MEPCO

Investment and Development Division

TEN YEARS NETWORK DEVELOPMENT PLAN PERIOD 2021 - 2030

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Title: TEN YEARS NETWORK DEVELOPMENT PLAN
PERIOD 2021 – 2030

Authors: Strategic Planning and Development Analyses Unit
Connections Unit

Context

1. INTRODUCTION

MEPSO as electricity transmission system operator, pursuant to Article 83 from the Law on Energy (Official Gazette of the Republic of Macedonia No.96/18 and Official Gazette of the Republic of Macedonia No.96/19) is obliged to prepare a plan for development of the power system for the subsequent period of 10 (ten) years, whose content has to be in compliance with the Grid Code for electricity transmission.

MEPSO in 2016/2017 carried out a study on the development of the transmission grid titled "Study on development concepts of the transmission grid in different regions for a long-term horizon" that represents an update/definition of the development plans for the electric power system (EPS), as MEPSO's obligation in correspondence to the legislation of the state.

The Study analyses future possible working conditions and it is prepared by use of a deterministic approach with more scenarios. The scenarios are defined for different time horizons (2020, 2025, 2030, and 2040) depending on factors like construction of power plants, system loading, hydrology, engagement of the plants that use renewable energy sources (RES – especially wind power plants), construction of power plants in the distribution network, etc. The final aim of the analysis of more scenarios is to fulfil the following basic principles:

- reliable electricity security
- reliable accessibility and capacity of the Macedonian transmission network for a uninterrupted flow of the activities of all of the participants in the electricity market (producers, traders, and suppliers, as well as other subjects);
- connection of new consumers to the transmission grid under equal, transparent, and non-discriminatory conditions;
- connection with the neighbouring transmission system operators, hence enabling connection to the neighbouring electricity market operators;
- integration of new power plants that use RES.

The future configuration of the Macedonian transmission network should be sufficiently flexible and resilient, in order to enable accomplishment of the above-mentioned principles with as little insecurity as possible. To provide the prior, it is necessary to:

- Continuously invest in the reconstruction and revitalization of the deteriorated elements of the transmission grid;
- Invest in construction of new facilities in the transmission grid (transmission lines, transformers (TR), information technology infrastructure, etc.) based on the criteria prescribed in the Grid Code;
- Invest in undertakings that will enable better utilization of the exciting and construction of new necessary cross-border capacities;
- Use modern technologies for transmission of electricity, such as utilization of new low sag conductors during revitalization and increase of the transmission capacity in the existing transmission lines (TL), possible installation of units based on power electronics (FACTS), possible installation of face shifting power transformers (control over the active power flow), etc.

Constantly promote and improve human resources due to obligational participation in the European processes under ENTSO-E and participation in other international organizations (CIGRE, IEEE, etc.).

The greatest risks for a successful realization of the previously listed principles and planned activities are the uncertain flows in the economy, constraints upon physical and regional planning and ecological demands, insecurities regarding the construction of new generation facilities, and uncertainties in the stable financing of all necessary activities. MEPSO prepares a study or environmental impact assessment with detailed analysis for all infrastructural projects as per the Law on Construction. In the procedures of preparation and realization of all projects, MEPSO pays close attention to protection of the flora and fauna.
MEPSO in September 2019 prepared a Study on reconstruction/revitalization of the transmission grid. Taking into consideration that a great number of the transmission lines of the Macedonian transmission network were built 40-50 years ago, one may expect that after 2020, a large number of the lines will be candidates for reconstruction/revitalization. Therefore, when making a schedule for reconstruction of the lines, besides the age of the lines, their significance for the secure operation of the transmission network should be taken into consideration, as well. Consequently, the focus of this Strategy was pointed towards two key factors:

- preparation of database about the condition of the functional units of the transmission lines which resulted in estimation for the condition and the urgency of undertakings on certain parts, thus forming priority list; and

- determination of the methodology that includes a schedule of works set up in given periods (2025-2030, 2030-2035, 2035-2040), created by deterministic approach, therefore carefully planning the schedule paying attention to all security criterion for grid operation.

So, the schedule of works on the lines during the periods 2025-2030, 2030-2035, 2035-2040 was prepared by taking into consideration the condition of the transmission lines, as well as their significance to the power system. Additionally, the recommendations from the already prepared development plans and studies in MEPSO were considered. The geographical connection of the lines was also acknowledged.

Although the average age of the transmission lines is relatively high and it is estimated to be 42 years, almost 2/3 of them have above-average good grades regarding their condition which indicates that they have been properly maintained. The total amount of investments for the three periods is 47.2 million euros, while the complete length of the transmission lines suggested for reconstruction/revitalization is 560 km. The mean value of the investments is 15.8 million euros, while the mean length is 187.5 km. Both the investments and lengths are equally allocated in periods, at an interval from ±10% from the mean value.

The development plan for the transmission grid for the period from 2021-2030 represents an updated version of the analysis and results from the two studies, giving a display of the state of the completed projects, projects which are in implementation phase, and the necessary measures and investments that need to be undertaken in the next 10 years.

2. CONDITION OF THE TRANSMISSION GRID IN 2020

A well-developed transmission grid with a large number of rings (contours) on two voltage levels: 110 kV and 400 kV is a key for the integration of producers and consumers in the power system.

The transmission grid consists of transmission lines, transformer substations as well as the overall accompanying primary and secondary high voltage equipment. Table 1 shows the given lengths of transmission lines in the transmission grid by voltage level, while Table 2 shows the number of transformer substations by voltage levels.

Table 1. Length of the transmission network by voltage level

Voltage level [kV]	110 kV	400 kV
Length [km]	1544,7	577,033

Table 2. Number of transformer substations by voltage level

Nominal voltage ratio	110/x kV	400/110 kV
Number of substations	73	5

The 400 kV transmission lines are the backbone of the Macedonian transmission grid. They form a 400 kV ring comprised of three transmission lines that connect the largest consumption concentration located in the northern part of the country with the largest production facilities located in the southeast region of the country. Moreover, the 400 kV transmission lines are used for interconnection between the neighbouring power systems. The transmission grid of 110 kV is the most outspread and the most developed one. It connects the large hydroelectric power plants and thermal power plants, all of the larger populated places, as well as the industrial parks. The connection between the 400 kV and 110 kV transmission networks is realized via five substations: SS Skopje 4, SS Skopje 5, SS Bitola 2, SS Dubrovo, and SS Shtip.

The Macedonian power system is connected with the neighbouring systems via 400 kV interconnections. With the market development, the interconnections acquire a role of major energy corridors through which a significant number of electricity transactions are realized.

On the northern side, towards Kosovo operates the 400 kV transmission line SS Skopje 5 - SS Ferizaj (Uroshevac), while with Serbia the connection is done via the 400 kV transmission line SS Shtip-SS Vranje. In the past, two more 220 kV transmission lines operated SS Skopje 1 - SS Kosovo A, as well as 110 kV transmission line SS Skopje 1 - SS Shari. Since 1999, these transmission lines have been out of operation due to damage. The development plans do not foresee their reconstruction, but only the corridors will be used for future construction of transmission lines.

The Macedonian power system is best connected with Greece. The Macedonian and Greek power systems are interconnected with two 400 kV interconnecting transmission lines: SS Bitola 2 - SS Lerin (Florina) and SS Dubrovo - SS Solun (Thessaloniki).

Towards the eastern side, after the 400 kV transmission line SS Shtip – Chervena Mogila was built, we have commenced mutual and synchronized collaboration with the Bulgarian power system. Until then, between the systems had occurred occasional electricity exchanges in an “islanding” operation, using the two 110 kV transmission lines SS Kriva Palanka –SS

Skakavica and SS Sushica-SS Petrich. Currently, both of the 110 kV transmission lines are still functioning but in an island mode.

