

Trend of alternative and renewable energy source use in chosen EU countries

Katarina Culkova^{1*}, Marcela Tausova¹, and Peter Taus¹

¹Technical University of Košice, FBERG, 042 00 Košice, Slovakia

Abstract. Currently, one of the most discussed topics is the development of alternative energy sources. The assumption is that the trend in the use of alternative energy sources will continue and will increase every year. The aim of the book chapter is to evaluate the development trend in the use of renewable energy sources in selected countries. The book chapter describes the current situation in the use of renewable energy sources in the world, as well as in the selected countries. We decided to describe and analyze in more detail the use of renewable energy sources such as the wind, solar, water and geothermal energy in countries within Europe such as Italy, Germany and Austria. At the end, there is a comparison of selected indicators with reference to reserves in their use. The results show the share of renewable energy sources has increased; however, it is still necessary to meet the targets in the area of reducing emissions and to increase the production of electricity from renewable energy sources. The results can be used to meet new challenges for the functioning of the energy systems of the European Union, so that European Union could become a world leader in renewable energy sources.

1. Introduction

Development of alternative energy sources is not only about the decreasing reserves of oil, natural gas and coal, but mainly about the ever-decreasing quality of the environment. This can be caused either by fossil fuel emissions or increased CO₂ values in the atmosphere, which increases the natural greenhouse effect and subsequent excessive heating of the earth's surface. According to the latest analysis from EURACTIV Climate Home News, more energy was produced from alternative energy sources than coal, oil or gas in the European Union over the past year for the first time [1]. Up to 40% of electricity in the 27 EU states was produced from renewable energy sources, while fossil fuels only accounted for 34 percent of energy production. This statement comes from a report by Ember, a think tank dedicated to global energy transformation [2]. As a result of the higher use of alternative energy sources, CO₂ emissions in the energy sector of the European Union have decreased by up to a quarter [3]. The Portuguese Association for Renewable Energy Sources also announced that Portugal was able to cover its electricity consumption from renewable sources for four consecutive days. In Denmark, on the other hand, more than 100% of Denmark's consumption can be produced from wind energy alone. Denmark can also supply parts of Germany and Sweden with this surplus. This is a symbolic moment in the transformation of the European energy sector, because e.g. nine years ago, fossil fuels produced twice as much energy in the EU as renewables [4]. Currently, even within the raging COVID-19 pandemic, the demand for electricity in the EU has decreased by up to 7%, while the production of electricity from renewable energy sources has increased by 11%. This increase in the use of renewable energy sources was due to the operation of new wind and solar installations, which produced up to a fifth of Europe's energy. The assumption is that the trend in the use of alternative energy sources will continue and will increase every year. Currently, even within the context of the COVID-19 pandemic, the European Union, in addition to its budget, also has the opportunity to use the recovery fund after the corona crisis in the amount of 1.8 billion EUR to accelerate the transition from fossil fuels to alternative energy sources and thus to clean energy. The dependence of states on raw materials is possible only with the help of renewable energy sources such as solar,

*Corresponding author: katarina.culkova@tuke.sk

wind, water, geothermal, which are available almost everywhere. The aim of the presented paper is to approximate the current situation in selected EU countries, to analyze the use of renewable energy sources in selected countries and to compare selected indicators with pointing to reserves in their use.

2. Materials and Methods

During the research, we resulted from the present state of RES use in the worldwide situation. Renewable energy sources are currently making great progress. However, their use is not very proportional in the member countries of the European Union. In Germany and Great Britain, growth in the use of renewable resources has increased by up to 56% in recent years [5]. In Great Britain, the so-called carbon tax, which came into force in 2013. This tax represents approximately €20 per carbon dioxide flow in the production of electricity. Also, for this reason, Great Britain moved from 20th place in the ranking of thirty countries using electricity with low carbon levels in 2012 to seventh place in 2017, which is the fastest move compared to other EU countries [6]. The European Parliament, which is a permanent supporter of the use of renewable energy sources, adopted a resolution on the European Green Agreement in January 2020, the so-called green pact for Europe. He recommended the priority principle of energy and the revision of directives on renewable energy sources to the fore. It also set binding national targets for each member state for the year 2030, where it recommends providing clean, affordable and safe energy [7]. Renewable energy sources are coming to the fore mainly due to the increase in the energy needs of humanity and the development of world energy consumption until 2025 (Figure 1).

