

# Energy transition in North Macedonia in the wake of the European Energy Crisis

*Vladimir Mijakovski<sup>a</sup>, Monika Lutovska<sup>b</sup> and Filip Mojsovski<sup>c</sup>*

*<sup>a</sup>Faculty of Technical Sciences, University „Kliment Ohridski”, Bitola, MK,  
vladimir.mijakovski@tfb.uklo.edu.mk*

*<sup>b</sup>Faculty of Technical Sciences, University „Mother Teresa”, Skopje, MK, monika.lutovska@unt.edu.mk*

*<sup>c</sup>Faculty of Mechanical Engineering, University „Ss. Cyril and Methodius”, Skopje, MK,  
filip.mojsovski@mf.edu.mk*

**Abstract:** The production of electricity in North Macedonia takes place through thermal power plants that use lignite, fuel oil and natural gas as their primary energy source, as well as power plants that use renewable energy sources: water, wind, solar, biomass and biogas. In 2019, almost 60% of the produced electricity came from thermal power plants that use low-calorie coal – lignite. In January 2020 the government adopted the new Energy Development Strategy 2020-2040 which elaborates three different scenarios: reference (business as usual), moderate transition and green (strong decarbonization) scenario. In the moderate transition and green scenario in the Strategy, phase out of the Thermal power plant Bitola lignite-fired power plant in 2025 is also recommended. In the reference scenario investments for modernization and pollution control are given instead of phase out. Phasing out of coal fired power plants in EU, despite other geo-political challenges, is seen as one of the reasons for current European energy crisis. The paper analysis the situation of the energy sector in the Republic of North Macedonia and the impact of the current energy crisis in Europe on Macedonian economy.

**Keywords:** energy, transition, Europe, North Macedonia.

## 1. Introduction

Electricity market during 2021 marked positive trends, despite Covid-19 pandemics. After the full liberalization of the market, the number of consumers that have independently chosen their supplier has increased, hence the number of procedures for electricity supplier switch in 2021 has increased for 14% compared to 2020. The number of active electricity suppliers was also increased and in 2021 it was 18, which is 4 more than in 2020. This means that the competitiveness in the retail electricity market was increased, and consumers had better offers by suppliers/traders [1].

The production of electricity in North Macedonia takes place through thermal power plants that use lignite, fuel oil and natural gas as their primary energy source, as well as power plants that use renewable energy sources: water, wind, solar, biomass and biogas. The total installed capacity of the power plants in 2021 is 2.117,4 MW which is 14,2 MW greater than the installed capacity in 2020. Figure 1 shows the installed capacity and the share of individual technologies in electricity generation in 2021 (in MW and %).

In the total of the installed capacity, the Thermal Power Plants (TPP) participate with highest percentage of 48,84 %, followed by the Hydro Power Plants with 33,35 %, and followed by the combined plants for electricity and district heating production with 13,58 %, whereas all the remaining contribute with 4,23 %.

In 2021, new electricity producers with installed capacity of 14,2 MW were connected to the Electricity Power System, and all are connected to the Electricity Distribution Network. The largest part of the new Power Plants is the Photovoltaic Power Plants with installed capacity of 14 MW and Small Hydro Power Plants with installed capacity of 0,2 MW.

