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FACULTY OF ELECTRICAL ENGINEERING

DEPARTMENT OF POWER ENGINEERING

DIPLOMA THESIS

Increasing energy efficiency in the Czech Republic power sector

Keyur Patel **2021**

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ZADÁNÍ DIPLOMOVÉ PRÁCE
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Zásady pro vypracování

1. Examine the national and European legislature and relevant documents in the area of increasing energy efficiency through targeted end-use energy savings.
2. Describe various policies of EU?s Member States with achieving end-use energy savings and raise of energy efficiency.
3. On analysed policies, observe and describe the role of relevant subjects (distributional and transmission companies, retailers, customers, governmental bodies, regulators etc.) included in the national energy efficiency schemes.
4. Evaluate the national policies and introduce the probable scenario of reaching end-use energy savings and raising energy efficiency until the 2030 based on the forthcoming European legislature.
5. Design the specific arrangements for the energy efficiency improvements for the Czech Republic and try to assess the financial complexity of designed arrangements.

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Rozsah grafických prací: **podle doporučení vedoucího**
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Seznam doporučené literatury:

1. The National Energy Efficiency Action Plan of the Czech Republic
2. The National Energy and Climate Plan of the Czech Republic
3. Project ENSPOL – Energy Savings Policies & Energy Efficiency Obligation Scheme, Final Report
4. Project ENSMOV – Enhancing the Implementation and Monitoring and Verification practices of Energy Saving Policies under Article 7 of the Energy Efficiency Directive

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Abstract

The master's thesis is focused on increasing the energy efficiency in the Czech Republic's power sector. The master's thesis is divided into four chapters. The first chapter is focused on the detailed description of energy efficiency, why do we need to the concept of energy efficiency, and its origin. The second chapter is based on the situation regarding energy efficiency in the Czech Republic. The third chapter is concerned with the international comparison of energy consumption trends and policy measures. The last chapter presents the result with the different new policy measures and some new technologies which can implement in the Czech Republic.

Key words

Energy efficiency, primary energy consumption, final energy consumption, policy measures, energy efficiency targets.

Declaration

I declare that I have prepared this diploma thesis independently, using the professional literature and sources listed in the list that is part of this diploma thesis.

I further declare that all software used in solving this diploma thesis is legal.

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signature

In Pilsen on May 27, 2021 Keyur Patel

Thanks

I would like to thank the thesis supervisor Ing. Vladimír Vajnar, Ph.D. for valuable professional advice, comments, and methodological guidance.

Content

List of symbols and abbreviations

LED..... Light Emitting Diode

CO_2..... Carbon Dioxide

CHP..... Combined heat and power

IEA..... International Energy agenecy

US..... United States

EU..... European Union

PJ..... Petajoule

TJ..... Terajoule

MJ..... Megajoule

GDP..... Gross Domestic Product

CZK..... Czech Koruna

Mtoe..... Million Tonnes of Oil Equivalent

VAT..... Value-Added Tex

EUR..... Euro

DLT..... Distributed Ledger Technology

Introduction

In today's world, energy is one of the vital elements in all of the economies over the world. The amounts of energy sources are very limited and the price of crude oil is constantly rising which forces the world to think about new and alternative energy sources. We all know that these alternative sources are solar, wind, hydro, and biogas. Solar energy is the most effective among all of these sources, but the cost of it is very high and also in some regions the sunlight is very limited which turns our vision towards another energy source. But the situation is the same with other sources as well. So we need such a kind of source which is accessible all over the world, which is "Energy Efficiency". Yes, energy efficiency is one kind of energy source if we deeply think about it. Energy efficiency is limiting the waste of energy or the most cost-effective way to reduce energy waste. So to limit the waste of energy can be considered as a one kind energy source and which is one of the best ways to manage and restrict the growth of energy consumption. If we can manage the use of energy consumption then it will be very good for our natural resources as they constantly get decrease. Energy efficiency is mainly focused on energy savings but it also comes with some other benefits as well like environmental improvements, energy security, increased energy security, economic competitiveness increment, and job creation.

From the start of the 20th century, the term energy efficiency draws attention all over the world and countries were working on its improvement for many years. The concept of energy efficiency is driven by the factors such as climate change, the limited nature of fossil fuels, and increasing energy demand. In attaining energy efficiency, options or methods such as appliance labeling, energy-efficient lighting, buildings, transport, industries, energy audits, market-based instruments, education and awareness, voluntary instruments among others may be used. Though energy efficiency is an important tool in addressing issues such as climate change, the finite nature of fossil fuel, secure energy supply, and increase energy demand, and its penetration into society remains somewhat slow. The energy within the Czech Republic is a vital tool for development and the Czech Republic is mostly relies on fossil fuels for its primary energy supply. To reduce the reliance on fossil fuels, the Czech Republic has to adopt energy efficiency measures at both regional and national levels. Beyond its use in daily life, fuel and electricity catalyze infrastructure projects that drive both regional integration and economic growth in the

Czech Republic. But still, improvement is necessary to achieve the full potential of the work. So the objective of this thesis work is to get to know about the current situation regarding energy efficiency in the Czech Republic through an analysis of the current trends in energy consumption and analysis of the current policy measures implemented in the Czech Republic. After this evolution, attention will be paid to the international comparison, which includes comparing the energy consumption trends and energy efficiency policy measures. And at the end, the methods or arrangement by which energy efficiency can increase will be present with some proposed new policy measures and technologies.

1 Energy Efficiency

1.1 What is Energy Efficiency?

Energy efficiency is that the portion of total energy input to a machine or system that's consumed in useful work and not wasted as useless heat or in another form. It quantifies how much energy is utilized by any framework or hardware to supply the required level of execution. In straightforward meaning, by utilizing the less energy for performing the same assignment - that's energy proficiency. For case, modern LED bulbs utilize 70-80 % less energy than ordinary old bulbs but give us the same level of light that old bulbs provide. Energy proficiency brings an assortment of advantages like diminishing greenhouse emission outflows, lessening the demand for energy imports, and bringing down our costs on a family's energy bills. Whereas renewable energy technologies also offer assistance to achieve these targets but improving energy efficiency is the cheapest and frequently the foremost prompt way to diminish the utilization of fossil fuels. There are enormous openings for effective advancements in each segment of the economy, whether it is buildings, transportation, industry, or the energy era. [2]

We can define Energy efficiency as the utilization of energy most cost-effectively to do manufacturing process or providing a service, thus energy waste is minimized, and uses of primary energy sources can be reduced. For the study and considering the common features of the diverse definitions, “energy efficiency” may be defined as (a) an improvement in energy equipment, technology, practices, products, and services (such as lighting, cooling, heating, manufacturing, cooking, and transport) or (b) a change in behavior of energy usage or (c) the presentation of energy management frameworks to diminish the sum of energy utilize. The general equation for energy efficiency is

$$\text{Energy Efficiency} = \frac{\text{Energy Output}}{\text{Energy Input}} * 100$$

The impacts of energy use affect all folks and consequently, we should always worry about the way to how to use energy more efficiently. In any case, the most bodies dependable for characterizing national approaches to energy effectiveness are regularly government organizations, whose obligations will more often than not to enacting

legislation relating to energy efficiency, deciding the budget for promoting and conducting energy efficiency activities and programs, promoting energy awareness, and disseminating useful information on energy efficiency measures, allocating the budget and carrying out energy efficiency programs concerning government-owned assets. There are many benefits of increased energy efficiency which are categorized into different groups like financial/economic, environmental, and social benefits. The relative importance of each of those benefits depends on the particular situation during a given country or area, including for instance the costs of various sorts of energy, the cost of energy efficiency measures and equipment, the tax regime, and therefore the current levels of energy efficiency already being achieved. [3]

Today, energy efficiency has been considered a source of energy around the world because it can fulfill the energy demand. The researchers pointed out that energy efficiency is a "hidden fuel". Energy efficiency is the cheapest source of energy because there is no need to produce energy in the first place. The only source of energy which is very effective and with no cost of generation and all the countries of the world can access is energy efficiency.

1.2 Why do we need to be energy efficient?

The world is witnessed the exponential growth of energy consumption in the last few decades and suffering from the problems like pollution and climate change. Due to these circumstances, our planet's three main natural resources air, water, and land are in danger. These all things happen because our energy requirement is more and we have to produce more to satisfy it. Also, a large part of our energy is still coming from coal and nuclear power plants which are expensive to run, wasteful, and polluting. So, to decrease energy production we need to decrease our energy consumption, which the energy efficiency concept can do wisely.

Energy efficiency is a method of managing and limiting the growth of energy consumption and making sure that, there is energy left for future generations. By putting some standards in place to ensure judicious use of energy products, we can save energy costs and reduce the impact on the environment. In recent times, public thoughts about using energy-efficient products are a bit hesitative. Because the technology which is going

to use in energy-efficient products does come with higher initial investment and that is enough to turn off some consumers at first. But it is important to remember that energy-efficient products do come with big savings in the future. In long term, we will not just end up saving energy costs but we will see a significant return on our investment over time.

Furthermore, improving energy efficiency is a key strategy to combat climate change. The International Energy Agency (IEA), which played a role in the landmark Paris Agreement, has researched the huge impact of energy efficiency on the global energy transition. "Energy efficiency is one of the main sources of energy that all countries have. I welcome improvements in global energy efficiency, especially when energy prices are low. This shows that many governments have implemented energy efficiency policies and are effective", said the executive director of the International Energy Agency (IEA), Dr. Fatih Birol. Research shows that by 2020, achieving energy efficiency in everything from house insulation to vehicle fuel use can help reduce carbon emissions by more than 10 %. That is why being energy efficient is very much important for the entire world in recent times. [4]

1.3 Units for measuring energy

A variety of units have been proposed and used historically, but none has gained absolute universal acceptance. The most established and simple unit for energy is, the joule (J), which is useful for measuring the conversion of energy from one form to another. Alternative units have been developed to make comparison simpler, to measure the quality of energy in addition to quantity, and to allow integration with economic measures. Some units which are important in the energy efficiency topic are shown in Table 1.

Measure	**Units**
Energy	J, BTU , kcal
Fuel energy	toe, boe, tce
Electricity	kWh
Energy intensity	J/£
Power	W, hp

Table 1 Units for measuring energy

These are some basic units to measure energy. Energy is often measured in joules (J) but alternative energy units include British Thermal Unit (BTU) which is equal to 1055 J and kilogram calorie (kcal) which is equal to 4,184 J used. Energy statistics for fuels are normally quoted in units such as a ton of oil equivalent (toe), a barrel of oil equivalent (boe), or a ton of coal equivalent (tce). A commonly used unit for measuring electricity is a kilowatt-hour (kWh), kilowatt-hour = 3.6×10^6 joules (J). Energy intensity is broadly referred to as the energy consumed per unit of activity, for example, energy consumption per unit of economic output. Unit for energy intensity is joules per US dollar (J/£). The official unit of measurement for power is the watt (W) and also horsepower (hp) which is 1 horsepower = 735.5 watts (W) used.

1.4 Origin of the requirement for energy efficiency

It is very necessary to figure out the origin of the requirement for energy efficiency as its influence in the development and introduction of new legal measures for energy efficiency is very huge. For getting to know about the origin of the requirement for energy efficiency, it is necessary to find out the main factors responsible for the need for energy efficiency. These factors include climate change, the finite nature of fossil fuels, and the increment in energy demand.

1.4.1 Climate change

The use of fossil fuels is regarded to be one of the primary contributors to climate change. The United Nation's Intergovernmental Panel on Climate Change made it clear that climate change is ongoing and human activities, especially the use of fossil fuel, is a primary cause. In 2012, the International Energy Agency (IEA) also stated that the direct combustion of fossil fuels represents by far the largest source of energy-related CO_2 emissions comprising more than 80 % of anthropogenic emissions. The burning of coal, oil, and natural gas in developed countries and rapidly developing countries account for the majority of human-caused emissions of carbon dioxide, the main greenhouse gas. [5]

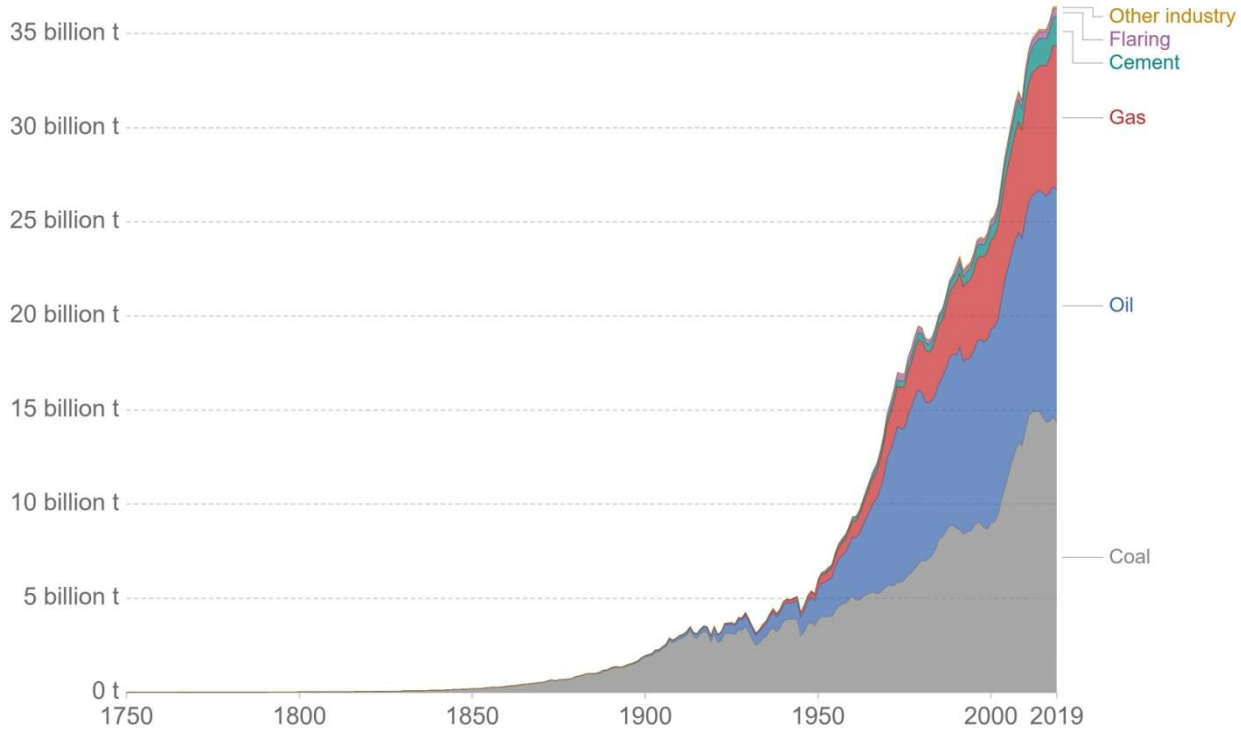

Figure no 1.1 CO_2 emissions by fuel type [7]

Burning fossil fuels emits carbon dioxide (CO_2). Fossil fuels are the largest source of global carbon dioxide (CO_2) emissions. Figure 1.1 shows the amount of carbon dioxide emitted by different fuel sources each year. As we consume more energy every year, fossil fuel emissions continue to increase. Climate change is driven by our carbon dioxide emissions plus other greenhouse gas emissions such as methane and nitrous oxide. Energy accounts for roughly three-quarters of total greenhouse gas emissions, with the remaining quarter coming from agriculture and land-use changes. To reduce global emissions, we must shift the energy system from fossil fuels to low-carbon energy. [7]

Approximately 70 % of greenhouse gas emissions are related to energy, and energy efficiency is considered one of the tools that help achieve global emission reduction targets. The International Energy Agency (IEA) noted in its 2010 report that energy efficiency is cost-effective and can achieve the greatest potential for carbon dioxide reduction by 2050. By improving energy efficiency, steps can be taken to reduce emissions of carbon dioxide by 57 % each year in all industries (such as energy, cement, steel, and mining), construction, households, and transportation fields worldwide. It is considered the best short-term measure to reduce greenhouse gas emissions. [5]

1.4.2 Finite nature of fossil fuels

The limited nature of fossil fuels is another important driving force for improving energy efficiency. Today, fossil fuels, including coal, oil, and natural gas, are the main sources of energy in the world. In the history of millions of years, fossil fuels are formed from organic materials and have promoted the development of the global economy in the last century. However, fossil fuels are limited resources, and their burning for getting energy can also cause irreparable damage to the environment. It can be estimated from Figure 1.2 that our remaining fossil fuel reserves are not large, which is a matter of great concern to the world. According to the US Energy Information Administration in 2016, the burning of fossil fuels accounted for 76 % of US greenhouse gas emissions. [6]

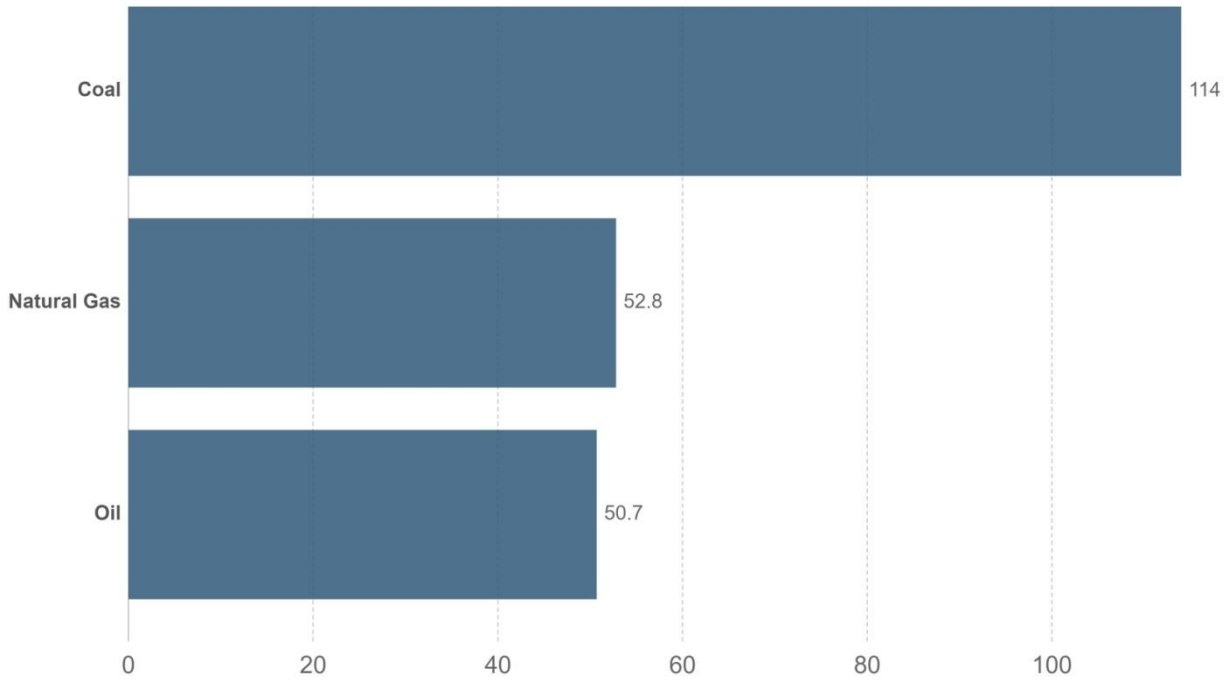

Figure no 1.2 Years of fossil fuel reserves left [8]

