

CONSTRUCTION OF FLOATING PHOTOVOLTAIC POWER PLANTS IN THE AREA OF JSC ESM RESERVOIRS

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Abstract

As a serious, socially responsible company as well as the largest production capacity of electricity in state ownership, JSC ESM fully follows the Strategy for the development of energy in the Republic of North Macedonia until 2040. Therefore, the company continuously advocates for the construction and realization of strategic capital projects for the production of electricity from renewable energy sources, which have a major impact on the economic development of the country as a whole, as well as on the protection of the environment. In this context, the problem elaborated in this paper is very current and aims to address the importance of the construction of the four floating photovoltaic power plants, within the company, with a total installed capacity of 312 MW, and their influence on the energy transition, that is, in the complete replacement of electricity production from coal, with production from solar energy.

Apart from the production of electricity from solar energy, these photovoltaic power plants are of great importance because they are not built and do not occupy fertile land, but are built in the area of the reservoirs of the hydroelectric power plants.

In general, the investment of JSC ESM in green energy has an important role and a great influence on the development strategy and in creating sustainable competitiveness of the company. All this will allow the company to be the most important and leading factor in the liberalized market, especially in the time after the great energy crisis in the country and beyond.

Keywords: electricity, production capacity, energy transition, floating photovoltaic power plants, renewable energy sources, solar energy.

1. Introduction

The company JSC "ESM" as the largest production capacity of electricity, also represents the most important segment of the electricity system.

Therefore, the problem that has been elaborated is very relevant due to the fact that it deals with part of the capital projects of JSC "ESM", i.e. floating photovoltaic power plants, which clearly affect the protection of the environment and investing in green energy will enable us to approach modern and technological developed European countries.

Hence, the paper is composed of two parts. The first part analyzes and gives a brief description of the global trend in the construction of photovoltaic power plants, in general. In the second part, we will refer to the construction of the four floating photovoltaic power plants of JSC "ESM", especially each of them, in terms of financial resources and sources of financing, their installed power and annual electricity production, as well as the possible location for their installation and finally, the paper ends with a conclusion.

2. The construction of photovoltaic power plants as a global trend

Using solar energy to produce electricity is a clean source of energy and does not produce gases that affect climate change, thus improving local air quality and reducing public health concerns. This helps reduce pollution and accelerates the use of renewable energy sources.

Given that the sun's energy is unlimited and cheap, with investments in photovoltaic power plants, societies and individuals can become more independent from traditional energy sources such as oil and coal.

The power generation industry is growing and has the potential to create many jobs in the production, installation and maintenance of photovoltaic plants. This can also contribute to the growth of local and global economies. So, in general, the electricity power production from photovoltaic power plants has a positive effect on the environment, economy and society in general.

On the other hand, the Green Deal (European Commission, 2019), which presents a roadmap to achieve a sustainable economy throughout the European Union (EU), building on the Energy Union, has multiple objectives, aiming to stop the emission of greenhouse gases by 2050, to decouple resource use and economic growth without leaving anyone or any country behind in this process (European Commission, 2015).

Clean energy is becoming more and more competitive. While the prices of fossil fuels fluctuate, following a relatively upward trend, the prices of renewable energy sources fall at an accelerated pace, a trend that is expected to continue in the coming years. The International Energy Agency (IEA) predicts that by 2027, the current capacity of renewable energy sources will increase by 2,400 GW, which represents an increase of 85% compared to the previous five years (<https://www.iea.org/reports/renewables-2022/executive-summary>).

On the other hand, the decarbonisation of the energy sector is becoming increasingly important as energy production and consumption account for more than 75% of greenhouse gas emissions in the EU, which aims to become the first continent by 2050 with neutral climate (<https://www.euoffice.euolympic.org/european-green-deal-striving-be-first-climate-neutral-continent/>).

Consequently, decarbonization is becoming a global imperative and one of the priorities of the world's governments, primarily because of its important role in limiting global warming.

To enable decarbonisation, significant change in energy systems will need to occur. The road to full decarbonization of the energy system is expected to be complicated, but if implemented accordingly, the benefits can be significant and visible in the short term (Merita Dema, 2023).

As for our country, the production of electricity in the Republic of North Macedonia takes place through power plants, which use lignite, fuel oil and natural gas as the primary source of energy, as well as power plants, which use renewable energy sources: water energy, wind energy, solar energy, biomass and biogas.

The Republic of North Macedonia is a country dependent on imports in relation to its electricity needs and is directly dependent on local electricity production.

The energy crisis, which started from the second half of 2021, on the one hand meant a drastic increase in electricity prices and a lack of the same, on the other hand resulted in an increased number of investments in renewable energy sources. In North Macedonia, a record number of investments in renewable energy sources was achieved, something that was not previously achieved even with measures to support renewable energy sources.

