CAPITAL PROJECTS

Prepared by: Development and Investments Department

May, 2022

1. CONSTRUCTION OF A PHOTOVOLTAIC POWER PLANT WITH INSTALLED CAPACITY OF 10 MW IN THE AREA OF REK OSLOMEJ - PVPP OSLOMEJ 1

Power AC (MW)	Annual production (GWh)	Financing source
10	14.6	5.9 MEur EBOR 2.871 MEur ESM

Description and realization status

PVPP Oslomej 1 with installed AC power of 10 MW is planned to have average annual electricity production of 14.6 GWh. The land of the existing mine in the vicinity of REK Oslomej on 19 hectares will be recultivated with installation of photovoltaic panels. The planned investment of the project is 8,771 million euros.

Since the signing of the contract, work has been done on the design of the power plant which includes all steps of studies, calculations and sizing of all elements of the power plant, taking steps to reduce the negative impact on the environment (avoiding animal habitats in the project scope), as well as providing all documentation required for implementation under Macedonian law. In addition, full delivery of photovoltaic modules, which are already in the field, has been performed. This is followed by the finalization of the Basic Design, completion of the project documentation, provision of a construction permit, delivery of the rest of the electromechanical equipment and installation of the power plant. Due to delays caused by "force majeure", ie the COVID-19 pandemic, the power plant is scheduled to be completed by the end of September 2022.

Site

Estimated production (MWh)

M	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Egrid	836	912	1278	1548	1813	1905	2096	2000	1652	1262	910	797

Annually Y1 (GWh)	PR	Yield (kWh/kWp)
17	84.29%	1446

2. CONSTRUCTION OF A PHOTOVOLTAIC POWER PLANT WITH INSTALLED CAPACITY OF 10 MW IN THE AREA OF REK OSLOMEJ - PVPP OSLOMEJ 2

Power AC (MW)	Annual production (GWh)	Financing source
10	16	Loan from EBOR, PVPP Oslomej 2 and PVPP Bitola 1 through one Loan Agreement

Description and realization status

PVPP Oslomej 2, analogous to PVPP Oslomej 1, with an installed capacity of 10 MW is expected to have an average annual electricity production of about 16 GWh. The land of the existing mine in the vicinity of REK Oslomej on 15 hectares will be recultivated by installing photovoltaic panels.

It is planned to connect the two power plants PVPP Oslomej 1 and Oslomej 2, as well as an additional underground line for redundant power supply, ie evacuation of the produced electricity.

A concept project and environmental aspects are being developed by the EBRD Consultants. This will be followed by preparation of technical specification and tender documentation for selection of a Contractor.

Site

Estimated production (MWh)

M	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Egrid	772	984	1257	1483	1813	1938	2043	1987	1587	1251	905	945

Annually Y1 (GWh)	PR	Yield (kWh/kWp)
16.966	87.07%	1416

3. CONSTRUCTION OF PHOTOVOLTAIC POWER PLANT WITH INSTALLED CAPACITY OF 2X40 MW (MAX. 2X50 MW) IN THE AREA OF REK OSLOMEJ - FE OSLOMEJ 3 WITH PPP

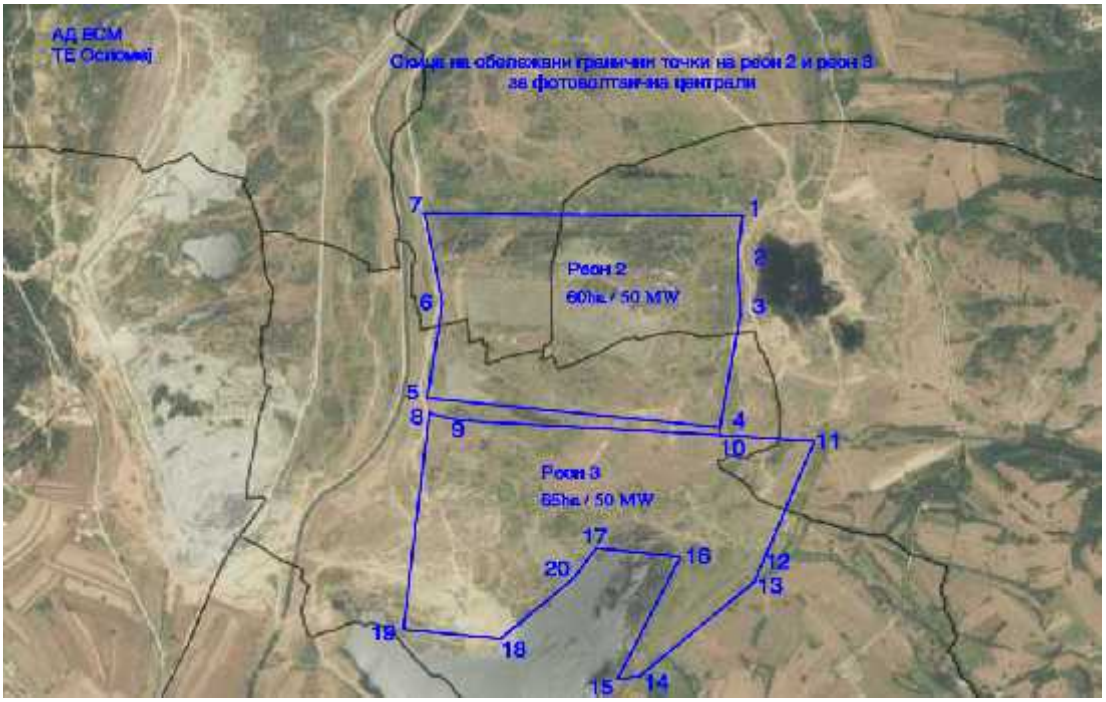
Power AC (MW)	Annual production (GWh)	Financing source
2X40 (макс.2x50)	2x80	The project is implemented with PPP

Description and realization status

PVPP Oslomej 3 with a maximum output of 2x50 MW, is planned to be built south of PVPP Oslomej 2, on an area owned by AD ESM. The average annual production is estimated at 2x80 GWh.

Construction is planned with a Public Private Partnership, where the private partner will cover the investment and operating costs and within 35 years will transfer the ownership to AD ESM. In the period of 35 years, the private partner of AD ESM will pay at least 10% of the produced electricity at an hourly HUPX price.

