

Czech University of Life Sciences Prague

Faculty of Economics and Management

Department of Management



Diploma Thesis

**The Impact of Adopting Renewable Energy Technologies
on the country's economy**

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CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Economics and Management

DIPLOMA THESIS ASSIGNMENT

Bc. Nurgul Zhanadilova

Economics and Management
Economics and Management

Thesis title

The impact of adopting renewable Energy Technologies on the developing countries economy

Objectives of thesis

The aim of this thesis is to identify the impact of renewable energy technologies on selected developing countries economy and evaluate their optimality.

Methodology

The thesis is divided into two parts:

The theoretical part consists of the exploration of literature, statistical data, and existing trends.

The practical part indicates comparison analysis.

1. Comparison of a set of developing countries from different regions

2. Assessment for a specific period of time.

3. Comparison of economic impact by :

- nonrenewable sources to generate energy
- projected data by using renewable sources instead

In the end, I will summarise the data and conclude based on the research.

The proposed extent of the thesis

60-80

Keywords

economy, developing countries, renewable resources, non-renewable

Recommended information sources

- Ibrahim, R.L., Ajide, K.B., Omokanmi, O.J. (2021). Non-renewable energy consumption and quality of life: Evidence from Sub-Saharan African economies. *Resources Policy*, Vol. 73, No. c, pp.102176. ISSN 0301-4207. DOI 10.1016/j.resourpol.2021.102176. Accessed October 2021.
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Expected date of thesis defence

2021/22 SS – FEM

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Declaration

I declare that I have worked on my diploma thesis titled "The Impact of adopting renewable energy technologies on the country's economy" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the diploma thesis, I declare that the thesis does not break copyrights of any their person.

In Prague on 27.03.2022

Acknowledgement

I would like to thank my supervisor and guide, Ing. Ghaeth Fandi, Ph.D. for consultations, instructions and advices, during work on the thesis.

The Impact of Adopting Renewable Energy Technologies on the country's economy.

Abstract

The main abstract of this work is to study the adoption of renewable energy technologies in developing countries, as well as to determine the impact on their economy and evaluate the optimality.

This task will be divided into two parts.

The first part is 'Theoretical part'. As this is an informational section, basic terminologies, factors, statistical dates will be explored. Furthermore, in this section the basic understanding of how they influence each other will be provided. The theoretical part is an integral part. It will be the main framework that will guide the rest of the thesis and give more clarity on history, terminologies, trends etc. The knowledge gained for the same will be applied in the analyses and comparison charts later in order to draw inferences.

A practical exercise of analyses, assessments projections will be carried out in the second part, herein known as 'Practical Part'. The main aim of aforementioned part in this dissertation is a comparative analysis of developing countries from different regions. The analysis will primarily focus on the economic impact of renewable and non-renewable sources for energy generation. Given the constraint of content limit, data availability and time, two case studies will be chosen to establish this section. At the end of the research there will be an attempt to draw inference on future trend and a conclusion will be provided.

Keywords:

Economy, Developing Countries, Renewable Energy, Non-Renewable Energy

Dopad přijetí technologií obnovitelných zdrojů energie na ekonomiku země.

Abstrakt

Hlavní tezí této práce je studium zavádění technologií obnovitelných zdrojů energie v rozvojových zemích se stanovením dopadu na jejich ekonomiku a posouzením optimálního využití.

Tento úkol bude rozdělen na dvě části. První část je "Teoretická část". Vzhledem k tomu, že se jedná o informační sekci, budou zkoumány hlavní pojmy, faktory, statistiky. Kromě toho tato část poskytne základní pochopení toho, jak se navzájem ovlivňují. Teoretická část je nedílnou součástí. To bude základní struktura, která se bude řídit zbytek diplomové práce a poskytne větší srozumitelnost ohledně historie, terminologie, trendů atd. Získané poznatky budou později použity v analýzách a srovnávacích grafech pro vyvození závěrů.

V druhé části nazvané "Praktická část" budou provedena praktická cvičení na analýzu, vyhodnocení prognóz. Hlavním účelem výše uvedené části této diplomové práce je komparativní analýza rozvojových zemí z různých regionů. Analýza se zaměří především na ekonomický dopad obnovitelných a neobnovitelných zdrojů na výrobu energie. Vzhledem k omezením v obsahu, dostupnosti dat a času budou pro vytvoření této části vybrány dvě případové studie. Na konci studie bude učiněn pokus vyvodit závěr o budoucím trendu a bude uveden závěr.

Klíčová slova:

Economika, Rozvojové země, Obnovitelná energie, Neobnovitelná energie.

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1. Introduction

Energy has existed since time immemorial. Even when civilizations did not yet exist, the sun was the very first source of energy for the very first people. The sun served them with light and warmth, and which in course , help them orient themselves when to get up and gather or hunt. With time, fire was invented and firewood and manure were used for heating. Later water and wind became the resource for creating a mill. We can observe here, that the first sources of energy were, the so-called in the modern world, renewable resources. Several centuries later, when people began to find minerals and learned how to use them, the first steam engines appeared. The steam engine worked on the chemical energy of coal. These were one of the first fossil fuel powered engines. From this, the evolution of mankind began, as steam engines began to be used in various industries, such as manufacturing, construction and transport.

Nowadays, energy plays a huge role in the life of the human race. It has invaded all spheres of human activity. In industries, energy is used to put some technologies into action, in everyday life as a source of heat and light, in transport as a lever of action for movement, and in science as a means for studying new knowledge and species.

At the moment, more than 90% of energy is extracted from fossil sources and 10% of energy from natural resources. Energy consumption in the modern world has increased a lot. Such expenses of sources will lead to a rapid depletion of reserves and humanity must switch to a more renewable energy system, as it was at the beginning of the formation of mankind, in fact under the sphere of much advanced technologies.

Countries with a stable economic situation over time began to replenish some part of the energy with the help of the Energy System based on renewable energy sources. However, for many developing countries, installing renewable energy technology is still not as affordable due to the initial cost.

This study focuses on identifying the impact of renewable energy system technologies on the economy and their optimality for implementation.

2. Objectives and Methodology

Objectives

The prime objective of this dissertation is to determine the impact of renewable energy technologies on the economies of developing countries and to evaluate their optimality for the same.

Methodology

This work consists of two parts.

The first part is the theoretical part : An informative section that describes basics of energy, economy, history, trends as well as factors affecting a country's economy.

The second part consists of a practical part : It will provide a comparative analysis of developing countries from different regions and summarize the results of the study, to draw conclusions from the same.

3. Theoretical part

All of the primary meanings of the topic's keywords will be defined in depth in this section of the work, and a practical section will be created on the basis of this work.

3.1. Economy

Economics is a type of social science that analyzes how limited resources should be allocated. Individuals or governments conduct these analyses in order to suit humanity's needs and demands. We are aware that most of the resources are limited, hence it is necessary to prioritize commodities that are a necessity over those that are luxury. In addition, economics also looks into problems such as; what is the most efficient method to produce, what to develop, who will manufacture these goods, for whom is this product intended, etc. This is all studied by the science of Economics. (MAITAH, Mansoor,2017, p.7-8).

According to a report by International Monetary Fund: “The study of economics gives us a simplified concept of reality, so we understand the inner workings. In the future, we can use this knowledge to push the economy to a more desirable result”. (2017, p.8). The study of economy consists of a set of mathematical equations and theories that describe the behaviors and choices made by individuals and the state. The structure of the equations shows and tries to show a simplified reality. (International Monetary Fund, 2017, p.8-9). Furthermore, the mathematical equations are accurate and logical, so one can determine some hypothetical situations and predict the result. (PROCHÁZKA, Petr, 2015, p. 10).

For instance, one of the mathematical equations tries to simplify how supply or demand affects prices. (International Monetary Fund, 2017, p.8-9).

All theories and mathematical equations were invented to correctly allocate limited resources or to explain why a resource was used. As Mansoor Maitah stated in his work “Resources are components of production or methods of production. Which can be classified into four categories as land, labor, capital and enterprise.” (2017, p.7). Almost all resources are considered as limited. Limitation is the basis of all decisions and choices. (MAITAH, Mansoor,2017, p.9)

3.2. Economic growth

The study of economics, theories and models, as well as individual economic decisions, have all been undertaken with the goal of enhancing and developing the economic growth. As a result, the evolution and advancement of human existence on Earth is impacted. (Boldeanu, F., Constantinescu, L., 2015). Every year, humanity's population on Earth grows, necessitating an ever-increasing amount of resources and knowledge for further progress.

Let's start by defining what economic growth is and what it exactly means? Economic growth can be defined in a variety of different ways. However, the key idea was that a country's output of goods and services had been increasing for some period. (Chappelow, J., 2021) Production of more products and services leads to an increase in productivity, which also leads to an increase in the wages of workers, thereby inducing more money to be spent on quality products and services, which as a result is an increase in the quality of life of mankind. (Chappelow, J., 2021). Thus, it can be concluded that economic growth is closely related to a nation's growth and the standard of living conditions of its population.

Economic growth is measured in Gross Domestic Product and National Domestic Product. As stated by MAITAH, Mansoor in his work "Macroeconomics Issues and Exercises" GDP means: "total money value of all final goods and services produced within a nation's border during a year". (2017, p.45). Furthermore, MAITAH, M. mentions GNP as "total money value of all final goods and services produced by an economy within a given time, usually a year". (2017, p.45).

The difference between the two dimensions is that one dimension calculates the total value of the product produced in the country by both citizens and foreign companies, and the other only by citizens of the country, but not only within its own country, but also within a foreign country. (Seth, S., 2019).

The use of both metrics is critical since they both indicate economic value. (Seth, S., 2019).

3.3. Factors affecting economic growth in countries

Consequently, what elements impact a country's economic growth? In fact, there are many several factors that affect the growth of the economy, both directly and indirectly. Every economic choice that has been made in the past could affect both the growth and loss of the economy. However, there are four major elements. These elements include: human resource, physical capital, natural resources and technology. (Boldeanu, F., Constantinescu, L., 2015, p. 330). Each element is important in its own way.

According to the work of Mr. Aleksey Poliduts and Assoc. Prof. Dr. Yuner Kapkaev , the factors of economic growth is considered as a supplier and responsible for the production process, which in the future can determine the ability to increase the real volume of production, as a result of which the efficiency and quality of growth will increase. (Poliduts and Kapkaev, n.d., p.63-64)

Let's take a look at each component independently and outline how it might help the whole economy in its own growth.