These gases have caused the greenhouse effect and may cause catastrophic events that may cause changes in the earth's climate. Technologies such as carbon capture and storage (CCS) can help reduce greenhouse gas emissions from fossil fuels, and nuclear power can become a carbon-free alternative to power generation. However, there are other more sustainable and less risky solutions: energy efficiency and renewable energy. Despite the

high degree of dependence on fossil fuels in the world today, there are still several options to start the necessary transition from the harmful fossil fuel economy. Improving the energy efficiency of buildings, vehicles, industrial processes, appliances, and equipment is the most direct and economical way to reduce energy use. Planning the community so that people can use public transportation safely and conveniently, walking or biking instead of using private cars, can also reduce energy requirements. [6]

1.4.3 Increased demand for the energy

Today, citizens of various economies are improving their living standards, thereby increasing their energy consumption. This could include houses and offices heated with fossil fuels, cars powered by petroleum or diesel, and reliable electricity revenue. For example, developing countries provide these services to more than 2.4 billion customers. It is estimated that by 2030, energy demand will increase to more than 50 %, which may harm energy security, resource depletion, and environmental damage, especially climate change.[5]

Therefore, the total global demand for primary energy increased by 2.3 % in 2018, the largest increase since 2010. The People's Republic of China, the United States, and India together accounted for 70 % of energy demand growth, up from 43 % in 2017. A total of 25 % of the global demand growth occurred in the United States, which is a big deviation from recent trends. The primary energy demand in the United States increased by more than 3.5 %, the highest growth in decades after three consecutive years of decline in demand, while the main demand in China and India increased by 3.5 % and 4 % respectively, slightly higher than 2017 levels. Fossil fuels accounted for 70 % of the increase in primary energy demand, of which natural gas accounted for 46 %, oil accounted for 15 %, and coal accounted for 9 %. Renewable energy accounted for more than 24 % of primary energy demand growth, while nuclear energy demand accounted for 7 % of primary energy demand. [9]

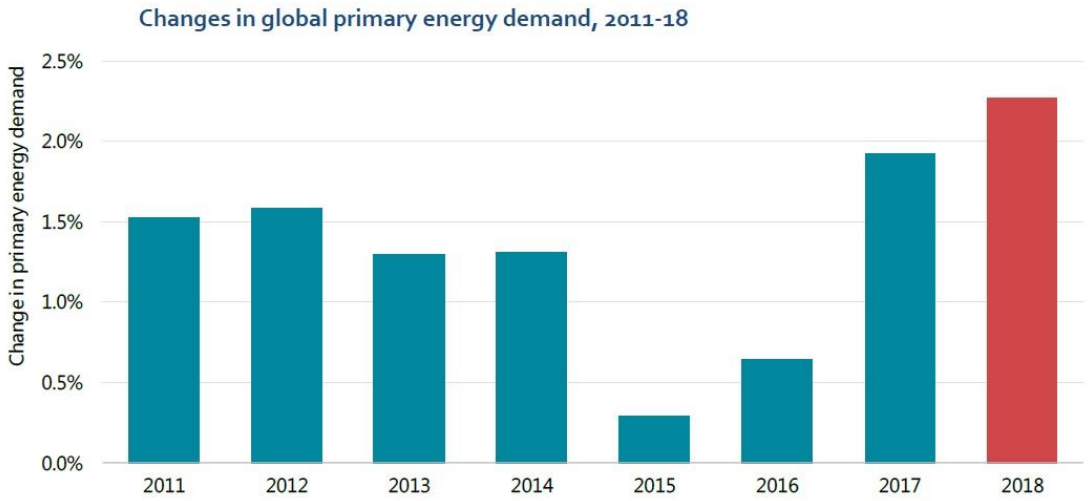

Figure no 1.3 Change in global primary energy demand between 2011-18 [9]

In 2011, the International Energy Agency (IEA) stated that the adoption of energy-saving measures would result in an absolute reduction in electricity demand. Furthermore, the study also shows that the energy saved by energy efficiency can greatly help countries avoid power outages, meet the country's energy demand, and other costly consequences of energy shortages. Saving energy is perhaps the most important way to reduce these consequences. [5]

2 Energy Efficiency in the Czech Republic

2.1 National Energy Efficiency targets for 2030

The targets and law implementation for increasing energy efficiency in European Union are mainly based on Energy Efficiency Directive (2012/27/EU), which was adopted in 2012 to mandates the energy efficiency improvements within the European Union. The Energy Efficiency Directive aims to achieve the reduction targets in primary and final energy consumption by decreasing energy consumption in all primary and end-use sectors within European Union. There are three articles in this directive that are very important to set up the targets and implementation of obligation schemes in member states, which are briefly mentioned below.

(1) Article 3: This article comprises of the suggestive targets for energy efficiency increasing, considering the member states for primary and final consumption, and energy intensity.

(2) Article 5: This article imposes the mandatory obligations to the member states for renovating the total floor area of the heated or cooled buildings which are owned and occupied by the central government by 3 % every year. These obligations are for those building which does not meet the minimum energy requirements and doesn't apply the measures which will generate the energy savings.

(3) Article 7: This article requires to implementation of the energy efficiency obligation schemes or the alternative measures to generate energy savings to achieve the cumulative savings requirements for the member states.

The Czech Republic aims to reach the target of primary energy sources at the level of 1735 PJ and final consumption at the level of 990 PJ by 2030. Also, the 2030 national target of the Czech Republic corresponds to the reduction of the energy intensity of GDP creation to the level of 0.157 MJ/CZK. Based on the assumed energy performance of central institution buildings in 2020, the Czech Republic set the commitment to achieve energy savings in buildings with the low energy performance of these institutions of 0.124 PJ, following the rules of the Energy Efficiency Directive. The Czech Republic's target

under Article 7 for 2021–2030 was set at 84 PJ of new energy savings, i.e. 462 PJ of cumulated energy savings by 2030. The commitment respects the requirement to meet the minimum annual energy savings of 0.8 % of annual final energy consumption. [10]

In energy efficiency, there are three objectives for the Czech Republic in the period 2021–2030: (1) an indicative target for the size of primary energy sources, final consumption, and energy intensity (2) a binding energy savings target for the public sector buildings (3) a binding year-on-year rate of final consumption savings. These objectives are corresponding to Articles 3, 5, and 7 of the Directive 2012/27/EU on energy efficiency. The targets for the year 2030 according to the different articles are shown in Table 2.

Article number	**Targets for the year 2030**
Article 3	Final energy consumption: 990 PJ Primary energy consumption: 1735 PJ Energy intensity of GDP: 0.157 MJ/CZK
Article 5	Energy savings in central institution buildings:- 0.124 PJ
Article 7	Annual energy savings: 84 PJ Cumulated energy savings: 462 PJ

Table 2 National Energy efficiency targets for 2030

The national target is determined as the maximum potential for reducing energy consumption in individual sectors of the economy. To meet its energy efficiency targets and commitments, the Czech Republic will continue to use economic measures, including public support, legislative measures, and measures in the field of education and counseling. Article 3 of Directive 2012/27/EU allows each member state to set indicative national energy efficiency targets based on primary or final energy consumption, primary or final energy savings, or energy intensity. At the same time, however, Member States should respect the EU energy efficiency target by 2020 and 2030, which is set at 20 % and

32.5 %, respectively. Achieving this target should lead in 2020 to EU primary energy consumption of no more than 1474 Mtoe and final energy consumption of more than 1078 Mtoe. For the year 2030, the revised EU Energy Efficiency Directive sets a target of at least 32.5 %, when converted to absolute values, the primary energy consumption should not exceed 1273 Mtoe and final energy consumption should not exceed 956 Mtoe for the EU. Achieving the 2020/2030 target for final and primary energy consumption is influenced by several factors and assumptions, which may evolve. For this reason, the contribution of the Czech Republic is supplemented to include a specification of 'boundary conditions. Significant changes in these input parameters may trigger the need for the Czech Republic to reassess national indicative indicators in the future. [10]

2.2 Development toward achieving energy efficiency targets

2.2.1 Analysis of trends in energy consumption

(1) Primary Energy Consumption

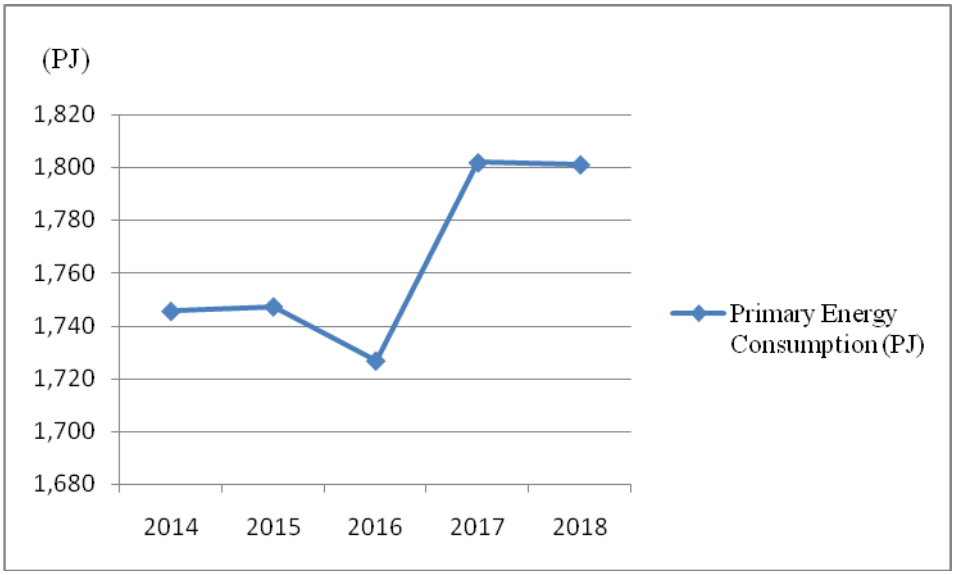

Figure no 2.1 Primary energy consumption

Primary energy is a form of energy in nature that has not undergone any human-engineered conversion process. It is the energy contained in the original fuel and other forms of energy received as input to the system. Primary energy can be renewable or non-renewable. Primary energy consumption measures the entire energy demand of a rustic. It covers the consumption of the energy section itself, losses in the transition process (for

example, from oil or natural gas to electricity), and energy distribution. It excludes energy carriers used for non-energy purposes (such as petroleum not used not for combustion apart from producing plastics). Energy demand is growing across many countries within the world, as people are getting richer and populations increase.

If this increased demand isn't compensated by increased energy efficiency elsewhere, then our global energy consumption will still grow year on year and makes the challenge of transitioning and it will become more difficult for our energy system to move from fossil fuels to low-carbon energy. The primary energy consumption of the Czech Republic between the period of 2014 to 2018 has shown in Fig 3.1. In 2014 it was about 1745.2 PJ, and 1747.2 PJ in 2015 but in 2016 value was fall around 1.18 % (1726.4 PJ in absolute terms). Again in 2017 trends have shown a drastic increase of around 4.26 % (1801.6 PJ) and in 2018 again it decreases and becomes 1801.2 PJ. The Czech Republic has already achieved its target for primary energy consumption in 2016 but it was increased again in 2017 and 2018 which is slightly disappointing.

(2) Final Energy Consumption

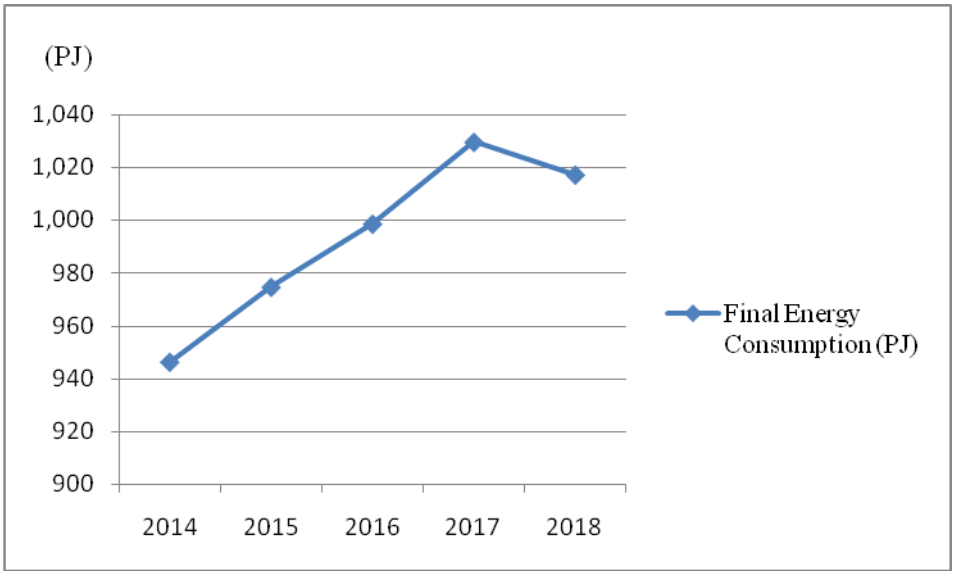

Figure no 2.2 Final energy consumption

Final energy consumption is the total amount of energy consumed by end-users (home, industry, agriculture, etc.). It is the energy that reaches the end user's door, excluding the energy used by the energy sector itself. Final energy consumption does not include energy used in energy sectors including transport and conversion. It also excludes the fuel and

coke that is converted to blast furnace gas when the converted fuel and coke at the power plant of a commercial vehicle manufacturer are usually part of the conversion industry rather than a part of general industrial consumption.

Since 2014, the trend of final energy consumption has shown a year-on-year increase, 946.3 PJ in 2014, 974.6 PJ in 2015, 998.6 PJ in 2016, and 1029.5 PJ in 2017. But in 2018 the trend falls around 1.2 % and comes on value 1017.1 PJ which indicates a really good sign. The final energy consumption and primary energy consumption of the Czech Republic in 2020 are 1060 PJ and 1855 PJ, respectively.

Therefore, we can see that the final energy consumption of the Czech Republic in 2018 (1017.1 PJ) has reached the target for 2020 (that is, 1060 PJ). Primary energy consumption (1801.1 PJ) in 2018 was lower than the target value of 1855 PJ. So if the value of final energy consumption will decrease at this rate then the Czech Republic's target for 2030 may be achieved before it. Now the final energy consumption in different sectors is discussed, so from it, we can get know about the situation of different sector and we will able to decide which sector need more improvement for reduction of consumption.

Final energy consumption in different sector

(1) Households

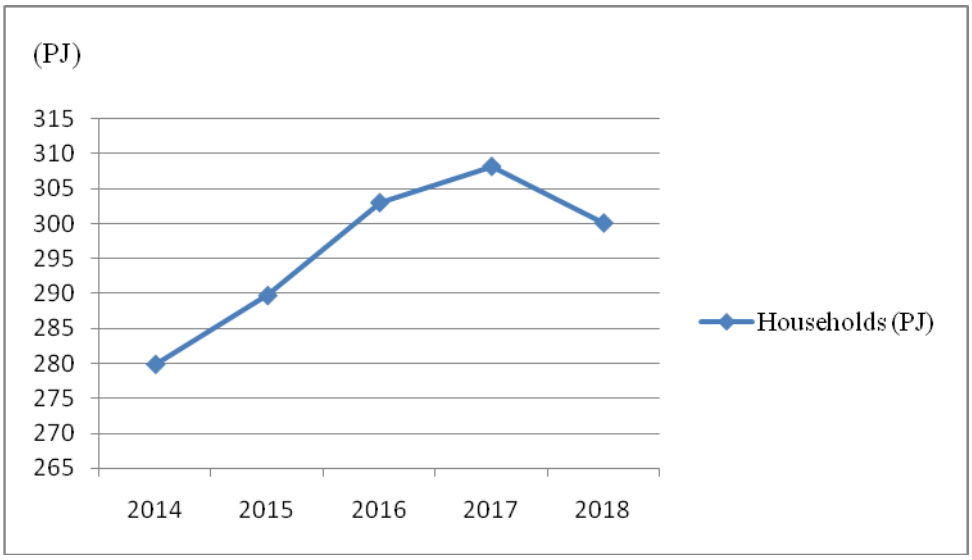

Figure no 2.3 Final energy consumption in households

In the long term, energy consumption in family dwellings is affected by the increase in the number of new dwellings and the decrease in the number of people per dwelling. Between 1994 and 2018, the global average energy consumption of Czech households continued to exceed the final total energy consumption of the Czech Republic, with an average of 28.3 %. The trend generated during this period was very high, averaging 288 PJ. Although there are public funds for measures to improve the energy performance of homes, their final energy consumption has not been reduced, which has also led to a high annual share of homes completed in single-family homes (it has been more than 50 % since 2010) It is the form of housing that consumes the most energy. On the contrary, in the last 20 years, only 30 % of the finished houses are located in multi-story apartments, which is the most ecological and economic form of housing. From a demographic perspective, the level of consumption reflects the increase in population and disposable household income, improvement in living standards, and consumption behavior that affects consumer behavior, thus affecting energy consumption. But compared to 2017, the final energy consumption in 2018 was 2.6 % and the absolute value was 8 PJ.

(2) Transport

The transportation sector shows a long-term high trend in energy consumption. However, this trend has slowed down in 2018 compared to 2017 (only a 0.7 % increase), with the previously recorded growth exceeding 4 %. The total growth between 2017 and 2018 is approximately 1.8 PJ. The increase in energy consumption is related to the increase in passenger-kilometers. The number of passenger kilometers increased from 1,24,165 in 2017 to 1,29,967 in 2018, that is, the number of passenger kilometers increased by nearly 5 % year-on-year. Nevertheless, the trend in 2018 has changed, and the decrease in energy consumption per passenger-kilometer (including private car transportation and public transportation) is related to the decrease in energy consumption per vehicle.