Site



4. CONSTRUCTION OF A PHOTOVOLTAIC POWER PLANT WITH INSTALLED CAPACITY OF 20 MW WITHIN REK BITOLA - FE BITOLA

Power AC (MW)	Annual production (GWh)	Financing source
20	32	The project is planned to be financed by the EBRD with a state guarantee, together with the project FE Oslomej 2.

Description and realization status

PVPP Bitola 20 MW ac will be built on an area of about 40 hectares, owned by AD ESM. The power plant will be connected to the existing electricity transmission grid through the mining substation Suvodol 110/6 kV, with adaptation of the same. The average annual production is estimated at 32 GWh.

A concept design and environmental aspects are being developed by the EBRD Consultants. This will be followed by preparation of technical specification and tender documentation for selection of a Contractor.

Site

Estimated production (MWh)

M	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Egrid	1744	2253	2950	3391	3665	3718	4604	4273	3693	2273	1848	1668

Годишно Y1 (GWh)	PR	Yield (kWh/kWp)
36.081	85.63%	1529

5. CONSTRUCTION OF A PHOTOVOLTAIC POWER PLANT WITH INSTALLED CAPACITY OF 60 MW IN THE AREA OF REK BITOLA - PVPP BITOLA 2

Power AC (MW)	Annual production (GWh)	Financing source
60	96	The capital investments are ~35MEur Loan from KfW is possible.

Description and realization status

PVPP Bitola 2 with installed capacity of 72MWp and power of AC inverters of 60MW is expected to have an average annual electricity production of ~ 96 GWh. The power plant will be installed on a location owned by AD ESM with an area of 110 ha. The power plant will be connected to a 110kV network owned by MEPSO through the existing SS Suvodol Mine. The capital investment is ~ 35M Eur while the project life cycle is 25 years. This project will avoid 67 Mton / year CO2 emissions. Negotiations are currently underway to obtain a grant from KfW Bank to develop a feasibility study and an environmental study, and then implement the project with the most appropriate implementation and financing model.

Site

Estimated production (MWh)

M	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Egrid	3400	6354	6467	8562	10536	10763	13218	10552	9429	6832	5213	4905

Annually Y1 (GWh)	PR	Yield (kWh/kWp)
96.2	83.87%	1412

6. CONSTRUCTION OF A PHOTOVOLTAIC POWER PLANT WITH INSTALLED CAPACITY OF 100 MW IN THE AREA OF REK BITOLA - PVPP BITOLA 3

Power AC (MW)	Annual production (GWh)	Financing source
100	160	Preparation of a feasibility study through a grant from KfW, the Government of RNM will make a Decision whether the implementation of this project will continue and if it continues, with which financial model

Description and realization status

Global energy trends highlight the transition to a low-carbon economy. For such a transition, one of the most important factors is the production of electricity from renewable energy sources.

In that sense, AD ESM is focused on the development of new projects for production of electricity from renewable energy sources, one of such projects is this project for development and construction of a photovoltaic power plant (PVPP) with an installed capacity of 100 MW. The estimated production is 160 GWh, while the connection is planned to be made to SS MEPSO, through the existing 110 kV transmission line. The site for this PVPP is located in the vicinity of the thermal power plant REK Bitola, more precisely on the site of part of the mine Suvodol on the part where the activities for coal mining have already been completed. The construction of this PVPP will significantly increase the share of renewable energy sources in the energy system of R. N. Macedonia.

Site

Estimated production (MWh)

M	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Egrid	5983	11187	12638	13733	18528	18939	23248	20080	16596	13256	8639	7604

Annually Y1 (GWh)	PR	Yield (kWh/kWp)
170.4	84.36%	1420

7. CONSTRUCTION OF A PHOTOVOLTAIC POWER PLANT WITH INSTALLED CAPACITY OF 100 MW AT THE SITE TIKVES-VITACHEVO WITH PPP

Power AC (MW)	Annual production (GWh)	Financing source
100	173	The project is planned to be realized with PPP

Description and realization status

A 100 MW photovoltaic power plant is planned to be built in the vicinity of Vitachevo / Tikves. The expected production would be around 173 GWh. The connection to the electricity transmission grid will be defined by MEPSO with the development of several variant solutions. AD ESM will make a choice of the most appropriate variant.

To start the implementation of this capital project, a feasibility study is planned which will show the next steps for the implementation of the project and the financial benefits.

Site

Estimated production (MWh)

M	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Egrid	7647	9992	13322	15894	19010	20146	20920	20008	16618	13029	9130	6991

Annually Y1 (GWh)	PR	Yield (kWh/kWp)
172.7	87.58%	1431

8. CONSTRUCTION OF A PHOTOVOLTAIC POWER PLANT ON THE SITE LEUNOVO 9 MW

Power AC (MW)	Annual production (GWh)	Financing source
9	15	The investment value is estimated at around 8 MEur The forthcoming feasibility study should examine all technical and environmental aspects

Description and realization status

Global energy trends highlight the transition to a low-carbon economy. For such a transition, one of the most important factors is the production of electricity from renewable energy sources.

In that sense, AD ESM is focused on the development of new projects for production of electricity from renewable energy sources, one of such projects is the development and construction of a photovoltaic power plant (PV) with an installed capacity of 9MW and planned average annual production of 15 GWh. The site for this PVPP is located in the vicinity of HPP Vrutok, at three separate locations around Mavrovo Lake.

The construction of this FE will further increase the share of renewable energy sources in the energy system of R. N. Macedonia.

Site

Estimated production (MWh)

M	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Egrid	767.2	913.9	1150.5	1304.9	1551.8	1687.1	1863.9	1778.5	1374.7	1092.7	821.4	873.9

Annually Y1 (GWh)	PR	Yield (kWh/kWp)
15.2	88.47%	1434

9. CONSTRUCTION OF A PHOTOVOLTAIC POWER PLANT ON THE SITE PISKUPSHTINA 1.5 MW

Power AC (MW)	Annual production (GWh)	Financing source
1.5	3.1	The investment value is estimated at around 1.2m euros. For this project, a tender documentation for preparation of a feasibility study is being prepared, which would show the future steps, including the financial model for this investment.

Description and realization status

Global energy trends highlight the transition to a low-carbon economy. For such a transition, one of the most important factors is the production of electricity from renewable energy sources.

In that sense, AD ESM is focused on the development of new projects for production of electricity from renewable energy sources, one of such projects is this project for development and construction of photovoltaic power plant (PV) with installed capacity of 1.5 MW and planned average annual production of 3.1 GWh.