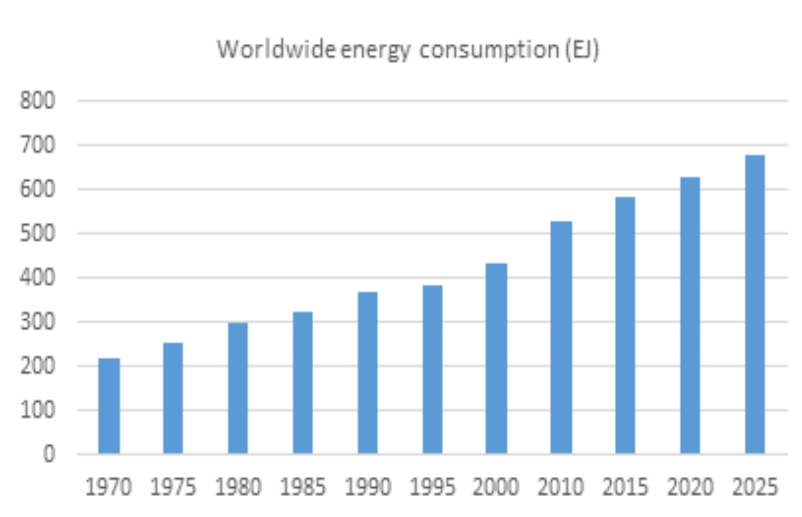


Fig. 1. Development and prediction of worldwide energy consumption [8]

Europe's energy system is currently accompanied by uncertainty, which stems from unstable and unpredictable fossil fuel prices, geopolitical risks of fossil fuel imports, which are concentrated only in a few countries that can supply oil or natural gas. In addition, fossil fuels have a negative impact on the environment, while the energy industry is one of the main producers of environmental pollution, especially in terms of greenhouse gases. Since the energy industry is the main component of the European economy, it is necessary to pay attention to it. The sustainability of energy and the economy of the European Union requires a change in the way energy is produced, supplied, and consumed [9]. For this reason, it is necessary to turn your attention and all possible incentives to renewable energy sources and achieve the desired state only by their maximum use. Potential renewable energy sources are different in each country of the European Union. As already mentioned, the European Parliament, which supports the use of renewable energy sources, recommended the principle of primacy of energy and the revision of directives on renewable energy sources to the fore. It has set binding national targets for each member state for 2030, where it recommends providing clean, affordable and secure energy and increasing the production of energy from renewable sources by 20% of total consumption in 2030 [7]. It is therefore necessary to convert these goals into small amounts for each member state and thus take into account a fair and reasonable distribution of production from individual renewable energy sources, take into account the starting positions of the existing share of energy from renewable sources and the overall capabilities of the member states. The RE-thinking 2050 report discusses the planned changes and visions until 2050 regarding the energy plan for the use of renewable energy sources. This report analyzes the economic, environmental and social conditions of the states so that by 2050 100% of renewable

energy sources are used in the states of the European Union [1]. Figure 2 shows the countries and their use of energy from renewable energy sources, where Iceland is the leader in 2019 according to Eurostat statistics [10]. They are followed by Scandinavian countries such as Norway, Sweden and Finland. Countries that use more than 37.37% of energy from alternative energy sources include Latvia, Bosnia and Herzegovina and Montenegro.



Fig. 2. Use of renewable energy source in Europe [10]

The task of all member states of the European Union is to achieve an improvement in energy efficiency, in which energy from renewable energy sources should mainly participate. Especially with regard to the transport sector, energy efficiency is essential, because currently the demand for energy is increasing precisely for the purposes of transport. Table 1 shows the shares of energy from renewable sources for selected countries of the European Union from 2010 to 2020.