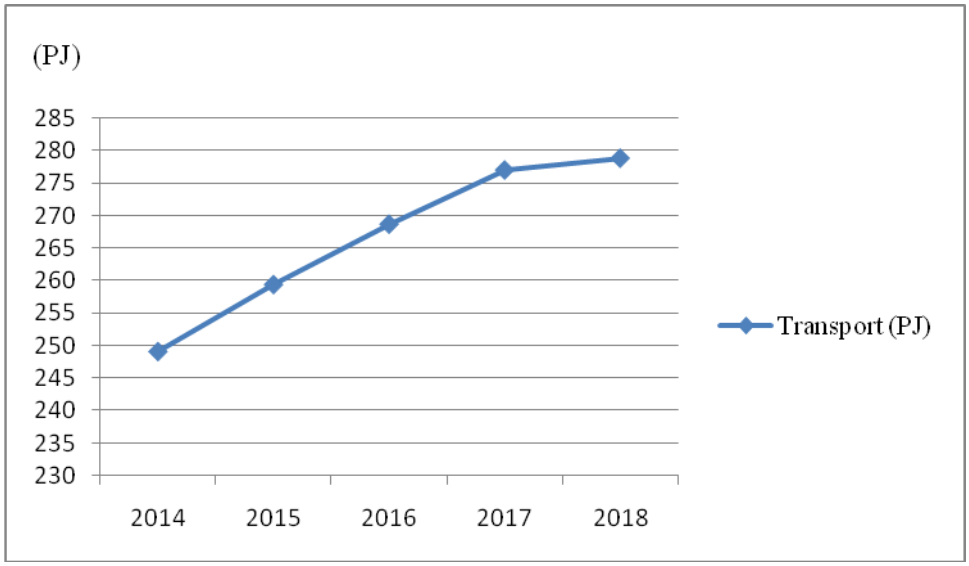

Figure no 2.4 Final energy consumption in transport

(3) Services:-

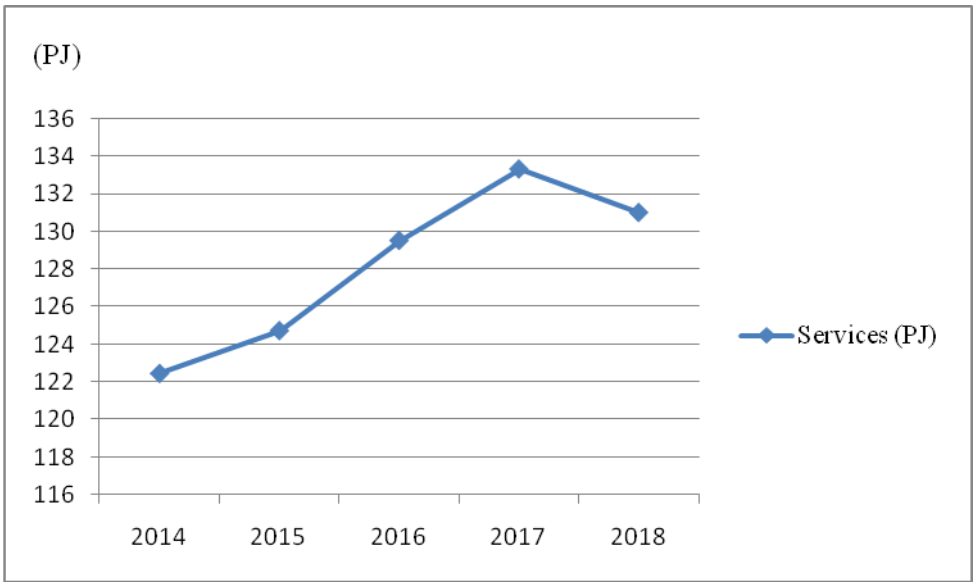

Figure no 2.5 Final energy consumption in services

From 2014 to 2017, the final energy consumption of the service industry continued to increase year after year. In 2014, the final energy consumption of the service industry was approximately 122.4 PJ, 2015 was 124.7 PJ, 2016 was 129.5 PJ and 2017 was 133.3 PJ. In 2017, the final energy consumption of the service industry peaked. But in 2018, it showed a decrease of about 1.75 % to 131 PJ.

(4) Industry:-

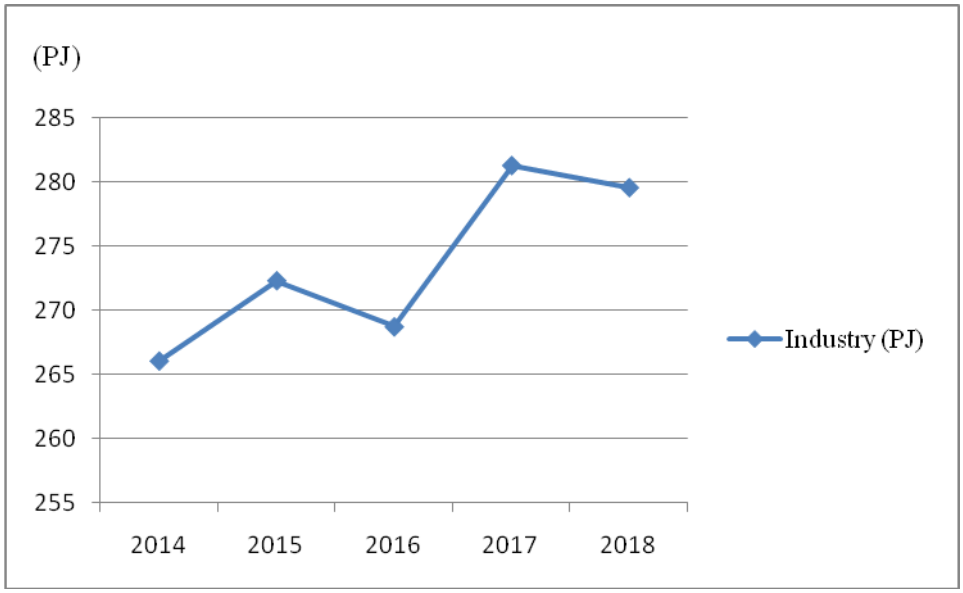

Figure no 2.6 Final energy consumption in industry

The industry sector saw year-on-year very big ups and downs in final energy consumption over the year in comparison with the other sectors. In 2014 the final energy consumption in the industry sector was about 266 PJ which was increased in 2015 and reached the value of 272.2 PJ. In the year 2016, every other sector has shown increment in final energy consumption but the industry sector has shown decrement and becomes 268.6 PJ. But again in 2017 it crosses the value 281.2 PJ and shown drastic change and finally in 2018 again it decreased and reached the value 279.5 PJ. So the industry sector has witnessed many changes according to trends in the market.

2.2.2 List of measures for energy savings in different sector

The Czech Republic's approach to achieving national energy efficiency targets is mainly based on the overall EU energy efficiency target of 20 %. The European Union has stated that, compared to the baseline scenario for the development of energy consumption in 2007, decreasing energy consumption by 20 % by 2020 is the main objective. To achieve the objectives set out in Article 7 of the Energy Efficiency Directive, the Czech Republic has implemented the following policy measures in different sectors:

Households:-

1. Regeneration of pre-fabricated concrete buildings – PANEL Program

Brief description:- The purpose of this policy measure is to provide low-interest loans to repair and modernize multi-family buildings. Comprehensive maintenance is emphasized so that the owner can spend financial resources with a purpose. This procedure applies to all multi-family building owners, regardless of the technology (precast parts, bricks) used in construction. The program is open for cooperatives, homeowners associations, individuals and legal entities, and municipalities with multi-family dwellings. The main focus is the general reconstruction of apartment buildings owned by the municipality. One of the requirements is to comply with the technical and heat parameters of the building required by the relevant standards. From this perspective, the measure can be considered effective. Under this program total of 149.8 TJ of energy-saving was achieved by 2019.

2. New Green Savings Program

Brief description:- This initiative focuses on energy conservation and the effective use of energy sources in various housing systems. It provides financial assistance for energy-efficient interventions in single-family and multi-family homes, as well as public-sector buildings. So far, funding has been declared under the program for improving the energy efficiency of existing single-family buildings, constructing single-family buildings with very high energy performance, and using energy sources efficiently in both single and multifamily buildings. This program resulted in a net energy savings of 3408 TJ by 2019.

3. Integrated Regional Operational Program

Brief description:- The basic objective of the program is to promote competitiveness and the use of the economic potential of each region (growth goal), reduce the widening gap in negative regional differences (balance goal) and strengthen environmental sustainability (prevention goal), and optimize the institutional framework for regional development (institutional goals). The focus of the program is to improve public services and living conditions for regional residents, good land management and more effective public institutions, community-led local development, and technical assistance. Individual support measures have an immediate effect on reducing energy consumption. The plan is expected to save a total of 893 TJ by 2019.

4. Operational Program Environment

Brief description:- The focus of the plan is to improve environmental quality. It is committed to improving air, water, and soil conditions to solve the problems of waste and industrial pollution, and to promote the care of the landscape, the use of renewable energy, and the construction of environmentally conscious infrastructure. The program also works in the service and industrial sectors, so especially for the household sector, its purpose is to reduce emissions from local heating of homes, which cause the population to be exposed to excessive concentrations of pollutants. Under this plan, the household sector saved a total of 1473.6 TJ of energy by 2019.

5. Support for the installation of cogeneration units

Brief description:- This plan focuses on investment support for micro-cogeneration as well as small and medium-sized cogeneration. The measure's goal is to provide investment assistance for cogeneration units. The measure will, among other things, contribute to the expansion of unused gas connections, the development of a decentralized energy sector, and, in some cases, improvements in air quality. It was put into action via. It was implemented throughout the Czech Republic and the target group is natural and legal persons. The expected saving from these measures is 600 TJ between 2017 and 2020.

6. Energy Savings Fund

Brief description:- The Energy Savings Fund is a possible measure for planning and implementation. It is a tool under consideration following Article 20 of the Energy Efficiency Directive. The fund can be used to apply various types of financial instruments to finance programs related to enhancing energy efficiency and possibly technical assistance. The fund manager will be an individual within the current state agencies in the best-case scenario. A financial instrument designed to aid in the implementation of policies aimed at raising energy efficiency in various areas (e.g. industry, buildings, transport). If the model for the flow of funds and their usage is properly set, expenditure can be assumed to be more efficient than in the case of direct grants. Between 2017 and 2020, these steps are estimated to save 2600 TJ.

7. Support for construction in the Czech Republic relating to energy efficiency and environmental protection

Brief description:- This policy measure state that private companies are required to actively contribute to energy efficiency and protecting the environment following the EU 2020 environmental policy regarding the design and usage of new building materials and systems, technology, and technological equipment of buildings, including their systematic use. Support for construction in the Czech Republic that improves energy efficiency and environmental protection in line with the EU 2020 environmental strategy operates entirely outside the private construction sector in the Czech Republic but targets a conscious and maximum increase in energy efficiency in construction in the Czech Republic across all the entities involved to clearly show the possibility for construction businesses to use this measure. Expected saving was about 1000 TJ after applying this measure between 2017-2020

8. Clean energy Prague program

Brief description:- The measure is planned to provide financial assistance for the conversion of original heating systems to more environmentally sustainable types or the use of renewable energy sources, to improve the energy efficiency and air quality of houses and apartment buildings. It emphasizes replacing inefficient heating systems with more energy-efficient alternatives and encouraging the use of renewable energy sources. The expected saving from these measures is 59 TJ between 2017 and 2020.

Services:-

1. State program to promote energy savings - EFEKT 2 Program

Brief description:- The emphasis of this action is primarily on supporting funding for public lighting non-investment aid to raise public and professional awareness of energy savings. The objective of the measure is to increase energy savings with investment projects that focus on energy efficiency decrease initiatives in street lighting, renovation of heating systems and building sources, energy-saving measures in buildings using the method of energy efficiency certificates, and pilot projects. The saving achieved by this program from 2017 to 2019 is 1039.9 TJ.

2. Operational Program Prague – Growth Pole in the service sector

Brief description:- The City of Prague's operative program focuses on funding to improve the energy efficiency of buildings and the techniques used to operate public and road transport in municipalities, the introduction of pilot projects to turn energy-intensive municipal buildings into almost zero energy buildings. This program has saved 28.8 TJ of energy between 2017 and 2019.

3. Operational Program Enterprise and Innovation for Competitiveness

Brief description:- The program aims to provide investment assistance to improve energy efficiency in the industry. Business entities (small, medium, and large enterprises) are the target groups for initiatives in the field of energy savings (thermal insulation of production and business structures), as well as agricultural entrepreneurs, food companies, and retail organizations. This measure is extremely successful because investments are channeled into extensive projects that encourage improved energy efficiency in the industry. Between 2017 and 2019, this measure was expected to save approximately 1444.4 TJ.

4. ENERG Program to support the achievement of final energy savings in the small and medium-sized enterprises sector

Brief description:- This initiative centered on the provision of low-interest loans for the implementation of energy-efficiency programs. The Czech-Moravian Guarantee and Development Bank manages the financial instrument. It is a supplementary yet highly efficient tool that opens the door to the use of financial instruments to encourage energy efficiency. Small and medium-sized businesses are the target audience. This measure was projected to save approximately 0.7 TJ between 2017 and 2019.

5. Energy Savings Fund for the service sector

Brief description:- The same measure is in the household sector just the target audience is small and medium-sized enterprises. The fund can be used to apply various types of financial instruments to finance programs related to enhancing energy efficiency and possibly technical assistance.

6. Programs supporting research and development in the service sector

Brief description:- The measure's goal is to increase energy savings by funding projects under scientific research and development programs, improving production energy efficiency, and funding programs aimed at research and development with corresponding knowledge transfer into effect. Support for applied science, experimental advances, and innovation that lead directly or indirectly to energy savings is included in the measure. The measure is effective in terms of the long-term need to continually develop new improved technologies to increase energy efficiency, as well as to establish the required room for the use of these technologies as one of the fundamental elements of the Czech Republic's and the EU's stable and sustainable environmental policy.

Transport:-

1. Operational Program Prague – Growth Pole

Brief description:- The program is also working in the services sector and focuses on funding to improve the energy efficiency of buildings. But in the transport sector, it focuses on the techniques used to operate public and road transport in municipalities, the introduction of pilot projects. This program has saved 28.8 TJ of energy between 2017 and 2019.

2. Operational Program Transport

Brief description:- The operational program aims to promote increased energy efficiency in the rail transportation business. A key component of the Operational Program Transport's support for energy savings in rail transport is the proposed introduction of a long-term project to minimize electricity losses caused by the transition from a direct current system to an alternating current single-phase system. This measure is effective because the investments are directed at reducing losses in the operation of power systems and equipment that use electric traction. A total of 12.4 TJ of energy was saved under this program from 2014 to 2019.

3. Promoting the eco-driving of cars

Brief description:- The measure is in the planning stages. It consists of encouraging car drivers to practice eco-driving by providing routine free training. A variety of sub-measures are involved, which educate and enhance drivers' driving habits, resulting in energy-efficient management, energy savings, improved safety, and the smooth flow of traffic.

4. Organization of eco-driving training for lorry and bus drivers

Brief description:- The Act requires subjects such as the application of national and international legislation relating to road transport, traffic safety and the ecological operation of the vehicle, the provision of services and logistics, the economic environment and the organization of the transport market, and the social aspects of driving to be taught.

Industry:-

1. Declaration on strategic cooperation by CEZ

Brief description:- This measure focuses on voluntary agreements to include a third party in improving energy quality or to introduce interventions and effective energy management to minimize energy use by the final user in the industry. Energy efficiency can be integrated into behavioral-change programs to incentivize businesses and local governments, such as the implementation of energy conservation, the promotion of energy-saving initiatives, information campaigns, guidance on energy audits and licenses, and the processing of studies.

There are also some other measures for the industry sector which are implemented in other sectors and call as multi-sector policy measures whose objective can differ according to the sector. These measures are:

1. Operational Program Environment
2. Promotion of energy efficiency under the Operational Program Enterprise and Innovation for the industry sector
3. ENERG Program to support the achievement of final energy savings in the small and medium-sized enterprises sector.

4. Energy Savings Fund in the industry sector
5. Support for construction in the Czech Republic relating to EE improvement and environmental protection in line with the strategy EU 2020 for smart, sustainable, and inclusive growth for the industry sector
6. Programs supporting research and development

Farming:-

1. Summary of measures to increase the energy efficiency of agricultural plants

This measure combines a legislative instrument with grant funds in agricultural plants. Energy savings can be achieved utilizing the following measures:

1. Renovation and construction of buildings including improvements to their insulation.
2. Purchase of new technologies, which are normally more energy-efficient and better sized to current business needs.
3. Modernization of ventilation, including recuperation of heat and cold.
4. Installation of more efficient lighting.
5. Use of cogeneration in the local production of electricity and heat.
6. More energy-efficient road and non-road transport and machines.

Investment measures (measures beyond the scope of Article 7):-

1. Investment support for the introduction of CHP.
2. Operating aid for the introduction of CHP.
3. Investment support for the modernization of the transmission and distribution networks to increase efficiency, and support for the renovation and modernization of distribution heating facilities.
4. Investment support for the construction of the charging infrastructure for electric vehicles and other infrastructures for alternative-drive vehicles.

Legislative measures (measures beyond the scope of Article 7):-

1. The obligation to improving the energy performance of buildings.
2. Obligation to prepare energy performance certificate of a building.
3. Obligations linked to energy label.
4. Obligation to carry out an energy audit and to prepare an energy assessment.
5. Obligations linked to the setting of specific energy efficiency conditions for public procurement.
6. Minimum energy efficiency obligation for energy sources and distribution.
7. Combustion sources inspection obligation.
8. Regulatory measures to reduce transmission, transport, and distribution losses.
9. Obligation to prepare Territorial Energy Concepts at the level of regions and City of Prague.
10. Promoting modal change in freight transport.

Other Measures:-

1. Fulfillment of the strategic framework for sustainable development according to specified priority axes, priorities, and objectives.
2. Additional alternative measures in the industry and services sectors, and the public sector – the guarantor of the Ministry of Industry and Trade agreement.
3. The Reasonable Energy Savings Program.
4. Taxation of fuel.
5. Taxation of household fuels.
6. Voluntary agreement with distributors and sellers of energy receivers.
7. Information campaign.

Additional measures (for the energy saving of which will be analyzed, is calculated, and subsequently notified):-

1. Voluntary agreements with major energy consumers.
2. Promoting modal change in favor of public transport.
3. Improving the energy performance of freight transport.
4. Support for the replacement of energy-intensive vehicles.
5. Obligations linked to the payment of industry compensations.

2.2.3 Expected savings from measures

In table 3, the estimated savings from some of the measures are presented including estimated new and cumulated energy savings in the 2021–2030 periods, which should ensure that the Czech Republic fulfills the cumulative savings commitment by 2030. Overlaps are taken into account in the calculation of the benefits of each measure and double counting of savings is removed.