During the past years, the import of electricity varied from 20% to 30% of gross electricity consumption. For the first time in 2023, the net import of electricity is 2.75%, while in 2022 it was 20.70%, while in 2021 it was 33.15% of gross total consumption. This decrease in the net import of electricity comes as a result of the increased production of electricity, especially from solar power plants, and the reduced consumption of electricity.

The Republic of North Macedonia, following the path of energy transition, in recent years made a large increase in investments for the production of energy from renewable sources, especially from the sun. In 2023, 531 new power plants with an installed capacity of 367 MW were built in North Macedonia. Of these, 527 newly built photovoltaic power plants with an installed capacity of 362 MW dominate. The total number of power plants from renewable energy

sources in 2023 is 1.147, with an installed capacity of 1.311 MW (Annual Report of the Energy, Water Services and Waste Management Services Regulatory Commission of the RNM, 2023). The total installed capacity of power plants in 2023 is 2,632 MW, which represents an increase of 367.3 MW over the installed capacity in 2022. The graph below shows the installed capacity and the participation of individual technologies for the production of electricity in 2023.

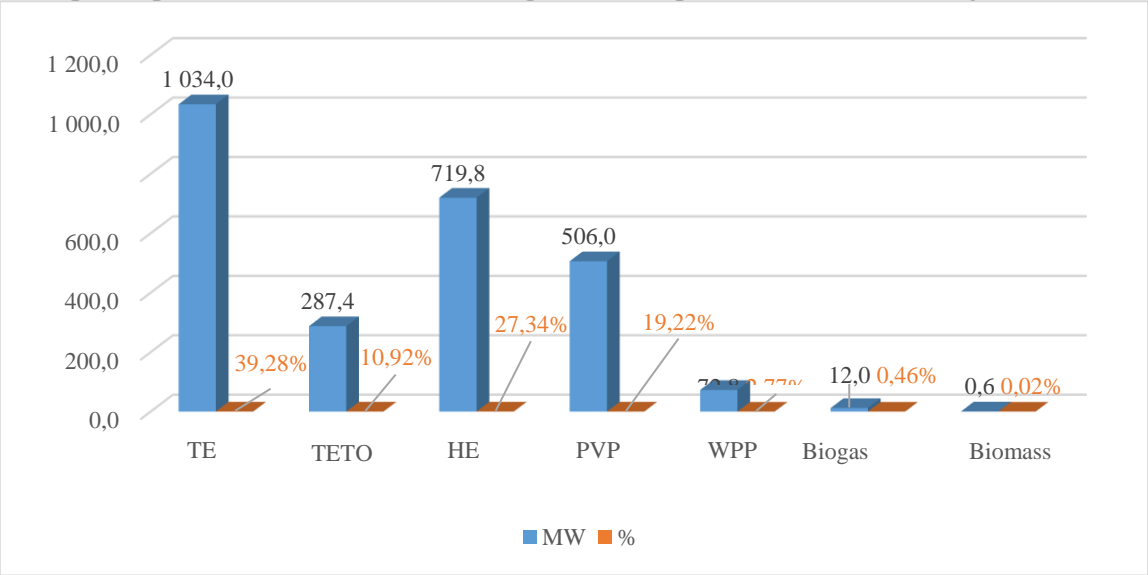


Figure 1. Installed capacity and participation of individual technologies for electricity production in 2023 (in MW and %). Source: Annual Report of the Energy, Water Services and Waste Management Services Regulatory Commission of the RNM, 2023

Renewable energy sources, namely the production of electricity from renewable sources is regulated in the Law on Energy (Assembly of the Republic of Macedonia, 2018). During the year 2023, a new proposal for the Law on Energy and the proposal for the Law on Renewable Energy Sources were drawn up. For the first time, renewable energy sources will be allocated by a new law, which is the case in many countries of the region. With this new bill, Directive 2018/2001 on the promotion of the use of renewable energy sources, which is part of the EU's clean energy package, will be transposed.

The chart below shows the number of power plants from renewable energy sources from 2020 to 2023 and we can clearly see the increase in the number of solar power plants during these years.

