution in the extraction of power sources, although the fact is that from one power source, which has a limited supply, another is produce. In the modern world, humanity uses almost 90% of the limited reserve of minerals that provide the world energy of our planet. Based on this percentage, we can confidently assume that in the near future, using non-renewable sources, our world may face a big energy crisis that will lead to big problems in human daily life, therefore our world needs to learn how to implement the process of obtaining energy using renewable sources, since neglecting minerals, the percentage of environmental pollution increases every year. Based on this, the thermal balance of the atmosphere is disturbed, therefore it can lead to global climate change.

2 Objectives and Methodology

2.1 Objectives

The objective of this work is to evaluate the possibility of a complete transition of countries' economies to renewable sources, as well as the economic contribution of countries to the production of electricity from renewable sources.

In the course of the analysis, the author strives for the objective, to answer the question - is it possible to switch to electricity using renewable sources and what economic benefits should this transition bring?

2.2 Methodology

The division of work into theoretical and practical parts will take place in such a way that the author, using an analysis of existing energy supply systems, analogy and concretization, which will include the study of the theory of economic efficiency, technical aspects of the use of renewable energy sources, socio-economic consequences for the transition, will explain that renewable energy sources will be able to generate sufficient electrical power, avoiding interaction with minerals.

In the practical part, the author will use inductive and deductive inference methods, using the annual research of international companies in the field of energy saving. As a result, the author will offer a model in the form of certain graphs, where a hypothetical answer will be given - both about the possibility of this transition, and about the economic benefits between countries. After the author will offer to get acquainted with the recommendations practical actions based on data analysis and theoretical conclusion. The recommendations will include proposals to improve infrastructure for renewable energy, encourage investment in renewable energy development, and develop more effective regulatory mechanisms for this transition.

3 Theoretical and Literature Review

3.1 Theoretical reasons for the transition to renewable sources.

At the moment, humanity is already facing limited fuel resources, based on this, the shortage of fuel resources in the form of non-renewable sources increasingly shows the inevitability of switching to alternative energy sources. These energy sources come from the nature of our universe, having renewable properties, which are based on the energy of the Sun and the Earth.

- **Economic reason.**

According to the author, the main reason for switching to renewable sources is to preserve the world's mineral reserves for backup use in case of a shortage of energy in the daily human needs, as well as processing in the chemical industry. According to the latest data, the cost of energy produced by renewable sources is approximately equal to the cost of energy from traditional sources, while the payback period for the construction of hydro, wind and solar power plants is significantly shorter. Prices for alternative energy are declining, while prices for traditional energy are constantly rising. Thus, according to preliminary data, the investment of new green generation will decrease by 45% by 2030, which means that renewable sources for electricity generation will have half of the amount spent with an equal amount comparable to traditional sources.

Table 1 : The price of energy produced from traditional and non-traditional sources in USA, 2022. Source: (Annual Energy Outlook, 2022)

Power Plant Type	Cost (LCOE) $/kW-hr
Coal with CCS	$0.12-0.13
CC Natural Gas	$0.043
CC with CCS	$0.075
Nuclear	$0.093
Wind onshore	$0.038
Wind offshore	$0.106

Solar PV	$0.036
Solar Thermal	$0.165
Geothermal	$0.040
Biomass	$0.090
Hydro	$0.039
Adapted from US DOE2	

The table shows that at the moment, the cost of installing renewable sources is higher than traditional ones. This is because renewable energy is practiced less. But the indicators may change significantly, that is, the use of renewable sources will decrease if the implementation is more intensive, which in the process will lead to cheapness compared to traditional sources.

- **Political reason.**

Having considered the territorial reserves on a political basis, we can say with confidence that those countries of the world that have a large amount of mineral reserves mainly dictate the prices of fuel resources. Accordingly, countries that will be able to develop and switch to alternative renewable energy sources are able to have a political advantage on an economic basis.

- **Global environmental reason.**

Currently, through long-term research, the fact of the negative impact on the environment of energy-producing technologies in the bowels of the earth, including nuclear and thermonuclear, has been proven. The use of these systems leads to fatal climate change, as well as to the pollution of our nature (Jenkins, 2002).

- **Historically progressive reason.**

Historically, having considered the evolution of the process of energy extraction, we can say with confidence that humanity has advanced, but at the same time the amount of energy resource produced has advanced. Based on this, the percentage increases, which in turn exhausts the limited supply of fuel resources, as well as the percentage of fatal changes in the atmosphere and biosphere increases. In accordance with this, in order to further support the vital activity of our planet, as well as the evolution of human

development, it is necessary to rapidly begin the transition to renewable sources (Smil, 2010).

- **Social reason.**

The world population is constantly growing, based on this, the boundaries of cities are expanding. Also, taking into account this fact, new settlements are being formed on empty plots of land that could previously serve for the needs of energy production programs. Accordingly, it is difficult for surveyors to find an area for the construction of gas, coal and nuclear power plants, so more and more buildings are located in the vicinity of many populated cities. Based on this, the fact of oncological and other malignant diseases in the vicinity of the location of these power plants has been established (Smil, 2010).

3.2 Non-renewable and renewable energy sources.

Currently, most of the energy consumption depends on non-renewable sources, that is, minerals such as coal, gas and oil, so these energy sources are called traditional, since they have long been the main sources of energy for mankind. It is not entirely true that renewable energy sources are considered untraditional, but they refer to energy sources that have only recently come into use or that are not widely used. Based on this, renewable energy sources such as solar, wind, hydroelectricity, geothermal and tidal energy are referred to in some countries as non-conventional or untraditional energy (Boyle, 2004).

3.2.1 Non-renewable sources

Non-renewable or traditional energy sources are natural organic reserves of substances and materials formed during the life of our planet. These organic substances can be used for energy production and further human use, though non-renewable energy sources are resources that cannot be restored within human time. Their use leads to a constant depletion of reserves, which is why they are often called depletable resources. Some of the more common non-renewable energy sources include:

1. Fossil fuels: Oil, coal and gas are fossil fuels derived from the remains of plant and animal life that were deposited millions of years ago. They are used to generate electricity and fuel for transport.
2. Nuclear energy: Energy derived from nuclear fission, non-renewable sources of plutonium, uranium and certain metals is used to generate electricity in nuclear power plants.

3. Gas hydrates: These are perennial frozen gases that are stored on the seafloor or in frozen soils. These gases can be used to generate electricity or as fuel for transport.

Although these energy sources are widely used in the world, they have disadvantages such as high cost, negative impact on the environment and safety risks when using them. Therefore, much attention has recently been paid to the development of renewable energy sources, which can replace non-renewable ones and reduce their negative impact (Howell, 2022).

3.2.2 Renewable sources

Renewable or untraditional sources are commonly referred to as energy, the replenishment of which occurs through the natural cycle from inexhaustible sources. Based on the cyclical nature of the natural processes of our universe, some sources have a process of self-replenishment during the passage of a full cycle, which allows humanity to regularly use them in the energy sector. Renewable energy sources (RES) are energy sources that are not exhausted and that can be used without harming the environment. Such sources include water, sun, wind, geothermal energy, and biomass. RES are becoming increasingly popular in the world, as their use contributes to more environmentally friendly and sustainable energy. Renewable energy sources are of great importance for our planet and the future of humanity. Untraditional sources make it possible to reduce dependence on oil, coal, and other fossil fuels, which are finite resources, and which, when used, are released into the atmosphere (Howell, 2022).

3.3 Methods of obtaining energy using renewable sources.

Humanity during evolution, was able to develop widely in the way of energy extraction. However, a large share was accounted for by the development in the extraction and production of energy with the help of minerals. Based on this, the organic reserves of our earth are exhaustive nature at the moment. Therefore, humanity is at the stage of developing new alternative methods of energy extraction.

3.3.1 The energy of sunlight.

One of the most basic among renewable sources is the energy obtained with the help of sunlight, moreover, this source is the main type of energy for daily consumption in the life

of human activity. The sun is an inexhaustible reservoir of energy, because due to annual research, scientists have settled on an approximate calculation that for 11 billion years, the sun consumes only 2% of all the energy stored in it. (According to the author, the conclusion of any research by scientists during the period when human life did not take place cannot be 100% justified, therefore the author uses the term - approximate calculation) (IEA Team, 2022).