Human Resource:

The first component is human capital. This element is in charge of the company's efficiency, as well as its capacity to generate goods or services. It is the of the same importance as the other three, since without labor, who will participate in reproduction and other professions for the expansion of production and economic growth? Human resource development is critical since the presence of more competent people will allow the task to be promoted more efficiently. Furthermore, educated and competent people may contribute significantly to production and economic progress. Society's construction delivers not only economic but also social advantages. (Poliduts and Kapkaev, n.d., p.63-64). Poverty is reducing, the supply of qualified employees is expanding, and people's standard of living is rising. (King, B., Osei, E., n.d.)

Physical Capital :

Physical capital is the second component. Physical capital refers to tangible assets that aid in the transformation of raw resources into commodities and services in the future. Buildings, equipment, machinery, computers, and other items that may be employed in production are all examples of physical capital. Physical capital investments create more inventive and sophisticated equipment that can generate higher-quality items much faster in the future.

Technological advancement:

The third aspect is technological advancement. Technology itself, via innovation and advancement, not only enhances the pace of production and the quality of goods and services, but it also creates new employment and improves working resource knowledge. As a result, the technology itself spans a wide range of economic areas. And which, via its creativity, contributes to humanity's progress. (Hausmann, R., Dominguez, J., 2021).

Natural Resources:

Last but not the least, natural resources are the fourth component. This element is one of the most important of all factors since other factors have developed on its foundation, and we acquire the products and services we need for survival due to natural resources. Natural resources can be utilized in the economy as raw materials for industry, as energy, as fuel, and as food. Natural resources such as oil, gas, minerals and timber play an important role in the economy as the demand for resources increases every year. The lack of minerals in one country and the presence of a large amount in another greatly affects the economy of the country. This factor very much depends on the geographical location of the country. In the future, natural resources may also affect other factors of economy. For example, natural resource revenues can help develop human capital through investment in education and training.

The surface of the planet is one of the most important natural resources. Land resources are necessary for managing in any sphere and life of people. Sources like soils, water, land, minerals can be used in food production. Natural resource like oil, coal, natural gas, wind, water etc. are used to produce energy for population. Energy resources are mostly used to satisfy heat and power demands. They can be divided into two categories: renewable and non-renewable. Renewable resources, when correctly and sustainably maintained, give an increase in resources that may be mined endlessly in the future.

3.4. Energy Sector

Let us begin by defining Energy. We know from physics lectures that energy is a physical quantity that is defined by the body's ability to conduct work. Energy, according to the Cambridge Dictionary, is “the power from something such as electricity or oil that can do work, such as providing light and heat” (2022).

3.4.1. Energy Production

Therefore, how is energy generated that may eventually be used in electricity ? There are various energy producing possibilities. For example, with the assistance of a hydroelectric power station, burning heat sources, wind power plants, and etc. At the moment, the most prevalent method is to employ burning heat sources. Wood, coal, oil, natural gas, and biogas may all be used as a heat source. When heat sources are burned, the boiling point of water rises and steam is produced. The turbines are powered by steam. The turbine rotates, which causes the generator to revolve, converting kinetic energy into electricity through magnets and circuits. The rotation of the turbine is fundamental. Wind may be used to rotate turbines and generate electricity. This procedure is less harmful to the environment. Hydropower is another approach that uses an inexhaustible resource. Water is kept back by a dam, and then this water at a high height is forced to flow via channels, which push the turbine blades, causing it to revolve.

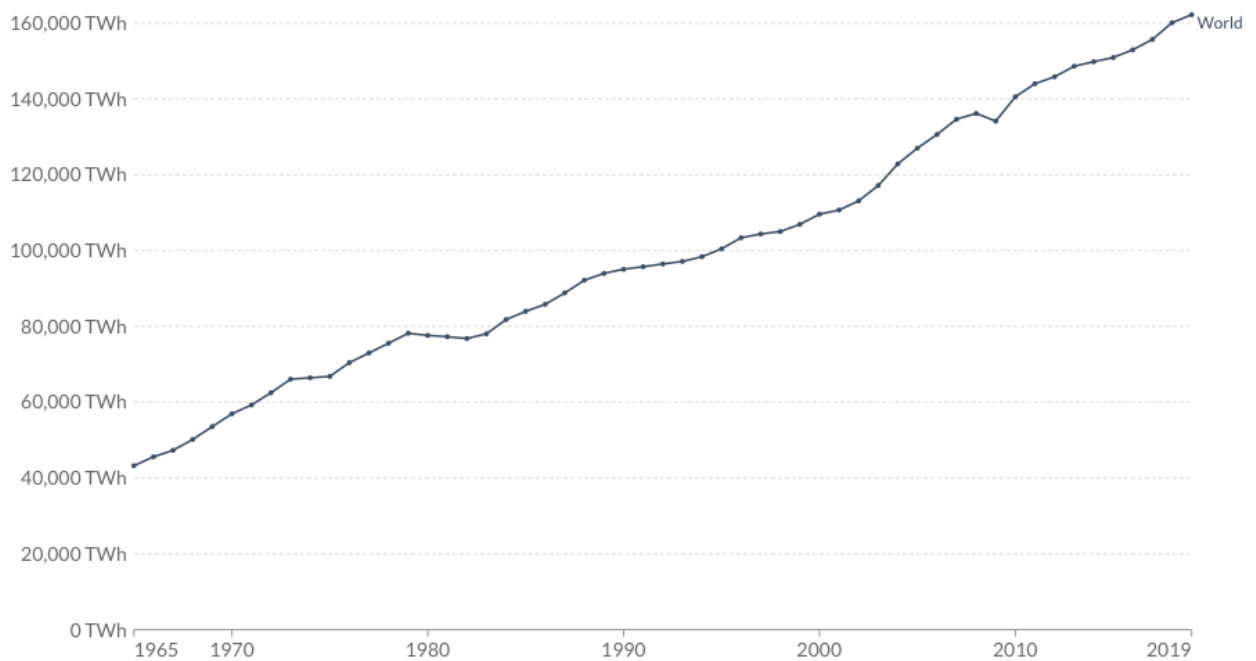
(Boechler, E., Cey, E., Hall, G., Hanania, J., Jenden, J., Lloyd, E., Rogers, F.,

Stenhouse, K., Suarez, L.V., Wiebe, D. and Donev, J. ,2016)

3.4.2. Energy Economics

As earlier mentioned, the energy business has a significant influence on both human daily lives and economic progress. The energy industry influences not only the supply of heat and electricity, but also the purchasing of other items such as appliances and home supplies. More energy is consumed as people's incomes rise. This can be ascribed to individuals having more possibilities and purchasing washing machines, dishwashers, phones, and other devices that make life simpler. (Ritchie, H., 2021).

Figure 1: World Primary Energy Consumption



Source: Ritchie and Roser, 2020

Note: The estimate is measured in terawatt-hours (TWh)

This line graph shows the primary energy consumption in the world from 1965 to 2019. From the graph we can see that in early 1965 world was consuming around 42,248 terawatt-hours and later in 2019 consumption was around 162,194 terawatt-

hours. The statistic displays a big change in the data in 54 years, the consumption increased approximately by 284% . This growth was facilitated by the evolution of mankind, infrastructure and technologies that require large amounts of energy appeared. Furthermore, the population has also increased. In 1965, the population was approximately 3.4 billion people and in 2019, approximately 7.7 billion people. (Worldometer, 2021)

Energy demand is a consequence of need of energy to perform desired services. It depends on the demand for desired services, availability and technology used for energy conversion, and costs of technology.

The automobiles is a good example. Gasoline is used for generating mechanical energy needed for moving automobiles. The amount of gasoline used increases as the kilometers the automobile is driven increases. It is also dependent on the efficiency of conversion to mechanical energy. Therefore, the distance the automobile is driven and the efficiency of conversion creates the demand for gasoline.

Likewise, electricity is used for lighting, refrigeration, heating, washing machine, electronic equipments and many such devices. Therefore, the demand for these activities creates the demand for the electricity.

The energy conversion equipment is typically long lived- automobile, air conditioning machines, refrigeration, etc. Among the alternatives, a particular type can be chosen. Since each type has its own efficiency, it influences energy demand. Consumers and firms chooses and buys these equipments with an understanding of future energy prices. For example, high natural gas prices will drive the investment in home insulation.

When the energy prices are high, it motivates people to reduce the usage of energy services and procurement of equipment with high conversion efficiency. For example, when benzene prices are high, it influences people choice of usage of automobiles and the brings them to consider buying better cars. Both outcomes will result in reduces benzene demand. These issues are relevant for industrial and commercial use of energy.

A few energy equipment may provide the same energy service. For example, to heat the room, electricity, natural gas, oil, or wood may be used. Electricity, gas, wood, or charcoal may be used for cooking. Therefore, each equipment can be substituted with one another. When prices incurred by one equipment increases, the demand for the other equipment increases. The substitution is possible due to various available energy conversion technologies. Typically one conversion technology can be used only for one energy commodity. For example, home heating system powered by gas cannot use oil. Since these conversion equipment is long lived, the substitution is usually takes long time. Substitution can be fast when several energy conversion technology are available for the consumer. For example, home that have gas heating system can be augmented by electric heating system. Therefore, various energy equipment are substitutes for one another. The development of renewable energy sources and increasing availability of these energy conversion technology is driving the substitution of conventional energy equipment powered by gas, fuel, or coal by equipment powered by renewable energy sources.