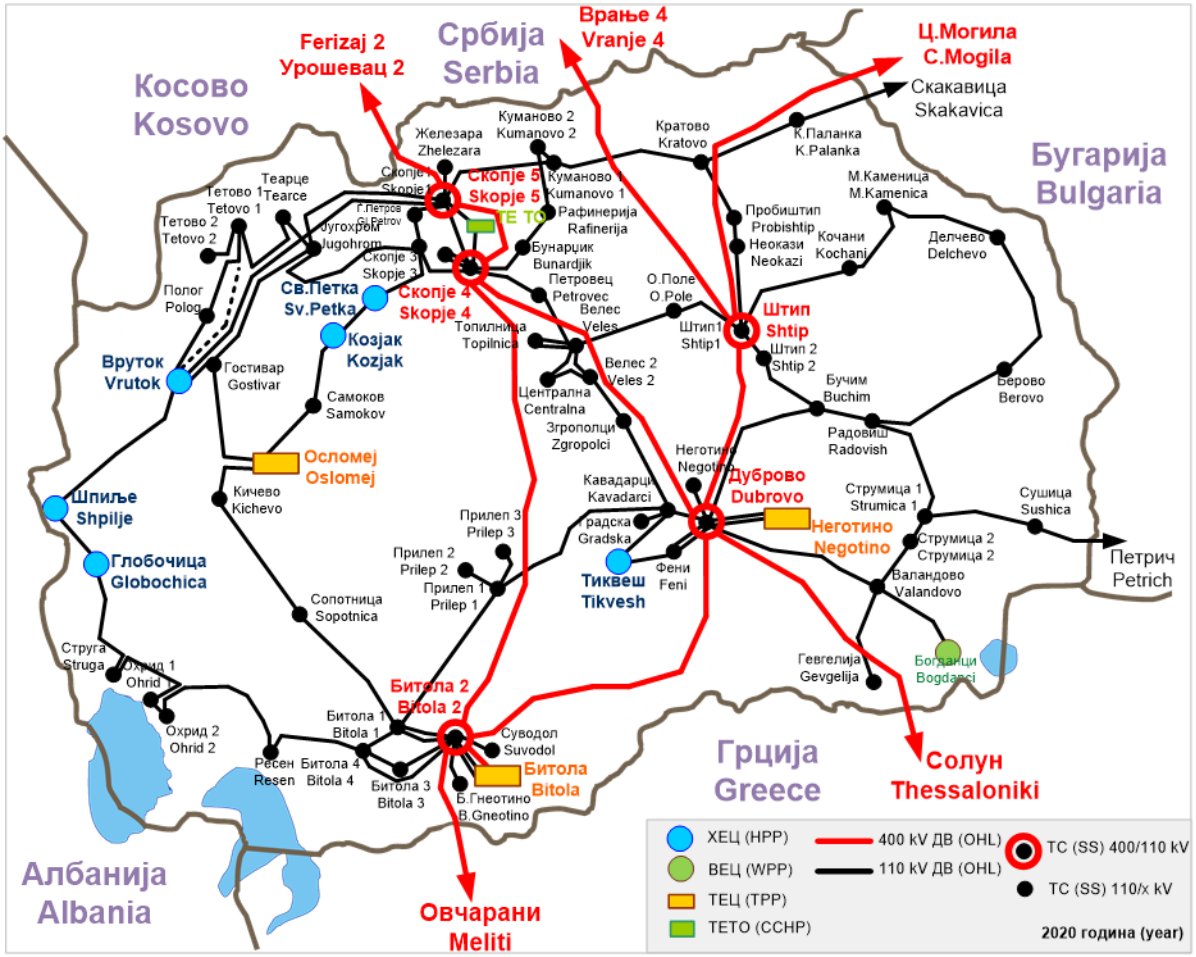


Figure 1. Topology of the transmission network in 2020

The following figures are of illustrated parameters from operating regimes with high loads in the transmission network.

The transmission network has good voltage profile (Figure 2), the voltages from the 110 kV nodes are close in value to the nominal voltage. A slightly lower voltage profile appears in the southeast region, Ohrid - Prespa. The problem arises from the long serial connection Globochica – Struga – Ohrid 1 – Ohrid 2 – Resen – Bitola 4 where a huge voltage outage appears. The voltage profiles will improve after the construction of the new 400/110 kV SS Ohrid (see 0 and 4). Similarly, the voltages are lower in the southeast region, Valandovo – Strumica due to a lack of generation facilities that support the voltage profile. The project for strengthening of the transmission network in the southeast region and construction of new RES (see 5.3) will mend the voltage conditions.

There are no transmission lines in the network whose load exceeds the permitted voltage levels in a normal working regime (without outages). The 110 kV lines which transmit electricity from the power plants and/or main 400/110 kV generation busbars towards the remaining consumers in the network are the most loaded.

Table 3 depicts the values of the short-circuit currents in different nodes from the transmission network. High voltage values of short-circuit currents, around 30 kA appear in the region of Skopje. In order to reduce the short-circuit currents, sectioning of the 110 kV busbars in the main substations SS Skopje 1 and SS Skopje 4 is planned (see 5.1).

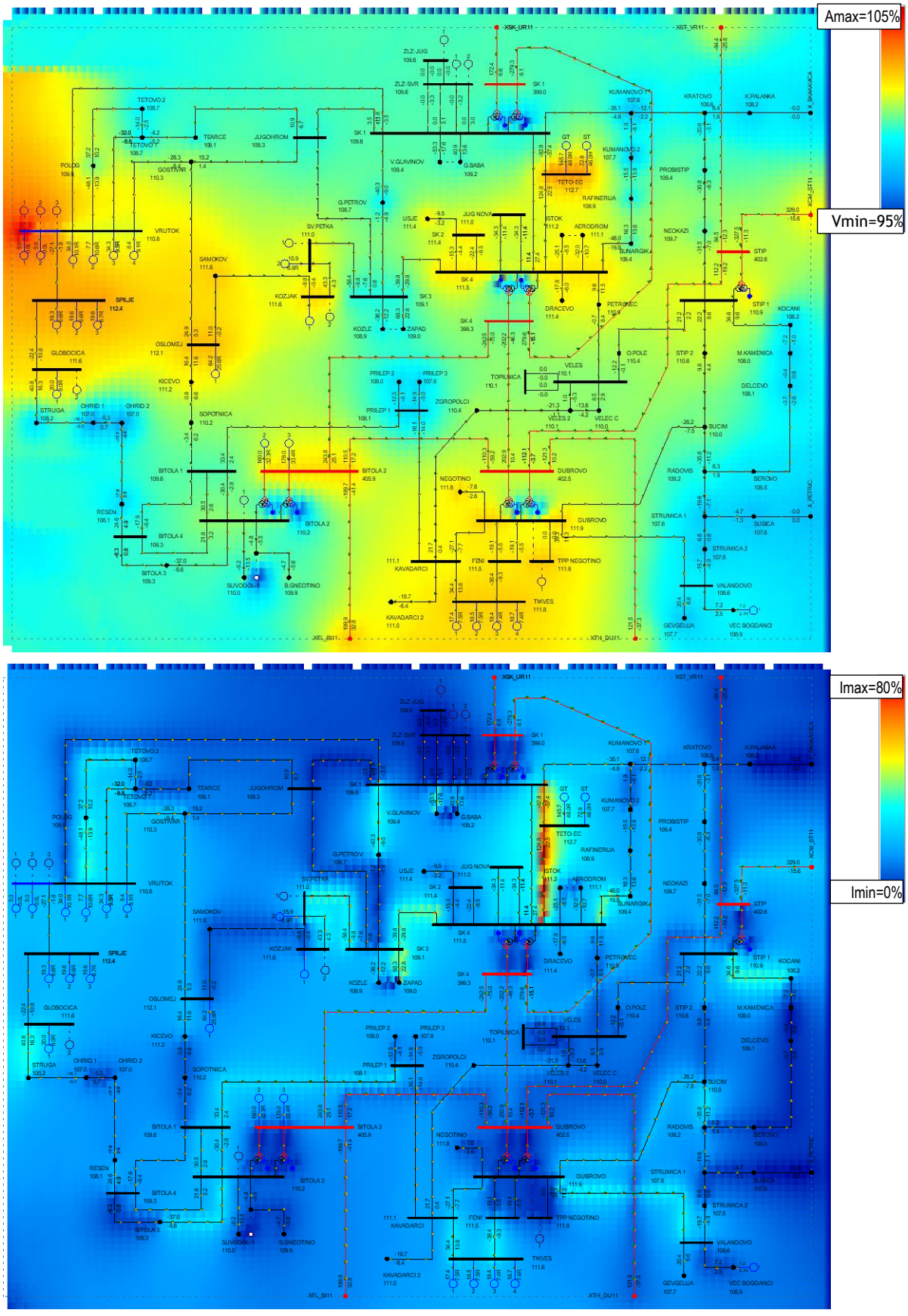


Figure 2. Operating regimes with high loading in 2020 - voltage profile and loading of lines

Table 3. Maximum values of the short-circuit currents in the transmission grid in 2020

Јазел	U [kV]	3-СКВ [kA]	1-СКВ [kA]
BITOLA 2	400	17.5	15.1
DUBROVO	400	17.3	14.1
SK 4	400	14.5	13.3
STIP	400	14.1	11.9
SK 1	400	13.6	12.3
SK 4	110	29.5	32.9
SK 1	110	28.4	31.7
ZLZ-SVR	110	25.7	26.0
DUBROVO	110	23.6	28.1
TETO-EC	110	22.9	27.8
SK 2	110	22.0	20.9
ZLZ-JUG	110	22.0	20.5
BITOLA 2	110	21.8	26.8
V.GLAVINOV	110	21.1	19.9
DRACEVO	110	20.2	17.1
TPP NEGOTINO	110	20.1	20.5
JUG NOVA	110	17.5	15.4
USJE	110	17.2	15.0
SUVODOL-1	110	15.9	13.6
BITOLA 1	110	15.8	14.4
STIP 1	110	15.2	17.8
G.BABA	110	15.1	13.6
FENI	110	15.0	13.6
KAVADARCI	110	14.3	13.0
TIKVES	110	14.1	13.4
BITOLA 4	110	13.6	12.7
SK 3	110	13.6	13.3
NEGOTINO	110	12.9	11.1
AERODROM	110	12.7	10.8
ISTOK	110	12.5	9.8
ZAPAD	110	12.5	12.1
KAVADARCI 2	110	12.2	10.5
G.PETROV	110	12.1	10.6
BITOLA 3	110	11.8	10.2
PETROVEC	110	11.4	9.8
STIP 2	110	11.3	10.4
VRUTOK	110	11.0	12.6
KOZLE	110	10.8	9.8
MILADINOVCI	110	10.1	7.1
JUGOHROM	110	9.8	10.1
GOSTIVAR	110	9.4	9.3
OSLOMEJ	110	8.9	9.7
VELES	110	8.9	8.8
BUNARGIK	110	8.8	8.0

Јазел	U [kV]	3-СКВ [kA]	1-СКВ [kA]
BUCIM	110	8.7	6.9
TEARCE	110	8.7	8.3
VELES 2	110	8.7	8.5
B.GNEOTINO	110	8.4	7.0
KUMANOVO 1	110	8.4	8.9
TOPILNICA	110	8.3	8.1
VELEC C	110	8.2	8.0
O.POLE	110	8.1	6.5
POLOG	110	7.8	7.8
KUMANOVO 2	110	7.8	7.8
RAFINERIJA	110	7.8	6.9
ZGROPOLCI	110	7.6	6.2
SV.PETKA	110	7.5	7.3
TETOVO 1	110	7.5	8.0
TETOVO 2	110	7.3	7.5
KOZJAK	110	6.9	7.2
RADOVIS	110	6.8	6.1
SAMOKOV	110	6.4	6.1
NEOKAZI	110	6.1	6.1
KICEVO	110	6.1	5.1
PRILEP 1	110	6.0	5.8
PROBISTIP	110	5.7	5.7
PRILEP 2	110	5.6	5.3
SOPOTNICA	110	5.5	4.2
SPILJE	110	5.3	5.7
VALANDOVO	110	5.3	6.2
KRATOVO	110	5.1	4.3
RESEN	110	5.0	4.7
PRILEP 3	110	4.9	4.5
STRUMICA 1	110	4.8	5.5
STRUMICA 2	110	4.8	5.4
KOCANI	110	4.6	4.6
GLOBOCICA	110	4.5	4.8
VEC BOGDANCI	110	3.8	5.6
M.KAMENICA	110	3.5	3.2
BEROVO	110	3.5	2.9
OHRID 2	110	3.4	3.7
STRUGA	110	3.4	3.6
OHRID 1	110	3.4	3.8
DELCEVO	110	3.2	2.9
GEVGELIJA	110	3.1	3.5
SUSICA	110	3.1	2.8
K.PALANKA	110	3.0	2.5

3. PROJECTS COMPLETED IN 2020

In 2020, MEPSO faced the challenge by the COVID-19 pandemic. MEPSO came to a crossroads between providing secure, reliable, and stable (secure) operation of the transmission grid and constant realization of the capital investment projects and studies. A great number of the projects were successfully conducted according to the expected dynamic. However, the pandemic with the COVID-19 virus was a reason for prolonging the realization period for some projects and studies, but without financial implications.