At the moment, humanity has two main ways of converting solar energy:

- Photovoltaic;

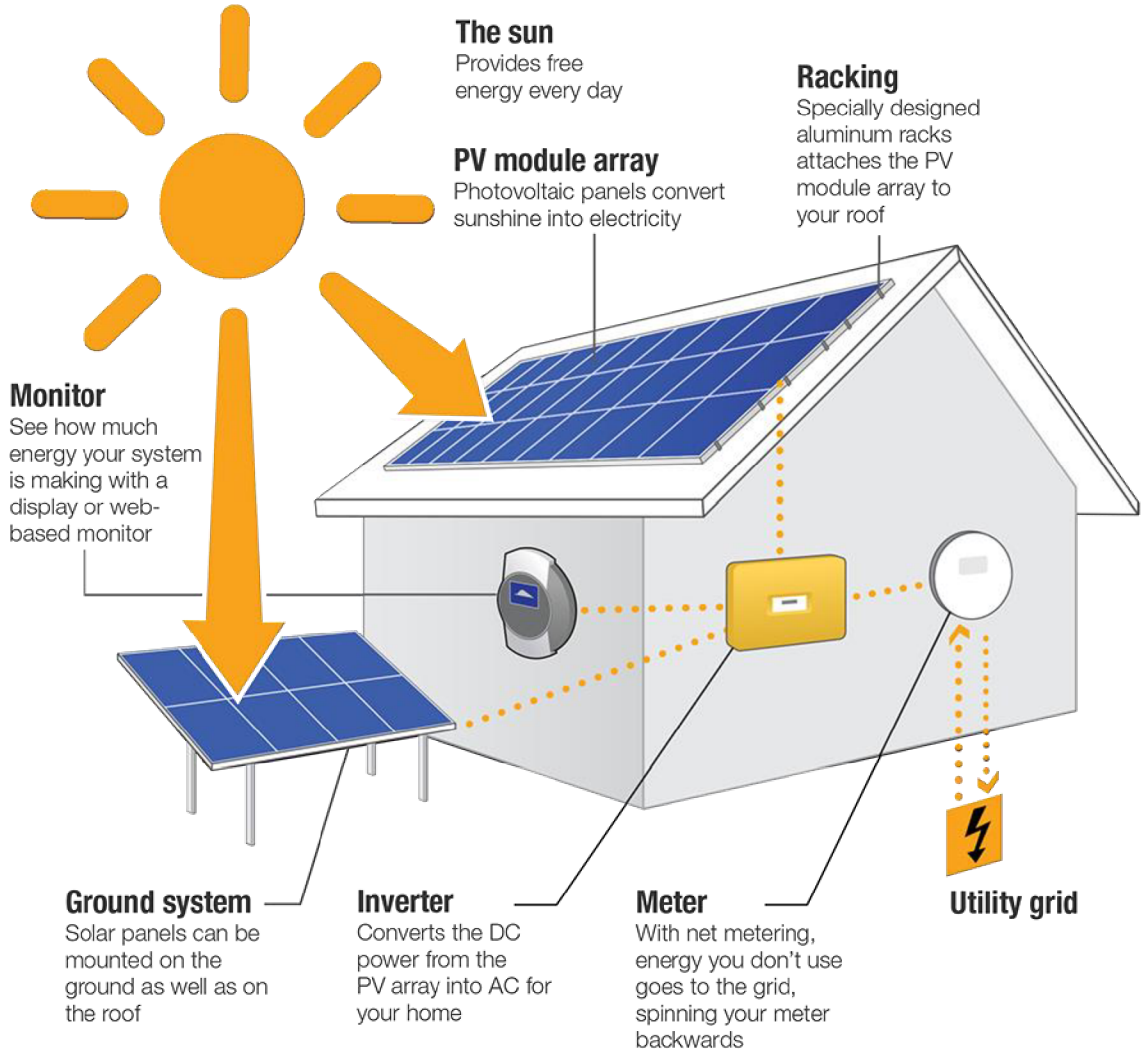
- Photothermal.

- **Photovoltaic method.**

In order to obtain solar energy through the PV method, engineers use solar panels on which boron and phosphorus elements interact, based on this, direct conversion of solar radiation into electric current occurs using these panels - semiconductor solar cells. This method is the most promising for the production of solar energy in the near future, since the plates of the panels on which boron and phosphorus are applied are made of silicon, whose reserves in the earth's crust have inexhaustible values.

Due to this fact, silicon is a very cheap chemical element, while it characterizes high productivity. Such energy panels are placed on the roofs of houses, cars, as well as on large-scale power plants, due to which they account for 1.3% of the share of global energy (Boyle, 2004).

Figure 1: The principle of operation of the photovoltaic method. Source: (Tillman Group, 2018)



- **Photothermal method**

The photothermal method is one of the simplest, since the principle of operation consists in a system of light-absorbing pipes called a solar collector. This collector is installed on the roof of the building so that the sun can illuminate the system as much as possible during the day, thereby heating the coolant to a high temperature, which in most cases is water. Based on the principle of operation of such a simple design, the collector can heat from 50 to 70 liters of water per day, up to a temperature of 90 degrees Celsius, which in the process allows the use of heated water for room heating (Boyle, 2004).

- **Advantages and disadvantages.**

The technology of generating energy using sunlight has some disadvantages, which include high maintenance costs and an efficiency of up to 20%. Based on this, the use of solar panels leads to low economic feasibility.

3.3.2 Wind energy.

One of the phenomena as a source of energy is wind. When generating energy with the help of wind, wind power plants are manufactured. We can observe these installations in many countries of the European Union, the USA, Asia and Eurasia. The principle of operation of these installations also depends on the difference in pressure in the atmosphere, which forms a natural phenomenon in the form of wind, due to which, under the force of its pressure, the wind rotates the blades of the towers of wind turbines, thus generating energy. Wind turbines consist of three main components: high-voltage generators, a mechanical system and impellers that rotate by the wind (Solari, 2019).

The main wind power plants are of 2 types:

- Floating;

- Stationary;

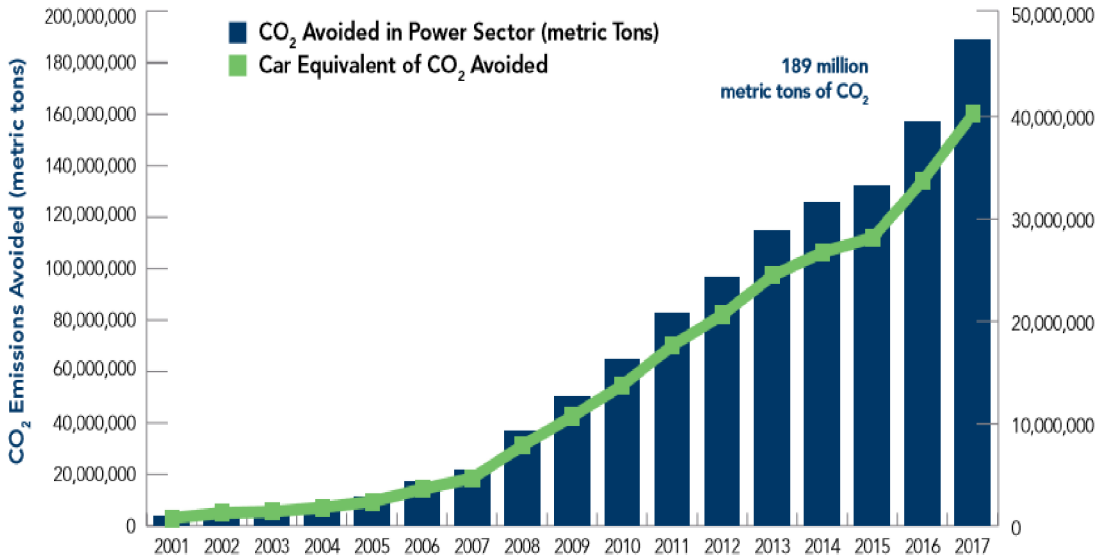
- **Floating wind installations**

Floating wind turbines are installations consisting of a wind turbine installed on a special floating platform, which is located on the open sea. When the wind blows, the turbine blades begin to rotate, due to which the wind energy is converted into mechanical rotational energy. This energy is then transferred through the transmission unit to the generator, which converts it into electrical energy.