Site

Estimated production (MWh)

M	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Egrid	113	148	202	291	319	335	402	414	290	225	240	133

Annually Y1 (GWh)	PR	Yield (kWh/kWp)
3.1	87.59	1438

10. PVPP BOGDANCI (16 MW)

Power AC (MW)	Annual production (GWh)	Financing source
16	29	For this project, a tender documentation for preparation of a feasibility study is being prepared, which would show the future steps, including the financial model for this investment. The estimated value of the project is around 11m euros.

Description and realization status

With the construction of this power plant in the vicinity of WP Bogdanci, in addition to wind production, the share of renewable energy sources will increase by another 16 MW. The costs for construction of FE will be significantly reduced due to the use of the existing infrastructure from PVE Bogdanci. The production of electricity from FE Bogdanci with installed capacity of 16 MW (AC), according to the analysis would be about 29 GWh per year. Energy connection of this power plant in the network can be performed to the nearest SS Bogdanci (20/110kV) which is about 3 km away from the location overhead line, or if the cable runs on the road about 7-8 km. In the next period the following activities are: preparation of a Feasibility Study, EIA and pre-qualification tender.

Site

Estimated production (MWh)

M	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Egrid	1425	1737	2315	2638	3138	3206	3367	3265	2863	2076	1585	1287

Annually Y1 (GWh)	PR	Yield (kWh/kWp)
28.9	86.40	1521

11. PVPP BROD – GNEOTINO (100 MW)

Power AC (MW)	Annual production (GWh)	Financing source
100	185	A feasibility study will be prepared for this project by IFC Further implementation is planned to be with PPP

Description and realization status

The site is located in the circle of REK Bitola, ie in the mine Brod-Gneotino. The envisaged installed capacities of this photovoltaic power plant are 100 MW, while the estimated production is 185 GWh per year. The International Finance Corporation (IFC) will prepare a feasibility study that will define the most appropriate model for the implementation of this Public Private Partnership (PPP) project.

Site

Estimated production (MWh)

M	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Egrid	8279	11347	16397	16468	19450	18953	23521	22842	16829	13962	9691	7391

Annually Y1 (GWh)	PR	Yield (kWh/kWp)
185.1	86.72%	1548

12. CONSTRUCTION OF A FLOATING PHOTOVOLTAIC POWER PLANT WITH INSTALLED CAPACITY OF 76 MW IN THE AREA OF MAVROVO ACCUMULATION – FPVPP VRUTOK

Power AC (MW)	Annual production (GWh)	Financing source
76	134,4	IFI / ESM/ SP

Description and realization status

Floating photovoltaic power plant (FSPP) installations open up new opportunities for scaling up solar generating capacity in North Macedonia.

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 the 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. AD 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.

Site

Estimated production (MWh)

M	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Egrid(MWh)	5617	7107	11540	12950	15549	16621	16356	15748	12170	9623	6066	5081

Annually Y1 (GWh)	PR	Yield (kWh/kWp)
134	88.05%	1477

13. CONSTRUCTION OF A FLOATING PHOTOVOLTAIC POWER PLANT WITH INSTALLED CAPACITY OF 76 MW IN THE AREA OF KOZJAK ACCUMULATION – FPVPP KOZJAK

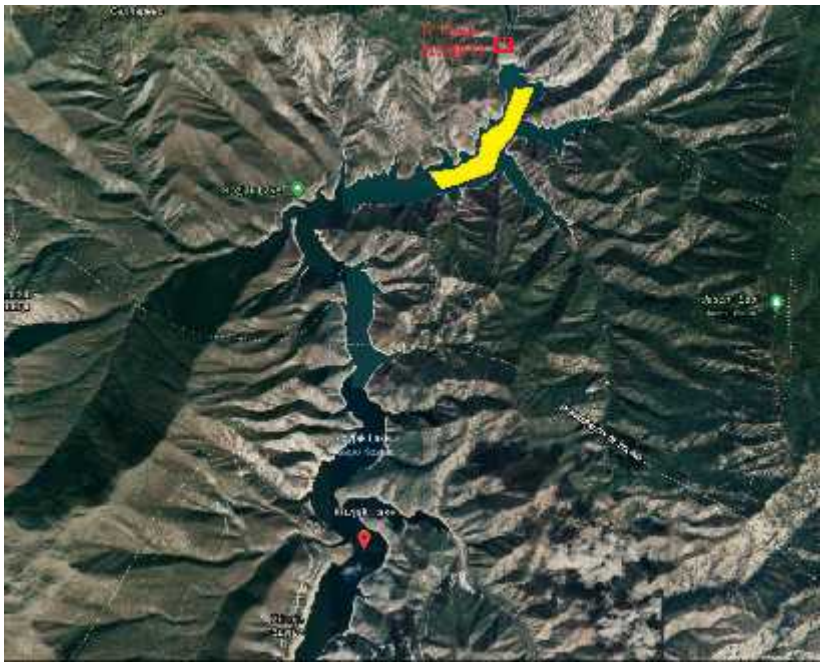
Power AC (MW)	Annual production (GWh)	Financing source
76	137,1	IFI / ESM/ SP

Description and realization status

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.

AD 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.

Site



Estimated production (MWh)

M	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Egrid (MWh)	5611	7456	11527	13439	16102	16924	16673	16225	12450	9675	6005	5047

Annually Y1 (GWh)	PR	Yield (kWh/kWp)
137	87.72%	1428

14. CONSTRUCTION OF A FLOATING PHOTOVOLTAIC POWER PLANT WITH INSTALLED CAPACITY OF 96 MW IN THE AREA OF DEBAR ACCUMULATION – FPVPP SHPILJE

Power AC (MW)	Annual production (GWh)	Financing source
96	176,1	IFI / ESM/ SP

Description and realization status

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.

AD 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.

Site

Estimated production (MWh)

M	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Egrid (MWh)	7598	9393	15056	17008	20167	21629	21488	20587	15870	12547	8081	6760

Annually Y1 (GWh)	PR	Yield (kWh/kWp)
176	88.28%	1506

15. CONSTRUCTION OF A FLOATING PHOTOVOLTAIC POWER PLANT WITH INSTALLED CAPACITY OF 64 MW IN THE AREA OF TIKVESH ACCUMULATION – FPVPP TIKVESH

Power AC (MW)	Annual production (GWh)	Financing source
64	121,5	IFI / ESM/ SP

Description and realization status

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.