Measure	New Savings (TJ)	Cumulative savings (TJ)
Operational Program Competitiveness 2021–2027	2 000	11 000
Operational Program Environment 2021–2027	2 000	11 000
Integrated Regional Operational Program 2021–2027	400	11 500
New Green Savings Program	19 000	85 600
EFEKT Program	3 000	16 500
Panel Program	1 000	5 500
Co-driving Support	2 000	6 000
Modernization Fund	12 300	-
Taxation of household fuels	500	500
Taxation of fuel	20 000	20 000

Table 3 Estimated energy savings from some of the measures for 2021–2030

2.2.4 Estimated development in final energy consumption

Industry:-

The outlook for the production of final consumption in the industry was calculated based on the estimation of the development of naturally expressed demand in basic industrial sectors (iron and steel, nonferrous metals, chemical industry, etc.), totaling 13 sectors, as well as assumptions about the anticipated shift in energy intensity. In each of these sectors, the most energy-intensive products, accounting for a significant part of the sector's energy consumption, were selected. These are productions that are statistically monitored by the Czech Statistical Office and it is, therefore, possible to evaluate historical trends and at the same time to continuously evaluate the differences between the anticipated and the real development. Energy consumption is also monitored for these products and it is, therefore, possible to determine the energy intensity of their production. In this respect, assumptions have been made on the expected reduction in energy intensity individually for each product, taking into account existing technologies and measures in the sector and the remaining potential for the use of technologies that meet the best available technology criterion. [10]

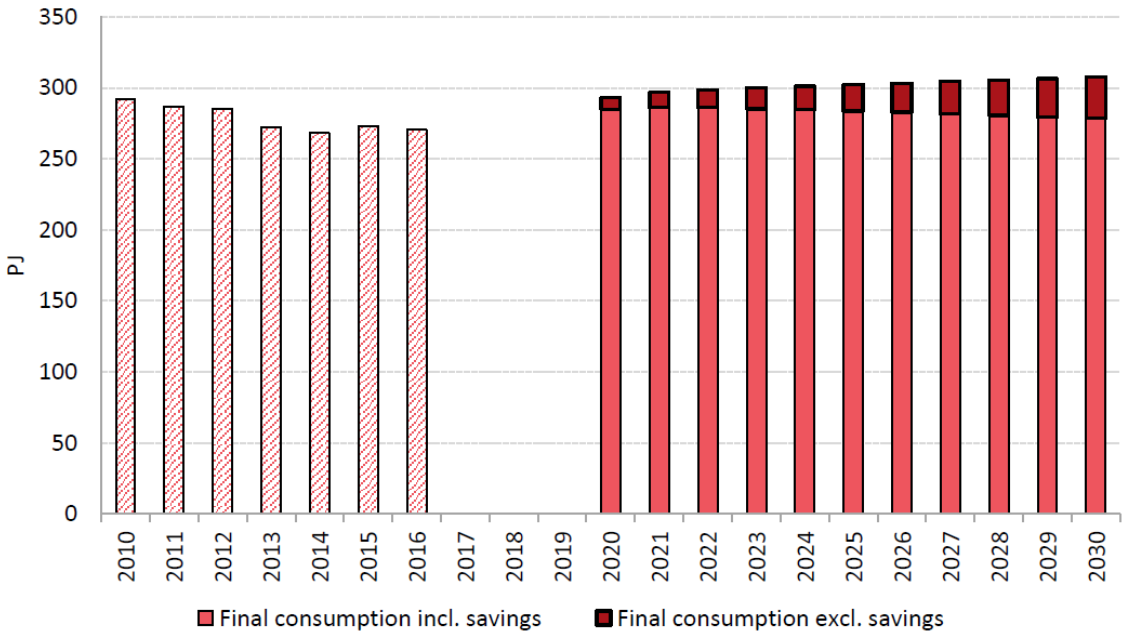

Figure no 2.7 Development of final energy consumption in the industry [10]

The tracked goods account for a large portion of the industry sector's energy consumption; the energy consumption that is not specifically linked to the technical process was then quantified separately. As per the development assumption, we can see that the final energy consumption in the industrial sector will get higher year by year but there is a significant change that will come in energy savings and because of that the total consumption will get decrease.[10]

Transport:-

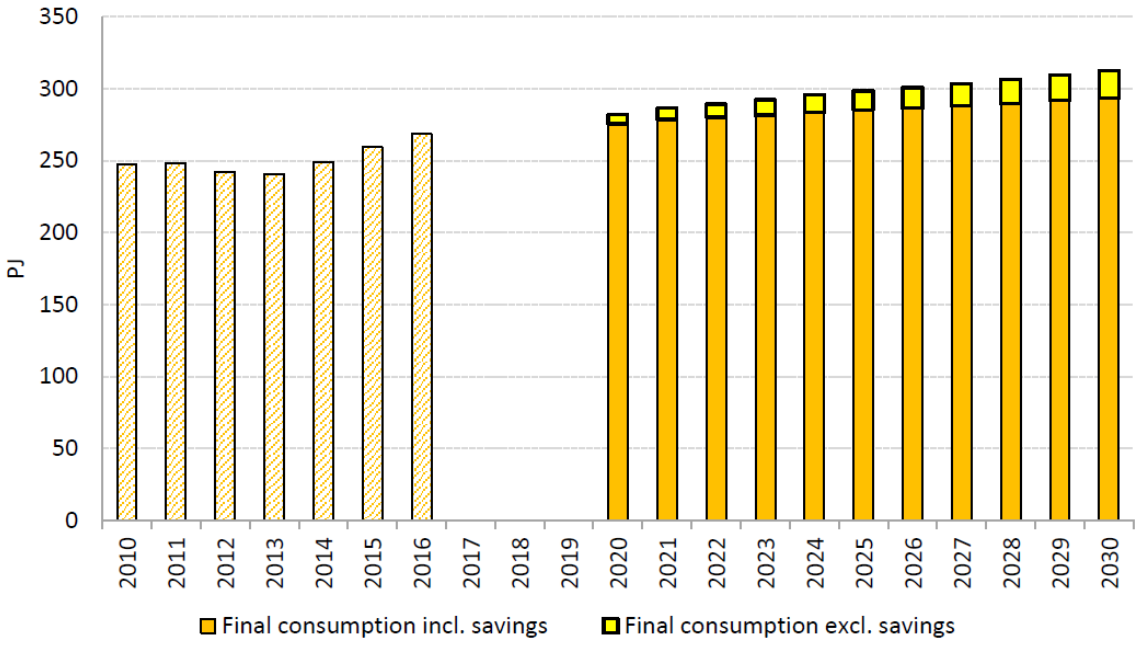

Figure no 2.8 Development of final energy consumption in transport [10]

The expected development of final consumption in the transport sector is based in particular on the expected development of passenger and freight transport performances, which are also based on assumptions about the economic growth production and other socio-economic variables. Final consumption without saving shows a situation where there would be no decrease in energy intensity in comparison to the unit of transport performance. Final consumption, including savings, then assumes decreased intensity about the expected development and the relevant policies in transport.[10]

Household:-

Energy consumption in the household sector represents the pace and depth of renovation of existing buildings, which corresponds to the possible scenario of a long-term renovation plan for buildings, as well as criteria for current building energy efficiency in the case of new construction. At the same time, continued construction is planned, under the assumptions of demographic change and household growth. The household sector will come up with big savings due to the renovation policies and the total share of energy-saving will increase in this sector as well.[10]

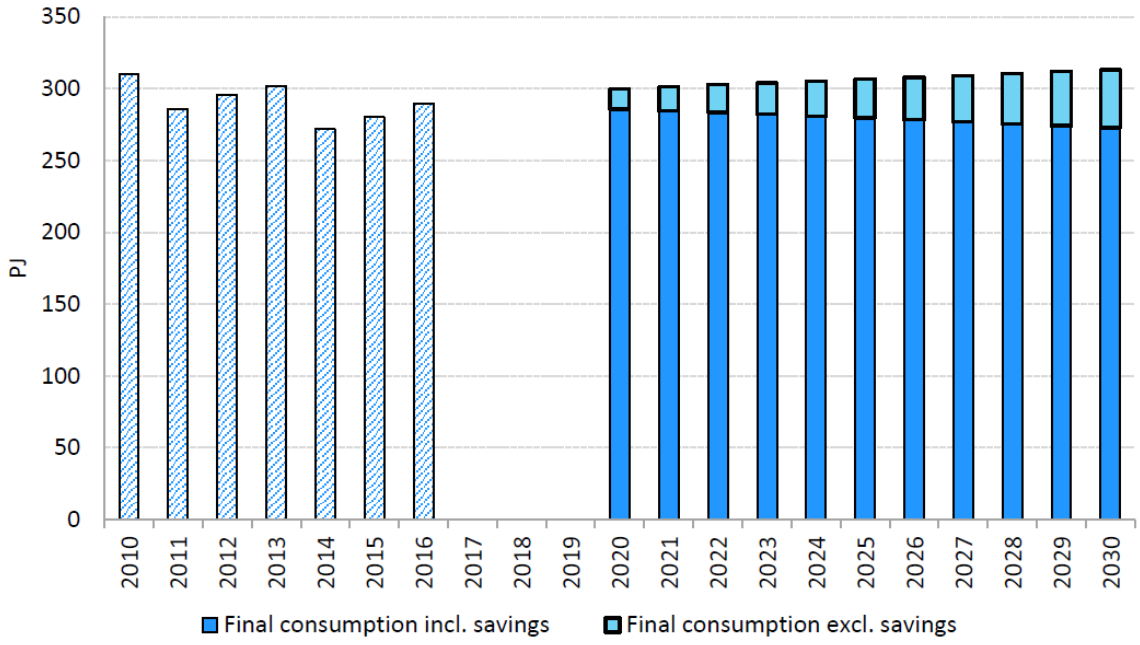

Figure no 2.9 Development of final energy consumption in the household [10]

Service:-

The evolution of final demand in the services sector represents the projected increase in this sector's economic growth. Simultaneously, the assumptions of ongoing building renovations in this sector in line with the renovation strategy are mirrored. There will be a significant change that will occur during 2020 to 2030 and according to it energy savings in this sector will increase due to the existing policy measures related to the service sector and the total consumption will decrease as the share of energy-saving will increase.[10]

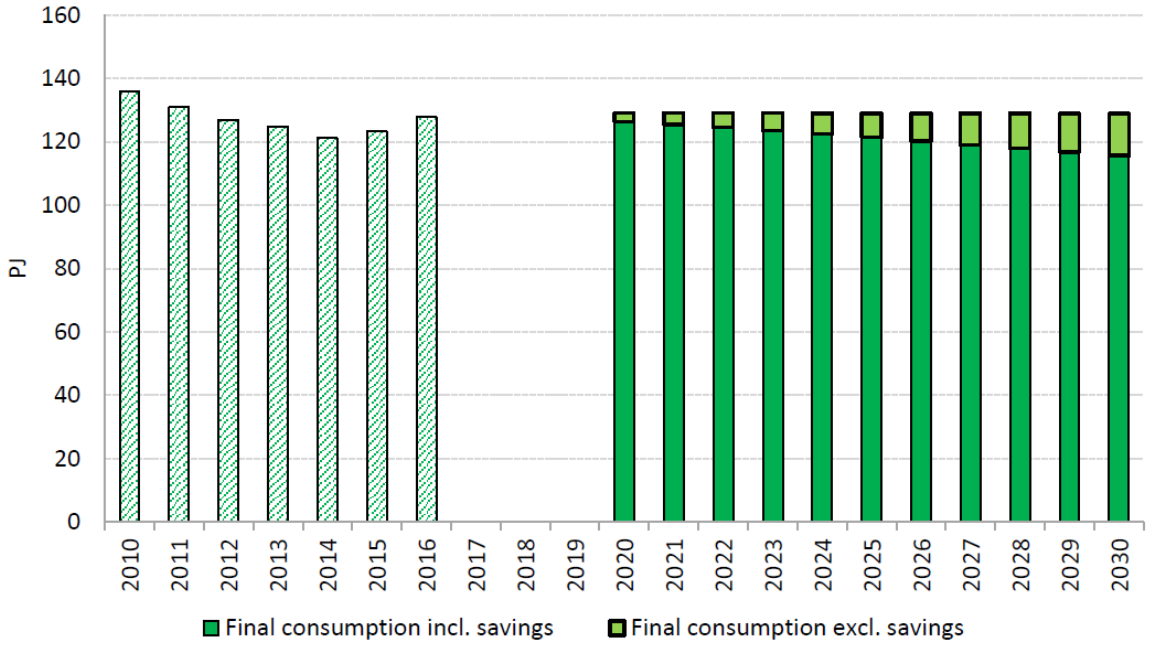

Figure no 2.10 Development of final energy consumption in services [10]

3 Czech Republic's Energy efficiency comparison with member states of European Union

The European Union has seen a reduction in primary and final energy demand by 9.8 % and 5.9 % respectively, between the periods from 2005 to 2018. However, the reduction still surpassed the theoretical linear target path for the period 2005-2020 in 2018, owing to increased energy consumption in many member countries in recent years. The main factors that led to this increment are economic growth, increased transport of passengers and goods, increased population and number of households, and increased disposable income. To meet the goals, member countries must amend their legislation and policy initiatives. Against this backdrop, 336 new policies were introduced or revised in 2019. Furthermore, the European Union's energy usage and energy intensity decreased, implying an improvement in energy efficiency and competitiveness. This section will compare various aspects of energy efficiency, such as strategies, primary and final energy consumption rates, and progress toward goal achievement, between the Czech Republic and European Union member states.

3.1 European Union's Progress towards the Energy Efficiency targets

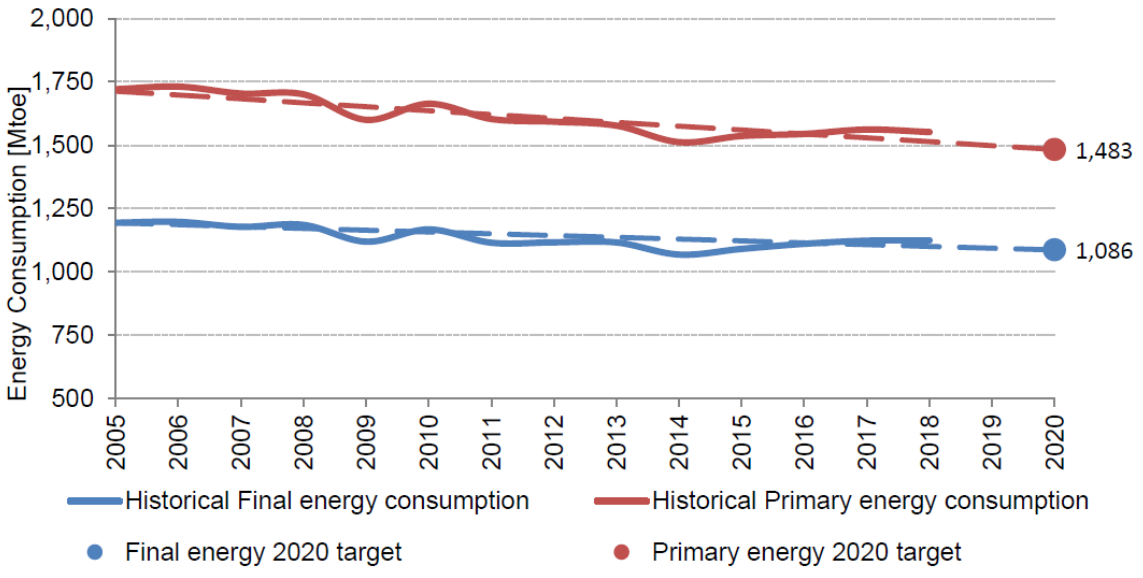

Figure no 3.1 Progress towards the 2020 Energy Efficiency targets [11]

As shown in Figure 3.1, the European Union's energy use has been on a downward trend between 2005 and 2018. This decrease was accompanied by a decrease in per capita energy consumption and energy intensity, indicating a potential increase in competition at the same time. In terms of final energy usage, the European Union had already met the target values set in the energy efficiency directive for 2020 in 2014. In 2014, the final energy consumption was approximately 1068 M toe, compared to the goal of 1086 M toe, which was a very good achievement. The European Union was also on track to meet the goal value for primary energy usage in 2014, with a value of 1512 M toe versus 1483 M toe. Nonetheless, between 2015 and 2018, final energy consumption rose steadily, reaching 1124 M toe in 2018, a 3.5 percent improvement over the target. Similarly, primary energy consumption rose to 1552 M toe in 2018, representing a 4.6 percent improvement over the goal.

3.2 Comparison of trends in energy consumption

3.2.1 Primary energy consumption comparison

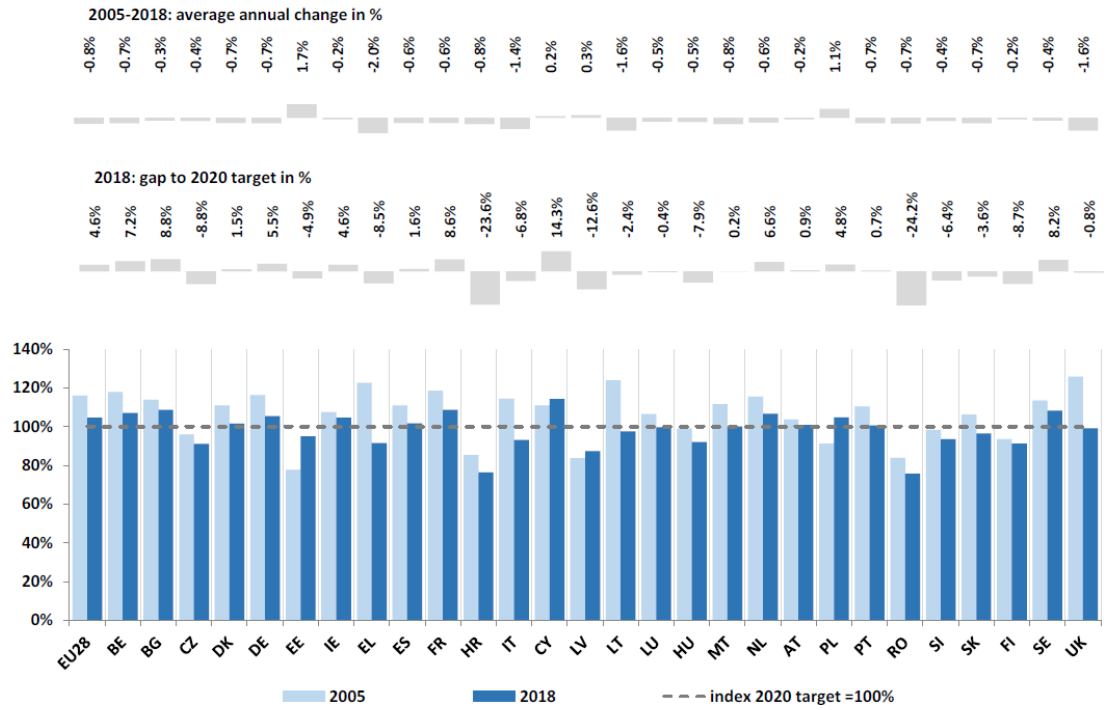

Figure no 3.2 Primary energy consumption comparison [11]

From 2005 to 2018, the primary energy usage of the majority of European Union member countries decreased other than Estonia, Cyprus, Latvia, and Poland. Estonia had suffered

from the huge primary energy consumption rise of about 1.7 %, which was one of the highest in all member states and Greece was the lowest in terms of increase about -2.0 %. The primary energy consumption in the Czech Republic has declined about 0.4 % in comparison with the year 2005. The average annual change in the primary energy consumption of the Czech Republic between the years 2005 to 2018 was not very much high in contrast with the other member states, a total of 17 countries were ahead of the Czech Republic in terms of the gap in average annual change. In terms of the gap between 2018 and the 2020 energy efficiency target, a total of thirteen countries (Belgium, Bulgaria, Denmark, Germany, Ireland, Spain, France, Cyprus, Malta, Austria, Netherlands, Poland, and Sweden) have recorded primary consumption values above their national indicative targets for 2020. The Czech Republic was one of the thirteen countries, who achieved their target value in 2018, and in terms of gap percentage, it was just behind Hungry, Latvia, and Romania. This has shown that the Czech Republic was well ahead in target achievement and decrement in primary energy consumption in comparison with other member states.