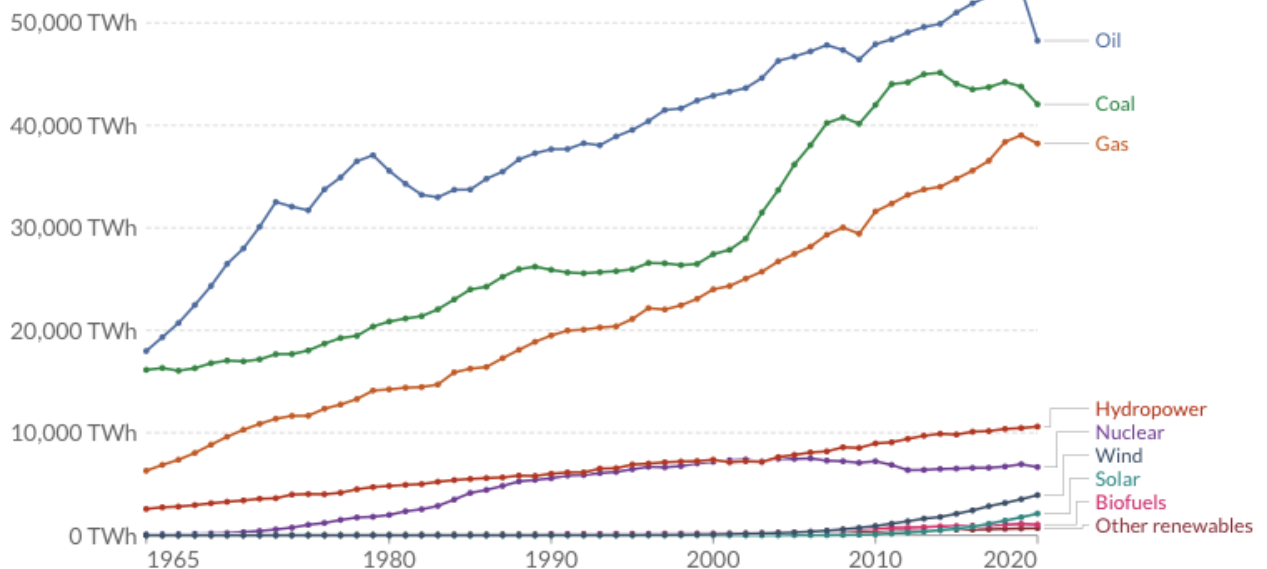
It is still uncertain which renewable energy source would dominate the future consumption. The time scale in which the the shift to renewable energy sources is not predictable. (James L. Sweeney)

3.4.3. Non – renewable energy

Non-renewable energy resources are those that cannot be replenished once depleted. Petroleum, hydrocarbon gas liquid, natural gas, coal, nuclear energy, crude oil, and diesel fuel are examples of non-renewable energies

The most often utilized energy today is that derived from nonrenewable sources. It accounts for over 89 % of total consumption (Ritchie, H., 2021)

Figure 2: World primary energy consumption by sources



Source: Ritchie, H., 2021

Note: The estimate is measured in terawatt-hours (TWh)

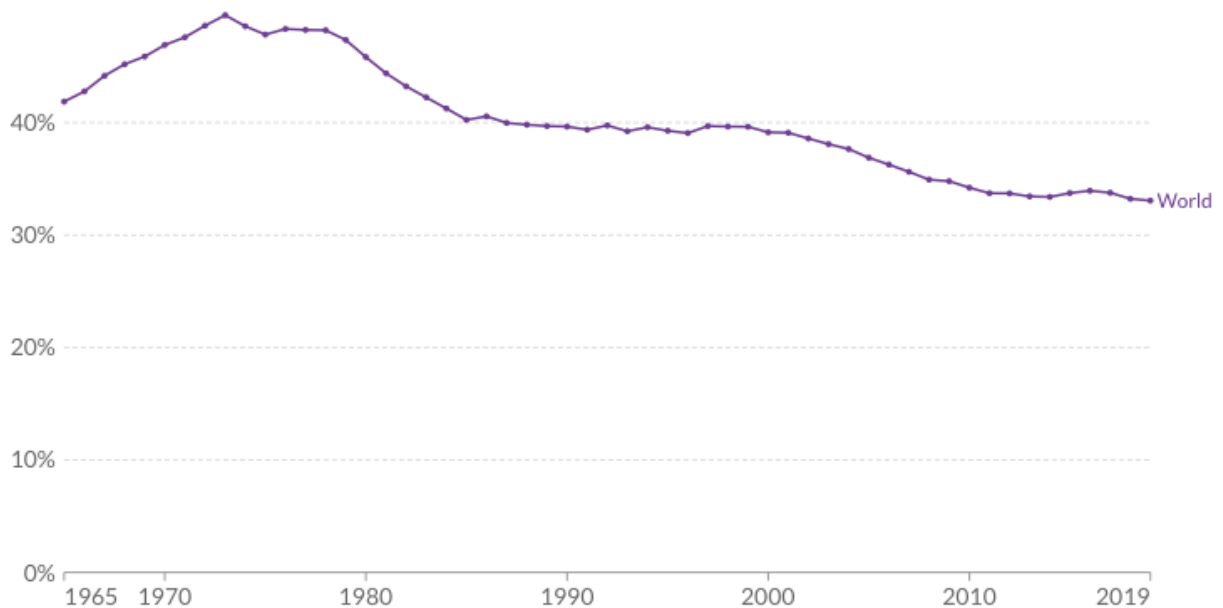
The Figure 2 demonstrates global primary energy consumption by source from 1965 to 2020. On the graph, you can see that oil is the most commonly consumed. In terms of consumption and production, coal ranks second, with 42,062 terawatt hours consumed in 2020. In terms of energy use from fossil fuels and gas is ranked third. Looking at the graph, you can see that there have been changes in oil and coal consumption, as well as declines, but there has been no change in gas use. Its

usage is constantly increasing.

Sources such as natural gas, coal, and crude oil are considered fossil fuels. They were formed from dead plants and animals inside the Earth that lived in the Carboniferous period. Due to the pressure and temperature inside the Earth, the remains of animals and plants were turned into fossils. (National Geographic Society, 2019)

Crude oil or Petroleum can be in liquid or gaseous form and mainly used as diesel fuel and gasoline for machines as well as heating product and produces plastic. (Eia.gov, 2016).

Figure 3: Share of Primary energy from oil, World



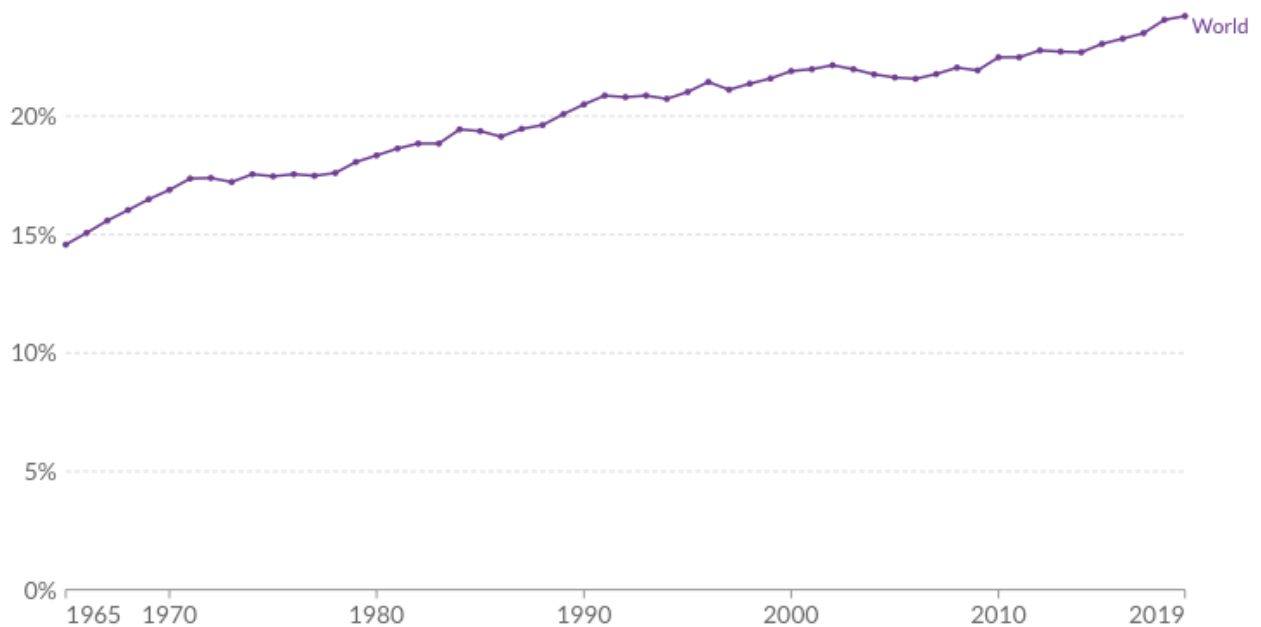
Source: Ritchie and Roser, 2020

On the above graph we can see the share of primary energy that comes from oil from 1965 to 2019. According to the graph, it can be seen that the share of oil in energy production grew from 1965 to 1973 and then slowly began to decrease. In

2019, the share of energy from oil has become 33%. This was facilitated by the oil crisis that occurred in 1973. Oil prices have risen sharply, before the crisis, the price of oil was three dollars per barrel and became \$ 12. Since then, oil has been considered one of the most expensive raw materials (Макаров и Чупилкин, 2021). (Makarov and Chupilkin, 2021).

Natural gas is the main provider of electricity and heat production. Natural gas may be formed from different compounds, but mostly consist of methane. Furthermore may be found near oil deposits. (Eia.gov, 2016).

Figure 4: Share of Primary energy from gas, World



Source: Ritchie and Roser, 2020

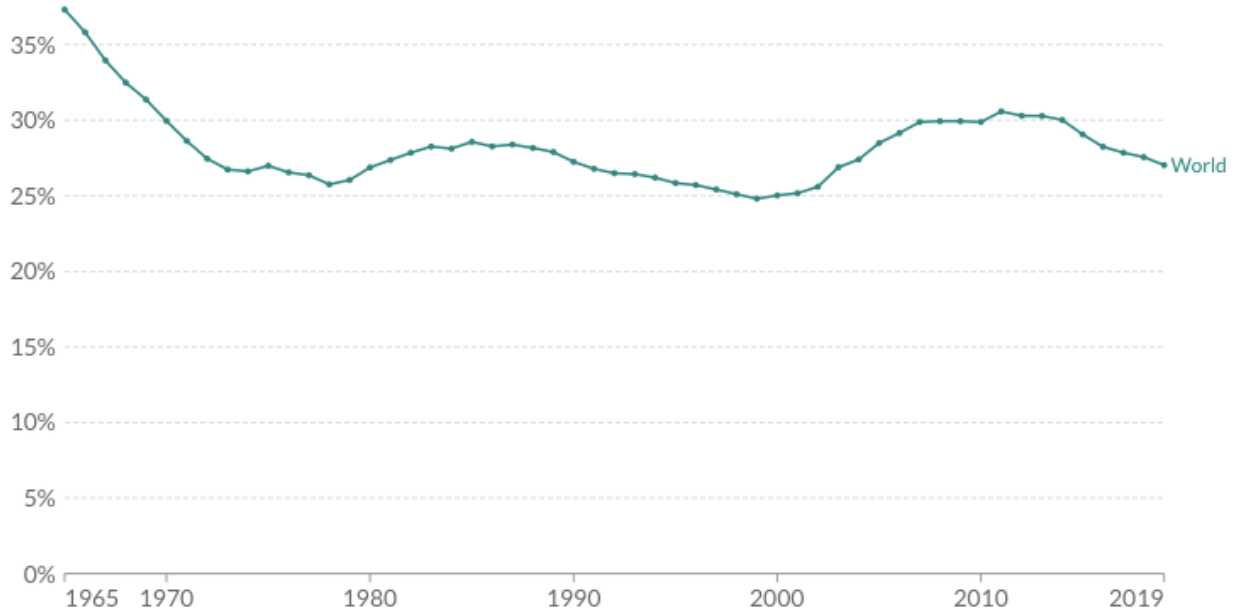
Figure 4 shows the share of primary energy from natural gas. In 1965 the share was approximately 15% and the share in 2019 was 24,23%. Compared to the oil the share of gas increasing. For last 55 years the increase was approximately by 55 percent. The reason that natural gas is considered one of the cleanest combustible products compared to other sources is that it emits much less carbon dioxide.