AD 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.

Site

Estimated production (MWh)

M	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Egrid(MWh)	5395	6754	10048	11936	14439	14976	14877	14029	10919	8293	5200	4643

Annually Y1 (GWh)	PR	Yield (kWh/kWp)
121	87.54%	1464

16. WIND PARK BOGDANCI – II PHASE

Power AC (MW)	Annual production (GWh)	Total investment
13.8	50	21 MEUR.

The wind park is located in the southeastern part of The Republic of Macedonia, on the territory of Bogdanci municipality. The location is located on the Ranavec and Glavi hills, at an altitude of 300–500 m, and is characterized by low vegetation and relatively bumpy terrain.

Given the size and complexity of the project, implementation is planned to take place in two phases, thus not violating the technical functionality of the facility.

The first phase, already implemented in 2014, included the construction of an access road, a substation, a power line, the installation of 16 wind turbines with a total installed capacity of 36.8 MW and an EES connection to the RM. After this phase is completed, the facility is already operational with more than half of the total predicted capacity.

The second phase would also round up WP Bogdanci's infrastructure by building access roads and a 20 kV cable network to new turbines.

The wind park Bogdanci – phase two will consist of 3 turbines. The second phase increases the capacity of the existing WP Bogdanci by an additional 13.2–15 MW. The project's planned investment is 21m euros, of which 18M euros is a loan from Germany's KfW Bank and 3M euros of AD ESM funds.

A tender procedure is underway for the selection of contractors for the two LOTs by the consultant - the Fichtner-Germany/Geing-Northern Macedonia consortium and approval by KfW Bank. Contracts are signed with the selected contractors. The realization of the second phase completely rounds out the WP Bogdanci project of the projected installed power of 50 MW and total annual production of about 137 GWh.

17. WIND PARK MIRAVCI 50 MW

Power AC (MW)	Annual production (GWh)	Financing source
50	127	Total investment of 75 MEUR. Grant of 1.2 MEUR from KfW for PVPP and SEA provided

The wind park Miravci with installed capacity of about 50 MW is planend to have average annual electricity production of about 127 GWh. In addition, the park includes the construction of access roads, platforms, 20 kV cable network, substation, transmission line and transmission grid connection.

The assessments made on the basis of WP Bogdanci show that, according to the Conclusion of the Government, on 12.06.2020 the Ministry of Finance and AD ESM addressed the KfW Bank for granting grant funds for the preparation of a Feasibility Study and EIA Study.

A tender is underway to select the most favorable Consultant for the development of Feasibility studies and environmental studies, and then the project will be implemented with the most appropriate implementation and funding model. The funds for the production of the studies are from a grant provided by KfW Bank.

18. HPP CEBREN

Project type: Electricity production

Power installed: 61.30 - 464.75 MW

Planned annual electricity production: 183 - 1097,30 GWh

The hydropower potential of the Crna River for electricity generation can be exploited immediately after the Pelagonian Basin, from the entrance to the canyon, in Mariovo, to the inflow into the Vardar River. The water solution for the use of Crna River waters in its central and lower flow provides that they will be used for energy purposes. In this location on the river flow has natural conditions for erecting high bulkheads and forming accumulations, which will in turn allow the available decline to be used for energy production - and create the possibility of irrigating spatial areas in the Tikvesh Region.

The Hydropower System (HPS) on Crna River was used at the lower stream before the Vardar river inflow by building the existing He Tikvesh, where 4 units are installed, each of 36 m3/s and installed power of 28 MW. The total installed power of this hydropower plant with a usable 100 m high gross drop is 112 MW and a total turbine expiration of 144 m3/s. The average annual production of HPP Tikvesh is about 150 GWh.

The idea of exploiting the upper course of the Crna River, in Mariovo, is decades old and many studies and projects have been developed so far, on several technical bases for various variants for the construction of HPP Cebren and HPP Galište as downstream plants of the existing HPP Tikvesh. The construction of cascading plants would exploit the hydropotential of the Crna River.

Best ranked pump-storage variant from Prefeasibility Study (prepared in 2017):

Pump Storage Plant (PSP) Cebren + HPP Orlov Kamen

Installed capacity: 458 MW

Annual energy production: 1044 GWh

Annual power consumption: 1011 GWh

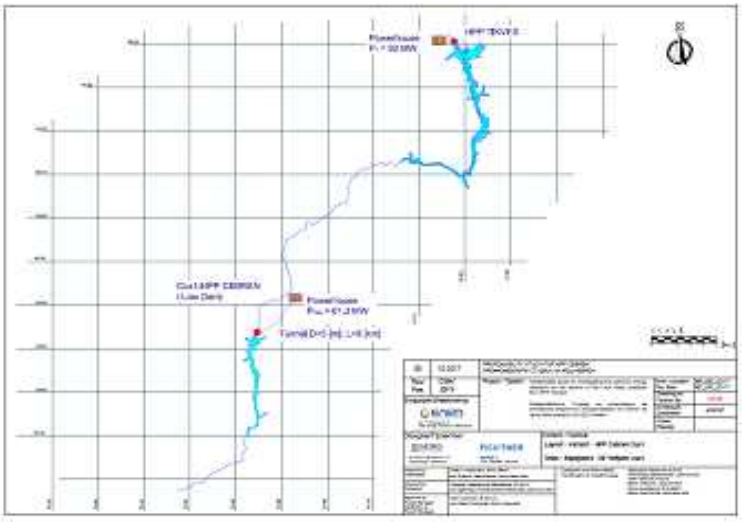
Investment cost: 553 M€

Main benefits from this Project are:

- Providing peaking energy capacity and load management capacities serving the South-eastern Europe region
- Increase of the share of renewable sources in the production of AD ESM from 25% to approximately 45%. Macedonia has obligations towards the European Union to meet the objectives for production from renewable sources in the energy balance, a goal set and supported by all relevant institutions in the country.
- CO2 reduction of approximately 200,000t CO2/year – (0.6674 t/MWh)

Other benefits of the HPP Cebren:

- Flood control of the Crna River and Vardar River in Macedonia and in Greece during periods of high flow
- Regulated flow of Crna River and the possibility of irrigation of vast agricultural areas in the Tikves region as well as in upper Pelagonia region
- Employment of cca. 1700 people during the construction of HPP Cebren
- 65.000 people directly benefiting from the electricity produced and over 2.000.000 indirectly benefiting from peak load and renewables output balancing
- 1.000.000 benefiting from flood control of the Vardar River



19. OPTIMAL ENERGY UTILIZATION OF THE WATERS FROM HPP RAVEN TO KOZJAK STORAGE

Project type: Electricity production

Planned annual electricity production: variant1 (81.78 GWh HPP Kozjak 2 + 120.26 GWh from HPP Kozjak, HPP Sveta Petka and HPP Matka 1) and viranta 2 (127.76 GWh by HPP Kozjak, HPP Sveta Petka and HPP Matka 1 without Lukovo Polje or 146.12 GWh from HPP Kozjak, HPP Sveta Petka and HPP Matka 1 with Lukovo Polje)

Project status: A pre-feasibility study was produced in 2017.