3.2.2 Final energy consumption comparison

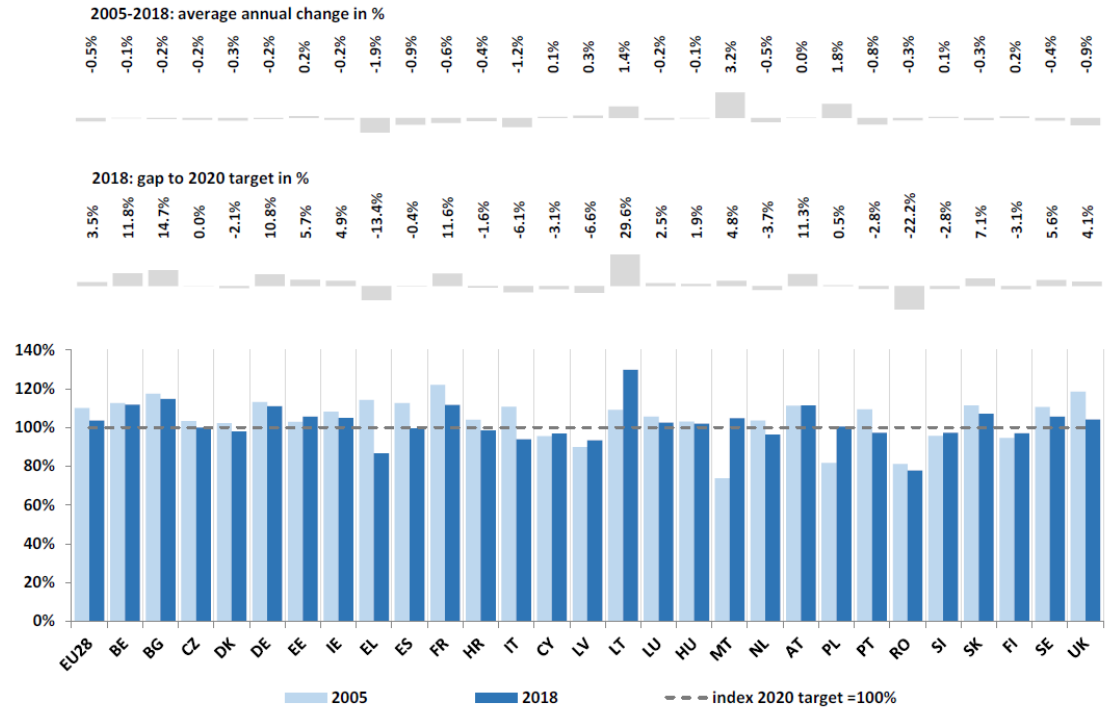

Figure no 3.3 Final energy consumption comparison [11]

Except for Estonia, Cyprus, Latvia, Lithuania, Malta, Austria, Finland, Slovakia, and Poland, the total final energy consumption of all European Union member states decreased between 2005 and 2018, following the same patterns as primary energy consumption. The highest rate of growth was about 3.2 % in Malta, and the lowest rate was about -1.9 % in Greece. Between 2005 and 2018, the Czech Republic's average annual change in final energy usage was -0.2 %, putting it in the negative and trailing thirteen other nations.

In terms of achieving the 2020 goal, thirteen member countries have already met final energy consumption goals that are lower or equal to the indicative final energy target for 2020. Czech Republic, Denmark, Greece, Spain, Croatia, Italy, Cyprus, Latvia, Netherlands, Portugal, Romania, Slovenia, and Finland are among them. As a result, the Czech Republic is among the countries that have already met their final energy consumption goals.

3.2.3 Final energy consumption comparison in the industrial sector

The final energy consumption trend in the industry has generally shown a downward trend in European Union since 2005. Most of the member states however decreased energy intensity in the industry in 2018 compared to 2005, except Hungary and Latvia. The Czech Republic has shown a very good decrement in final energy consumption in the industry about (-4.6 %) which is the second-highest after Estonia (-5.5 %). So in terms of final energy consumption in industry, Czech Republic is much more ahead of the fellow member states

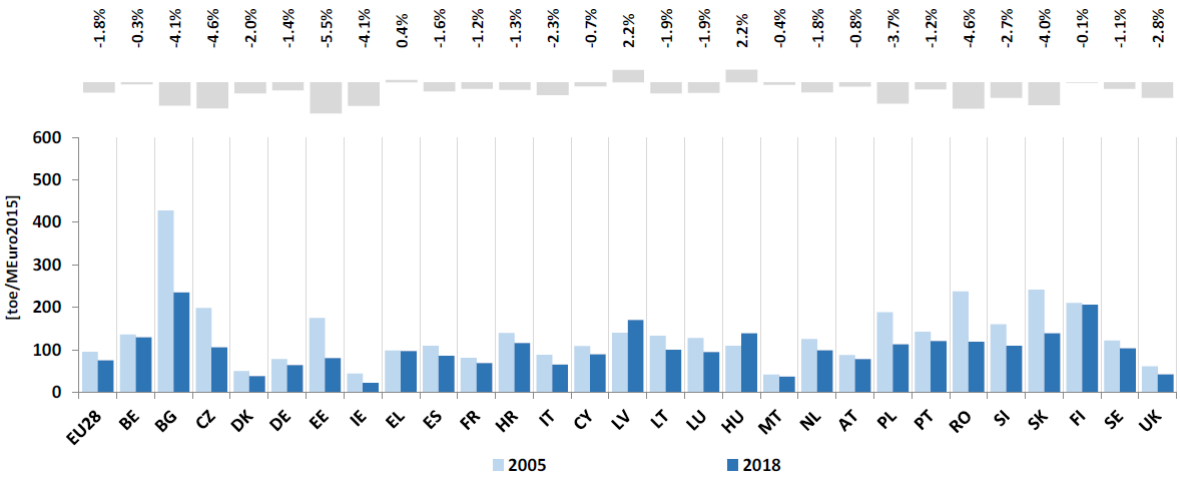

Figure no 3.4 Final energy consumption comparison in the industry [11]

3.2.4 Final energy consumption comparison in the household sector

Between 2005 and 2018, the European Union's member countries' average final energy consumption in the household sector decreased by around -0.30 %. However, only a few countries have reduced their final energy consumption: Belgium, Ireland, Greece, Luxembourg, the Netherlands, Slovakia, Sweden, and the United Kingdom. In terms of average annual change, all other countries were experiencing an increase. The highest percentage increase was observed in Malta, at 11.82 %. The Czech Republic is in the group of improved consumption ratios, with a 1.53 % raise over 2005.

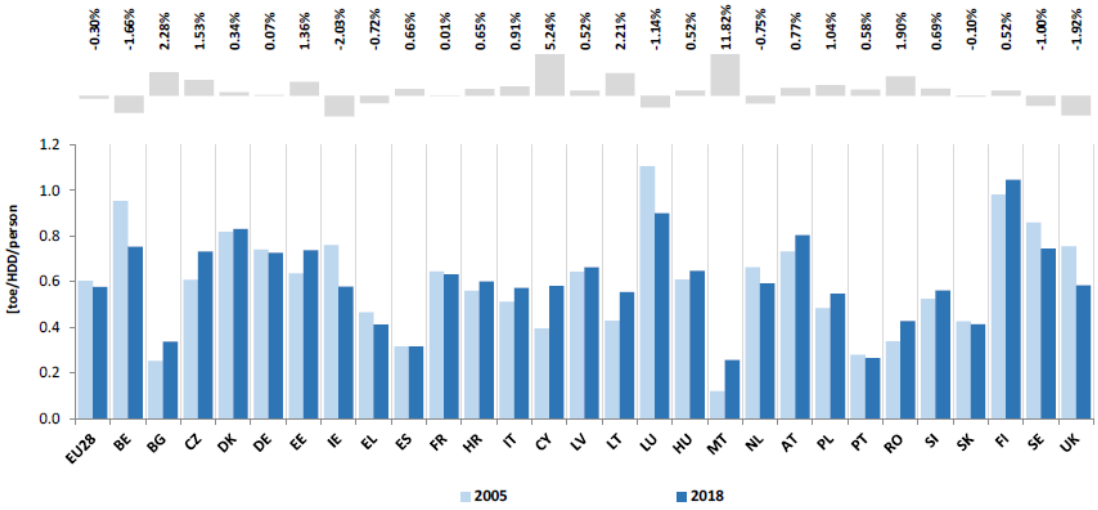

Figure no 3.5 Final energy consumption comparison in the household sector [11]

3.2.5 Final energy consumption comparison in the service sector

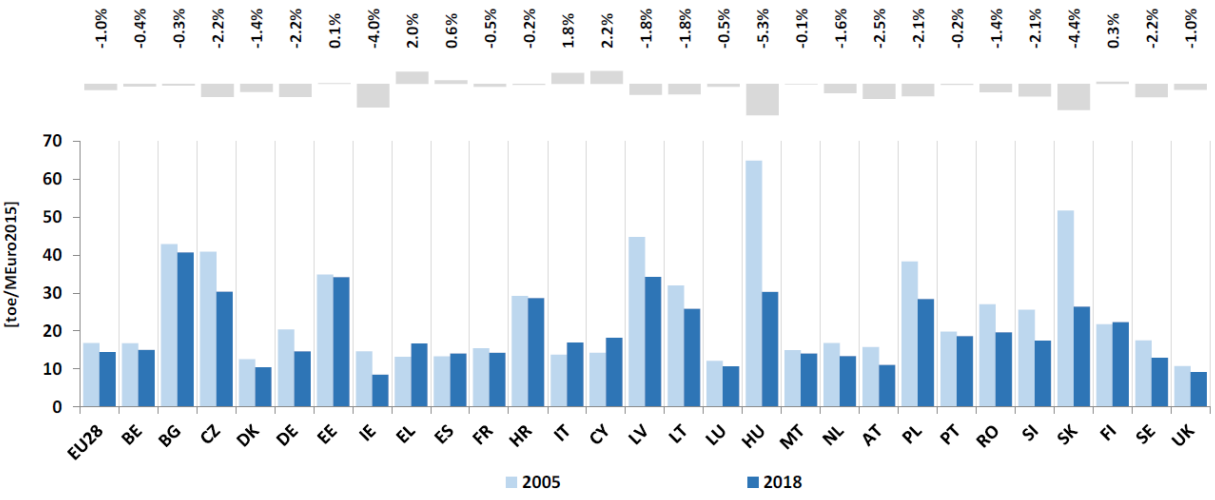

Figure no 3.6 Final energy consumption comparison in the service sector [11]

Similar to the other areas, the final energy use of the service sector in the European Union increased by 1.0 % between 2005 and 2018. The greatest changes occurred in three countries: Hungary (-5.3 %), Slovakia (-4.4 %), and Ireland (-4.0 %). Just six countries have seen an increase in consumption over the year: Estonia (0.1 %), Greece (2.0 %), Spain (0.6 %), Italy (1.8 %), Cyprus (2.2 %), and Finland (0.3 %). The Czech Republic is in a rather strong spot, with -2.2 %, which is significantly better than many other countries.

3.2.6 Final energy consumption comparison in the transport sector

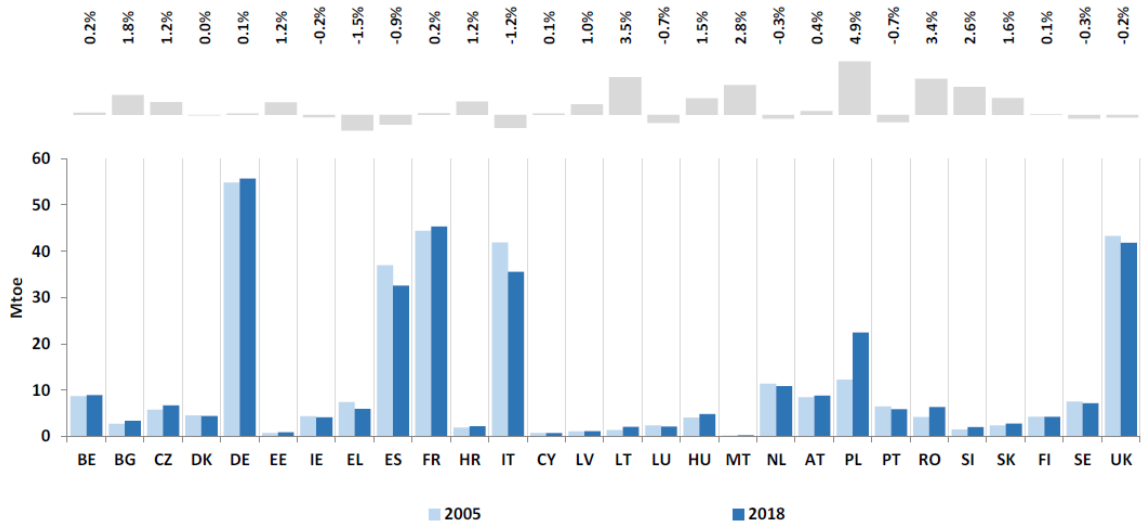

Figure no 3.7 Final energy consumption comparison in the transport sector [11]

Comparative analysis between member states should be made with caution because final energy usage is based on the fuels sold rather than the fuel used on a rustic territory. As a result, considerations other than energy efficiency come into play. As shown in figure 3.7, 18 Member States increased their consumption in this sector on average from 2005 to 2018. The highest increase was observed in Poland (4.9 %), while the lowest was observed in Greece (-1.5 %). The Czech Republic's final energy consumption rose by around 1.2 % in 2018 as compared to 2005.

3.3 Objectives of policy measures in different countries

Based on data on energy consumption among European Union member states as well as overall goals, it is fair to claim that the Czech Republic is one of the European Union

member states whose overall energy efficiency output has improved since 2005. The Czech Republic's primary and final energy intake were both significantly reduced. However, several other EU member countries outperformed the Czech Republic in terms of energy efficiency from 2005 to 2018. As a result, it is useful to understand what the primary focus area or goals of these countries' policy initiatives are. From 2005 to 2018, nine countries reduced their primary and final energy consumption at a faster pace than the Czech Republic. Greece, Slovakia, Italy, the Netherlands, Denmark, Spain, France, Croatia, and Portugal are among them. The following objectives are classified by sector:

3.3.1 Household sector

Greece:-

1. Regulations on energy performance in the building.
2. Financial incentives.
3. Mandatory installation of a solar thermal system.
4. Upgrading the public buildings nearly to the zero energy buildings.
5. Improving the energy efficiency of small and medium-sized enterprises.
6. Replacement of oil-fired heating systems with gas-fired ones in residences.

Croatia:-

1. Ensuring compliance with the best energy efficiency standards for buildings.
2. Increasing the number of nearly zero-energy buildings.
3. Integral renovation of multifamily housing with low-energy standards.
4. Implementation of measures of energy efficiency of buildings and the replacement of lighting with more energy-efficient lighting.
5. Renovation of existing family homes.
6. Provide financial aid to natural persons investing in the improvement of building energy performance.
7. Provide financial aid to natural persons investing in the replacement of existing heating systems by new, more energy-efficient ones.
8. Energy audits and energy certification of buildings.
9. Individual thermal energy consumption metering system installation.

Slovakia:-

1. Energy certification of buildings.
2. Regular inspection of boilers, heating systems, and air-conditioning systems.
3. Support program for building development, subsidies for removing system bugs in residential buildings plus government heating program.
4. Refurbishment of residential and family buildings.
5. Improving the thermal and technical characteristics of family houses, apartment buildings, non-residential buildings.

Portugal:-

1. Replacement of equipment in the residential sector with efficient lighting, – efficient windows, – efficient insulation.
2. Heat recovery in dwelling units as a complement and alternative to traditional means of space heating.
3. Improve the energy performance of buildings.
4. Integration of solar thermal systems into the building stock.
5. Promoting energy from renewable sources to promote greater energy independence and integration, with a reduction of energy consumption costs.

Italy:-

1. Increase the number of nearly zero-energy buildings.
2. Fund for the purchase or restructuring of buildings.
3. Set the minimum requirements for new and for existing buildings that undergo major renovation according to the type of building and the climatic area.
4. Incentive scheme to encourage public administrations and private parties to implement energy efficiency improvement actions in buildings and technical installations as well as for the generation of renewable thermal energy.
5. Tex deduction scheme.
6. Reduction in construction costs at the regional and national levels to encourage energy efficiency obligations.

Netherlands:-

1. Requirement of Energy Performance Certificate in homes and other buildings.
2. The transition of existing homes from natural gas to low-carbon heating.
3. Provides subsidies for energy advice from a certified energy performance advisor.
4. Reduced interest rate loans to individual owner-occupiers and homeowners associations for investments in a variety of energy efficiency measures.
5. Encourages small and medium-sized enterprises, housing co-operatives, and homeowners to invest in solar thermal heating and heat pumps.
6. Changes to the Housing Valuation System.
7. Extending mortgage options for energy-saving measures.

Denmark:-

1. Energy performance standards.
2. Mandatory reporting on taken energy savings measures.
3. Increase the use of energy-efficient appliances and equipment.
4. Strategy for the Energy Renovation of Buildings.

France:-

1. Implementation of the Building Energy Renovation Plan.
2. Undertake actions to eradicate inefficient homes.
3. Thermal Regulations for existing buildings.
4. Labels to encourage the emergence of more energy-efficient renovated buildings.
5. Removal of obstacles to renovation.
6. Incentive schemes for private individuals have been implemented to encourage the energy performance of housing to be improved.
7. Benefit from a tax credit for the purchase and installation of the most energy-efficient materials or equipment in terms of energy savings (in existing buildings only) or for the production of renewable energy.
8. Interest-free eco-loan.

Spain:-

1. Building renovation strategy.
2. Regulation on building heating systems.
3. Provide the buyers or users of buildings with an energy efficiency certificate that must include objective information on the energy efficiency of the building and reference values.
4. Efficient hot water, heating, and cooling systems powered by biomass, solar or geothermal energy.

In comparison with these countries, objectives for the policy measures in the Czech Republic are as follows.

Czech Republic:-

1. The provision of subsidies to cover the interest on loans and to secure and provide loans for the comprehensive regeneration of multi-family buildings.
2. Focuses on energy savings and the efficient use of the energy sources in structures.
3. Long-term low-interest loans for the reconstruction and upgrading of multi-family buildings in deprived zones.
4. Grants for the replacement of manually filled boilers running on solid fuel with new efficient low-emission heat sources in households.
5. Investment support for micro-cogeneration and small and medium cogeneration.

3.3.2 Transport sector

Greece:-

1. Increase the percentage of citizens using public transport.
2. Improve transport quality, safety and achieve energy savings by reducing the travel time for cars and public transport.
3. Promotion of economical, safe, and eco-driving.
4. Provide financial and tax incentives to replace old energy-intensive vehicles with a new ones.
5. Improving energy efficiency and lower emissions in vehicles.