3.1. RECONSTRUCTION AND REVITALIZATION OF TRANSMISSION LINES

Following the plan for reconstruction and revitalization of transmission lines, the SS Shtip - SS Probishtip transmission line with a length of 25.2 km was renovated in 2020. The project was financed by EBRD's loan (44114) and MEPSO's funds.

3.2. RECONSTRUCTION AND REVITALIZATION OF SUBSTATIONS

The reconstruction and revitalization of the equipment in the substations in 2020 runs smoothly and according to the planned work dynamics.

With the revitalization of the 110 kV switchyard in SS Dubrovo included replacement of the old primary and secondary equipment, which was in function since 1977. This complex project covered replacement of primary equipment (circuit breakers, disconnectors, and current and voltage measurement transformers), as well as the revitalization of the secondary equipment on 400 kV and 110 kV voltage level that includes delivery and installation of relay protection systems, for remote supervision and control, systems for AC/DC supplies and complete revitalization of the electricity measuring system.

In SS Valandovo and the substation within TPP Oslomej was replaced part of the high-voltage equipment (circuit breakers, disconnectors, and metering transformers) and secondary equipment.

In SS Prilep was replaced part of the high-voltage equipment (circuit-breakers, disconnectors, and metering transformers) and secondary equipment.

The relay protection was replaced in the substations connected to the power plants: HPP Tikvesh, HPP Vrutok, HPP Globochica, and HPP Shpilje.

As part of the project for revitalization of the primary equipment in part of the 400 kV substation owned by MEPSO, in SS Bitola 2 was obtained new 400/110 kV power transformer with automatic voltage control, with a nominal power of 300 MVA. The installation of this new transformer increases the reliability of the substation, reduces power losses in the transmission network, and lowers the costs for maintenance of the installed transformers in SS Bitola 2.

3.3. PROJECTS FOR POWER SYSTEM MODERNIZATION

The Wide Area Monitoring System (WAMS) enables prompt detection of deviation from the operational safety margins. WAMS is based on real-time phasor and current measurement units, simultaneously using GPS synchronization.

With this project was established a system for assessment of precise information about possible violations in the synchronously connected power system in real-time, and it will enable the undertaking of proper corrective measures.

The realization of the project included determination of optimal locations for installation of WAMS in order to deal with the stability problems of the power system via high-quality supervision in real-time, WAMS installation with the necessary technical specifications, and

installation of the central unit in the National Dispatch Centre with dynamic system stability control.

Figure 3. Fieldwork activities – substations and transmission lines

4. NEW INTERCONNECTONS TOWARDS THE NEIGHBORS

Interconnections bring benefits that reflect incomes like an increase of the cross-border transmission capacity, boost in transits among the power systems from the region, decrease of electricity losses, and electricity price balancing in the region. Besides the above-mentioned fundamental benefits, there are other positive impacts regarding the social values such as improved supply reliability, cut investments in generation facilities for national system reserves, regional dispatching and reduced generation costs, as well as generation of reactive power.

4.1. 400 KV INTERCONNECTION MK – AL

The realization of Corridor 8 is of great significance for our country. Regarded from the geostrategic aspect, Corridor 8 is an integral part of one much larger and exclusively significant project that includes exploitation of energetic sources from the Caspian region and Central Asia. Therefore, a "Joint Statement for Energy Infrastructure Cooperation" was signed on 13 April 2005 in Sofia by the Ministers from the energy sector of Albania, Bulgaria, Italy, and North Macedonia, whose aim is to support the implementation of the energetic infrastructural projects according to the EU legislation including the projects of Trans-European Networks (TEN) and in the European-Mediterranean Energetic Ring.

From power engineering aspect the 400 kV interconnecting overhead transmission line Bitola (MK) – Elbasan (AL) represents the last part from the realization of Corridor 8 (East-West) for transmission of electric power between Bulgaria, North Macedonia, Albania, and Italy. The part between BG and MK is completed, and the realization of the submarine cable between IT and ME is in progress by now completed the first phase and installed capacity of 600 MW from foreseen 1200 MW. The 400 kV interconnection between AL and ME and AL and KS are already in service.

Regarding the development of the Macedonian transmission grid, the problems that exist in the south-western part of the transmission grid will be solved with the construction of a new 400/110 kV transformer substation in the Ohrid-Struga region with in/out connections to the new 400 kV transmission line Bitola (MK) –Elbasan (AL).

400 kV transmission line MK-AL has regional significance and PECI status (Project of Energy Community Interest), by a decision made by the Energy Community Ministerial Council from 14 October 2016.

The project is presented in Table 12, positions 1 and 2.

4.1.1. Technical Specifications

The project for the 400 kV interconnection MK-AL on the Macedonian territory is comprised of:

- 400 kV transmission line from SS Bitola 2 to the Macedonian/Albanian border,
- 400/110 kV SS Ohrid, and
- 400 kV transmission bay in SS Bitola 2

Technical specification of the Macedonian part of the 400 kV transmission line Bitola (MK) – Elbasan (AL) are given in Table 4.

Table 4. Technical specification of 400 kV TL SS Bitola – MK/AL border

Nominal voltage	400 kV
Length on Macedonian territory	97,409 km
Type of towers	Steel-lattice tower, type "Y"
Total number of towers	269
Type of conductors	ACSR 490/65 mm2, 2 conductors by phase
Type of ground wires	One with AWG 19/9, 126.1 mm2, other with OPGW
Altitude	550 – 1200 mnv
Middle span	358,26 m

Figure 4. 400 kV interconnection TL SS Bitola 2 – Macedonian-Albanian border and SS 400/110 kV Ohrid route

The 400/110 kV SS Ohrid is planned to be built near the village of Mesheishta. Power transformer is planned to be installed in the substation with apparent power of 300 MVA, and will be comprised of:

Table 4. Structure of 400 kV and 110 kV switchyard 400/110 kV SS Ohrid

400 kV facility:	110 kV facility:
1. Coupling bay 2. TL bay "SS Elbasan 3" 3. SS bay 1 4. Auxiliary SS bay 5. Auxiliary TL bay 6. TL bay "SS Bitola 2"	1. Coupling bay 2. TL bay "SS Struga" 3. Auxiliary TL bay 4. SS bay 1 5. TL bay "SS Ohrid 1" 6. TL bay "SS Ohrid 2" 7. TL bay "SS Resen" 8. Auxiliary TL bay 9. Auxiliary SS bay 10. Auxiliary load

4.1.2. Financial and Economic Parameters

Feasibility Study for 400 kV Interconnection MK-AL

The financial and economical parameters by the Macedonian part of the project according to the Feasibility *Study 400 kV interconnection Bitola-Elbasan* completed in January 2013, are shown in the following Table:

Table 5. Financial parameters of the 400 kV interconnection Bitola (MK) – Elbasan (AL)

Main indicators:	MK
Required investment	43.500.000 EUR
Net present value (NPV)	6.300.000 EUR
Simple Payback period	15 years
Benefit Cost Ratio	2.6
Intern Rate of Return (IRR)	12,5 %

The estimated investment value for the Macedonian part of the project, according to the *Feasibility Study for 400 kV interconnection Bitola-Elbasan* is the following:

Table 6. Estimated investment for components of the 400 kV interconnection MK – AL

1. 400 kV transmission line from SS Bitola 2 - MK/AL border	28,3 MEUR
2. 400/110 kV SS Ohrid	14,3 MEUR
3. 400 kV transmission line in SS Bitola 2	0,85 MEUR
TOTAL	43,5 MEUR

Provided funds for implementation of the Macedonian part of the 400 kV interconnection Bitola-Elbasan

For the realization of the project, the Western Balkans Investment Framework (WBIF) approved the following three grants:

- WBIF regional grant for technical support (WBIF4bis-REG-ENE-01) – 803.000 euros
- The following studies were prepared as part of this regional grant:
- Feasibility Study for 400 kV interconnection Elbasan (AL) – Bitola (MK)
- Studies on Environmental Impact Assessment of the 400 kV TL SS Bitola 2 – Macedonian/Albanian border
- Studies on Environmental Impact Assessment of the 400 kV TL SS Elbasan 3 – Albanian/Macedonian border
- WBIF grant for technical support (WB9-MKD-ENE-01) – 900.000 euros
- Complete project documentation was prepared within the framework of this grant:
- 400 kV transmission line from SS Bitola 2 – Macedonian/Albanian border
- 400/110 kV SS Ohrid
- 400 kV transmission bay in SS Bitola 2

- 110 kV connection transmission lines to 400/110 kV SS Ohrid
- WBIF investment grant (WB-IG00-MKD-ENE-01) – 12.000.000 euros

In December 2015 was signed a financial agreement with the European Bank for Reconstruction and Development (EBRD) for a loan for the project with the following parameters:

- Loan Agreement No. EBRD loan No.46274,
- Signed on date: 10 December 2015,
- Loan: 37.000.000 euros, and
- Repayment period of 15 years including a grace period of 3,5 years

The total costs as per the signed agreements, the structure of the financing resources, and the time dynamics for realization for the period 2021-2030 are presented in Table 12, position 1 and position 2.