Project Description

The idea of a tunnel that will divert some of the water from the river Vardar into the river Treska, i.e. from the location of Tenovo to the reservoir of Kozjak, is more than 50 years old. Based on the first Study regarding this idea, developed by a Norwegian consulting company, technical documentation was prepared only regarding the Tenovo-Kozjak Tunnel, which provides energy indicators and some financial analysis at today's prices and in North Macedonia's power system completeness. This endeavor of building a tunnel would actually divert part of the waters of the river Vardar, instead through the Polog Plain and Vardar River, to move through the river Treska after being used for energy generation in Treska Hydro-system (HS), and flow into the Vardar before Skopje.

In further support of this idea to build a diversion tunnel in order to divert water from the Vardar into the Treska and use it for power generation, is also the completion of Treska Hydro-system. By building Kozjak HPP (2004) and Sveta Petka HPP (2012) with their reservoirs, as well as with the revitalized and upgraded Matka HPP, the water diverted from the river Vardar would be additionally used in these three hydro-power plants, and it would be pumped into the river Vardar at the estuary of the river Treska before Skopje.

The tunnel envisaged to be build from the location of Tenovo (on the Gostivar-Tetovo stretch) to the Kozjak Reservoir is about 14.5 kilometers long, which is the shortest distance to divert part of the waters from Vardar River to Treska River.

Benefits

- Additional generation in HES Treska
- Possibility of increased production of peak energy
- Flood protection in Polog region
- Water supply in Polog
- Regulating upper Vardar

Meaning of the project:

The realisation of this project would connect the two hydropower systems, Mavrovo and Treska, and round off the energy utilisation of the upper Vardar river. The benefits of this project would be as follows:

Energy benefits

- Additional power generation of power plants at Treska River of about 110 GWh annual average.
- Higher engaged power of Kozjak HPP due to the increased higher elevation operating time of Kozjak Reservoir.
- Operational work of hydro-power plants on the river Treska in high tariff periods as operational plants in a liberalized electricity market, which means a higher income for the power plant and ESM as an operator.
- Opportunities for additional production in newly built hydro-power plants on the Raven-Kozjak stretch.

Other benefits (flood protection, water supply and irrigation need)

- Avoidance of overflows and floods of the river Vardar into the Polog Valley in periods of high water level, where part of the waters would be diverted to Treska River.
- Additional water for water supply of settlements in the Valley of Polog.
- Flow of the river Vardar regulated in its upper stream and a possibility for irrigation of Polog agricultural region.

20. VARDAR VALLEY

Results from the Prefeasibility Study (prepared in 2017) are presented below:

Total Installed capacity 338 MW

Total Generation 1200 GWh

Project Description

The Vardar Valley project is a multi-purpose project that would mean increasing energy production by exploiting water resources, but also strengthening the transport, agricultural, tourism and industrial sectors, all in the direction of sustainable development and environmental protection.

In the lower part of Vardar Valley, 12 hydropower plants are envisaged, including larger ones with medium-sized tanks, namely HPP Veles with an estimated production of about 270 GWh per year and HPP Gradec with an estimated production of 200 GWh/year. The remaining 10 HPP would be cascading along the river, seven hydropower plants, between the Veles and Gradec reservoirs and 3 hydropower plants downstream from Gradec. All are considered flow plants with a total production capacity of about 1,200 GWh per year.

Conclusions of the 2017 prefesibilitis study

At this stage of the study, the development of the lower vardar valley can be considered favorable in terms of geological conditions, construction logistics (access, materials, etc.), as well as environmental and social impact. Average monthly and annual inflows, in each of the twelve hydropower plants, are assessed on the basis of the hydrological period 1961–2010. The maximum energy potential, which depends on the flow of the Vardar River, can be confirmed by this study as 338 MW with an average total annual energy production of 1,197,180 MWh/year. (scenario V01).

The more realistic scenario – V02 processes the assessment, which includes the irrigation obligation and minimal environmental flow, with total energy production reduced by energy loss of -7.6% in view of the cascading system or 1,072,080 MWh/year.

The V03 scenario optimized the installed capacity, thus optimizing the investment cost. The analysis includes a total potential of 300 MW and annual energy production of 991390 MWh/year or -7.5% decrease compared to V02.

A more comprehensive analysis was made for the V04 scenario, increasing the installed power to 360 MW and reducing the investment cost, with annual energy production of 1,075,227 MWh.

The total estimated investment cost for a maximum potential of 338 MW of the 12 hydropower plants (V02) is 1,120m euros, or 50% for construction work, 30% for electrical mechanical, hydromechanical and electrical equipment, 2% for network connection and 18% for land use.

Meaning of the project:

A key goal is to increase its own electricity production by exploiting water resources, while R.N. Macedonia, through the construction of these hydropower plants on the Vardar River, seeks to regulate the following segments – mode and exploitation of water potential, rational space

planning, protection of goods, social aspects, as well as the exploitation of water resources in different ways.

