REVIEW OF CLIMATE POLICIES OF SELECTED EUROPEAN COUNTRIES

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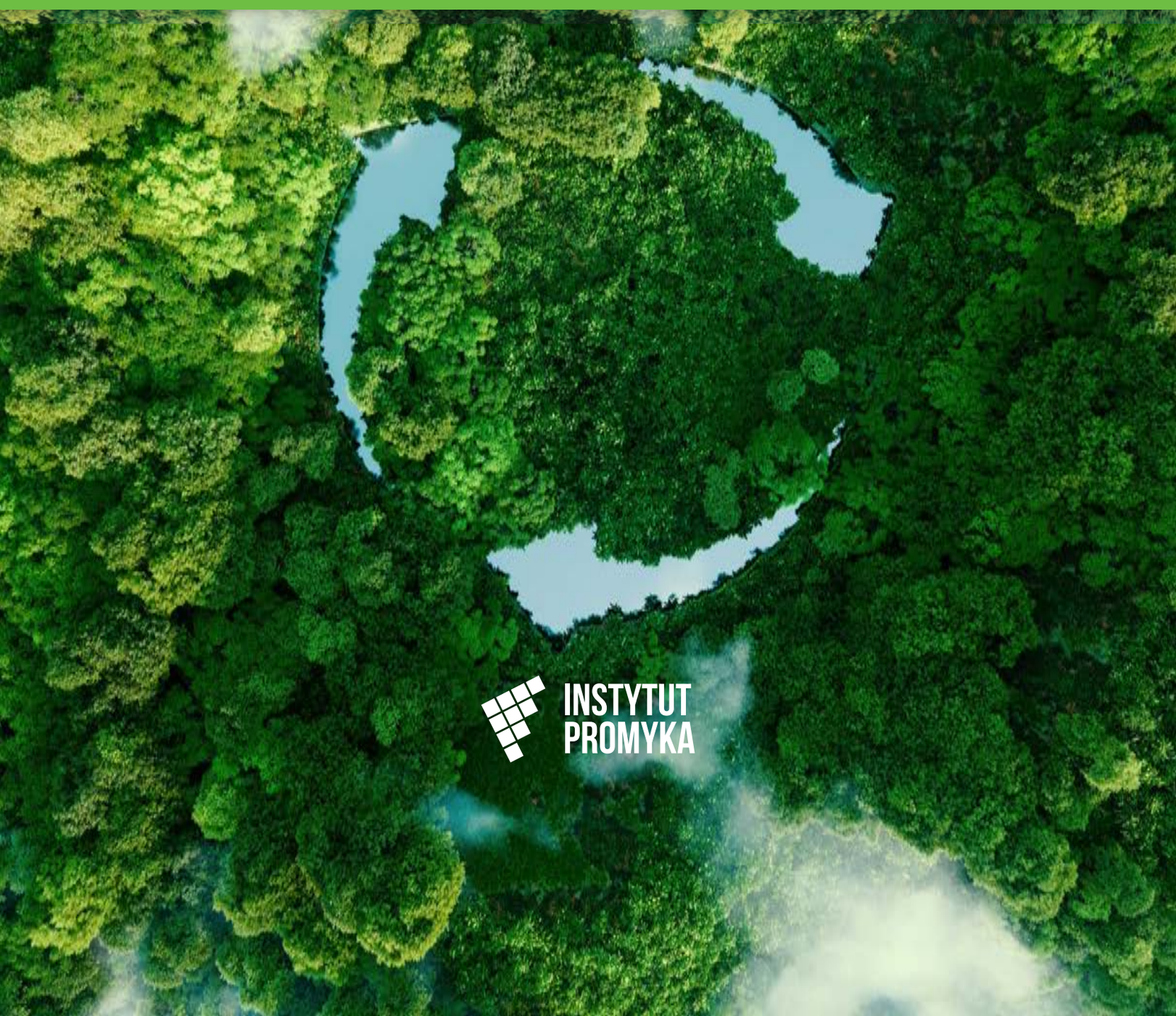

REVIEW OF CLIMATE POLICIES OF SELECTED EUROPEAN COUNTRIES

A joint publication edited by Piotr Mazur

Krzysztof Białas

Maria Cholewińska

Karolina Czerwińska

Weronika Dumin

Berenika Grabowska

Michał Kucharski

Piotr Mazur

Instytut im. Kazimierza Promyka

ul. Obozowa 82A/19
01-434 Warszawa
www.instytutpromyka.pl
e-mail: kontakt@instytutpromyka.pl

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List of abbreviations

BAFA – Federal Office for Economic Affairs and Export Control (German: Bundesamt für Wirtschaft und Ausfuhrkontrolle)

BWE – German Wind Energy Association (German: Bundesverband WindEnergie e.V)

CAP – Climate Awareness Plan

CBAM – Carbon Border Adjustment Mechanism

CCAP – Plan Działań na Rzecz Zmian Klimatu (ang. Climate Change Action Plan)

CCS - Climate Change Action Plan

CNG – compressed natural gas

CO_2 – carbon dioxide

ČEZ – Czech Power Plants (Czech: České Energetické Závody)

EEG – Renewable Energy Act (German: Erneuerbare-Energien-Gesetz)

EU ETS – EU Emissions Trading Scheme

EUR - euro

EGD – European Green Dea

JTF – Just Transition Fund

GHG – greenhouse gas

GW – gigawatt

HUF – Hungarian forint

IPCC - The Intergovernmental Panel on Climate Change

IRENA - International Renewable Energy Agency

EC – European Commission

km^2 - square kilometer

kWh - kilowatt hour

LNG – liquefied natural gas

LPG – liqufied petroleum gas

MIT – Ministry of Industry and Trade of the Czech Republic

MOL - Magyar Ola

MW – megawatt

NAS – megawatt

NCCS 2 – National Climate Change Strategy

Nm^3/h – normal cubic meter per hour (unit of gas flow)

AMSL – above sea level

OAPEC - Organization of Arab Petroleum Exporting Countries

UN – United Nations

PJ - petajoule

GDP – gross domestic product

PNIEC - National Integrated Energy and Climate Plan (Italian: Piano Nazionale Integrato per l'Energia e il Clima)

PPE - Multiannual energy strategy of France (French: Programmation pluriannuelle de l'énergie)

BSL – below sea level

PPT – Plastic Packaging Tax

SEK – swedish krona

SEP – State Energy Policy

SER - Renewable Energy Trade Association (French: Syndicat des énergies renouvelables)

SMR – small modular reactor

SNBC – National Low Carbon Strategy (French: La Stratégie Nationale Bas-Carbone)

°C – degrees Celsius

TWh - terawatt hour

EU – European Union

USD – US dollar

VAT – value added tax

VUZ - Czech Railway Research Institute (Czech: Výzkumný Ústav Železniční)

INTRODUCTION

The concept of a climate policy has emerged with accelerating global climate change. It encompasses a range of legal and political measures aimed at counteracting these changes. The main task of climate policies developed by institutions and states is to reduce emissions of greenhouse gases, which cause an increase in global average temperature and, consequently, global warming.

Research on the negative effects of climate change began as early as the 1980s in the United Nations. This led to the adoption of the United Nations Framework Convention on Climate Change, also known as the Climate Convention. The document, signed in 1992 and adopted by 196 countries, set out the principles of international cooperation in reducing greenhouse gas emissions. It also became the basis for subsequent agreements: The Kyoto Protocol and the Paris Agreement.

From the perspective of Poland and other countries of the Old Continent, the steps taken by the European Union play a key role. Over the years, the EU, which currently has 27 member states, has gained a number of new competencies at the expense of its members, e.g. in the field of climate policy. As early as 1993, the EU was one of the first entities ratifying the UN „Climate Convention". Moreover, the organization referred to the fight against climate change in the provisions of the Treaty on the Functioning of the European Union. In 2014 the EU unveiled a 2030 climate and energy policy framework that called for:

- reduction in greenhouse gas emissions of at least 40% from 1990 levels,
- share of renewable energy up to at least 32%,
- improvement in energy efficiency of at least 32.5%.

In late 2019 the European Commission adopted the European Green Deal (EGD), a development strategy aimed at transforming the EU into a climate-neutral region by 2050. However, EGD's provisions aimed at transforming EU economies into zero-carbon environments have aroused considerable controversy. This concerns, among other things, the costs of the energy transformation, expected at national level, and reluctance to recognise certain energy sources as neutral. These concerns did not fade after the „Fit for 55" package of legislation was announced in the summer of 2021. The key and most contentious change brought about by it is an even greater reduction in greenhouse gas emissions by member states by 2030 - from 40% to 55%.

The goal of the following report, prepared by experts of the Kazimierz Promyk Institute, is to review climate policies from 7 selected European countries. The analysis focuses on socially, economically and geographically diverse states. The last part of the report consists of a chapter containing a list of the best climate and energy solutions, presented in the form of recommendations for Poland. For this reason, the vast majority of the described countries are members of the European Union, adapting their climate plans to the EU policy and facing similar problems in this area. The United Kingdom is an exception. The climate policy pursued by the UK, which was a member of the EU until the end of 2020, overlaps with EU climate and energy plans.

CZECH REPUBLIC

Figure 1. Map of the Czech Republic

GEOGRAPHICAL CONDITIONS

The Czech Republic is located in the central part of Europe and covers an area of 78,866 km2. It is a landlocked country, 326 km from the Baltic Sea and 322 km from the Adriatic Sea. The Czech Republic borders with Germany (810 km), Poland (762 km), Austria (466 km) and Slovakia (265 km). The highest elevation in the country is Sněžka (1602 m), and the lowest spot is located near Hřensko, where the Elbe River flows out of Czech territory (117 m). The Czech Republic lies on the border of two European mountain systems: the Alpine-Himalayan and the Hercynian. The topography is quite diverse: valleys (4.5% of the area), plains (50%), highlands (33.9%), and mountains (11.6%). Areas below 200 m a.s.l. cover 5% of the country, areas between 200-500 m AMSL 74.1%, areas between 600-1000 m AMSL 19.3%, and areas above 1000 m AMSL 1,6%.

The Czech Republic is located in a moderate climate zone, which results in mild winters and summers. The average temperature in July in lowland areas is 20 °C. In Prague, the capital city, the average temperature is 19.5 °C, while in the mountain regions it is 8-11 °C. The average temperature in January ranges from -1 °C to -2 °C in the lowlands and from -5 °C to -7 °C in the mountains.[1]

The Czech Republic belongs to the catchment areas of three seas: the North Sea, which covers 51,399 km^2 and occupies the largest area of the country; the second largest catchment area of the Black Sea, which covers an area of 22,744 km^2 in the east of the country; and the smallest catchment area of the Baltic Sea, which covers an area of 4,721 km^2 in territories bordering Poland.

The Czech Republic has few natural lakes. The largest natural reservoir is Lake Černé with an area of 18.4 hectares. A large number of retention reservoirs exist to protect the country from floods, which are a common occurrence due to the terrain and high precipitation in the mountains. The main reservoirs are: Orlicki, Lipienski and Slapski.[2]

Brown and flat soils dominate the Czech Republic. Forests cover nearly 35% of the country, a higher percentage than in Poland (about 30%). Most forests cover the higher parts of mountain ridges, acting as the highest vegetation storey. These forests have not been cleared for agricultural purposes due to difficult access.[3]

1 *Kraj i jego mieszkańcy*, https://www.mzv.cz/warsaw/pl/informacje_o_rcz/kraj_i_jego_mieszkancy/index.html, access: 28.12.2021.

2 *Geografia Czech*, https://pl.wikipedia.org/wiki/Geografia_Czech#Wody, access: 28.12.2021.

3 Środowisko przyrodnicze i gospodarka Republiki Czeskiej, https://zpe.gov.pl/a/srodowisko-przyrodnicze-i-gospodarka-republiki-czeskiej/DrKuCuz8q, access: 28.12.2021.

The largest urban centers in the Czech Republic are the capital city of Prague with a population of 1.3 million, Brno (381,000) and Ostrava (287,000).

The same cities are also the most important centers associated with transport, including aviation.

ECONOMY

The population of the Czech Republic in 2021 was 10.7 million.[4] 20.5% of the population is under the age of twenty, 58.7% is between the ages of twenty and sixty-four, and 20.8% is over the age of sixty-five.[5]

The Czech economy is one of the most developed industrial economies in Europe. It is based primarily on the automobile, electromechanical, chemical, metallurgical, and electrical engineering sectors. Light industry and agriculture are the lowest contributors to the GDP. Between 2005 and 2016, the Czech Republic recorded a significantly higher economic growth rate than the EU average, which contributed to strengthening its international economic position. In 2016, the country's GDP exceeded 88% of the EU average.[6] The Czech economy is strongly dependent on trade relations with other countries. It is worth noting that in 2016, nearly 36% of the total production of goods and services were exports, showing the strong relationship of the Czech Republic's economic position's dependence on its relations with other countries.

The official currency is the Czech Crown (CZK). The country belongs to international political organizations such as the United Nations (1945), NATO (1999), the Visegrad Group, and the Central European Initiative. In terms of economic cooperation, the Czech Republic belongs to the European Union (2004), the Organization for Economic Cooperation and Development (1995), the International Monetary Fund (1993) and the Schengen Agreement (2007).[7]

4 *Population in Czech Republic*, https://ec.europa.eu/eurostat/cache/digpub/keyfigures/, access: 07.01.2022.

5 *Demografia Czech*, https://www.populationof.net/pl/czechia/, access: 12.04.2022.

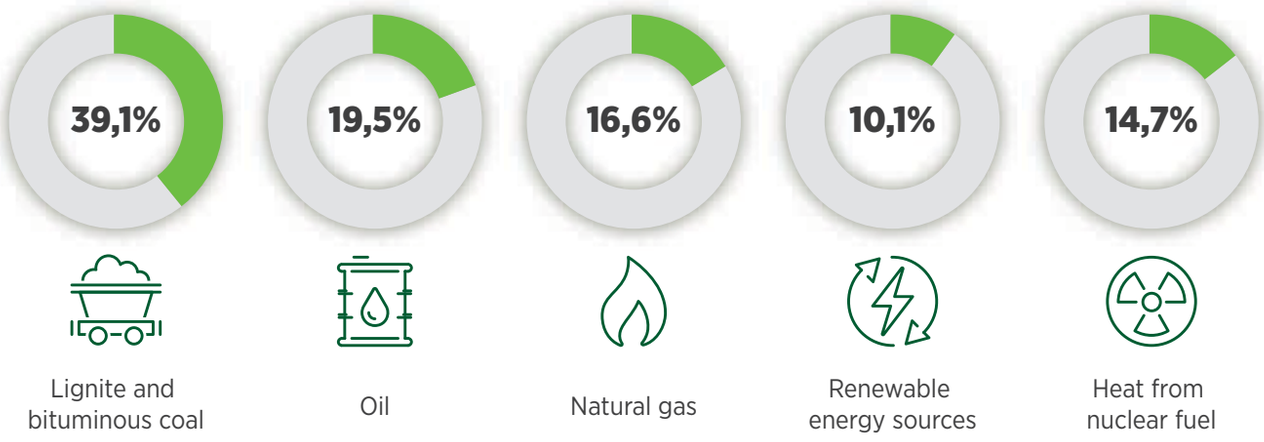
6 *Czechy: Przewodnik po rynku*, Polska Agencja Inwestycji i Handlu S.A. 2018.

7 *Ibidem.*

ENERGY MARKET

Lignite is the most important domestic source of primary energy, used for both electricity and heat production in the Czech Republic. The country is also highly dependent on imports of oil, natural gas and nuclear fuel. The gross consumption of primary energy sources is 1749 PJ, for the structure of consumption of primary energy sources.

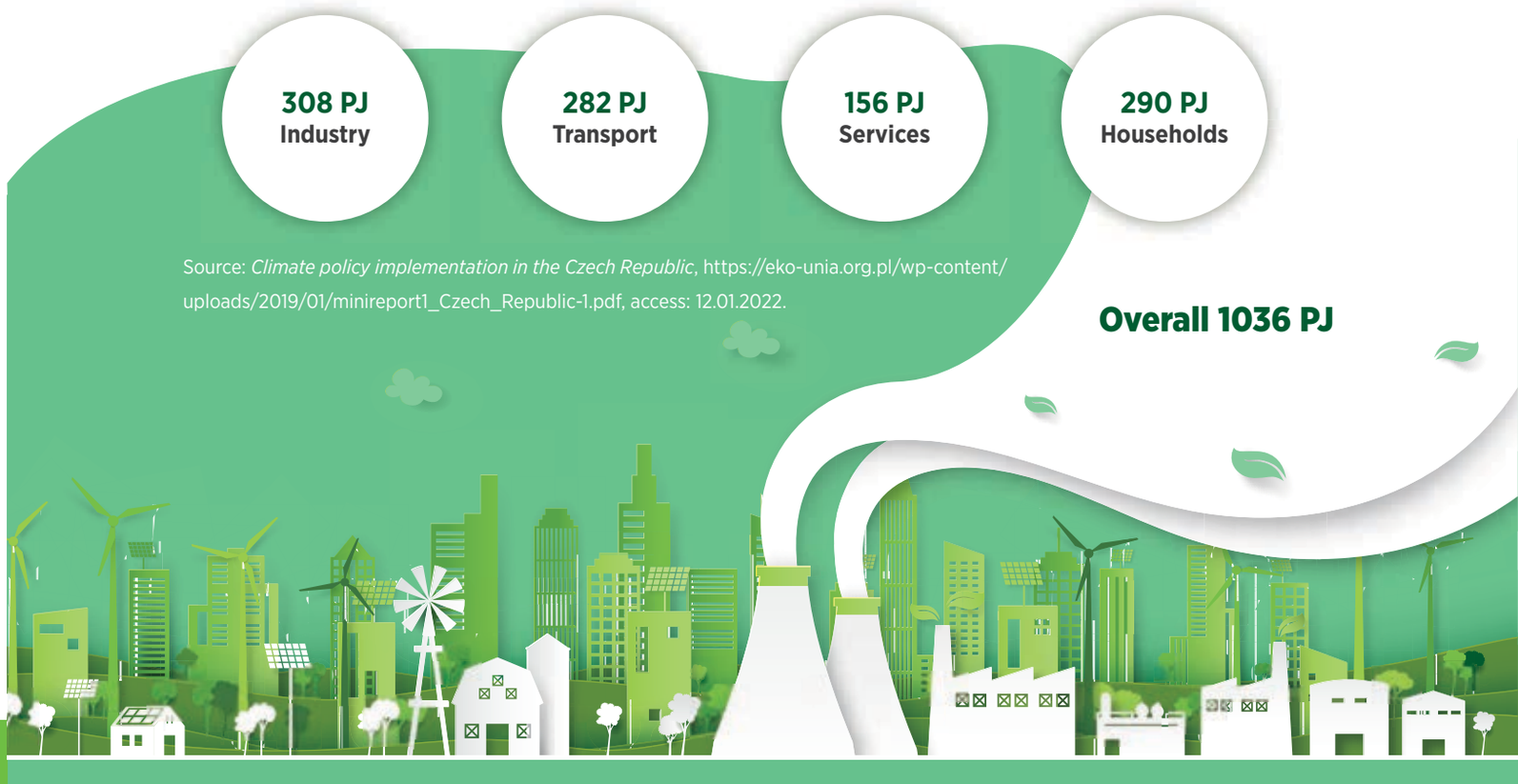
Figure 2. Share in primary energy consumption in the Czech Republic



Source: *Climate policy implementation in the Czech Republic*, https://eko-unia.org.pl/wp-content/uploads/2019/01/minireport1_Czech_Republic-1.pdf, access: 12.01.2022.

Compared to the EU average, the industrial sector in the Czech Republic has a rather high share in final energy consumption. The share of industry in the structure of the Czech GDP is the main reason behind this. The final structure of energy consumption is presented in the table below.

Figure 3. Structure of energy consumption in the Czech Republic



Source: *Climate policy implementation in the Czech Republic*, https://eko-unia.org.pl/wp-content/uploads/2019/01/minireport1_Czech_Republic-1.pdf, access: 12.01.2022.

The Czech power system is largely based on coal-fired power plants, including those using lignite and bituminous coal (50% of production) as well as nuclear power plants (32% of energy production). The vast majority of the country's installed coal-fired capacity 8.5 GW (85%) is in lignite-fired power plants and only 1.4 GW (15%) in bituminous coal-fired power plants. The remaining 18% is generated mainly by gas, biogas, biomass and hydroelectric power plants. A small part of the Czech electricity production (about 3.5%) is accounted for by wind and photovoltaic power plants. The Czech Republic is an important exporter of electricity. In 2016, the country's electricity exports reached 10.8 TWh net.

Renewable energy sources in the Czech Republic produced 92 petajoules (PJ) of heat in addition to 9.38 TWh of electricity. Biomass (excluding biogas and liquid biofuels) provides 2/3 of renewable energy in the Czech Republic, making biomass the most important Czech renewable energy source. Domestic heating with biomass (especially firewood) covers more than 40% of the Czech renewable energy production.[8]

As confirmed by the Czech Government Commission, the potential of domestic renewable sources is estimated at 50 TWh of electricity, including the use of biomass for heat production (the long-term potential of renewable heat is 152 petajoules, 77% of which comes from biomass combustion). A large part of this potential is photovoltaic (about 10 TWh from PV systems installed on buildings) and wind.

Currently, there are three regions in the Czech Republic where coal is mined. Two regions in the northwest have several opencast lignite mines. In contrast, the Moravian-Silesian region is known for underground coal mining. Both regions are known for their very poor environmental and social conditions.

Given the potential shift away from coal in national energy policy, a significant social problem in terms of employment is taken into account. The mining and energy sectors in the Czech Republic currently employ approx. 30,000. It is expected that mines and related power plants will systematically close in the next 20 years or so. The closure of a single mine is expected to result in approximately 1,500 lay-offs, which represent more than 10% of the current state of unemployment in the Ústecký region. While there are plans to develop renewable energy sources at the former mine sites, it is not an industry that can replace coal-related jobs in the future. Therefore, all regions are counting on an extensive transformation that will address the employment issues of local residents who had mining-related occupations for years. In fact, the Czech Republic is one of the few countries in Central and Eastern Europe that has a governmental strategy for the transformation of its coal regions. With the strategies in place, the likelihood that the transformation will be carried out effectively increases. Public participation has to be a key element of the strategy to ensure its positive impact. It is also necessary to identify and overcome barriers related to the low ability of regions to receive funding from EU funds and other sources, including employment opportunities in other areas of the energy sector in the country.[9]

Both districts have developed thermal power generation, electrical machinery and chemical industries. It is worth noting that these centers are located near Polish coal mining sites - Turoszów and Upper Silesian Industrial District. Mining of bituminous coal in the Czech Republic amounts to approximately 10 million tons per year, which is 6 times less than in Poland. Moreover, the Czech Republic and Poland are the only two countries in the European Union which extract bituminous coal, after Germany, France and Spain abandoned its extraction. Our southern neighbors mine approximately 40-50 million tonnes of lignite a year, which is only slightly less than Poland. Another important Czech energy resource is the uranium ore mined in the south of the country. It is used almost entirely in the Czech nuclear power plant „Temelin". Various other energy sources, such as wind turbines and solar panels, are found in larger quantities especially in the south of the country.[10]

8 *Ibidem.*

9 Karel Polanecky, *Climate policy implementation in the Czech Republic*, https://eko-unia.org.pl/wp-content/uploads/2019/01/minireport1_Czech_Republic-1.pdf, access: 16.01.2022.

10 *Czech Republic 2021 Energy Policy Review*, https://iea.blob.core.windows.net/assets/301b7295-c0aa-4a3e-be6b-2d79aba3680e/CzechRepublic2021.pdf, access: 16.01.2022.

Transport

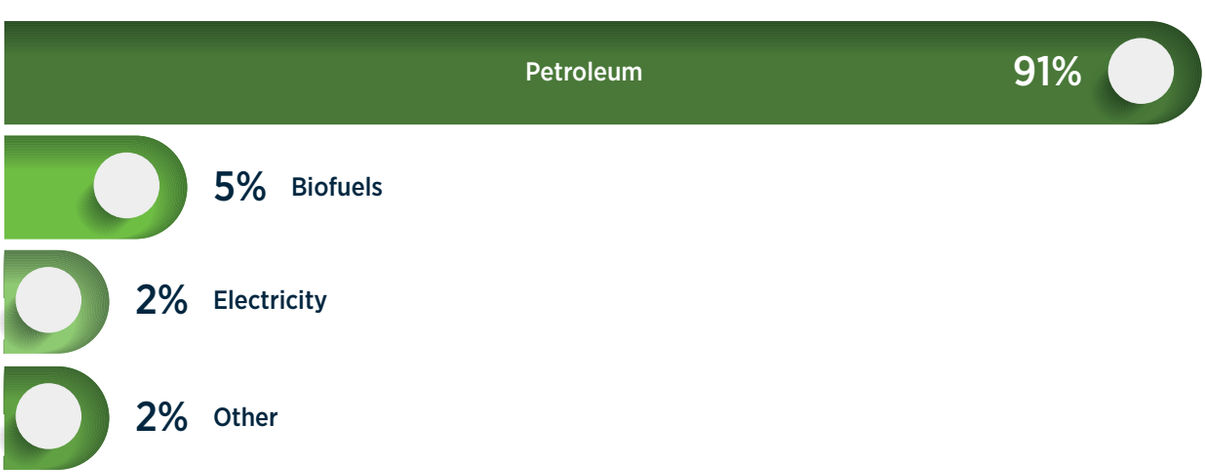
In 2019, petroleum accounted for 91% of energy demand in the transport sector, with a much smaller share of biofuels (5%) and electricity (2%). Electricity, among other energy sources, accounted for the remaining 2%, which may indicate a lower potential for reducing CO_2 emissions in Czech transport. Considering the demand in the transport sector, road transport accounted for 96% of the national transport demand in 2018, with a much smaller share of air transport and rail. This distribution may be due to the fact that the Czech Republic is an exporter of goods and a transit country for freight traffic. The most common type of fuel used in the domestic transport sector is diesel (almost 66% of demand) and gasoline (23% of demand). Vehicles in the Czech Republic using alternative fuels are mainly powered by liquefied petroleum gas (LPG). The fleet of LPG cars in the Czech Republic in 2020, amounted to about 115,000 of the total fleet of about 8.5 million passenger vehicles. Electric vehicles numbered about 7.5 thousand, which is a very modest number compared to the stock of vehicles running on traditional fuels. The figure below presents total energy consumption by source in the Czech transport.[11]

The Czech Republic is an industrial country with very high per capita GHG emissions. The energy production structure, with 50% of lignite coal-fired power plants, is the most important reason for the high greenhouse gas emission intensity. Regarding the actual energy balance of the Czech Republic, the country plans to take basic steps to significantly reduce GHG emissions, i.e.:

- effectively phasing out the operation of coal-fired power plants,
- ensuring the development of renewable energy to replace retiring capacity.

However, opponents of this kind of energy policy, which takes into account the reduction of emissions, are also present. The blackout threat is an important argument against the withdrawal of coal and the development of renewable energy. According to the opponents of the coal power plant phase-out, such measures could result in the country's unstable energy situation. Opposition to the development of exclusively wind and photovoltaic power plants is also emphasized. As a result, the energy transition in the Czech Republic will pose a serious social challenge to properly implement a communication strategy for the public, especially for those groups that will eventually have to change the industries they work in.

Figure 4. Energy demand in the Czech transport sector in 2019



11 *Czech Republic 2021 Energy Policy Review*, https://iea.blob.core.windows.net/assets/301b7295-c0aa-4a3e-be6b-2d79aba3680e/CzechRepublic2021.pdf, dostęp: 16.01.2022.

CLIMATE POLICY

Phasing out coal-fired power plants and significant development of renewable energy sources are the main challenges of the Czech climate policy for the coming years.

„State Energy Policy" (SEP) is the main strategic document driving energy policy in the Czech Republic. The document is dated May 2015 and contains a perspective until 2040. The Ministry of Industry and Trade (MIT) is the central authority responsible for the energy sector and the implementation of the energy policy, including SEP. MIT is required to report to the government on the achievements and progress of SEP every five years. Based on the 2015 SEP assessment, the Czech government decided to update the document in March 2021. It is to be updated by the end of 2023. The strategic directions of the 2015 SEP are expressed in a number of quantitative targets. The most important of these is the commitment to reduce carbon dioxide (CO_2) emissions by 40% in 2030 compared to 1990. The Czech Republic further commits to undertake efforts to decarbonize the economy by 2050, in line with the country's financial capacity.[12]

The three main goals of the 2015 Czech Energy Policy (SEP):

- security of energy supply (in normal operations and in emergency situations),
- competitiveness of the energy sector (energy prices are comparable to prices in other countries in the region) and social acceptance,
- sustainability (environmental, financial and social).

The five strategic priorities listed below support the three goals above:

- achieving a balanced energy mix,
- improving energy efficiency and energy savings,
- infrastructure development,
- investing in energy and industrial research as well as human resource development,
- ensuring energy security and resilience.

The Czech energy policy is also supported by a number of other strategic documents that help implement SEP by setting out specific plans, targets and measures. These include, among others, the National Action Plan for Smart Grids and the National Action Plan for Clean Mobility, which was updated in 2019 to cover activities up to 2030. The National Development Plan for Nuclear Energy Development dates back to June 2015 and provides for the construction of new nuclear power generation capacity in order to maintain the current level, with the aim of maintaining self-sufficiency and accelerating the energy transition towards a low-carbon energy sector.

Expectations for a low-carbon national economy are subject to change over the years, especially with political changes in the country. In 2021, a parliamentary election was held in the Czech Republic, resulting in a change of government. The climate policy of the country and the previously chosen course of moving away from coal were revised once again. According to the current Czech Prime Minister, the country plans to move away from coal by 2033.[13] A program to support the installation of photovoltaic panels on 100,000 roofs by 2025 and the introduction of relevant legislation to enable the creation of energy cooperatives by the end of 2022 were also announced. In addition, the Czech energy company ČEZ (České Energetické Závody) has announced its plans to reduce coal in its power and heating operations by 2030, and that the energy

12 *Ibidem.*

13 A. Beldowicz, *Nowy rząd Czech: elektrownie węglowe zostaną wyłączone*, https://klimat.rp.pl/energia/art19275521-nowy-rzad-czech-elektrownie-weglowe-zostana-wylaczone, access: 22.01.2022.

produced from it is to decrease from 39% to 12.5%.

The Czech Republic's energy policy is equally based on obtaining energy from nuclear power plants. In 2021, the Czech Republic's power plants produced more than one-third of the country's electricity, making it the country's largest source. In the same year 30.73 TWh were supplied to the national power system from nuclear power plants, which increased energy production from this source by 3% compared to the previous year.[14] Today, the Czech company ČEZ, which owns and operates nuclear power plants, operates four WWER-440 units at the Dukovany Nuclear Power Plant and two WWER-1000 units at the Temelin Nuclear Power Plant. The same company announced a tender to build a new 1200 MWe unit at Dukovany in 2022. According to the statement, ČEZ plans to build two additional units at Temelin and Dukovany, which will probably increase the share of nuclear energy in the Czech power system.