6. Raising the awareness of the public on their contribution to the problems of climate change and environmental pollution.
7. Linking of vehicle taxation to energy efficiency and CO_2 emissions.
8. Replacing old public and private light trucks, and private passenger vehicles with a new efficient one.
9. Provision of incentives for CNG and LPG-powered passenger vehicles.
10. Provision of tax incentives for the purchasing the electric vehicles and introduction of electric vehicle recharging points.

Croatia:-

1. Education and training about eco-driving.
2. Legislative adaptation to the provision on the deployment of alternative fuels infrastructure.
3. Intelligent management of public parking spaces, integrated passenger transport, Public city bicycles and the construction of the corresponding infrastructure, intelligent transport management.
4. Development of alternative fuel infrastructure on a local and regional level.
5. Financial incentives for energy-efficient vehicles.
6. Motor vehicle tax based on CO_2 emissions.
7. Enable city and intercity traffic for electric vehicles, thus reducing emissions of harmful gases and noise in urban areas.
8. Reducing road traffic emissions is the introduction of a new special environmental fee payment for motor vehicles.

Slovakia:-

1. Building and up-gradation of transport infrastructure.
2. Renewal and modernization of vehicle fleet.
3. Cycling to work.
4. Support for development of non-motorized transport system.
5. Increasing the share of public passenger transport in rail transport.
6. Renovation of trolleybuses.

Portugal:-

1. Review of the private vehicle tax regime.
2. Increase the market introduction of energy-efficient tires, with low rolling resistance.
3. Encourage the purchase and introduction of electric vehicles in the light-duty and passenger vehicles market.
4. Encourage public transportation use to detriment of individual transportation, particularly in urban areas.
5. Restructuring the passenger railway transportation offer.
6. Regulation for Energy Management in the Transport Sector.

Italy:-

1. Achieve minimum efficiency standards for new cars.
2. The incentive for road or sea shift, through the creation of new maritime services and the improvement of existing ones.
3. Intelligent transport system.
4. The construction of alternative fuels infrastructure.
5. Introduce the technical and administrative procedures that will allow cars, buses, and light vehicles originally fitted with a petrol or diesel engine, to be converted into an electric vehicle.
6. Introducing electric vehicle recharging points.
7. Financing plan to upgrade the fleet of road vehicles used for local public transport.

Netherlands:-

1. Lower taxes and prices for more efficient vehicles.
2. Supporting the uptake of zero-emission vehicles.
3. Deployment of EV charging infrastructure.
4. Encouraging the use of more efficient means of transport for people and goods.
5. Reduce emissions from commuting by encouraging mobility through public transport, bicycling, walking, carpooling, and mobility as a service.
6. Choose the best tire publicity campaign.
7. Enforcement of the Environmental Management Act.

Denmark:-

1. The transition from diesel to electric trains on main lines.
2. Energy efficiency requirements for taxis.
3. Investments for improvements to public transport.
4. Establishment of light railways.
5. Programs to encourage eco-driving.
6. Financial support for sustainable transport measures.
7. Tax incentives.

France:-

1. Speeding up the replacement of cars.
2. Encouraging low-emission modes of transport.
3. Developing cable transport and electric mobility.
4. Incentives to use bicycles.
5. Encourage and enhance local initiatives through the financing of innovative environmental and energy progress projects encouraging sustainable economic growth and jobs for the future.
6. Specific transport plan for rural territories.
7. Action on traffic.
8. Improving the environmental performance of aircraft.
9. Support the development of sustainable aviation biofuels.
10. Reducing the CO_2 emissions of air transport.

Spain:-

1. Promoting shift modal in personal mobility and freight transport towards more energy-efficient modes.
2. Improving national vehicle fleet efficiency by renewing fleets and incorporating technological advancements.
3. Promoting efficient use of means of transport.

Czech Republic:-

1. Increase in energy efficiency in the rail transport sector.
2. Support for eco-driving by car drivers through the introduction of regular free training.

3.3.3 Industrial sector

Greece:-

1. Relocation of enterprises to industrial-business zones and business parks.
2. Enhancing investments that promote innovation and improve the competitiveness of products and service enterprises.
3. Create conditions for integrating environmental concerns into business operations to make interventions in production chain processes.
4. Improve the energy efficiency of manufacturing enterprises.
5. Financing the business plans for small and medium-sized enterprises.

Croatia:-

1. Increase the awareness and knowledge of the management and employees of industrial companies to fully utilize the potential of achievable energy savings measures.
2. Use of renewable energy sources in manufacturing industries.
3. Introduction of energy-efficient electric motor drives.
4. CO_2 emissions fee for large emitters.

Slovakia:-

1. Supporting the implementation of investment projects to reduce energy intensity and CO_2 production in enterprises.
2. Support the implementation of investment projects in industrial enterprises to reduce energy intensity with a payback period of over 2 years.
3. Support energy audits for small and medium-sized enterprises.

4. Creation of an information platform to provide information and news on energy efficiency in the industry.
5. Exchange of experience and knowledge between enterprises.

Portugal:-

1. Production of one energy efficiency manual in the industry.
2. Industrial demand management.
3. High-efficiency lighting equipment to replace less efficient equipment in the industry.
4. Promote high-efficiency motors.

Italy:-

1. Introduces the mandatory energy audits.
2. Supports private investments for innovation and digitalization of production processes.
3. Improvement of technical skills of employees and the development of new products and processes through the tax credit.
4. Supports micro and small-medium enterprises for investments in new capital goods, machinery, equipment, and digital technologies for energy efficiency.

Netherlands:-

1. Agreements on energy efficiency with companies to require four-year energy efficiency plans and reporting of implemented measures.
2. Achieve greenhouse gas emissions reductions in line with the Climate Agreement through an integrated approach to the development.
3. Use of industrial infrastructure and more sustainable use of resources through a variety of measures including energy efficiency.
4. Establishing a carbon levy.
5. Enforcement of the Environmental Management Act.

Denmark:-

1. Ensure the competitiveness of energy-intensive enterprises by energy taxes.
2. Promote energy efficiency in energy-intensive enterprises.
3. International cooperation on energy efficiency in the industry.
4. Surcharge for CO_2 emissions.
5. Investments in new environmental technologies can be subtracted from fiscal profits.
6. Energy production and CO_2- reduction Subsidy.

France:-

1. Energy savings certificates.
2. Financial support to businesses and authorities to set up an energy management system.
3. Targets setting and implementation of an energy performance improvement plan to benefit from a preferential electricity tariff.
4. Obligation for periodic energy audits.
5. A cost-benefit analysis for installations generating waste heat.
6. Support for standardization and innovation.
7. Technologies and services can be offered that enable the transition to a green economy.

Spain:-

1. Stimulate business investment that would contribute significantly towards generating added value in the industrial sector.
2. Aid program for energy efficiency measures in small, medium, and large industrial enterprises.

Czech Republic:-

1. Provide investment support to increase energy efficiency in the industry.
2. Provision of soft loans for the implementation of projects improving energy performance.

3. Development of awareness about the benefits of energy savings and to stimulate the development and preparation of high-quality energy-saving measures without using investment funds.
4. Support for projects under scientific research and development programs.

3.3.4 Service sector

Greece:-

1. Development of information system incorporating all necessary digital services for energy modeling and statistical databases.
2. Financial support for investment in energy-saving technologies and research.
3. Introduction of tax incentives to promote energy-efficient technologies.
4. Implementation of an energy management system.
5. Energy upgrading of street lighting.

Croatia:-

1. Implementation of energy renovation of service sector buildings.
2. Implementation of measures for improving energy efficiency.
3. Systematic energy management system.
4. Energy-efficient public lighting.
5. Enabling equal or better results (services) using less input energy.
6. Reduction of the share of conventional (fossil) fuels in total consumption of energy by introducing renewable energy sources.

Slovakia:-

1. Renovating public buildings.
2. Modernization of public lighting.
3. Promote energy efficiency improvements and renewable energy source development in districts, self-governments, and higher territorial units.
4. Support for energy audits, implementation of energy management, environmental management.

Portugal:-

1. Promote traffic signal lighting installation of LED technology.
2. Co-finance the installation of electronic variable speed drives in electric motors.
3. Reduce the consumption in pumping systems associated with the capture, adduction, purification, and distribution of water and wastewater.
4. Promote the installation of energy-efficient lighting solutions in public buildings.

Italy:-

1. Upgrading the energy efficiency of central government buildings.
2. Energy efficiency upgrading in publicly owned school and university buildings.
3. Energy efficiency renovation of municipal buildings.
4. Energy Efficiency Certificates.

Netherlands:-

1. Energy tax that covers consumption of electricity natural gas and district heating.
2. Tax deduction for energy efficiency investments by private companies.
3. Attainment of energy efficiency with a large number of sectors as part of its energy conservation policy for business and industry.
4. Reduced VAT rates on labor costs for installing insulation and glass.

Denmark:-

1. Ensure that the competitiveness of energy-intensive enterprises is not weakened by energy taxes and promote energy efficiency in energy-intensive enterprises.
2. Energy-saving by energy companies.

France:-

1. Reducing the energy consumption of the state's property stock.
2. Purchase products with high energy-efficiency performance.
3. Regional planning of climate and energy policies.

Spain:-

1. Improving the efficiency of street lighting technologies.
2. Improving the efficiency of water supply, treatment, and desalination technologies.

In comparison with these countries, objectives for the policy measures in the Czech Republic are as follows.

Czech Republic:-

1. Improving the quality of the environment.
2. Increase energy savings through investment projects aimed at increasing the energy performance of public lighting or at reconstructing heating systems or sources in a building.
3. Improving the energy performance of buildings and the technical equipment used to ensure the operation of municipal public and road transport.
4. Implementation of pilot projects to convert energy-intensive municipal buildings into nearly-zero energy buildings.

From all of the above objectives, it is clear that there are wide ranges of different policy measures are implemented in those 9 countries whose energy performance is better than the Czech Republic. And there is a scope to adopt some new policy measures in the Czech Republic from these countries and improve energy performance. For example, in the transport sector other countries had adopted many unique ideas but in the Czech Republic transport sector doesn't have a wide range of policy measures adopted. So after this soft comparison, many options are coming out from the different countries to which the Czech Republic can adopt and implement in the upcoming future to increasing energy efficiency.

4 Methods to improve energy efficiency in the Czech Republic

After the comparison of different policy measures objectives from the different countries, there is a scope to adopt some new measures with the different objectives which are currently not implemented in the Czech Republic. The core structure of energy efficiency policy measures in the Czech Republic is very strong as it covers most of the basic ideas to improve energy efficiency in different sectors, but to fill out the small gaps or to improve the structure at the highest level it is necessary to adopt new policy measures as well. So in this section, several different new policy measures from the different countries will mention, which can improve the existing energy efficiency policy measures system.

4.1 New proposed policy measures

1. Incentives and bonuses for the replacement of energy-intensive vehicles with energy-efficient vehicles

Country of origin: - Greece

Type of measure: - Financial incentives

Area of implementation: - Transport sector

Description:-

The purpose of the measure is to provide financial and tax incentives to replace old energy-intensive vehicles with new ones and to promote energy-efficient vehicles. It is already implemented in Greece for energy efficiency improvement. The following recommendation has proposed to provide different types of economic incentives: [12]

1. Tax incentives for alternative technology vehicles like natural gas vehicles or hybrid vehicles, and improved engine specifications vehicles. Taxes are adjusted and are calculated based on the engine capacity and the environmental pollution caused by the engine of vehicles. [12]

2. Financial incentives or subsidies for the scrapping of private cars which are energy-intensive to purchase new vehicles with EURO 4 and EURO 5 engines. The amount of subsidy depends on the engine capacity of the vehicle. [12]

The energy-saving can be calculated according to the number of vehicles replaced by the energy-efficient vehicles and the number of energy-efficient vehicles sold into the market. [12]

The required fund for this measure depends upon what level of scale the government wants to implement the measure like only urban area or only rural area or on both of the area. [12]

Reason to implement the measure:-

Financial benefits are always a very good term for implementing any scheme. And if the government has provided it to the public then it always attracts them to follow that scheme. The same thing is with this measure as well. If the government will provide any financial benefits to replace the old vehicles with energy-efficient on then response towards would be great. Also, this measure has the potential to save a huge amount of energy. So to increase the energy savings in transport sector this policy measure could be very effective.

Advantage:-

1. This measure would be very good to promote the use of energy-efficient vehicles in the Czech Republic.
2. The replacement of the energy-intensive vehicle can also reduce the fuel consumption by which the overall fuel requirement and total cost of making and importing the fuel can be reduced.
3. Financial incentives can influence people for buying more energy-efficient vehicles.

Disadvantage:-

1. The energy-efficient vehicle technology is still costly which increases the overall costs of the vehicle, which can make people slightly hesitate for buying them.
2. The financial burden on the government will be more in the beginning.

2. Raising energy efficiency in road transport:-

Country of origin:- Greece

Type of measure:- Informational, organizational, and financial incentives

Area of implementation:- Transport sector

Description:-

The main purpose of this measure is to raise the awareness in the public on their contribution to the problems of climate change and environmental pollution. More specifically, it includes the actions to provide the public with systematic information to ensure the majority of vehicles have lower fuel consumption and lower emissions. The target of the measure is for the majority of vehicles to have improved energy efficiency and lower emissions. [12]

The implementation of this measure is done by using several different sub measures.

1. Vehicle taxation on the CO_2 emissions: - The purpose of the measure is to promote vehicles with lower fuel consumption and lower emissions. Tax is henceforth directly linked with each vehicle's pollutants, namely carbon dioxide emissions. The amount of the tax is calculated by multiplying the CO_2 g/km of the vehicle by the coefficient applicable to each scale. The CO_2 emissions coefficient varies from 0.95 for vehicles emitting up to 100g/km and 2.00 for vehicles emitting more than 250 g/km. [12]

2. Replacing old public and private light trucks: - The objective of the measure is the replacement of old public and private light trucks which meet EURO III standards with new vehicles which meet EURO V standards. Private new technology light trucks (up to 2 000 ccs), bought in place of old ones, will be partially or wholly exempted from the specific registration fee. [12]

   How to measure energy savings:- The target calculation methodology is based on data according to which the specific consumption of old light trucks amounts to 15 lt/100 km, the specific consumption of new technology light trucks is 9 lt/100 km and the average distance covered by vehicles in this category is 25 000 km. Moreover, it is assumed that they are all petrol vehicles and that their replacement will not alter their use. [12]

3. Replacing old private passenger vehicles:- The measure aims at replacing public and private old passenger vehicles which meet EURO III standards with new vehicles which meet EURO V standards. Under the measure, private new technology passenger vehicles (up to 2000 cc) bought in place of old ones will be partially or wholly exempted from the specific registration fee. Old vehicles are sent for scrapping under the approved system for alternative management of End-of-Life Vehicles. [12]

   How to measure energy savings:- The target calculation methodology is based on estimated energy savings based on specific consumption and the average kilometers covered by these vehicles. According to existing data, the specific consumption of old passenger vehicles amounts to 10 lt/100 km, whereas the specific consumption of new technology passenger vehicles is 6 lt/100 km. The average distance covered by vehicles in this category is 15 000 km. Moreover, it is assumed that they are all petrol vehicles and that their replacement will not alter their use. [12]

4. Promotion of CNG and LPG-powered passenger vehicles: - This measure involves the provision of incentives to facilitate the market penetration of private passenger vehicles fuelled by compressed natural gas (CNG) or liquefied petroleum gas (LPG). [12]

5. Introduction of electric vehicles and electric vehicle recharging points:- The measure involves the provision of favorable tax incentives and subsidies for the purchase of electric vehicles of any type for private motorists and public agencies operating vehicle fleets. In addition to the purchase of vehicles, this measure will include a subsidy for the construction of public and private vehicle recharging points, powered mainly by renewable energy sources and/or conventional energy sources. [12]

The required fund for this measure depends upon what level of execution the government wants to implement the measure.

The amount of savings could be different according to the public interest in the Czech Republic. In Greece where this measure is already in work, the saving done in past was about the following amount

1. Replacing old public and private light trucks:- Under this program total of 3 165 TJ energy savings was done between 2014-2020 [12]
2. Replacing old private passenger vehicles:- Under this program total of 19 372 TJ energy savings was done between 2014-2020 [12]

Reason to implement the measure:-

The transport sector of the Czech Republic has undergone an increase in energy consumption in the last few years. So it is necessary to implement such a kind of policy measure which can do huge energy saving and decrease the consumption rate. This measure is the perfect fit for this role as it contains many sub measures. And these sub measures are the steps to implement many perspectives together which increase the effectiveness of this measure.

Advantage:-

1. The vehicle taxation on the emission of CO_2 could decrease the level of pollutants.
2. The trucks are one of the most energy-intensive vehicles, so replacing them with the new energy-efficient version could increase overall efficiency in the transport sector.

Disadvantage:-

1. This measure is the combination of replacement old vehicles, and promotion and the infrastructure development of energy-efficient vehicles, which could require very good level planning and management otherwise the impact of overall measure can be decreased.