The allocation of the costs for the realization of the project (as per the signed agreements, excluding the feasibility studies, technical documentation, and consultant's services) according to the financing resources is as follows:

Table 7. Costs as per the contracts for construction for the 400 kV interconnection MK-AL

Components	Summed values (MEUR)	Loan (MEUR)	Own funds (MEUR)	Grant (MEUR)
400 kV interconnection line SS Bitola 2 – Macedonian/Albanian border	14,59	9,59	0	5,00
400/110 kV SS Ohrid and new 400kV TL bay in SS Bitola 2	14,37	10,37	0	4,00

4.1.3. Project Implementation

Completed activities:

- Preparation of Feasibility Studies and Studies on environmental impact assessment (both the Macedonian and Albanian part of the interconnection)
- Financed by Grant I by WBIF: 800.000 euros (650.000 euros for the Macedonian part of the project)
- Final version: January 2013.
- Prepared by COWI (WBIF Consultant team).
- Decision on approval for the Study on environmental impact assessment
- Issued on 27 July 2015 by the Ministry of Environment and Physical Planning after the competition of the procedure for assessment of the project impact on the environment.
- Research on vulnerable group fauna (birds and bets) across the corridor from the Macedonian part of the interconnection
- One-year research in the period from 2016-2017 was conducted on demand by the Ministry of Environment and Physical Planning.
- The research was conducted by the Civil Engineering Institute Macedonia (GIM) –Skopje
- Preparation of complete project documentation
- Financed by Grant II by WBIF, awarded in 2013: 899.098 euros

- It is prepared by the Consultant/Contractor GEING-Skopje, which has begun with the preparation of the documentation in 2016.
- The tender was opened in August 2019
- Construction Contracts were signed:
  - 400 kV transmission line Bitola – MK/AL border: Energoinvest, Sarajevo,
  - 400/110 kV SS Ohrid: Končar, Zagreb.

Further steps:

- Finalization of the transformer substation and transmission line design,
- Marking of the transformer substation and transmission line location,
- Geomechanical researches,
- Construction works, access way, equipment procurement, and supply of a part of the equipment.

Due to the COVID -19 pandemic, the project was prolonged for a year, and it is expected to be completed by 2023.

5. MEASURES AND INVESTMENTS IN THE PERIOD 2021-2030

Generally, the transmission grid operates satisfyingly from the aspect of safety, reliability and, security of supply.

Potential faults in the operational security of the grid in the short-term will be solved with re-dispatching of the production and/or with system unloading, by taking on some undertakings on the grid and with completion of the already started projects, while in the middle-term/long-term period such faults will be solved with the realization of new projects.

5.1. NORTHERN REGION OF THE TRANSMISSION NETWORK

The calculation of the maximum short-circuit currents for the transmission grid in the short-term period revealed that very high values of short-circuit currents may be expected at 110 kV busbars in SS Skopje 1 and SS Skopje 4 (over 90% from 40 kA).

In the medium-term and during a normal operating regime of the EPS, the value of the short-circuit current at the 110 kV busbars exceeds the switching power of the installed equipment.

Busbars shall be sectioned to reduce the short-circuit currents at the 110 kV busbars in SS Skopje 1 and SS Skopje 4, sectioning of busbars shall be done. Those switchyards have a double and auxiliary system of busbars (more complicated design) and considerable flexibility in the system operation is possible, more precisely, every unit (transmission line, transformer substation) may be connected to one of the two busbar systems. While sectioning, the choice of units that will be connected to particular sections is important and there are several ways how the sectioning may be done. Sectioning of 110 kV busbars in SS Skopje 4 and SS Skopje 1 shall be performed in such a way that the single-phase and the three-phase short-circuit currents after the sectioning have to be almost equal in two sections, thus fulfilling the N-1 system security criterion.

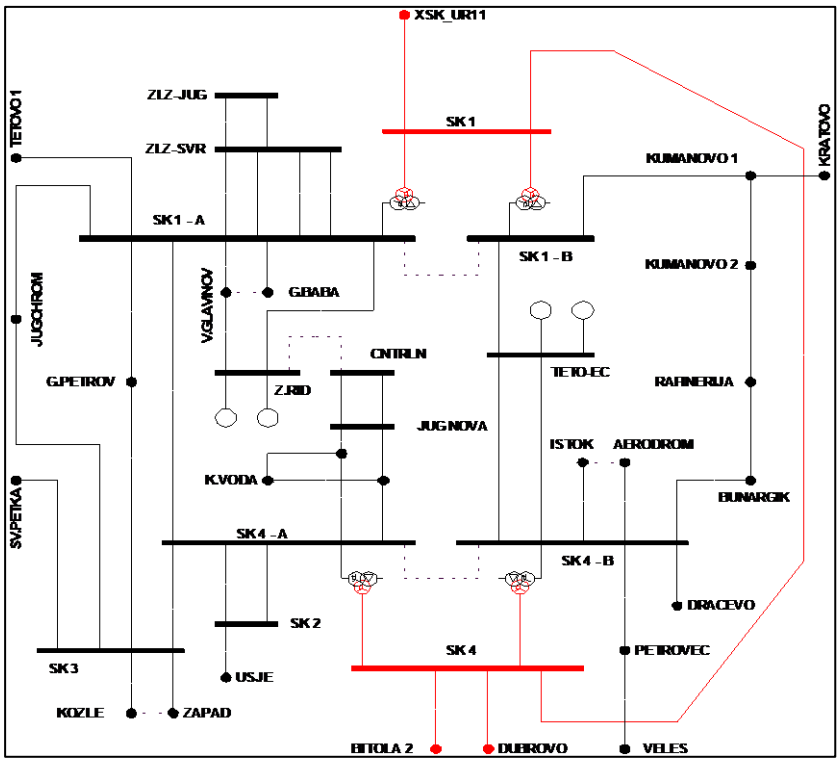
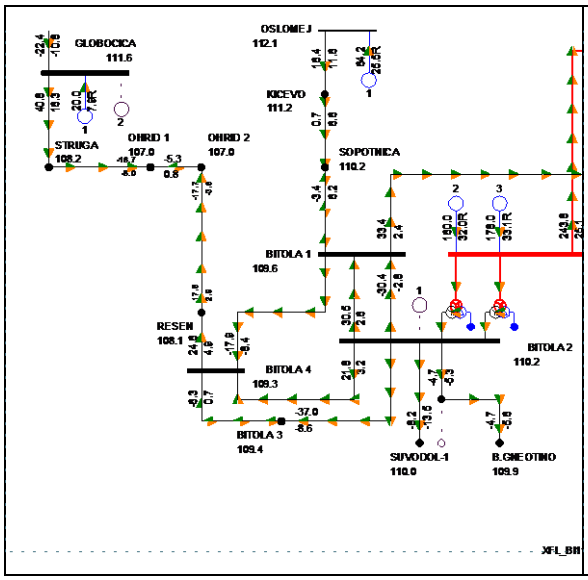


Figure 5. Options for transmission network sectioning in Skopje region, planned topology in the middle-term horizon

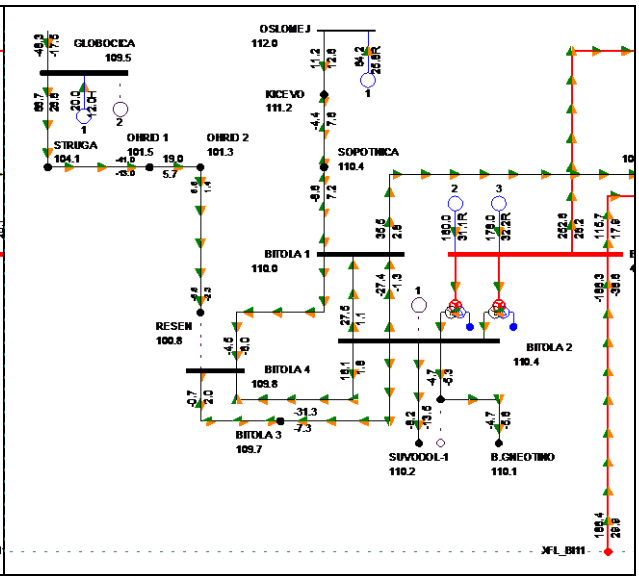
5.2. WESTERN REGION OF THE TRANSMISSION NETWORK

In the region of Polog, in the process of realization is the project for the construction of the 110 kV double-circuit transmission line, which spreads from HPP Vrutok to SS Tetovo 1, as well as reconfiguration of the transmission network. In 2021, for completion and supervision of the construction transmission line shall be undertaken civil engineering and electrical engineering actions; Table 12, position 7.

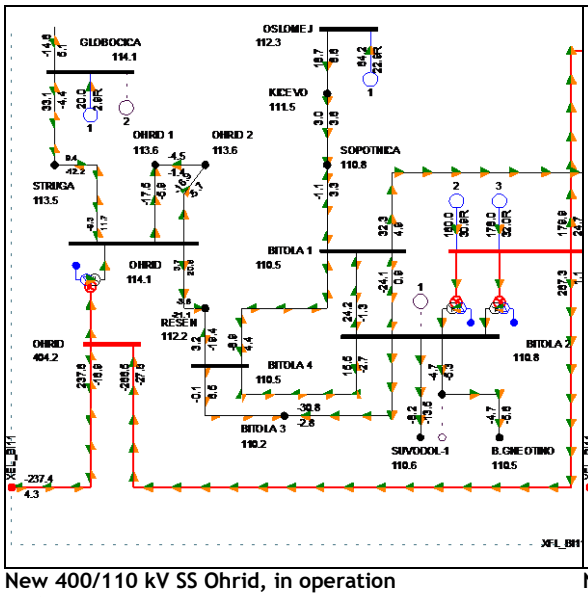
To surpass ultimate design loads, which occur when there is an outage at the 110 kV TL Vrutok – Tetovo 1, the Study on transmission grid development suggests connection of the already existing 110 kV TL Vrutok – Skopje 1 via connection type line in/ line out in SS Tetovo 1. So additional reconfiguration in the Polog region will be made, and new connections will be formed: HPP Vrutok –SS Tetovo 1 and SS Tetovo 1 – SS Skopje 1.This action is prolonged for a year, and it is expected to be executed in the period from 2021-2025; Table 12, position 3.