A significant reduction of coal mining in the Czech Republic is dictated by the climate policy of the European Union and the efforts of the entire European community to reduce CO_2 emissions from the economy. The COVID-19 pandemic has also caused a high decline in the price of coal, which is also becoming a reason for moving away from this form of energy production. The Czech Republic draws attention to the possibilities of reducing CO_2 emissions in transport by implementing greener modes of transport, which is also a high priority for EU countries and the adopted concept of the European Green Deal. To make these measures effective, the Czech Republic has obtained €223 million in 2019 from the cohesion funds, for investment purposes in electric rail transport, which is the greenest form of public transport.[15]

The Czech Republic has been strongly lobbying the European Union to qualify nuclear energy as a green energy source. The standpoint of the former government of Prime Minister Andrej Babiš was dictated by the fact that once this energy source was accepted as green, it would be possible to obtain adequate funds for further development of the nuclear energy sector. In order to come closer to achieving these goals, the government of Prime Minister Babiš withdrew its opposition to the EU climate goals, blocked earlier. Given the above, the Czech Republic is prioritising the increase of nuclear energy in the national energy mix. The development of Renewable Energy Sources is not a priority for the Czech Republic, however it is a firm part of the whole process of moving away from coal. Information regarding the Czech Republic's planned investments in hydrogen-powered trains emerged at the end of 2021. The Czech Railway Research Institute (Výzkumný Ústav Železniční; ab. VUZ) plans to invest in this area of green energy, so that renewable energy could be combined with the production of green hydrogen. Thus, investments in hydrogen railroads, according to VUZ representatives, are expected to contribute to the reduction of carbon dioxide emissions and the carbon footprint, both on the rail tracks and in the centers of large agglomerations.[16] The EU funds, with a special focus on the Just Transition Fund (JTF), will play a major role in the overall transformation in all economic sectors of the Czech Republic.

14 *Lokalizacja elektrowni węglowych w Republice Czech*, https://nuclear.pl/lokalizacja,czechy,republika-czeska,0,0.html, access: 22.01.2022.

15 Ł. Ogrodnik, *Czechy w procesie transformacji klimatyczno-energetycznej*, https://www.pism.pl/publikacje/Czechy_w_procesie_transformacji_klimatycznoenergetycznej, access: 28.01.2022.

16 K. Nowak, *Czeska kolej: autonomiczne i wodorowe pociągi*, https://swiatoze.pl/czeska-kolej-autonomiczne-i-wodorowe-pociagi/, access: 29.01.2022.

SUMMARY

The Czech Republic has pushed hard for the implementation of national plans to abandon coal, thus in line with the adopted climate policy within the EU, almost all economic sectors will undergo partial transformations aimed at reducing CO_2 emissions. However, lignite is still the most important domestic source of primary energy, used for both electricity and heat production in the Czech Republic. This illustrates the scale of the challenge that awaits the Czech Republic and all countries in the EU in order to implement climate policy measures. Nuclear power plants provide a good basis for the continued development of green energy, producing more than 1/3 of the country's electricity in 2021 in the Czech Republic. In the same year, 30.73 TWh were supplied to the national energy system from nuclear power plants, increasing energy production from this source in 2021 by 3% compared to the previous year. In addition to nuclear energy, the Czech Republic, within the framework of acquired European funds, will implement investments related to transport and development of low-carbon means of transport, with particular emphasis on public transport. The Czech energy company aims to reduce the use of coal in power and heating operations, as part of the transformation, which is expected to lead to a decrease in coal-fired power generation from 39% to 12.5% in 2030. According to the latest announcements of the Czech government, the implementation of the change will last until 2033.

The most important conclusions that can be drawn from the Czech climate policy so far include particular attention to the widest possible development of nuclear power plants in the country and significant pressure on the European arena to accept the atom as green energy. From the point of view of the Czech Republic, this is particularly important in the context of securing the country's energy stability, which could be undermined if the state moves away from coal as an energy source, combined with the lack of clarity over gas transit via the Nord Stream 2 pipeline, which was halted as a result of Russia's attack on Ukraine. The Czech Republic's approach to the atom as green energy is a guideline for the countries of the European community, where the transition away from the atom is being advocated more and more often, such as Germany, a country that is implementing its Energiewende policy by shutting down its nuclear reactors and seeking to get other EU countries to do the same, a move that, from the point of view of the climate policy, may have a significant impact in terms of its failure.

FRANCE

Figure 5. Map of France

GEOGRAPHICAL CONDITIONS

France is the largest country in Western Europe, covering an area of 543,965 km2. The northern and western parts of the country consist of fertile and extensive plains, while the central and southern parts are characterized by the forested plateau of the Massif Central, a range of mountains and extinct volcanoes.[17] The country's continental territory is bordered by Belgium, Luxembourg and Germany to the northeast, Switzerland and Italy to the east, the Mediterranean Sea, Monaco, Spain, Andorra to the south and the Bay of Biscay of the Atlantic Ocean to the west, and the English Channel to the northwest. To the north, France (Calais) is connected to southeastern England (Dover) by the Strait of Calais. The island of Corsica in the Mediterranean Sea is also an integral part of the country.[18]

The majority of France is located in the temperate zone, the subtropical zone covers only its southern periphery. The whole country is under affected by the oceanic influences, which are mitigated by the North Atlantic Drift in the west and the Mediterranean Sea

17 *France*, https://kids.nationalgeographic.com/geography/countries/article/france, access: 09.04.2022.

18 *Land of France*, https://www.britannica.com/place/France/Land, access: 08.04.2022 .

in the south. Average annual temperatures drop to 15°C in Nice on the Côte d'Azur and to 10°C in Lille on the country's northern border. Precipitation comes mainly from westerly winds from the Atlantic Ocean, with annual totals exceeding 1270 mm at higher altitudes in western and northwestern France, the western Pyrenees, the Massif Central, the Alps and the Jura. In winter, eastern France can be influenced by a continental high pressure system, causing extreme cold and temperature inversions in urban areas. France's climate comprises of three main climate zones: oceanic, continental and mediterranean, with some variations in the Aquitaine basin and the highlands.[19]

A dense river system runs through the country with the largest rivers being the Loire, the Seine and the Garonna. Many canals were built in the country to facilitate water transport, such as „Briare" which links the Loire with the Seine, „Burgundy" - Saone with the Seine, etc.. There are only a few lakes in France, the largest of which is shared with Switzerland - Lake Geneva.[20]

19 *Climate of France*, https://www.britannica.com/place/France/Climate, access: 10.04.2022.

20 *Geografia Francji*, https://pl.wikipedia.org/wiki/Geografia_Francji, access: 10.04.2022.

ECONOMY

France's population in 2021 was 68.1 million.[21] According to 2020 data, France's economy ranked 3rd in Europe and 7th in the world in terms of gross domestic product, reaching $2.63 trillion.[22]

The country is an important participant in global trade,with trade accounting for about 58% of its GDP. It ranks 9th as an exporter and 7th as an importer[23]

Figure 6. Main goods exported and imported by France

Source: https://santandertrade.com/en/portal/analyse-markets/france/foreign-trade-in-figures, access: 14.04.2022

21 *Francja liczba ludności*, https://www.populationof.net/pl/france/, access: 17.05.2022.

22 *GDP (current US$) – France*, https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=FR&most_recent_value_desc=true, access: 09.04.2022.

23 *French foreign trade in figures*, https://santandertrade.com/en/portal/analyse-markets/france/foreign-trade-in-figures, access: 14.04.2022.

France is also an importer (about 10%) and exporter of energy (about 6%). It exports energy to Great Britain, Switzerland, Italy (northern parts) and Spain, while importing energy from Belgium, Germany, Spain and Great Britain.[24]

Bauxite production in France is now negligible and lead, zinc, and silver ores are mined in very small quantities. Larger quantities of potassium (in Alsace), sodium chloride (from the mines of Lorraine and Franche-Comté and from the salt meadows of western and southern France), and sulphur (made from Aquitaine natural gas) are extracted, although the output in this case is declining due to the exhaustion of reserves. The reserves of rock, sand and gravel, on the other hand, are considerable.[25] Other natural resources include crude oil, natural gas, coal, minerals, and forests. Revenue from natural resources in 2019 amounted to 0.04% of GDP .[26]

Thomas Douenne and Adrien Fabre of the Paris School of Economics conducted a survey addressing climate issues in the first quarter of 2019. Questions focused on respondents' household characteristics, climate change, access to public transport and mobility habits, as well as political orientation. According to the results, the majority (72%) of respondents know that climate change is anthropogenic and only 4% do not believe in climate change as a fact. In contrast, knowledge of climate science appears to be limited. 77% of respondents know that carbon dioxide (CO_2) is a greenhouse gas, however, when asked about the rest of the items, such as methane and particulate matter, respondents are unsure of the correct answer. It can be concluded that most people do not understand the factors and consequences of climate change. The responses also indicated the need for a significant change in consumption behavior to deal with this growing problem.[27]

ENERGY MARKET

Carbon dioxide emissions in France have been steadily declining since 1970. The transition policy has contributed to lowering emissions.[28] France is currently one of the countries with the lowest CO_2 emissions in the European Union and has the potential to lead the way in Europe's energy transition. As of April 23, 2022, the country emitted only 47g CO_2eq/kWh. France utilizes 96% low-carbon energy sources, including 36% renewable.[29]

The consumption of and demand for different energy sources has changed considerably in recent decades. In the post-war years, energy demand was met by coal, which over time began to be replaced by crude oil, which in turn was replaced by nuclear energy and partially by natural gas as France became more independent from external energy sources. Since the beginning of the 21st century, renewable energy sources, such as solar and wind power started to grow in importance.[30]

24 *Francja*, https://app.electricitymap.org/zone/FR, access: 23.04.2022.

25 *Minerals*, https://www.britannica.com/place/France/Resources-and-power#ref41129, access: 10.04.2022.

26 *France: Natural resources income*, https://www.theglobaleconomy.com/France/Natural_resources_income/, access: 10.04.2022.

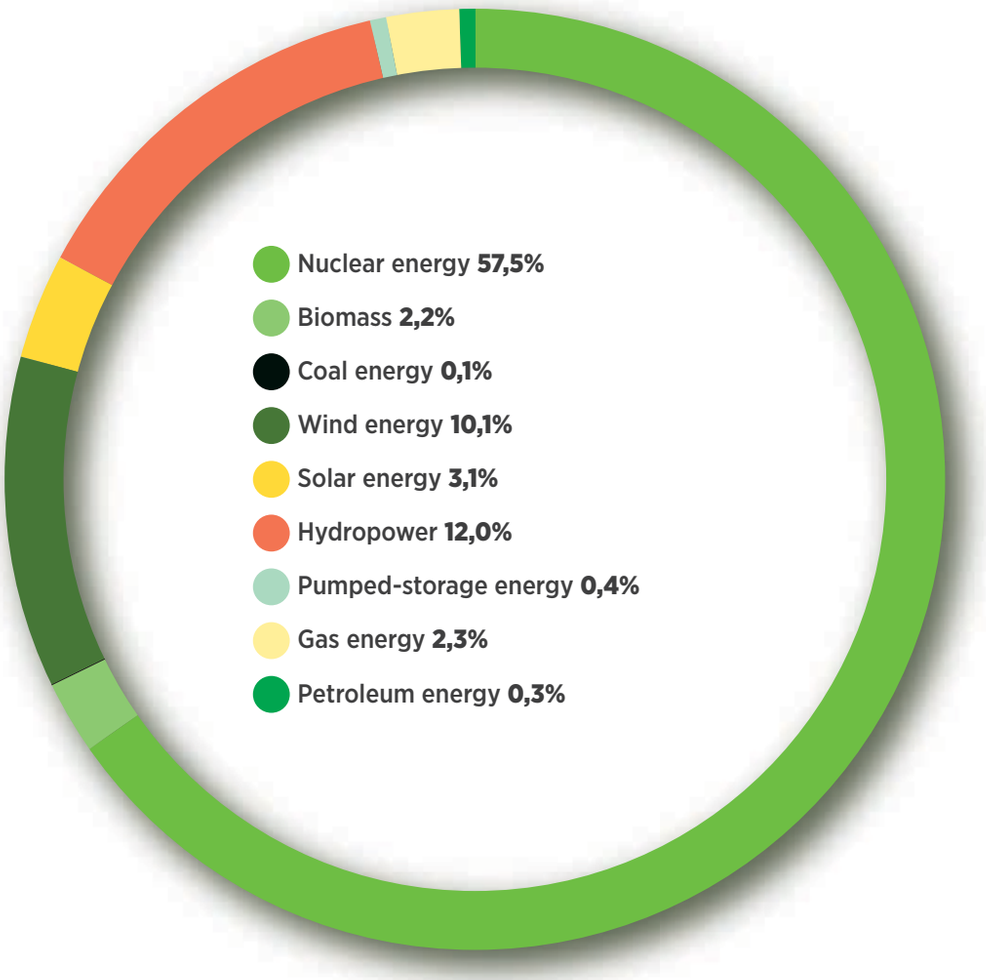
27 T. Douenne, A. Fabre, *French Attitudes on Climate Change, Carbon Taxation and other Climate Policies*, Paris School of Economics 2019, https://www.parisschoolofeconomics.eu/docs/fabre-adrien/last-version--french-attitudes.pdf, access: 14.04.2022.

28 *France's turning point. Accelerating new growth on the path to net zero*, Deloitte 2021, https://www2.deloitte.com/content/dam/Deloitte/fr/Documents/sustainability-services/deloitte-etude-frances-turning-point.pdf, access: 14.04.2022.

29 *Francja*, https://app.electricitymap.org/zone/FR, access: 23.04.2022.

30 *Energy*, https://www.britannica.com/place/France/Resources-and-power#ref41129, access: 10.04.2022.

Figure 7. Electricity consumption by energy source (as of April 23, 2022)



Source: https://app.electricitymap.org/zone/FR, access: 23.04.2022

Fossil fuels

France's transition to a decarbonized economy has been underway for some time. The share of fossil fuels in the energy balance of the country is systematically decreasing. This is due to the increasing use of nuclear energy and renewable energy sources.

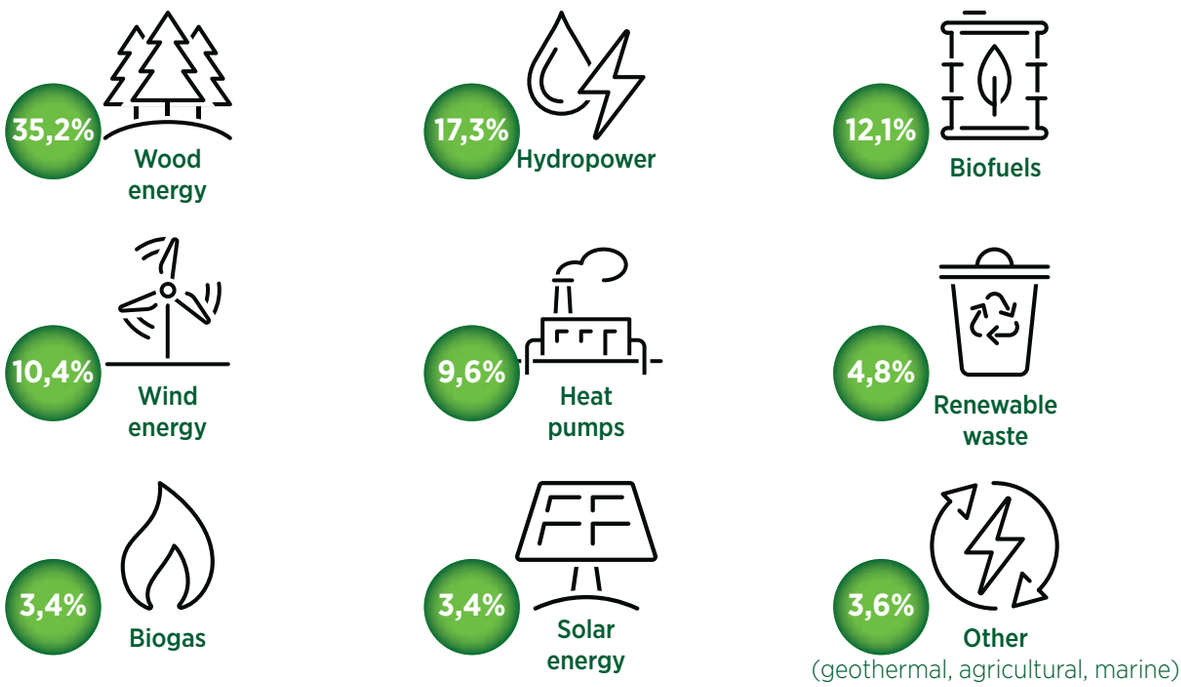
Border taxes on carbon emissions are being considered at the EU level. European Emissions Trading System (EU-ETS) aims to bring about a strengthening of the reduction of emission targets by reducing the number of industries using it. The European Green Deal proposes the Carbon Border Adjustment Mechanism (CBAM), which requires importers into EU countries to pay a CO_2 price equivalent to the emissions generated by their products. A supplementary solution involves reindustrialization of the French economy towards its decarbonization. Sectoral regulations have also been introduced, for example via a cap on carbon emissions from building materials (mainly cement, concrete and wood) by 2031.[31]

31 *France's turning point. Accelerating new growth on the path to net zero*, https://www2.deloitte.com/content/dam/Deloitte/fr/Documents/sustainability-services/deloitte-etude-frances-turning-point.pdf, access: 14.04.2022.

Renewable energy sources

The share of renewable energy is growing and is expected to reach 25.3% of France's gross final energy consumption in 2022. Green energy is central to the French economic recovery efforts under France Relance. The renewable energy sector is very diverse and includes ten different subsectors:

Figure 8. Structure of renewable energy sources in France



The most developed renewable energy sources in France are wood energy and hydroelectricity, but the greatest progress has been observed in onshore wind farms and heat pumps. Wind farms are under development. In absolute values France is the largest producer of hydroelectric energy and the second largest producer of biofuels among the EU member states.[32]

Wind energy

The total onshore wind power capacity in France as of March 31, 2021 was 17,932 MW. In 2020, wind power generation was 39,685 GWh, accounting for 8.9% of national electricity consumption.

In December 2020, French wind production ranked 4th in Europe (17,612 MW). Outperforming countries were Germany, Spain and the United Kingdom. The offshore wind farm off the coast of Saint Nazaire is currently under construction and is scheduled for completion in 2022. It will be equipped with 80 wind turbines and will provide the equivalent of the annual electricity consumption of 700,000 people. Several projects involving offshore wind energy are currently underway on the west coast of France (Saint Nazaire, Fécamp, Courseulles-sur-Mer, Saint Brieuc, Ile d'Yeux, Dieppe).[33]

32 *Energy*, https://www.trade.gov/country-commercial-guides/france-energy-eng, access: 14.04.2022.

33 *Ibidem*.

Solar energy

Solar energy in France reached a capacity of 11.2 GW in 2020. Its use is expected to follow an upward trend and reach about 18-20 GW by 2023.[34] President Emmanuel Macron conveyed that solar energy capacity is expected to grow to 100 GW by 2050.[35]

Geothermal energy

In 2020, the French Renewable Energy Trade Association (*French*: Syndicat des énergies renouvelables, SER) published a report on geothermal energy - both deep and shallow geothermal. The report analyzed the conditions that would have to be met for geothermal energy to become part of a new energy model in France. The authors of the report concluded that geothermal energy will have a crucial role in achieving the goals of the energy transition in France. The rate of geothermal development is insufficient to achieve them, according to the Multi-Year Energy Planning (the share of renewable energy in 2019 was 1.7%).

Heat production from shallow/surface geothermal energy accounts for 3/4 of the geothermal energy produced in France, while the potential for heat production from deep geothermal resources is largely untapped.

The SER Geothermal Commission concludes that if measures were taken to enable the growth of the geothermal energy sector, it would become possible to produce as much as 530,000 tons of heat in 2030 (in 2018, production stood at 153,000 tons). Taking measures to unlock the potential of the deep geothermal sector will result in geothermal power generation capacity that could reach 53 MW in 2030. Deep geothermal enables the extraction of lithium present in geothermal waters, which can be equivalent to 6% of the world's production of this industrially used element, obtained from about ten geothermal power plants.

The Renewable Energy Trade Association proposes a variety of measures, such as:

- conduct an exploration campaign for known deep aquifers,
- establish a minimum of one geothermal specialist in each administrative region and introduce renewable heat/cold animators,
- remove regulatory restrictions and reduce the area of implementation of geothermal projects subject to the Mining Code by adjusting the geothermal framework of lesser importance,
- support economic and national development targets for electricity production from deep geothermal, while developing the French lithium extraction sector from geothermal waters,
- develop geothermal cooling networks by supporting renewable cooling production,
- make renewable cooling networks subject to a reduced VAT rate similar to renewable heat networks,
- include emitters in the heat and cooling production work base,
- provide assistance for installation of heat and cooling pumps,
- increase the bonus for geo-cooling,
- establish a Geothermal Innovation Fund,
- model financing based on potential impact on the local economy.[36]

34 *Solar power in France*, https://en.wikipedia.org/wiki/Solar_power_in_France, access: 14.04.2022.

35 *France to boost solar energy capacity beyond 100 GW by 2050, says Macron*, https://www.reuters.com/business/environment/france-boost-solar-energy-capacity-beyond-100-gw-by-2050-says-macron-2022-02-10/, access: 15.04.2022.

36 *Geothermal energy in France – what is needed for tapping its potential?*, https://www.thinkgeoenergy.com/geothermal-energy-in-france-what-is-needed-for-tapping-its-potential/, access: 14.04.2022.

Hydropower

Hydropower is the second largest source of electricity generation after nuclear power and the primary source of renewable energy in France.[37] Thanks to the mountain ranges of the Alps, Pyrenees and Massif Central, the hydropower sector in France has a huge potential - around 120,000 GWh. The capacity is largely used already, but there is still a potential estimated at around 91 TWh/year - mainly through the use of small hydro and pumped storage plants, as well as the refurbishment of existing facilities.[38]

Biogas energy

In 2021, a company called „Bioges"t has been contracted to build two additional biomethane plants based on agricultural waste and by-products from chicken farms in the western region of France. Biomethane production from animal, agricultural and food waste is one of the most rapidly growing renewable energy sectors.

The biomethane plant of the „Enerfées project" is fed with manure, slurry and agricultural by-products from about 50 farmers to produce 400 Nm^3/h of biomethane. A second project called „Methagriloué" will use similar feedstocks. The waste delivered by about 11 farmers throughout the year allows for the production of 130 Nm^3/h of biomethane.[39]

Nuclear power industry

Nuclear power plants

France's Multi-Year Energy Strategy (PPE) plans to reduce the share of nuclear power in the energy mix of electricity generation from over 70% to 50% by 2035 and increase the role of renewables. However, nuclear energy will continue to play a key role in France's efforts to meet its strategic priorities of reducing CO_2 emissions, securing supply chains, increasing the competitiveness of businesses, maintaining household purchasing power, preserving skilled jobs in the industry, and developing technological know-how in the field.

France is home to one of the most important nuclear parks in the world. With 56 reactors spread over 19 nuclear centers, France produces about 405 TWh of nuclear power each year. [40]

Small nuclear reactors

President Emmanuel Macron outlined plans, as part of the „France 2030" program, to invest in small nuclear reactors (SMRs). Potentially, SMR technology will become a French export product as well as an energy booster. The investment will amount to €1 billion.[41]

37 *Hydroelectric Energy*, https://www.edf.fr/en/the-edf-group/producing-a-climate-friendly-energy/doubling-the-share-of-renewable-energies-by-2030/hydroelectric-energy/hydroelectric-energy, access: 14.04.2022.

38 *France – Big on Electricity*, https://www.andritz.com/hydro-en/hydronews/hn-europe/france, access: 14.04.2022.

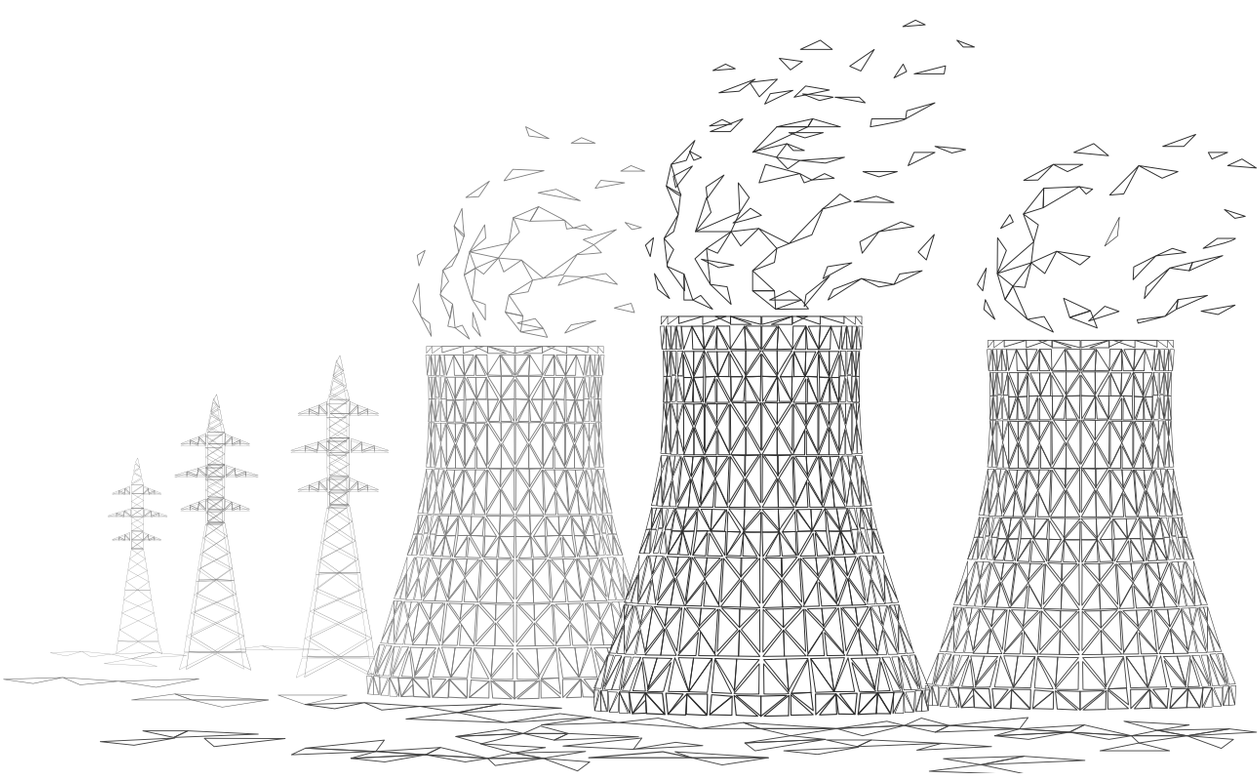
39 *BIOGEST builds two more biomethane (RNG) plants in France*, https://www.europeanbiogas.eu/biogest-builds-two-more-biomethane-rng-plants-in-france/, access: 16.04.2022.

40 *Energy*, https://www.trade.gov/country-commercial-guides/france-energy-eng, access: 14.04.2022.

41 *Macron zapowiada inwestycje w małe reaktory SMR. Mają powstać* do 2030, https://smoglab.pl/macron-reaktory-smr-do-2030/, access: 14.04.2022.

Hydrogen Energy

A €2 billion investment in hydrogen has been planned by the French government in 2022. A figure that is expected to rise to €5.7 billion by 2030. The hydrogen plan aims to encourage sub-national projects for developing the use of hydrogen in industry and mobility. The plan involves producing „green" hydrogen via electrolysis from emissions-reduced electricity sources. Another method is to use methane and store the CO_2 emitted during the conversion, resulting in a so-called „blue" hydrogen.[42]



42 *Energy*, https://www.trade.gov/country-commercial-guides/france-energy-eng, access: 14.04.2022.

Transport

Electromobility

The French Energy Transition for Green Growth Act aims to increase the share of renewable energy and mobility in line with sustainable development. Transport is a priority sector for the French government as it accounts for 1/3 of all greenhouse gas emissions.

France is one of the European leaders in electromobility, with 100,000 registered electric vehicles in 2017. It is assumed that by 2030 more than 4 million electric cars will drive on French roads, by 2028 the level of greenhouse gas emissions will be reduced by nearly 30% (compared to 2013). As of 2040, it will not be possible to buy a car powered by gasoline or diesel.

A system of subsidies has been introduced in France to encourage people to buy electric cars - buyers of vehicles with the lowest CO_2 emissions are to receive subsidies of up to €6,000. Funds come from so-called ecological fines imposed on owners of the most polluting vehicles, so they do not constitute an additional burden on the state budget.

A €1,000 diesel-to-gasoline exchange bonus has been introduced in 2018. The bonus also applies if you scrap a vehicle with a pre-1997 petrol engine or a pre-2001 diesel engine.

Increasing restrictions on vehicles entering city centers constitute another government initiative. Vehicles are increasingly required to carry so-called „Clean Air Certificates", confirming their CO_2 emissions. Electric cars can move freely around the city, including the days when entry into the city is restricted due to air pollution.[43]

Low-emission public transport

To encourage citizens to use public transport, an increasing number of French cities have introduced various forms of free transport. In 2018, the city of Dunkirk became the largest city in France with waived fares on 18 bus lines.[44] A €90 million investment is planned in 2021 to create two new zero-emission bus routes.[45] In the Alpes-Maritimes region, in addition to a 30% increase in routes frequency, „Keolis" company will be responsible for helping the region fight climate change, mainly by implementing a more sustainable mobility offer. It is assumed that the entire bus fleet will be replaced by electric buses by July 1, 2023.[46]

CLIMATE POLICY

France aims to become the first decarbonised economy and achieve carbon neutrality by 2050.

The 2030 target is a 33% share of renewable energy within the national energy use.[47] France has proposed legislation to reduce emissions by 2030 and to achieve net zero emissions by 2050 in line with the Paris Agreement. Key documents in this area are also the 2015 Energy Transition for Green Growth Act and the National Low Carbon Strategy (SNBC), or the Multi-Year Energy Planning (Programmation pluriannuelle de l'énergie, PPE).[48]

43 *Electromobility in France*, https://www.iabmevent.com/electromobility-in-france/, access: 14.04.2022

44 *How France is testing free public transport*, https://www.bbc.com/worklife/article/20210519-how-france-is-testing-free-public-transport, access: 16.04.2022.

45 *France: Financing of two zero-emission bus rapid transit lines in the Clermont-Ferrand area*, https://www.eib.org/en/press/all/2021-241-france-financement-de-deux-lignes-de-bus-a-haut-niveau-de-service-zero-emission-de-la-metropole-clermontoise, access: 14.04.2022.

46 *A suburban bus network to be converted to zero emissions by 2023. Keolis awarded two contracts in South France*, https://www.sustainable-bus.com/electric-bus/keolis-suburban-bus-network-electric/, access: 16.04.2022.

47 *Geothermal energy in France – what is needed for tapping its potential?*, https://www.thinkgeoenergy.com/geothermal-energy-in-france-what-is-needed-for-tapping-its-potential/, access: 14.04.2022.