3. Fostering integrated and intelligent transport and development of alternative fuels infrastructure on a local and regional level

Country of origin:- Croatia

Category:- Information and organizational measure, infrastructure

Area of implementation:- Transport sector

Description:-

Traffic congestion is becoming a growing problem in cities and it has a great impact on unnecessarily increased fuel consumption. Sustainable development of urban transport systems should therefore be promoted through the following: [13]

1. Optimizing city logistics of freight transport and intelligent management of public parking spaces:- Optimizing the logistics of freight transport poses a special challenge due to the specific features of urban terrain configuration, local market requirements, and suppliers' habits. To actively contribute to energy efficiency improvement in the process of urban logistics of freight transport, the measure will primarily define guidelines for increasing the efficiency of freight transport based on which training for operators of delivery fleet vehicles will be implemented. Cities are preparing guidelines for transporters optimizing the time of the entry of freight and delivery vehicles in city centers. This approach improves the capacity and reduces traffic congestion, especially in peak morning hours. [13]

2. Introducing integrated and sustainable passenger transport:- It is necessary to encourage passengers to use public city transport and combine various means/modules of public city transport. The aim is to encourage as many passengers in urban and suburban transport to switch from personal vehicles to combines public transport systems. The national coordinating body for energy efficiency encourages cities to promote and actively work on solving this problem when drafting and implementing planning documents for energy efficiency. [13]

Examples of activities aimed at integrated and sustainable passenger transport: [13]

- Introducing the option of purchasing a cheaper ticket to use for all public transport and other urban passenger transport services [13]

- Provide information on the status of available public transport services using ICT technologies and/or on-site (bus stops, tram stops, bicycle parking spots, etc.) [13]

- Further development of the urban and suburban network available to a wider circle of users (bus, tram, railway lines, and cycling lines and bicycle parking spots) [13]

- Other measures contributing to motivating users to switch from personal vehicles to public transport systems (enabling cheaper, faster, easier, and more efficient public transport) [13]

3. Intelligent transport management:- Introducing advanced technologies in regulation and management of transport contributes to the reduction of primary energy consumption, as well as the emissions of carbon dioxide and other harmful gases. Some of the proposed activities for introducing intelligent transport management include the following: [13]

    - Upgrading, adapting, and replacing obsolete signaling devices and equipment, [13]

    - Installing advanced traffic equipment and intelligent traffic lights with an autonomous system of energy supply from renewable sources (the Sun, the wind), [13]

    - Constructing and equipping central operational centers for the surveillance and management of intersections with traffic lights, [13]

    - Connecting existing and future systems of advanced regulation of intersections with intelligent traffic lights in cities (systems of advanced regulation of intersections with intelligent traffic lights). [13]

    - Intelligent management of public parking spaces (ICT technologies) establishment of simple tracking of current availability of parking spots on public parking spaces and in garages. [13]

4. Introducing a car-sharing scheme:- Based on the experiences of the Member States of the European Union, the practice has shown that one vehicle in a car-sharing scheme substitutes 4–8 regular (personal) vehicles on roads. To implement a car-sharing scheme, as one of the measures of increasing energy efficiency in transport, the successive introduction of a minimum of 100 electric and/or plug-in hybrid cars a year into the scheme in the largest cities is proposed by 2020. This measure also has an indirect effect on the environment like it shall lead to a reduction in the

number of cars on roads, unburdening of parking spaces in city centers, reduction of the emission of pollutants and in fuel consumption especially fossil fuels. [13]

5. Development of alternative fuels infrastructure on a local and regional level:- The aim to include this measure is for the development of the alternative fuels infrastructure in their action and annual energy efficiency plans. Some of the proposed activities for the development of alternative fuels infrastructure on a local and regional level: [13]

   Parking spots: - It is necessary to introduce the possibility of privileged parking for zero-emission vehicles or of limiting the access to a parking spot for vehicles with internal combustion engines. To implement the measure, it will be necessary to define guidelines based on which decisions can be made on exemptions or discounts for using the public parking service for eco-friendly vehicles. [13]
   Clean traffic zones:- Similarly to the introduction of privileged parking for zero-emission vehicles, it is suggested that a ban be introduced on traffic of all vehicles other than zero-emission vehicles through the central parts of cities and that zero-emission vehicles be allowed in parts of cities that currently have a ban on all vehicles other than public transport vehicles. [13]

The effects of this measure will be recorded individually by projects, using the proscribed top-down methodology with supplement/developing new bottom-up methodology, if necessary. [13]

Also, the amount of saving was done by this measure in Croatia is shown below, from which we can estimate the amount of saving possible by this policy but it again depends on the level of execution of the program in the country. [13]

1. Intelligent transport management: 201 TJ
2. Introducing a car-sharing scheme: 9.3 TJ
3. Introducing public city bicycles and acquiring cycling parking infrastructure: 0.5 TJ

Reason to implement the measure:-

The intelligent transport system is one of the best ways to decrease energy consumption. Implementing this system in the Czech Republic could increase the awareness in public. In the large cities where the amount of people is more, this measure could be the perfect fit

and possibly save large energy.

Advantage:-

1. The very large level of policy measure containing different sub measures, by which more focus on a different area of the transport system.
2. Transportation of logistics is the area where the energy consumption is very large. So optimization of it could be very effective.
3. In big cities, parking is the big problem now, so by intelligent parking system a person can directly find the parking spaces which possibly save the fuel

Disadvantage:-

The measure is very good and effective but including technology on it could make it financially very expensive

4. Green Tire

Country of origin: - Portugal

Type of measure: - Introductory and awareness

Area of implementation: - Transport sector

Description:-

This measure intends to increase the market introduction of energy-efficient tires, with low rolling resistance, and the reduction of passenger vehicles that are circulating with the wrong tire pressure. This measure is divided into two: Efficient tires and Right pressure tires [14]

Efficient tire: - It is estimated that the sub-measure efficient tires will produce a fuel consumption average reduction between 1 and 2%. This Regulation intends to increase the sale of energy-efficient tires, through the quality improvement of the information that's available about these products, namely the ones concerning fuel consumption reduction and vehicle security increase. Furthermore, with collaborating the sector associations and tires manufacturers is the advantages of the use of more efficient, safer, and with lower noise emissions levels tires. [14]

Right pressure tire:- The Right pressure tires sub-measure intends to reduce the number of passenger vehicles that are circulating with the wrong tire pressure. The number of vehicles that can be covered by this measure is projected to be high. The fuel consumption increase due to the vehicle circulation with the wrong tire pressure is estimated to go from 1 to 2.5%. The mechanisms implemented along with this measure should essentially be campaigns to promote the use of the correct tire pressure and its calibration, as well as incentives to the periodic tire pressure check. [14]

In Portugal, the amount of approx estimated saving done by this measure is 90 TJ by efficient tire technology and 70 TJ by right pressure tire technology. [14]

Reason to implement the measure:-

Not many people in the country know that by putting on efficient tires they can contribute to the energy-saving program of the country. This measure is the best example of it. If just by putting the right pressure and efficient tires to the cars and public vehicles could save huge energy then it is a very effective and easiest way to promote energy saving. Also, it doesn't require a huge amount of investment by the government which can make the work easy. Just adding campaigning and financial incentive could increase the popularity of this measure.

Advantage:-

1. It is a kind of very new policy measure which is not required very much funding and very effective as well.
2. Vehicle security can be increased and the level of accidents can be decreased.
3. Fuel consumption can be decreased.

Disadvantage:-

A very less percentage of the population is aware of the saving through changing the tire with an efficient one so a good amount of promotion is needed.

5. Incentives to use bicycles

Country of origin: - France

Type of measure: - Financial incentive

Area of implementation: - Transport sector

Description:-

This measure aims to encourage cycling as a means of daily commuting. It aims to change behavior to reduce pollutant and greenhouse gas emissions during commutes: [15]

The bicycle kilometrage allowance can be decided by the government. Also, employers can volunteer to cover all or part of the costs incurred by employees who use bicycles for their commutes. The Ministries of the Environment and Housing of France have paved the way for this measure to be implemented within the civil service. [15]

The tax reduction for businesses making a fleet of bicycles available to their staff was created in France. Businesses subject to corporation tax may benefit from a tax reduction equal to the costs incurred in providing their employees, free of charge, for their travel between their home and workplace, with a fleet of bicycles, subject to a limit of 25 % of the purchase price of the said fleet of bicycles. [15]

In this way, the use of the bicycle in the daily commuting within the company employee will be increase which will contribute towards the energy efficiency improvement. [15]

The allowance is set in France is at EUR 0.25 per kilometer traveled. This allowance can be different in the Czech Republic according to the public interest. [15]

Reason to implement the measure:-

Increase the use of the bicycle is one the best way to save energy and decrease the environmental pollution**.** And if the government could provide incentives for using it then it could increase the daily percentage of people who can commute via bicycle. If government provide the incentive for using bicycle then it doesn't affect financially to the government because the amount of cost-saving by reducing the fuel consumption is higher then the total incentives amount overall.

Advantage:-

1. The use of the bicycle in daily commuting within the companies will be increase.
2. Investment cost could not very high as compared with the other measures.

Disadvantage:-

For the long distances the people will have use their cars instead of the bicycle which can be limit of this measure.

6. Improving the environmental performance of aircraft

Country of origin: - France

Type of measure: - Information and organizational measure

Area of implementation: - Transport sector

Description:-

The environmental performance of aircraft is already a core priority of the aeronautical industry, particularly in terms of designing aircraft with ever lower CO_2 emissions. The considerable technological research efforts made in the past have resulted in a very significant improvement in the environmental performance and energy efficiency of aviation. As a result, over the last five decades, the unit fuel consumption of aircraft and the associated CO_2 emissions has been reduced by 70 % to 80 %. However, to further reduce the environmental impact of aviation, despite the sector's growth in the coming years, air transport stakeholders have committed to ambitious emissions reduction targets. [15]

At the international level, the Committee on Aviation Environmental Protection (CAEP), which is part of the International Civil Aviation Organization (ICAO), has adopted a recommendation on developing the first global CO_2 emissions certification standard for aircraft. This standard will apply not only to new types of aircraft from 2020 but also, from 2023 to new deliveries of aircraft that are already in production. From 2028, all aircraft produced must comply with the level of stringency required by the standard. The standard will apply to the entire fleet (large aircraft, regional aircraft, and business aircraft) with levels of stringency and dates of applicability adapted to the various types of aircraft. This CO_2 emissions standard will help to improve the environmental performance of the fleets used by the airlines, by gradually removing the most polluting aircraft and encouraging manufacturers to design aircraft that are ever more efficient in environmental terms. [15]

The funds required for implementing this measure will may high because the cost of changing parts or aircraft itself is very high and a very high amount of energy will be expected to be saved by using this measure.

Reason to implement the measure:-

As we know that the aircraft is one of the most energy-intensive ways of transportation as it required a huge amount of fuel. But it is a very necessary way of transportation all over the world so we can not restrict it. But improving its environmental and energy performance could the best way to limit fuel consumption. Also by improving the performance many cost benefits will open for airlines and the government. So this measure is very effective and gives long-term benefits.

Advantage:-

1. CO_2 emission will get decrease.
2. Fuel consumption will decrease.
3. Improve overall environmental performance in the aviation industry.

Disadvantage:-

A high amount of investment is needed initially.

7. Systematic energy management in the public sector

Country of origin:- Croatia
Category:- Information and mandatory information measures
Area of implementation:- Public sector

Description:-

The objective of the project is to apply a model of continuous and systematic energy management, strategic energy planning, and sustainable management of energy resources at the local and regional level, which would contribute to reducing the consumption of energy commodities and consequently reducing harmful gas emissions, which encourages the development of new activities and entrepreneurship. [13]

The other objective of the measure is to introduce, implement and verify measures of

systematic energy management in public administration. Systematic energy management is carried out through four segments: [13]

1. Collection of relevant data: - Collection of relevant data on the consumption of facilities owned and used by the public sector and public lighting by designated persons and via the remote measurement system through the national energy management information system. [13]

2. Analysis of collected data: - Analysis of collected data indicates the potential for energy savings and related economic savings. This defines the priorities and allows strategic planning. Based on these analyses, several national programs will be implemented. [13]

3. Reporting and verification: - The purpose of the collection of data is the possibility of reporting results obtained via analysis and valorization of energy efficiency measures through different segments. [13]

4. Technical support and education:- From the above, all steps the provision of technical assistance regarding energy efficiency measures in form of preparation of technical documentation as well as educating public sector employees through specialized courses and workshops would be possible. [13]

Reason to implement the measure:-

Management is the best way to improve the system's efficiency. If we implement a management system in the energy sector then it could be a great combination. This measure is effective as it works on the management of energy resources. By managing the use of energy resources and their consumption, we can improve the environment and save energy as a dual partnership.

Advantage:-

1. The energy management system is proven as a very efficient method for energy saving.
2. Through the real-time data, the loopholes in the system can be identified.

Disadvantage:-

It required a very huge funding and very effective man power to perform the tasks.

8. Switching off the illuminated signage and advertisements at night

Country of origin: - France
Type of measure: - Lighting related measure
Area of implementation: - Public sector

Description:-

This measure is applied to all installations and all-new illuminated signage and advertisements in France, which must be switched off between 01:00 am to 06:00 am. The implementation of this measure represents a substantial source of energy savings and will allow a saving of around 800 GWh each year for signs and more than 200 GWh for advertisements. [15]

On 1 July 2013, the order regulating how long certain lighting installations can remain switched on entered into force to prevent energy wastage and reduce light pollution in France. The Order lays down a general switching off a rule that is applied in various ways depending on the type of lighting in question: [15]

1. The interior lighting of buildings for professional use must be switched off one hour after the premises have been vacated. [15]

2. Building facade lighting must be switched off no later than 01:00 am. [15]

3. Shop window lighting or window display lighting must be switched off no later than 01:00 am or one hour after the premises have been vacated, whichever occurs later. [15]

Rules governing when this lighting can be switched back on are also laid down:

1. Shop window lighting or window display lighting can be switched back on from 07:00 am or one hour before the start of the activity, whichever occurs earlier. [15]

2. Building facade lighting cannot be switched on before sunset. [15]

There is no such kind of special fund is required for implementing this measure and the amount of savings were done by this policy measure is 2 880 TJ each year from signs and more than 720 TJ from advertisements in France. [15]

Reason to implement the measure:-

This is one of the best measures in all of the proposed measures. The reason is by just performing simple tasks a huge amount of energy savings will be done. The advertisement and signboard need a considerable amount of energy to illuminate at night. And if we see from the energy-saving side the amount of saving is a higher than many other measures and also advertisement and signboards are not the very important thing which we have to keep on at the night. So that's why its importance is very much.

Advantage:-

1. This is a very simple kind of policy measure as it doesn't require any special funding.
2. Energy-saving can be done most easily.
3. Amount of saving is much higher then many other measures

Disadvantage:-

This measure could be oppose create by the companies who own the sign and ad board.

9. Awareness-raising campaign on environmentally friendly practices

Country of origin: - France
Type of measure: - Informational and digitalization
Area of implementation: - Public sector

Description:-

This measure aims to raise the awareness in the public about practices allowing them to reduce their day-to-day electricity consumption, particularly during cold periods. Practical advice can be available over the internet, supplemented by a radio spot. A survey conducted among 1000 people in France revealed that advice to moderate consumption during the cold snap was largely heard, and heeded by over half of the population (52 %). At work, 59 % of people took action to reduce their electricity consumption during the cold snap. There are different types of schemes to implement this measure. [15]

1. The Eco-Watt scheme:- It involves an alert system (by email or SMS) to encouraging the reduction of electricity consumption in those regions which are most threatened by electricity cuts during winter cold snaps. [15]

2. Private individuals and eco-citizens:- It offers information and advice to private individuals on making their day-to-day lives more environmentally friendly on the government website. It can be structured around moments in the lives of people; these pages provide very specific information and explanations that are accessible to everyone. Every week a topical report is published for users to read. These pages offer users a variety of tools, such as practical guides, videos, graphics, and links to further information. The most visited sections are: 1) How to finance my project; 2) My home; 3) My waste. [15]

The amount of funds required for this policy measure depends upon the individual government and the amount of savings were done by this policy measure in France is 10 to 15 TJ per year. [15]

Reason to implement the measure:-

Public awareness is very important to adopt any regulation or scheme. This measure does the same with digitalization. It can be adopted in the area where power shortage is high. By using the online information campaign the public awareness could be increase and also people will get know about their bills and how to reduce them.

Advantage:-

Awareness about savings in the home in daily electricity consumption will increase.

Disadvantage:-

The amount of savings done is very small compared with other policy measures.

10. Waste recycling

Country of origin: - France

Type of measure: - Recycling

Area of implementation: - Public sector

Description:-

This measure allows a significant energy saving and also allows natural resources to be preserved by re-using the materials in waste, and energy consumption, greenhouse gas emissions, and consumption of water linked to industrial production to be reduced. For example, the production of secondary aluminum consumes only 5 % of the energy needed to produce primary aluminum. The recycling statement for France produced that, in 2014, 15 million tonnes of recycled material were incorporated in the production of 36 million tonnes of five materials (steel, nonferrous metals, paper and cardboard, plastic, glass). This recycling has in particular allowed the following savings: [15]

1. Total 18.7 million tones of CO_2 equivalent, i.e. around 3.6 % of French annual gross emissions. [15]

2. Total 158 million m^3 of water, i.e. around 2.9 % of the French annual net consumption. In terms of energy savings, this study shows that, in 2014, waste recycling allowed around 100 TWh to be saved, i.e. around 8.6 Mtoe. [15]

Lastly, the intensification of material recycling indirectly results in the generation of sorting residues or residues from industrial processes to prepare for recycling. Certain fractions are too small and too mixed to extract recyclable materials from them. As a result, the industrial sorting of packaging and paper, previously separated at source by households, generates around 15 % to 20 % of recycling rejects that must be disposed of. This type of waste can be used for heat recovery, with differing efficiencies in terms of energy generation. The search for energy efficiency can result in solid recovered fuel being obtained, which will then be used to replace fossil fuels (in the cement industry; as a source of power for urban district heating networks). [15]

The total energy savings were done by this policy measure is 360 000 TJ. [15]

Reason to implement the measure:-

Waste management is a very important term nowadays, because of the increasing amount of different types of wastes. The measure will do two things together, waste management and energy savings. As we know that for making any product energy is needed. But recycling or waste management requires the half amount of energy to reproduce that product. So effective waste management is necessary and has great potential to save energy.

Advantage:-

1. A total of 3 problems can be solved by implementing this measure; reduction in CO_2 emission, waste recycling, energy-saving.
2. The amount of energy saving is very high

Disadvantage:-

No such huge disadvantage of this policy measure.

11. PV School and Kindergarten

Country of origin: - Austria
Type of measure: - Financial incentives
Area of implementation: - Public sector
Description:-

This measure aims to provide provincial subsidy for photovoltaic systems in Austria's schools and kindergartens that has enabled the installation of photovoltaic and it also supported the topics of green electricity and saving electricity at school and kindergarten. Grid-connected photovoltaic systems with 3 kW output which were newly constructed in Austrian schools were subsidized in this initiative. [16]

In total, it involves over 360 schools with a total installed output of over 1 100 kWp. Within the scope of the program, there was a series of measures for teachers which were intended to help them to incorporate the subject in their lessons, such for example the training seminar "PV for teachers", conferences relating to the subject of photovoltaics, teaching materials, and a technology box produced by the Energy Agency on the subject of "solar energy and energy-saving" for primary schools. [16]

A total of 1500 euro/kW is provided by the Austrian government for the implementation of this program, but it can differ in the Czech Republic according to the interest level. This program saves approximately 80 TJ/year of energy in Austria. [16]

Reason to implement the measure:-

Solar power schools and kindergarten is a kind of thing which may be implemented

somewhere in the country. But it is not a very usual thing that we are seeing everywhere. Every building can implement the solar system on it, and in schools, it has dual benefits as energy generation for schools is free and also the education about the solar energy can provide to the primary to higher standards students easily. This is the reason that makes this policy measure considerable effective.

Advantage:-

1. Very good use of the public property by implementing the solar system on it.
2. Also, knowledge about energy savings and renewable energy sources can be provided to the students easily.

Disadvantage:-

No possible huge disadvantage of this policy measure.

12. Energy efficiency of cowsheds and pig farms

Country of origin: - Finland
Type of measure: - Finance and investment
Area of implementation: - Agriculture sector

Description:-

This measure aims to promote construction relating to agriculture, other rural business, and rural living, as well as developing the rural built environment. The goal is to create economical and functional livestock production buildings that provide a high level of animal welfare and a good rural environment. Means of reaching this goal include construction steering, cooperation between public authorities, and research and development. [17]

The Finnish Ministry of Agriculture and Forestry promotes the use of materials and renewable natural resources in construction, by means such as investment subsidies. It encourages the use of renewable forms of energy and energy efficiency, and grants subsidies towards the construction of unheated livestock shed where these do not compromise animal welfare. Cows generate a considerable amount of heat. No such type of special heating is required in cowsheds. Other areas such as milk processing areas and staff facilities do require heating, but this can be arranged using heat generated when

cooling milk, heating plants built for other purposes, or electric radiators. Calving pens may require additional heating. Electricity consumption attributable to ventilation on farms with adult animals can be lowered utilizing curtain solutions and natural ventilation, and the amount of electricity needed for lighting can be reduced utilizing curtain solutions and skylights. The thermal energy contained in liquid manure gutters on pig farms can be recovered and used to heat pig production facilities or staff facilities. The net saving amounts to approximately one-third of the thermal energy contained in manure in Finnish conditions. Lowering the temperature of manure also helps to prevent the evaporation of gaseous nitrogen compounds, which reduces the need for ventilation, as well as mitigating harmful climatic effects. Total 42.12 TJ of savings were done by this policy measure. [17]

Reason to implement the measure:-

The agriculture sector is also one of the energy-intensive sectors and also there is a bright sign of energy savings. To promote and construct the infrastructure for energy savings in cows, pigs, and other animals shed could save a considerable amount of energy and also make that structure energy efficient.