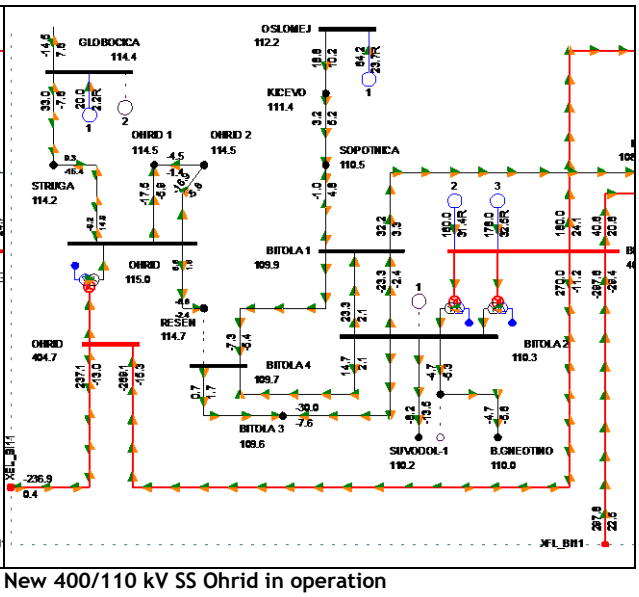
present topology in southeast region
without power outages



present topology in southeast region
outage at 110 kV TL Resen - Bitola 4



New 400/110 kV SS Ohrid, in operation
without power outages



New 400/110 kV SS Ohrid in operation
outage at 110 kV TL Resen - Bitola 4

Figure 6. Benefits from 400/110 kV SS Ohrid regarding critical operating regimes

Regarding the quality of the voltages in the transmission grid and the security of the power supply, of crucial importance is the construction of the 400/110 kV SS Ohrid, part of the south-western region of the transmission grid. In line with expectations, this substation shall be completed by 2023. Without its construction and active involvement of the power plants in the power regulations, the south-western region is subject to possible voltage collapse and loss in the power supply in the 110 kV network (N-1 criterion) (see Figure 6). Until the 400/110 kV SS Ohrid (see 4.1) is constructed, the power plants in the south-western region: HPP Vrutok, HPP Globochica, and HPP Shpilje must actively participate in the regulation of power and reactive power flows.

Calculations from the security analysis (N-1 criterion) in the Study on transmission grid development indicate that in the western region when there is high hydrology (with the maximum engagement of HPP Kozjak and HPP Sv.Petka, and high engagement of TPP Oslomej), and regimes with single power outages, then critical loads appear in the following 110 kV transmission lines: SS Kichevo - TPP Oslomej (105 %), SS Gostivar – HPP Oslomej (108%), SS Sopotnica – SS Bitola 1 (110%), HPP Kozjak – HPP Sv.Petka (from 100% to 105%) and HPP Sv.Petka – SS Skopje 3 (from 100% to 105%). As a middle-term solution of the overload problem in the western region is discerned the reconstruction/revitalization of the whole 110 kV link Gostivar – Oslomej – Kichevo – Sopotnica – Bitola 1 via utilization of conductors with higher transmission power (AAAC 324 mm2, 149 MVA). This reconstruction/revitalization is planned to be carried out in the period from 2021-2024. The 110 kV link TPP Oslomej – Kichevo – Sopotnica – Bitola is built in 1960 and has ACSR 150/25 mm2, 93 MVA types of conductors; Table 12, position 13.

The solution of the problem with overload in the western region in a long-term period foresees additional reconstruction/revitalization of the 110 kV connection SS Polog – HPP Vrutok – HPP Shpilje – HPP Globochica – SS Struga with utilization of the conductors with higher transmission capacity (AAAC 324 mm^2, 149 MVA), and low sag-tension value of conductors (AAAC). This reconstruction/revitalization is planned to be carried out after 2030, while the preparation of the technical documentation shall start from 2027. The 110 kV connection SS Polog – HPP Vrutok – HPP Shpilje – HPP Globochica - SS Struga is built in the period 1964 -1970 and has ACSR 240/40 mm^2, 121 MVA types of conductors; Table 12, position 15.

5.3. EASTERN REGION OF THE TRANSMISSION NETWORK

In the southeast region (Valandovo-Strumica), a great number of renewable energy sources (RES) – wind farms and solar[1] power plants are planned to be built. Their connection to the transmission network causes overloads on the 110 kV transmission lines and low loadings in operating regimes with outages (N-1 criterion). To achieve secure operational conditions of the system, and therefore taking into account the announced connections of RES in the southeast region, in the middle-term period, as a variant is suggested construction of a 110 kV double-circular transmission lines with greater transmission capacity and low sag-tension value of conductors (AAAC) during the reconstruction of the existing 110 kV transmission lines: SS Dubrovo – SS Valandovo and SS Valandovo – SS Strumica 2 – SS Strumica 1. Another variant is improvement of the network with new 400/110 kV transformer substation in the region, which opens up the opportunity for future construction of a second 400 kV

[1] Solar power plants (SPP) use different generation technology. Currently, most present are farms with photovoltaic panels, but there are also photovoltaic panels used on roofs or façade. For large capacities, there are reflecting surfaces and generation through condensation. In the text, for all types of solar power plants, in general, is used the abbreviation “SPP” while for precise connections of users is mentioned the used technology; up to the present, all users plan to build photovoltaic solar power plants (PVPP).

interconnection towards Bulgaria. The optimal solution shall be defined in Study 8.6. This project is presented in Table 12, position 14.

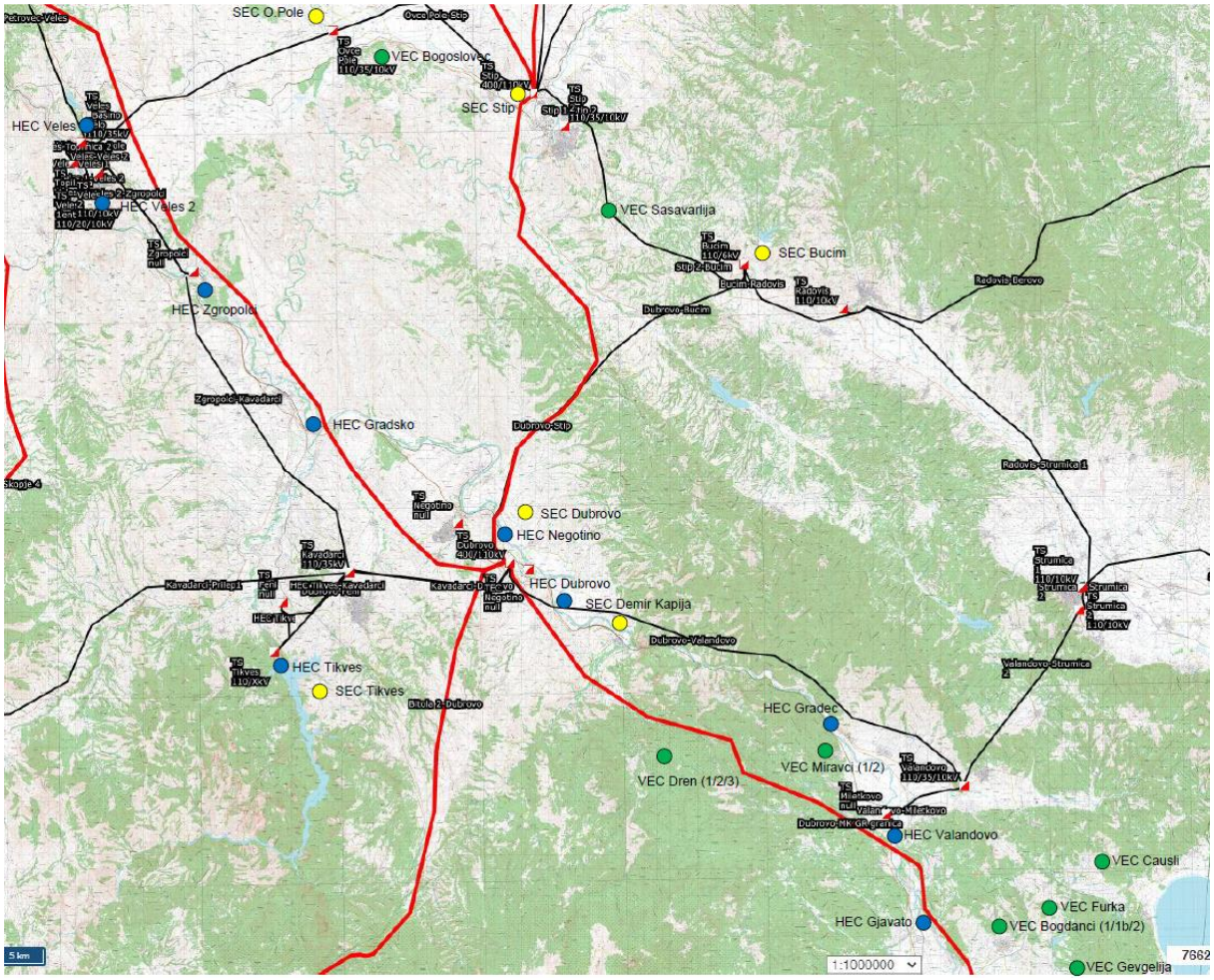


Figure 7. New power plants in the southeast region
(potential capacity as per "green" scenario: PVPP 388 MW, VPP 536 MW, HPP 341 MW)

To overcome low voltages condition in the eastern region in the long-term period is foreseen installation of compensational device (reactive power source) in the 110 kV SS Kochani with minimal power of 25 MVAr; Table 12, position 26.