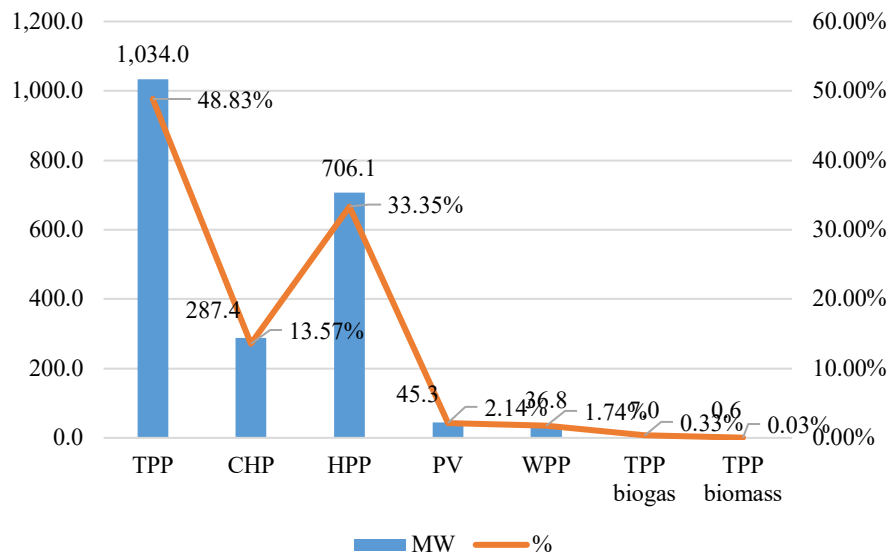


Figure 1. Installed capacity and share of technologies for electricity generation in 2021 (in MW and %)

The production of electricity from renewable energy sources is unstable on annual level, foremost depending on the meteorology conditions. In the total production of electricity for 2021, the renewable energy sources participate with 31,46%, indicating increase by 14,72% compared to 2020, while the production of electricity by the Thermal Power Plants participate with 68,54%, i.e., by 17,12% lower compared to 2020.

In 2021, four companies operated power plants with an installed unit capacity of more than 10 MW: AD 'Elektrani na Severna Makedonija' - Skopje (hereinafter: AD ESM Skopje), AD TE-TO Skopje, AD TEC Negotino and EVN Makedonija Elektrani DOOEL Skopje. The largest producer of electricity in the country, in 2021, remains to be AD ESM Skopje, state-owned company. Installed capacity and electricity production in 2021 are given in Table 1.

Table 1. Installed capacity and electricity production in North Macedonia in 2021

Producer	Number of power plants	Installed capacity in MW	Share in %	Production in GWh	Share in %
AD ESM - Skopje	15	1.478,61	69,83	3.273,60	61,95
TPP	4	824,00	38,91	2.078,30	39,33
HPP	8	557,40	26,32	1.078,60	20,41
WPP	1	36,80	1,74	103,3	1,95
CHP	2	60,41	2,85	13,9	0,26
AD TEC Negotino	1	210,00	9,92	27,08	0,51
TPP	1	210,00	9,92	27,08	0,51
TE-TO AD Skopje	1	227,00	10,72	1.503,20	28,45
CHP	1	227,00	10,72	1.503,20	28,45
EVN Power Plants	14	61,60	2,91	148,71	2,81
HPP	11	58,56	2,77	145,95	2,76
PV plants	3	3,00	0,14	2,76	0,05
Other	321	139,79	6,60	331,84	6,28
Small HPP	98	89,89	4,25	229,14	3,85
PV plants	219	42,30	1,99	48,70	0,73
Biogas	3	7,00	0,22	54,00	1,12
Biomass	1	0,60	0,03	0,00	0,00
<b>TOTAL</b>	<b>352</b>	<b>2.117,00</b>	<b>100.00</b>	<b>5.285,15</b>	<b>100.00</b>



## 2. Energy and climate change

Whereas climate change is an existential threat and there is a need to take appropriate and timely action to mitigate and adapt to the effects of change, global energy trends are moving towards defining increasingly ambitious climate goals to prevent global temperature rises of more than 2 °C, but also to make additional efforts to limit that rise to 1,5 °C. In order to prevent a larger rise in global temperature of 1,5 °C, according to the latest official report of the Intergovernmental Panel on Climate Change (IPCC) in 2022, [2], several possible scenarios have been created:

- Radical change. Changes in society, business and technology are causing a dramatic reduction in energy demand, achieving an almost carbon-free society by 2050;
- Improved sustainability. Sustainability that with the widespread use of Renewable Energy Sources (RES) and "carbon capture" technologies to compensate for emissions, makes energy demand stable despite economic growth;
- Managed growth. Social and technological progress, but also the transition to RES dictates a moderate pace of continued growth of demand, and reduction of emissions;
- Intensive economy. The great need for energy in transport and the growing population of cattle for food needs, emit large amounts of net emissions, which with "capture and removal of carbon" are kept under control.