The platform is mounted on floating elements, such as cylinders, to provide it with the necessary buoyancy. Thus, floating wind turbines can be installed in deep-sea areas where the wind speed is higher than on land. Floating wind turbines also have control and monitoring systems that allow operators to monitor the operation of the installation and monitor its condition. This makes it possible to ensure safe and efficient operation of the installation throughout its entire service life. The use of floating wind turbines can be an effective way to generate energy from wind on the open sea and reduce dependence on traditional energy sources. It can also help in the fight against climate change, since the

production of energy from wind is not a source of greenhouse gas emissions (Lloyd James, Craig Bruce, Campbell Hutcheon, 2021).

Figure 2: In 2018, with the help of wind energy generated in the world, 200 million tons of carbon pollution were avoided. Source: (Reurasia Team, 2019)



- **Stationary wind installations**

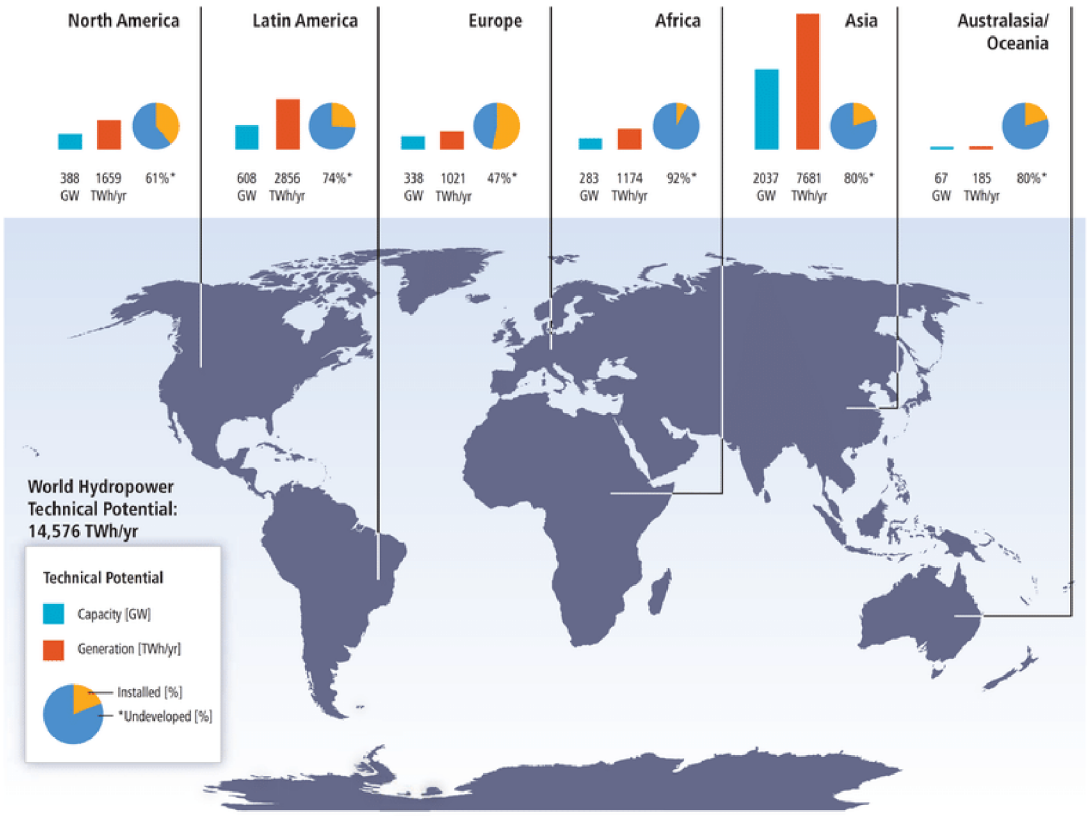
Stationary wind turbines and floating wind turbines differ in their design and installation location. Stationary wind turbines are installed on the ground or on the roof of a building. They usually consist of a high tower on which a rotor with blades is mounted, rotating under the influence of wind. The design and dimensions of such installations can be different, and they can generate different power - from several kilowatts to several megawatts. The advantage of stationary wind turbines is higher efficiency, since they can be optimized for specific wind conditions on the ground (Boyle, 2004).

3.3.3 Hydropower.

The main source for generating energy in hydropower is pressure. To generate energy in this way, hydroelectric power plants are being built, which, due to their location, block the riverbeds, thus forming a reservoir. Due to this, a difference in water levels is formed, which creates a pressure of a certain force with its flow, rotating the turbines, thus generating electricity. According to the 2021 study, hydropower facilities provide up to 41% of renewable and up to 16.8% of the total electricity of our planet, while readings in

one hour, the hydropower capacity reaches 1,170 GW at the same time, the work potential can reach up to 3,721 GW or 14,576 TWh/yr (LCP Team, 2021).

Figure 3: Regional hydropower technical potentials in 2009. Source: (Deshmukh, 2010)



3.3.4 Tidal energy.

One of the ways to obtain energy using renewable sources is also installations similar to hydroelectric power plants, the basis for which is the phenomenon of our earth - the tides occurring due to the gravity of the sun and moon. Energy generation occurs at high tide, when the water level rises, thus rotating the screws, as well as according to the analogies of the process of operation of a hydroelectric power plant, when after a certain cycle, the tide ebbs, and due to its pressure, the water rotates the blades again, thus generating energy (PNNL Team, 2021).

Such power plants are of no particular importance, due to their expensive installation at depth near the shore, and instability of operation due to their cyclical nature. However, according to the author, the instability of these installations can be used for backup energy storage in certain energy banks.

3.3.5 Geothermal energy.

Geothermal energy is the use of the earth's heat to generate electricity. To do this, wells are drilled at a depth of 3 to 10 kilometers, through which hot water flows out, used to drive turbines. Geothermal energy includes the use of geothermal sources, which can be located both in the depths of the earth and on the surface. Also, unlike other types of energy, geothermal energy does not depend on the variability of weather conditions since the heat underground is always at a constant level. Geothermal energy can be used to generate electricity, to heat buildings, heat supply and even to cool buildings. When geothermal energy is used to generate electricity, thermal energy obtained from the depths of the earth is used to drive generators that produce electricity. This reduces the use of fossil fuels, such as coal and oil, which are negative for the environment. Geothermal energy also reduces the amount of emissions into the atmosphere, which has a positive impact on the environmental situation in the world. However, the creation of geothermal energy infrastructure requires large investments and technical skills, which can be problematic for many countries. Some experts also point to possible negative consequences for the environment, such as geological changes and the risks of earthquakes. In general, geothermal energy has great potential as a source of free, environmentally friendly energy that can be used for electricity generation, heating of buildings, heat supply and other needs (Treece, 2022).