Table 1. Rate of RES use in chosen EU countries [10]

Country	2011	2013	2015	2017	2019	2020
Czech Republic	10,514	12,813	15,073	14,924	15,138	16,244
Hungary	12,742	15,530	14,618	14,377	12,535	12,614
German	11,667	13,543	14,385	14,889	16,673	17,354
Poland	9,300	10,970	11,614	11,400	11,477	12,164
Austria	31,207	32,736	33,553	33,374	33,806	33,626
Slovakia	9,099	10,453	11,713	12,029	11,896	16,894
Italy	13,023	15,441	17,082	17,415	17,796	18,181

Table 1 shows that Austria had the highest potential in the use of renewable energy sources from our neighboring states in 2019 (33.626%). Comparable or Italy (18.181%) and Germany (17.354%) had slightly higher utilization of renewable energy sources with the Slovak Republic.

3. Results and Discussion

In accord with previous evaluation, we have chosen the countries of Austria, Germany and Italy for a more detailed analysis of the use of renewable energy sources, which is described in more detail in the following part of the chapter.

3.1. Austria

In Austria, electricity from renewable sources is mainly supported through investment subsidies and grants. This is mainly the construction of small (< 10 MW) and medium (< 15 MW) hydropower facilities. Heating and cooling

from renewable energy sources is supported through various incentive schemes, both at the state level and at the level of the individual federal states. Environmental Assistance (UFI) provides the most important form of support for heating and cooling using renewable energy sources. There are also special investment incentives for solar thermal devices, heat pumps, geothermal energy and biomass heating plants. In August 2020, the Climate and Energy Fund provided 2.5 million euros for large solar thermal power plants for heating and heat treatment. In Austria, the main area of support for energy from renewable energy sources is transport. Biofuels are supported through the tax regulation mechanism (tax exemption). Support for biofuels, electric vehicles and fuel cell vehicles is planned for 2021 with a budget of €80 million [11]. Austria makes significant use of renewable energy sources and the share of so-called up to $\frac{3}{4}$ of green electricity is energy. The remaining quarter is represented by fossil fuels, the percentage of which is decreasing every year. According to statistics from 2019, hydropower had the largest share in renewable energy sources and waste used for energy production in Austria, with the help of which up to 44,223 GWh were produced annually [12]. This was followed by wind energy with a production of 7,421 GWh and solid biofuels with a production of 3,688 GWh. Solar energy contributed to the production of electricity with a value of 1,702 GWh/year (Figure 3).

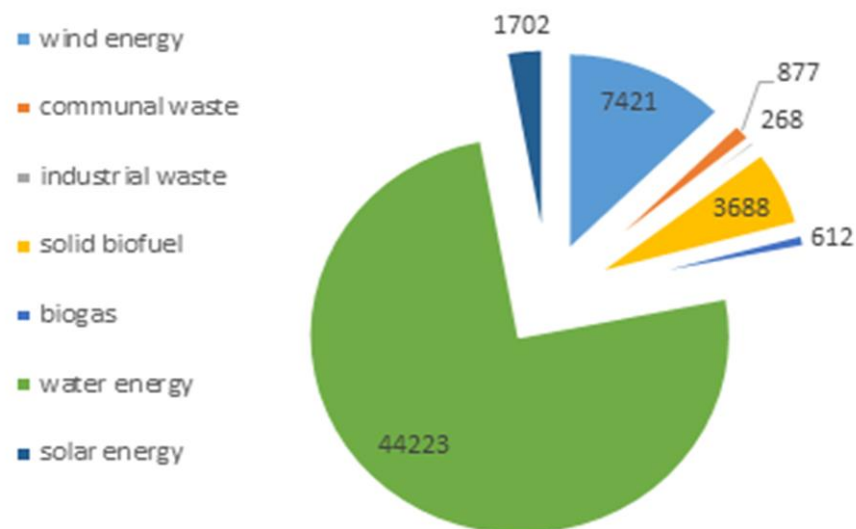


Fig. 3. RES energy production in Austria in 2020 in GWh [11].