Natural Gas also has other advantages. Gas is easy to deliver and store, and gas-

fired power plants can turn on and off quickly, allowing natural gas to respond to seasonal fluctuations in demand. (IEA, 2022).

Coal is a solid fossil fuel. Considered as one of the oldest sources that have been used for centuries. Mainly used for heating and generating energy. It usually can be found in fossilized swamps. (Eia.gov, 2016).

Figure 5: Share of Primary energy from coal, World



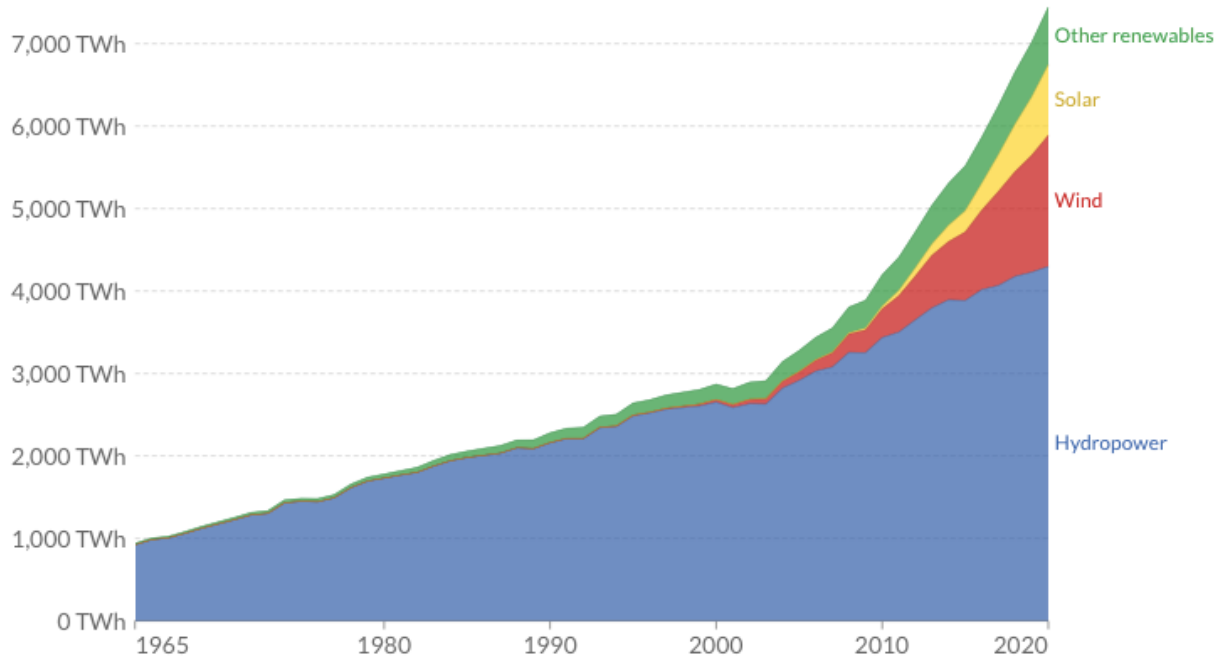
Source: Ritchie and Roser, 2020

Figure 5 demonstrates the share of energy from coal. According to the linear graph, we can see that the share of energy from coal is slowly decreasing. In 1965, the share was equal to 37.32% and in 2019 it is equal to 27.24%. The decrease was about 10%. This was facilitated by a policy that is against environmental pollution. Coal is considered as one of the major polluting energy sources. While burning coal, the source emits a large amount of carbon dioxide. (IEA, 2022).

3.4.4. Renewable energy

Renewable energy resources - are the sources that can be derived from replenishable sources. Solar energy, geothermal energy, wind energy, biomass, and hydropower are perhaps the most major renewable energy sources.

Figure 6: Renewable energy generation, world



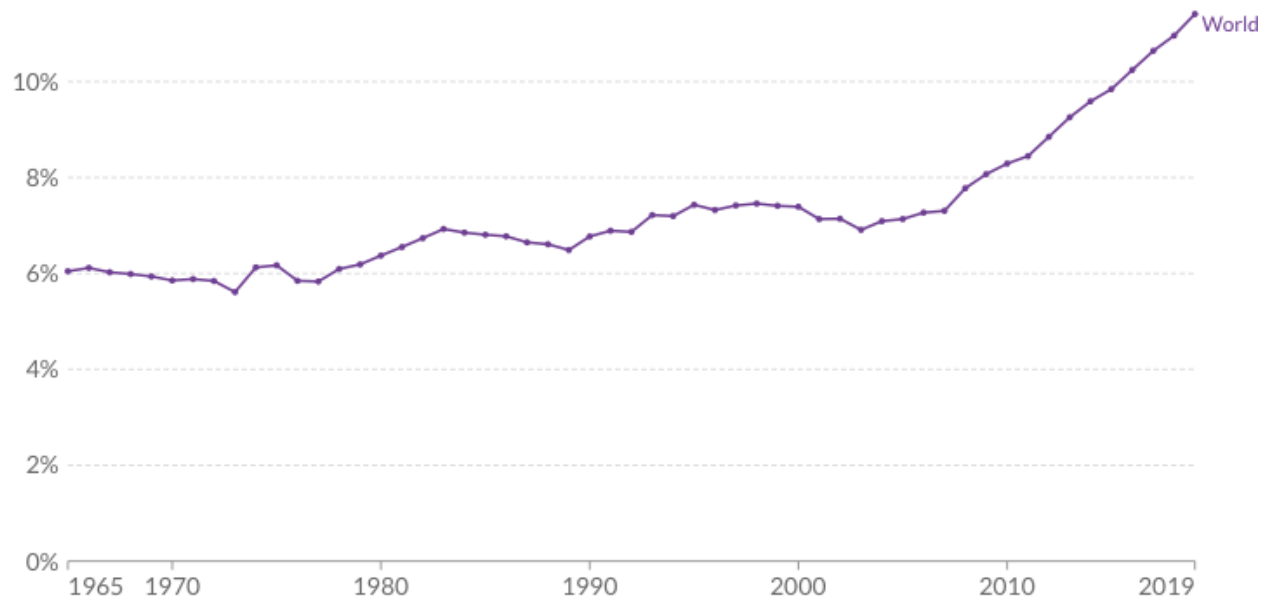
Source: Ritchie, H., 2021

This graph shows which renewable resources are used to produce energy around the world. From 1965 to the present day, the biggest contributor of renewable energy is the Hydropower. Hydropower is more widely used since it is an old technology and it is amenable to produce large amount of energy when there is sufficient availability of water. The other sources of energy are being used less since the technology is relatively new.

The second biggest contributor is the energy produced from wind at a wind farm, although it began its production only in the early 90s. In 2020, the wind farm produced 1,591 terawatt hours.

Every year, the consumption and production of energy produced from renewable sources is growing as non-renewable reserves are becoming less and less, as well as due to policies supporting the environment as the production of energy from non-renewable energy is highly damaging. (IEA, 2022).

Figure 7: Share of primary energy from renewable sources, World



Source: Ritchie, H., 2021

The line graph in Figure 4 mentions share of primary energy from renewable sources in the world. From the above data, we can see that from 1965 to 2019, the growth in the share of energy from renewable sources was insignificant and increased by only about 5.40%. But if you look closely, we can see that from 1965 to 2007, the share growth fluctuated all the time. And from 2007 to 2019, it has increased rapidly.

There are various factors that have led to the increased utilization of renewable energy sources. The factors were taken into account in Joel Jaegers work. According his research, the following factors were prevalent:

- a) A decrease in price.

The cost of solar photovoltaic power has dropped by 85%. Furthermore, the

wind energy prices have been reduced by around half. Positive feedback helped to the significant cost reduction. The lower the cost got as more renewable energy technologies were developed. In addition, broad and diverse supply chains play a role. (Jaeger, 2021)

b) The ability of self-reinforcement.

Thanks to political influence and funding for the introduction of technology, it has become popular and socially contagious. (Jaeger, 2021).

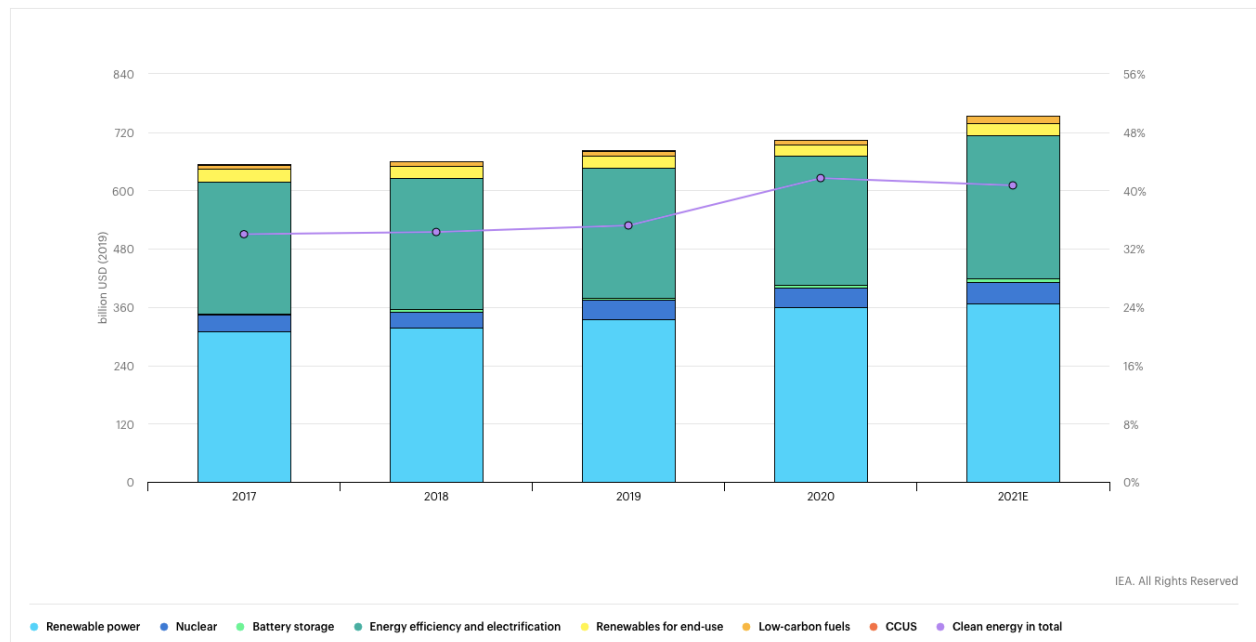
c) Policy aid was critical to the rise of renewable energy.