48 *France's turning point. Accelerating new growth on the path to net zero*, https://www2.deloitte.com/content/dam/Deloitte/fr/Documents/sustainability-services/deloitte-etude-frances-turning-point.pdf, access: 14.04.2022.

Energy Transition for Green Growth Act

In August 2015, the European Parliament passed the Energy Transition for Green Growth Act (*French: transition* énergétique *pour la croissance verte*). The document sets out a plan to transform the French energy sector with a focus on introducing new technologies using renewable energy sources (including in transport) and increasing energy efficiency (to achieve energy independence and reduce greenhouse gas emissions into the atmosphere). The act sets six main objectives for energy production and consumption:

1. Reduce greenhouse gas emissions by 40% by 2030 (compared to 1990).
2. Phase out fossil fuels - 30% reduction by 2030 (compared to 2012).
3. Reduce nuclear power to 50% of electric power by 2025.
4. Increase the share of renewable energy sources to 32% and production to 40% in 2030.
5. Reduce energy consumption by 50% by 2050 (compared to 2012).
6. Reduce landfill waste by 50% by 2050 (compared to 2012).

The act includes the following additional provisions:

- maintain optimal energy prices for businesses and households,
- raise public awareness of the importance of energy,
- support the creation of a European Energy Union,
- increase the use of renewable sources fivefold by 2030,
- maintain nuclear capacity at 63.2 GW,
- make 2.4 million electric and hybrid cars available by 2023,
- implement hydroelectric storage projects, resulting in increased flexibility of the power system,
- close all coal-fired plants by 2023.[49]

49 J. Popławska, *Transformacja polityki energetycznej Francji*, Studia de Securitate 2019, nr 9(2), https://studiadesecuritate.up.krakow.pl/wp-content/uploads/sites/43/2019/10/8.pdf, access: 14.04.2022.

France Relance

In 2020, the French government presented the „France Relance" - a recovery plan to reduce the impact of the COVID-19 pandemic. The €100 billion plan aims to support businesses, analyze production models, transform infrastructure and invest in training courses. The plan also envisages changes in the context of ecology and provides €30 billion to reduce the environmental impact of economic activities and accelerate the ecological transition. France will support the thermo-modernisation of buildings, decarbonisation of industry, green hydrogen, cleaner transport and the transformation of the agricultural sector. Key measures include:

- **Green Hydrogen Development.**
  Allocate funds to support projects led by companies across the country, encouraging the creation of indigenous solutions for renewable hydrogen production and low-carbon technologies. France will also organize a mechanism to keep hydrogen produced by water electrolysis and create „Important Projects of Common European Interest" (IPCEI) to support the industrialization.

- **Improve mobility.**
  Mobilise €1.2 billion to encourage cycling and develop public transport by improving existing services.

- **Support for the rail sector.**
  Improve the rail network, which will help increase the supply of trains for various purposes. The aim is to connect less densely populated areas to urban areas, accelerate works aimed at improving conditions at railroad stations (especially for people with reduced mobility), and develop freight transport to serve businesses, logistics platforms and ports.

- **Ensure biodiversity, combat land grabbing and agricultural conversion.**
  Increase food sovereignty and meet increased demand for local products by transforming agricultural patterns towards more resilient systems. This transformation will help restore biodiversity in a given area.[50]

50 *France Relance recovery plan: building the France of 2030*, https://www.diplomatie.gouv.fr/en/french-foreign-policy/economic-diplomacy-foreign-trade/promoting-france-s-attractiveness/france-relance-recovery-plan-building-the-france-of-2030/, access: 14.04.2022.

France 2030

At the end of 2021, President Emmanuel Macron presented the „France 2030" investment plan. The investments, worth €34 billion, will follow the French economic recovery plan „France Relance". Their aim will be to support the ecological transformation in areas of outstanding performance (energy, automotive, aeronautics and space), underdeveloped sectors and the creation of new industrial and technological areas. „France 2030" has defined the following objectives:

- creation of innovative small nuclear reactors with a better waste management system,
- leadership status in clean hydrogen,
- decarbonization of French industry,
- introduction of nearly 2 million electric and hybrid vehicles,
- production of the first low-emission aircraft,
- investment in healthy and sustainable food,
- improved healthcare in France, with a special focus on areas such as oncology and chronic diseases,
- put France at the forefront of cultural and creative content production,
- invest €2 billion in space and the seabed.[51]

SUMMARY

France is a country with a high land-use potential and many innovative solutions, making it a pioneer in the energy transformation and in the pursuit of zero emissions. The government aims for France to become the first decarbonized economy and achieve carbon neutrality by 2050. The country is achieving outstanding results in this regard through a number of initiatives aimed at decarbonizing industry, reducing the importance of nuclear power, and most importantly increasing the importance of renewables in the energy sector. Plans are underway to replace cars with electric vehicles, develop renewable energy power plants, make greater use of geothermal water, or develop biomethane plants in order to achieve the planned zero-carbon goal.

51 *Bpifrance, A Key Operator In French Investment Plan "France 2030"*, https://www.bpifrance.com/news-insights/bpifrance-a-key-operator-in-french-investment-plan-france-2030, access: 14.04.2022.

GERMANY

Figure 9. Map of Germany

GEOGRAPHICAL CONDITIONS

The Federal Republic of Germany is located in Western Europe and borders 9 countries: Denmark to the north, Poland and the Czech Republic to the east, Austria and Switzerland to the south, France and Luxembourg to the southwest, and Belgium and the Netherlands to the northwest. The country covers a total area of 357,021 km2, including 349,223 km2 on land and 7,798 km2 offshore, making it the seventh largest country in Europe.

Geographically, Germany stretches from the Alps in the south to the shores of the North Sea in the northwest and the Baltic Sea in the northeast. The German coastline is 2,389 km and the land borders 3,621 km. The country is divided into four main geographical regions: the North German Lowlands, the German Middle Highlands, the foothills of the Alps - the Bavarian Plateau and the Alps.

The relief of Germany, similar to that of Poland, is characterized by a belt system. A belt of the German Lowlands is located in the north and diversified by the post-glacial Mecklenburg Lake District in the east. The entire central part of the country is occupied by the uplands of the German Central Highlands. In the east, along the border with the Czech Republic, one can find slightly higher mountain ranges, including the Šumava with its highest peak at 1,457 m. Naturally, the Alps are the highest mountains, with a small German, or more precisely Bavarian, part located along the border with Austria.

The varied terrain and increased precipitation have resulted in a dense and abundant river network throughout Germany. The northern and central parts of the country belong to the catchment areas of the North Sea and the Baltic Sea, while the south is part of the catchment area of the Black Sea. Germany's two longest rivers, the Rhine-Main and the Elbe, flow into the North Sea. The Oder River, which in part serves as a border with Poland, has its mouth in the Baltic Sea. The Danube drains in the south and has numerous tributaries that flow into the Black Sea. The basins of the main rivers are connected by canals, the total length of which is 2,029 km. The canal system in the German Lowlands connects the Rhine, Weser, Elbe and Oder catchment areas, while the Rhine-Main-Danube Canal, opened in 1992, connects the North Sea and Black Sea catchment area.[52]

Germany has a cool temperate climate with cloudy, wet winters and summers. Most of the country lies in the warm temperate zone, with dominant humid westerly winds. The oceanic climate dominates in the north with year-round precipitation. Winters are relatively mild and summers are quite warm. In the east, a continental climate emerges with very cold winters and hot summers. The central part of the country and the south exhibit a climate with transitional characteristics - both oceanic and continental. The warmest region of Germany is the southwestern corner of the country: the Deutsche Weinstraße and the Upper Rhine Plain. Summers can be very warm and longer than in the rest of the country. Sometimes the minimum temperature does not fall below +20 °C, which is rare in other regions.[53] West and southwest winds predominate. In the Bavarian Highlands, warm and dry winds blow during the spring and autumn months. Extreme phenomena such as summer and spring storms occur.

In Germany, as in other European countries, summers have become downright hot in recent years, characterized by long periods of drought and extreme weather conditions: violent wind storms and heavy rain. The years 2018 and 2019 were the warmest since measurements began. The average annual air temperature increased by 1.5 °C from 1881 to 2018. In the summer, rivers carry less and less water, making months in which groundwater levels are below average more frequent.

ECONOMY

The population of the Federal Republic as of 2020 was 83.24 million, making Germany the most populous country in the European Union, the second most populous in Europe and the nineteenth most populous in the world. The population density is relatively even with a high density of approximately 230 persons/km2. The most densely populated areas are the Ruhrgebiet (5 million inhabitants), the metropolitan areas of Berlin and Potsdam (almost 4 million inhabitants), and the metropolitan areas of Hamburg and Munich (2 million inhabitants each). The vast majority of the German population - 74% - lives in cities, whereas in Poland this figure is 61%.

German economy is very well developed and is the largest in Europe and fourth in the world - after China, the United States and Japan. It is worth noting that the German budget generates surpluses every year.

Exports have become the backbone of the German economy and have been instrumental in the country's economic recovery. Germany is currently the second largest exporter in the world after China, surpassing even the United States. The main exports include

52 *Encyklopedia PWN*, hasło: *Niemcy Warunki naturalne,* https://encyklopedia.pwn.pl/haslo/Niemcy-Warunki-naturalne;4574875.html, access: 06.04.2022.

53 *Środowisko przyrodnicze i gospodarka Niemiec*, https://zpe.gov.pl/a/srodowisko-przyrodnicze-i-gospodarka-niemiec/DD20MtgUQ, access: 02.04.2022.

machinery, automobiles, industrial tools, electronics, textiles, chemicals, precision instruments, steel, and agricultural and food products. Germany also exports hard coal and lignite, as well as uranium - the latter has strengthened in exports due to the closure of nuclear power plants in Germany.

Nevertheless, the economic power of Germany is determined by other factors as well. One of them is industry and its enormous role in building the economy of our western neighbors. The share of industry in gross value added is the highest among the G7 countries, at 22.9%. The strongest sectors are the automotive industry, engineering and chemicals. Companies from over the Rhine dominate the engineering industry (17% of exports), the automotive industry (15% of exports) and the pharmaceutical industry (6% of exports).[54] One of the biggest and well-known companies – „Volkswagen", the world's largest car manufacturer, the industrial giant „Siemens" or the drug and chemical manufacturer „Bayer" - are often behind such great industrial and export success.

The Federal Republic of Germany, evaluated in terms of the amount of trade in goods in foreign trade in the generation of gross domestic product (GDP), is the most open economy among the G7 countries. The foreign trade share ratio is nearly 84.4% - the sum of total imports and exports relative to gross domestic product.[55] By comparison, the U.S. rate was 26%.

Small and medium-sized enterprises, where annual turnover does not exceed €50 million that employ fewer than 500 people, are extremely important in the German economy. These companies make up 99.6% of German businesses. More than 1,000 of them constitute the so-called „Hidden Champions", i.e. global market leaders, often hardly known to the general public. Germany is home to very strong economic centers, namely the metropolitan regions of Munich (high-tech), Stuttgart (automotive industry), Rhine-Neckar (chemical industry, IT), Frankfurt am Main (finance) and Hamburg (port, aircraft construction, media). The Berlin/Brandenburg region offers the fastest growing startups. A multitude of factors - from infrastructure to special legal and tax regulations - are conducive to the development and expansion of these companies.

ENERGY MARKET

Under current guidelines, the power sector will be required to reduce greenhouse gas emissions to 175-183 million tons of CO_2 by 2030. Compared to 1990, this is a 62% reduction.[56] Going forward, by 2050 energy sources must be „almost fully decarbonized" and come from renewable sources. So far, there are no solid numbers behind the „almost" statement.

Germany has an ambitious plan to base its entire energy mix on renewables and has indicated the use of clean energy for heating and transport in industry - including heavy industry. Furthermore, Germany promises to reduce its use of biomass. Throughout the Climate Action Plan, natural gas is mentioned only as a temporary fuel to support the transition.[57]

54 *UN Comtrade,* https://comtrade.un.org/, access: 05.04.2022.

55 M. Orth, *Dlaczego Niemcy mają tak silną gospodarkę?,* https://www.deutschland.de/pl/topic/wirtschaft/warum-ist-die-deutsche-wirtschaft-so-stark-sieben-gruende, access: 05.04.2022.

56 *Zmiany klimatu: ostatnie siedem lat było najcieplejsze w dziejach*, https://www.dw.com/pl/zmiany-klimatu-ostatnie-siedem-lat-by%C5%82o-najcieplejsze-w-dziejach/a-60382567, access: 05.04.2022.

57 *Climate Action Plan 2050*, Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) 2016, p. 6.

Coal

The Climate Action Plan announced in 2016 provides a shift away from energy produced from coal and lignite and the closure of operating mines. The 2016 version does not set any specific dates. Rather, it focuses on the transition process itself: phasing out mines, establishing special commissions to oversee the entire process, and ensuring that regions with local economies that rely on coal have a safe and peaceful „transition".

The plan to transition away from coal by 2038, announced and adopted in 2020, includes the following steps:

- By the end of 2022, capacity will be maintained at 15 GW for hard coal and 15 GW for lignite (down from 22.8 GW for hard coal and 21.1 GW for lignite);
- By the end of 2030, capacity of 8 GW for hard coal and 9 GW for lignite;
- By the end of 2038 at the latest, the mines will be removed from the German energy system;
- In 2025, 2029 and 2032, analyses will be conducted and decisions will be made on the possibility of an earlier (2035) abandonment of coal mining for power generation.

Nevertheless, newly elected German Chancellor Olaf Scholz announced in November 2021 that coal mining in Germany would be discontinued by the end of 2030 with the possibility of importing hard coal from Russia.[58] After the outbreak of the war in Ukraine and the imposition of global sanctions against Russia, a wave of criticism fell on Germany due to the continuous import of Russian coal. Chancellor Scholz explained the lack of a firm reaction by saying that the German economy is too dependent on Russian coal. One should ask whether the German energy sector is really striving for independence or is it seeking the best possible financial conditions and good relations with strategic partners?

Crude oil

In 2021 Germany imported 81 million tons of crude oil. Russia was the largest supplier of oil in 2021 - 34.1% of it came from there, 12.5% from the United States, 9.8% from Kazakhstan and 9.6% from Norway.[59] In total, crude oil flowed to Germany in 2021 from about 30 countries.

Transport accounts for most of Germany's oil consumption, so the transition to renewables, which has largely focused on electricity, has had little impact so far. Nevertheless, the energy transition has reduced the already small role of oil in power generation (0.8% share of gross energy production in 2021), as low-cost renewable energy has displaced oil-based generation.[60]

58 *Kanclerz Scholz: zmiana polityki energetycznej Niemiec. OZE szybciej, nowe terminale LNG*, https://energia.rp.pl/surowce-i-paliwa/art3576131-kanclerz-scholz-zmiana-polityki-energetycznej-niemiec-oze-szybciej-nowe-terminale-lng, access: 03.04.2022.

59 *Niemcy-Rosja: stosunki handlowe pod presją*, https://www.dw.com/pl/niemcy-rosja-stosunki-handlowe-pod-presj%C4%85/a-6092718, access: 07.04.2022.

60 *Climate Action Plan 2050*, Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) 2016, p. 34.

The German government aims to reduce energy consumption in transport up to 60% by 2050, compared to 2005 levels. Unfortunately, consumption continues to increase due to the ongoing development of road infrastructure and changes in people's lifestyles. The same is true for heavy transport and air transport. It was only during the COVID-19 pandemic that Germany saw marked declines in these areas. The current government expects 15 million electric cars to be on Germany's roads by 2030, with a growing trend of reducing oil consumption in favor of renewable energy sources.

Natural gas

Natural gas covered more than ¼ of German energy consumption in 2021. This makes it Germany's second most important energy source[61] The Federal Republic of Germany is among the largest importers of natural gas in the world - 95% of German demand for gas comes from import (data from BGR - Federal Institute for Geosciences and Natural Resources). It is worth noting, that Germany sells about half of its imported gas to other countries, including Poland. In turn, Germany produced 5.7 billion cubic metres of natural gas from its own resources in 2020, however German geologists make no secret of the fact that these sources are not prospective.[62] Domestic natural gas production has steadily declined since 2004 and is likely to cease entirely in the coming years.

According to the Federal Office of Economic Affairs and Export Control (BAFA) Germany imported 5009 petajoules (PJ) of natural gas in 2021. The share of imports by country of origin is unclear. Due to data privacy regulations, BAFA stopped publishing import volumes by country in 2016. However, the Ministry of Economic and Climate reported in 2022 that 55% of gas imports came from Russia, 30% from Norway and 13% from the Netherlands.

Germany imports gas exclusively through pipelines. Construction of Gazprom's controversial Russian-German „Nord Stream 2" pipeline project is now complete, but bureaucratic obstacles and Russia's war with Ukraine continue to put the project's future in doubt. The certification process was halted at the beginning of the war.

Germany does not currently have the infrastructure to directly import liquefied natural gas (LNG). Some attempts have been made to create a domestic LNG import infrastructure, but so far they have failed due to lack of economic interest. As a result of Russia's war with Ukraine and concerns about security of supply, the German government has announced the construction of two domestic import terminals. The German government said it would provide half of the funds needed to build one of the two plausible projects. Germany can currently use terminals in neighboring countries where LNG is regasified and fed into the pipeline infrastructure.

Today, most of the gas is used in the industrial sector (e.g. for production of electricity and heat, or in chemical processes), followed by households (mainly for heating purposes), the power and public heating, manufacturing and trade. The consumption of natural gas in transport is marginal.[63] Most of the gas is burned to produce heat, and only a small portion is used to produce electricity.

The German government as well as numerous experts see natural gas as a bridge to a low-carbon economy because it emits significantly less CO_2 than coal or oil when burned. However, fugitive emissions, such as methane leakage during production and transportation, must be taken into account when assessing the total life cycle of greenhouse gas emissions. Gas complements variable renewable energy supplies quite well because modern gas-fired power plants (unlike coal) can switch from idle to full power in minutes if needed.

So far, various German governments have predicted that the planned shift from nuclear and coal power means that medium-term gas demand will increase. However, a number of analysts doubt these predictions. Renewables, energy storage and other

61 *Germany's energy consumption and power mix in charts,* https://www.cleanenergywire.org/factsheets/germanys-energy-consumption-and-power-mix-charts, access: 07.04.2022.

62 *Klima-Energie*, https://www.umweltbundesamt.de/themen/klima-energie/treibhausgasemissionen, access: 08.04.2022.

63 Julian Wttengel, *Germany and the EU remain heavily dependent on imported fossil fuels,* https://www.cleanenergywire.org/factsheets/germanys-dependence-imported-fossil-fuels, access: 15.04.2022.

green solutions will cover more and more energy needs across Europe. Forecasts for future gas demand in the EU and Germany vary widely, with many experts predicting a significant decline. In the third quarter of 2021, natural gas accounted for just 8.7% of Germany's energy mix - a decrease of 5.7%, compared to the same period in 2020.[64] According to „Destatis" (Federal Statistical Office of Germany), this is largely due to the fact that the price of natural gas increased in the second half of 2021.

Solar energy

Germany is one of the largest producers of solar energy in the world, despite its geographic location and relatively few hours of sunshine per day. According to the International Renewable Energy Agency (IRENA), the country ranked 4th in 2021 with an installed capacity of nearly 60 gigawatts (GW) after several years of leading the ranking of countries with the largest solar energy production.

In contrast to conventional energy systems focused on large and centralized manufacturers, thousands of small solar panel operators have become an important part of the German energy system. Small installations mounted on the roofs of single-family homes have played a huge role. According to the Fraunhofer ISE research institute, in 2021 all photovoltaic prosumers combined produced about ten percent of the country's net energy consumption, with a total renewable energy share of nearly 46 percent.[65] According to the International Energy Agency (IEA) , the global share of solar energy in power generation exceeded 2% for the first time in 2019. In 2021 about 5.3 GW of solar panels were built in Germany, 10% more than the year before but still significantly less than during the photovoltaic boom years between 2008 and 2013. The industry can expect the number of installations to rise soon, as it is a key component of the country's push for greater energy independence following Russia's invasion of Ukraine. In April 2022, the German government issued the so-called „Easter Package" regarding renewable energy policy reforms. Its goal is to achieve an 80% renewable energy share in 2030 and 100% in 2035, meaning that the annual volume of expansion must quadruple to meet the target of installing 215 GW by the end of the decade.

Following serious declarations by the government of Chancellor Olaf Scholz, German local governments are implementing local solutions to comply with climate policy. In early 2022, the first two German states implemented mandatory photovoltaics for certain construction projects, and several other states are expected to follow suit with similar legislation. The central government has come out with a proposal to make solar panels on roofs mandatory for new commercial buildings and to introduce them „in principle" in new private buildings. The government has also agreed to open up more agricultural land and uncultivated greenfields to photovoltaic installations.

Several commentators regretted the fact that the German government was allowing an increasing influx of solar panels from China, rather than supporting German entrepreneurs.[66] Allegations have been made that German power consumers are subsidizing Chinese manufacturers, against whom domestic suppliers are unable to compete due to higher labor costs and stricter environmental regulations for panel production. Others praised the combination of steady German capital and cheap Chinese labor as a cost-cutting catalyst that helped boost capacity growth and paved the way for the technology's competitiveness.

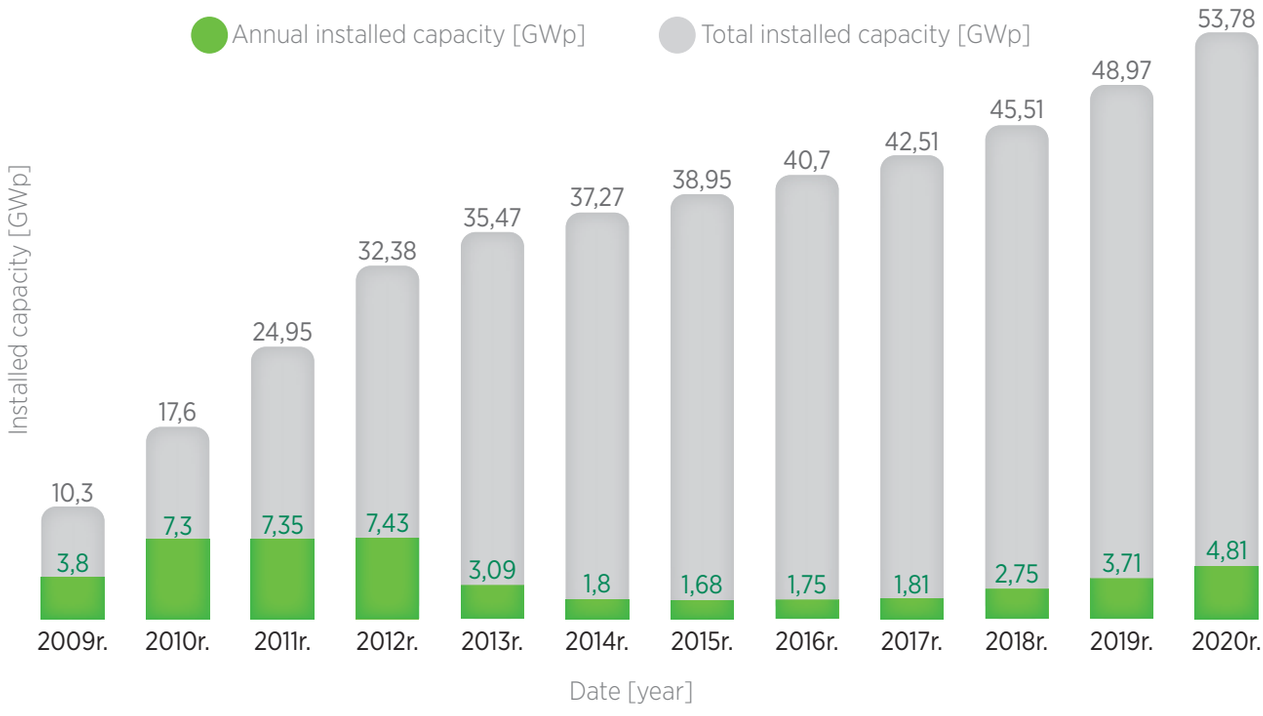
According to the Fraunhofer ISE research institute, solar energy has become the cheapest way to generate energy in Germany. Depending on the type of installation and the intensity of the sunlight, it costs no more than 3.7 euro cents to produce one kilowatt hour (kWh) using solar panels. The cost of new panels fell by about 90% between 2010 and 2021. An analysis by the British climate NGO „Sandbag" found that the drop in costs was so large that new solar (and wind)

64 *Niemiecki miks energetyczny: Wzrósł udział węgla w III kwartale*, https://www.dw.com/pl/niemiecki-miks-energetyczny-wzr%C3%B3s%C5%82-udzia%C5%82-w%C4%99gla-w-iii-kwartale/a-60148462, access: 08.04.2022.

65 B. Wehrmann , *German onshore wind power – output, business and perspectives,* https://www.cleanenergywire.org/factsheets/german-onshore-wind-power-output-business-andperspectives, access: 06.04.2022.

66 *Photovoltaics – the key to the Energy Transition*, https://www.solarwirtschaft.de/en/topics-of-interest/photovoltaics/, access: 12.04.2022.

Figure 10. Growth of installed solar capacity in Germany, 2009-2020



Source: https://www.solarwirtschaft.de/en/home/, acess: 12.04.2022.

installations at German auctions are not only cheaper than new coal- and gas-fired power plants, but also undercut the operating costs of existing fossil-fuel plants.

However, falling panel prices, which have been a major driver of the recent growth in solar expansion, may soon reach a standstill. This would make other factors such as increased productivity, sustainability and flexibility more important to users and investors. Regardless of future breakthroughs in panel development, German consumers already rank solar power as their favorite form of renewable energy generation, claiming that greater expansion of the technology will bother them the least. In fact, solar energy ranked first in a poll conducted by pollster „Allensbach" on what Germans consider to be the most important energy source in the future. 80% of respondents expected solar energy to take the lead, and 85% said they wished this would happen.

German solarpower companies are struggling to compete with Asian manufacturers while maintaining their edge when it comes to researching module system integration and implementing innovative applications. Foreign market leaders often focus on large projects with high returns, which are likely to be only part of future growth, where small-scale prosumers are also expected to play an important role.

German companies such as „Solarwatt" and „Sonnen" offer integrated solutions that allow to store surplus solar energy at home and share or trade it with neighbors and other prosumers around the clock. As the price of home energy storage technologies has fallen sharply in recent years, they are set to benefit from the trend toward self-supply and decentralized production, making them less dependent on external factors and possibly sparking a new wave of solar investment in the country soon.

Wind energy

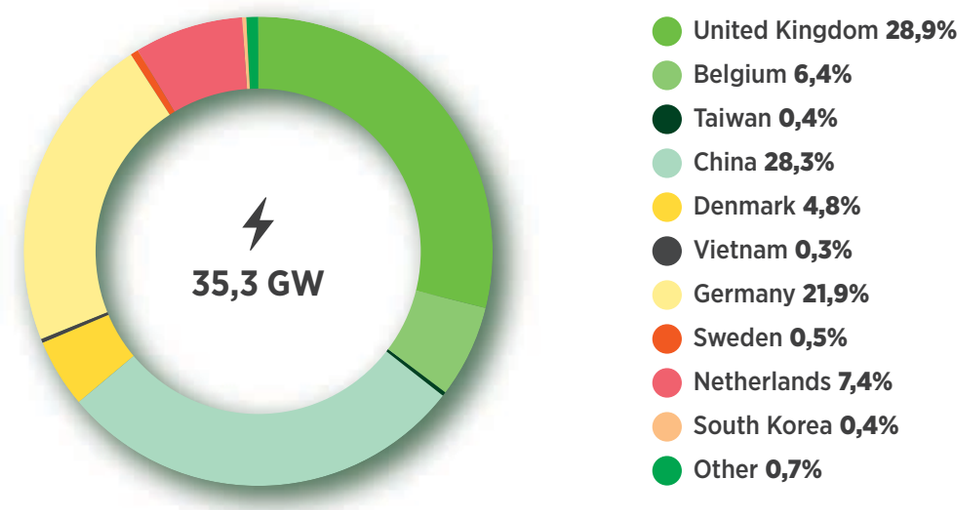
Offshore wind energy was the last of several renewable energy technologies to be introduced on a large scale during Germany's energy transformation, and it is catching up fast. While investors initially avoided high investment costs and risky operating conditions, price drops and technological advances have made offshore wind increasingly attractive. Yet despite the fact that reliable offshore winds have shown that offshore turbines can make a significant contribution to Germany's climate goals, the expansion of offshore wind capacity came to a halt in 2021.

Offshore wind energy is a relatively young industry in Germany. While experience in onshore wind energy dates back to the early 1990s, the country's first offshore wind farm did not begin operating until 2009 (in test mode). Over the next decade, the technology underwent rapid development in Germany and several other countries. By early 2022, there were about 1,500 turbines operating in German waters in the North and Baltic Seas with a capacity of nearly 7.8 GW.

Despite the fact that Germany has only a relatively small offshore area available for offshore wind, the technology is now seen as a key component of its energy transformation plans. Unfortunately, as of 2021, not a single new turbine has been built in the country.[67] Back in 2017, turbines installed in German waters accounted for about 40% of global capacity, making it the world's second-largest offshore wind market after the UK. However, Germany has since been overtaken by China.

The share of offshore wind in Germany's energy mix reached almost 5% in 2021, a significant increase from just 0.1% in 2014. The cumulative offshore capacity of 7.7 GW provided more than 24 terawatt hours (TWh) of electricity in 2021, whilst the new government has set an ambitious target of reaching 30 GW by 2030.

Figure 11. Total installed capacity of offshore wind turbines in the world



Source: https://gwec.net/, acess: 12.04.2022.

67 J. Lee, F. Zhao, *GWEC | GLOBAL WIND REPORT 2022,* Global Wind Energy Council 2022, p. 108.

Onshore wind energy is a major pillar of the German energy transition and at the same time the most important source of energy in Germany. The country has been the European leader in installing onshore windmills for many years and the world leader in developing this technology. German companies have struggled in the wind industry in recent years, as domestic expansion fell to its lowest level in 2019. The 2021 expansion, on the other hand, saw exactly as many new wind turbines built as a decade earlier. However, the wind industry can expect a quick reversal of the trend, as Germany will have to push towards wider energy independence after Russia's invasion of Ukraine. This has resulted in the release of the so-called „Easter Package", which includes a number of renewable energy policy reforms, including plans to push onshore wind expansion with double the rate.

A total of 28,230 onshore turbines with a combined capacity of about 56 GW were in operation throughout Germany at the end of 2021. The new expansion target is an annual capacity increase of 10 GW by 2025 and an increase in total installed capacity to 115 GW by 2030. Turbines added in 2021 had an average capacity of more than 3.9 MW, a hub height of 140 meters and a rotor diameter of 133 meters. Average turbine heights have more than doubled over the past two decades, meaning new installations can produce more power. A single modern onshore turbine produces enough energy to power up to 6,000 households.

Electricity generation has become much cheaper over the years due to more stable power supplies and better grid compatibility of new installations. According to the wind energy association „BWE", depending on location and turbine size, average prices per kilowatt-hour (kWh) of electricity were just over 4 euro cents by mid-2021.