According to statistics, hydropower is the largest producer of energy in Austria, but during periods when the country has a lack of precipitation, this production must be replaced by wind power plants, waste recovery, or biomass. Although wind energy in Austria has limited potential, the government has pledged to support the sector and limit the import of nuclear energy.

3.2. Germany

The expansion of renewable energy sources in Germany remains one of the key pillars and policy instruments. From the current level of use of renewable energy sources, which is around 42%, Germany has a plan for 2025 to use renewable energy sources in the range of up to 45%. The main driving force behind the use of renewable energy sources is the Law on Renewable Energy Sources (EEG), which has been in force since 2000 and is currently being revised. The Renewable Energy Act (EEWärmeG) is the main instrument for increasing the share of heat produced from renewable sources for heating or cooling [13]. This law obliges new buildings and actually the architects themselves to include renewable energy systems (e.g. heat pumps, solar panels and other thermal devices) when designing buildings. There are also MAP market incentives on the German market, which support the owners of already existing buildings to install technologies using renewable energy sources, either for heating or cooling. In 2020, the share of renewable energy sources represented 14% of the final energy consumption for heat and cooling. Renewable sources in the transport sector (biofuels such as bioethanol, biodiesel and biogas) accounted for about 5.6% of the fuels used in Germany in 2019. Using a mixture of conventional fuel and biofuel reduced greenhouse gas emissions by 7% from 2006 to 2020. The use of biofuels at gas stations was also supported by the reduction of fuel taxes for these renewable energy sources [11]. Based on available data, electricity production in Germany from renewable energy sources has increased from 19.7 TWh since 1990 to 251.7 TWh in 2020 [5]. On the contrary,

brown coal, black coal and nuclear energy have decreased in electricity production. Figure 4 shows the values of energy production from renewable energy sources and waste used for energy production in Germany in 2020.

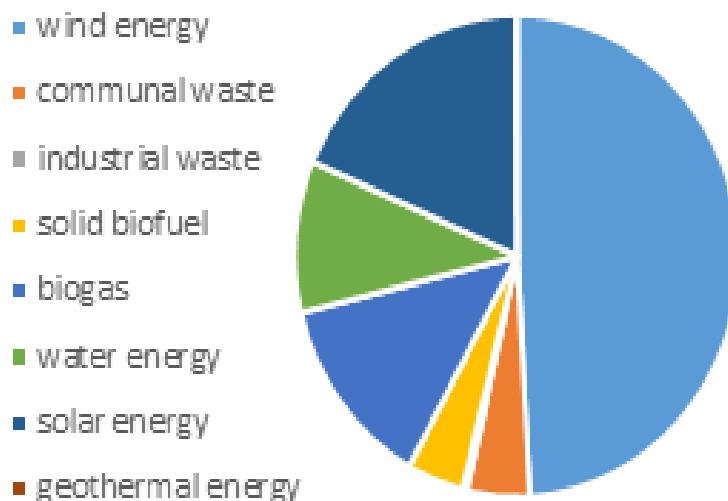


Fig. 4. RES energy production in Germany in 2020 in GWh [12].

In terms of renewable energy sources, onshore wind energy has the largest share in electricity production in Germany, which accounted for up to 125,975 GWh in 2020. It is followed by solar energy with a production of 47,517 GWh, biogas with 33,723 GWh and hydropower with 26,201 GWh. The current direction of the country leads to the complete shutdown of nuclear energy, which Germany succeeds mainly with the effective integration of renewable energy sources. In addition to wind energy, biomass is also coming to the fore thanks to biogas and thanks to the reduction in prices of photovoltaic cells. Solar energy is also coming to the fore. Compared to other European countries, Germany is the leader in the use of solar energy, followed by Italy, but before which it has a double lead.