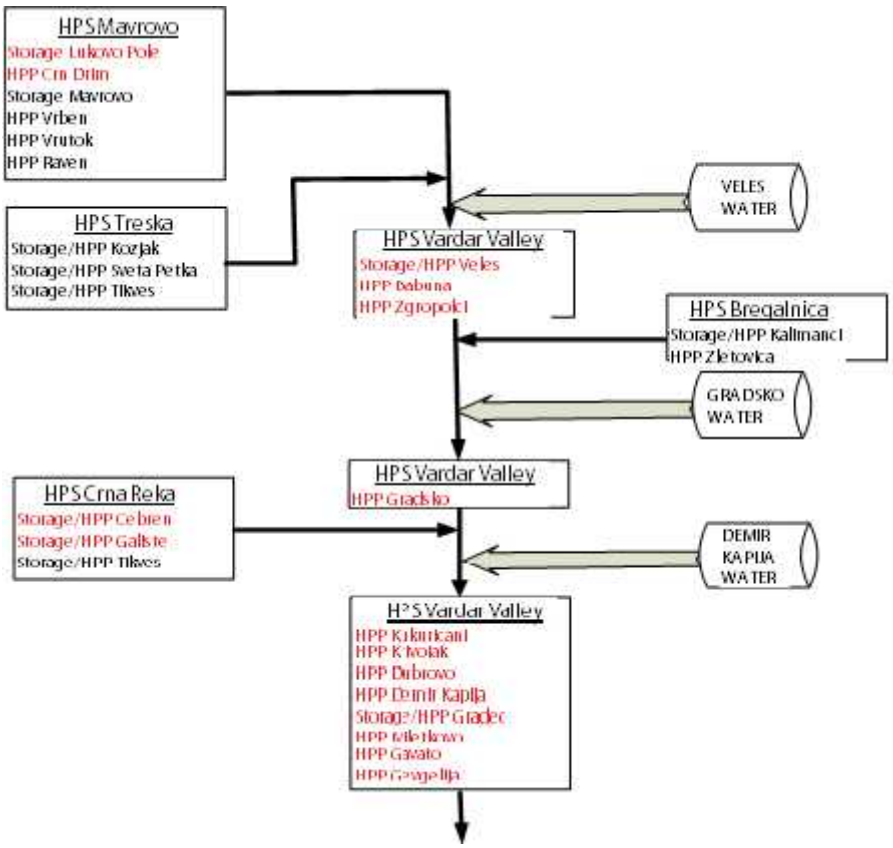
With the construction of HPP on the Vardar River, the following goals are set:

- Change the structure of electricity production by increasing the share of hydropower, i.e. energy obtained from renewable sources.
- Minimize environmental impact using water as a renewable and efficient energy source.
- Reducing the state's energy dependence by building hydropower plants as a domestic energy source.
- Improving flood protection through water bed regulation.
- Prevent ing the reduction of underwater levels throughout the area.
- Promoting national development by exploiting water potential as an efficient source for electricity generation.

Benefits

The water from the accumulations and the small cascade hydropower plants will be used for:

- energy production purposes,
- Irrigation,
- for industrial purposes,
- Flood protection,
- Environmental protection



21. REVITALIZATION OF THE HPP - PHASE III

Project type: Electricity production

Project status: Pre-feasibility study has been completed with an assessment of the necessary equipment and construction activities

Project Description

In parallel with the construction of the new capacities, in the upcoming period AD ESM continues the process of revitalizing and modernizing existing hydropower capacities -PHASE III.

These investments in hydropower plants aim to fully exploit the water potential of existing hydropower plants, modernize all equipment with new ones, following recent technological advances in this area, increasing the power of aggregates, obtaining as much production as possible, reducing current maintenance costs, and ultimately increasing the security and stability of Macedonia's entire electricity system.

Meaning of the project:

The following activities are envisaged in the process of the third phase of modernization of existing hydropower plants as larger activities:

- Procurement, delivery, installation and commissioning of synchronous A&B generators in HPP Globocica
- Procurement, delivery, installation and commissioning of synchronous generator 1 in HPP Spilje
- Replacement of rotor poles of generators G2 and G3 HPP Spilje
- Replacement of rotor poles of generators generators in HPP Raven
- Replacement of conductive wire Al/Fe 150/50mm2 and classic protection wire Fe II35 with protection wire with integrated optical fibers of 35kV line HPP Vrutok - HPP Vrben
- Intake measuring devices for water level (Mavrovo Dam)
- Dam monitoring system upgrade
- Reconstruction of turbine equipment of the aggregates in HPP Vrben .
- Replacement of the turbine bearings and turbine axle in HPP Vrutok
- Servomotor nozzles replacement of aggregates C and D in HPP Vrutok
- Replacement of bushings of the aggregate 1, 2, 3 conducting blades in HPP Spilje and HPP Raven
- Reconstruction of Francis turbine TF 1.65/213-13 wicket gates of aggregates A and B - HPP Globochica
- Replacement of the table gates in the intake structure of the Shar and Gorna Radika region
- Replacement of hydro mechanical and electrical equipment in the gate house of HPP Crn Drim and HPP Tikves
- Reconstruction and repair of the chamber at the joint of the intake from the tailing tanks of the surge thank in HPP Vrutok and the rapid flow
- Reconstruction of the grout curtain of Globocica dam, HPP Globocica
- Reconstruction of the grout curtain of Mavrovo Dam, HPP Mavrovo

21. GAS POWER PLANT BITOLA 250 MW

Introduction

According to the current situation in relation to the insufficiently produced quantities of electricity from its own production capacities (mainly coal TE), the need to analyze possible variants for alternative production from high-efficiency natural gas plants has been imposed.

Given that the development of the pipeline network in the next phase will be implemented according to the scheduled deadlines by the Bitola TPP, the possibility of using natural gas as fuel for a new block in TE Bitola will be analysed in the coming period, while examining the physicality and possible contribution to increasing energy security in the country.

Project Description

A 250MW gas plant with installed power is planned to be designed to operate in a gas/steam cycle in order to achieve the highest efficiency threshold expected to be above 58%.

The basic parameters that characterize the plant are listed in the table.

Techno-economic parameters

Gas Power Plant Bitola - 250MW (combined cycle)	
Fuel	Natural gas
Installed capacity [MW]	250
Threshold production of plant [MW]	225
Necessary natural gas quantity annually [Nm^3]	253.000.000
Plant Efficiency	54%
Operating hours annually [h]	6.000
Nominal load factor	0,85
Annual electricity production [GWh]	1.275

The main prerequisite for the realisation of the project was to bring natural gas to the threshold of the Bitola TPP, and at this time according to the information from NER, the gas network branch towards TE Bitola has a capacity of at least 40,000Nm4/h, creating the possibility of building a gas plant with a capacity of 250MW (according to the assumed efficiency).

According to empirical data on the relative/specific investment of about 0.8 MEUR/MW, capital investments for such a block are expected to be 200MEUR.

The required annual amount of natural gas will depend on the availability of the plant (a maximum of 240,000,000,000Nm4 would be spent in 6,000 working hours).