The entire development of wind power in Germany was made possible thanks to the introduction of the so-called „Guaranteed Tariffs" - regulations implemented with the German National Renewable Energy Act (EEG) in 2000. These tariffs provided renewable energy investors with a secure cash flow for a period of 20 years. In 2021, the first early wind installations reached the end of their guaranteed funding period, and operators began to look for alternative ways to keep their installations operating at some profit. However, a concern has also arisen that with the end of the „guaranteed periods" and a low rate of expansion, a drop in installed capacity could occur. Industry association „Deutsche Windguard" has calculated that by 2025, some 16,000 MW will face the end of the 20-year guaranteed payments.[68]

Estimating the time at which individual windmills will close is a difficult task. Germany is looking for new business models, such as power purchase agreements, that can mitigate the effects of the expiration of guaranteed support. Other investors, such as local government officials in Munich, are following a different model and plan to buy old wind farms no longer eligible for support, retrofit them and continue to generate profit by operating them at market prices. Similar plans have been announced by „Daimler", the car manufacturer, which intends to use older wind turbines to meet its goal of decarbonizing production.

68 K. Appunn, *Germany scraps support plans for old wind turbines over state aid concerns,* https://www.cleanenergywire.org/news/germany-scraps-support-plans-old-wind-turbines-over-state-aid-concens, access: 07.04.2022.

CLIMATE POLICY

It is difficult to pinpoint one specific date or event that would indicate the official emergence of the idea of „Energiewiede", a program of comprehensive energy transformation affecting virtually every aspect of lives of the people of the Federal Republic of Germany. The year 2022 and the conflict between Russia and Ukraine showed that „Energiewiede" has a significant impact on Europe and the world. In the 1970s, the global oil crisis forced national leaders to reflect on the transformation of the energy system. It was when the Organization of Arab Petroleum Exporting Countries (OAPEC) imposed an embargo on oil supplies to countries that had supported Israel in the Yom Kippur War that we had the first example of the use of energy resources as a political weapon.

Movements and organizations opposed to nuclear energy in Germany began to emerge in the 1980s. In 1983, the Green Party entered the Bundestag for the first time advocating for nuclear energy to be phased out. The Chernobyl disaster in 1986 greatly intensified anti-nuclear sentiments in Germany. The combination of these events led to the closure of the first two nuclear power plants in 1990 for economic and safety reasons. With the signing of the Kyoto Protocol, the German government began to take a realistic approach towards the reduction of CO_2 emissions and diversification of domestic energy sources. In 2000, the so-called „Erneuerbare Energien Gesetz" was passed - a package of legal tools facilitating the use of renewable energy and even giving it priority.[69] The then government also reached a consensus that Germany would phase out all nuclear power plants by 2022. Between 2010 and 2015, influenced by the growing demands of the European Union, the German government announced further commitments to increase the share of renewable energy in the energy mix by 2020 and 2050, respectively.[70] Following the Fukushima nuclear power plant disaster, Chancellor Angela Merkel announced an acceleration of the plan to shut down all nuclear power plants in Germany.

In 2016, the federal government agreed on its 2050 Climate Action Plan, which provides the basic framework for the substantial decarbonization of the German economy and the achievement of climate targets by 2050. The plan includes specific targets for reducing greenhouse gas emissions in individual economic sectors.

The Climate Action Plan provides guidance, solutions and proposed legislation for all areas of activity covered by the implementation of the climate targets set by the 2015 Paris Agreement. These action areas are: energy, construction, transport, trade and industry, agriculture and forestry. The key elements of the plan include:

- Long-term goal: to achieve climate neutrality for the Federal Republic of Germany by 2050;
- Guidelines and possible pathways for the transformation in all areas of activity by 2050;
- Milestones and targets needed to be achieved by all sectors of the economy by 2030;
- A list of strategic measures for each area of activity;
- Establishing a process of knowledge sharing and competence enhancement to further develop and set more ambitious targets in relation to the Paris Agreement.

69M. Bischoff, Dr. E. Chauvistré, C. Kleis, J. Wil, *Niemcy w świetle faktów i liczb*, FAZIT Communication GmbH, Berlin 2018, p. 83.

70 B. Wehrmann, *The Energiewende's booming flagship braces for stormy Times,* https://www.cleanenergywire.org/dossiers/onshore-wind-power-germany, access: 31.03.2022.

SUMMARY

Undoubtedly, the Federal Republic of Germany is a role model for countries aspiring to become climate neutral. After all, the German „Energiewiede" has affected not only the German economy and energy sector, but the German society itself. For years, Germans have been aware of the dangers of excessive CO_2 emissions or lack of proper waste management. Installing photovoltaic panels on their roofs, domestic sewage treatment plants, thorough waste segregation are obvious to the average German citizen, the same cannot be said of many European communities. One should learn from the Germans, but also learn from their mistakes. The outbreak of the war caused by Russia's invasion of Ukraine has effectively revealed all the downsides of „Energiewiede". Germans find themselves in an extremely difficult position: between the European states and the USA, seeking to cut off the supply of raw materials from the East and Russia, Germany's largest supplier of gas and energy fuels. It is important to consider whether it is wise to bet all your cards on renewable energy given the current state of knowledge and level of technology, proven to be insufficient even for the current pioneers of these areas. Having studied the „Energiewende" against the backdrop of recent history, the European Union and its member states should reconsider their ambitious plans and targets for eliminating nuclear power and coal mining. Furthermore, the EU and its member states should, like Germany, consistently implement plans for the development of renewable energy.

SWEDEN

Figure 12. Map of Sweden

GEOGRAPHICAL CONDITIONS

The Kingdom of Sweden is a country located in the northern part of Europe, on the Scandinavian Peninsula. Sweden has a total area of 449 964 km2. The country is bordered by Norway (1,619 km) and Finland (586 km). The Baltic Sea and the Gulf of Bothnia form the country's eastern and southern borders. The coastline is 3218 km long.[71]

71 *Geografia Szwecji*, https://pl.wikipedia.org/wiki/Geografia_Szwecji, access: 15.12.2021.

Sweden's population in 2021 was 10,255,000. The country's capital is Stockholm, which is also its largest city with nearly 1.7 million inhabitants.[72] The population of the capital represents more than 16% of the total population of Sweden. The other major Swedish cities are Gothenburg, Malmö and Uppsala.

Sweden is an upland country with an average altitude of 276 m above sea level. 80% of the country is between 100 and 500 meters above sea level. Only 2.6% of Sweden is situated above 1000 m above sea level. Lowlands also make up a large part of the country, covering about a quarter of its land area. Sweden's highest peak is Kebnekaise rising 2111 m above sea level. It is located in the Scandinavian Mountains along the border with Norway.

Sweden is located in the catchment area of the Baltic Sea. The country has large inland water resources with almost 100,000 lakes and a dense river network. The country's largest lake - Wener (5650 km2) is the third largest lake in Europe.[73] It can be reached by Sweden's longest river, the Klar. In addition, Sweden has 237 glaciers with a total area of 310 km2.

Most of Sweden has a temperate climate. Subpolar climates prevail in the northern parts of the country. Therefore, Sweden is characterized by large temperature differences. The average temperature in January is +1 degrees Celsius in the south and -14 degrees Celsius in the north, July is respectively +16 to +10 degrees Celsius. Sweden is a rainy country. The annual precipitation ranges from 400 mm in the mid-mountain basins, 600-700 mm in the south and 1500 mm in the mountains. Much of the precipitation is snow.

Due to their glacial origin, Swedish soils are extremely poorly developed and often rocky. Because of the large number of erratic boulders left behind by the ice sheet, the soils cannot be used agriculturally.

ECONOMY

Sweden is one of the world's most stable economies. In 2021, Swedish GDP was $541.22 billion.[74] At the same time Sweden was ranked among the wealthiest countries in the world. GDP per capita in 2020 reached $52 274, 409.[75] Sweden has a very diverse and highly competitive economy. According to the IMD World Competitiveness Ranking 2021 - in which 64 economies from around the world were evaluated - Sweden ranked second, after Switzerland and before Denmark. According to the World Bank, a key feature of the Swedish economy is its openness and liberal approach to trade and business. Sweden is traditionally an export-oriented country and usually runs a trade surplus, i.e. the value of its exports of goods and services is greater than the value of its imports.[76]

The state sector has a dominant role (over 50%) in the Swedish economy. The state owns or has controlling stakes in numerous Swedish companies in various fields of industry. The state also holds a monopoly in a large number of sectors. Among them are alcohol trade, drug trade (pharmacies) and gambling. The state also dominates the energy, mining, forestry and arms industries by virtue of ownership. There are currently 46 wholly or partially state-owned companies, two of which are listed on the stock exchange. In addition, the state manages two business foundations. State-owned enterprises employ a total of about 135,000 people.[77] The largest and best known entities include „Apotekt" AB (drug distribution), „Green Cargo" AB (rail transport), „LKAB" (iron mining), „PostNord" (postal operator,

72 *Stockholm, Sweden Metro Area Population 1950 -2022*, https://www.macrotrends.net/cities/22597/stockholm/population, access: 15.12.2021.

73 *Vänern*, https://en.wikipedia.org/wiki/V%C3%A4nern, access: 15.12.2021.

74 *GDP (current US$) – Sweden*, https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=SE, access: 15.12.2021.

75 *Ibidem.*

76 *Long-term policies and a global approach have made's Sweden economic growth possible. Find out more*, https://sweden.se/work-business/business-in-sweden/the-swedish-economy, access: 15.12.2021.

77 *State-owned enterprises*, https://www.government.se/government-policy/state-owned-enterprises/, access: 15.12.2021.

the government owns 60% of the shares). In addition to the state sector, large companies with international connections play an important role in the Swedish economy. Sweden is the cradle of such well-known brands as „Volvo" (now owned by the Chinese corporation „Geely"), „H&M" (production and sale of clothing), „Electrolux" (production of household appliances) and" IKEA" (furniture industry). Traditional industry, such as mineral extraction and timber production, is also an important part of the Swedish economy. The Arctic Circle town of Kiruna is home to the world's largest iron ore mine.

The mine accounts for 90% of iron ore production in Europe.[78] Swedish deposits are considered to be the cleanest in the world. The raw material extracted by the aforementioned state-owned company „LKAB" is primarily intended for export. Swedish forests are also a natural wealth. The country has the largest forest area in Europe. This makes Sweden one of the leading producers of sawn timber, pulp, paper and cardboard. Woodworking facilities are located mainly in the northern part of the country, on the coast of the Gulf of Bothnia. 60% of the timber industry's production is exported.[79]

ENERGY MARKET

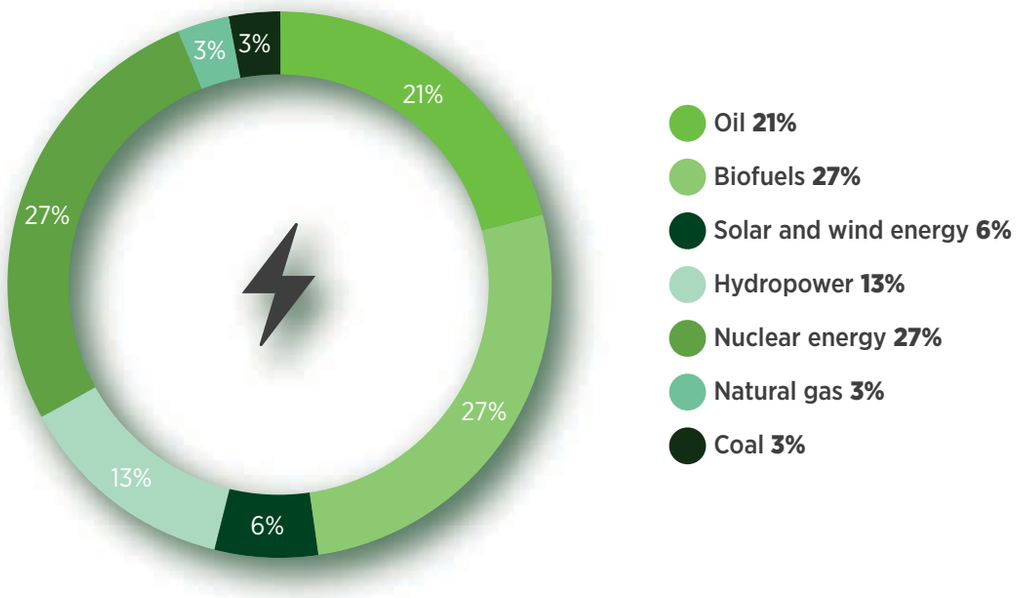
Sweden is one of the top energy consuming countries per capita. According to 2018 data, one Swede consumes a total of 14.03 kWh per year on average. However, unlike other countries, Sweden's high energy consumption is not associated with the emission of large amounts of greenhouse gases. According to World Bank data, emissions of CO_2 per capita were just over 3.5 tons in 2018. Thus, Swedes emit less carbon dioxide than both leading world economies e.g. the United States, China and Germany, but also less than comparable and smaller countries in terms of area and population (e.g. Norway, Belgium and Estonia). Sweden's energy sector is characterized by a high share of renewable energy sources. More than 70% of the energy used by Swedes comes from „green" sources such as water, wind, biofuel and nuclear. This makes Sweden a leader among the EU countries in terms of the share of renewables in the energy sector. Renewable energy sources cover the entire national electricity production. According to a report prepared by the Swedish Energy Agency, mainly nuclear power (39%), hydropower (39%) and wind farms (12%) are used to produce electricity.[80]

78 *Kiruna – jak powstało szwedzkie Klondike,* [na:] https://przegladbaltycki.pl/3085,kiruna-jak-powstalo-szwedzkie-klondike.html, dostęp: 15.12.2021.

79 *Gospodarka Szwecji*, [na:] https://www.travelplanet.pl/przewodnik/szwecja/gospodarka.html, dostęp: 15.12.2021.

80 *Energy in Sweden 2021*, [na:] https://energimyndigheten.a-w2m.se/Home.mvc?ResourceId=198022, dostęp: 17.12.2021.

Figure 13. Sweden's energy supply according to the sources used to produce it in 2020



Source: https://www.iea.org/countries/sweden, access: 16.12.2021

Nuclear energy

Nuclear power plants have been a key part of the Swedish energy system since the first nuclear CHP plant at „Agesta" came online in 1963, providing heat to the suburbs of Stockholm.[81] On May 18, 1972, Sweden's first nuclear electric power plant located in Oskarshamn was opened. Until 1977, Sweden was powered by three nuclear power plants with a total of six reactors. These power plants produced 20 TWh in total and thus accounted for about 20-25 % of the total electricity production.[82] The next six reactors began operating between 1980 and 1985. Despite the fear caused by the accident at the American Three Mile Island power plant in 1979 and the referendum in which Swedes voted to halt the development of nuclear power, all the investments that had been started in the sector were completed.[83] According to the referendum, all nuclear power plants in Sweden were to be phased out by 2010. The ban on the development of nuclear power was regulated by law in the „Nuclear Phase-out Act". However, this date has become obsolete in light of climate change and its impact on the country's economy. In 1997, the Swedish parliament decided to close the two oldest units at „Barsebäck", but abandoned the 2010 deadline for phasing out nuclear power. In addition, in 2010, the government decided to lift the ban on building new nuclear units on the condition that they replace the existing reactors slated for shutdown.

Nuclear power was taxed in Sweden in the 1980s. In 2000, the nuclear tax was changed from a tax on power generation to a tax on installed thermal capacity, which was set at SEK 5 514 (about €528) per MWh per month. The tax was then gradually increased to SEK 14 440/MWh (about €1377/MWh) per month, or more than SEK 70 per MWh (about €8/MWh). The levy represented about one-third of the operating costs of nuclear power and, combined with low wholesale electricity prices in the Nordic market, severely undermined the economics of Swedish

81 *Energetyka jądrowa w Szwecji. Najlepsza w surowym klimacie*, https://www.cire.pl/pliki/2/szwecja.pdf, access: 17.12.2021.

82 *Rawa: Szwecja odchodzi od atomu, ale powoli*, https://biznesalert.pl/atom-fukushima-szwecja-czarnobyl-energetyka-awarie/, access: 17.12.2021.

83 *Szwecja podzielona w sprawie energii jądrowej*, https://www.cire.pl/artykuly/serwis-informacyjny-cire-24/178880-szwecja-podzielona-w-sprawie-energii-jadrowej, access: 17.12.2021.

nuclear energy. The government began phasing out the nuclear capacity tax in 2017 and finally eliminated it in January 2018.[84]

In 2020, nuclear power accounted for nearly 40% of the nation's electricity production. However, this value will decrease in the following years. This is strongly influenced by the closure of three nuclear units in 2005, 2015 and 2017. The rapid growth of electricity generation from strictly renewable sources, supported by the green energy certificate scheme introduced in 2003, is contributing to the decline of nuclear power. The Energy Agreement of 2016 did not ban the operation of existing nuclear reactors or the construction of new power plants (provided they are built on the site of old facilities and the investments are not supported or subsidized to a limited extent by the state). The rising costs of maintaining and upgrading existing power plants, low wholesale electricity prices in Scandinavia, and the power generation planned in the 2016 Agreement exclusively from renewables (with hydropower and wind power dominant) do not support the development of Swedish nuclear power. In 2019 and 2020, two reactors of the Ringhals nuclear power plant were shut down for economic reasons ahead of the originally planned date.[85] Sweden currently operates six nuclear reactors. The complete shutdown of Sweden's nuclear power plants is expected to take place by 2040.

Hydropower

Water is the most important renewable energy source in Sweden. A dense network of rivers and lakes enables its widespread use in the energy production process. Both watercourses and reservoirs are used for energy purposes. The Swedish hydropower industry started in 1882 with the first hydroelectric power station. Water as a source of energy has been used since the Middle Ages. The first legal regulation on the subject dates back to 1228. The „Mills Act" stipulated that at least one third of the river must be free flowing, including for fish living in it.[86] The development of the Swedish hydropower industry began after 1918 as a result of legislation passed by parliament to accelerate the expansion of the industry. Today, Sweden has nearly 1,800 hydropower plants and 600 dams.[87] The 203 largest power plants, with more than 10 MW of capacity, supply 93% of the 65 TWh of hydropower. The total installed capacity in hydroelectric power plants totals about 16,301 MW or about 40% of the national energy production.[88] Most of the power stations are located on the four largest rivers in the country - Luleälv, Indalsälv, Umeälv and Ångermanälv. There are 15 hydropower plants on the 460-kilometer-long Luleälv river alone, owned by the state-owned energy company „Vattenfall".[89] The Harsprånget hydroelectric power plant, the largest in Sweden and the fourth largest in Scandinavia, was also built on this river. Its construction began back in the 1920s and due to the economic crisis following World War I resulted in a delay of more than 30 years. Its first generator started in 1951. The largest turbine-generator unit in Harsprånget, „Gerhard", was put into operation in 1980. This makes it the largest hydroelectric unit in the country. The output of the generator is 475 MW. The total capacity of the power plant is 977 MW.[90]

Because of its inexhaustibility and zero emissions, hydropower will continue to be a pillar of the energy industry in Sweden. However, the average age of Swedish hydropower plants is currently 45 years. For that reason, and because there are no plans to build new large-capacity power plants, investments are needed to modernize these plants, and increase the

84 *Energy policies of IEA countries. Sweden 2019 Review*, https://iea.blob.core.windows.net/assets/abf9ceee-2f8f-46a0-8e3b-78fb93f602b0/Energy_Policies_of_IEA_Countries_Sweden_2019_Review, access: 17.12.2021.

85 *Po 45 latach wyłączono reaktor R1 w szwedzkiej elektrowni jądrowej Ringhals*, https://serwisy.gazetaprawna.pl/energetyka/artykuly/8057305,ringhals-reaktor-r1-szwecja.html, access: 17.12.2021.

86 *Towards sustainable hydropower in Sweden*, https://www.havochvatten.se/en/eu-and-international/towards-sustainable-hydropower-in-sweden.html, access: 20.12.2021.

87 *Ibidem.*

88 *Sweden – Towards 100% renewable Energy*, https://www.andritz.com/hydro-en/hydronews/hn-europe/sweden, access: 20.12.2021.

89 *Sweden's biggest hydroelectric plant going stron after 56 years*, https://www.reliableplant.com/Read/18560/sweden's-biggest-hydroelectric-plant-going-strong-after-56-years, access: 20.12.2021.

90 *Harsprånget hydroelectric power station*, https://en.wikipedia.org/wiki/Harspr%C3%A5nget_hydroelectric_power_station, access: 20.12.2021.

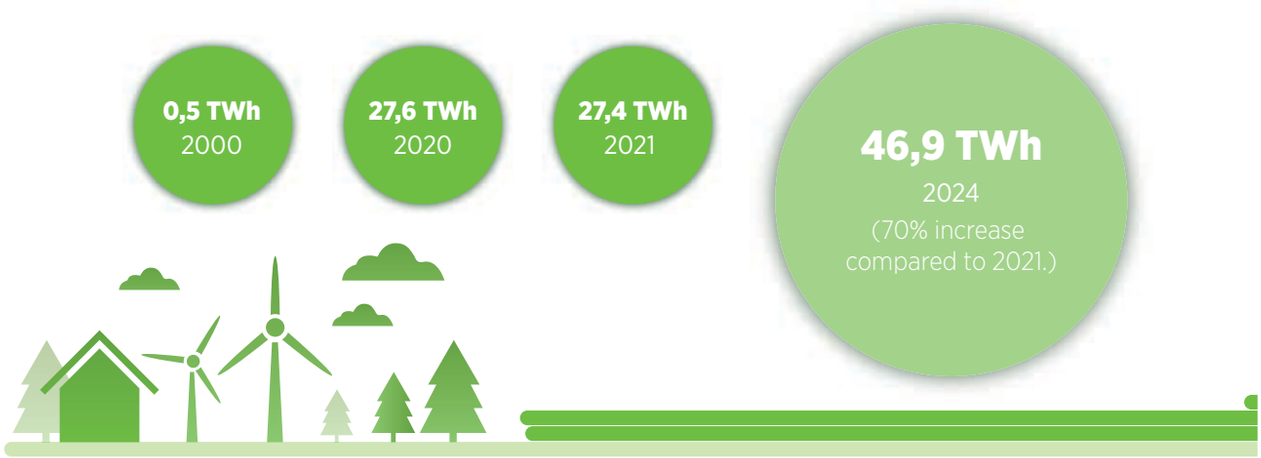
capacity of existing ones. The four rivers in the north, Vindelälven, Pite älv, Kalix älv and Torne älv, which are currently protected by an act of the Swedish Parliament, can also be used for hydropower.

Wind energy

Sweden offers good conditions for the development of wind energy. The construction of wind power plants is favored by a long coastline and high average annual wind speeds. Taking into account the provisions of the 2016 Energy Agreement where electricity demand in Sweden is to be covered 100% by renewable sources by 2040, a rapid and significant increase in the share of wind power is evident. Wind power plants will be tasked with filling the energy gap that will be created when all nuclear power plants are decommissioned by 2040.

There were 4835 wind trubines with a total capacity of 12.2 GW in the country in 2022. By the end of 2022, this number will increase by another 414 windmills, which will reach a capacity of 14.3 GW in total.[91] By 2040, Swedish wind power is expected to generate up to 100 TWh per year, 80 TWh of which will be produced by onshore farms. „General Electric" company is building one of these sites at „Önusberget" in northern Sweden. The farm, consisting of 137 turbines with a unit capacity of 5.5 MW and a rotor blade diameter of 158 m, will be Europe's largest onshore wind power plant with a single point of connection to the grid. Electricity produced at „Önusberget" will be distributed to 200,000 households annually.[92] The construction of onshore farms may face social problems, however. As shown by a University of Gothenburg survey published in 2020, despite an increase in support for wind energy in 2019 compared to 2015 (from 59% to 65%) there is still a noticeable difference from 2008. Back then, wind farm development was met with approval of as many as 80% of those taking part in the survey. Wind turbines arouse greatest opposition among residents of regions designated for windmill

Figure 14. Growth in Swedish wind power generation



91 D. Kulin, *4th quarter 2021. Including figures for full year 2021. Statistics and forecast*, Swedish Wind Energy Association 2022.

92 *Największa lądowa farma wiatrowa w Szwecji. Czy inwestycja zadowala Szwedów?*, https://swiatoze.pl/najwieksza-ladowa-farma-wiatrowa-w-szwecji-czy-inwestycja-zadowala-szwedow/, access: 21.12.2021.

construction. People often point to environmental threats, excessive noise or negative impact on tourism. A good example is the village of Malung in the western part of Sweden. In a referendum held in 2020, more than 52% of Malung's inhabitants voted against the construction of the wind power plant.[93]

The development of offshore wind power may be a solution to public opposition. The construction of offshore wind farms may be beneficial not only due to their location far from human settlements. Above all, offshore windmills can yield much greater results in terms of the energy they produce. In early 2022, the Swedish government announced a search for new locations where offshore wind turbines could be built. According to previous assumptions, 20-30 TWh of electricity could be obtained annually from areas already designated in the Baltic and North Seas as well as in the Gulf of Bothnia. Once the plans are updated, the target figure will be as high as 120 TWh per year.

Bioenergy

Bioenergy is obtained from ecological sources commonly referred to as biomass. Biomass is widely used in Sweden for heating homes and apartments, generating electricity and powering vehicles. In 2020 biofuels, i.e. fuels produced from the processing of biomass, will supply more than a quarter of the Swedish energy market. Forests are the largest source of biomass, covering 69% of the country's land area.[94] The high utilization of this type of biomass is possible due to Sweden's well-developed wood industry. By-products of wood processing include waste used, among others, in heating. Swedes also use municipal waste as a source of energy. Even 99% of waste may be processed for this purpose (for comparison, only 6% is used in Poland).[95] The development of waste incineration plants was accelerated by the implementation of relevant regulations that established municipalities as owners of waste, introduced a landfill tax and a restrictive ban on landfilling.

Another source of bioenergy increasingly used in Sweden is biogas. In 2020, Sweden had 71 biogas plants, making it the fourth largest biogas market in Europe .[96] Swedish biogas is produced mailny from food waste, animal waste, distillery waste or sewage sludge. The environmentally friendly fuel has many everyday applications. The city of Vasteros, a center for the electric industry, uses biogas to heat homes and generate electricity. A similar system is also used in Uppsala. Biogas is also widely used as a vehicle fuel e.g. in public buses in many Swedish cities. The first biogas charging station for biogas vehicles was built in Linkoping in 2001. Stockholm, the capital, is served by buses that run exclusively on biomethane. Moreover, many towns in Sweden offer refueling of CNG cars with biogas produced by a local biogas plant.[97] By 2030 Sweden wants to completely replace natural gas in transportation with biogas. In 2018 The Swedish Gas Association published the National Biogas Strategy 2.0. Its goal is to achieve at least 15 TWh of biogas consumption per year by 2030 through increased use in the transport, industrial and cogeneration sectors.[98] In 2022 alone, the Swedish government will allocate almost €48 million to support the biogas sector. In the near future, this figure could rise to €67 million per year[99] In the long term, these measures will make it possible for Sweden to free itself from dependence on natural gas imports from, among other sources, Russia.

93 *Szwecja: „Tylko nie w mojej okolicy". Nadchodzi zmierzch entuzjazmu wobec energetyki wiatrowej?*, https://www.euractiv.pl/section/energia-i-srodowisko/news/energia-oze-wiatraki-prad-elektrycznosc-atom-elektrownia-jadrowa-odnawialne-zrodla-szwecja-sztokholm-zielona-transformacja-plany-polityka-energetyczna/, access: 21.12.2021.

94 *Swedes use a lot of energy – yet, emission are low. The key? Renewable Energy*, https://sweden.se/climate/sustainability/energy-use-in-sweden, access: 21.12.2021.

95 *Transformacja energetyczna w Szwecji,* http://eko.org.pl/index_news.php?dzial=2&kat=20&art=171, access: 21.12.2021.

96 *Szwecja przechodzi na biogaz*, https://magazynbiomasa.pl/szwecja-przechodzi-na-biogaz-rzad-wesprze-lokalnych-producentow/, access: 21.12.2021.

97 *Sposób na bioodpady w Szwecji. Biogaz priorytetem*, https://www.teraz-srodowisko.pl/aktualnosci/Bioodpady-Szwecja-biogaz-Larsson-7549.html, access: 22.12.2021.

98 *Biogas is the renewable alternative to fossil fuels*, https://scandinavianbiogas.com/en/about-biogas-2/, access: 22.12.2021.

99 *Szwecja przechodzi na biogaz*, https://magazynbiomasa.pl/szwecja-przechodzi-na-biogaz-rzad-wesprze-lokalnych-producentow/, access: 21.12.2021.

Energy transformation

Sweden is a global leader in energy transformation. The Three Crowns country ranked first in 2021 in the annual ranking prepared by the World Economic Forum.[100] The Swedes were also ranked first in 2020 and in the 2019 ranking by the International Energy Agency[101] The origins of Sweden's energy transformation date back to the 1970s and 1980s. The oil crises caused by the Israeli-Arab War (1973) and the revolution in Iran (1979-1982) resulted in a temporary halt in oil trade with Western European countries and the USA, a sharp reduction in oil production and a jump in fuel prices. The Swedish government faced the necessity of ensuring energy security for a country in which 75% of energy was produced from oil. Both nuclear power and hydropower, as described earlier, were chosen. Between 1972 and 1985, Sweden launched 12 nuclear reactors located in four power plants.[102] The existing hydropower plants were modernized - in 1980 the largest turbine-generator unit „Gerhard" was put into operation. Consequently, the share of renewables in the national energy mix was increasing - it amounted to 33% as early as 1990.[103] The decarbonisation of the Swedish energy sector was accelerated by the introduction of a CO_2 tax in 1991. The levy provided an economic „incentive" for various sectors of the economy to switch to low-carbon energy sources. Sweden currently applies the highest carbon tax in the world. The tax rate in 2020 was about SEK 1182 (about €113) per tonne of carbon dioxide.[104] Despite the above, the price of electricity in Sweden in 2021 was SEK 1,77 (about €0,17) per kWh, not much higher than the price in Poland (0,165 € per kWh). It is also worth mentioning that the Swedish electricity and heat market was liberalised fairly early. Swedish consumers are able to choose their energy supplier since 1996. Today, energy services are provided by about 140 companies.[105]

The decarbonization of the Swedish energy industry was further accelerated by the introduction of green energy certificates in 2003. These certificates were set up with the aim of increasing the production of electricity from renewables (60% of total electricity consumption from renewables by 2010 and 50% share of renewables in the total energy market by 2020) and its cost-effectiveness. These goals have been achieved, and in 2017 the Swedish Parliament extended the certificates until 2045 while setting a further plan to increase the share of electricity from renewables by 18 TWh between 2020 and 2030.[106] Norway joined the certificate system in 2012. The cooperation between Sweden and Norway makes it possible to receive certificates for the production of electricity from renewable sources in each of these countries. The certificates are granted to producers for every megawatt hour of electricity produced from renewable sources. Demand for certificates exists because suppliers are obliged by law to purchase a certain amount of certified energy from producers. The cost of the certificates, included in the final price of energy, is borne by its end users. Therefore, consumers pay for the development of renewable energy. In 2020, 50 million certificates were issued in Sweden and Norway. The largest number of certificates in Sweden was issued to wind power generators.[107]

100 *Fostering Effective Energy Transition 2021 Edition,* https://www3.weforum.org/docs/WEF_Fostering_Effective_Energy_Transition_2021.pdf, access: 22.12.2021.