3.3. Italy

Currently, a very large part of the electricity in Italy comes from fossil fuels. However, this country is known for its highly diversified energy mix, i.e. from that electricity production is represented by each component of renewable energy sources [14]. Figure 5 shows the energy share, or energy production in Italy from renewable energy sources and waste used for energy production. Hydropower is the most represented at 47,499 GWh, followed by solar energy at 23,689 GWh, wind energy at 20,245 GWh and geothermal energy at 6,031 GWh. Although the share of geothermal energy is small, Italy represents a European unit with its electricity production using geothermal energy. Solar energy has experienced the greatest boom in recent years, with the help of which, for example, compared to 2011, it produced up to 75% more in 2020, and the performance of photovoltaic cells has increased tenfold in recent years.

The government in Italy supports the use of renewable energy sources for electricity production and thus promotes the reduction of fossil fuel use. The Italian government also published the National Energy Strategy (NES) in November 2017, which sets out the path to achieving Italy's sustainability, security and competitiveness in the national energy system in the EU. The main goal is: to reduce Italy's total energy consumption by 10 million tons by 2030, increase the share of renewable energy sources in total energy consumption to 28%, increase the use of renewable energy sources in electricity consumption to 55% by 2030, gradual decreasing of coal use in electricity production until 2025, and support of ecological fuels and sustainable public mobility. All countries of the European Union have the effective potential to use renewable energy sources largely. The share of renewable energy in gross final energy consumption compared to 2015, 2020 (Target) and the potential in 2030 (REmap) is shown in Figure 6.

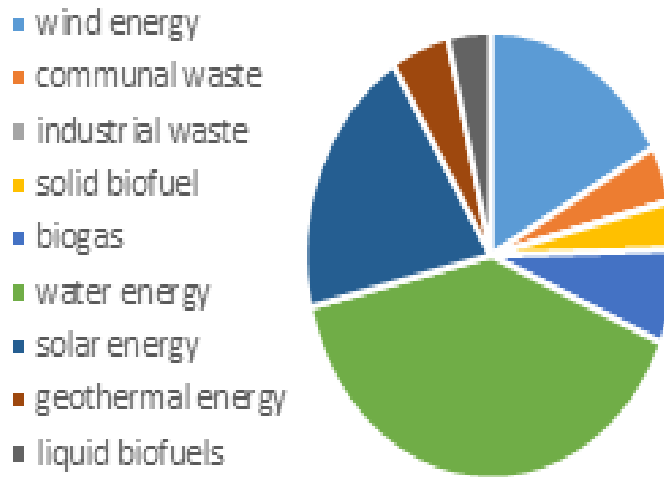


Fig. 5. RES energy production in Italy in 2020 in GWh [12].

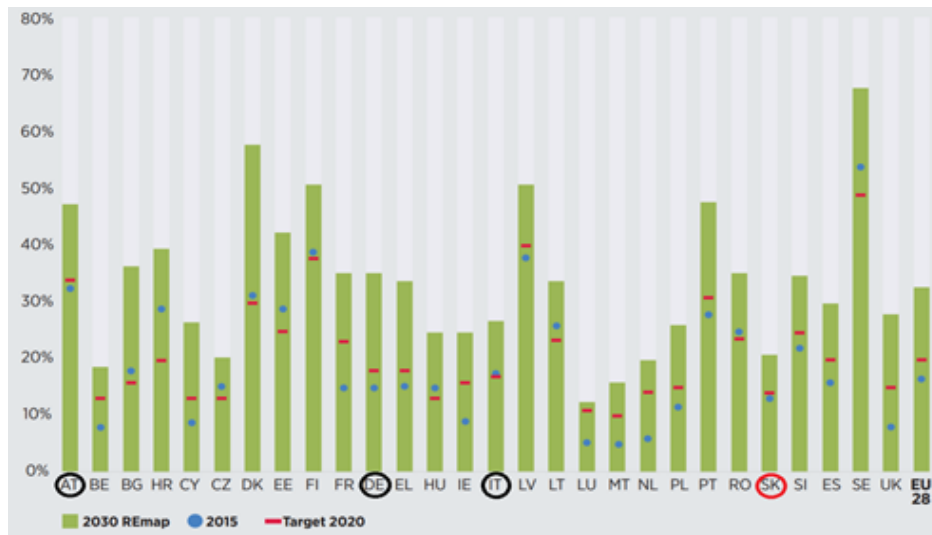


Fig. 6. Rate of RES energy on total gross energy consumption [15].