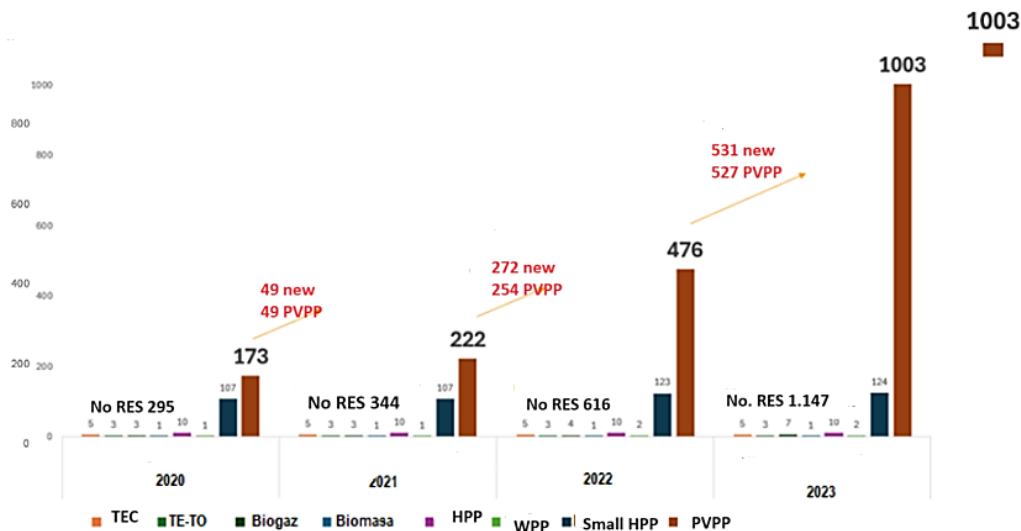


Figure 2. The number of power plants from renewable energy sources from 2020 to 2023.
Source: Annual Report of the Energy, Water Services and Waste Management Services Regulatory Commission of the RNM, 2023

The total installed capacity of the planned capital projects from JSC ESM is mostly attributed to RES, i.e., 1718.8 MW or 85%, while the remaining part of 300 MW or 15% is attributed to gas power plants (Bitola and Energetika), for the production of base energy (JSC ESM, 2022a). Photovoltaic and wind power plants in the section of electricity production from renewable sources in the Energy Development Strategy until 2040 (Government of the RNM, 2019) are predicted to be the fastest growing technologies for electricity production in all scenarios (up to 1,400 MW PVPP and 750 MW wind).

Accordingly, North Macedonia became a member of the PCCA Alliance during the London Week for Climate Action (JSC ESM, 2021) and the first country from the Western Balkans, which, together with Spain, committed to abandon the production of electricity from coal by 2030 (META.MK, 2021).

For this based on the Intervention Plan for Investments 2021-2027 in the value of 8.2 billion euros, of which 3.144 billion euros are planned in the energy sector (Government of the RNM, 2021).

For the production of electricity from RES, the Government of the Republic of North Macedonia through the Law on Energy enables investments in RES, whether public, private or public-private. According to the Strategy, the participation of RES in the final gross energy consumption in 2030 is expected to be at least 33%.

3. Construction of Floating Photovoltaic Power Plants of JSC "ESM"

In this chapter we will focus on the construction of four floating photovoltaic power plants (FPVPP) of JSC "ESM", especially in each of them, in terms of financial resources and sources of financing, their installed power and annual electricity production, as well as the possible location for their installation.

FPVPP installations open up new opportunities for scaling up solar generating capacity in North Macedonia.

JSC ESM intends to increase the total production of electricity from renewable sources and invest in the construction of floating PVPP on the accumulations of hydropower plants in order to provide energy-balancing, stability, storage capacity, and ancillary grid services such as network frequency control and reserves (JSC ESM, 2022a).

Table 1- Basic Data For The Four Fpvpp Of Jsc Esm (Jsc Esm, 2022a)

FPVPP	Power AC (MW)	Annual production (GWh)	Financing source
FPVPP Vrutok	76	134,4	IFI/ESM/SP
FPVPP Kozjak	76	137,1	IFI/ESM/SP
FPVPP Shpilje	96	176,1	IFI/ESM/SP
FPVPP Tikvesh	64	121,5	IFI/ESM/SP
Total	312	569,1	

3.1 Construction of a FPVPP Vrutok: FPVPP Vrutok with installed AC power of 76 MW is planned to have average annual electricity production of 134,4 GWh. At a minimal operation level of 1207,00 maSL, the available area of Mavrovo accumulation is 720 ha. Part of that area, i.e 72 ha (10%) can be used for installation of floating PV.

Energy connection of this power plant in the network can be performed to the nearest substation i.e should be connected to the same connection point as the HPP Vrutok, in order to make them project cost-effective. One of the added benefits of employing FSPV system is improvement in cooling of the solar modules due to which the efficiency of the system as a whole increase and the rate of evaporation of water is also reduced concomitantly (JSC ESM, 2022a).