Advantage:-

The overall efficiency of cowsheds and pig farms will be increase and the potential of energy saving is very high by using the ways mentioned in the policy measure.

Disadvantage:-

No such huge disadvantage of this policy measure**.**

13. Energy declarations

Country of origin: - Sweden
Type of measure: - Information and organizational measure
Area of implementation: - Household sector

Description:-

Energy declarations contain information about the building's energy consumption and are aimed at prospective house buyers or tenants. Through the information of energy declaration, buyers will aware of the energy consumption so that it is taken into account at

the time of purchase. An energy declaration must be drawn up for a building at the moment of sale, rental and new construction as well as for larger buildings frequently visited by the public. The energy declaration in Sweden is issued by an independent expert commissioned by the owner and is valid for ten years. Declarations have now existed for ten years and there are a total of approximately 632,000 buildings with energy declarations registered in the Swedish National Board of Housing, Building, and Planning database. [19]

Reason to implement the measure:-

Energy declaration is a very small topic ahead of the other measures but still a very effective one. When someone is buying the house or rent the house and if they know about the higher energy consumption of that building then they can push the seller to make changes in energy appliances to decrease the energy consumption. So all the owners will indirectly get aware of the energy declaration and to sell or rent the house they will make changes in the energy appliances, which could automatically increase the energy savings.

Advantage:-

Increase the awareness among the house buyers about the energy consumption of the house.

Disadvantage:-

No such huge disadvantage of this policy measure

14. Electricity-saving project for low-income households

Country of origin: - Austria
Type of measure: - Information and organizational measure
Area of implementation: - Household sector

Description:-

Energy costs are increasing day by day and low-income households often have old and therefore inefficient heating appliances and electrical appliances, but do not have the financial resources for a switch to modern, energy-efficient appliances. Energy consumption and therefore also energy costs often bear no relation to the size of the living

space or the income situation. Low-income households often have above-average electricity consumption. To implement this measure, a project can conduct to distribute energy-efficient appliances and permanently reduce the electricity costs of low-income households. In addition, low-income households were given a free and individual energy consultation by an adviser with tailored tips and hints about how energy costs can be reduced by way of organizational measures (i.e. without having to invest themselves). If a corresponding need was identified in the context of the energy consultation, there can be a subsidy from the government of up to some money per household for the replacement of an electrical appliance with an efficient new appliance (fridge, freezer, washing machine). This measure has the potential to save around 20 TJ of energy per year according to the Austrian government. [16]

The required fund can be calculated differently in each country. In Austria government provide 250 Euro for a replacement for the electrical appliances.

Total required fund = Subsidy amount * number of households interested in the scheme [16]

Reason to implement the measure:-

The lower-income households are the most suffered one from the high bills due to the not affords efficient appliances for energy. So if the goverment could help them to implement the energy efficiency appliances then there could good both parties, as households get the energy-efficient appliance and reduce their bills. And government could save energy as well.

Advantage:-

1. Make access to energy-saving appliances among the lower-income household.
2. Decrease the electricity bill of lower-income households, which possibly affect positively into their monthly expenses.

Disadvantage:-

If the cost of the appliance is greater than the subsidy amount then an extra charge has to pay by the lower-income households.

15. Housing Aid for Older People

Country of origin: - Ireland

Type of measure: - Financial aid

Area of implementation: - Household sector

Description:-

This measure aims to provide housing aid for older people. As per this measure, the Irish government provides grants of up to €8,000 to assist older people living in poor housing conditions to have necessary repairs or improvements carried out. Grant-eligible works include structural repairs or improvements, re-wiring, repairs to or replacement of windows and doors, provision of water supply and sanitary facilities, provision of heating, cleaning, and painting. [18]

Reason to implement the measure:-

Older people who live alone are also in the same condition as the lower-income households. So giving financial aid to them to improve the condition of their house can improve their quality of life and also save energy by changing the inefficient appliances.

Advantage:-

Increase the life quality of older people and also increase the energy efficiency of the house.

Disadvantage:-

No such disadvantage of this policy measure**.**

16. Mandatory installation of solar thermal systems in new residential buildings

Country of origin:- Greece

Type of measure:- Mandatory regulation

Area of implementation:- Household sector

Description:-

This measure is adopted in Greece in the household sector. These measures focusing on the installation of solar thermal systems in under-construction buildings which will replace 50-100 % of conventional fuels and electricity, depending on the climatic conditions in each

area, the load, and the position of the building. Also, the use of solar thermal systems can cover the part of hot water needs in the country. The minimum percentage of the solar share on an annual basis is set at 60 %. This program was started in November 2020 and will offer substantial support to the improvement of energy efficiency and renewable in residential buildings. There is a measure related to the installation of solar thermal and photovoltaic systems named The Green Savings program, which is not specifically only focused on the solar system but also on other areas like implementing biomass system and increase the energy performance in the building. So there might be a possibility to implement one specific program which is only focused on the installation of the solar thermal system in the Czech Republic to increase the share of solar energy and to contribute to energy efficiency improvement. The expectations regarding this program are quite positive, with an estimated 60 000 families expected to install a solar thermal system under this specific program in Greece during 2021. A total of 40 000 EUR is invested in this program by the government of Greece. [12]

Advantage:-

1. The share of renewable energy sources will increase in energy efficiency improvement.
2. Cost of electricity bill in-household can be decreed.

Disadvantage:-

1. The initial cost of implementing the solar system is very high, so the need for financial aid or subsidy to promote the scheme.
2. Also, solar energy is not very accessible during winter in the Czech Republic.

Reason to implement the measure:-

As we know that solar energy system is one of the most effective manners of renewable energy sources. If we mandate the installation of the solar thermal system in new construction then it could have huge potential to save energy and improve the overall efficiency of the new house.

17. Energy audits in industry

Country of origin: - Finland
Type of measure: - Energy audit
Area of implementation: - Industrial sector

Description:-

An energy audit includes an evaluation of current energy and water consumption, an examination of potential energy-saving measures, an estimation of their saving effects, and reporting. Energy audits are carried out by consultants who are trained and certified for taking energy audits. Three different energy audit templates are available in the industrial sector: industrial energy audit, industrial energy analysis, and two-stage energy analysis for the process industry. [17]

Reason to implement the measure:-

Energy Audit is one of the best manners to survey the energy performance of any industrial unit. An energy audit is there in the Czech industries but it is not included as the measure in the energy efficiency plan. So by implementing this measure and mandate the energy audit potential of new savings will come out.

Advantages:-

1. Improve the energy efficiency in the companies
2. Awareness about energy efficiency will be increased.

Disadvantage:-

No such huge disadvantage of this policy measure

18. Energy efficiency agreement for businesses – energy services/own operations

Country of origin: - Finland
Type of measure: - Information and organizational measure
Area of implementation: - Industrial sector

Description:-

This energy efficiency agreement scheme has been an important element of Finland's

electricity sector since 2001. A total of 95 businesses and their more than 130 offices have joined the energy services action plan associated with the energy efficiency agreement for businesses. Businesses that have joined this action plan is represented almost 90 % of Finland's electricity distribution businesses, just over 90 % of all electricity sales, and 86 % of all district heating sales. Businesses that have signed the energy efficiency agreement have to submit annual reports, via a web-based monitoring system, on measures aimed at increasing the energy efficiency of their customers, as well as on their energy consumption, any energy-saving measures implemented, and progress made with their other contractual obligations. [17]

Reason to implement the measure:-

Connecting the businesses and offices for energy efficiency improvement is a great scheme. By connecting them all the energy efficiency transparency will increase and their aim will pin out towards increasing the energy efficiency in their product will come out.

Advantage:-

Connectivity between big businesses and small businesses will increase, which is good for their sharing knowledge of energy efficiency technologies between them.

Disadvantage:-

No such huge disadvantage of this policy measure.

4.2 New Efficient technologies

1. Platooning:-

The possible future gain in transport energy efficiency is "platooning". Platooning refers to operating two or more vehicles at high speeds with a small enough gap between them to reduce drag losses. In road freight, trucks that are equipped with state-of-the-art driving support systems can form a "platoon", guided by smart vehicle communication and automation technologies. Platooning of freight trucks could improve highway fuel economy by up to 10-25 %. [9]

The truck at the head of the platoon acts as the leader, with the vehicles behind reacting and adapting to changes in its movement – requiring little to no action from drivers. In the

first instance, drivers will remain in control at all times, so they can also decide to leave the platoon and drive independently. As well as the sensors found on most modern vehicles, additional types of sensors are crucial for platooning. Radar-based collision mitigation systems precisely detect the distance from one truck to another as well as other objects and obstacles on the road. These sensors can track everything around the vehicle simultaneously, 50 times per second.GPS sensors are also used to track the location of individual vehicles within the platoon. They also provide information about the platoon's location relative to hazards or obstacles that might slow the journey or increase fuel consumption, such as traffic congestion. [9]

Why adopt the technology?

As we have seen in previous chapters that the energy consumption of the transport sector in the Czech Republic has increased over the year. So to decrease consumption it is necessary to implement new measures and adopt new technologies. We have seen the policy measure related to the intelligent transport system in the previous chapter. And Platooning is considered as the type of intelligent transport system. It contains the different types of sensors and radar-based systems which will enhance energy-saving in transport. Also, it will help to reduce the traffic problems created by the heavy trucks and also the accidents will reduce because of technology-based driving system.

2. Block chain:-

Blockchain is a system of recording information in a way that makes it difficult or impossible to change, hack, or cheat the system. A blockchain is essentially a digital ledger of transactions that is duplicated and distributed across the entire network of the computer system on the blockchain. Each block in the chain contains some transactions, and every time a new transaction occurs on the block, a record of that transaction is added to every participant's ledger. The decentralized database managed by multiple participants is known as Distributed Ledger Technology (DLT). [9]

In the buildings sector, blockchain could simplify the process of establishing energy performance contracts involving multiple parties (customers, utilities, financial institutions) and reduce administrative costs. As a secure ledger of transactions, blockchain could also support the creation of digital building energy performance certificates,

increasing building owners' confidence that their building energy performance rating matches the physical properties of the building. It could also greatly improve the traceability and transparency of white certificates and other tradable certificate programs.[9]

In transport, DLTs including blockchain could support the delivery of emerging mobility services in cities, including Mobility as a Service, by allowing users to enter into direct relationships with each other with a high degree of trust without having to go through a central authority. In freight transport, a blockchain could help better match freight capacity with demand, ensuring vehicle loads are maximized. Also, storing customs information in a digital ledger could reduce paperwork associated with border crossings, as well as time spent in transit and the associated risks of spoilage (of temperature-controlled goods, for example). In industry, blockchain could be used to record data on inputs (including energy inputs) at every step along a supply chain. This would allow energy managers, or environmental impact assessors, to identify ways to minimize wastage and maximize efficiency. Blockchain may also have implications for energy efficiency policy. Case studies from Italy and the United Kingdom show that blockchain could improve white certificate schemes by increasing transparency and speed while reducing transaction costs. [9]

Why adopt the technology:-

Blockchain is an emerging technology that can work in different sectors to do multiple things. As we need such kind of technology which can work in the different sector not only bind to do one work. It works digitally to do many energy savings tasks like recording the data related to the supply chain in the industry which will help to reduce wastage of energy, improve the energy certificate schemes by fast speed and with transparency. And also it is very difficult to hack the system of blockchain which improves work effectiveness.

3. Intelligent building energy management

In a traditional building energy management system, networked sensors and controls collect data from heating, ventilation, and air-conditioning, from thermostats, networked lighting systems, room occupancy sensors, and/or other building technologies. These data

are then displayed on a standard dashboard for a building energy manager or facility manager, for example, who can make decisions that improve the energy or operational efficiency of the facility.[9]

A smart building energy management system combines data from a traditional building energy management system with other data sources (for example weather conditions, planned staffing levels or traffic patterns affecting staff arrival times, patient operation scheduling, lecture hall times, etc.) These data are then analyzed using advanced software, incorporating AI algorithms.[9]

The Artificial Intelligence in these systems generates much larger quantities and ranges of real-time, actionable insights than traditional building energy management systems can. For example, a smart building energy management system can provide intelligence on when a building should operate certain systems to maximize the consumption of renewable energy, while also balancing building occupants' comfort requirements.[9]

An AI-enabled smart building energy management system can also forecast how a facility is likely to "behave", based on patterns identified in historical data such as weather, occupancy rates, and energy prices. These predictive capabilities open up the possibility of buildings providing their flexible load to the grid, a process the software can also manage automatically. This results in not only more efficient buildings but also a more efficient grid, as flexible load resources can reduce the curtailment of renewable energy sources and shave peaks in demand. [9]

Why adopt this technology:-

The building energy management system is very popular in recent times in many countries. It is based on the digitalization of household electrical appliances and connects them to get data related to energy. And potentially it saves a huge amount of energy by doing small things. In the Czech Republic, the government has to invest in this technology and by some campaign or use of the internet, they have made it popular so people who can afford it can implement it in their house. In this way beyond the conventional ways of energy saving by heating, cooling, and reconstruction can get more support by this kind of technology.

4. 3D printing in the construction sector

3D printing, or additive manufacturing, is a computer-controlled technology that processes digital instructions to build objects by depositing consecutive layers of material. 3D printers are a good example of a technology that bridges the gap between data-driven analysis and the physical world to achieve real gains in energy efficiency. Every 3D-printed object begins as a software-generated digital model. The 3D printer itself uses these models as instructions for "printing" an object in 3D.[9]

Building construction is one area where 3D printers are beginning to show great promise for efficiency gains. Construction waste and the quantity of raw material required for construction can be reduced by up to 30 % through the use of 3D printing. Reducing construction waste could improve the energy and carbon footprint of the construction industry, as building materials such as bricks and cement are energy and carbon-intensive and the cement industry is the second-largest industrial sector emitter of CO_2, producing 7 % of total energy-related CO_2 emissions.3D-printed buildings may also save energy during a building's use. Accurately reproducing digital models as printed buildings, relying less and less on human intervention, reduces building defects such as cracks, leaks, and other common problems in the integrity and envelope of buildings, which compromise air-tightness and energy performance. 3D printing also opens up the possibility of improving efficiency through design, producing highly efficient building geometries that are often avoided using traditional construction methods due to their complexity and cost. For example, designs that avoid unnecessary joins are more air-tight, improving energy efficiency by reducing heat losses while others take advantage of natural resources to enable passive heating, cooling, lighting, and natural ventilation.[9]

3D printers have several advantages over conventional manufacturing, including reductions in lead time, reduction of scrap materials, lower inventory costs, less manufacturing complexity, reduced floor space, and the ability to deliver manufactured pieces with complex shapes and geometries that can optimize material efficiency and weight. One of the key advantages of 3D printers from an energy efficiency perspective is that they can receive instructions remotely, allowing industrial process engineers and building construction managers to change printers' actions and outputs without having to spend time, energy, and resources traveling to industrial plants or building sites to retool production lines. [9]

Why adopt the technology:-

During the construction of any house they energy waste is a normal thing. But if the technology can use for construction then it can surely reduce the waste of energy and 3D printing in construction is one of the technology among it. Of course by using technology the accuracy of work will improve and also the construction waste will reduce. Which can save a numerous amount of energy.

5. Virtual assistants and smart speakers

Virtual assistants, including Amazon's Alexa, Google Assistant, and Apple's Siri, are now present in many homes, owing to their integration into smartphones and other smart devices such as smart speakers. Smart speakers – voice-controlled speakers with integrated virtual assistants are growing rapidly in popularity: expected sales of around 94 million in 2019 are forecast to increase the installed base to more than 200 million in 2019, growing to 500 million in 2023. [9]

Increasingly, virtual assistants are being recognized for their potential to boost household energy management. Several utilities in the United States, Canada, and the United Kingdom are now delivering information to customers on their energy use, account balances, electricity outages, as well as allowing customers to make payments via virtual assistants. Virtual assistants could also be an effective interface for increasing energy efficiency, and some utilities are now using them to provide consumers with energy efficiency tips. However, much of the advice provided to consumers tend to be generic, and the more sophisticated uses of virtual assistants to improve energy efficiency are still largely untapped. For example, virtual assistants could provide consumers with tailored information about available energy efficiency rebates; help them to take advantage of time-of-use tariffs; permit utilities to access households' smart devices as part of a demand-response program, or even walk them through a virtual energy audit.[9]

Why adopt this technology:-

Virtual assistance is one of the most effective ways to save energy. As we have seen in our home that some time we are very lazy to even switch off the bulb which leads us to energy wastage. So by implementing virtual assistance this kind of situation can be avoided and people will encourage more to save energy.

Conclusion

This thesis has examined the energy efficiency performance of the Czech Republic and compares it with the other countries of the European Union. Attention has been paid mainly to the primary and final energy consumption of the Czech Republic and its comparison with the European Union's member states, energy efficiency policy measures in the Czech Republic, energy efficiency targets for the future, and methods to improve energy efficiency in the Czech Republic. With the data and information available in the thesis, the following two points are making stands very clearly,

1. After analysis of energy performance, it is very clear that the Czech Republic's overall energy consumption is reduced in the past 10 years which means that energy efficiency is increased.
2. Also, the Czech Republic is constantly moving forward to achieve the energy efficiency targets set by the European Commission for the year 2030 and the Czech Republic has already achieved the targets of primary and final consumption for the year 2020 back in 2018.

The structure of the policy measure in the Czech Republic is very organized and covers most of the areas which are energy-intensive in the different sectors but there is always a need of adopting something new which will lead you to the targets very efficiently. Despite the good overall structure of policy measures and very good results in target achievement, there has been a lack of policy measures in the transport sector. There is a total of 4 policy measures observed in that sector which is not enough to use the potential of energy saving in the transport sector as this sector is one of the most energy-intensive countries that need to implement more policy measures to increase the percentage of savings. Also, the lack of actions was noted in different fields like waste management, and agriculture. This analysis of lack of actions is not end in itself but it underlines the weak point more apparent of energy efficiency policies present in Europe. The final section which is methods to improving energy efficiency is, therefore, more focused on the improvement in these weak points. There are many proposed policies from the different European countries which can implement in the Czech Republic that were presented in that section and it may cover all the weal point in policy measure structure. Although, some of the policy measures are

financially very expensive to implement, and also some other drawbacks are there. So it depends on the government to choose the most appropriate policy measures from it and make the structure for energy efficiency more strong.

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