101 Rapacka P., *MAE: Szwecja jest liderem transformacji energetycznej*, https://biznesalert.pl/szwecja-transformacja-energetyczna-mae/, access: 22.12.2021.

102 *Lokalizacja elektrowni jądrowych,* https://nuclear.pl/lokalizacja,szwecja,krolestwo-szwecji.html, access: 22.12.2021.

103 *Szwedzi przerabiają domy na elektrownie. Do 2040 r. chcą oprzeć energetykę w 100% na OZE,* https://www.cire.pl/artykuly/serwis-informacyjny-cire-24/180494-szwedzi-przerabiaja-domy-na-elektrownie-do-2040-r-chca-oprzec-energetyke-w-100-na-oze, access: 22.12.2021.

104 *Ibidem.*

105 *Swedes use a lot of energy – yet, emission are low. The key? Renewable Energy*, https://sweden.se/climate/sustainability/energy-use-in-sweden, access: 22.12.2021.

106 *Energy policies of IEA countries. Sweden 2019 Review*, https://iea.blob.core.windows.net/assets/abf9ceee-2f8f-46a0-8e3b-78fb93f602b0/Energy_Policies_of_IEA_Countries_Sweden_2019_Review, access: 22.12.2022

107 *Energy in Sweden 2021*, https://energimyndigheten.a-w2m.se/Home.mvc?ResourceId=198022, access: 22.12.2021

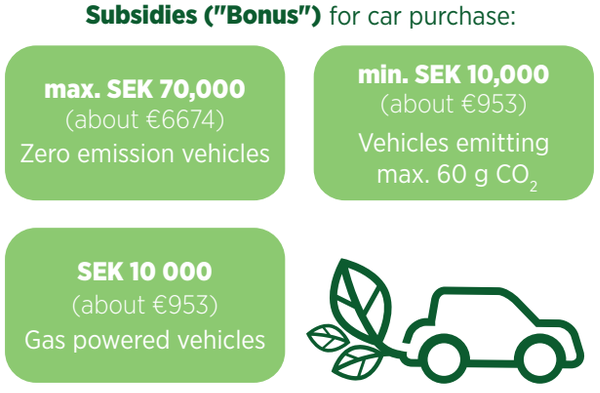
Transport

The most important sector of the Swedish economy that is undergoing extensive decarbonization is transport. In 2019 alone, transport emitted 16.4 million tons of CO_2 into the atmosphere. According to a report by the Swedish Energy Agency, in 2019, energy in transport came from oil and petroleum products to the tune of 75%. Its vast majority was consumed by road transport (92%). A push for change was given in 2017 by the Swedish Parliament, which adopted the Climate Policy Framework. One of the postulates included in the document was to reduce greenhouse gas emissions from transport by 70% by 2030 (compared to 2010). Instead, the Swedish government decided to achieve zero-carbon in transport by 2045.[108] Nevertheless, the first steps to reduce the share of petroleum-based fuels took place as early as 2005. At that time, MPs passed the „Swedish Pump Act", which obliged large petrol stations to sell at least one renewable fuel. Initially, only ethanol enjoyed a surge in interest in biofuels. Over time, other types of biofuels became popular, such as biodiesel, which became the most popular among car drivers. The market share of biofuels has increased up to five times in ten years and in 2019 amounted to 17 TWh.[109] In addition, as of July 2018, gasoline and diesel suppliers are required to reduce carbon emissions by blending biofuel into traditional fuel. This is equivalent to 25% biodiesel in diesel and 5% ethanol in gasoline.

Vehicle owners in Sweden are subject to a system of fees and discounts. These measures are intended to reduce traffic density and encourage drivers to buy and use low-emission cars. A CO_2 tax is levied on passenger cars from 2006 and light commercial vehicles from 2010. The levy consists of a base fee of SEK 360 (about €34) and a carbon-based additional fee. The carbon-based fee is SEK 22 (about €2) for each gram of CO_2 emitted above 111 grams of CO_2/km that the vehicle emits in mixed (urban - suburban) traffic. Diesel owners pay more - the tax is multiplied by 2.37 and an extra 250 SEK (about €24) is charged (500 SEK – about €48, for vehicles registered before 2008).

On July 1, 2018, the Swedish authorities introduced a new system that rewards low-emission vehicles and charges high CO_2-emitting cars. „Bonus-Malus" (bonus - good, malus - bad) covers „new" passenger cars and commercial vehicles up to 3.5 tonnes manufactured in 2018 or later. Cars with low CO_2 emissions are eligible for a subsidy (bonus) on purchase. The subsidy may amount to a maximum of 25% of the vehicle price.

Figure 15. Subsidies for the purchase of low- and zero-emission vehicles in Sweden



Cars with high CO_2 emissions are charged (malus) with a higher carbon tax for the first three years after registration. „Malus" for cars taxed between July 1, 2018 and March 31, 2021 is SEK 82 (about €8) per gram of CO_2 if the vehicle's emissions are between 95 and 140 g CO_2/km, and SEK 107 (about €10) per gram if the vehicle emits more than 140 g CO_2/km. For vehicles put into service and taxable for the first time on 1 April 2021 or thereafter, the carbon charge is SEK 107 per gram of CO_2 if the vehicle emits between 90 g and 130 g CO_2/km, and SEK 132 (about €13) per gram if the vehicle emits more than 130 g CO_2/km. Additional charges also apply to diesel cars - SEK 250 (environmental chargé, about €24) and a fuel charge (multiplying total CO_2 emissions/km in mixed driving by 13.52)[110].

108 *State-owned enterprises*, https://www.government.se/government-policy/state-owned-enterprises/, access: 22.12.2021.

109 *Energy in Sweden 2021*, https://energimyndigheten.a-w2m.se/Home.mvc?ResourceId=198022, access: 22.12.2021.

110 *Malus – for high emission vehicles*, https://www.transportstyrelsen.se/en/road/Vehicles/bonus-malus/malus/, access: 23.12.2021.

The support provided by the state to buyers of electric vehicles has translated into their widespread popularity among Swedish drivers. The number of vehicles registered per year, which rose from 157 in 2009 to 56,000 in 2020, is testament to this.[111] At the end of 2021, 110,177 electric cars drove on Swedish roads. A nearly 100% increase compared to 2020. Electric cars also accounted for 18% of all new cars registered in Sweden in 2021.[112] Sweden, ranks third in the world (after Norway and Iceland) in terms of the total number of electric cars, which account for more than 1/3 (32%) of all registered cars.[113] The growth of the electric car sales market is accompanied by the expansion of the infrastructure needed to support them. In 2018, subsidies were introduced for chargers that allow the vehicle to be charged at home. The subsidy provided up to 50% of the purchase and installation costs of the device - up to SEK 10,000 (about €953). A network of public chargers is being developed to enable electric vehicles to move around the country. In 8 years, the network has grown from 500 in 2012 to almost 9500 units in 2020.[114] The Swedish government is supporting the development of other electromobility modes of transport as well. A subsidy for the purchase of an electric two-wheeled vehicle was introduced in 2018. The aid covers 25% (maximum SEK 10,000) of the purchase value of a bicycle, scooter or a motorcycle. Since 2016, on the other hand, regional public transport agencies can apply for subsidies for the purchase of electric buses. The size of the grant depends on whether the vehicle is fully electric.

In addition to the development of electromobility, a number of other measures are being implemented to reduce the harmful environmental impact of Swedish transport and make it zero-emission:[115]

- granting environmental compensation for rail freight to strengthen rail competitiveness and shift freight from road to rail,
- launching international night passenger trains,
- introducing an „Eco-bonus" scheme to strengthen maritime and inland waterway freight transport,
- introducing an aviation tax for passengers travelling from Swedish airports,
- ban on the sale of gasoline and diesel cars after 2030,
- introducing a tax for entering the centers of the largest Swedish cities (Stockholm, Gothenburg) - this also would apply to electric cars.

111 Number of registered electric passenger cars in Sweden from 2009 to 2020, https://www.statista.com/statistics/736413/number-of-registered-electric-passenger-cars-in-sweden/, access: 23.12.2021.

112 *Liczba samochodów elektrycznych w Szwecji podwoiła się w ciągu roku,* https://skandynawiainfo.pl/liczba-samochodow-elektrycznych-w-szwecji-podwoila-sie-w-ciagu-roku/, access: 23.12.2021.

113 *Gdzie jeździ najwięcej aut elektrycznych – ranking krajów*, https://www.auto-swiat.pl/wiadomosci/aktualnosci/gdzie-jezdzi-najwiecej-aut-elektrycznych-ranking-krajow/hp2bbmh, access: 23.12.2021.

114 Rawa T., *Rawa: Szwecja. Elektromobilne eldorado*, https://biznesalert.pl/rawa-szwecja-elektromobilne-eldorado/, access: 23.12.2021.

115 *Transport efficiency, Energy-efficient vehicles and ships and Sustainable renewable fuels,* https://www.government.se/government-policy/transport-sector-transitioning-for-the-climate/transport-efficiency-energy-efficient-vehicles-and-ships-and-sustainable-renewable-fuels/, access: 23.12.2021.

CLIMATE POLICY

In June 2017, the Swedish parliament adopted a climate policy framework. This document represents the most significant climate reform in the country's history, and sets out Sweden's implementation of the Paris Agreement (an agreement requiring all UN member states to submit action plans to reduce greenhouse gas emissions). Sweden's climate policy framework consists of:

- New climate targets,
- Climate Act,
- Climate Policy Council.[116]

As part of its climate targets, Sweden has committed to:

- achieve zero greenhouse gas emissions by 2045 and negative emissions after the indicated date (the amount of gases emitted by the state will be less than the amount of gases reduced by the natural ecological cycle or by international climate projects),
- reduction of greenhouse gas emissions from the national transport sector (excluding aviation) by at least 70% by 2030 (compared to 2010),
- reduction of GHG emissions in the sectors (road transport, agriculture, heating, waste management) covered by the EU Effort Sharing Regulation by at least 63% by 2030 and 75% by 2040 (compared to 1990).[117]

The Climate Act requires the Swedish government to implement its climate policy in accordance with the goals listed above. The Climate Act requires the government to submit an annual report on its climate policy as part of the Finance Act. Such a report must contain a summary of the most important climate policy decisions taken during the year, together with a description of the possible impact of those decisions on GHG emissions. In addition, every four years the government is required to prepare a climate policy action plan. The plan must include a description of how the climate targets will be achieved and has to be presented to the parliament one year after the parliamentary elections.[118]

The third pillar of Swedish climate policy is the Climate Policy Council. It is an expert body consisting of specialists from various scientific fields including climate science, social policy and economics.[119] The Council's main task is to independently assess the consistency of the government's overall policies with its climate goals.

116 *Sweden's climate policy framework,* https://www.government.se/articles/2021/03/swedens-climate-policy-framework/, access: 23.12.2021.

117 *The Swedish climate policy framework*, https://www.government.se/495f60/contentassets/883ae8e123bc4e42aa8d59296ebe0478/the-swedish-climate-policy-framework.pdf, access: 23.12.2021.

118 *The Swedish Climate Act*, https://www.government.se/49c150/contentassets/811c575eb9654a6383cf0ed4e0d5db14/the-swedish-climate-act.pdf, access: 23.12.2021.

119 *The Swedish Climate Policy Council*, https://www.klimatpolitiskaradet.se/summary-in-english/, access: 23.12.2021.

SUMMARY

Sweden is one of the leaders in implementing climate-friendly solutions in the economy. A flagship example are the changes carried out in the energy sector, aimed at its complete decarbonization. The skillful use of natural resources that can be used on a massive scale as renewable energy sources deserves particular praise. Since the interwar period, a large number of watercourses and reservoirs have been utilized in this way. Sweden wants to harness wind power on a massive scale by developing wind farms. Obstacles may arise in this case due to negative public reactions and weather conditions. Concerns are also raised about Sweden's intention to completely phase out nuclear power plants (the main source of electricity next to hydropower) in favor of wind power. Nuclear power plants could still be a reliable and independent source of energy regardless of many factors (e.g. climate or geopolitical factors). The production and increasingly widespread use of biogas is also noteworthy. These activities can be called „doubly" ecological - biogas production disposes of waste and results in the production of biofuel, which is used to power vehicles and heat buildings. Moreover, biogas production is often coordinated by the local government, which builds and supervises the biogas plants. The Swedes are equally successful in implementing a widespread electromobility program. The popularity of electric cars among Swedish drivers is influenced not only by the possibility of subsidizing the purchase of the vehicle, but also by the financial support provided for the installation of infrastructure for charging these vehicles.

The adoption of the climate policy guidelines in 2017 represented the political consensus of seven of the eight political parties sitting in the Riksdag at the time. The jointly developed proposals were then voted through with an overwhelming majority of 254 to 41. The cross-party importance of climate and environmental issues is also confirmed by the objectives of the Climate Act. The act requires the Swedish government to prepare a climate action plan every four years, which is then approved by the parliament.

UNITED KINGDOM

Figure 16. Map of the United Kingdom

GEOGRAPHICAL CONDITIONS

The United Kingdom of Great Britain and Northern Ireland (UK) is an island nation with a population of over 67 million people.[120] The UK covers an area of 245,000 km2 and has a population density of 270 people per km^2.

The United Kingdom consists of England, Wales and Scotland located on the island of Great Britain and Northern Ireland located in the northern part of the island of Ireland. The UK has many dependent territories that are not part of the United Kingdom, including the British Virgin Islands.

120 *Population estimates*, https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates, access: 20.12.2021.

The northern part of the UK is composed of upland and mountainous areas, while the south is home to lowland areas, also accounting for the increased population density in this part of the country. The river network of Great Britain is very dense: The Thames (length 338 km), flows through the London Basin and enters the North Sea by a wide (7-8 km) estuary. The Trent (length 274 km), Ouse, Tees, Tyne, Tweed also drain into the North Sea. The Mersey flows into the Irish Sea, the Severn (290 km) flows into the Bristol Channel, and the main Scottish river, the Clyde, flows into the Firth of Clyde.[121] Most of the rivers were regulated, meaning that locks, dams, and embankments were built on them. In the 18th century new canals were built to connect the River Thames with the River Avon as well as the River Mersey with the Rivers Ouse and Trent. These waterways connect the Irish Sea with the North Sea. The Caledonian Canal (97 km long) was built in the early 19th century, linking the Moray Firth and Firth of Lorne. The public makes use of the rivers, mainly for domestic and industrial water supply and as shipping routes, while the wide estuaries of the rivers are used for harbours. The climate of Great Britain can be classified as temperate, warm.

The UK has iron ore deposits, but due to the cost of extracting this resource, it is imported. Gold is mined in Scotland, and it is the third most valuable product exported by the United Kingdom.[122] The deposit of crude oil located at the bottom of the North Sea is also one of the main export pillars of the United Kingdom. The UK also has deposits of coal and natural gas.

ECONOMY

The UK is the second largest economy in Europe after Germany, with a GDP of $2829 billion.[123] It is a highly developed country with a market-oriented economy. Services, particularly financial services, account for almost 80% of the monarchy's gross domestic product. [124] London, the capital of the United Kingdom, is the second largest financial center in the world after New York.[125] The GDP generation structure also includes industry at just over 19% and agriculture at about 1%. Industrial production is largely comprised of advanced technologies, making the United Kingdom one of the top leaders in innovation. The agricultural sector is highly mechanized and provides 60% of the country's demand, with only 1% of the working population employed in this sector.[126]

The British government has allowed for privatization of many state-owned enterprises, thus largely departing from the principles of the so-called welfare state, where the state is to protect citizens from the risks associated with the functioning of the market economy. The economic policy of Great Britain is built on the Industrial Strategy, which was developed by the so-called „Plan for Growth". The strategy aims to strengthen the British economy by fostering innovation, increasing public-private partnerships to invest in research and development. The strategy focuses on measures to ensure that every citizen has the opportunity to obtain high qualifications and quality employment, leading to the strengthening of their purchasing power and, in the long run, to the development of the whole economy. The Industrial Strategy is based on five elements that form the basis of British economic success: Ideas, People, Infrastructure, Business Environment and Places.[127]

The „Plan for Growth", which is a follow-up to the Industrial Strategy, contains a number of objectives,

121 *Wielka Brytania, warunki naturalne*, https://encyklopedia.pwn.pl/haslo/Wielka-Brytania-Warunki-naturalne;4575708.html, access: 20.12.2021.

122 *United Kingdom, overview*, https://oec.world/en/profile/country/gbr, access: 20.12.2021.

123 *United Kingdom*, https://www.imf.org/en/Countries/GBR, access: 20.12.2021.

124 Booth Lorna, *Components of GDP: Key Economic Indicators*. House of Commons Library, https://commonslibrary.parliament.uk/research-briefings/sn02787/, access: 20.12.2021.

125 *The Global Financials Cetres*, https://globalfinancialcentres.net/explore/, access 20.12.2021.

126 *United Kingdom, Employment in Agriculture*, https://tradingeconomics.com/united-kingdom/employment-in-agriculture-percent-of-total-employment-wb-data.html, access: 20.12.2021.

127 *Industrial Strategy: the 5 foundations*, https://www.gov.uk/government/publications/industrial-strategy-the-foundations/industrial-strategy-the-5-foundations, access 30.12.2021.

particularly focusing on infrastructure development, community skills and innovation. Examples of „Plan for Growth" policies that Boris Johnson's government plans to introduce in the coming years include[128]:

- supporting productivity growth through high quality skills and training: transforming the education system through additional investment and reforming vocational education to align the 16+ vocational education system with employers' needs;
- introducing a lifetime guarantee of free education through vocational courses.

The United Kingdom's economy began to decelerate following the post-referendum decision to leave the European Union (Brexit) in June 2016. In the second quarter of 2019, UK's GDP fell by 0.1 percent compared to the first quarter, marking the first economic decline since 2012. The economy was further adversely affected by the COVID-19 pandemic, with data for Q2 2020 showing a 20% decline in GDP compared to Q1 (2.2% in Q1 2020 compared to Q4 2019).[129] It was the worst performance among the G7 countries.

The UK prioritizes the issue of climate change. The government sees climate policy as an opportunity to accelerate economic development. In 2008, the UK was the first country in the world to take a binding decision to reduce greenhouse gas emissions. At that time, the Climate Change Act was passed, which provided for a 34% reduction in greenhouse gas emissions compared to 1990, and by 80% by 2050.[130] By 2019, the generation of negative gases had been eliminated by 42% compared to 1990. The UK government's objectives to accelerate economic development, using renewable energy sources to replace coal-fired power generation have been successful. The British recognized the need to shift the economy to renewables as an opportunity to strengthen industry and gain an edge in foreign markets. The British hope that the low-carbon energy sector will grow by 2040, increasing export revenues by at least £60 billion, creating a budget surplus.

ENERGY MARKET

Coal was the foundation of Britain's dominant position in the 18th and 19th centuries. This resource was the driving force behind today's industrialized and urbanized world. The development of the coal-powered steam engine and its subsequent modernization freed the textile industry from water mills. Modernization allowed factories to increase in size and move freely. Coal power concentrated factories and labor in urban areas, allowing Britain's industrialization process to gain momentum. By 1830, the United Kingdom accounted for 80% of the world's coal output and 50% of the world's iron production.[131] In 1850, British CO_2 emissions were six times higher than those of the United States, the second economy at the time. The large-scale use of coal was associated with a large increase in pollution. Acid rain became a problem, and London grew to become one of the most polluted cities in the world. Coal burning was one of the reasons for the great smog that persisted in the British capital from December 5 to 9, 1952. This event is considered an environmental disaster that led to the death of 12,000 residents of the city.

The beginning of the 1950s brought a decline in coal mining that marked the end of an era for this resource in Britain. An attempt to restructure the mining industry was made by the Conservative Prime Minister Edward Heath in the first half of the 1970s, which led to strikes of mining unions and the fall of the government.[132] The decline of the mining industry was also brought about by the launch of Britain's first nuclear power stations and the start of oil and gas production in the North Sea.

128 *Build Back Better: our plan for growth*, https://www.gov.uk/government/publications/build-back-better-our-plan-for-growth, access: 30.12.2021.

129 *Gross Domestic Product*, https://www.ons.gov.uk/economy/grossdomesticproductgdp, access: 30.12.2021.

130 *Climate Change Act 2008*, ttps://www.legislation.gov.uk/ukpga/2008/27/contents, access: 30.12.2021.

131 *The History of Energy in the United Kingdom*, https://www.planete-energies.com/en/medias/saga-energies/history-energy-united-kingdom, access: 30.12.2021.

132 Piotr Jachowicz, *Strajk górników brytyjskich w latach 1984 – 1985*, Dzieje Najnowsze, Instytut Historii Polskiej Akademii Nauk, p. 137.

In 1979, when Margaret Thatcher assumed leadership in a country in severe decline, there were 170 deep mines operating, producing 130 million tons of coal a year, and employing less than a quarter of a million miners. Unfortunately, British coal was about 25% more expensive than imported coal. In the early months of 1984, Prime Minister Margaret Thatcher announced a plan to close the 20 most unprofitable mines at once and 70 more later. The trade unions went on strike again, but the Prime Minister did not give in. The British economy was already in good shape at the time, making things easier. Furthermore, after the victory in the Falklands War, the Prime Minister had the support of the media, which in turn pointed to the pro-communist sympathies of some of the strike leaders. The strike lasted a year and ended with Thatcher's victory and the dismantling of the trade union movement. The year-long shutdown of the mines caused British coal to lose even more of its market share. In 1986, annual production was just over 100 million tons, and continued to decline in subsequent years.

The restructuring of the coal industry was completed by Margaret Thatcher's successor, John Major. As a result, several mines owned by the state-owned „British Coal" were privatized. In the early 21st century, for the first time, the amount of imported coal exceeded the coal mined in Britain. From 1990 to 2019, an estimated 40% of coal-fired power generation has been eliminated.[133]

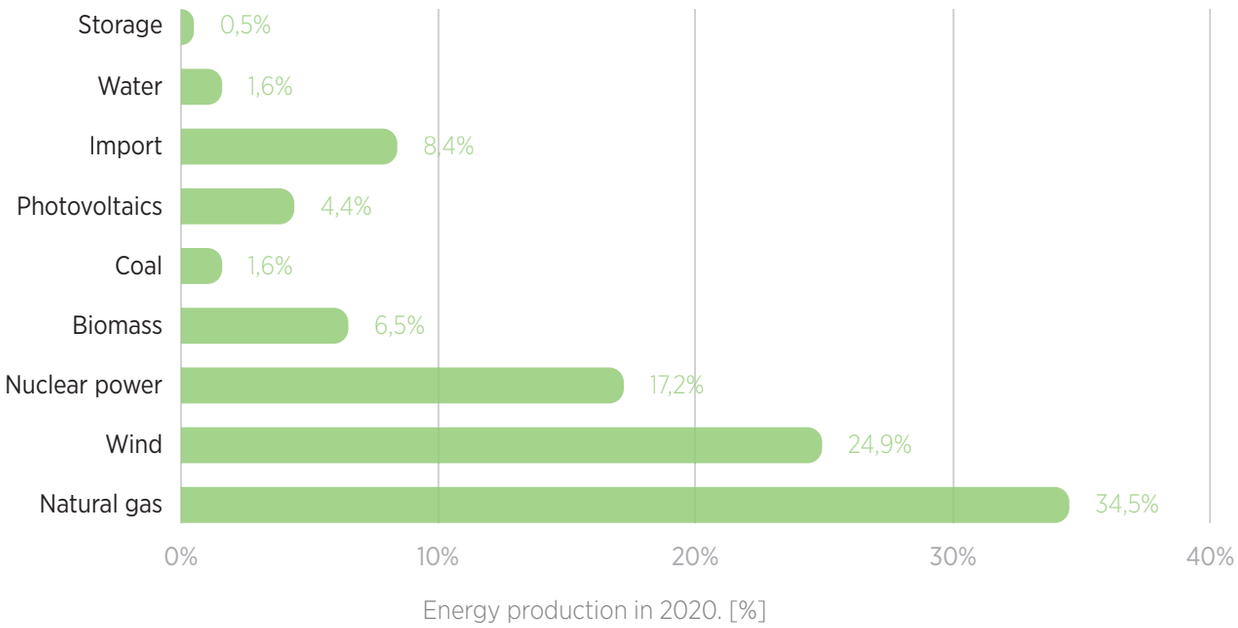
In 2015, the British government increased the carbon tax rate. As a result energy from gas has become cheaper than the one from coal since burning coal produces twice as much CO_2. Gas satisfies a sizable portion of the country's electricity needs. The UK has maximised the potential of its geographical location in the case of offshore wind farms. Investment in the construction of offshore wind farms has contributed to the fact that in 2016 the level of wind power generation exceeded that of coal.[134] The decline of coal in the UK mirrors the ongoing trend in Europe, where coal's share of electricity generation has fallen by 10% over the past decade. The withdrawal of many carbon sequestration projects (CCS) has been one of the consequences of progressive decarbonisation. A 2014 report by the IPCC (The Intergovernmental Panel on Climate Change) predicted that CCS would be implemented on a massive scale in the future. Germany withdrew from the project due to environmental concerns. The US announced the abandonment of the CCS project in Kemper, Mississippi. In 2015, the idea of clean coal also collapsed in the UK. The plan was to pump carbon dioxide through pipes from power plants to former oil and gas wells in the North Sea.

133 *Provisional UK greenhouse gas emissions national statistics 2019*, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/875482/2019_UK_greenhouse_gas_emissions_provisional_figures_statistical_summary.pdf, access: 30.12.2021.

134 *UK Energy Statistics, 2016 & Q4 2016*, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/604695/Press_Notice_March_2017.pdf, access: 30.12.2021.

Current figures show a negligible contribution to UK power generation by coal. The leading source is natural gas. This trend has continued for several years. Nuclear energy and energy generated from wind and biomass are also present in the UK's energy mix.

Figure 17. Energy production in the United Kingdom, 2020



source: https://www.nationalgrideso.com/news/record-breaking-2020 becomes-greenest-year-britains-electricity, access: 30.12.2021.

The UK's Department for Business, Energy and Industrial Strategy regularly reports on the performance of different energy sources. According to the 2019 figures, renewable energy generated around 40% of the country's energy needs. The trend for 2019 was upward, with wind energy playing an important role, accounting for about 20% of the total energy generated from renewable sources.[135] The United Kingdom is a leader in offshore wind energy. It is estimated that energy generated from turbines powers 4.5 million homes each year. Between 2016 and 2020, almost £19 billion was invested in wind energy.[136] These investments have created many jobs, both for the people who designed the investment projects and for those who executed them. However, dependence on specific weather conditions limits the ability to harness the energy generated by wind. Analysis of the available data showed that between 2008 and 2010, windmills were able to produce a total of 20 MW less during downtime, when wind power declined. Downtime periods repeated consecutively every 5/6 days and lasted for 5 hours on average.

Another important source of zero-carbon energy in the UK's energy mix is nuclear power. Nuclear power plants generate 17% of the country's energy needs. About 6% of power comes from biomass. The Biomass Feedstocks Innovation Programme was established in March 2021 and provided £30 million in funding.[137] The government is also allocating funds for innovative projects, benefiting start-ups as well as family-owned businesses that engage in the energy industry. In turn, more than 4% of the generated energy comes from photovoltaics, with the vast majority generated from solar panels placed on household roofs. Energy generated from water relies primarily on power plants built on rivers. Despite the potential that was recognized in the 1970s in geothermia - hot water

135 *Regional Renewable Statistics*, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1021774/Regional_renewable_electricity_2020.pdf, access: 20.12.2021.

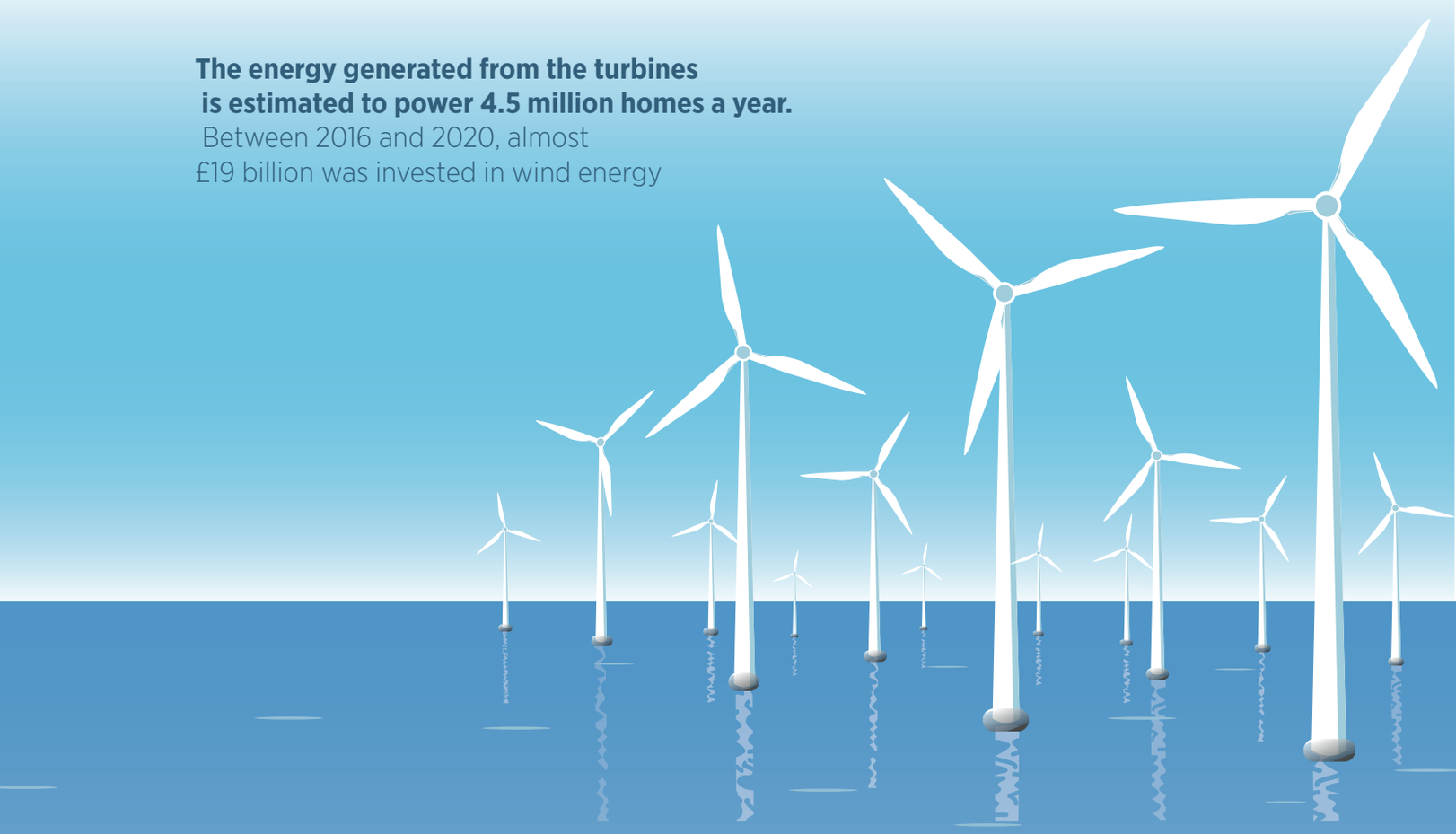
136 *Wind Energy*, https://www.renewableuk.com/page/WindEnergy, access: 20.12.2021.