3.4 The economic benefits of switching to renewable energy.

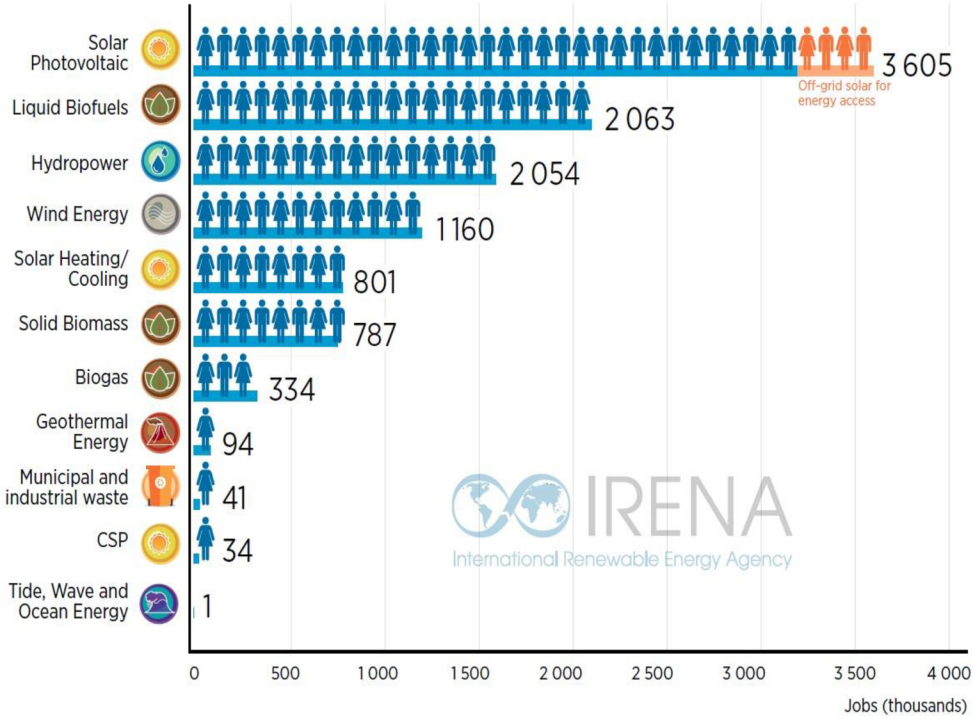
The development of non-traditional, renewable energy is the highest priority in terms of importance for developed countries. The benefits from the development of renewable energy sources are also very significant for developing countries. The transition to renewable energy sources can be beneficial from a political point of view for several reasons:

1. Reduction of dependence on energy imports: the transition to renewable sources can reduce the country's dependence on imports of oil, gas and other fossil fuels, which can reduce geopolitical risks and improve national security, moreover, the transition to unconventional energy can contribute to reducing the risks associated

with the constantly varying monetary unit, as well as the proposed cost of the purchased product.

2. Job creation: The development of the renewable energy industry can lead to the creation of new jobs and stimulate economic growth.

Figure 4: An increase indicator in jobs in the field of renewable sources during of 2018. Source: (IRENA, 2019)



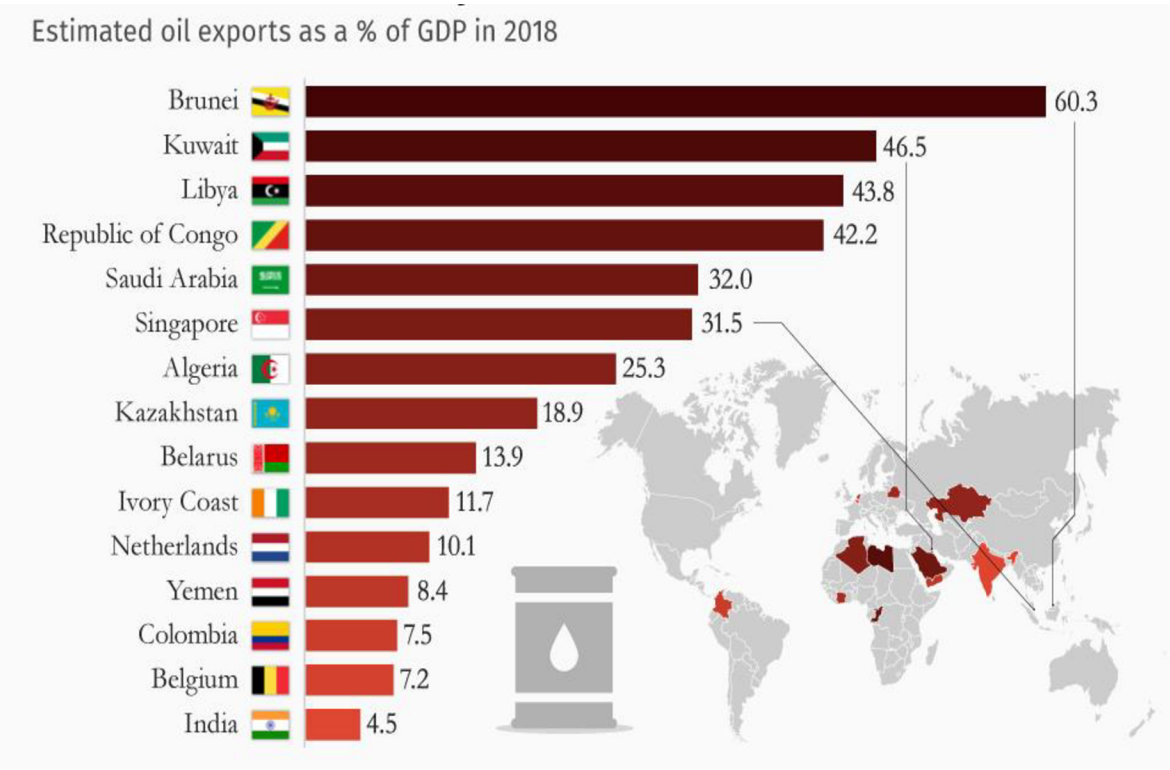
3. Environmental improvement: The use of renewable energy sources can reduce emissions of greenhouse gases and other pollutants, which has a positive effect on the environment and human health.
4. Improving the country's image: Switching to renewable energy sources can enhance the country's reputation in the eyes of the international community and improve its international position.

The transition to renewable energy sources may also have its drawbacks and cause some political problems. For example, this may lead to a change in the economic structure, which may lead to the need for retraining of the workforce and possible social problems. In addition, the transition to renewable energy sources may require significant investments, which may become a problem in conditions of limited budget resources (Earthava Team, 2020).

3.5 Global gross product increase.

1. One of the risks is that switching to renewable sources may reduce revenues from oil, gas and other fossil fuels, which may adversely affect the economies of those countries that depend on revenues from oil and gas sales.

Figure 5:The economies most dependent on oil. Source: (McCarthy, 2018)



2. The transition to renewable sources may require significant investments in infrastructure and technology, which may create additional financial burden for governments and taxpayers. This can become a problem in conditions of limited budgetary resources (Pyke, 2017).
3. It should be noted that renewable energy sources may be less reliable than traditional sources such as oil and gas, and may be less accessible in bad weather or other extreme situations. This may require additional investments in energy storage and distribution, which may not be available for some countries or regions.
4. Another disadvantage of switching to renewable energy sources is that the infrastructure for the production and use of renewable energy may require a large area and land resources, which may create conflicts with other interests, such as the use of land for agriculture or residential development (Pyke, 2017).

5. Finally, the transition to renewable energy sources may require changes in legislation and regulation, which can be a complex and lengthy process that can cause political disputes and disagreement in society.

4 Practical part. Switching to renewable sources.

There are many companies that have conducted research on the transition to renewable energy sources. Many international companies are exploring the possibility of switching to renewable energy sources, as they recognize the need to reduce greenhouse gas emissions and more environmentally sustainable production practices.

Large companies such as Google, Amazon, Facebook, Microsoft, Apple, Ikea, Unilever, Coca-Cola, PepsiCo and many others are increasingly using renewable energy sources for their operations and production. Some of them install solar panels and wind generators at their facilities, others conclude deals for the purchase of electricity from renewable sources from third-party suppliers. They are also actively exploring new technologies such as energy storage and electric vehicles that can help them become even more environmentally sustainable. In addition, many international companies participate in research projects in collaboration with scientists and experts in the field of renewable energy to develop new technologies and optimize existing ones, increasing the efficiency and cost-effectiveness of renewable energy sources. Some of these research projects include the creation of new solar panels with higher efficiency, the development of more efficient wind turbines and energy storage systems, as well as the creation of innovative energy management and monitoring systems to optimize the use of renewable energy sources (Mathi, 2020).

4.1 Global gross product increase. Research.

Research by IRENA.