These goals will define the path that the world will take towards intensified climate activities and net zero emissions. In the fight against climate change and increasing resilience, the energy sector remains the most important sector that can be transformed through the accelerated adoption of renewable energy sources. Energy currently contributes more than two-thirds of total global greenhouse gas emissions, and significant efforts are needed to reduce the sector's carbon footprint and achieve mid-century carbon neutrality. The growing demand for affordable and safe energy on a global scale is moving humanity towards a wider use of low carbon energy, but also towards ensuring a competitive economy and quality environmental protection. European Union (EU), as the main leader of the global decarbonization process, in accordance to the adopted Energy Roadmap by 2050, has developed a long-term vision for a prosperous, modern, competitive and climate-neutral economy by 2050. This sets the basic targets for reducing greenhouse gas (GHG) emissions by 80% compared to 1990 levels, for using 50% of energy from renewable energy sources. Hence, renewable energy sources are a key component and central tool for the implementation of the 2015 Paris Agreement, which varies from country to country, in meeting the GHG reduction targets. Huge support for the 72 parties to the Paris Agreement, in order to encourage their efforts to improve their climate promises and implement the existing Climate Action Plan through the energy transition, was provided by the International Renewable Energy Agency (IRENA). This support targeted a total population of about 1.8 billion people with a carbon footprint of 3.2 billion tons of carbon dioxide equivalent.

In this regard, North Macedonia, as a country not included in Annex I of the United Nations Framework Convention on Climate Change (UNFCCC), ratified the Paris Agreement with the most important strategic goals for the adoption of a long-term climate action strategy and the Climate Action Law. Thus, joining the EU energy trends, North Macedonia is committed to ensuring sustainable development and environmental protection.

## 3. Energy development strategy

The energy sector has the greatest impact on GHG emissions. This sector participates with 65% in the total GHG emissions in 2014. Consequently, most of the SO<sub>x</sub> and NO<sub>x</sub> emissions come from the energy sector with a dominant influence on TPP Bitola. So, total SO<sub>2</sub> emissions in 2016 were 59 kt, which is a decrease of 47% compared to 1990. The trend is similar for NO<sub>x</sub>, where in 2016 the emissions were 21.6 kt, which is 51% less than the 1990 level. The decrease in emissions after 2012 is mainly due to the reduced amount combustible coal in TPP Bitola and TPP Oslomej, as well as the replacement of fuel oil with natural gas in the heating plants, Figure 2 and Figure 3, [3]

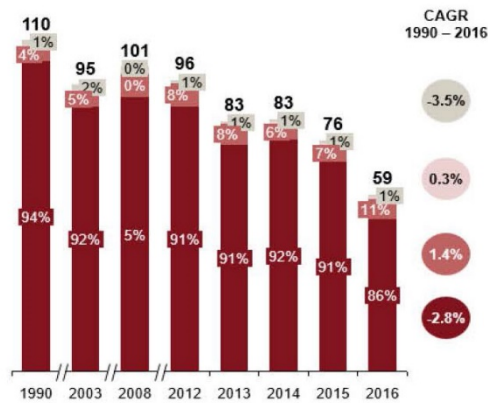


Figure 2. SO<sub>2</sub> emissions by sector, kt 1990 - 2016

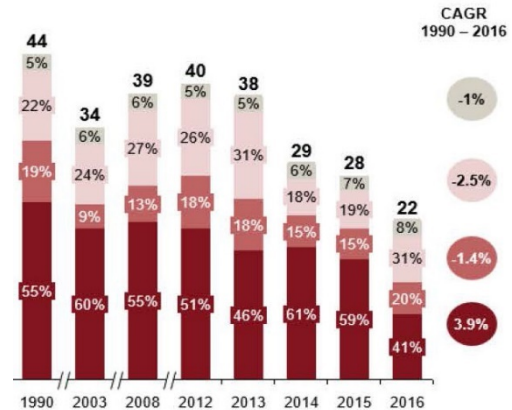


Figure 3. NO<sub>x</sub> emissions by sector, kt 1990 - 2016

In 2021, almost 40% of the produced electricity came from thermal power plants that use low-calorie coal – lignite. In January 2020 the government adopted the new Energy Development Strategy 2020-2040 which elaborates three different scenarios: reference (business as usual), moderate transition and green (strong decarbonization) scenario.