137 *Biomass Feedstocks Innovation Programme*, https://www.gov.uk/government/publications/apply-for-the-biomass-feedstocks-innovation-programme, access: 30.12.2021.

extracted from the Earth's interior - it still does not play a key role in the energy mix. Nonetheless, an interesting project based on a completely different technology from the one used so far has emerged. A drilling site near the town of Redruth in Cornwall is to be used to pump cold water underground, bring it to a depth where the temperature reaches 200°C and pump it back out. Steam from the heated water is expected to drive turbines that generate electricity for about 3,000 homes.[138]

The energy generated from the turbines is estimated to power 4.5 million homes a year.

Between 2016 and 2020, almost £19 billion was invested in wind energy



138 *United Downs Deep Geothermal Power Project*, http://geothermalengineering.co.uk/united-downs/, access: 30.12.2021.

CLIMATE POLICY

In October 2021, the UK Government adopted a document approving the implementation of a plan for green energy - The Ten Point Plan for a Green Industrial Revolution.[139] Just as it says, the plan includes 10 key measures for renewable energy development:

1. **Expand wind power** - offshore is a leading source of renewable energy, participating in economic development. By 2030, the UK government plans to quadruple power generation to produce more than the household demand. Investment in offshore wind energy is expected to provide new jobs in ports. It will also provide employment for people in former mining regions. The 2030 target is to reach 40 GW of offshore wind capacity, including 1 GW from the windiest site in territorial waters. The government plans to allocate £160 million to the sector. The mentioned figure includes port upgrades. According to estimates, the plan to generate so much power from wind could attract private investment of £20 billion.

2. **Fuel the growth of low-carbon hydrogen** - the goal is to generate 5 GW of power from low-carbon hydrogen by 2030. The UK will commit £240 million of funding from the Net Zero Hydrogen Fund.[140]

3. **Provide and developed energy from the atom** - the first nuclear power stations were established in the UK over 60 years ago. This energy sector still provides jobs for 60,000 people today. The plan calls for investment in new nuclear power technology. A £385 million Advanced Nuclear Fund will be set up, with a target of £215 million for Small Modular Reactors.[141] Additionally, the government plans to spend £170 million on research and development in this area. Electricite de France's Hinkley Point C SMR power plant project in southwest England began in 2016. The investment is scheduled to be completed in 2026.

4. **Accelerate the replacement of combustion-powered cars with zero emissions vehicles** - according to the objectives developed by the government of Prime Minister Boris Johnson, the plan is to end sales of petrol and diesel-powered cars by 2030. Sales of the Nissan Leaf produced in the UK have already reached the third best in Europe in 2019. Parliament has announced that it will allocate £500 million to boost the electrification of the car market, as well as protect existing jobs. £1.3 billion will be dedicated to the development of charging infrastructure for cars, with a particular focus on setting up fast-charging points on freeways and major roads. The entire infrastructure development is to ensure that the public has as easy access to charging stations as it does to petrol stations. The program also includes grants provided between 2022 and 2023 for vans, cabs and motorcycles to reduce their price. The government plans to allocate £582 million for this purpose.

5. **Green public transport, cycle paths, pedestrian routes** - the British government plans to increase funding for sustainable public transport. The government will spend tens of billions of pounds on upgrading the rail network, £4.2 billion on public transport and £5 billion on electric buses, and increasing access to this mode of transport. A dedicated National Bus Strategy was developed to modernize the bus sector[142] The plan is to increase the number of buses so that the public has more opportunities to use this mode of transport, including on the outskirts of cities.[143]

139 *The Ten Point Plan for a Green Industrial Revolution*, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/936567/10_POINT_PLAN_BOOKLET.pdf, access: 30.12.2021.

140 *Designing the Net Zero Hydrogen Fund – Consultation*, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1011468/Designing_the_Net_Zero_Hydrogen_Fund.pdf, access: 30.12.2021.

141 *Advanced Nuclear Technologies*, https://www.gov.uk/government/publications/advanced-nuclear-technologies/advanced-nuclear-technologies, access: 30.12.2021.

142 *Local transport update: national bus strategy for England published*, https://www.gov.uk/government/speeches/local-transport-update-national-bus-strategy-for-england-published, access: 30.12.2021.

143 *Bus Back Better*, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/980227/DfT-Bus-Back-Better-national-bus-strategy-for-England.pdf, access 30.12.2021.

6. **Zero-emission aircraft and ships - Jet Zero** - an industry-government partnership, aims to modernize the aviation sector by adopting new technologies to enable zero-emission aviation.[144] To this end, the Aerospace Technology Institute, in collaboration with the government, is working on the FlyZero project to provide the necessary information: an assessment of the potential market, economic, and environmental impact of a zero carbon commercial aircraft by 2030, identification of key development issues, and preliminary design of a zero carbon commercial aircraft.[145] The government will provide £15 million for this purpose. A further £15 million will go towards the production of Sustainable Aviation Fuels. For the maritime sector, The Clean Maritime Demonstration programme has been set up with £20 million going towards technology to power ships with hydrogen, as well as the development of the Port of Teesside, which would serve as a hydrogen refuelling facility.[146]

7. **Sustainable construction** - to future-proof new buildings and avoid the need for costly refurbishment, the Future Home Standard project is planned to be implemented as soon as possible, introducing low carbon heating standards and rules to enable new buildings to be highly efficient.[147] As part of the sustainable construction, Boris Johnson's government plans to get the public to replace coal-fired district heating boilers with ones that emit less carbon dioxide. In doing so, a target of 600,000 heat pump installations a year by 2028 has been set. The scheme sets aside £1 billion in Green Home Grants to improve the energy efficiency of homes and replace fossil fuel heating. It also aims to reduce carbon emissions in the public sector, including schools, and hospitals.

8. **Carbon sequestration (Carbon Capture, Use and Storage)** - the process of preventing large amounts of carbon dioxide from being released into the atmosphere from point sources of pollution such as power plants and heavy industry factories. It involves capturing CO_2 from fumes, transporting it to a storage site and depositing it in such a way as to prevent it from entering the atmosphere.[148] Boris Johnson's government is revisiting the introduction of the technology, which was abandoned during David Cameron's tenure. £1 billion has already been earmarked for the project. „Tata Chemicals Europe" is building the UK's first industrial-scale carbon capture and utilisation (CCU) demonstration plant at the group's Northwich site, which produces high-purity sodium bicarbonate, with the support of a £4.2 million grant from the Department for Business Energy and Industrial Strategy.[149]

9. **Protection of the natural environment** - as part of Partnering for Accelerated Climate Transitions, the UK is committed to tackling climate change. The Green Recovery Challenge Fund has committed £80 million to 100 nature projects.[150] [151] The programme also includes £5.2 billion for flood prevention and coastal protection.

10. **Green Finance and Innovation -** allocating 2.4% of GDP to research and development with a particular focus on the environment. £100 million will fund investment in a brand new system for removing greenhouse gases, including direct air capture. A further £100 million will go towards energy storage solutions and new technologies to store energy for hours, days or even months.

144 *Jet Zero Consultation*, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1009448/decarbonising-transport-a-better-greener-britain.pdf, access: 30.12.2021.

145 *Fly Zero*, https://www.ati.org.uk/flyzero/, access: 30.12.2021.

146 *Clean maritime demonstration competition*, https://www.gov.uk/government/publications/clean-maritime-demonstration-competition-cmdc, access: 30.12.2021.

147 *The Future Buildings Standard*, https://www.gov.uk/government/consultations/the-future-buildings-standard, access: 30.12.2021.

148 Carbon Capture, Use and Storage, https://unece.org/sustainable-energy/cleaner-electricity-systems/carbon-capture-use-and-storage-ccus, access: 30.12.2021.

149 https://www.tatachemicalseurope.com/, access: 30.12.2021.

150 Partnering for Accelerated Climate Transitions, https://www.ukpact.co.uk/about, access 30.12.2021.

151 *Green Recovery Challenge Fund*, https://www.ukpact.co.uk/green-recovery-challenge-fund, access 30.12.2021.

In addition to the key measures listed above that Boris Johnson's government is implementing or planning to implement, a tax on plastic packaging materials (PPT) will be introduced from April 1, 2022.[152] The intention of the tax is to encourage the use of recycled plastic packaging materials. It applies to plastic packaging manufactured or imported into the UK that contains less than 30% recycled plastic measured by weight. The tax charge is £200 per tonne. Smaller companies that produce or import less than 10 tonnes of plastic packaging in a 12-month period will be exempt from the levy.

152 *Introduction of Plastic Packaging Tax from April 2022*, https://www.gov.uk/government/publications/introduction-of-plastic-packaging-tax-from-april-2022/introduction-of-plastic-packaging-tax-2021, access 30.12.2021.

SUMMARY

The UK is undoubtedly one of the European countries that is working hard to introduce innovative solutions for environmental protection and, above all, to reduce carbon dioxide emissions into the atmosphere. The current government under the leadership of Prime Minister Boris Johnson places great emphasis on the issue of climate change. It is implementing a number of solutions aimed at achieving zero emissions, such as increasing the production of wind energy, investing in small nuclear reactors, implementing innovative plans for hydrogen-powered ships, or creating a plane that will not produce any CO_2. Analysts say that the UK's goal of climate neutrality by 2050 is realistic, assuming the country moves away from coal and gas and replaces them with renewable sources. The programs mentioned above show that the United Kingdom is allocating large funds to achieve its goals. It also sees the energy transformation as an opportunity for economic development, largely through investment and job creation. It is important to diversify the sources of energy in order to avoid blackouts. The UK's drive for climate neutrality must be based on both offshore development and the construction of small nuclear reactors and carbon sequestration.

Due to the nature of the UK's market economy, investments based on public-private partnerships play an important role in the energy transformation. One such program is Bill Gates' Breakthrough Energy Catalyst, which brings together business, governments, philanthropists and individuals. The goal is to stimulate investment in technology to help stop global warming and climate change. Breakthrough Energy Catalyst focuses on four key areas related to green technologies: hydrogen, energy storage, sustainable jet fuels and direct capture of CO_2 from the atmosphere.

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HUNGARY

Figure 18. Map of Hungary

GEOGRAPHICAL CONDITIONS

Hungary is a landlocked country located in Central Europe. The country is inhabited by 9.8 million people.[153] Budapest is the capital and also the largest city, with a population of 1.8 million.[154] Hungary borders Slovakia to the north, Ukraine to the northeast, Romania to the east, Serbia and Croatia to the south, Slovenia to the southwest and Austria to the west.[155] Hungary's longest rivers, the Danube and the Tisza, divide the country into three parts: Transdanubia (west of the Danube), the plain between the Danube and the Tisza, and the Trans-Tisza region (east of the Tisza). Hungary is located in the temperate zone and has a relatively dry continental climate.

The country is home to Central Europe's largest lake, Lake Balaton, with an area of 598 km2. The highest mountain is Kékes situated at 1014 m above sea level in the Mátra Mountains in the north of the country, in the Carpathian region. Hungary has a significant share of soils known as chernozem, which make up 50% of the country's total land area. Hungary has relatively diverse, though not abundant, mineral deposits. The most important of these are bauxite, coal, natural gas, and hot springs of medicinal waters. Hungary has some of the best geothermal resources in the European Union, providing hot water - mainly used in spas.

ECONOMY

Contrary to trends in recent years, Hungary's GDP declined sharply after the outbreak of the COVID-19 pandemic and fell by 4.7% in 2020. Public debt, on the other hand, amounted to 76.6% of the GDP. Fitch rating agency predicts that the debt will slowly decline, but could still be as high as 74.9% of the GDP by the end of 2023. The economy rebounded in 2021, despite problems related to the disruption of global supply chains created by the pandemic outbreak. Hungary's GDP grew by 7.1%. Nevertheless, one must recognize that COVID-19 hit Hungary's export-oriented economy hard, ending the period of stable growth prevailing between 2016 and 2019, when incomes rose significantly and the unemployment rate

153 *Hungary,* OECD Data, https://data.oecd.org/hungary.htm, access: 01.04.2022.

154 *World Population Review*, https://worldpopulationreview.com/world-cities/budapest-population, access: 01.04.2022.

155 *Basic information about Hungary,* http://studyinhungary.hu/why-hungary/menu/basic-information-about-hungary.html, access: 01.04.2022.

declined.[156] GDP is projected to remain high around 5% in 2022 and decline to 3% in 2023.[157] For a long time, economic development was based on attracting large international investments. The growth driver of Hungary's economy is industrial production, primarily of vehicles and car parts, wholesale trade, retail trade, hotel and catering services. Industry accounts for 24.5% of the country's GDP and provides employment for 32% of the population.[158] The two main industrial sectors are cars and electronics. Hungary has several factories that manufacture passenger cars, and most of them are owned by German corporations. The manufacturing sector alone accounts for 17.5% of the country's GDP. The electronics industry is one of Hungary's largest economic sectors and accounts for 1/5 of total industrial production. Hungary also has a large share of outsourcing in the region, with the IT sector employing 80,100 professionals.[159]

According to the Hungarian Statistical Office, in 2021 the foreign trade turnover amounted to €236.721 billion, with exports worth €119.309 billion and imports worth €117.412 billion.[160] The main products exported and imported are cars and spare parts. Hungary's major exports also include medicines and data processing machinery. In contrast, imported goods are mainly telephones, electronic equipment, and petroleum products. Hungary's main economic partners are members of the European Union, primarily Germany (27.9% of exports, 24.6% of imports), Italy (€6.99 billion), and Romania (€6.289 billion).

ENERGY MARKET

Hungary sits on a small stock of fossil fuels, while being heavily dependent on supplies from external sources, particularly Russia. According to Hungary's Central Statistical Office, dependence on energy imports was around 70% in 2019 and just over 55% in 2020.[161] Electricity in Hungary is generated mainly from nuclear power (48%) and coal (12%), with natural gas accounting for about 1/4 of the total energy generated in 2019. According to the Energy Strategy and National Energy and Climate Plan adopted in January 2020, Hungary's energy policy aims to base energy on three main pillars: clean, smart and affordable. The government aims for generating most of Hungary's energy from two sources: nuclear energy and renewable energy, mainly produced by solar power plants.

Nuclear power

Nuclear power, in a country that does not have access to many natural resources, is the primary and cheapest source of energy. Hungary has four nuclear reactors, collectively generating almost 50% of the country's electricity.[162] The reactors are located in the town of Paks, 100 km from Budapest. The nuclear power plant was built at the turn of 70/80s.[163] The facility consists of 4 nuclear units. However, due to their lifetime, designated reactors will have to be shut down by the end of 2032, 2034, 2036 and

156 *Hungary: reforms to raise productivity would strengthen recovery from COVID-19, says OECD,* https://www.oecd.org/newsroom/hungary-reforms-to-raise-productivity-would-strengthen-recovery-from-covid-19-says-oecd.htm, access: 25.03.2022.

157 *Hungary Economic Snapshot,* https://www.oecd.org/economy/hungary-economic-snapshot/, access: 25.03.2022.

158 *Ibidem.*

159 *Information and communication technology,* https://www.trade.gov/country-commercial-guides/hungary-information-and-communication-technology, access: 25.03.2022.

160 *Informator ekonomiczny, Węgry,* https://www.gov.pl/web/wegry/informator-ekonomiczny, access: 25.03.2022.

161 *Energy resources and market structure, Hungary*, https://www.oecd-ilibrary.org/sites/5a3efe65-en/1/3/22/index.html?itemId=/content/publication/5a3efe65-en&_csp_=2ffa7a733148fec42dccf926d7619e1c&itemIGO=oecd&itemContentType=book, access: 05.04.2022.

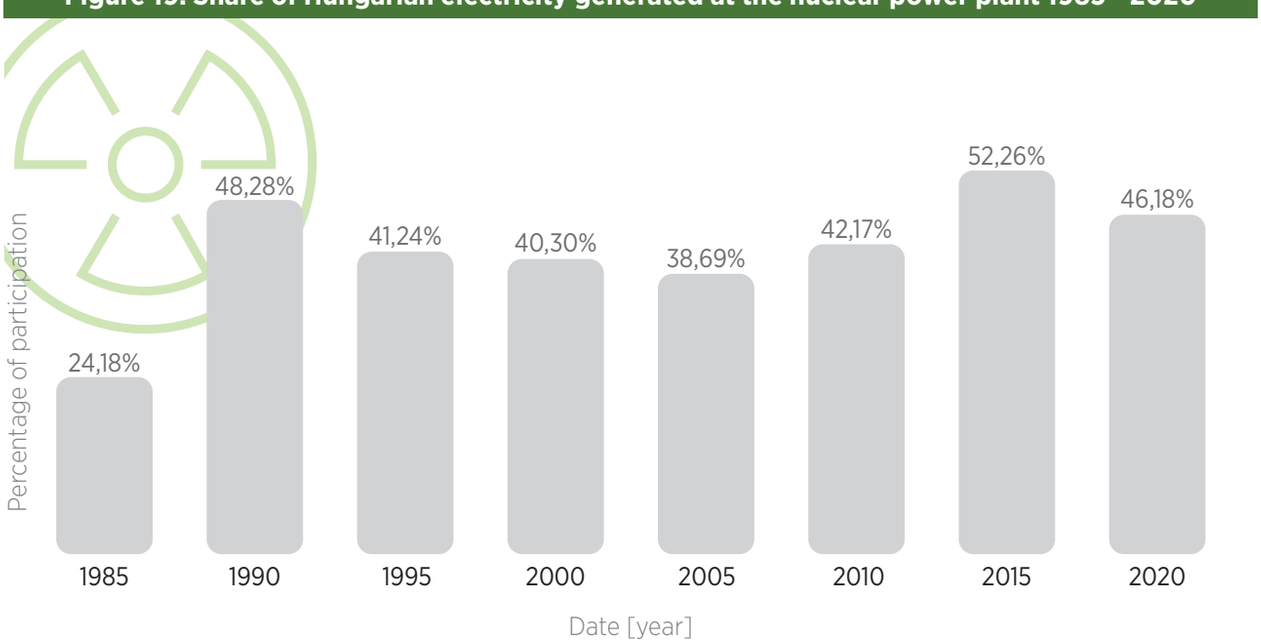
162 *Country Nuclear Power Profiles, Hungary,* IAEA https://cnpp.iaea.org/countryprofiles/Hungary/Hungary.htm, access: 02.04.2022.

163 *About us*, MVM Paks NPP, https://atomeromu.mvm.hu/en/Rolunk, access: 02.04.2022.

2037, respectively, with no possibility of further use.[164] Therefore, on 30 March 2009, the Hungarian Parliament, with a majority of 330 members out of 346 present in the plenary chamber, passed an amendment to the Atomic Energy Act, stipulating the construction of new nuclear EJ 30 units.[165] The decision was made in 2009, when the left-liberal coalition MSzP-SzDSz was in power, hence before the Fidesz-KDNP coalition took over in 2010. There was a general consensus in Hungary at that time for the development of nuclear energy.

The new government continued efforts to develop nuclear energy in the country. As a result, an intergovernmental agreement on nuclear energy cooperation was signed in Moscow on January 14, 2014, by Hungarian Prime Minister Viktor Orbán and Russian President Vladimir Putin.[166] The document addressed the construction of two new nuclear units at Paks with a capacity of 1200 MW each. It was agreed that the Russian state-owned company „Rosatom" would be the contractor for the project. It was also agreed that the work on the investment called „Paks 2", which is estimated to be worth €10-12 billion, is to be financed in 80% by a Russian loan of €10 billion. In 2017, during a press conference in Budapest, Putin announced that Russia was ready to provide financing for the entire project.[167] Hungary ultimately did not take up this offer. It was expected that the first unit could be commissioned in 2023.

Figure 19. Share of Hungarian electricity generated at the nuclear power plant 1985 - 2020



Source: https://ourworldindata.org/energy/country/hungary, access: 02.04.2022.

164 *Country profile: Hungary*, OECD, NEA, https://www.oecd-nea.org/general/profiles/hungary.html, access: 02.04.2022..

165 *Energy Policies of IEA Countries Hungary,* International Energy Agency, 2011, https://iea.blob.core.windows.net/assets/fd3596f4-05cc-42ac-96e4-01fee13d21b3/hungary2011_web.pdf, access: 02.04.2022.

166 Kardaś S., Sadecki A., *Russian-Hungarian nuclear agreement,* Centre for Eastern Studies, https://www.osw.waw.pl/en/publikacje/analyses/2014-01-15/russian-hungarian-nuclear-agreement, access: 02.04.2022.

167 *Putin: Russia ready to fund entire Paks II project,* https://www.world-nuclear-news.org/NN-Putin-Russia-ready-to-fund-entire-Paks-II-project-03021703.html, access: 02.04.2022.

The implementation of the project has encountered many challenges. After signing the contract for the expansion of „Paks 2", the European Commission initiated a total of 3 proceedings on: the supply of fuel, the procurement procedure for the investment, and the granting of public aid, all of which were finally concluded in March 2017, thus allowing the actual execution of the project.[168] However, the problems with the expansion of the „Paks 2" power plant were not over once the Commission issued the permits and all the proceedings were completed. It was planned to start the expansion of the first reactor in 2018 and finalize it in late 2025/2026.[169] In the meantime, the Hungarian company „Paks II Atomerőmű", responsible for the project, handed over the site for the construction of the first facilities to the main contractor, „ASE Engineering Company", part of the Rosatom Group.[170] However, due to the lack of relevant permits received from the Hungarian regulator, the construction and commissioning works have not been started yet. This means that the project is already delayed by more than 5 years. The Minister - Investment Coordinator of „Paks 2", said that the main construction phase of the project will start in 2022, and the new completion dates for the units are 2029 and 2030.[171]

Today, Viktor Orbán, who prioritizes this project in his government, does not plan to abandon the expansion of the „Paks 2" power plant, despite Russia's attack on Ukraine.[172] In an interview conducted just after the outbreak of the war, the Hungarian prime minister indicated that the consequence of ending energy cooperation with Russia would be a threefold increase in electricity charges borne by Hungarian families.[173] The outbreak of the war in Ukraine and serious delays in the construction of „Paks 2" are not the only problems the project is facing. The loan obtained from Russia has increased by about 20% since the contract was signed.[174] The issue of the declining level of the Danube River, which is supposed to cool the „Paks 2" reactors, is also uncertain. In 2018, the energy produced at the plant had to be reduced as the Danube temperature approached 30 degrees Celsius.[175] Any delay in construction of the facility, could contribute to problems in meeting Hungary's climate goals.

Natural gas

Natural gas is yet another important energy resource for Hungary. The share of gas in the Hungarian electricity production is 28%.[176] It is the second source of energy after the atom. In contrast, a gradual reduction in the consumption of this resource can be observed in recent years. For comparison, Hungary in 2015 consumed more than 14 billion m3 of the blue fuel and only 9.7 billion m3 in 2019.[177]

In late September 2021, Hungary signed a natural gas supply contract with Russia. The agreement was established for 15 years and is expected to cover 90% of Budapest's demand for the commodity. The document envisages supplying a total of up to 4.5

168 Decision of the Commission (EU) 2017/2112 of 6 March 2017 on the aid measure/scheme/state aid SA.38454 - 2015/C (ex 2015/N) which Hungary plans to implement to support the establishment of two new nuclear reactors at the Paks II Nuclear Power Plant, https://eur-lex.europa.eu/legal-content/PL/TXT/HTML/?uri=CELEX:32017D2112&from=HU, access: 05.04.2022.

169 D. Héjj, *Rozbudowa elektrowni atomowej w Paks – znaczenie i perspektywy,* https://ies.lublin.pl/aktualnosc/rozbudowa-elektrowni-atomowej-w-paks-znaczenie-i-perspektywy-dr-dominik-hejj/, access 05.04.2022.

170 *Country Nuclear Power Profiles, Hungary,* IAEA https://cnpp.iaea.org/countryprofiles/Hungary/Hungary.htm, access: 05.04.2022.

171 *Construction Phase of Paks Nuclear Plant Upgrade Set to Start in 2022*, https://hungarytoday.hu/paks-nuclear-plant-janos-suli/, access: 05.04.2022.

172 *Węgry nie zrezygnują z budowy elektrowni jądrowej Paks II*, https://nuclear.pl/wiadomosci,news,22022801,0,0.html, access: 05.04.2022.

173 *Interview with Viktor Orbán in the political weekly "Mandiner"*, Cabinet Office Of The Prime Minister, https://miniszterelnok.hu/interview-with-viktor-orban-in-the-political-weekly-mandiner/, access: 05.04.2022.

174 V. Jóźwiak, *Hungary's Relations with Russia*, The Polish Institute of International Affairs, https://pism.pl/publikacje/stosunki-wegier-z-rosja, doaccessstęp: 05.04.2022.

175 D. Héjj, *Rozbudowa elektrowni atomowej w Paks – znaczenie i perspektywy,* https://ies.lublin.pl/aktualnosc/rozbudowa-elektrowni-atomowej-w-paks-znaczenie-i-perspektywy-dr-dominik-hejj/, access 05.04.2022.

176 *Distribution of electricity generation in Hungary in 2021*, https://www.statista.com/statistics/1235432/hungary-distribution-of-electricity-production-by-source/, access: 05.04.2022.

177 *Umowa gazowa Węgry-Rosja i napięcia z Ukrainą w tle*, Analizy Think Tanku Trimarium, https://trimarium.pl/analiza-umowa-gazowa-wegry-rosja-i-napiecia-z-ukraina-w-tle/, access: 05.04.2022.

bcm of Russian natural gas per year. The previous long-term contract with Russia, concluded back in the days of the left-liberal coalition (MSZP-SzDSz), was valid until 2015. In the meantime, Hungary has been buying gas from Russia under annual agreements. The new transport route bypasses Ukraine, where the main route for transporting Russian gas to Central Europe is located. 3.5 bcm of gas is to be transported via the Black Sea and received at the border with Serbia (Turkish Stream), and 1 bcm of gas is to flow via Austria. The remaining part of the resource, i.e. 250 million m3, is supplied to Hungary by the British-Dutch energy company „Shell" through the Croatian LNG terminal on Krk Island, which accounts for the remaining 10% of Hungary's natural gas demand.[178] Other alternatives that were sought by Hungary, such as the possibility of gas transit from Azerbaijan, should only be regarded as a declaration that was not backed up by real action. The possibility of obtaining gas from the Black Sea deposits from Romania, was not an option for Budapest, due to difficulties in implementing the project resulting from Bucharest's policy (the BRUA pipeline).[179] The investment is continuing anyway and could be a very important transit route for Hungary.

The financial terms of the contract signed between the Hungarian energy company MVM and the Russian company „Gazprom Export" have not been disclosed. Hence, it is difficult to assess the actual cost-effectiveness of the contract for Hungary. Hungarian Minister of Foreign Affairs and Trade Péter Szijjártó said that it is more favourable than the previous contract, which was in force from 1996 to 2015.[180] Undoubtedly, the new agreement makes Hungary almost entirely dependent on Russian supplies. For the Hungarian prime minister, however, building independence from the transit countries was more important than diversifying the sources of natural gas supply. Just before signing the agreement, Minister Szijjártó said that Russian-Hungarian energy cooperation contributes to Hungary's energy security. It should be stressed, however, that the significance of natural gas in Hungary will gradually decrease. In the longer term, the expansion of the aforementioned BRUA project and the possibility of extracting gas from the Black Sea shelf will be particularly important for Budapest. Hungary indicates that thanks to this investment, the country could cover nearly half of its annual demand for gas.

Crude oil

Hungary's dependence on Russia for the supply of energy resources is also particularly evident in the case of crude oil. Hungary receives it from two sources. The first is the Druzhba pipeline from the east, which is one of the major oil transport routes from Russia to the continent. The second is the Adria pipeline, which supplies oil from the south - the Croatian port of Omisajl.[181] The production of oil in Hungary, has been declining steadily since the 1990s. In 2017, the country produced 0.98 million tons of oil. This represents only 1/10 of the domestic consumption. The main source of crude oil and petroleum products is imports from other countries. In 2017 Hungary imported oil with a net value of 6.6 million tons. Currently, the largest supplier is Russia, which supplies 60% of the oil used by Hungary.[182] Gradual efforts to diversify the supply of oil and to use new sources of supply for Hungary can be noticed. In 2012, Hungary was 95% dependent on oil imports from Russia. In 2017, this figure was 80%, whereas now imports are 60%. Hungary has been able to achieve this by upgrading the Slovak-Hungarian oil link between the Slovak town of Šahy and Hungary's „Százhalombatta" refinery. The upgrade of the Adria pipeline was completed in 2015, doubling its capacity to 6 million tons of oil per year from its previous capacity of only 3.5 million tons. Delivered from the Croatian port of Omisajl, the oil flows through

178 *Shell dostarczy gaz Węgrom przez chorwacki terminal LNG*, https://biznesalert.pl/shell-krk-lng-gas-wegry-energetyka/, access: 05.04.2022.

179 M. Paczkowski, *Złoże Neptun: problemy gazowe Rumunii*, Instytut Europy Środkowej, https://ies.lublin.pl/komentarze/zloze-neptun-problemy-gazowe-rumunii/, access: 05.04.2022.

180 S. Kardaś A. Sadecki, *New Hungarian-Russian gas agreement, Centre for Eastern Studies* https://www.osw.waw.pl/en/publikacje/analyses/2021-09-29/new-hungarian-russian-gas-agreement, access: 05.04.2022.

181 Mayer B., *Słowacja nie jest już zależna od dostaw rosyjskiej ropy. Otwarto rurociąg Adria/Barátság I*, https://forsal.pl/artykuly/852639,slowacja-nie-jest-juz-zalezna-od-dostaw-rosyjskiej-ropy-otwarto-rurociag-adriabaratsag-i.html, access: 06.04.2022.

182 *MOL: Immediate Withdrawal from Russian Oil Would Create Supply Problems*, https://hungarytoday.hu/mol-immediate-withdrawal-from-russian-oil-would-create-supply-problems/, access: 06.04.2022.