Renewable energy has received tax subsidies, as well as feed-in tariffs and competitive auctions. Furthermore, the government has invested in research and development, which has played a significant role in supporting innovation in the sector of renewable energy. (Jaeger, 2021)

The government encourages the use of renewable energy sources owing to their minimal environmental impact and to reduce the usage of non-renewable resources.

Financing is critical for any business wanting to grow. Along with terms of renewable energy. Financing of renewable energy has changed markedly.

Figure 8: Global investment in clean energy and energy efficiency



Sources: International energy Agency (IEA), 2021

Note: The estimate is as/ value of USD

Figure 5 shows global investments in clean energy and energy efficiency during the period , 2017 to 2021. From the data obtained, we can see that financing for clean energy is growing every year. In 2017, the total financing for clean energy amounted to 34% of the total investment in energy, and by 2021 it has already amounted to approximately 41%. Renewable energy and energy efficiency and electrification cemented their dominance from 2017 to 2021, garnering around 24 percent and 19 percent of global clean energy, respectively. Although the rate of growth in finance is slow, it should go up in the future so that the globe can meet the globally agreed-upon climate targets. (IRENA and CPI, 2020, p. 8)

4. Practical Part

The practical part of this thesis focuses on the study of use of nonrenewable and renewable energy, and its impact on economies of two developing countries.

The first part consists of the following steps:

1. Comparison of economies of two developing countries.
2. Demand and consumption of renewable and nonrenewable energy.
3. Increase in the share of renewable energy.
4. Assessment for a specific period of time.
5. Forecasting the growth (or decline) of renewable energy consumption.

The final part consists of comparative analysis. This analysis will be made with data from two countries. This analysis and the study of data in the theoretical sections, will help to identify the impact of renewable energy technologies in the economy of the two said countries and evaluate the optimality of using renewable energy.

4.1. Case Study 1: Federative Republic of Brazil

The Federal Republic of Brazil is one of the largest countries in the world by area with 8.5 million square kilometers. With an area of around 8.5 million square kilometers, it is the world's fifth biggest country. The country is located in Eastern South America. Borders with Argentina and Paraguay to the southwest, Bolivia and Peru to the west, Colombia to the northwest, French Guiana, Guyana, Suriname and Venezuela to the north, Uruguay to the south. The country has a population of around 215 million people, making it the sixth most populated country in the world. (Worldometer, 2021)

4.1.1. Economy of Brazil

According to World Bank the GDP of Brazil in 2019 was 1.878 trillion US dollars and in 2020 was 1.44 trillion US dollars. (The World Bank, 2010).

Brazil ranks twelfth among the highest-ranked countries in the world by nominal GDP. (World Population Review, 2021). Service sector contributes the most to the GDP in Brazil, about 63%. The second sector is Industry, with 17.7%. The third sector is Manufacturing, with about 9.8% and Agriculture sector contributes approximately 6%. (The World Bank, 2015).

Brazil's biggest industries include shoe, textiles and chemicals, cement, aviation, motor vehicles, and machinery manufacturing. (Globoledge.msu.edu, 2018)

The labor force in 2020 was 96,539,743 million and in 2019 was 104,376,954 million. Mainly Employment is in the area of service, with about 71%. In industry sector employment is approximately 19,60% and in agriculture sector about 9%. (World Bank, 2022). Unemployment rate from share of total labor force in Brazil in 2019 was 12% and in 2020 was about 14%. (Globoledge.msu.edu, 2018)

In 2019, around 9.12 percent of the population lived on less than \$3.20 USD per day. (Statista, 2017).

Brazil is also a major producer of a variety of minerals. Iron ore, tin, bauxite,

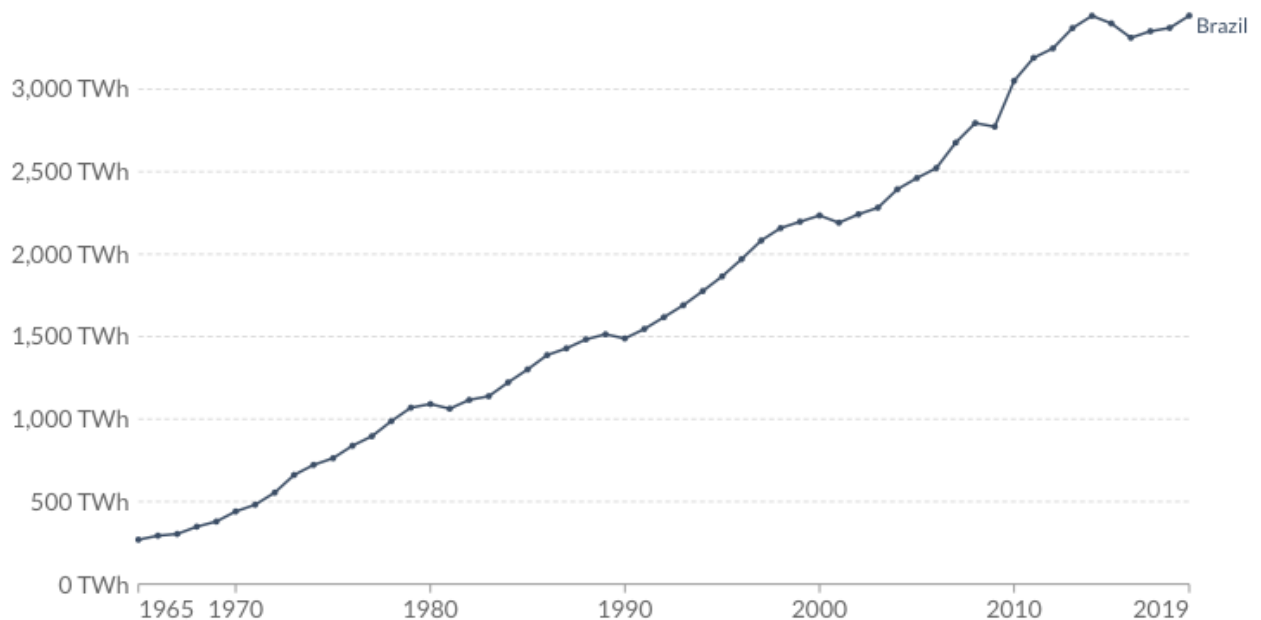
manganese, gold, quartz, diamonds, and other valuable stones are among them. Exports soybeans, iron ore, automobiles, raw sugar and crude petroleum.

Federative Republic of Brazil possesses some of the world's wealthiest renewable and nonrenewable resources, which is beneficial to the country's rising industry and population. (Burns, E. Bradford , Martins, . Luciano , Momsen, . Richard P. , Schneider, . Ronald Milton and James, . Preston E. , 2019)

4.1.2. Energy Sector in Brazil

Brazil's energy industry is regarded as the most promising industrial sector. Electricity is available to over 99 percent of the population.

Figure 9: Primary energy consumption, Brazil.



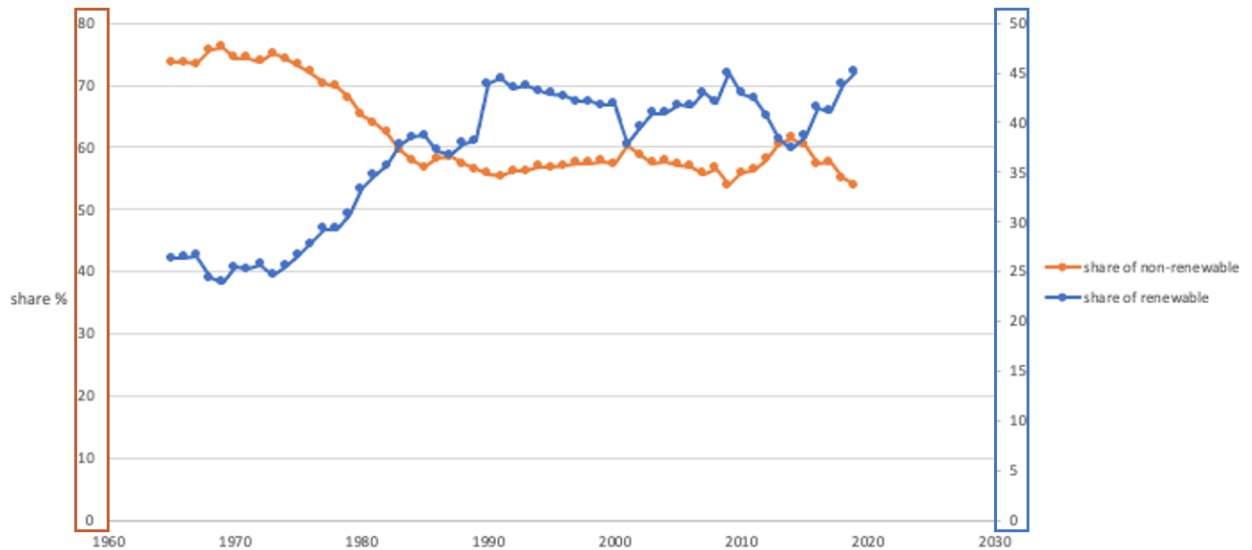
Source: Ritchie and Roser, 2020

Note: The estimate is measured in terawatt-hours (TWh)

The Figure 9 shows the total primary energy consumption from 1965 to 2019. From the data we can notice that consumption is growing rapidly. In 1965 the consumption of energy was around 269 terawatt-hours and in 2019 the consumption is equal to 3 445

terawatt-hours. The increase was around 1180 percent. Population increase contributed to the expansion, and the middle class's economic situation has improved as a result of consistent economic growth. As a result, the population began to use more energy. Furthermore, increased the need for transportation fuel. (International Energy Agency, n.d.)