**The Reference Scenario** includes revitalization of TPP Bitola and a prerequisite for installing equipment for control of local pollutants, in order to meet the requirements of the Large Combustion Plants Directive, superseded by the Industrial Emissions Directive [3]. The revitalization of TPP Bitola includes the necessary precondition for opening new mines Zivojno and ensuring a continuous supply of coal at competitive prices. On the other hand, TPP Oslomej stops working in all three scenarios, through an alternative transformation with a solar power plant (80 - 120 MW), designed to use the existing infrastructure and employees. Therefore, this energy transition is characterized by the development of socially responsible transition programs, in order to redeploy employees and stimulate new job opportunities in RES technologies and low carbon services, [4].

The importance of developing socially responsible transition programs in order to redeploy staff and stimulate new job opportunities in low-carbon technologies and services should be emphasized. This incentive is aimed especially at small and medium enterprises (SMEs), so that North Macedonia has a positive business environment, which is a very good precondition for supporting these SMEs in strengthening new investments, reducing unemployment and stimulating overall growth. Decarbonisation and liberalization also pose challenges for electricity companies in maintaining their revenues and profitability, which is already evident in Western Europe.

At the same time, in order to satisfy the increased demand for domestic needs and transit, which is due to the improved market integration in the region, continuous investments in the transmission network will be needed.

In the **Moderate Transition Scenario and the Green Scenario**, the greatest energy savings can be achieved in primary energy consumption, which is a direct consequence of the reduction in coal consumption. The aspiration to enter the Emissions Trading System (ETS) should be considered as a key strategic measure to reduce CO<sub>2</sub> emissions in electricity and heat production, due to which the Moderate Transition Scenario and the Green Scenario envisage the abolition of coal after 2025. Higher CO<sub>2</sub> prices and lower natural gas prices in the moderate and green scenario result in the termination of the operation of TPP Bitola, which will be complemented by a combination of new RES, natural gas facilities, but also energy from imports.

In addition to the continuous improvement of the security and distribution network, more attention will be paid to the integration of more RES in a way that ensures sustainable energy development. Reducing the cost of RES technologies for electricity generation makes them competitive with traditional energy sources. Since 2009, the price of electricity produced from PV has decreased by almost 70%, while a reduction of 20% has been registered in wind power plants. According to the EU Reference Scenario in the period after 2020, the electricity produced by RES will be cheaper than electricity from conventional sources, Figure 4.

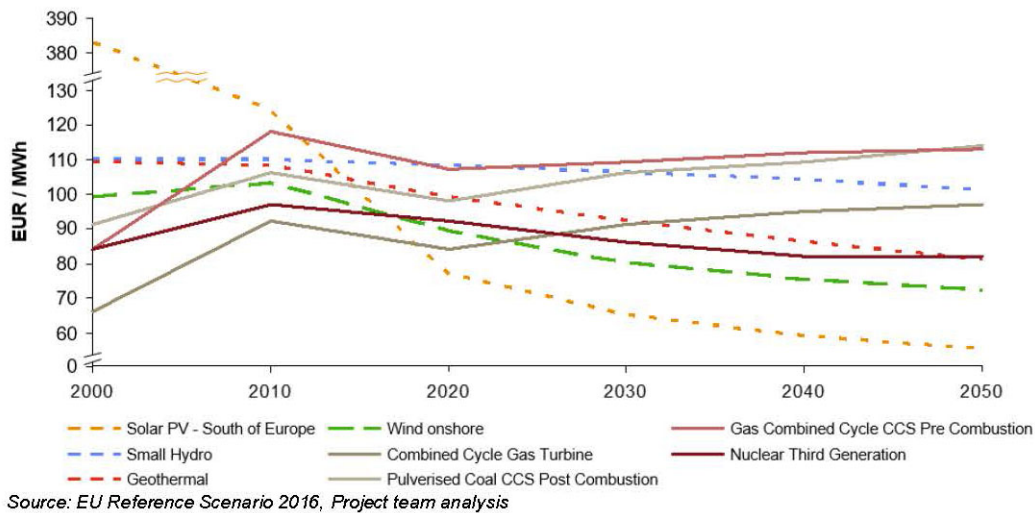


Figure 4. Levelized costs for electricity generation technologies, 2000 – 2050

However, the involvement of producers-consumers, ie prosumers, is also important, so that mechanisms for financial support through preferential tariffs are provided to encourage the production of new RES, especially for the period from 2020 to 2025.