The International Renewable Energy Agency (IRENA) in its report "Renewable Energy Outlook" from 2019 predicts that the transition to renewable energy sources can lead to an increase in the gross product (GP) of the world economy by 2.5-3% by 2030. This GP growth is because the transition to renewable energy sources can lead to the creation of new jobs, increased investment in infrastructure, increased energy efficiency and lower energy costs in many sectors of the economy.

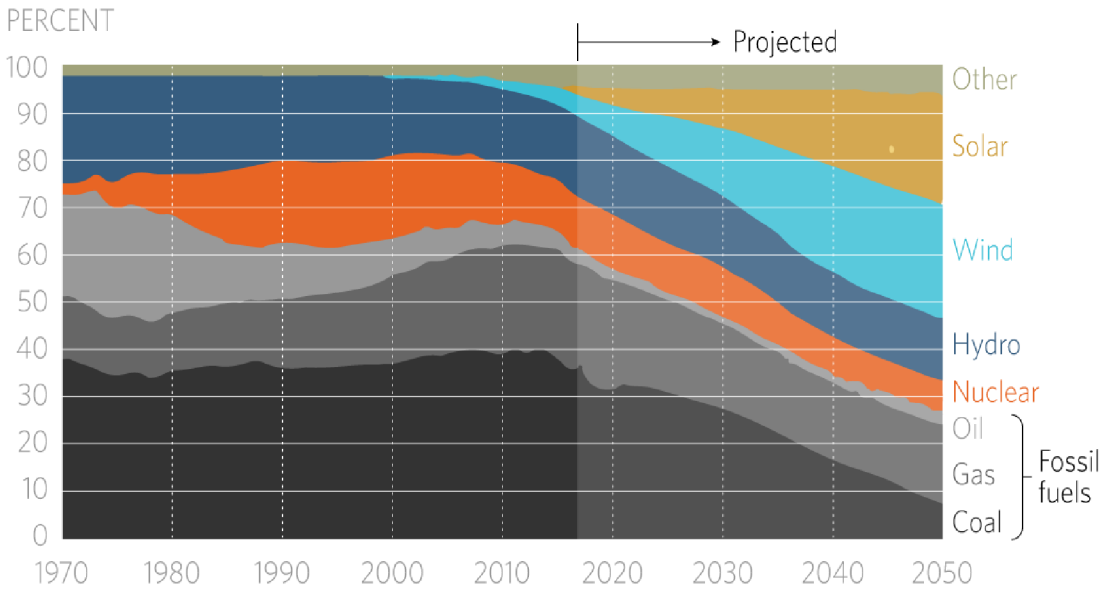
In addition, the IRENA report indicates that the transition to renewable energy sources could lead to a reduction in energy costs by 15% in general by 2030, which could lead to a reduction in the trade deficit and increase the competitiveness of many countries. But it should be noted that these forecasts are based on many factors that may change in the future. For example, the speed of development of renewable energy technologies, political and economic factors, as well as social and cultural changes can have an impact on the growth of GP and other economic indicators (IRENA, 2019).

Research by Bloomberg New Energy Finance.

Bloomberg New Energy Finance conducts research in the field of renewable energy and publishes reports containing market analysis and forecasts of industry development. One of these reports, published in 2019, is dedicated to the transition to renewable energy sources.

The report entitled "New Energy Outlook 2019" is an analysis of the prospects for the development of the energy industry in the period from 2019 to 2050. He presents several scenarios based on various factors, such as technological progress, legislation and changes in energy prices (BloombergNEF, 2019).

Figure 6: The world's electricity generation mix until 2050 year. Source: (BloombergNEF, 2019)



In general, the report suggests that the transition to renewable energy sources will accelerate and become more cost-effective. According to forecasts, the share of renewable energy sources in the global energy mix will be 50% by 2037, and by 2050 renewable energy sources will become the cheapest source of energy. The report also notes that the main factor that will contribute to the transition to renewable energy sources is the increase in the use of solar and wind power plants. In 2050, they will account for more than 50% of the world's installed capacity of energy facilities (BloombergNEF, 2019).

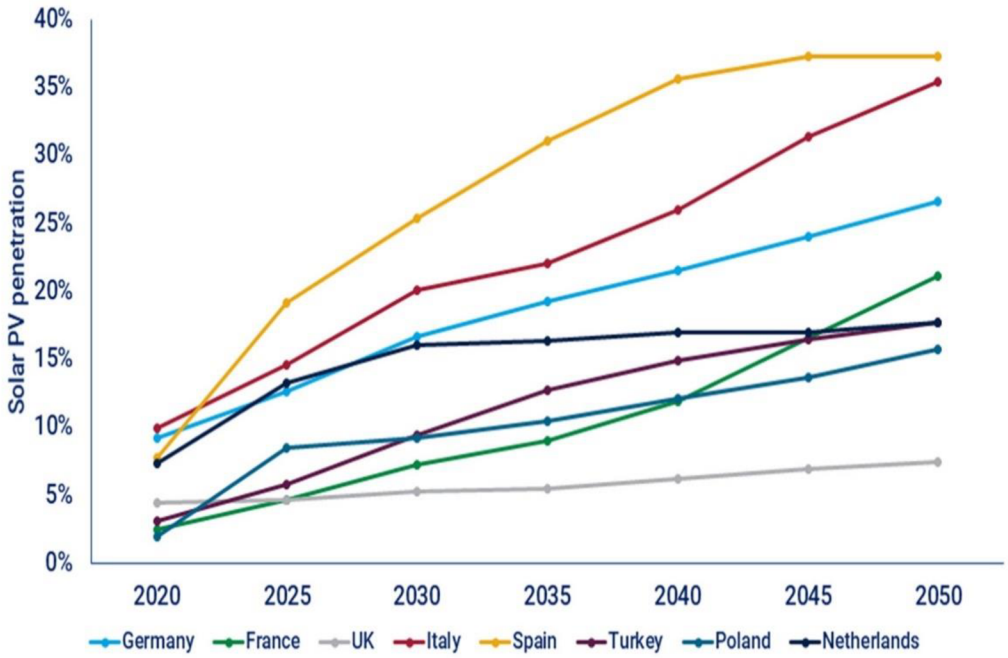
An important conclusion of the study is that the transition to renewable energy sources will largely depend on the economic efficiency of these sources, as well as on support from governments and investors. Therefore, according to BNEF, governments and companies should continue to invest in renewable energy and create favorable conditions for its development.

Wood Mackenzie research.

Wood Mackenzie is an international consulting company that conducts research in the field of energy, ecology, climate, and other industries. In one of its studies conducted in 2019, Wood Mackenzie considers the transition to renewable energy sources in Europe. The company's report, called "Europe Power & Renewables Service Outlook 2019", is an analysis of the renewable energy market in Europe and forecasts of the development of the industry. The study covers the electricity market, including various energy sources such as coal, gas, nuclear energy, wind and solar energy.

According to the report, the transition to renewable energy sources will continue in Europe, and by 2030 the share of renewable energy in electricity production will be about 50%. By 2040, this share may reach 70%. The report notes that wind and solar power plants will be the main sources of renewable energy in Europe (Wood Mackenzie, 2019).

Figure 7: Penetration of solar PV generation in Europe to 2050. Source: (Wood Mackenzie, 2019)



The research also draws attention to the fact that switching to renewable energy sources can be more expensive than using traditional energy sources such as coal and gas. However, the decline in prices for solar panels and wind turbines in recent years has made renewable energy increasingly competitive.

The research also discusses various obstacles to the development of renewable energy, such as restrictions on network connectivity and the need to create energy storage facilities. However, Wood Mackenzie is confident that the transition to renewable energy sources is inevitable and that investing in renewable energy will have a positive effect on the economy and the environment as a whole (Wood Mackenzie, 2019).

4.1.2 General conclusion of the research.

According to the author of this thesis, studies of international companies on the transition to renewable energy sources help to create more environmentally sustainable and efficient business models, promote the development of new technologies and ensure the transition to a more sustainable future for everyone. However, according to the author, the

research of international companies cannot be 100% reliable, since in the reports of each, different dates of both full and partial transition to renewable energy sources are presented. In this regard, the author suggests that a practical transition to alternative energy sources, comparable to the dates of transition to renewable sources based on research, can be provided that the governments of the countries conduct a constant analysis of the economic situation in the world so that external and internal problems cannot stop the chain of investment and production of renewable energy sources.