The annual production of 1275 GWh is expressed as net production ('on the threshold of a plant').

For a 250MW power plant, the production price of electricity will depend most on the price of natural gas to be provided.

To obtain a more complete "picture" in terms of production and economic parameters, a more precise sensitivity analysis will be needed to take into account the most influential characteristics (production, fuel price and capital investments).

In terms of "ecological benefit", it is underlined that natural gas has incomparably more attractive results (low carbon and nitrogen oxide emissions and virtually no emissions of sulfur oxides and dust).

The analysis did not take the possibility of delivering thermal energy to grow agricultural crops or heat facilities, and it is expected to have an impact in the direction of reducing the production price, but with slightly higher capital investments. This option should be further analyzed taking into account the outcome of the Bitola Warmification project, which provides for connections to heat a particular agricultural area.

According to the results of this analysis, and in order to confirm and more accurately analyze the possibility of using natural gas, studies need to be carried out:

Based on the studies produced, a final position will be given on the future direction in which the most favorable option for the production capacity of TPP Bitola would be defined.

It should be noted that natural gas-based energy projects are far more environmentally friendly than all other alternatives to base electricity generation, but due to the relatively higher purchase price of fuel per unit energy value, gas plant production is not yet competitive.

Documentation and activities so far

A brief analysis and previous information about the project has been produced so far.

Current project status

A Project Task for Selecting a Consultant has been developed to develop a Feasibility Study for the Project.

Planned activities in the next period

- Development of Prefeasibility/Feasibility Study: The study should contain a recommendation for a possible solution, the justification of it and the steps to follow for the development of investment–technical documentation.
- Environmental study and audit: If the Prefeasibility Study shows a possible solution that will be techno – economically justified, the next step is to prepare a Feasibility Study, followed by an Environmental Study. This study should be prepared for the proposed technical solution, and in accordance with the laws of the Republic of Northern Macedonia.,
- Basic Project and Audit: The basic project should be drafted in accordance with the law on the construction of the Republic of Northern Macedonia and the accompanying technical regulations, recommendations and standards applicable in the Republic of Northern Macedonia. The adoption of the Basic Project by the Investor should be conditional on a positive audit by a reputable institution.

Summary

The benefits of such a project are in ensuring the base production of electricity, i.e. increasing the capacity of the Bitola TPP by an additional 250MW and meeting high environmental standards.

An additional justification for the realization of the project is that it will be a partial substitution of some of the blocks in REK Bitola, which will cease operations over the next 20 years.

Proposed site (nearby TPP Bitola)

23. ТОПЛИФИКАЦИЈА НА БИТОЛА, МОГИЛА И НОВАЦИ-ПРВА ФАЗА

Project type: Production and distribution of heat ing energy for heating
Power installed: 100 MW
Planned annual heat production: about 125,000MWh
Project status: Project consultant selected

Project Description

The central heating system provides for the production of heating energy by way of deprivation of steam from turbines 2 and 3 in TE Bitola. With the means of transport heating, which passes through arable agricultural land – next to the settlements of Novaci and Logovardi, a length of 12.83km, will provide a supply of thermal energy to the city of Bitola.

The steam taken from the turbines, through heat exchangers (steam – water), generates heat that is transmitted through the transport heat to the primary pumping station in the city of Bitola.

The distribution of thermal energy in Bitola is planned to be implemented with a primary and secondary hot water network to final consumers. The distribution heating line (DV) from REK Bitola to the municipality of Bitola is constructed from previously isolated pipes with a leak detection system. The temperature mode of the heat carrier is defined at 115/700C (inlet temperature 1150C, return temperature 700C).
The Bitola, Mogila and Novaci warming project consists of the construction of:
1) Thermal energy production system (TS-REK)
2) transport hotwater (TV),
3) primary pumping-heat station in Bitola (PPTS),
4) hot water distribution network (VDM) in Bitola
5) thermal substations (TP) in objects.

Meaning of the project

The realisation of this project will allow for the replacement of the use of electricity for heating, thereby increasing the security and continuity of the transmission and distribution electricity network.

It can be noted that this project will affect:

- Reducing emissions from burning firewood, burning oil for households and coal in small domestic stoves, but also in the stoves of public and commercial facilities, while also reducing SOx, NOx, CO, etc.;
- Reduction of CO2 emissions;
- Increase in ambient air quality;
- Reducing the likelihood of possible inadequate treatment of waste oil in preparation, which is used for heating;
- Reduction of various respiratory diseases;
- Increasing quality and service of living;
- Reduction of electricity consumption used for space heating;
- Reduction of losses in the distribution of electricity to low voltage and high voltage network;
- Optimization of energy resources used to heat spaces in individual facilities.

Investment investments

The total value of the project according to the study is 87.73m euros, up from 66.65m euros for the first phase. Given the revision of the accession factor and the increasing concentration of consumption for the first phase for the city of Bitola, the costs at this stage will be lower than the originally predicted value. In co-operation between the Implementation Team of AD ESM and the Faculty of Mechanical Engineering – Skopje, a new project task was developed with a new thermal consumption in the first phase of 100 MW and a reduced cross-cross-border heat pipeline from 700mm to 500 mm. On the basis of such an offered solution, the developer of the basic project continued its development in this regard. The investment for the above-mentioned solution will be about 46m euros. In the direction of realising the project on 29.12.2015, a loan agreement was signed with the KfW Bank of 39 Meuros.

24. NUCLEAR ENERGY PROGRAM

Description

The project can be divided into 6(six) main tasks – a brief description of each task is given below. The content of the tasks is chosen to cover all the objectives of this project

Task 1 - Options and directions in nuclear energy

Taking into account the activities after all tasks of the Project, the purpose of this task is to bring preliminary assessments and opinions on the possibilities of using nuclear energy facilities for the needs of North Macedonia.