Due to the increase of the power load in the middle-term and long-term period in the Kumanovo region, and unfulfillment of the system security N-1 criterion, a new SS 400/110 kV Kumanovo is necessary to be built, including decoupling of the 110 kV transmission lines, and redistribution of loads among 110 kV SS Kumanovo 1, 110 kV SS Kumanovo 2 and the new 110 kV SS Kumanovo 3; Table 12, position 4.

6. RECONSTRUCTION AND REVITALIZATION WITHIN THE TRANSMISSION NETWORK

The aging process of the transmission facilities and equipment has a significant effect on the system operation and planning of the transmission grid. Unreliable and older switchyards may endanger the reliability and safety of the whole power system. For MEPSO, it is important to make a choice of optimal moment for revitalization or replacement of the equipment, in order to preserve a satisfactory level of system reliability and security.

Transmission facilities and equipment (overhead transmission lines, cables, transformer substations, protection systems, systems for control and management, measurement systems, telecommunication installations, etc.) are aging during their operation. Every transmission facility and equipment has its life expectancy. The transmission equipment is expected to work according to the declared specifications during their life expectancy, without a major number of faults and problems. The life expectancy for the same type of equipment may be changed over a broad span due to different factors of influence like climate conditions, operational conditions, and specifications. During the aging process, the equipment gradually loses its characteristics and so the number of defects and their duration increases. Providing satisfactory and periodical maintenance the transmission equipment could reliably work in accordance with the declared specifications until that is possible because of its age.

The reconstruction and revitalization of the existing equipment, in the ten-year development plan, are expected to give the following positive effects:

- Strengthened operational security of the switchyards;
- Decreased amortization rate of the equipment installed at the transmission bays in the transformer substations;
- Significantly reduced number of outages in the transmission lines, thus decreased no-voltage condition towards the consumers;
- Increased level of a consistent supply of electric power to the consumers;
- Lower costs for maintenance and elimination management problems with the old transmission lines;
- Improvement of the quality of the electricity at power system level
- Improvement of the employees and environment safety

6.1. RECONSTRUCTION AND REVITALIZATION OF TRANSMISSION LINES

The Macedonian transmission grid is intensively built during the 1960s and 1970s. One of the main challenges of MEPSO for the upcoming years is reconstruction of the obsolete 110 kV transmission lines. Those transmission lines that are estimated to have impaired operational parameters will be reconstructed with an aim to maintain the operational reliability and security of the power system.

6.1.1. RECONSTRUCTION OF TRANSMISSION LINES

The reconstruction of the 110 kV transmission lines has begun and is financed by a loan from EBRP (44114) as component 4 given in the following Table:

Table 9. Reconstruction of the 110 kV transmission lines in the period 2021-2030 (Table 10, positions from 8 to 13)

Transmission line	Length (km)	Year of construction	Activities in 2020
SS Bunardjik – SS Miladinovci 1	17	1971	Change of route
SS Veles – SS Ovche Pole	21	1960	In designing and construction phase
SS Ovche Pole – SS Shtip	17.9	1960	In designing and construction phase
SS Bitola 1 – SS Prilep 1	33.7	1963	In designing and construction phase
SS Skopje 4 – SS Petrovec – SS Veles	37	1953	In designing and construction phase
SS Gostivar (Bukovikj) – TPP Oslomej - Kichevo - Sopotnica - Bitola 1 (length ≈ 100 km AAAC)	100	1960	In designing phase

For the reconstruction of the 110 kV transmission lines SS Veles – SS Ovche Pole, SS Ovche Pole – SS Shtip, SS Bitola 1 – SS Prilep, and SS Skopje 4 – SS Petrovec – SS Veles (Table 12, positions for 9 to 12), in 2021 the following activities are foreseen: expropriation, audit of the project, civil engineering works, electrical engineering activities, and supervision of the complete work. For the reconstruction of the transmission line SS Bunardjik – SS Miladinovci, during 2021, besides the above-mentioned activities, also it is foreseen preparation Environmental Impact Assessment.

According to the measures that have to be undertaken in the following 10-years period, in order to ensure a stable electric power supply without overloads and low voltages in the transmission system, precisely to provide qualitative electric power transmission, the following 110 V transmission lines are planned to be reconstructed/revitalized:

Table 8. Reconstruction/revitalization of the 110 kV transmission lines in the period 2021-2030 (Table 10, positions 6 and from 13 to 15)

Transmission line	Length (km)	Year of construction	Intervention
2x110kV TL section Vapila – SS Ohrid 1	11	1970	
SS Gostivar (Bukovikj) – TPP Oslomej		1958/1978/2001	New conductor AAAC
TPP Oslomej – SS Kichevo	15	1960	
SS Kichevo – SS Sopotnica	33,3	1960	
SS Sopotnica – SS Bitola 1	30,7	1960	
SS Durbinovo –SS Valandovo	39,3	1971	Double-circuit TL with conductor AAAC option 400/110 kV SS
SS Valandovo – SS Strumica 2 – SS Strimica 1	~ 18	1971	

HPP Vrutok – SS Polog	9	2010	New conductor AAAC
HPP Vrutok – HPP Shpilje	15,6	1964	
HPP Shpilje – HPP Globochica	13,5	1964	
HPP Globochica – SS Struga	32	1970	

In 2021, for the reconstruction of the 2x110 kV transmission line, section Vapila – Ohrid 1, tender for preparation of project documentation will be organized. For the 110 kV TL Gostivar – Bitola 1, a designer is selected who is already preparing the project. During the current year will be prepared tender for Contractor.

6.1.2. REVITALIZATION OF TRANSMISSION LINE

The plans for maintenance of the transmission grid include continuous revitalization of the existing transmission lines of MEPSO via replacement of the fittings and suspension set, earthing wires, and replacement of the existing conductors with a new type of wires with better specifications compared to the existing; Table 12, position 5.

Figure 8. Interventions on transmission lines

6.2. Reconstruction and Revitalization of Substations

The reconstruction and revitalization of the equipment in the substations comes because of real technical needs identified from different points of view:

- Equipment older than 30 years and inability to procure spare components
- Difficulties in the maintenance of the equipment
- Bad operational parameters of the equipment that is in function
- Obstacles to manage the equipment
- Risk to the employees and environment during manipulation with the equipment.

Analysis had been made for the condition of the 400/110 kV power transformers based on the results from the “periodical surveys”, operation supervision, and laboratory testing.

Based on these analyses, in the long-term period, replacement by one power transformer in SS Skopje 4- SS Dubrovo is foreseen. These replacements of power transformers are given in Table 12, positions 21 and 22.

The procedure for replacement of the old and unreliable 400 kV and 110 kV primary equipment with average age over 30 years (circuit breakers, disconnectors, metering transformers, and surge/lightning arrestors), and replacement of the secondary equipment (relay protection, remote control, and control systems, supply, electric energy measurement) continues with an aim to increase the stability and reliability of the substations and the power system.

Due to the age of the buildings (control buildings, premises, objects, fences, etc.) within the substations, constant actions are being undertaken for their repair. The repair of the control buildings, premises, objects is carried out with an aim to improve the energy efficiency as well.

The reconstruction and revitalization of the substations are carried out through more projects/packages, described below.

6.2.1. Revitalization of High-voltage Equipment

The plan for revitalization of part of the high-voltage equipment – disconnectors, in several substations results from the necessity to lower costs for maintenance, and to increase the reliability and availability of system elements. The existing disconnectors are old (average age is 35 years), with often defects because of which the maintenance costs are high.

This project will cover the replacement of disconnectors in the following substations:

Table 9. Revitalization of disconnectors in 13 substations (Table 10, position 17)

Transformer substation	Number of bays	Number of disconnectors
Bitola 1	8	23
Bitola 3	3	5
Bitola 4	4	6
Buchim	5	13
Radovish	5	8
Strumica 2	3	5
Skopje 3	10	22
Gjorche Petrov	5	6
Kriva Palanka	5	7
Makedonska Kamenica	3	5
Kumanovo 2	5	7
Kochani	5	7
Samokov	4	6
Total	65	120

6.2.2. Reconstruction of Switchyard Kratovo

The reconstruction of the switchyard in Kratovo includes realization of 3 transmission bays, new 110 kV busbar-system and reconstruction of the secondary circuits using the most modern digital technology; Table 12, position 18.

6.2.3. Revitalization of the 400/110 kV Substations (SS Skopje 4, SS Bitola 2, SS Dubrovo)

Within these substations will be replaced part of the high-voltage equipment and part of the secondary equipment; Table 12, positions 19-25. Whereas in SS Skopje 4 will be replaced the supports and foundations of the 400 kV facility.

According to the new contract signed by MEPSO, in the following three years is foreseen reconstruction of the high-voltage equipment in SS Bitola 2, precisely the 400 kV and 110 kV disconnectors and metering transformers, as well as reconstruction of the secondary equipment; Table 6. position 25. As part of this reconstruction, withinin the 400 kV switchyard will be procured and installed 25 disconnectors in all 9 bays, and 14 post insulators in 8 bays, while within the 110 kV switchyard will be procured and installed 42 disconnectors in all of the 14 bays and 75 metering transformers in 13 bays.

In SS Dubrovo in the past period, the 110 kV switchyard was completely reconstructed (replacement of circuit-breakers, disconnectors, metering transformers, relay, protection, and control system-SCADA), and the 400 kV switchyard was partially reconstructed replacing the relay protection and control. Since the circuit-breakers and metering transformers had been previously replaced, in the upcoming period the disconnectors in the 400 kV switchyard will be replaced.