4.2 Assessment of renewable energy generation

The author of this thesis understands that it is quite difficult to calculate the exact amount of energy required for all types of activities in the world. However, there are estimates that allow us to conclude that renewable energy sources can cover a significant part of the world's energy needs. Earlier, the author analyzed some studies of international energy companies where, for example, in 2019, according to the International Renewable Energy Agency (IRENA), renewable energy sources (solar, wind, hydropower and others) provided more than 72% of the new installed capacity of energy systems in the world (IRENA, 2019).

If we consider each type of renewable energy sources separately, we can provide the following data:

- **Solar energy generation**

The assessment of solar energy production depends on many factors, including geographical location, climatic conditions, orientation, and inclination of solar panels, as well as the effectiveness of the solar panel technology itself. However, for example, we can consider the assessment of solar energy production in the United States. According to the National Oceanic and Atmospheric Administration (NOAA), solar radiation falling on the territory of the United States averages about 4.8 kWh/m2 per day. Taking into account the fact that the efficiency of modern solar panels is about 15%, then one square meter of solar panels can generate about 0.72 kWh of electricity per day. Thus, if you install 100 square meters of solar panels, then the production of solar energy will be about 72 kWh per day. This value may vary depending on location and other factors, but it gives a general idea of how solar energy production is estimated.

If we consider one square meter of a solar panel located at mid-latitude, we will get an approximate calculation of 170-watt hours of energy generation per day. This means that to cover the energy demand at the level of 30 terawatts (roughly equivalent to the consumption of the world in 2019), it will be necessary to install solar panels with a total area of about 176,000 square kilometers (NOAA Team, 2022).

- **Wind power generation:**

One kilowatt of a wind turbine can produce approximately 3,000 kilowatt hours of energy per year. If we assume that on average a wind turbine operates at 40% of its maximum capacity per year, then to cover the energy demand at the level of 30 terawatts, it will be necessary to install wind turbines with a total capacity of about 100 million kilowatts (Lloyd James, Craig Bruce, Campbell Hutcheon, 2021).

- **Hydropower generation:**

Hydropower provides more than 16% of all electricity produced in the world. At the same time, it is possible to build additional capacities on reservoirs, dams, and others (LCP Team, 2021).

- **Conclusion: Assessment of renewable energy production.**

Energy generation from renewable sources has sufficient potential to cover a significant part of the world's energy needs. In order for renewable energy sources to cover an even greater share of the world's energy needs, it is necessary to continue developing technologies and infrastructure for their production and use.

1. Improved technology for energy collection and storage. Renewable energy sources have several limitations, such as the variable nature of energy production depending on weather conditions and time of day. Energy storage technologies such as batteries and hydrogen storage systems can help reduce these limitations.
2. Development of network infrastructure. The transfer of energy from the place of its production to the place of consumption is an important aspect of the use of renewable energy sources. It is necessary to create new networks and modernize existing ones so that energy can be transmitted over long distances without large losses.

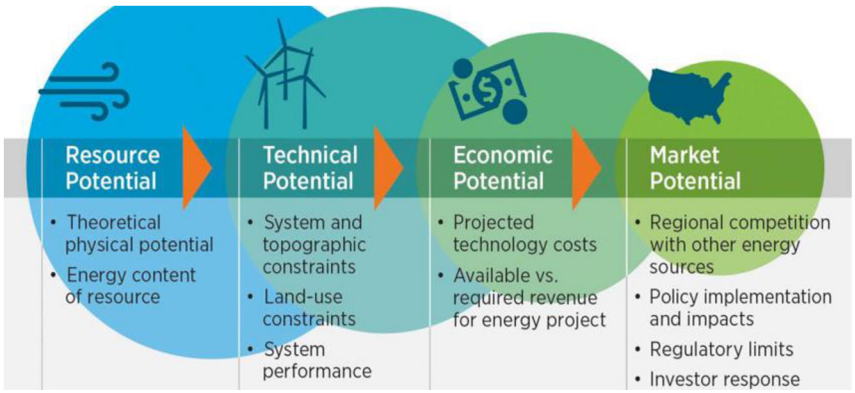
3. Encouraging the use of renewable energy sources. States can encourage the use of renewable energy sources through tax incentives and other incentives to reduce the cost of using them and attract more investment.
4. Research and development of new technologies. New technologies, such as hydrogen energy technologies and next-generation solar panels, can help increase productivity and reduce renewable energy costs.

4.3 The practice of introducing renewable sources.

The practice of introducing renewable energy sources is one of the most pressing issues of our time. Due to the threat of climate change and the need to reduce carbon dioxide emissions, many countries are beginning to actively switch to renewable energy.

The process of introducing renewable energy sources requires an integrated approach and includes several stages. The first stage is to analyze energy needs and determine the most appropriate types of renewable energy sources for a particular region or country. This is followed by the choice of technology and the feasibility study, which will assess the effectiveness of investments and determine the payback period of the project. An important step is also the development of project documentation and obtaining the necessary permits and licenses. After that, the process of installing equipment and carrying out construction work begins. After the construction is completed, it is necessary to test and adjust the operation of the system. An important stage is also the training of personnel and the organization of maintenance and repair of the system.

Figure 8: Process to build renewable energy projects. Source: (CC Team, 2022)



4.3.1 Stages of introduction of renewable energy sources.

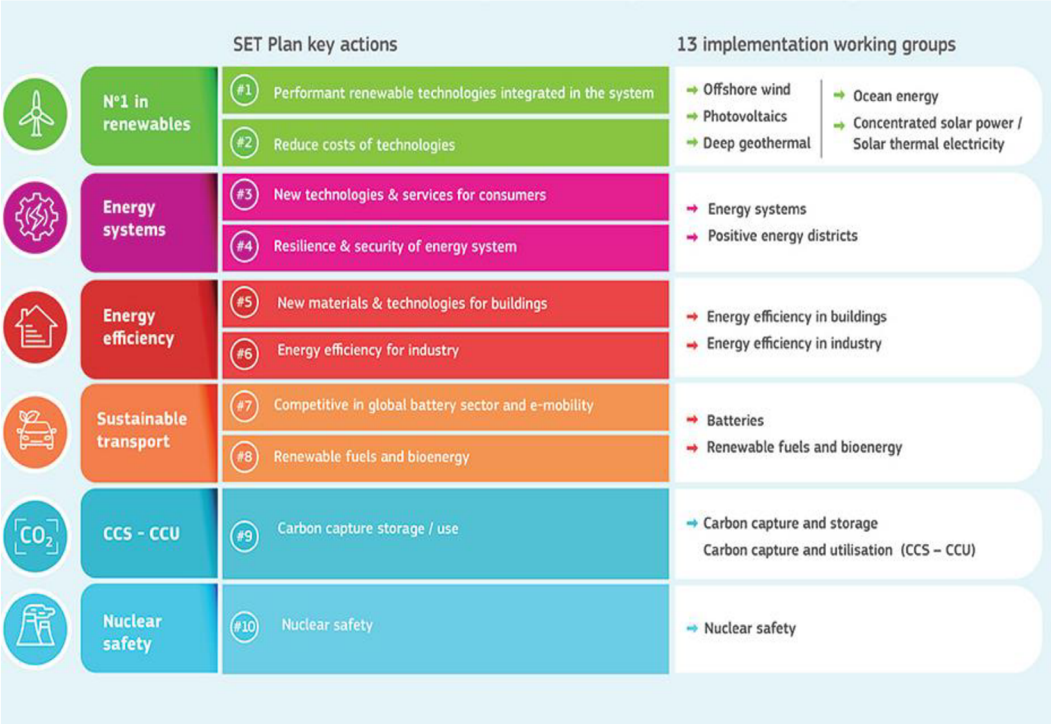
- **Stage 1. Analysis of energy needs.**