In all three scenarios, photovoltaic (PV) and wind farms will be the fastest growing technologies for electricity generation (up to 1.400 MW PV and 750 MW wind). Despite the benefits of generated electricity, the construction of new small hydropower plants should be carefully assessed in terms of environmental impacts. Consequently, technological advances based on the promotion of energy efficiency, low carbon technologies and energy storage will accelerate the energy transition. With such a share of RES, electricity storage will have an increased role in the energy systems [5].

On the other hand, the planned natural gas interconnections with neighboring countries, especially with Greece, and the already ambitious gasification plan already started, will play an important role in the fuel transition by 2050 and the replacement of coal. Therefore, the role of natural gas in the Moderate Transition Scenario and the Green Scenario is of special importance, due to the partial replenishment of TPP Bitola in the coal industry.

#### 4. Analysis of the current situation

Table 2 presents an overview of the electricity production in the North Macedonia for the period of eleven years, from 2010 to 2021. The displayed data do not include the quantities of electricity that the largest producer has used for its own consumption, and for the mines' electricity needs, thus differing from the data enclosed in Table 1, [1].

Table 2. Electricity production by domestic producers from 2010 to 2020

Years	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
GWh	6.744, 2	6.287, 9	5.806, 6	5.676, 4	4.982, 3	5.271, 5	5.302, 7	5.229, 0	5.287, 5	5.655, 5	5.128, 3	5.284, 8
AD ESM (former AD ELEM)	6.476, 5	6.050, 2	5.370, 1	5.113, 0	4.535, 0	4.741, 8	4.299, 9	4.080, 1	4.114, 3	4.283, 7	3.642, 8	3.273, 6
TPP (Total)	4.277, 4	4.775, 7	4.475, 7	3.742, 6	3.506, 4	3.092, 7	2.699, 1	3.145, 1	2.613, 0	3.293, 8	2.509, 8	2.078, 3
TPP Bitola	3.699, 9	4.188, 9	3.971, 0	3.572, 6	3.316, 8	2.986, 2	2.672, 3	3.076, 1	2.545, 3	3.200, 9	2.415, 1	1.864, 4

TPP Oslomej	577,5	586,8	504,7	170,0	189,6	106,5	26,8	69,0	67,7	92,9	94,7	213,9
HPP (Total)	2.184,8	1.267,9	887,5	1.362,5	958,2	1.528,3	1.490,1	816,1	1.391,1	879,5	965,3	1.078,6
HPP Mavrovo	800,0	560,1	263,2	287,0	398,0	438,9	553,2	393,3	433,5	418,0	386,7	423,5
HPP Spilje	516,7	257,4	239,7	393,3	190,3	303,7	353,2	157,5	366,7	172,6	204,6	257,9
HPP Tikves	326,3	145,5	104,8	211,0	116,1	312,8	145,2	63,1	138,1	67,5	98,6	90,5
HPP Globocica	291,0	167,6	169,8	247,6	136,2	225,5	232,6	96,9	229,3	112,7	137,7	160,5
HPP Kozjak	250,9	137,4	97,8	184,0	80,4	171,6	142,8	71,0	156,7	73,1	95,8	97,9
HPP Sveta Petka			12,2	39,6	37,2	75,8	63,1	34,3	66,8	35,5	41,9	48,2
WPP Bogdanci					70,4	120,8	109,5	110,5	97,3	101,8	116,9	103,3
TE-TO Energetika	14,2	6,7	6,8	7,9	0,0	0,0	1,2	8,4	12,9	8,6	8	0
KOGEL Sever	0,0	2,9	2,2	4,3	1,2	0,7	3,7	7,0	0,0	0,0	42,8	13,9
TPP Negotino	0	0	0	0	0	0	0	0	0	0	0	27
TE-TO AD	0,0	74,4	280,1	340,8	189,8	177,8	550,1	794,7	716,6	987,0	1.067,8	1.503,2
SHPP	241,6	159,2	151,2	209,6	241,9	308,4	389,3	271,8	379,2	304,0	322,05	375,0
PV	26,2	1,1	3,1	8,7	14,3	22,6	23,7	23,9	23,3	25,6	37,3	52,0
Biogas TPP						20,2	36,0	51,6	54,1	55,1	57,3	54