The revitalization involves replacement of the 400 kV disconnectors in all bays (22 sets), construction of a new 110 kV bay (C2) for the auxiliary load (with 110 kV metering transformers with high capacity), and partial reconstruction of 6 kV switchyard (replacement of circuit-breakers, metering transformers, relay protection, and control system – SCADA).

6.2.4. Revitalization of SS Veles and SS Kavadarci 1

This project foresees replacement of part of the high-voltage equipment and secondary equipment in SS Veles and SS Kavadarci 1, and installation of the already procured equipment for DC supply and AC/DC supply; Table 12, position 27.

Figure 9. Installation of equipment in substations

6.3. REVITALIZATION/RECONSTRUCTION OF CONTROL SYSTEMS IN SUBSTATIONS

6.3.1. Revitalization and Modernization of the Control System in SS Samokov

Installation of a system for control and supervision of SS Samokov based on SCADA software and Bay Control Unit (BCU) devices. The reconstruction is planned to cover designing and realization of electrical installation works, testing and commissioning, preparation of main design and set of as-built records; Table 6, position 28.

6.3.2. Revitalization and Modernization of the Control System in SS Strumica1

Installation of a system for control and supervision including designing and realization of electrical installation works, testing, and commissioning, preparation of design. Besides the increase of availability and reliability of the SS, the acquired data from the SS will be implemented in SCADA/EMS system in NDC; Table 6, position 29.

6.3.3. Revitalization and Modernization of the Control System in SS Sushica

Installation of a system for control and supervision including designing and realization of electrical installation works, testing, and commissioning, preparation of design. Regarding that SS Sushica is interconnected with Bulgaria, it is very important that all necessary measurements, statuses, alarms are available in SCADA/EMS system in NDC; Table 6, position 30.

Figure 10. National Dispatch Center

7. MODERNIZATION OF THE POWER SYSTEM

Modernization, digitalization, and cyber security in the power system are significant part of the operation of MEPSO. For that purpose, in this year's plan for development of the power system MEPSO introduces five new projects: procurement and installation of new SCADA/EMS system, Data Room, ENTSO-E Electronic Highway in NDC and BDC, smart maintenance and management of the equipment whose realization starts in 2021. In mid-term is planned procurement of voltage profile compensator.

7.1. TELECOMMUNICATION EQUIPMENT AND REMOTE MONITORING OF THE SUBSTATIONS

MEPSO has built telecommunication infrastructure for telecommunication connection of the power plants. This infrastructure is comprised of optical fiber network integrated into the ground wires (OPGW) of the line and the telecommunication equipment. The optical network integrated into the ground wires of the transmission lines is depicted in the following Figure:

Figure 11. OPGW across the transmission lines of the transmission network

This project will include procurement and installation of telecommunication equipment, construction of a new network for data transmission from the supervision and control system, electric power metering, relay protection, LAN and WLAN network, telephone lines; Table 12, position 31.

Telecommunication equipment is a base for achieving "real-time" data for SCADA/EMS[2], as well as for interconnection with the neighbors and connecting the data from all locations of

[2] Supervisory control and data acquisition

MEPSO. In order to modernize the complete telecommunication equipment, MEPSO will offer new system solution i.e. installation of DWDM[3] equipment.

This solution will contribute towards optimization of the usage of the optical fibres simultaneously acquiring encryption at physical level that is the most acceptable for MEPSO because of prompt delivery and complete protection of the information to be transported. The system will offer additional interfaces for internal and outer connection with other systems and entities.

Working with DWDM, MPLS-TP and IP/MPLS, MEPSO will have consistent way of security, problem solving and control over its grid.

The plan for 2021 expects opening of tender documentation and project kick off.

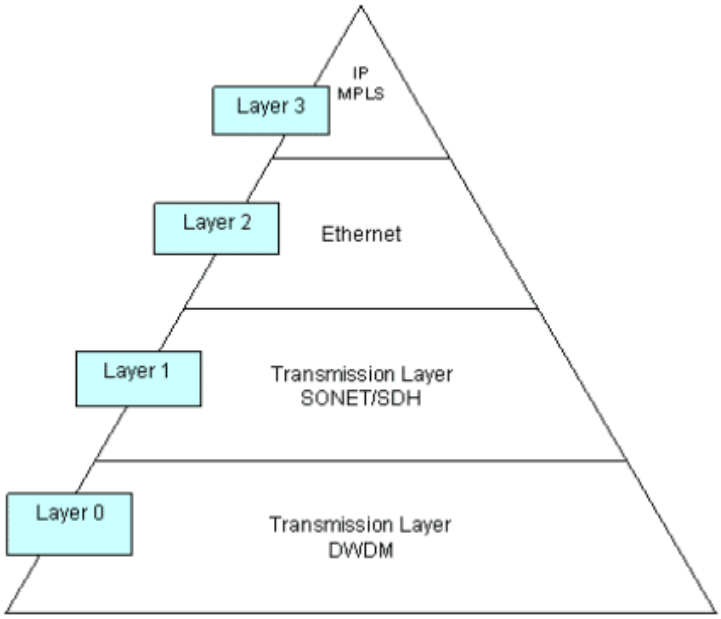


Figure 12. Structure of the MEPSO's telecommunication equipment

7.2. Optical Ground Wire Connection

The optical ground wire connection will be carried out via connection of NDC with SS Gjorche Petrov and TETO. The project is in phase of approval of the infrastructure project in the Ministry of Transport and Communications. After the approval follows preparation of main design and commissioning with construction; Table 12, position 32.

7.3. Balkan Digital Highway

The accessibility of the broadband infrastructure is considered a significant baseline of the economic and social development of a country. The exchange of infrastructure that may be reached with a contract between two or more transmission system operators is an efficient way to reduce the expanses for deployment of the broadband communication networks, to gain better connection which contributes to protect the environment, to decrease the consumption of resources and to increase energy efficiency.

[3] Dense wavelength division multiplexing (DWDM) is a technology that puts together -- multiplexes -- data signals from different sources so they can share a single optical fiber pair while maintaining complete separation of the data streams.

Regarding the advantages, The World Bank formed the initiative ”Balkan Digital Highway” to research and upgrade the possibilities for infrastructure sharing in the Western Balkan. In the project, besides MEPSO, also participate the transmission system operators from Kosovo, Albania and Montenegro, with an open option to spread among power systems from the Balkans. The initiative conducted numerous pre-feasibility studies in order to:

- investigate the possibilities for use of the capacity surplus of the existing network fibres (OPGW networks) located near the electrical networks controlled by the TSOs in the six countries from the Western Balkan with an aim to generate the additional income,
- make a technical assessment of the existing OPGW capacity surplus in the TSOs grids,
- determine what type of changes are needed in the national telecommunication and energy frameworks in the countries to operationalize the infrastructure sharing, and
- develop an action to improve the infrastructure sharing in the region that includes technical, organizational, and regulatory bottlenecks in each country.

Currently, the project is in an initial phase that is, the World Bank and FWBI signed a contract for technical support. This part is completely financed by a grant from WBIF, and it includes all power systems. Because of the pandemic, the whole process is postponed, and the expectation is by the end of 2021, a consultant, who shall estimate the shortfalls within the transmission network and data sharing, to be selected. Subsequently, MEPSO will decide whether to invest in improvement of the performances for data sharing between the transmission system operators.

Balkan Digital Highway Initiative as a project will provide improvement of the wholesale access to the fast broadband services on the national and a regional level of the participant countries by establishing regional network for a broadband network via OPGW infrastructure; Table 12, position 33.

Figure 13. OPGW

7.4. PROCUREMENT AND INSTALLATION OF OPGW IN 400 KV TL SKOPJE 4 - BITOLA 2

The plan about the 400 kV transmission line Skopje 4 – Bitola 2 includes installation of a second, additional OPGW-wire that will reinforce the security and information sharing. The first wire had been installed in 1997 and it has 12 optical fibers. This wire is part of two rings – eastern and western at the same time. Taking into account that in the rings are installed wires with 12 fibers, section Skopje 4 – Bitola 2 has a lower capacity. Assuming that whithin the ring are mounted 24 fibers, the Skopje 4 –Bitola 2 section has lower capacity. The wire that will be supplied and installed will have a greater number of optical fibers, produced by

the most modern technology and improved effectiveness. The project is presented in Tapble 12, position 34.

7.5. DYNAMIC LINE RATING -DLR

The DLR technology determines the momentary net transfer capacity value via encryption algorithms, based on measurements in real-time, and using mathematical models. The implementation of DLR may cause decrease of investments in the transmission network, and it may simultaneously increase the safety of the power system operation.

To determine the economic viability of the DLR technology implementation, MEPSO shall firstly carry out initial researches in the frameworks of Study 8.6 with which will confirm the optimal transmission lines and routes to which the DLR technology shall be implemented; Table 12, position 35.

7.6. VOLTAGE REGULATION TECHNOLOGY

Following the *Regional feasibility study for voltage profile improvement*, see 8.3, MEPSO needs to make procurement of technology for voltage control – variable shunt reactor. That is an absorber of reactive power, which by use of a tap changer compensates the reactive power in the system on different voltage levels, in pre-defined range. According to the Study, the Macedonian power system needs to be reinforced with the installation of a 150 MVAr reactor in SS Dubrovo at the 400 kV busbar system. The Macedonian power system will use the installed reactor to decrease high voltages in regimes with low loading. To achieve optimal voltage profile, the reactor's consumption in SS Dubrovo will be controlled through the consumption of the reactors that will be installed in the region, Table 12, position 36.

7.7. PROCUREMENT AND INSTALLATION OF NEW SCADA/EMS SYSTEM

The SCADA system is of key importance for constant operation of the National Dispatch Center (NDC), which controls and maintains the power system. Through this system is gathered data about the operation of the power system in real-time in order to provide constant, reliable, and secure electricity supply to the consumers.