Renewable sources are vital for the long-term functioning of the EU's energy system. For example, if emissions are to be reduced by 40% by 2030, which is the goal of the European Union, then CO₂ production should be reduced by 412 Mt, which is comparable to Italy's total emissions today.

Within the European Union, the biggest reserves are in the use of solar photovoltaic and wind energy [16]. Their potential increase by 2030 is expected to be approx. 100 GW. From that wind energy could produce up to 327 GW of energy, which is 97 GW more compared to the reference case, and with solar energy and its use with photovoltaic cells, energy production could be 270 GW, which is 86 GW more in the same comparison with reference case. Other energies such as hydro, geothermal and solar could contribute another 23 GW. In addition to the already mentioned countries of the European Union, up to 64% of electricity was produced using wind or solar energy in Denmark, which are suitably supplemented. While the intensity of solar radiation in summer reaches 100% in Denmark, it is only 18% in January. On the contrary, wind power plants produce 100% in January and only 55% in July. In Portugal, coal consumption also fell by a record 95%, speeding up the country's planned burning of fossil fuels such as coal by two years. Since they plan the termination in 2023, according to the latest statistics, they will achieve it already this year. In Spain, coal production fell by as much as 58% and they shut down half of their production in June 2020. However, the demand for coal historically fell the most in Germany, and on the contrary, for the first time in Poland, more electricity was produced from coal than in Germany. However, a downward trend in coal mining and decreasing demand with certain financial losses can already be felt in Poland [17]. Poland does not yet have a timetable for phasing out electricity from coal, and the country has not yet committed itself to the EU's goal

of carbon neutrality by 2050. Despite this, up to 50% of European Union funds intended to help transition away from fossil fuels have been made available to Poland to renewable energy sources. In addition to the decrease in coal consumption, the demand for electricity generation from gas also decreased last year. This decrease is approximately six percent and was recorded in eleven countries. The biggest decline was recorded in Spain and Italy. Although the share of renewable energy sources has increased, it is still necessary to meet the targets in the area of reducing emissions by 55% by 2030 and to increase the production of electricity from renewable energy sources two to three times more in the next ten years [18]. The RES use can contribute to the solution of the living environment pollution and energy supply policy [19]. Even though the European Union is a community of different independent states, it could be an example in promoting its goals for similar blocs such as the African Union, India, or the USA. Moreover, the increase RES use can contribute to the solving of problems with employment and poverty worldwide [20].

4. Conclusions

1. Ensuring the sustainability of the European Union's energy and economic future requires a profound change in the way energy is produced, supplied and consumed. Full use of the energy potential of renewable energy sources is the only way to achieve the desired state.
2. The amount of energy produced from renewable energy sources will bring new challenges for the functioning of the energy systems of the European Union. The key question remains whether there will be sufficient flexibility in the production and use of the energy produced in this way. However, such a scenario could be technically feasible.
3. At the same time, equipment for the production of energy from renewable sources would also reduce the overall energy prices. As for their use, this should be increased mainly in the heating or cooling sector and of course in the transport sector. Rapid adoption of electric vehicles will be key to accelerating the use of renewable electricity in road transport. Although by 2030, electric or hybrid vehicles are expected to account for 16% of the total number of cars in Europe, this would represent only 3% of the consumption of energy produced from renewable energy sources in this sector.
4. To fulfill the European Union's desire to become a world leader in renewable energy sources, a new industrial base in the renewable energy sector will have to be created by 2030. This would reduce greenhouse gas emissions, diversify energy supplies, reduce dependence on fossil fuel markets, primarily oil, and gas.
5. In addition, the growth of renewable energy sources can stimulate employment in the EU through the creation of jobs in new "green" technologies. If EU meet the required criteria and achieve key solutions by 2050, EU will be able to hand over to the next generation the world and life on it, which they deserve, and which they themselves are currently participating in supporting and improving.