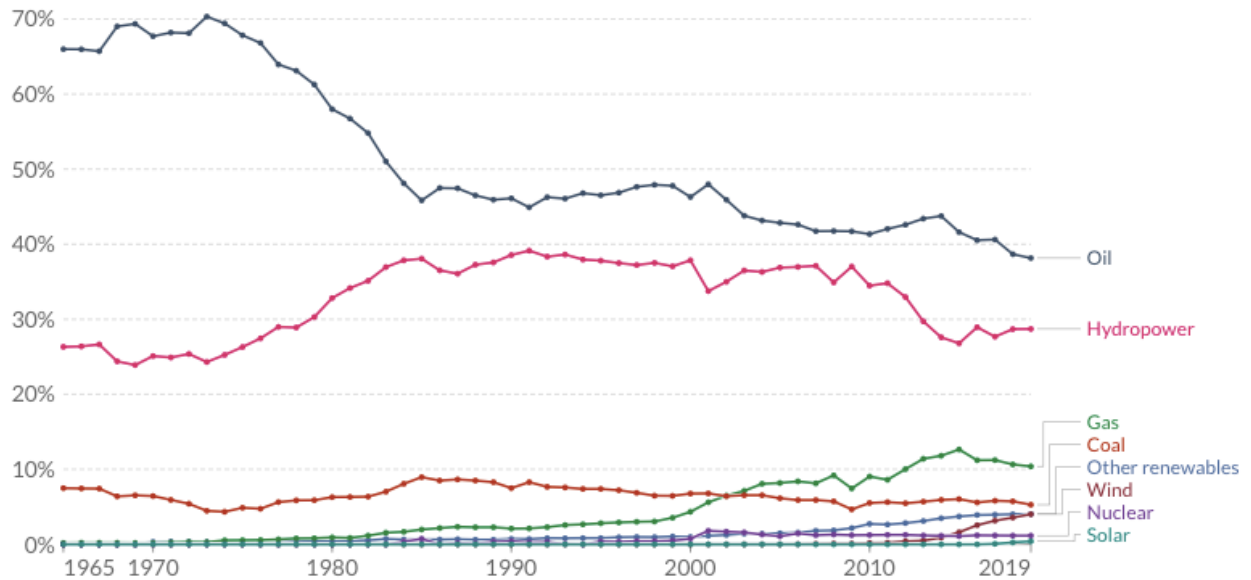
Figure 10: Share of primary energy from renewable and non-renewable, Brazil.



Source: Ritchie and Roser, 2020

From 1965 through 2019, the line graph above depicts the proportions of primary energy derived from renewable and nonrenewable sources in Brazil. The share of energy obtained from non-renewable sources is decreasing every year. For 2019, the share obtained from non-renewable sources is 53.82%. At the same time, the share of energy obtained from renewable sources is increasing every year. For 2019, the share is 45%.

Figure 11: Share of energy consumption by sources, Brazil.



Source: Ritchie and Roser, 2020

This line graph shows the share of energy consumption by source in Brazil. And according to the linear graph, it can be seen that oil is considered the main energy supplier. About 38% of the energy comes from oil. In Brazil, oil is mostly utilized as an energy source for automobiles. Transportation accounts for 33% of Brazil's total energy usage. (IEA, 2021).

The presence of enormous oil and natural gas resources offshore, particularly in the south-east of Brazil, has resulted in oil being regarded as the primary source of energy. (Burns, E. Bradford , Martins, . Luciano , Momsen, . Richard P. , Schneider, . Ronald Milton and James, . Preston E. , 2019). Oil reserves in Brazil are equal to 16,184,100,000 barrels, which allows Brazil to take the 15th place in the world in terms of oil reserves. According to the data Worldometers.info , the oil may be used 15 more years at current consumption level.(worldometers.info, 2022)

Hydropower is the second largest source of energy in Brazil. In 2019, about 29% of the energy comes from hydropower. Hydropower has long had a dominant position in the country's energy sector. In 1965, hydropower provided around 26% of total energy. Hydroelectric power plants generate over 80% of the country's

electricity. (IEA, 2021).

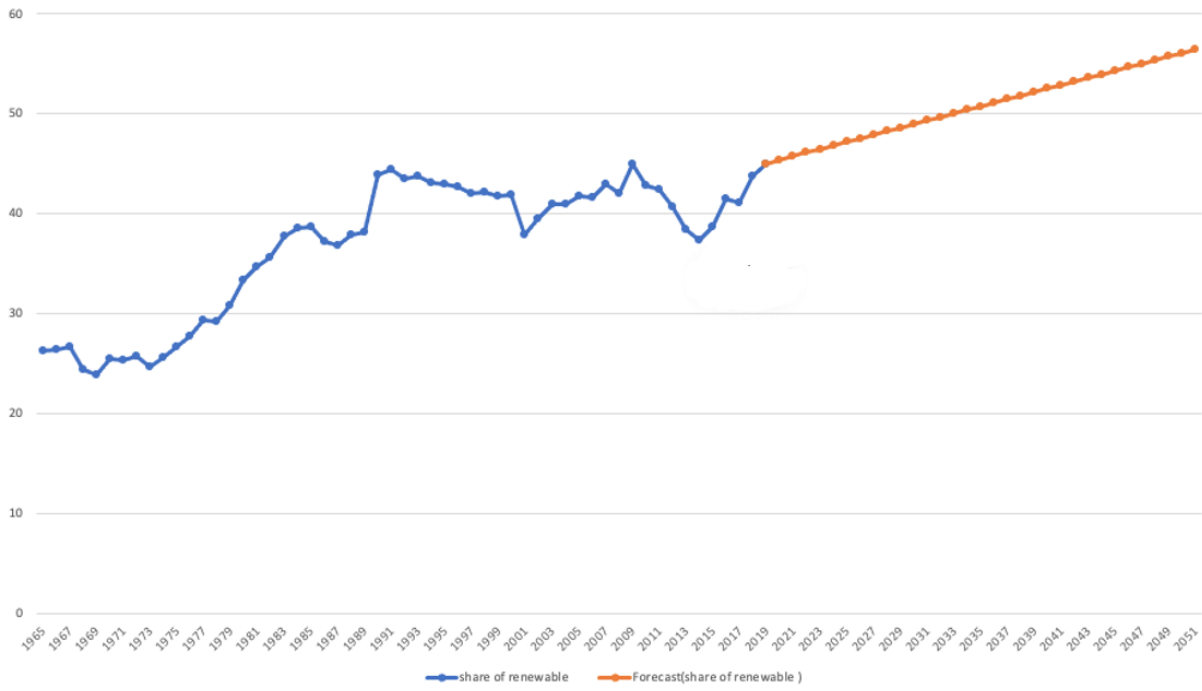
Other renewable energy sources, while having a minor role in Brazil's energy output, are increasing in use year after year. Brazil has started to use such resources as solar and wind in energy production operationally since the beginning of 2000. Brazil has rich wind resources. With 4600 miles of windy coastline. (U.S. Energy Information Administration, 2021).

In the future, the country plans to use more wind and solar in energy production.

4.1.3. Forecasting – Brazil

In this section of the practical part the Forecasting the growth (or decline) of renewable energy consumption will be provided.

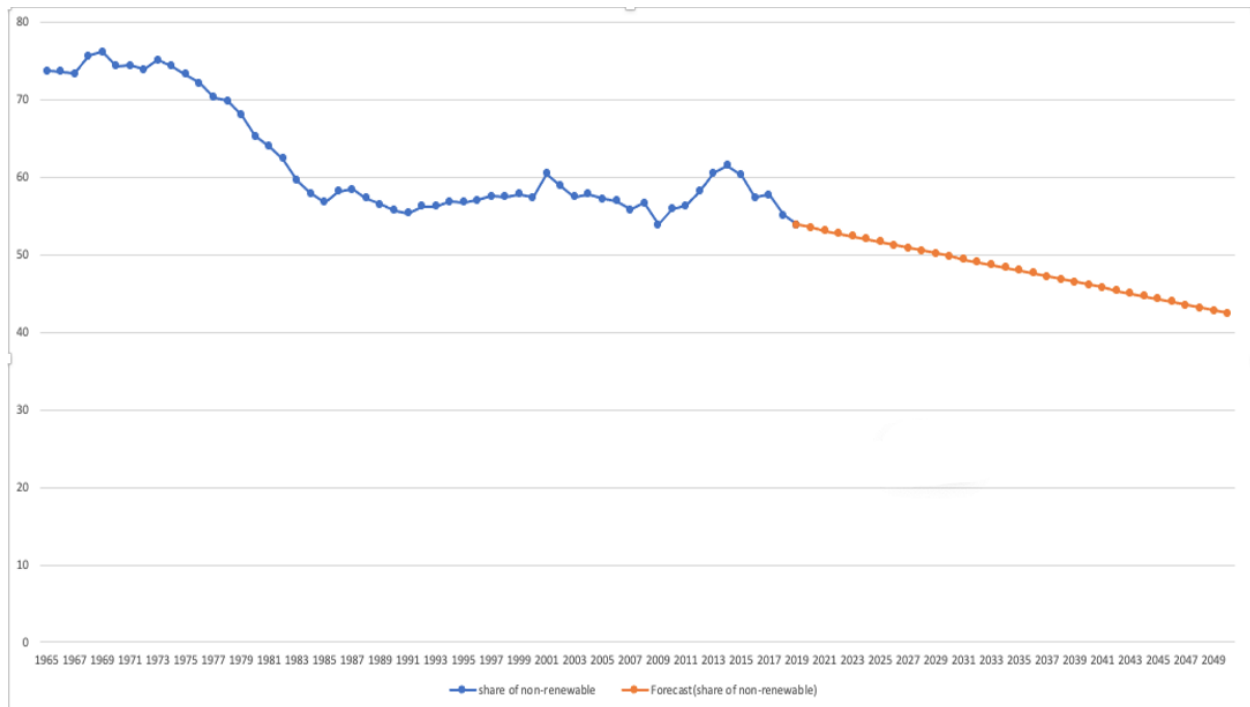
Figure 12: Forecast share of primary energy from renewable in Brazil, 2019-2051



Source: Own elaboration based on the data taken from Ritchie and Roser, 2020

From this graph we can note that in last 50 year starting 1965 to 2015 we see 10% of growth in renewable energy consumption, but 2015 onwards the same increase happen in just 35 years. We can see that the use of renewable sources is increasing at a much faster rate than ever.

Figure 13: Forecast share of primary energy from non-renewable in Brazil, 2019-2051



Source: Own elaboration based on the data taken from the Ritchie and Roser, 2020

According to the line graph above, the reduction in non-renewable energy has been roughly 20% during the last 54 years, and it will be about 10% in the next 30 years. The usage of nonrenewable fuels is declining, but earlier data shows that oil reserves in Brazil will last another 15 years and natural gas reserves will last 13 years. (Worldometers.info, n.d.)