Hungary and then to Slovakia, where it is processed at the „Slovnaft" refinery, owned by Hungarian Oil and Gas Public Limited Company (MOL). In order to increase the capacity of the Adriatic pipeline, expand its shipping capacity and reduce its dependence on Russian oil, MOL has invested over €159 million in the project. There is only one oil distillation plant in Hungary itself. It is the Danube Refinery, adapted for proper processing of the mixture of oil from Russia. The refinery also belongs to the Hungarian company MOL, which owns another refinery located in Croatia.[183]

Despite the measures taken to become independent from Russia in terms of oil supplies, such as the modernisation of the Adria gas pipeline and the purchase of shares in MOL from the Russian company „Surgutneftegaz", Hungary is still fully dependent on Moscow. After Russia's aggression against Ukraine, Viktor Orban explicitly opposed the European Union's proposal to impose sanctions in the form of cutting off imports of Russian gas and oil. The Hungarian prime minister stated that Hungary would be left with no energy if supplies from Russia were interrupted.[184] According to MOL's statement, switching from Russian oil to other types of oil would require hundreds of millions of dollars of investment and several years of efforts. The key issue now is not to find new oil suppliers, but to technically upgrade MOL's refinery, which is currently only adequately equipped to handle the so-called „Russian export blend".

Coal

Bituminous coal and lignite have a relatively small share in electricity generation in Hungary. Coal accounts for only 18% of the country's energy production. As of January 1, 2020, the estimated coal reserves in Hungary were almost 10.5 billion t. The coal found in Hungary has a low calorific value. The main sites of its extraction are the „Visonta" and „Bükkábrány" opencast mines, which belong to „MÁTRAI ERŐMŰ ZRT". Coal is used to produce electricity at the „Mátra" power plant, which is the second-largest electricity-generating unit in Hungary after the Paks power plant. Mátra has a capacity of approximately 950 MW, while Paks generates 2000 MW. Mátra plant supplies 20% of electricity to the Hungarian economy and Paks almost 50%. As part of the company's development strategy, upgrades to the power plant's units are underway, with Mátra starting to use biomass while displacing coal. The power plant modernization plans also include investments related to increasing the share of renewable energy sources and gas-fired power plants, including the construction of 200 MW of solar farms and solar panels, as well as the production of 31.5 MW of precipitation fuel.[185] The company's aim is to gradually phase out coal until 2029, when the operating permits for the lignite blocks are likely to expire. Moreover, the gradual modernisation of the company's operations should also enable the preservation of jobs and the development of the region.[186]

The low share of coal in the Hungarian energy mix makes the country's energy transformation possible in accordance with the plans set out by the European Union. During the summit of the Powering Past Coal Alliance, which took place in March this year, the Hungarian minister responsible for energy and climate issues, Attila Steiner, declared that Hungary would abandon the use of coal in the power industry in 2025, and not in 2030 as originally planned.[187] The minister also indicated that Hungary wants to achieve 90% CO_2 neutrality by 2030. Therefore, the priority for Budapest will be to maintain the existing nuclear power production and photovoltaic production. It is worth mentioning, that it was the Mátra power plant that produced almost 14% of the national carbon dioxide emissions and half of the Hungarian power

183 M. Paszkowski, *Grupa MOL: strategia i plany inwestycyjne*, Instytut Studiów Wschodnich, https://ies.lublin.pl/komentarze/grupa-mol-strategia-i-plany-inwestycyjne/, access: 06.04.2022.

184 *MOL: Immediate Withdrawal from Russian Oil Would Create Supply Problems*, https://hungarytoday.hu/mol-immediate-withdrawal-from-russian-oil-would-create-supply-problems/, access: 06.04.2022.

185 *Hungary*, https://euracoal.eu/info/country-profiles/hungary/, access: 6.04.2022.

186 *Hungary: Converting the Mátra Power Plant into a Diversified Hub of Green Energy and Industry*, https://www.wri.org/update/hungary-converting-matra-power-plant-diversified-hub-green-energy-and-industry, access: 06.04.2022.

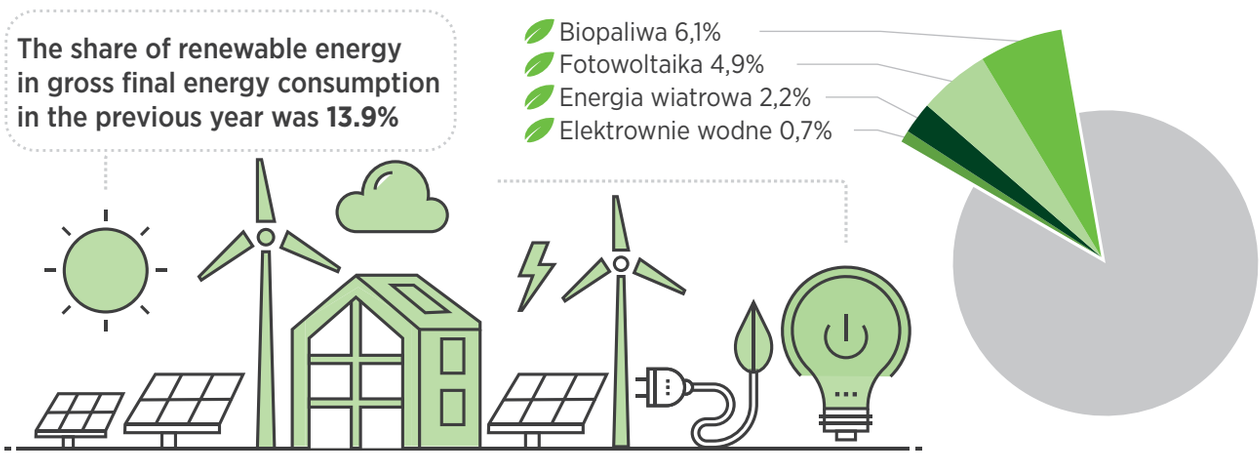
187 *Coal Mines in Europe*, https://energyindustryreview.com/analysis/coal-mines-in-europe/, access: 08.04.2022.

sector's pollution in 2016.[188] Nuclear power, natural gas and renewables are the alternatives to coal when considering Hungary's overall energy mix. However, ambitious plans to completely phase out coal by 2025, achieve zero-carbon by 2050, and reduce natural gas consumption by about 3.8 billion m^3 by 2030 will not be possible if the expansion of the Paks 2 nuclear power plant continues to be systematically delayed.

Renewable energy sources

Hungary has managed to reach the 2020 target set by the European Union in Directive 2009/28/EC as part of its gradual efforts to increase the share of renewable energy in the overall energy mix. The share of renewable energy in gross final energy consumption in the previous year was 13.9%, with biofuels accounting for 6.1%, photovoltaics 4.9%, wind energy 2.2% and hydropower 0.7%.[189] This represents a 1.3% increase in renewable energy over 2019. In contrast, the target indicated in the EU document is 13% for 2020. Comparing the results achieved in 2020, against 2019, one can see that the consumption of energy from renewable sources increased by 4.6%, while the consumption of energy from fossil fuels decreased by 2.1%. Energy production from biomass decreased slightly, while the use of solar energy increased by 59.3% compared to 2019.[190] According to the data, wind energy does not constitute a significant part of the renewable energy structure. Moreover, due to the geographical conditions, the Hungarian government does not plan to develop this form of energy generation.[191]

Figure 20. Share of renewable energy in Hungary's gross final energy consumption in 2020



188 *Hungary: Converting the Mátra Power Plant into a Diversified Hub of Green Energy and Industry*, https://www.wri.org/update/hungary-converting-matra-power-plant-diversified-hub-green-energy-and-industry, access: 08.04.2022.

189 K. Tucki, M. Krzywonos, O. Orynycz , A. Kupczyk, Anna Bączyk, I. Wielewska, *Analysis of the Possibility of Fulfilling the Paris Agreement by the Visegrad Group Countries*, https://www.mdpi.com/2071-1050/13/16/8826, access: 08.04.2022.

190 *Hungary reaches 13.9% renewables share in 2020 final Energy*, https://renewablesnow.com/news/hungary-reaches-139-renewables-share-in-2020-final-energy-767481/, access: 08.04.2022.

191 Bart I., Csernus D., Sáfián F., *Analysis of climate-energy policies & implementation in Hungary*, Climate Strategy 2050 Institute, 2018, https://eko-unia.org.pl/wp-content/uploads/2018/06/mini-report-1_Hungary.pdf, access: 08.04.2022.

Hydrogen energy

Hungary has ambitious plans, when it comes to the future use of hydrogen energy. Hungary's National Hydrogen Strategy has a long-term focus on „green" hydrogen, based on electricity generation from renewable sources, particularly solar energy.[192] Furthermore, the document indicates that Hungary is not ignoring the possibility of hydrogen production based on carbon-free, nuclear-based energy. Hydrogen's significance for Hungary was emphasized by Péter Kaderják, Hungary's Minister of Energy and Climate Policy, during a meeting of European Union ministers responsible for research and innovation - *„Hydrogen produced from nuclear energy will play a key role in the Hungarian energy system and the Hungarian economy as a whole in the long term."*.[193] Currently, domestic hydrogen production is dominated by „grey" hydrogen produced by the carbon-intensive steam reforming of hydrocarbons (SMR) process. A priority for Budapest is to shift to „green" hydrogen production, as this would reduce greenhouse gas emissions in the industry and the national economy as a whole. Electrolysis-based production using the Paks nuclear power plant, where excess electricity generated by the plant can be used to produce „green" hydrogen, could provide such an opportunity. Hungary's National Hydrogen Strategy aims to achieve an annual production of 36,000 t of „green" hydrogen by 2030. In order to achieve these goals, Hungary plans to expand existing hydrogen production methods to reduce its carbon footprint, to establish electrolysis centers as pilot projects for photovoltaic and grid-mixed power generation, and to develop international cooperation to bring ready-made solutions to the market.[194]

Transport

Hydrogen is intended to be used effectively in transport, with a gradual reduction in diesel consumption to move towards clean traffic methods. Budapest's priority is to reduce the carbon footprint produced by lorries. In addition, Hungary plans to expand the use of hydrogen by buses and build at least 20 hydrogen refueling stations by 2030. In order to create a low-carbon transport infrastructure, the Hungarian government introduced the National Electromobility Development Program, which was approved in 2015 and includes a strategy of steps planned until 2030. It sets ambitious goals to have 182,000 electric vehicles and more than 20,600 charging stations by that time.[195] In 2019, the document was updated and the Jedlik Anyos 2.0 Action Plan was adopted. In the established document, electromobility was recognized as an important part of the decarbonization of the road transport sector, which is necessary to achieve national and EU climate policy goals. The new strategy envisages that nearly 300,000 electric vehicles will drive on the roads by 2025, with further plans for 500,000 such vehicles by 2030. 23,000 charging stations are also expected to be operational by 2025, rising to over 53,000 by 2030. Hungary has adopted a national plan for electrification of public transport (Green Bus) in 2019 as part of the development of its electromobility program.[196] The aim of this strategy is to ensure at least a 30% share of zero-emission buses in the urban bus fleet by 2030. The Hungarian government plans to allocate HUF 35.9 billion (over 91 million euro) between 2020 and 2029 to support the purchase of electric buses and self-driving trolleybuses in cities with a population of more than 25,000. As pointed out by László Palkovics, Minister of Innovation and Technology, making transport greener is a key element of the government's commitment to achieve climate neutrality for the country by 2050.[197]

192 *Węgry apelują o wykorzystanie energii jądrowej jako źródła czystego* wodoru, https://www.cire.pl/artykuly/serwis-informacyjny-cire-24/173632-wegry-apeluja-o-wykorzystanie-energii-jadrowej,-jako-zrodla-czystego-wodoru, access: 07.04.2022.

193 *Ibidem*.

194 *Hungary's National Hydrogen Strategy*, https://cdn.kormany.hu/uploads/document/a/a2/a2b/a2b2b7ed5179b17694659b8f050ba9648e75a0bf.pdf, access: 07.04.2022.

195 J. Mizak, *Visegrad Electromobility – State, perspectives and challenges*, Forum Energii, https://euagenda.eu/upload/publications/visegrad-electromobility.pdf, access: 09.04.2022.

196 *Climate and Nature Protection Action Plan - Green Bus Program*, IEA, https://www.iea.org/policies/13933-climate-and-nature-protection-action-plan-green-bus-program, access: 09.04.2022.

197 *Green Bus Programme to Help Cities to Electric Transport*, https://hungarytoday.hu/green-bus-programme-help-cities-electric-transport/, access: 09.04.2022.

CLIMATE POLICY

The European Union has made it mandatory for member states to adopt national energy and climate plans for 2021 - 2030. As a result, the Hungarian Parliament updated the second National Climate Change Strategy (NCCS 2) in 2018, which was originally adopted in 2014.[198] The document sets out the 3 most important pillars of Hungary's climate policy: the National Climate Change Mitigation Decarbonization Roadmap, the National Adaptation Strategy, and the Climate Change Awareness Action Plan. The implementation of the goals indicated in NCCS 2 is to be based on the Climate Change Action Plan (CCAP), which is set every 3 years. The first document was adopted by the government in 2020 and outlines short-term measures designed to contribute to reaching the goals set out in NCCS 2.

The National Adaptation Strategy (NAS) sets out directions, including preparation for possible impacts caused by climate change, in the most relevant sectors in Hungary.[199] The adaptation measures indicated in it are to be determined on the basis of a detailed analysis of the situation, which will show the consequences of climate change for natural resources (water, soil, biodiversity and forests), people and the socio-economic environment. To this end, a permanent system is to be set up, generating specified data based on national surveys and earth observation, to help prepare and plan concrete decisions adapted to changing circumstances. The main area of intervention under the Adaptation Strategy, is to save natural and semi-natural ecosystems and restore degraded ones, as well as to preserve natural resources both in terms of quantity and quality. The purpose of implementing these measures is to mitigate the effects of climate change.

The EU Climate and Energy Framework approved by the European Council in 2014 stipulates a 40% reduction in greenhouse gas emissions by 2030 compared to the 1990 value. Hungary aims for renewable energy to account for 21% of its total energy mix by then. The reduction of CO_2 emissions in Hungary's energy sector is to be based in particular on nuclear energy.[200] In addition, in order to achieve its decarbonisation goals, Hungary is taking the following measures: reducing electricity generation, which generates high GHG emissions, increasing the use of solar energy, supporting biomass in its broadest sense as a stable source of renewables, developing small domestic power plants with energy storage, supporting electromobility and developing rolling stock.[201] Achieving decarbonization requires coherence of technological and environmental sectors as well as social adaptation, which is only possible through the interaction of natural ecosystems, establishment of appropriate institutional regulations, development of infrastructure, implementation of technological innovations and development of appropriate behavioral practices. In this regard, Budapest plans to prepare relevant public awareness programs, including the „Partnership for Climate" project and implement the Climate Awareness Plan (CAP).[202]

198 Climate ADAPT, *Hungary,* https://climate-adapt.eea.europa.eu/countries-regions/countries/hungary, access: 11.04.2022.

199 *Hungary climate resilience policy indicator*, https://www.preventionweb.net/news/hungary-climate-resilience-policy-indicator, access: 11.04.2022.

200 *National Energy and Climate Plan of Hungary*, https://ec.europa.eu/energy/sites/ener/files/documents/ec_courtesy_translation_hu_necp.pdf, access: 11.04.2022.

201 *Ibidem.*

202 *Climate Change Action Plan*, https://nakfo.mbfsz.gov.hu/en/node/367, access: 11.04.2022.

SUMMARY

„Fidesz" initially criticized the former ruling coalition for its close contacts with Russia. However, Hungary has been closely dependent on Moscow for its energy since 2014. This applies both to the supply of raw materials, but also to the know-how used to implement other energy projects. In 2018, Russia fulfilled 75% of Hungary's demand for oil and at least 60% for natural gas. In addition, Russia provided 80% of financing for the expansion of the new nuclear units at Paks, where the Russian state-owned company „Rosatom" is the project contractor. Due to the recent election victory of Viktor Orbán's party, one can be sure that the project will be continued, thus creating further opportunities for deepening bilateral relations between Moscow and Budapest. In practice, the only raw material that Russia is not a dominant supplier of is coal, having less and less importance for Hungary's energy sector. The country plans to retire all coal-fired power plants and achieve climate neutrality by 2050. Consequently, Hungary is gradually implementing a plan to modernize the Mátra power plant. It is a major emitter of carbon dioxide and accounts for almost half of the CO_2 emissions from the power sector in Hungary. As part of the ongoing reorganization of the plant, it is planned to phase out coal-based production and switch to low-carbon technologies, such as the construction of solar farms and the production of rainfuel.

Hungary's energy security will depend on the expansion of the Paks 2 nuclear power plant on schedule and the European Union's recognition of the atom as a source of green, low-carbon energy. Today, there is no consensus on the matter. Although nuclear energy is part of achieving the key energy policy goal of zero-emission energy production and climate neutrality by 2050 for EU member states, it is not being treated as an equal to renewable energy technologies. Nuclear power is not included in the index of classified technologies that can count on support from the EU budget. Raising the share of Paks in the energy mix will enable Hungary to significantly reduce CO_2 emissions.[203] Budapest's main policy priority is the action strategy related to „rezsicsökkentés", the Hungarian government's citizen-oriented policy programme. It is based on the assumption that energy is to be, first and foremost, cheap for the population, and that the costs of combating climate change cannot be borne by households. This means that the pricing policy is completely regulated by the Hungarian state, which sets the maximum charge rates. The program was announced in 2012 and is one of the government's key socio-economic packages.

However, Hungary's energy policy, which is heavily dependent on Russia, could have serious political consequences, especially after Russia's attack on Ukraine. Despite the outbreak of the war in Ukraine, Hungary does not want to withdraw from its energy policy aimed at co-operation with Moscow and is maintaining the agreement signed with the Russians on gas imports and the expansion of its nuclear power plant. Cooperation with an economically weakening Russia, which is embroiled in international conflicts, could have serious consequences for Hungary through the country's international isolation in the region. Hungary currently holds the presidency of the Visegrad Group (V4) under the slogan „Let's renew Europe", and one of its pillars is cooperation aimed at strengthening the global significance of the international project that is V4.[204] However, individual Visegrad countries are not unanimous regarding the war in Ukraine. Poland and the Czech Republic strongly support Ukraine, while Hungary, which is pro-Russian, and Slovakia, which is torn apart internally, are on the other side.[205] Budapest has been reluctant to move away from its close relationship with Russia, with which it has strengthened energy relations over the years and has become almost entirely dependent on, in terms of energy sources. Hungary's relations with the European Union have remained extremely strained over the years. Budapest could count on regional alliances and very good relations with Poland in the past. However, the war in Ukraine has disturbed the foundations of the long-standing Polish-Hungarian

203 M. Ruszel, A. Witkowska, *Polish-Hungarian Cooperation for Energy Security in the context of Energy Transition and Economy Competitiveness*, Ignacy Lukasiewicz Institute for Energy Policy, https://www.instytutpe.pl/wp-content/uploads/2021/07/Ebook-Polish-Hungarian-Cooperation-for-Energy-Security-in-the-context-of-Energy-Transition-and-Economy-Competitiveness.pdf, access: 09.04.2022.

204 Héjj D., *Recharging Europe - węgierska prezydencja w Grupie Wyszehradzkiej*, https://ies.lublin.pl/komentarze/wegierska-prezydencja-w-grupie-wyszehradzkiej/, access: 12.04.2022.

205 *The Position of the V4 towards War in Ukraine,* https://visegradinsight.eu/the-position-of-the-v4-towards-war-in-ukraine/, access: 12.04.2022.

political friendship. Hungary's conduct caused Poland and the Czech Republic to cancel their presence at the planned V4 meeting, which was to be held in March this year. Meanwhile, President of Poland Andrzej Duda cancelled a planned meeting with the Hungarian president, which was to take place on the occasion of the annual Polish-Hungarian Friendship Day celebrations. In addition, in a recent interview, the Polish president stated that it is difficult for him to understand the Hungarian government's attitude towards the Russian aggression against Ukraine, the deaths of thousands of people and the bombing of residential areas.[206] The rift between the V4 countries was also evident at the recent meeting between the foreign ministers of Hungary and the Czech Republic, when Péter Szijjártó indicated that Hungary would not support further fossil fuel sanctions related to Russia because he did not want to jeopardize his own energy security. Minister Jan Lipavský, on the other hand, stressed that ending Russian oil imports is expected to reduce Russia's profits from trade with the European Union. Viktor Orbán's policy of close cooperation with Russia, which is based on energy dependence on Moscow, has undoubtedly caused deep cracks in Polish-Hungarian relations after the outbreak of the war in Ukraine, and has strongly diverged from the standpoints of the individual Visegrad Group countries. It is now difficult to clearly assess the real consequences of these developments, and it is difficult to talk about returning to the same level of cooperation and relations from before the war.

206 *Andrzej Duda: Trudno mi zrozumieć postawę Węgier*, https://www.rp.pl/polityka/art35951601-andrzej-duda-trudno-mi-zrozumiec-postawe-wegier, access: 12.04.2022.

ITALY

Figure 21. Map of Italy

GEOGRAPHICAL CONDITIONS

The Italian Republic is located in Southern Europe. Almost entirely situated on the Apennine Peninsula. Italy also includes three islands: Sardinia, Sicily and Elba. The capital city is Rome and the official language is Italian. The population of Italy is approximately 60 million, with an average of almost 200 people per square kilometer. The total area of the country is similar to Poland and amounts to 301 268 km2. The territory is surrounded by the Ligurian, Tyrrhenian, Mediterranean, Ionian and Adriatic Seas. The length of the Italian coast is 7375 km. Italy is adjacent to France, Switzerland, Austria and Slovenia. The total length of the borders is 1932 km. The country consists of 20 regions and 107 provinces, including two enclaves: Vatican City and San Marino.

Italy is dominated by an upland and mountainous landscape. It is prevalent both on the mainland and on the Italian islands - it accounts for 77% of the country's land area. There are two major mountain systems in Italy - the Alps and the Apennines. The Alps are made up of crystalline rocks (gypsum and

granite) and sedimentary rocks (limestone and dolomite). Apennines, classified as a young fold mountains less uplifted than the Alps, are similar to them in geological structure. The main lowland area, which is also the most important economic region in Italy, is the Po plain, which covers an area of 46,000 sq km, making it the largest lowland in Italy. The rest of the lowlands are located on a narrow coastal strip.

The climate is very diverse as a result of several factors: the long latitudinal range from 36°N to 47°N, the passage of two mountain ranges that act as natural climate barriers, and the proximity of Africa. The country is largely located in a subtropical climate zone with a Mediterranean variant. The central part, however, is dominated by a continental climate. Temperate climate occurs in the north, near the mountain range of the Alps, where climatic stacking is typical - the lowest parts feature a mountain climate, and the highest parts an alpine climate. Consequently, winters in the northern regions are cold and summers hot, while the further south you go the milder the climate becomes.

Italy's river network is dense, especially in the northern part, thanks to the Po River, the longest river in Italy (about 652 km long). The longest rivers besides the Po are the Adige and the Tiber. Italy has many lakes of varying origins. The Alps are home to numerous circus lakes and large and deep tectonic-glacial lakes such as Garda, Como, and Lugano. The Apennine Peninsula is also home to tectonic lakes such as Trazymena, volcanic lakes such as Bolsena or Bracciano, and lagoon lakes such as Valli di Comacchio or Varano.

Italy is blessed with a variety of natural and mineral resources. Building stone stocks, gravels and sands, which are used by the cement and construction industries. Raw building materials (including the famous Carrara marbles) are found throughout the country, but the most famous mining areas are in the Alps and the central Apennines. Large deposits of sulfur can be found in Sicily - it was the basis for the development of large acid and heavy chemical factories. Sardinia, on the other hand, has significant deposits of zinc and lead ore. The exploitation of bauxite, nickel, mercury and salt is limited. The extraction of hard coal in Italy is currently declining and amounts to less than one million tons per year (mainly in Sardinia). Lignite mining in Umbria and Tuscany is also of little significance. Significant oil and gas reserves were discovered in Italy after World War II. This discovery allowed to dramatically improve the energy balance of the country. About 80% of crude oil is extracted in Sicily and on the coastal shelves. Natural gas is extracted mainly in the Po Plain. Water is also utilized to meet energy needs, especially the Alpine tributaries of the Po and Adige rivers. Italy also has an abundance of mineral waters, especially thermal waters, which are used for geothermal energy. Despite the access to various natural resources, their quantity is not sufficient to completely cover the energy demand and make the country independent from the supply of raw materials from other, external sources.

ECONOMY

In economic terms, Italy is one of the most important countries in both Europe and the world. In 2020, the country's nominal GDP amounted to $1.888 trillion, making it the eighth largest economy in the world and, despite the crisis, the fourth largest economy in Europe.[207] Unemployment at its current level of nearly 9%[208] and the country's domestic debt of 134.8% of GDP (in 2019) are significant economic problems.[209] Another problem of the Italian economy is the uneven level of development of the country's various regions. Economically, Italy is clearly divided into a highly developed north and a less developed south.

The Italian economy is based on several well-developed sectors. First of all, it is the automotive sector. One of the most important branches of this sector is the smelting industry located in the area of Genoa, Naples, Turin and Milan, which caters entirely for the needs of the electromechanical industry, especially shipbuilding and automobiles. Consequently, it establishes Italy as one of the most important producers of all kinds of machinery and vehicles and of electrical engineering. The textile and clothing sector, concentrated in the northern part of the country, also represents a long tradition and is highly influential. Food processing within the agri-food sector is also important. It is one of the few branches of industry that is evenly distributed throughout the country. An extremely important field of the economy is tourism, which has excellent development opportunities, thanks to the rich cultural heritage and natural assets. Italy is ranked 5th in the world in terms of foreign tourist arrivals, with more than 55 million tourists visiting the country in 2019.[210] The center of the chemical industry, an important part of the economy, is located in two regions: Lombardy and Piedmont. The largest production and processing plants of soda, fertilizers, plastics and synthetic fibers, glass, cement, and oil are located there.

ENERGY MARKET

The energy sector plays a key role in the functioning of the state. In 2020, more than 90% of the national demand for electricity was met by domestic production, with the remainder coming from foreign production.[211] One can observe that the downward trend of imported energy has continued for several years, while its exports in 2020 increased significantly.[212] Electricity is still generated in Italy both from non-renewable energy sources, through the exploitation of fossil fuels such as oil, coal and natural gas, and increasingly from renewable energy sources.

Gas is the main source according to the distribution of production and consumption structures in the energy sector, based on various sources and methods of energy production, i.e. in the so-called energy mix. Referring to the shares of diverse renewable energy sources within the total energy production, it is worth noting that they are distributed almost evenly - however, hydroelectric production has a definite advantage.

207 *GDP(current US$) Italy,* https://data.worldbank.org/indicator/NY.GDP.MKTP.CD, access: 25.03.2022.

208 *Włochy - Stopa bezrobocia,* https://pl.tradingeconomics.com/italy/unemployment-rate, access: 25.03.2022

209 *Włochy – zadłużenie zewnętrzne,* https://ec.europa.eu/eurostat/en/web/products-datasets/-/GOV_10DD_EDPT1, access: 25.03.2022.

210 *Włochy: 55 mln osób w muzeach, zabytkach i na terenach wykopalisk,* https://www.pap.pl/aktualnosci/news%2C577044%2Cwlochy-55-mln-osob-w-muzeach-zabytkach-i-na-terenach-wykopalisk.html, access: 25.03.2022.

211*Relazione annuale sullo stato dei servizi e sull'attività svolta,* https://www.arera.it/it/relaz_ann/21/21.htm, access: 26.03.2022.

212 *Ibidem.*

Figure 22. Electricity production in Italy, expressed in TWh, by source

Energy source	2016	2017	2018	2019	2020
Thermoelectric generation	**179,915**	**190,106**	**173,578**	**176,171**	**163,541**
Gas	126,148	140,349	128,538	141,687	137,649
Oil production	4,127	4,083	3,289	3,453	3,325
Solid fuels - coal	35,608	32,627	28,470	18,839	10,399
Other	14,032	13,047	13,281	12,192	12,168
Renewable sources	**108,028**	**103,898**	**114,415**	**115,847**	**116,054**
Hydropower	42,438	36,199	48,786	46,319	46,666
Wind power	17,689	17,742	17,716	20,202	18,702
Photovoltaics	22,104	24,378	22,654	23,689	24,942
Geothermal	6,289	6,201	6,105	6,075	6,029
Biomass	19,509	19,378	19,153	19,563	19,715
Overall production	**289,768**	**295,830**	**289,709**	**293,853**	**281,487**

Source: Relazione annuale sullo stato dei servizi e sull'attività svolta, [na:] https://www.arera.it/it/relaz_ann/21/21.htm, access: 26.03.2022.

The high demand for electricity makes Italy's natural resources insufficient. In Italy, only 7% of oil demand and 4% of gas demand is met from its own production.[213] [214] Consequently, the country is dependent on the import of energy resources. This creates the need to import a significant amount of minerals into the country. Security of supply is a key element of foreign and economic policy from the point of view of Italian interests. Italy is the fourth largest consumer of oil in Europe after Germany, Great Britain and France - the total import of oil amounts to approximately 93% of the demand for this raw material. Italy also leads the way as one of Europe's largest consumers of gas, with total imports accounting for approximately 96% of the demand, with only Germany and the UK being larger importers.[215] As a result, various downturns in global markets have an immediate impact on the state of the economy. Italy is seeking to diversify its oil and gas supply sources and develop transmission and storage infrastructure. The largest suppliers of gas continue to be: Russia - in 2021 40% of supplies came from this country, Algeria and Libya.[216] Oil imports to Italy are dominated by Azerbaijan, which guarantees 19% of total imports, while Russia and Libya are far behind.

Fossil fuels

Fossil fuels are one of the main sources of energy in Italy. Their widespread use, resulting in CO_2 emissions into the atmosphere, is responsible for climate change. Italy is strongly committed to using various types of renewable sources to generate electricity, but it remains dependent on fossil fuels - domestic and imported. The extent of their contribution to the energy sector was 58% of domestic demand in 2020. Gas and oil have the largest share, together accounting for more than 50 % of demand.

The share of coal, on the other hand, represents

213 *La dipendenza della'Italia dalle importazioni di gas,* https://italyforclimate.org/la-dipendenza-dellitalia-dalle-importazioni-di-gas/, access: 08.04.2022.

214 *La dipendenza della'Italia dalle importazioni di petrolio,* https://italyforclimate.org/la-dipendenza-dellitalia-dalle-importazioni-di-petrolio/, access: 08.04.2022

215 *Energetyka Włoch,* http://www.novaenergia.agh.edu.pl/energetyka-wloch/, access 26.03.2022.

216 *Importazioni italiane di gas naturale per paese di origine,* https://dgsaie.mise.gov.it/gas_naturale_importazioni.php?lang=it_IT, access: 26.03.2022.

about 4% of Italy's energy needs. The country has only one significant coal mine, located in Sardinia. It is estimated to produce about one million tons of coal per year. Due to the poor quality of coal and low reserves, Italy has begun to obtain large amounts of coal from other countries. There are only twelve coal-fired plants operating in Italy that convert the heat generated by coal into electricity.

Italy expects to phase out coal by 2025. The energy catch-up is to be achieved by developing gas-fired power plants and increasing the share of energy produced from renewable sources. In this context, the gradual abandonment of fossil fuels, starting with coal, leads to the evolution and transformation of the Italian energy system.