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References

1. Lins Ch, Zervos A, Muth, J Re-thinking 2050: A 100% Renewable Energy Vision for the European Union. *Built Up*, 2015. Available online: <https://www.buildup.eu/en/practices/publications/re-thinking-2050-100-renewable-energy-vision-european-union> (accessed on 2021-05-26).
2. Gielen D, Boshell F, Saygin D, Bazilian MD, Morgan D, Wagner N, Gorini R The role of renewable energy in the global energy transformation, *Energy strategy reviews* **24** 38-50 (2019)
3. Carfora A, Pansini RV, Scandurra G Energy dependence, renewable energy generation and import demand: Are EU countries resilient? *Renewable energy* **195** 1262-1274 (2022)
4. Andreas JJ, Burns, C, Touza, J Renewable energy as a luxury? A qualitative comparative analysis of the role of the economy in the EU's Renewable energy transitions during the 'Double Crisis', *Ecological Economics* **142** 81-90 (2017)
5. Appunn K, Haas Y, Wettengel, J Germany's energy consumption and power mix in charts BDEW, 2020. Available online: <https://www.cleanenergywire.org/factsheets/germanys-energy-consumption-and-power-mix-charts> (accessed on 2021-05-13).
6. Gonel FD, Ahmed A Perspectives of renewable energy usage in Turkey: how far- how close to EU standards, *World sustainable development outlook 2006: Global and local resources in achieving sustainable development* **1** 282-293 (2006)

7. Resolution of European Parliament,. Available online: <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020IP0273> (2020)
8. Witt J, Kaltschmitt M Worldwide use of renewable energies. *BWK*, **57** 12 43-51 (2005)
9. Amigues JP, Le Kama AA, Moreaux M Equilibrium transitions from non-renewable energy to renewable energy under capacity constraints, *Journal of economic dynamics & control* **55** 89-112 (2015)
10. Eurostat, 2021, Share of energy from renewable sources. Available online: https://ec.europa.eu/eurostat/databrowser/view/nrg_ind_ren/default/map?lang=en (accessed on 2021-05-14).
11. Eurobserv, 2021, Policy and statistic reports. Available online: <https://www.eurobserv-er.org/euroobserver-policy-files-for-all-eu-28-member-states/> (accessed on 2021-05-18).
12. IEA, 2021, Available online: <https://www.iea.org/> (accessed on 2021-05-28).
13. The Renewable Energy Act (EEWärmeG), Available at: <http://www.res-legal.eu/search-by-country/germany/sources/t/source/src/eewaermeg/> (2021)
14. Ignat ND, Moiceanu G, Paraschiv G *Renewable energy production evolution and analysis in EU countries in South-Eastern Europe. Education excellence and innovation management through vision 2020*, in 33rd International-Business-Information-Management-Association, IBIMA Conference, 10-11 April, 2019, Granada, Spain (2019)
15. IRENA, 2018. Available online:
16. https://www.irena.org/media/Files/IRENA/Agency/Publication/2018/Feb/IRENA_A_REmap_EU_2018.pdf (accessed on 2021-05-30).
17. Scholten D, Bosman R The geopolitics of renewables; exploring the political implications of renewable energy systems, *Technological forecasting and social change* **103** 273-283 (2016)
18. BASF, 2021. Polska uses renewable energy. *Przemysl Chemiczny*, **100**(8) 711-712 (2021)
19. Winyuchakrit P, Limmeechokchai B Trends of energy intensity and CO₂ emissions in the Thai industrial sector. The decomposition analysis, *Energy sources - part B-Economics planning and policy* **11**(6) 504-510 (2016)
20. Borawski P, Beldycka-Borawska A, Szymanska EJ, Jankowski KJ, Dubis B, Dunn JW Development of renewable energy sources market and biofuels in the European Union, *Journal of Cleaner Production* **228** 467-484 (2019)
21. Bouzarovski S, Thomson H, Cornelis M Confronting energy poverty in Europe: A research and policy agenda, *Energies* **14**(4) art No 858 (2021)