Therefore, we can say that there may be changes in the use of non-renewable energy sources.

The table below shows the Energy supply evaluation in next 30 years in Brazil

Table 1: Domestic Energy Supply Evolution in 30-year Period, Brazil

Domestic Energy Supply Evolution in 30-year Period	2019 (%)	2029 (%)	2039 (%)	2049 (%)

Non-Renewable Energy	~54	~51	~47	~43
Renewable Energy	~46	~49	~53	~ 57
Total	100	100	100	100

Source: Author

4.2. Case Study: People’s Republic of China

The Republic of China is one of the most populous countries in the world. With a population of about more than 1.4 billion people, making it the first densely populated country in the world. China accounts for around 18.50 percent of the world's population. (Worldometer , 2021). The country is located East Asia and neighbors with Kazakhstan, Afghanistan, Tajikistan, Kyrgyzstan to the West, Mongolia to the north, with Russia and North Korea to the northeast, with Vietnam, Laos, Myanmar, India, Bhutan, and Nepal to the south; Pakistan to the southwest. China ranks third in area with 9,706,961 million sq. km. (Worldometer, 2019).

4.2.1. Economy of China

China comes into view as one of the major economy in the world that is rapidly growing. Despite the fact that China is classified as a developing country, the country's economy is fast developing. By nominal gross domestic product ranking by country, ranks second in in the world. (World Population Review, 2021). With 14.28 trillion US dollars GDP in 2019 and 14.723 trillion US dollars GDP in 2020. (The World Bank, 2021).

The main sectors that make the largest contribution to China's GDP are considered to be Service, agriculture, industry and manufacturing. Service sectors contributes about 55% of GDP. The next most contributor to GDP is Industry, with about 38%. The least contributors are manufacturing and agriculture, with share of 26% and 7.6%. . (Globaledge.msu.edu,2018)

The World Bank estimates that the unemployment rate in 2019 is about 5%. In addition, the labour force in 2019 was over 8 million individuals, and it is likely to be approximately the same in 2020.

Mining and ore processing, mechanical engineering, weapons, textiles and apparel, oil, cement, and chemicals are the major industries. (Globaledge.msu.edu,2018).

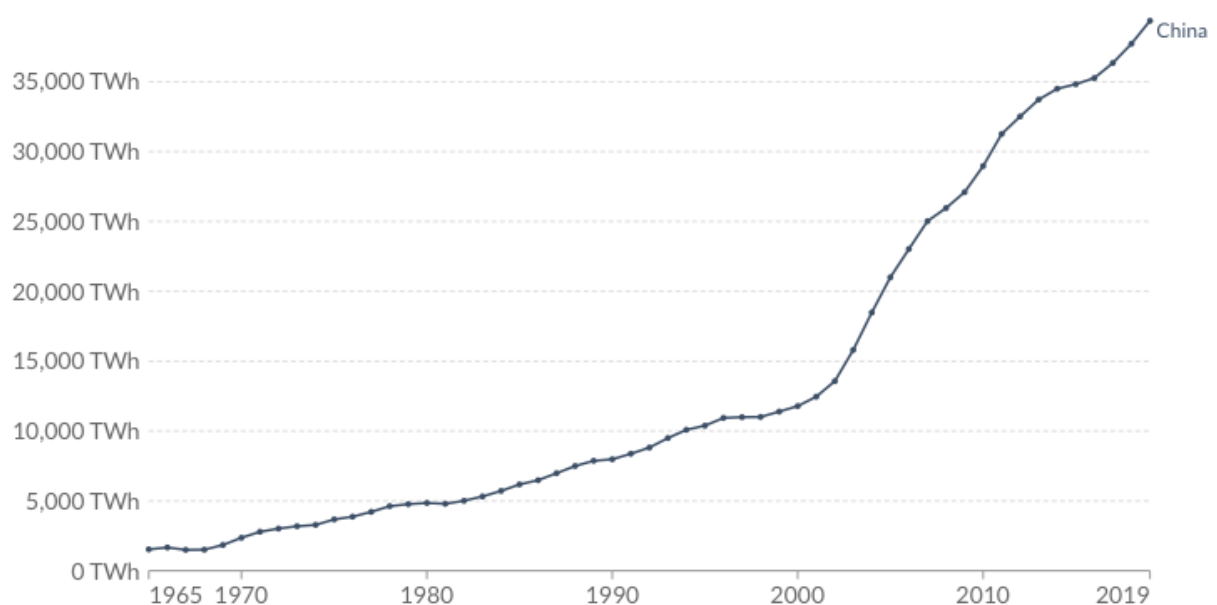
Furthermore, the country's economy has grown as a result of substantial exports. Broadcasting equipment, machinery, and integrated circuits are examples of exported items. World leaders such as the United States, Hong Kong, Japan, Germany, and South Korea are commercial partners or export customers.

From the country's resources, Coal, gas, ores, and timber are all harvested in great numbers.

4.2.2. Energy Sector in China

China is considered fastest growing country in technology way and in population way. Therefore the energy sector has significant role. Around 100% of population has access to electricity.

Figure 14: China Energy Consumption



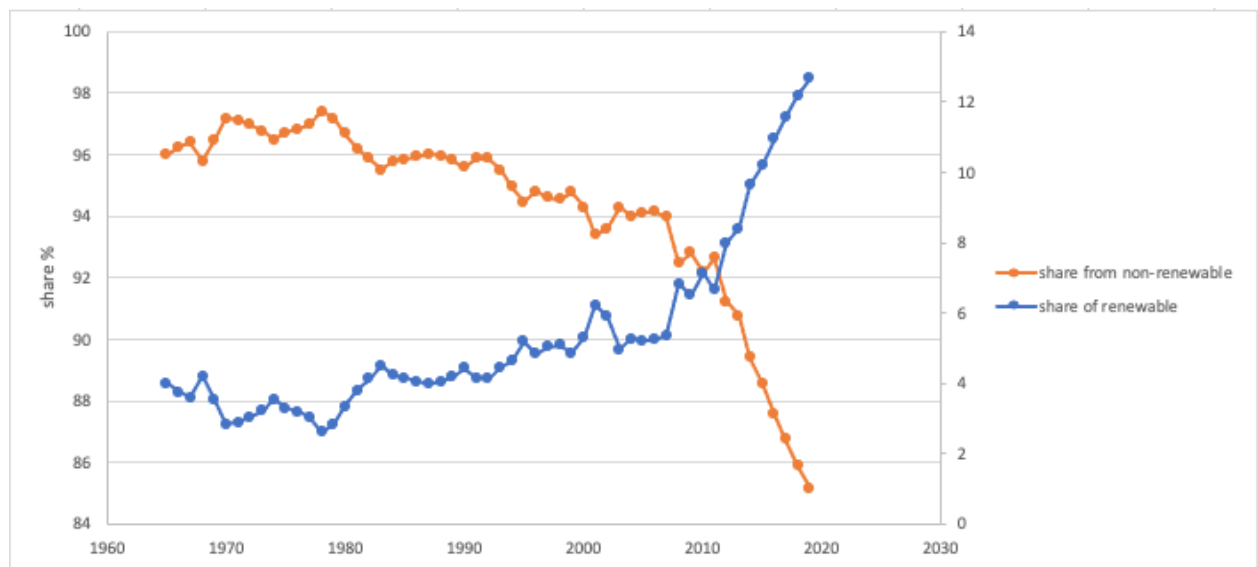
Source: Ritchie and Roser, 2020

Note: The estimate is measured in terawatt-hours (TWh)

The graph above shows the total energy China consumption from 1965 to 2019. According to the data on the graph, we can see that consumption growth is significant and has grown by about 2469% since 1965. The factors that lead to increase in energy consumption all around the world also led to the consumption increase in China. During this time period, the world population increased by 100%. In China, the population increased also by 100%. This should have contributed to the increase in the energy consumption.

There are several additional elements that influence energy use. The industrial sector of the country consumes the majority of the country's energy. Approximately 60%. Residential consumption is followed by transportation consumption, which accounts for 13% and 9% of total energy use, respectively. (China Power Team, 2016).

Figure 10: Share of primary energy from renewable and non-renewable, China.

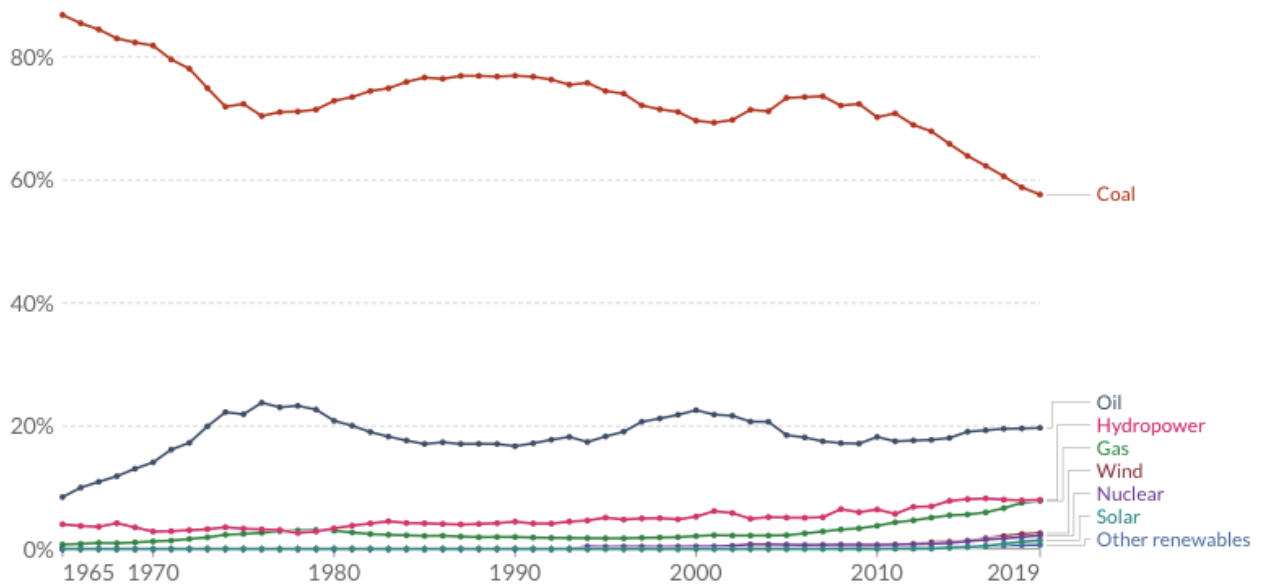


Source: Ritchie and Roser, 2020

The figure 10 shows the share of energy from renewable and non-renewable in China from 1965 to 2019. From the statistics we can observe that China's energy

share from non- renewable gradually decreasing and the share from renewable is deliberately increasing. The decrease between 54 years in the share of non-renewable energy sources is 10%. The increase 54 years in the share of renewable energy sources is about 9%.