Wind energy

Wind energy is one of the key renewable energy sources implemented as part of the green transition and is of significant importance for the Italian energy sector. Italy ranks fifth in Europe in terms of energy production obtained through wind turbines.[217] Wind production represents approximately 7% of the national electricity production. According to the provisions of the National Integrated Energy and Climate Plan, Italy aims to increase wind capacity by 10 GW by 2030 (doubling the current capacity).

Approximately 90% of wind farms are concentrated in the South and on the islands, due to the availability of sufficiently windy sites in these regions. This trend is also confirmed by a study carried out by the Associazione Nazionale Energia del Vento[218] (ANEV, National Association of Wind Energy), according to which the Italian coast has significant potential for possible wind energy production in the near future.

The development of wind farms is one of the means of achieving climate neutrality in Italy. The Italians have undertaken a number of revisions of the obstacles to the development of the sector concerning administration. The ANEV's „Manifesto per lo sviluppo dell'eolico" contains the necessary guidelines that should become the basis for the development of Italy's climate policy for wind energy.[219] The document includes the following proposals:

- renewal and simplification of authorization procedures and shortening of their implementation time;
- revision and update of national guidelines for wind energy;
- creation of an appropriate body under the Council of Ministers which would allow coordination of renewable energy development;
- implementation of support mechanisms, which would allow wind companies to invest by extending the validity of auctions and registers;
- creation of tools for the development of power purchase agreements; establishment of a Renewable Public Guarantee Fund with an estimated budget of €150 million to be distributed by 2030;
- creation of a system of tax relief for consumers on long-term purchases of energy from renewable sources.

Italian wind farms are currently located mainly onshore, but in the midst of development prospects, new plants will be increasingly able to be connected to offshore wind energy. Such farms, located off the Italian coast, will be able to take advantage of the strong exposure to airborne currents in order to make even greater use of the potential to generate renewable and clean wind energy.

217 *Energia eolica: la situazione attuale in Italia,* https://modofluido.hydac.it/energia-eolica, access: 26.03.2022

218 *Presentazione "Il contributo dell'eolico italiano per il raggiungimento degli obiettivi al 2030,* https://www.anev.org/services/italia-2030/, access, 26.03.2022

219 *ANEV PRESENTA IL MANIFESTO PER LO SVILUPPO DELL'EOLICO IN ITALIA,* https://www.anev.org/2021/05/27/anev-presenta-il-manifesto-per-lo-sviluppo-delleolico-in-italia-togni-il-buon-vento-della-ripresa-parte-da-qui-associazione-aziende-e-istituzioni-collaborino-per-lo-sviluppo-di-un/, access: 26.03.2022.

Photovoltaics

The generation of electricity from sunlight is set to play a fundamental role in Italy's environmental transformation. Photovoltaic technology is considered a relatively young way of generating electricity - back in 2007 it was still considered an experimental technology. The gradual development of photovoltaics continues to this day - in fact, photovoltaics in Italy has reached about 21.7 GW of installed capacity.[220] Looking at electricity generation, photovoltaic production has grown to generate about 25.5 TWh in 2020, accounting for nearly 9% of the national production.

Without a doubt, Italy is now entering the next stage in the development of photovoltaic systems. According to the National Integrated Energy and Climate Plan, solar PV will be one of the cornerstones of the Italian electricity system. The plan sets a goal of reaching 52 GW of photovoltaic capacity by 2030, about twice the current installed capacity. An increase is expected particularly between 2023 and 2025. Nonetheless, growth in both new systems connected and installed capacity was already evident in 2021 compared to 2020 - last year each quarter had more connected capacity than the previous quarter, in addition, the connected capacity of smaller systems (less than 12 kW) more than doubled compared to 61 MW in Q1.

Between 2009 and 2020, the number of systems installed in Italy increased more than tenfold, from 76,000 to about 900,000.[221] This number is expected to grow thanks to tax reliefs offered by the state. The distribution of photovoltaic systems within Italy is very diverse. It would seem that the southern regions of Italy, which enjoy the best sunlight, will potentially be the largest hotbed of PV systems. However, the highest concentration is observed in the North at around 55%, while the rest is divided between the South at 28% and the center of the country at 17%. The region with the highest number of systems is Lombardy, which concentrates about 11.7% of the total installed capacity in the country, followed by Veneto. Overall, 45% of Italy's total installed capacity at the end of 2020 was concentrated in the northern regions, 37% in the southern regions, and the remaining 18% in the central regions.[222] These figures converged in 2021. The price of a 3 kW photovoltaic system is almost the same in all regions of Italy and can range from €4500 to €8000.

Hydropower

Hydropower is a renewable energy source with the longest tradition in Italy - back in the 19th century, Italy became one of the leaders in the development of hydroelectric systems capable of generating clean energy. Even if, in the long run, solar and wind energy will be the basis of the country's green future, it must not be forgotten that today hydroelectric power still accounts for the majority of renewable energy sources.

Hydropower may be considered the undisputed protagonist of the Italian energy transformation. Until the 1920s, hydropower represented almost all of Italy's green energy, with a small share of other sources such as geothermal energy. Italians were convinced that energy obtained in this manner could guarantee total energy self-sufficiency in the future. By the middle of the 20th century, maximum utilization of Italy's hydroelectric potential had been achieved. However, over time, partly due to the lack of further profitable sources to exploit, partly due to the increase in the share of other energy sources, hydropower began to lose its importance.

220 *Fotovoltaico in Italia, a fine 2020 oltre 935mila impianti solari,* https://www.rinnovabili.it/energia/fotovoltaico/fotovoltaico-in-italia-capacita-solare/, access: 26.03.2022.

221 *Il fotovoltaico in Italia: tutto quello che devi sapere,* https://www.otovo.it/blog/fotovoltaico-in-italia/, access: 26.03.2022.

222 *Ibidem.*

Based on the calculations carried out by the Gestore dei servizi energetici (GSE), at the end of 2018, the number of Italian hydropower plants was 4331 units. The company „Terna" carried out a survey in the same scope in 2019, resulting in 4401 units.[223]

Hydropower is not evenly distributed across Italy - the vast majority of power plants and installed capacity are located in the foothills of the Alps. At the end of 2018, 930 power plants were registered in Piedmont, which corresponds to more than a fifth of the total number and nearly 15% in terms of national capacity. It is Lombardy, however (with 661 hydroelectric plants) that ranks first in terms of capacity, with 27.2% of national production.[224] According to data collected by GSE, Italy had a total installed hydropower capacity of about 19 GW at the end of 2018. In terms of produced energy, the annual calculation of hydropower was 48.8 TWh, corresponding to about 17% of the national energy demand and about 42% of the share of production from renewable sources. The share in 2020 was about 46.7 TWh which was about 16% of the national demand. By upgrading just 1/3 of the plants in operation, many of which have lower hydroelectric potential due to their age, it is possible to generate nearly 6 GW of power and 4.4 TWh of energy per year, saving more than 2 million tons of CO_2.

It is worth noting that hydroelectric power still dominates the renewable energy sector in Italy.

Geothermal energy

Italy is one of the world leaders in producing electricity from the Earth's heat. It has a tremendous potential for the extraction and exploitation of geothermal energy. However, renewable, clean and essentially inexhaustible energy released as heat from the Earth still occupies a relatively marginal role in the Italian energy mix. Nevertheless, the country is one of the main producers of geothermal energy at the European level and in the global context. The abundance of geothermal resources is concentrated in different spots on the Apennine Peninsula and in the future could become a key element of the energy transformation in Italy.

The origin of geothermal energy in Italy dates back to the early 20th century. The first geothermal power plant in history was built in Tuscany, at Larderello in 1904. Since then, Italy has played a world-leading role in geothermal energy innovation and in the ability to exploit geothermal sources. The region that primarily represents Italian geothermal energy is Tuscany. Starting with Larderello, which today houses the largest geothermal power plant in Europe, through the years the number of geothermal power plants in this region has grown to over thirty.

In recent years, the amount of geothermal energy produced and its capacity has steadily increased, but at a fairly slow rate. In the decade between 2007 and 2017, the overall increase in installed capacity was only about 10%.[225] This means that geothermal energy in Italy has never become a dominant source of renewable energy, despite its huge potential.

Around 6 TWh of geothermal energy is extracted every year in Italy. Compared to the national energy needs, geothermal power represents about 2% of the total energy production and about 5% of the renewable component. With an installed capacity of ~ 1.1 GW, Italy stands out at the European level in terms of geothermal energy.[226] By comparison, France is approaching 0.7 GW and Germany 0.4 GW.

Energy from geothermal sources could provide an important contribution in the future as part of the process of achieving climate neutrality. Data from the Italian Geothermal Union indicate that the volume of CO_2 emissions avoided by geothermal energy

223 *Quanta energia idroelettrica si produce in Italia e dove,* https://www.enelgreenpower.com/it/learning-hub/energie-rinnovabili/energia-idroelettrica/italia, access: 26.03.2022.

224 *Ibidem.*

225 *L'energia geotermica in Italia: dove viene prodotta e come*, https://www.enelgreenpower.com/it/learning-hub/energie-rinnovabili/energia-geotermica/italia, access 26.03.2022.

226 *EGEC Geothermal Market Report 2019*, https://www.egec.org/wp-content/uploads/2020/06/MR19_KeyFindings_new-cover.pdf, access: 26.03.2022.

managed to increase from 3.7 million tons in 2010 to 4 million tons in 2015.[227] Projections indicate the possibility of reaching an installed capacity of almost 1140 MW by 2030 and between 2000 and 2500 MW by 2050. At the same time, the generated energy could be close to 7 TWh per year by 2030 and reach 13 to 16 TWh in 2050. Geothermal energy from Tuscany alone could represent 5-6% of the national production before 2030 and 30-40% in 2050.

Nuclear energy

In the 1950s, Italy, lacking sufficient energy resources to support autonomous industrial development, was one of the first countries to undertake the construction of nuclear power plants to produce electricity. The first research reactor at Ispra was built in 1959, and the first power plant at Latina was built in 1963. The Sessa Aurunca plant, near Caserta, and the Trino plant in the province of Vercelli followed shortly thereafter. By 1966, Italy was already the third largest producer of nuclear power in the world after the United States and Great Britain. The fourth power plant at Caorso was put into operation in 1978. Shortly after the inauguration, the parliament approved the National Energy Plan, initially aiming to build 20 nuclear reactors, which were later reduced to 6. Due to the risks associated with the construction of nuclear reactors, anti-nuclear movements increased in Italy. The culmination point for the Italian nuclear power industry was the explosion of Reactor No. 4 at the Chernobyl Power Plant (then in the USSR) on April 26, 1986, which was the gravest disaster in the history of civil nuclear power. Following these events, a referendum was held on November 8, 1987, in which an overwhelming majority of Italians voted to abandon nuclear power as a form of energy supply. In 2009, the Italian government proposed resuming preparatory activities for nuclear power generation. Two years later, as a consequence of the Fukushima (Japan) Nuclear Power Plant disaster, a new nationwide referendum once again put an end to nuclear power in Italy. To date, Italy is one of the few countries that, having had nuclear power plants in the past, has completely phased out nuclear power for electricity generation.

Nuclear power has recently resurfaced among Italians as part of the debate over the country's dependence on fossil energy sources and the possibility of finding alternatives. Last July, a study commissioned by the Comitato Nucleare e Ragione found that one-third of those surveyed favored nuclear power, with a growing percentage among young people.[228] The majority of Italians (close to 60%) still declare that they are poorly informed about nuclear energy, which certainly affects the ability to form an opinion and, consequently, to participate in an informed, nationwide debate on the subject.

227 *L'energia geotermica in Italia: dove viene prodotta e come*, https://www.enelgreenpower.com/it/learning-hub/energie-rinnovabili/energia-geotermica/italia, access 26.03.2022.

228 *Sondaggio SWG: oltre un italiano su due possibilista sui nuovi reattori nucleari,* https://italianucleare.it/2021/07/06/sondaggio-swg-oltre-un-italiano-su-due-possibilista-sui-nuovi-reattori-nucleari/, access: 26.03.2022.

Hydrogen energy

Efforts to develop an efficient hydrogen economy have been growing in Italy for a long time - the aim is to support the decarbonization process along with other technologies for low CO_2 emissions. Hydrogen is expected to play an important role in transport, including aviation. The system of energy extraction through hydrogen is not yet fully developed, although it is extremely promising. Italy has the potential to position itself in a number of sectors, where hydrogen can make a contribution, including manufacturing, logistics and transport, industry, and mobility. There are a number of challenges yet to be overcome in the development of the country's hydrogen economy.

Today, hydrogen plays a marginal role in the energy supply chain - accounting for about 1% of the total energy mix in Italy[229] The issue of increasing its share in the energy sector is included in the National Integrated Energy and Climate Plan.[230] The Ministry of Development drafted a document - „Strategy Nazionale Idrogeno" (National Hydrogen Strategy) - at the end of 2020, providing directions and guidelines to identify sectors where hydrogen energy can become competitive in the short term. [231] The document also identifies areas of intervention best suited for the development and implementation of hydrogen. The draft provides that the National Hydrogen Strategy will apply in long-distance transport, railroads and heavy industry. The strategy moves through two time horizons, setting interrelated goals. The first phase covers a short-term perspective until 2030, when hydrogen will gradually become competitive in selected areas. The second phase covers the longer term to 2050, when hydrogen will be seen as a key element in the decarbonisation of difficult sectors.

In this context, the Italian goals set by the Ministry of Development aim to achieve a 20% share of hydrogen by 2050, compared to the current 1%. The envisaged action plan aims to continue the energy transformation along with investment and promotion activities in research and development, with a significant impact on the production and use of hydrogen. As part of the development of the hydrogen economy, about €10 billion of investments are expected between 2020 and 2030, distributed in the following way: €5-7 billion for hydrogen production; €2-3 billion for adapting hydrogen distribution and consumption structures (hydrogen vehicles, filling stations, etc.), €1 billion to finance R&D.[232]

The measures included in the National Hydrogen Strategy in 2022 are to be coordinated with the National Integrated Energy and Climate Plan. One should note that the initial steps taken by the Italian legislator in the framework of the hydrogen economy are a concrete response to the European decarbonization goal by 2050 and are aimed at improving energy security, protecting the environment, and indirectly reducing energy costs.

229 *Economia dell'idrogeno: urgente definire una politica nazionale,* https://www.agendadigitale.eu/smart-city/economia-dellidrogeno-urgente-definire-una-politica-nazionale/, access: 26.03.2022.

230 *Pubblicato il testo definitivo del Piano Energia e Clima (PNIEC),* https://www.mise.gov.it/index.php/it/198-notizie-stampa/2040668-pniec2030, access: 26.03.2022

231 *Strategia Nazionale Idrogeno Linee Guida Preliminari,* https://www.mise.gov.it/index.php/it/per-i-media/notizie/2041719-avviata-la-consultazione-pubblica-della-strategia-nazionale-sull-idrogeno, access: 26.03.2022 r.

232 *Idrogeno in Italia: le linee guida normative,* https://modofluido.hydac.it/idrogeno-in-italia-linee-guida-normative#A2, access: 26.03.2022 r.

Transport

The need for green mobility among Italians is growing - they want to move decisively on the path of zero CO_2 emissions in transport. The promotion of electromobility is to be the means of reducing it. The zero-emission mobility strategy has been outlined in the National Integrated Energy and Climate Plan, which focuses on the technological development of electric vehicles and „smart charging stations", digital development, public financing of electric mobility in the road and industrial sectors, and the creation of financial incentives for individuals.

The rapid electrification of cars has become a reality in Italy. More and more Italian automakers are joining the electric revolution, while subsidies and tax breaks are encouraging citizens to buy electric vehicles. According to the Smart Mobility 2021 Report by Energy & Strategy Group School of Management del Politecnico di Milano, electric mobility in Italy, compared to the rest of Europe, can be summarized in the following elements:[233]

- In 2019, more than 17,000 electric cars were registered in Italy out of a total of 2 million registrations. However, this represented only 3% of electric vehicle registrations in Europe. The number of electric cars in Italy has doubled in 2021.
- Carsharing companies grew rapidly in 2019, registering a total of 8200 vehicles, 25% of which were electric.
- In 2019, 20% of bicycle rentals, were powered by electricity.
- In August 2021, sales of „pure" electric cars strengthened to reach 8% of the market, while sales of plug-in hybrids stalled at 5.2%. This indicates that the dominance of plug-in cars is slowly declining.
- Between 2017 and 2020, 13,000 slow charging stations and 6,000 fast charging stations were built, averaging 15 charging spots per 100,000 residents.

The National Integrated Energy and Climate Plan expects that 6 million electric cars should be circulating in Italy by 2030, thus around €200 billion should be invested over the next 10 years in cars and charging infrastructure, including appropriate support mechanisms.

The Italian government has developed an incentive program for the automotive sector, particularly for the production of electric, hybrid and low-emission cars and motorcycles. The creation of the program is a prerequisite for further development of one of Italy's key industries, the automotive industry. The pandemic, the lack of raw materials and the war in Ukraine have forced the Italian government to act. According to the Minister of Economic Development Giancarlo Giorgetti, an ecological transformation is necessary, which will lead to a thorough renewal of the industry, while being sustainable.

On April 6, 2022, Italy's Prime Minister, Mario Draghi, signed the „Documento di economia e finanza 2022," where the government allocated €650 million for each year from 2022 to 2024, as part of the government's allocation to the Automotive Fund, with a total of €8.7 billion provided through 2030.[234]

Italians recognize the need to replace the local public transport fleet with zero-emission vehicles. The most important measure will be to support the electrification of local public transport, emphasizing in particular the purchase of zero-emission buses. Such a solution represents a long-term investment.

Consequently, Italians also recognize the need to reinvent cities. In order to improve the quality of life in terms of air quality and health, it is necessary to guarantee more and more space for active, gentle and shared mobility, and to modernize public transport in cities. „Smart City" is one of the models that are being implemented, i.e. the strengthening of urban networks, consisting of more efficient electricity distribution, the latest generations of digital technology, modern roads, upgraded local public transport and more charging points for vehicles. In fact, intermodality and modal interchanges are

233 *Smart Mobility 2021,* https://www.energystrategy.it/, access: 27.03.2022 r.

234 *Comunicato stampa del Consiglio dei Ministri n. 71,* https://www.governo.it/en/node/19593, access: 06.04.2022 r.

critical for both passenger and freight electrification (public transport terminals, railroad stations, logistic interchanges, as well as ports).

Italians are aware, however, that the implementation of these measures will require significant funds for the modernization of local public transport. It is estimated that a subsidy of around €3.6 billion in this area would make it possible to cover the price difference compared to diesel vehicles if the planned 15,000 zero-emission buses were purchased and the charging infrastructure created for them. Implementation of the reforms requires diversification of funding by allowing stakeholders to access funds through the adoption of public-private partnerships for bus line electrification projects and directing more private funds to investments in the replacement of bus fleets.

Rail transport plays a key role in people's quality of life and community well-being, and can help prevent climate change. In terms of energy and emissions, rail transport is one of the most efficient types of transport, which can make greater use of renewable energy sources. People in Italy who have chosen the train over the car for travel have contributed to reducing CO_2 emissions into the atmosphere by around 20 million tonnes over the last ten years. The International Union of Railways has committed to reduce CO_2 emissions by 50% by 2030 and to achieve total CO_2 neutrality by 2050, while increasing rail traffic, by modernizing regional rail systems and producing innovative trains powered by alternative fuels.[235]

CLIMATE POLICY

Italy focuses on an ambitious execution of the energy transformation as part of the European Green Deal. To this end, it is initiating a number of measures to exclude coal from its energy mix and promote electromobility. The Piano Nazionale Integrato per l'Energia e il Clima (PNIEC), i.e. the National Integrated Energy and Climate Plan, was introduced in 2020 as part of the implementation of the Regulation (EU), 2018/1999, setting out the national objectives for 2030 in terms of energy efficiency, renewables and CO_2 emissions reduction, as well as the objectives for energy security, interconnection, single energy market and competitiveness, development and sustainable mobility, specifying measures for each of these areas to be implemented to ensure their achievement. The execution of the plan is to be ensured by decrees transposing European directives on energy efficiency, renewable energy sources and electricity markets. The Minister of Economic Development, Stefano Patuanelli, in one of his speeches, assured that the objective of the steps taken by Italy is to contribute decisively to the realization of a major change in the energy and environmental policy of the European Union.[236] The Integrated National Plan provides 5 main lines of intervention - decarbonization (elimination of coal from energy production), efficiency (reduction of end-use energy waste by 40%), energy security (continuous energy supply at sustainable prices), development of the internal energy market (reduction of imports of energy resources by 63% by 2030), and research, innovation and competitiveness.

Italy intends to accelerate the transition from traditional fuels to renewables by promoting the gradual abandonment of coal for electricity generation in favor of an energy mix based on a growing share of renewables and, for the remainder, gas. PNIEC assumes that by 2030, 55% of domestic electricity generation will come from renewable sources, CO_2 emissions are to be reduced by 56% in the large enterprise sector and by 35% in surface transport, whereas by 2050 Italy is to completely decarbonize its economy - coal is to be completely replaced by renewables and gas. These targets correspond to the goals developed by the European Union. As a result of this scenario, PNIEC anticipates a great number of infrastructure developments, with an estimated level of investment of more than €50 billion by 2030.

235 *Emissioni,* https://www.fsitaliane.it/content/fsitaliane/it/sostenibilita/tutelare-l-ambiente/emissioni-e-rifiuti.html, access: 27.03.2022 r.

236 *Pubblicato il testo definitivo del Piano Energia e Clima (PNIEC),* https://www.mise.gov.it/index.php/it/198-notizie-stampa/2040668-pniec2030, access: 26.03.2022 r.

Italy intends to continuously align its activities with the objectives set by the EU in terms of energy security and efficiency, the use of renewable energy sources, the construction of a single European energy market and a closed-loop economy. Italy has made s ignificant progress in the development of its energy policy, particularly focusing on meeting environmental targets, strengthening security of energy supply and promoting sustainable economic growth.

SUMMARY

Italy wishes to pursue an ambitious strategy that meets the requirements of the European Union. The plan is to implement a wide-ranging energy transformation, where decarbonization, efficiency and the rational and equitable use of natural resources will be the cornerstone of Italy's climate policy. As part of the National Integrated Energy and Climate Plan, Italy intends to achieve 10 key objectives:

- Accelerate the decarbonization process;
- Make individuals and businesses the main beneficiaries of the energy transformation;
- Encourage the evolution of the energy system towards a transformation based mainly on renewable sources;
- Adopt measures to improve the efficiency of renewable energy sources;
- Strive for security and continuity of supply;
- Promote energy efficiency in all sectors;
- Promote electrification, in particular in the civil sector and transport;
- Invest in research and innovation;
- Adopt precautionary measures that will reduce the potential negative impacts of energy transformation on the environment and the country as a whole;
- Continue the process of integration of the national energy system into the EU system.

Italy is paying particular attention in its energy transformation to the availability of important renewable resources that could be further exploited in the future as part of sustainable economic and social development in line with other environmental objectives, which would allow it to become a European leader in environmental transformation. The biggest challenge in the longer term is to coordinate all environmental policies (particularly those concerning the reduction of emissions of gases that affect the climate) in order to make them as effective as possible.

Italy's approach to EU proposals is very cautious. All regulations are adopted after a thorough analysis of various scenarios and alternatives, guided by the basic criterion of ensuring sustainable development. For this reason, Italy was one of the few countries that did not sign the COP25 agreement in Glasgow, because the Italian government did not agree with the all-electric future of the automotive industry in Europe, thus defending the principle of technological neutrality.

Italy's climate policy was supplemented by a law passed by parliament on February 8, 2022, which included a provision on environmental protection in the Italian Constitution. According to this provision, it is the duty of the state to protect the environment, biodiversity and the ecosystem. It was emphasized that this measure was applied in the interest of future generations.

RECOMMENDATIONS FOR POLAND

- **Poland should work towards the recognition of nuclear energy as a green energy source on the EU forum.**

In early February 2022, the European Commission published a draft of the so-called „EU taxonomy" (a document indicating which investments are in line with the EU climate policy and not at risk of losses due to the energy transformation) including the atom as a green energy source. The EC's decision was influenced by the efforts of the „nuclear alliance" initiated by France and the Czech Republic. The alliance additionally includes Bulgaria, Croatia, Finland, Romania, Slovakia, Slovenia, Hungary and Poland. In October 2021, the „nuclear alliance" published a letter in defense of nuclear energy in major European newspapers. It has also reached key European policy makers via France. The final approval of the taxonomy opens the way to financing investments in nuclear power from EU funds - which is particularly important from Poland's point of view. Due to strong criticism of the project by opponents of nuclear power, such as Germany, Austria and non-governmental organizations, it is necessary for Poland to continue its active participation in the so-called „nuclear alliance".

- **The introduction of small modular reactor (SMR) technology could be a breakthrough in decarbonization.**

Small Modular Reactors (SMRs) have an output of up to 300 MW (traditional large reactors have an output of 1000 MW or more). Due to their size, cost-effectiveness, and limited environmental impact, they can serve as an alternative to coal or gas-fired boilers. Consequently, introduction of SMRs may contribute to decarbonization of Polish heating systems. The innovative nature of these solutions is, however, a risk. Currently, all SMR projects are at astage of development or implementation. The first facilities of this type will emerge no sooner than in 2026. Despite that, large Polish enterprises, such as KGHM and „PKN Orlen", have already decided to invest in the technology. The copper mining company (KGHM) signed an agreement with an American company „NuScale" on the implementation of SMR technology in February 2022. This would mean that the first small modular reactors would begin operating in Poland by 2029. „Tauron Polska Energia", one of Poland's largest power companies, has also announced its cooperation with KGHM in using SMRs to create low-carbon energy sources.

- **Construction of offshore wind farms in the Baltic Sea will increase the share of green energy in the energy mix.**

The Baltic Sea has great potential for offshore wind energy development. Favourable wind conditions and shallow seabed are the main reasons why such projects are possible. Swedish energy company „Vattenfall", which owns the largest wind farm on the Baltic Sea – „Kriegers Flak" - has taken advantage of these conditions. Offshore wind energy is one of the key elements of Poland's energy transformation. According to the document „Energy Policy of Poland until 2040", the capacity of Polish wind farms installed in the Baltic Sea will amount from 5.9 GW in 2030 to 11 GW in 2040. The „PGE Group" is currently implementing a project to build three Baltica wind farms. The first turbines with the PGE logo will start generating electricity in 2026. „PKN Orlen" is also planning to invest in offshore wind energy by applying for as many as 11 licenses for the construction of offshore wind farms in autumn 2021. The new wind power plants would have a total capacity of 20 GW, twice as much as the government plans by 2040.

- **The expansion of biogas production will increase its popularity and competitiveness against natural gas.**

The gas produced as a result of anaerobic decomposition of organic compounds, such as e.g. agricultural waste, is a popular source of energy in many countries of the European Union. It is commonly used in Germany, being the biggest biogas market in Europe (ca. 9000 biogas plants) and in Great Britain, using sewage for its production. It is commonly used in Sweden as car fuel. There are only about 300 installations capable of producing biogas in Poland at the moment. Nevertheless, our country has a huge potential to develop this sector. The production of large amounts of biogas would be possible thanks to substrates supplied by developed agriculture and agri-food industry. Changes may be brought about by the „Agreement on cooperation in the biogas and biomethane sector" signed in 2021 by representatives of the government and the world of business and science. The agreement will enable the development of joint projects aimed at expanding the biogas sector. Legislative changes concerning the use of biogas injected into the grid and the ways of accounting for it are indicated in the agreement. Institutions and companies such as the National Agricultural Support

Centre (building biogas plants on farms) or „Orlen" also want to invest in this sector. Biogas can be an important element in the transformation of the Polish energy sector. The possibility of using it in various industries (heating, transport) creates an economic and green alternative to natural gas.

- **Hydrogen plays an important role in the energy transformation.**

The European Union has identified hydrogen as one of the key energy sources for decarbonization and climate neutrality. Poland, being the third, after Germany and the Netherlands, producer of hydrogen in the EU, should use the experience obtained in this field. Hydrogen produced in our country by large industrial plants, such as the „Azoty Group", and subjected to purification processes can be used as fuel for vehicles. „PKN Orlen" has plans in this respect for both road and rail transport. The real breakthrough, however, may come in the production and use of the so-called „green hydrogen". Its production is based entirely on electrolysis of water using electricity from renewable sources. Green hydrogen may be widely used in transport, heating and industry and replace natural gas. The government adopted the „2030 Polish Hydrogen Strategy" in 2021, setting out key objectives for the development of a Polish hydrogen economy based on low-emission hydrogen (generated from renewables and created using zero-emission technologies). According to the provisions of the document, 5 hydrogen valleys should be established in Poland by 2030 and the capacity of the installations for production of low-emission hydrogen should amount to 2 GW. Furthermore, the strategy envisages an important role for green hydrogen as an alternative fuel for public transport, with a particular focus on buses (from 800 to 1,000 vehicles in operation by 2030).

- **Investments in low and zero emission public transport will increase its popularity among potential users.**

The transport sector is the second largest emitter of greenhouse gases in the European Union. The way to limit its emissions may be partial or complete abandonment of the use of means of individual transport (cars) and popularization of public transport. Polish authorities are successfully using EU funds for construction and reconstruction of infrastructure as well as modernization and purchase of vehicles such as buses, streetcars and trains. Buses with low-emission hybrid or zero-emission electric propulsion can be found on the streets of many Polish cities. Railroads play an important role as an environmentally friendly mode of transport. Modern trains with attractive travel times are already competing with car transport or high-emission airplanes. An increase in the number of passengers would not be possible without the investment in rolling stock carried out with the use of EU funds by carriers such as „PKP Intercity". Thanks to the reconstruction and modernization of infrastructure, the railroad will also benefit on shorter, regional distances. The European Green Deal is a great opportunity for the development of low- and zero-emission public transport in Poland. This EU strategy, announced in 2019, aims to reduce greenhouse gas emissions in transport by 90%, while strengthening the role of public transport. Poland should allocate some of the additional funds provided under the European Green Deal to further develop environmentally friendly public transport.

- **Subsidies for building home charging infrastructure will accelerate the development of electromobility.**

Electric vehicles are an increasingly common sight on Polish roads. By the end of March 2022, more than 43 000 electric cars and plug-in hybrids were registered. The government programme „Mój elektryk" (*English: „My electric vehicle"),* which allows for the co-financing of purchase of such vehicles, has had an impact on their rapidly growing number. Unfortunately, the increase in sales of electric vehicles has not been followed by the expansion of infrastructure. Today, Poland has only 2113 charging stations, where less than 1/3 of them are fast chargers. The program of co-financing construction of 17 thousand public charging stations seems to be insufficient as well. A program providing financial aid for those, who want to install a home charging station may be the solution to the problem of the missing infrastructure. Today, the cost of such an investment ranges from several to tens of thousands of zlotys. According to the reports, funding for home charging stations will be possible as early as 2022, within the fourth edition of the program „Mój prąd" (*English: My electricity*).

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Instytut im. Kazimierza Promyka
ul. Obozowa 82A/19
01-434 Warszawa
www.instytutpromyka.pl
e-mail: kontakt@instytutpromyka.pl