The analysis of energy needs and the identification of the most suitable types of renewable energy sources for a particular region or country is a multi-step process that can be performed as follows:

1. Data collection and analysis: it is necessary to collect data on energy consumption in a given area, including the types of energy sources used, their share in total consumption, as well as the projected consumption growth. This data can be obtained from official sources such as statistical reports and databases.
2. Assessment of the potential of renewable energy sources: The next step is to assess the potential of renewable energy sources for this area. This may include analysis of the potential of wind, solar energy, hydropower, biomass and geothermal energy.
3. Identification of the most suitable types of renewable energy sources: based on the data obtained in the previous stages, it is possible to determine which types of renewable energy sources can be the most efficient and cost-effective for a given area. For example, if an area has a high potential for solar energy, then solar energy may be the most suitable type of renewable energy.
4. Economic Feasibility assessment: The next step is to assess the economic feasibility of using various types of renewable energy sources. This includes an analysis of the costs of installing and operating the system, the payback period of investments, as well as possible government benefits and subsidies.
5. Development and implementation of an action plan: based on the data obtained in the previous stages, it is possible to develop an action plan for the introduction of renewable energy sources in this area. This may include the selection of specific technologies, the introduction of new energy generation systems, the modernization of existing infrastructure facilities, regulation and promotion of the use of renewable energy sources. In addition, it is necessary to identify specific measures to reduce energy consumption, such as improving energy efficiency, raising public awareness about the use of renewable energy sources.

6. Monitoring and evaluation of results: Finally, it is necessary to monitor and evaluate the results of the introduction of renewable energy sources. This includes an analysis of the efficiency of the system, a comparison of the costs of energy production before and after the introduction of renewable energy sources, as well as an assessment of the social and environmental consequences of the use of new technologies.

Figure 9: Example of renewable energy transition plan based on European strategic energy plan. Source: (Buildup Team, 2021)



In general, the analysis of energy needs and the identification of the most suitable types of renewable energy sources for a particular region or country requires an integrated approach and cooperation between various stakeholders, including government agencies, investors, enterprises and the population (IEA Team, 2022).

- **Stage 2. Technology selection.**

The transition to renewable energy sources is a complex process that requires the introduction of various technologies in different fields. Some of the key technologies that are needed for a full transition to renewable sources include:

1. Solar energy technologies: Solar energy can be used to generate electricity, and this requires the introduction of technologies such as photovoltaic panels, concentrated solar installations and solar panels.
2. Wind energy technologies: Wind energy can be used to generate electricity, and this requires the introduction of technologies such as wind turbines and wind turbines.
3. Hydropower technologies: Hydropower can be used to generate electricity, and this requires the introduction of technologies such as hydroelectric power plants and tidal generators.
4. Biomass technologies: biomass can be used to generate energy, and this requires the introduction of technologies such as bioenergy plants and biofuel production.
5. Energy storage technologies: Energy storage is a key factor for increasing the efficiency of renewable energy sources. This requires the introduction of technologies such as batteries, hydrogen fuel cells and heat storage systems.
6. Transmission network technologies: Energy produced from renewable sources is often produced in remote locations where there are no necessary transmission networks. This requires the introduction of technologies such as "smart grids" and direct current energy transmission technologies.
7. Energy efficiency technologies: Improving energy efficiency will help reduce energy consumption and reduce the load on the energy supply system. This requires the introduction of technologies such as LED lighting, energy-efficient household appliances and buildings with low energy consumption.
8. Waste disposal technologies: Renewable energy sources can also be obtained from waste disposal, for example, by producing biogas from food industry waste. This requires the introduction of technologies such as waste treatment plants and waste management systems.
    a. Sharing technologies: Sharing renewable energy sources can help increase the efficiency of the energy supply system. For example, solar energy and wind energy can be used together to produce electricity. This requires the introduction of technologies such as hybrid energy supply systems and renewable energy sharing systems.
    b. Digitalization technologies: Digitalization can help manage the production, storage and distribution of renewable energy. This requires the introduction

of technologies such as monitoring and management systems, cloud computing and the Internet of Things.

The introduction of all these technologies in combination can help ensure a complete transition to renewable energy sources. However, it will also require significant investment and support from the government and the business community (OES Team, 2022).

- **Stage 3. Project documentation. Licenses.**

The development of project documentation and obtaining permits and licenses for the introduction of renewable energy sources in a certain territory includes several steps:

1. Study of legislation: it is necessary to study the legislation of the country, region or municipality in which the project will be deployed. Laws, rules and regulations governing the introduction of renewable energy sources in a particular territory should be studied in order to understand what requirements need to be met in order to obtain permits.
2. Site selection and assessment of the potential of renewable sources: the next step is to choose the location where the project will be deployed. It is necessary to assess the potential of renewable sources to make sure that investments are appropriate.
3. Development of project documentation: after selecting a location and conducting a potential assessment, the development of project documentation should begin. It should contain all the necessary technical characteristics, layout and design of the project, as well as other important details, such as estimated construction and operation costs, projected capacity and amount of energy produced and construction time.
4. Obtaining permits and licenses: after the development of the project documentation, it is necessary to obtain all necessary permits and licenses from the competent authorities. This may include a construction permit, equipment certification, permission to connect to the power grid, and others.
5. Construction and commissioning: after obtaining all necessary permits and licenses, construction can begin. After completion of construction, it is necessary to obtain a permit for commissioning.

Depending on the specific conditions and legislation in a certain territory, the process may vary. It is important to carry out all the necessary research and develop project documentation in accordance with the requirements of legislation and in accordance with industry standards, in order to ensure effective work on the introduction of renewable energy sources in a certain area, it is also necessary to ensure proper management and operation of installed systems (Jenkins, 2002).

- **Stage 4. Installation and testing.**

The process of installing equipment and carrying out construction work when introducing renewable energy may vary depending on the type of energy you want to use. Below the author gives the general steps that need to be performed when installing equipment and carrying out construction work:

1. Terrain survey: Before proceeding with the installation of equipment, it is necessary to conduct a survey of the terrain to determine its suitability for the use of renewable energy. For example, to install solar panels, you need to choose a place with a good exposure to the sun, and to install wind turbines, you need to choose places with high wind speeds.
2. Purchase of equipment: After preparing the project, it is necessary to purchase equipment and materials for construction. It is necessary to make sure that the equipment meets the project and the requirements of the terrain.
3. Preparation of the installation site: Before installing the equipment, you need to prepare the installation site. This may include cleaning the area, installing the foundation and marking the installation site.
4. Installation of equipment: After preparing the installation site, you can proceed with the installation of equipment and construction. This may include the installation of solar panels, wind turbines, hydro generators and other equipment.
5. Connecting to the power grid: After installing the equipment, it is necessary to connect it to the power grid. To do this, you may need to install inverters, transformers and other devices.
6. Tests: After connecting the equipment to the power grid, it is necessary to conduct tests to make sure that it is operable and meets the requirements. If necessary, additional work may be required to configure the equipment.

7. Operation: After testing and confirming the operability of the equipment, it is possible to start using renewable energy for electricity production. It is important to carry out regular maintenance and control of the equipment to ensure its reliability and efficiency. When conducting tests for the introduction of renewable energy, various methods and technologies are used. For example, when testing solar panels, special devices are used to measure output power and efficiency, and when testing wind turbines, similar devices are used to measure wind speed, output power and efficiency. One of the key stages of testing is carrying out load tests to check the operability and reliability of equipment in various conditions. Tests for compliance with standards and safety requirements are also carried out.

In general, the process of installing equipment and carrying out construction work during the introduction of renewable energy requires careful preparation and a professional approach to ensure maximum efficiency and reliability of the use of renewable energy (Boyle, 2004).

- **Stage 5. Staff training.**

The personnel training stage with the operation of renewable energy equipment includes several steps:

1. Introduction to the theory: employees should study the theoretical foundations of the equipment, the principles of its operation, management features and technical characteristics. This will allow them to better understand the processes and make decisions in case of problems.
2. Practical classes: after getting acquainted with the theory, employees should start practical classes, during which they will learn how to work with equipment in practice. This may include training on simulators, training stands or training on real equipment under the guidance of experienced specialists.
3. Familiarization with safety measures: When working with renewable energy equipment, certain safety measures must be observed. Employees should be familiar with the operating rules, safety procedures and requirements for protection from hazardous influences.
4. Maintenance and repair training: In case of equipment failure, employees should be able to quickly diagnose and fix the problem. To do this, they need to be trained in equipment maintenance and repair.