Figure 15: Share of energy consumption by sources, China.



Source: Ritchie and Roser, 2020

The figure above demonstrates the share of energy consumption by sources in China. The major energy supplier in China is Coal. In 1965 about 86% share of energy was coming from coal. Later, the share of coal decreased and in 2019 the share is about 58%. The decline was due to the fact that the country has found alternative resources for energy production and coal emits the most carbon dioxide from all non-renewable energy sources. Coal has long been used as a fuel for burning and generating energy in China. Because the country is rich in coal and is seen as a low-cost supply.). Coal reserves in China are equal to 149,818,259,000 tons, which allows China to take the 4th place in the world in terms of coal reserves. According to the data Worldometers.info , the coal may be used 35 more years at current consumption level.(worldometers.info, 2022)

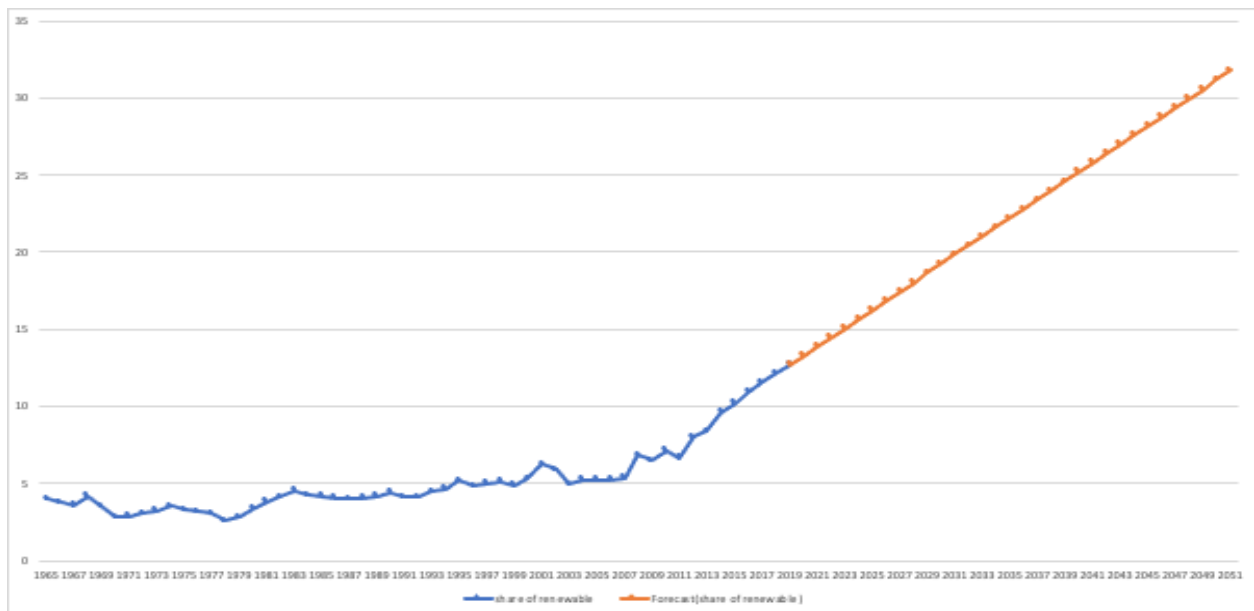
The second energy supplier is oil. With about 20% of share in 2019. Mainly oil in China is used as transportation energy. In China, oil is primarily utilized as a source of transportation energy. In addition to gasoline and jet fuel. According to the data Worldometers.info , the oil may be used in China about 5 more years at current consumption level.(worldometers.info, 2022)

Energy is also collected from renewable energy sources in China. The majority of renewable energy is derived from hydropower. It accounts for around 8% of overall energy output. Wind and solar energy generation accounts for roughly 3% and 2% of total energy output, respectively.

4.2.3. Forecasting – China

In this section of the practical part the Forecasting the growth (or decline) of renewable energy consumption will be provided.

Figure 16: Forecast share of primary energy from renewable in China , 2019-2051

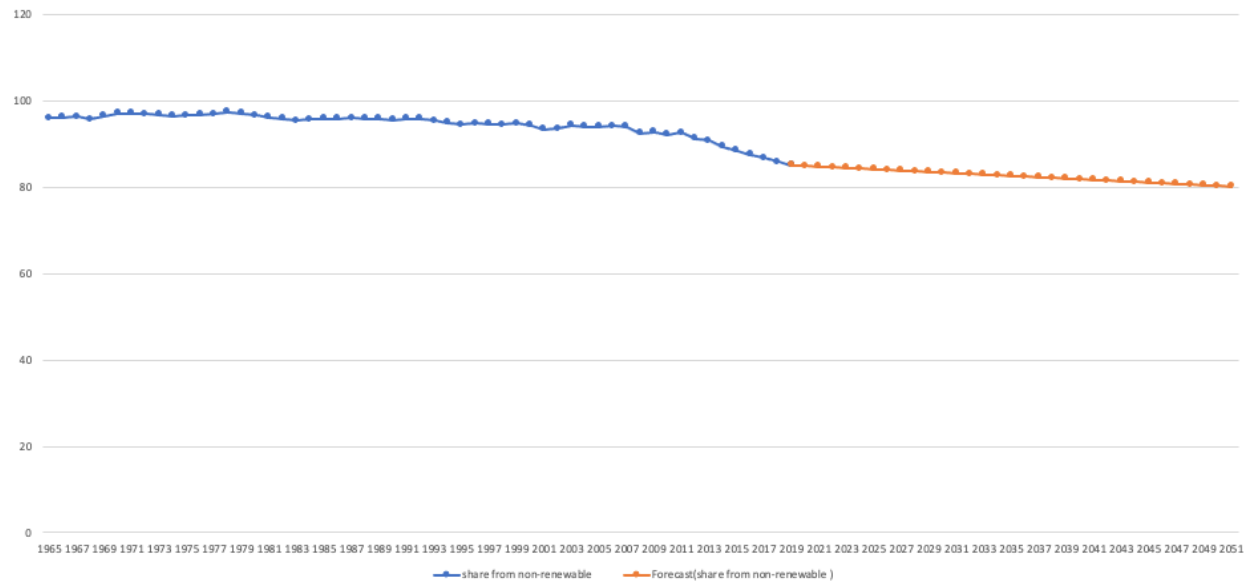


Source : Source: Own elaboration based on the data taken from the Ritchie and Roser, 2020

In above Figure the forecast share of primary energy from renewable in China is

provide. The data shows that last 46 years, starting 1965 to 2011 there as only 3% of growth in renewable energy consumption. In 2011 the share of renewable was around 6% and by 2050 it is predicted to be 30%, hence there will be an increase by 24% . In 39 years increase will be much bigger than before.

Figure 17: Forecast share of primary energy from non-renewable in China, 2019-2051



Source: Own elaboration based on the data taken from the Ritchie and Roser, 2020

The graph above shows the projected share of primary energy from non-renewable sources in China. From the graph we can note that from 1965 to 2010 there was no big change. But starting from 2011 by 2050 there are going to be decrease in use of non -renewable energy. Decrease will be by 15% approximately. However there also can be changes, due to the oil and coal reserves. According to the data Worldometers.info , the oil may be used in China about 5 more years at current consumption level and coal about 35 more years. .(worldometers.info, 2022)

The table below shows the Energy supply evaluation in next 30 years in China

Table 2: Domestic Energy Supply Evolution in 30-year Period, China

Domestic Energy Supply Evolution in 30-year Period	2019 (%)	2029 (%)	2039 (%)	2049 (%)
Non-Renewable Energy	~86.5	~82	~76	~70
Renewable Energy	~13.5	~18	~24	~30
Total	100	100	100	100

Source: Author

4.3. Comparative analysis

Table 3: Existing Data

Factors	Brazil	China
Population	215 million people	1.4 billion people
Area	8.5 million square kilometers.	9.7 million square kilometers.
GDP	1.878 trillion US dollars (2019)	14.28 trillion US dollars (2019)
Energy consumption (2019)	3,445 TWh	39,361 TWh
Share of energy from renewable sources	45,02%	12,66%
Share of energy from non-renewable sources	53,82%	85,14%

Source: Author

Table 4: Analytical data

Factors	Brazil	China
Increase in percentage of renewable sources in next 10 years (2029)	3%	5.5%
Increase in percentage of renewable sources in next 20 years (2039)	4%	6%
Increase in percentage of renewable sources in next 30 years (2039)	4-5%	6-7%
Decrease in percentage of non - renewable sources in next 10 years	3%	4.5%
Decrease in percentage of non - renewable sources in next 20 years	4%	6%
Decrease in percentage of non - renewable sources in next 30 years	4-5%	6-7%
Oil reserves	The oil can be used for 10-15 more years	The oil can be used for 4-5 more years
Coal reserves	The coal can be used for 200-260 more years	The coal can be used for 30-35 more years

Natural gas reserves	The natural gas can be used for 10-13 more years	The natural gas can be used for 20-22 more years
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Source: Author

From the comparative analysis, we can conclude that energy demand is increasing by the year. And countries are trying to meet the demand rate of energy as they can. China is not doing good job as Brazil. Despite the fact that Brazil is smaller than China, the share of renewable energy is growing rapidly and it predicted that by 2050 country will have around 58% of share by renewable.

Brazil suffers from less pollution than China. The environment in China is polluted due to the high amount of carbon dioxide emitted during energy production.

5. Conclusion

From the above analysis and data, we can conclude that :

- 1.The demand for energy is on an all time high.
- 2.Almost all growing economies are hugely dependent on it.
- 3.The supply of non renewable sources are limited and decreasing over time.
- 4.There is an intrinsic need for an alternative, which is sustainable.
- 5.Renewable sources of energy, that have been always known to mankind, is taking an about turn, and coming back in the picture.
- 6.Besides being more environmentally friendly, there is a positive economic impact of it.
- 7.The infrastructure is the main challenge to overcome, after which it is going to be an easy path.
- 8.It is estimated that the use of renewable sources will increase twice its consumption in the next 50 years.
- 9.Some great economies have already taken this path and it is imperative that the rest of the world follows.

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