It can be noted that there is significant decrease of the domestic production from 6.744 GWh in 2010 to 5.284 GWh in 2021, with the lowest electricity production in 2020 which was 5.128 GWh. Largest influence on the mentioned reduction is the production by the AD ESM Skopje, which in 2010 was 6.476 GWh, while in 2021 it amounted with 3.274 GWh, i.e., decrease by 3.202 GWh, or decrease of around 50%.

Since 2014, AD ESM Skopje produces electricity below 5.000 GWh annually. The reduction in the electricity production is noticed in both, by the Hydro Power Plants and by the Thermal Power Plants. The production of electricity by the Hydro Power Plants foremost is dependable on the meteorology conditions, and the period of review shows variations by 2.185 GWh in 2010, followed by 816 GWh in 2017. Hence, in the last 12 years, the production of electricity was never reached as in 2010, although in 2012 the new Hydro Power Plant 'Sveta Petka' enters in operations.

The production of electricity by the Thermal Power Plants records downfall, too. The average electricity production in Thermal Power Plants for the period from:

- 2002 to 2006, is 4.866 GWh,
- 2007 to 2010 is 4.636 GWh,
- 2011 to 2014 is 4.125 GWh,

- 2015 to 2018 is 2.946 GWh and
- 2019 to 2021 is 2.627 GWh.

A historic decline in electricity production from thermal power plants was recorded in 2021, at the level of 2.078,3 GWh, where thermal power plants in TPP Bitola produced only 1.864,4 GWh of electricity. It covers 44.5% of electricity production in 2011, which was the largest production in the last twelve years.

On the other hand, TPP Oslomej records a significant increase in electricity production in 2021 compared to 2020, as well as in the years back to 2012. In 2021, TPP Oslomej has produced 213,9 GWh, which is 2,26 times more than in 2020, i.e. 2 times more than the average electricity production in the period from 2013 to 2019. The average production of electricity at TPP Oslomej in the period 2013-2019 is 102,15 GWh. The lowest production of electricity in TPP Oslomej was in 2016 of only 26,8 GWh.

The reasons for the downward trend in production in thermal power plants are the numerous defects and interruptions in the operation of TPP Bitola, reduction of excavated quantities and quality of coal, approaching the end of life of thermal power plants and inadequate investments, reducing efficiency and more. TPP Oslomej in recent years has very little production of electricity, primarily because the entire coal reserves in are already used. The increase in production in 2021 is due primarily to the supply of coal from external suppliers.

The production of electricity in AD ESM, in 2021, is halved compared to 2011 (Table 2). Despite this, the electricity supply in 2021 was continuous, primarily due to the good interconnection connections with the neighbouring power transmission systems. However, it should be borne in mind that the reduced production and increased electricity prices on the regional and European electricity market, in the second half of 2021, resulted in a significant deviation between the purchased and required electricity in the electricity system in North Macedonia.

In North Macedonia, in 2021 there was significant interest in the construction of large parks of wind farms and photovoltaic power plants in accordance with the Law on Strategic Investments. Plans for the development of large power plants, which use renewable energy sources, especially wind power plants, should be supported by plans for the development of large hydropower plants or natural gas thermal power plants, which should provide certain services of the transmission system operator for proper management of the system and taking the necessary actions in order to maintain its stability. But, unfortunately, the interest for construction of such large power plants is very small, not only in our country, but also in the wider region, i.e. new large power plants are not under construction in the region either. Due to this, it is necessary for the competent institutions to take concrete measures to attract investments in this part of the energy sector, because, as with other energy facilities, the time limit for construction of large power plants is significantly longer, i.e. it is multi-year.