Figure 3. Location of FPVPP Vrutok
Source: (JSC ESM, 2022a)

3.2 Construction of a FPVPP Kozjak: FPVPP Kozjak with installed AC power of 76 MW is planned to have average annual electricity production of 137,1 GWh. At a minimal operation level of 435,00 maSL, the available area of Kozjak accumulation is 763 ha. Part of that area, i.e 76,3 ha (10%) can be used for installation of floating PV. Energy connection of this power plant in the network can be performed to the nearest substation i.e should be connected to the same connection point as the HPP Kozjak, in order to make the project cost-effective (JSC ESM, 2022a).



Figure 4. Location of FPVPP Kozjak
Source: (JSC ESM, 2022a)

3.3 Construction of a FPVPP Shpilje: FPVPP Shpilje with installed AC power of 96 MW is planned to have average annual electricity production of 176,1 GWh. At a minimal operation level of 560,00 maSL, the available area of Debar accumulation is 903 ha. Part of that area, i.e 90,3 ha (10%) can be used for installation of floating PV. Energy connection of this power plant in the network can be performed to the nearest substation i.e should be connected to the same connection point as the HPP Shpilje, in order to make the project cost-effective (JSC ESM, 2022a).



Figure 5. Location of FPVPP Shpilje
Source: (JSC ESM, 2022a)

3.4 Construction of a FPVPP Tikvesh: FPVPP Tikvesh with installed AC power of 64 MW is planned to have average annual electricity production of 121,5 GWh. At a minimal operation level of 233,00 maSL, the available area of Tikvesh accumulation is 650 ha. Part of that area, i.e 65 ha (10%) can be used for installation of floating PV. Energy connection of this power plant in the network can be performed to the nearest substation i.e should be connected to the same connection point as the HPP Tikvesh, in order to make the project cost-effective (JSC ESM, 2022a).



Figure 6. Location of FPVPP Tikvesh
Source: (JSC ESM, 2022a)

4. Challenges and Recommendations

In order to realize the green scenario, foreseen in the Energy Development Strategy in the Republic of North Macedonia until 2040, the existing thermal power plants with fossil materials with an installed capacity of 1010 MW must be continuously closed in the next period. For the same reason, the Republic of North Macedonia became a member of the PPCA Alliance (Powering Past Coal Alliance) and the first country from the Western Balkans that, together with Spain, pledged to abandon the production of electricity from coal by 2030.

Based on this, the energy transition, namely the replacement of electricity production from coal and other fossil materials, with production from solar energy and other renewable energy sources must continue.

So, it is a global trend and a future challenge for JSC ESM that the existing power plants within it be closed, and that no new power plants be built. In their place, it is recommended to build new electrical facilities within the ESM JSC for the production of electricity from RES. Also, JSC ESM must continue with the construction of these facilities in its depleted mines and on the surfaces of its hydroelectric power plant reservoirs, as well as on fertile lands.

Conclusion

The paper is of great importance because it deals with and analyzes the global trend of construction photovoltaic plants in general as well as the construction of four floating photovoltaic plants within JSC "ESM", with a total installed power of 312 MW.

In the time of globalization and as an imperative of the modern economy, in the current situation, the increase in electricity production, especially through investment in green energy, namely the construction of photovoltaic power plants has a direct impact on the protection and preservation of the environment.

The construction of photovoltaic power plants will contribute to meeting the growing needs of consumers and increasing the participation of RES in energy consumption in the Republic of North Macedonia. This will enable the economic development of the entire local economy and the macroeconomic stability of the country in general.

These floating photovoltaic power plants are of great importance for JSC ESM as a state-owned company that is a leader in the production of electricity in the RNM, as well as a company with social responsibility that follows the energy development strategy in the RNM until 2040.

These Floating Photovoltaic Power Plants (FPVPP), along with other photovoltaic plants under construction in the depleted mine area at MPC Oslomej and those planned at the MPC Manastir mine, are of great and significant public interest, which consists of reducing local pollution, reducing greenhouse gas emissions, creating green jobs, increasing production from renewable energy sources, reducing electricity imports, meeting targets for the participation of renewable energy sources in gross final energy consumption, the electrical system as a whole, etc.

For the same, of great importance and significance are the other planned energy capacities from renewable energy sources in the ambitious investment program of JSC ESM, with which through investment in green energy we approach technologically developed European countries and as a candidate country one step closer to integration into the European Union.

Nomenclature

AC- Alternating Current

FPVPP-Floating Photovoltaic Power Plant

GW-Giga Watt

GWh-Giga Watt Hour

HPP-Hidro Power Plant

JSC ESM-Joint Stock Company Power Plants of North Macedonia

maSL-meters above sea level

MPC-Mining Power Combine

MWh-Mega Watt hour

MW-Mega Watt

PPCA-Powering Past Coal Alliance

PVPP-Photovoltaic Power Plant

RES-Renewable Energy Sources

RNM- Republic of North Macedonia

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