This task covers the following alternative options that need to be analyzed:

a) Construction of nuclear energy facilities on the territory of North Macedonia with partial participation of foreign investors;

b) Construction of nuclear energy facilities on the territory of North Macedonia owned by foreign investors, and managed by foreign organizations;

c) Participation in financing and construction of nuclear facilities outside North Macedonia, with the possibility of using an appropriate part of the produced electricity in North Macedonia;

Task 2 - Review of required IAEA regulations and documents

The purpose of this task is to review relevant IAEA (International Atomic Energy Agency) documents targeting countries embarking on a nuclear energy program, including the following documents:

a) Documents that provide guidance to countries on developing nuclear programs;

b) Documents relating to the preparatory work for the start (commencement) of a nuclear energy program;

c) Documents explaining the responsibilities of the Government, state and other organizations in relation to the peaceful use of nuclear energy;

d) Documents and information that should serve to guide the work of the Project;

e) Other relevant documents

This task aims to ensure a regulated, systematic and legal process for entering the nuclear energy program and for cooperation with countries that already have a nuclear program, in accordance with international regulations adopted by the IAEA and other international organizations.

Task 3 - Overview of nuclear energy in the world and in relevant countries

Within this task, relevant situations have been chosen and reviewed for entering the nuclear energy program in selected countries of interest to Macedonia. Also, in this task trends for the implementation of nuclear energy in the world have been reviewed, and plans of new buildings that are published by various international organizations.

The research of nuclear programs in certain countries has been used to find an optimal way to make an appropriate decision in North Macedonia. In the selected countries are neighboring Balkan countries and beyond, which are similar to North Macedonia in accordance with relevant criteria. The purpose of this task is to use the experiences of these countries and apply them in the decision-making process of launching the nuclear energy program in North Macedonia.

Balkan countries are of special importance for North Macedonia for several reasons, of course in terms of possible regional cooperation and partnership for joint participation in investment projects as well as in educational and scientific activities. This task also includes other countries outside the Balkan regional activities that are considered to be interesting for cooperation with North Macedonia (for example Jordan, Turkey, etc.).

Task 4 - Cooperation with the IAEA

The purpose of this task is to cooperate with the IAEA, which would serve to gather the necessary information, opinions and suggestions for the work on all tasks of this project, and at the same time to meet international regulations and requirements for cooperation on issues of peaceful use of nuclear energy.

Cooperation with the IAEA is highly necessary in terms of experience for new countries to enter the nuclear energy program, as well as to ensure adequate compliance with the recommendations, international requirements and obligations of countries entering the nuclear energy program, which are prescribed by the IAEA and other international organizations. Also, the cooperation with the IAEA in the project is aimed at finding opportunities to provide financial assistance for the work and requirements of this project in the coming years.

Within this task, meetings were organized with the relevant experts and IAEA managers in order to discuss relevant topics from the work of this project, to obtain opinions and suggestions from the review of the results of the work, and to receive recommendations for further activities in the following years.

Task 5 - Planning for the construction of the nuclear infrastructure

The purpose of this task is to review the legal normative acts and other organizational preparations that North Macedonia needs to consider for decision-making on entering the nuclear energy program. Within this task, various legal and other needs were considered for establishing the infrastructure for deciding to enter the nuclear energy program, as well as the infrastructure for supporting the nuclear energy program after entering it. Here are included activities to establish an organization for the preparation of decision-making materials, site selection activities, nuclear regulation organization, decision-making and licensing procedures, preparation of financial institutions and financing models, development of industrial facilities, educational activities for formation of staffing, etc.

One element of this task is to identify a preliminary timeframe for completing the preparatory work for decision-making and to support the development of the nuclear infrastructure after a positive decision has been made.

Task 6 - Information activities and public relations

The purpose of this task is to organize informative activities with the professional and scientific public in North Macedonia and other countries in the region and abroad, in particular:

1. To organize educational presentations for information and introduction of the professional and scientific public in North Macedonia with various topics in the field of nuclear energy, including the benefits and implications of entering a nuclear energy program;

2. To maintain regular contact(communication) with the Government of R. of North Macedonia for systematic and continuous reporting on the progress of the project, the results of the work, and opinions on relevant key issues; and

3. To maintain contact with the scientific and professional public in North Macedonia, in order to exchange views on the results of the project work, and on the possibilities of entrance of North Macedonia in the nuclear energy program.

Completed activities

Below are the activities completed so far within this project :

1. Two projects for technical cooperation with IAEA with a duration of 4 years (2 + 2)
2. Energy planning of electricity consumption by 2030
3. Energy planning of electricity supply until 2030
4. Initial development of the nuclear energy infrastructure
5. Conceptual project for human resources development for a nuclear power plant
6. Conceptual project for hydrology and cooling of a nuclear power plant
7. Conceptual design for seismicity of potential locations for a nuclear power plant
8. Conceptual project transport of equipment to potential locations for a nuclear power plant
9. Cooperation with regional countries (Slovenia, Croatia, Albania, Bulgaria)

In all these activities, two types of nuclear power plants with a capacity of 1000 MW and 300 MW (small modular reactors) were analyzed. A NPP with a capacity of 300 MW would be a more realistic option for implementation after 2040, as the development of these reactors is envisaged for countries with lower economic power.

Future activities

The main next steps would be:

1. Continuation of cooperation with the IAEA
2. Development of nuclear infrastructure in all 19 areas
3. Preparation of a Pre-feasibility study for implementation of a nuclear power plant with emphasis on small modular reactors
4. Preparation of a Seismicity Study at potential locations for construction of NPP
5. Preparation of a Human Resources Study for a nuclear energy program
6. Preparation of a study for hydrology and cooling of potential locations for a nuclear power plant
7. Preparation of a study for transport of equipment to potential locations for NPP
8. Monitoring the development of small modular reactors
9. Establishment of NEPIO (Nuclear Energy Program Implementation Organization)

Summary

Stable and independent production of electricity in N. Macedonia after 2040 will be uncertain, because coal reserves will be depleted. As a realistic option for meeting electricity needs and providing base energy after 2040 would be the nuclear option.

In addition, global energy trends are emphasizing the transition to a low-carbon economy. For such a transition, one of the most important factors is the production of electricity from two types of sources - renewable energy sources and nuclear power plants.

In addition to conventional nuclear power plants, small modular reactors are currently under development, designed for countries with low economic power. In some countries, a kind of modular reactors have already been implemented, and by 2040 we would have a complete picture of their development, implementation, management and operational stability.

AD ESM as the largest producer of electricity in North Macedonia needs to analyze this nuclear possibility in the long run, whether it implements a nuclear power plant or not.

The development of a nuclear energy program requires a long-term and systematic commitment, and therefore monitoring nuclear trends, cooperating with neighboring countries and countries that use nuclear energy, is of high importance.

Cooperation with the International Atomic Energy Agency is also very important, as it provides technical and financial assistance in the research and development of nuclear energy infrastructure.