In December 2021, TPP Negotino was put into operation, which uses fuel oil as the primary fuel for electricity production. During this period, TPP Negotino operated with one boiler, and the total production was 27 GWh. TPP Negotino was last put into operation in 2009. The commissioning of TPP Negotino was economically justified because in this power plant the price for production of fuel oil was lower than the stock exchange prices of electricity in the last quarter of 2021 and therefore, instead of importing, part of the required electricity provided by the domestic production of TPP Negotino.

In the part of electricity production, it should be noted the significantly higher electricity production of TE-TO AD Skopje in 2021 compared to previous years. During the reporting period, AD TE-TO Skopje, i.e. the combined thermal power plant, has produced 1.503 GWh of electricity, which is an increase of 435 GWh or 40,73% compared to the production in 2020 when it was 1.068 GWh. AD TE-TO Skopje participates with 41,5% of the total produced electricity from the thermal power plants which in 2021 is 3.622 GWh.

## 4. Conclusion

By signing the Sofia Declaration, [6], on the Green Agenda for the Western Balkans (WB), at the WB Summit within the Berlin Process initiative, on November 10, 2020, the countries of the region recognize the European Green Agreement as a new growth strategy for the EU with a view to modernity, a climate-neutral and competitive resource-efficient economy, [7].

One of the important elements contained in the Declaration is the Economic and Investment Plan, which is designed to support the long-term green socio-economic recovery of this region, that will achieve sustainable



economic growth, implement reforms needed to progress on the EU path and rapprochement. With a population of almost 18 million people, the region is an important market for the EU and a transit area for European and international goods, with a skilled workforce for companies willing to invest. The countries of the WB, therefore, play a key role in the global value chains that supply the EU, [8].

The countries of the region have adopted the Green Agenda for the WB, expressing their commitment to action in the five-pillar areas. Below is a complete overview of activities within the indicated areas, contained in the Declaration, [8].

The energy transformation worldwide is driven by man-made global climate change caused by greenhouse gas emissions (GHG) and the national and international climate policy targets that have been developed in response, [9]. From the technical point of view, there are several issues to be addressed including: integration of renewable energies into an increasingly flexible electricity system, transition to electricity production entirely from RES, transition of fossil fuels to new, eco-friendly fuels in the transportation sector (trend towards electric vehicles). In addition, apart from the current technological challenges, a significant increase in energy efficiency is necessary to reduce energy consumption and make the transition to 100% renewables viable.

However, despite the positive trends in the electricity production from RES and foreseen scenarios in the Strategy, the situation in the country's energy sector further deteriorated in 2021 and in the first months of this year. This is mainly due to domestic and external circumstances.

North Macedonia is in the initial phase of this process and the first steps are not very encouraging. Despite the noted problems in the state-owned company AD ESM, further growth of electricity production from RES is slowed down due to long, time-consuming bureaucratic obstacles and regulatory limitations. There are announcements for change of the regulation in order to increase the installed capacity of photovoltaic systems for households and legal entities for production of electricity for own needs. Yet, without further easing of the regulations, we cannot expect higher take-off in the installation of new RES capacities. Furthermore, the current geo-political situation in Europe does not go in the direction of timely transformation of the energy sector in North Macedonia, according to the Strategy.

## References

- [1] The Annual Report on operations of the Energy and Water Services Regulatory Commission of the Republic of North Macedonia (ERC) for 2021 published on 29.04.2022.
- [2] IPCC WGII Sixth Assessment Report, Climate change 2022 – Impacts, Adaptation and Vulnerability, published on 27.02.2022.
- [3] Directive 2010/75/EU (Industrial Emissions Directive) of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control).
- [4] The strategy for energy development of the Republic of North Macedonia until 2040, Macedonian Academy of Sciences and Art (MANU), 2020.
- [5] Electricity storage and renewables: cost and markets to 2030, International Renewable Energy Agency (IRENA), October 2017.
- [6] Sofia declaration on the Green Agenda for the Western Balkans, Regional Cooperation Council, Co-funded by the European Union, November 2020.
- [7] <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020SC0223> accessed on 10.05.2022.
- [8] Communication from the Commission to the European parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, An Economic and Investment Plan for the Western Balkans, Brussels, 6.10.2020 COM (2020) 641 final.
- [9] Phasing out coal in the German energy sector, published by the German Institute for Economic Research (DIW Berlin), February 2019.