5. Systematic professional development: the staff should constantly improve their knowledge and skills in the field of renewable energy and working with equipment. To do this, it is necessary to conduct systematic trainings, seminars and training programs.

All the above steps, according to the author, are important stages of training personnel with the operation of renewable energy equipment, which allow efficient use of energy from renewable sources and ensure safety when working with equipment (Zippia Team, 2022).

5 Recommendations for implementation.

The introduction of renewable energy sources can be carried out at the local, regional or national level. Here are some practical recommendations selected by the author with the help of analysis on the introduction of alternative energy sources:

1. Government support.

According to the author, government support is a key factor in the successful introduction of renewable energy sources. State support can be manifested in various forms, such as tax incentives, subsidies for research and development, financial assistance, legislative measures.

Government support not only stimulates the development of renewable energy sources, but also reduces the cost of production and improves technology, which ultimately leads to greater availability of clean energy for the population and businesses. In addition, government support can contribute to the creation of new jobs in the field of renewable energy, which contributes to economic development and reduces unemployment. Thus, government support is an important factor in the successful introduction of renewable energy sources and should continue to be actively applied to achieve sustainable development goals (DAO, 2017).

2. Cooperation with local communities.

Cooperation with local communities is an important component of the successful implementation of alternative energy sources. One of the main reasons is that the introduction of renewable energy sources, as a rule, is carried out in specific territories where people live and enterprises work.

Local communities may have different interests and needs that need to be taken into account when developing and implementing projects for the introduction of alternative energy sources. In addition, local residents can play an important role in the installation and operation of equipment, as well as in its maintenance and maintenance. Cooperation

with local communities may include consultations and communication with residents to determine their interests and needs, organization of training courses for local residents, creation of jobs at the local level. Moreover, local communities can become important partners in the field of financing and project management. Cooperation with local communities can help improve relations between local residents, businesses and government bodies, as well as lead to more sustainable and long-term development (OES Team, 2022).

3. System integration.

The systemic integration of renewable energy sources into the existing energy system is one of the main challenges in the transition to the use of renewable energy. The use of renewable energy sources, such as solar and wind energy, can be unpredictable and depend on many factors, such as weather and time of day. Therefore, it is necessary to ensure the stability of the energy system, taking into account the peculiarities of renewable sources.

To ensure the integration of renewable energy sources into the energy system, it is necessary to develop an appropriate infrastructure and energy management system. For example, solar panels require inverters that convert direct current into alternating current so that it can be used in the electricity grid. Wind turbines require control mechanisms to ensure safe operation of the generator and connection to the grid.

Additional investments in infrastructure and energy management system may be required to ensure the stable operation of the energy system. For example, it may be necessary to install additional electrical networks to ensure a sufficient amount of energy and its distribution throughout the system. In addition, the energy management system must be able to instantly switch between different energy sources depending on changing conditions in order to ensure the stability of the power system.

To ensure the stability and reliability of the energy system, it is also necessary to monitor and manage energy. For example, it is necessary to monitor the amount of energy generated, energy consumed and the state of the network so that energy

production and distribution can be regulated. Thus, the system integration of renewable energy sources is a key factor for ensuring a successful transition to the use of renewable energy (IEA Team, 2022).

4 Monitoring.

Monitoring is an important component in the implementation of renewable energy, as it allows you to monitor the production, consumption and distribution of energy, as well as monitor the operation of the system and detect possible problems.

Firstly, monitoring energy production allows you to track the volume of energy production from renewable sources, such as solar and wind power plants. This is important for planning and optimizing the operation of the power system, as well as for regulating the volume of energy production depending on changing conditions.

Secondly, monitoring energy consumption allows you to determine which energy sources are used in different conditions, and how energy production and distribution can be optimized. For example, monitoring consumption can help determine which hours of the day require more energy and which energy source is best used to meet energy needs during the day.

Thirdly, monitoring the network status allows you to monitor the operation of the system and identify possible problems in the network. For example, monitoring can help identify network congestion, connection interruptions and other problems that can lead to a decrease in system performance and reliability.

Fourth, monitoring the energy management system helps to ensure efficient and reliable energy management. For example, monitoring can help determine which energy sources are used in different conditions and how energy production and distribution can be optimized.

Monitoring makes it possible to ensure effective management and optimization of the system, including the maximum use of renewable energy sources and optimization

of the energy management system. Monitoring also allows you to quickly respond to changes in energy production and consumption and adjust the operation of the system to ensure the best result. In general, monitoring is a necessary tool for the introduction of renewable energy, as it allows you to get a complete picture of the production, consumption and distribution of energy in the system, as well as to detect possible problems and optimize the operation of the system. When monitoring, many factors should be taken into account, such as production parameters, consumer characteristics, management parameters, as well as economic and environmental parameters. To do this, various sensors, sensors, control systems and software for data analysis and processing are used. It is important to note that monitoring should be reliable, accurate and timely. Incorrect or delayed data can lead to a decrease in the efficiency and reliability of the system, which can lead to serious economic and environmental consequences. Therefore, it is necessary to use reliable hardware and software, as well as to carry out regular maintenance and technical support of the monitoring system. Finally, monitoring should be considered as part of a broad energy management strategy that should include both technical and economic aspects. This is the only way to ensure the efficient and reliable introduction of renewable energy into the system and ensure stable and environmentally friendly operation of the energy system as a whole (Jakupov, 2021).

6 Conclusion

Based on the assessment of all aspects in this thesis, the author assumes that a complete transition in the world to renewable energy is technically possible, but this will require significant investments and changes in the economic, social, and political systems. However, such a transition is necessary to reduce dependence on oil and gas, reduce greenhouse gas emissions and combat climate change. Renewable energy sources such as solar, wind, hydro, geothermal and biomass will not disappear anytime soon, and their use has significant environmental, economic and social benefits. The truth is that the world is still dependent on oil and gas, which are the main sources of energy used in transportation, industry and households. Based on this, during the study in this thesis, the transition to renewable energy will require significant investment in the development of new technologies and infrastructure, as well as changes in political and economic systems. For example, laws are needed to regulate greenhouse gas emissions and incentives for companies that switch to renewable energy.

However, a full transition to renewable energy can lead to some negative consequences. For example, the manufacture and disposal of batteries and other energy storage devices can lead to problems with waste management. In addition, some forms of renewable energy, such as wind and solar, can be unstable and do not necessarily provide a constant source of energy. One of the main challenges facing a full transition to renewable energy is the lack of sufficient energy produced by these sources to meet the growing demand for energy around the world. For example, electricity generation from solar and wind energy cannot supply a stable flow of energy, as it depends on weather conditions. The solution to this problem could be the use of energy storage technologies such as batteries, which can store the energy produced during periods when demand is low and use it during periods of peak demand. Currently, there are many different energy storage technologies such as liquid and gas batteries, kinetic batteries, and hydrogen storage technologies.

Another problem is the high cost of producing energy from renewable sources. Despite the fact that the price of solar and wind installations has dropped significantly over the past few years, they are still more expensive than traditional energy sources such as coal and oil. However, as the scale of production increases and technology improves, the price of

renewable energy will decrease. It is also necessary to take into account the social and political aspects of the transition to renewable energy. In some regions, such as oil and gas production areas, such a transition may cause resistance from local communities and lead to loss of jobs and income. Therefore, a successful transition to renewable energy requires not only technical, but also social and political support.

Switching to renewable energy is an important step in combating climate change and reducing greenhouse gas emissions. It is important to consider potential negative impacts and develop appropriate strategies to mitigate them. In conclusion of this thesis, a full transition to renewable energy is technically possible, but this will require decades of significant efforts, investments and global cooperation of countries.

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