Considering the existing condition of the SCADA/EMS system that is installed in NDC and BDC, regarding the hardware (obsolescence of the equipment, the equipment reaches its technological lifespan, servicing problems, maintenance, etc.), as well as the software (applicative components that are technologically outdated in terms of approaches, demands, opportunities and the way of fulfilling MEPSO's obligation towards ENTSO-E), emphasizes the necessity for MEPSO to promptly begin and plan all compulsory steps for realization of the new SCADA/EMS system, Table12, position 37.

In 2021, a consultant who will prepare the tender documentation for procurement of SCADA/EMS shall be decided.

7.8. DATA ROOM

The Security Room is central location/room within the TCS (Technical Control System). There are positioned the Supervisory Control And Data Acquisition (SCADA/EMS), storage and processing of data from the EE metering equipment (AMR/MDM), data exchange systems, and the system for allocation of available cross-border capacities of MEPSO.

The goal of this project is development of a design concept for the security room under the functional requirements, standards, and regulations on force, defining the detailed design, preparation of technical documentation as project, realization (delivery and installation) of Security Room including systems for the protection of the data centre. It would cover the following systems: server security room modular inbuilt – type "room in room," system for cable installation, lighting, signalization, system for fire detection, alarming and

extinguishing in the Security Room, system for monitoring, access control and video surveillance over the Security Room, as well as modification or replacement of the existing system for cooling dependent on the current and future needs.

Therefore, the availability of the data room will be increased by creating a controlled and safe environment with appropriate conditions for optimal functioning, remote monitoring of the functionality of the protection systems, access control, and video surveillance. There will be uninterrupted service, data availability, and continuity in work under the security controls and standards for protecting the data rooms within the transmission system operators; Table 12, position 38.

7.9. ENTSO-E ELECTRONIC HIGHWAY IN NDC AND BDC

Electronic Highway is a private communication network of the European transmission systems, completely independent from the internet, which enables highly reliable data exchange among the TSOs, in real-time using the TASE.2 protocol. Each transmission system operator locally administrates the network.

The completion of this project will mean replacement of the existing system, older than ten years, with new hardware and software. Such a replacement will reduce interruptions within real-time data exchange, greater reliability, security, and data availability that will fulfil requirements, criteria, and standards dictated by ENTSO-E regarding the network infrastructure and power system security as a critical system of strategical significance; Table 12, position 39.

7.10. SMART MAINTENANCE AND ASSET MANAGEMENT

To improve the efficiency, time, promptness, and scope of completed works at the transmission lines and transformer substation, as well as real-time operation, the plan is to provide specialized software and hardware package for maintenance of the transmission grid.

The specialized software package will encompass licensed and notably prepared solutions. Its objective is logging and processing of data from and for regular checks, maintenance, interventions, as well as equipment repairs. The software will be installed on adequate hardware equipment (servers, desktops, and rugged laptops) and it will file, share, and analyse given data in real-time.

This project will contribute to achieving standardization and digitalization of all work procedures in terms of regular checks, maintenance, interventions, as well as repairs for all 57 substations and more than 2000 km transmission lines including over 7000towers; Table 12, position 40.

8. POWER SYSTEM RESEARCH AND DEVELOPMENT

Following the advanced development goals of the electric power systems and the obligations arising from the European regulation, MEPSO as a member of regional and European projects, tends to keep pace with the advanced researches.

For that purpose, MEPSO in the ten-year development plan presents the existing and future researches that will define paths for a modern development of the electric power system and modern functionality of the company.

8.1. CROSSBOW

CROSSBOW (CROSS BOrder management of variable renewable energies and storage units enabling a transnational Wholesale market) is a project for management of the cross-border

variable power flows intending to develop trans-national electricity market; Table 12, position 41.

http://crossbowproject.eu/

The main objectives of the project are:

- Improvement in the cross-border power flow control;
- Use of energy storage for provision of systematic services;
- Improvement in the utilization of telecommunications equipment and information technology for observation of the system and load profiling on distribution level;
- Development of transnational electricity markets by integrating renewable energy sources, RES.

This project is financed by the European Commission development fund, Horizon2020. The CROSSBOW project consortium involves partners of 24 companies from 13 countries. All transmission system operators from the SEE region participate in the consortium. From North Macedonia, despite MEPSO, participate ESM and The Faculty of Electrical Engineering and Information Technologies (FEEIT), as well.

8.2. TRINITY

TRINITY (TRansmission system enhancement of regIoNal borders by means of IntellIgenT market technology) is a project for development of solutions for improvement of the collaboration between the transmission system operators from the Balkan and integration support of the electricity markets, promoting higher penetration of clean energy; Table 12, position 42.

http://trinityh2020.eu/

The main objectives of the project are:

- New coordinative mechanisms for calculation of the consumption and exchange of electricity.
- Advanced use of renewable energy sources.
- Coupling of the electricity markets.

The products of the project are:

- T-MARKET COUPLING FRAMEWORK – a tool for improvement and integration of the electricity market in SEE.
- T-SENTINEL TOOLSET – regional system management in terms of secure and reliable operation.
- T-RES CONTROL CENTER – centre for optimization and control of RES on a regional level.
- T-COORDINATION PLATFORM – information system set up to coordinate and support the Trans-European Transport Network (TEN-T) policy/ RES producers/ regional safety centres.

The project is financed by the European Commission's development fund Horizon2020. 19 companies are partners in the consortium of the CROSSBOW project. All transmission system operators from the SEE region participate in the consortium. From North Macedonia, despite MEPSO, also participates the Faculty of Technical Sciences Bitola.

8.3. REGIONAL FEASIBILITY STUDY ON VOLTAGE PROFILE IMPROVEMENT

The appearance of high voltages in certain operating regimes is an ongoing problem in the regional transmission network of the Western Balkan, which reflects in Croatia and Slovenia. In the future, the situation is expected to get worse by energizing several new 400 kV transmission lines.

For that reason, a study that will investigate the problems and will offer an efficient solution for the higher voltages is in a process of preparation; Table 12, position 43. The optimal solution for voltage control requires synchronized and simultaneous mutual activities on all involved transmission system operators. The solution shall include investment proposals in necessary equipment and facilities, as well as procedures for cross-border collaboration during operational planning and grid control in real-time.

8.4. STUDY ON NETWORK DEVELOPMENT

The Study on the transmission network development is the foundation for the preparation of the national plan for power system development for a period of ten years, under the Energy Law and the Grid Code. The Study follows the planning process of the transmission network in Europe under the methodology and recommendations by ENTSO-E.

This Study is a strategic document, and simultaneously, it is an investment and operational plan with precise deadlines and amounts prepared to satisfy all the transmission requirements of the consumers and producers of electric power in the short, middle, and long term. The main basis for the Study is the Energy Strategy adopted in 2019 that defines different scenarios for the development of the conditions and requirements of the transmission system of the country; Table 12, position 44.

8.5. STUDIES ON INTEGRATION OF RES

The integration of RES in the transmission network is technically limited from the supply of system reserves and problems caused from the imbalance between production and consumption in the power system. The wind power plants (WPP) and the photovoltaic power plants (PVPP) are an extraordinary challenge because of their unpredictable way of production and potential installed capacities. Currently, MEPSO works on two studies for integration of RES: *Action Plan for Power Grid Strengthening to Support Renewable Projects in North Macedonia* and *Least Cost Generation Planning and Variable Renewable Energy Grid Integration Analysis*; Table 12, position 45.

The Action Plan for Power Grid Strengthening to Support Renewable Projects in North Macedonia is financed by EBRD grant. The Study will survey the technical measures and investments for support of the installation of big RES capacities in the Macedonian power system. The integration of RES will be reviewed in terms of:

- Identification of different types of RES (locations, installed capacities) which are in use or will be in use in the country, with emphasis on WPP and PVPP.

- Estimation of the expected changes in the production of the RES power plants on annual, seasonal, daily, and hourly levels.

- Estimation of the impact of the RES on the electricity consumption and loads, from the aspect of the whole system and the transmission grid.

- Analysis of the possible technical limitations in the operation of the transmission network due to the integration of RES.

- Estimation of possible ancillary services within the limits of the power system on different levels of RES integration.

- Recommendations for technical measures and systems for integration of RES power plants.

Least Cost Generation Planning and Variable Renewable Energy Grid Integration Analysis is part of the initiative for support countries from the Western Balkans that transit to clean energy, and the World Bank finances it with a grant. The Study, in two of its components, will offer several scenarios for the planning of the generation capacities in the long-term and will estimate the effect of the RES integration into the power system. As part of the second component will be examined several specific conditions during RES integration such as dispatching and needs of system reserves, the impact of the RES on the planning of the system reserves, congestion in the transmission system, and need for spread of the transmission network.

8.6. STRENGTHENING THE TRANSMISSION NETWORK IN THE SOUTHEAST REGION OF NORTH MACEDONIA

According to the development plans, current requirements, and expressed interest for connecting to the transmission network in the southeast region, it is expected to appear concentration of more wind power plants, part of hydropower plants from the Vardar Valley Project, as well as large industrial consumers. Certain researches in ENTSO-E showed that in the long-term, a new 400 kV interconnection between the Republic of North Macedonia and Bulgaria or Greece could be expected to be necessary.

Additionally, on a medium-term horizon, the 110 kV connection Dubrovo-Valandovo-Strumica 2-Strumica 1 will be a candidate for reconstruction due to the aging of the equipment. The studies for grid development and integration of renewable energy sources suggest a pragmatic solution for the construction of a new double-circuit 110 kV transmission line between Dubrovo-Valandovo-Stumica with new conductors with higher transmission capacity and low sag (AAAC). Besides the already considered options, there will be research on other variants with a new 400/110 kV substation, also interconnection from that region towards Bulgaria or Greece.

Regarding the uncertainty in the prognosis and realization of the projects, as well as the future role of this part of the network, the development concept for the southeast region is a considerable challenge and deserves special attention.

MEPSO plans to prepare a separate study that will research different variants for development/upgrade of the network and will make technical and economical optimization; Table 12, position 46. The Study has two components. The first component foresees preparation of feasibility study and social and environmental impact estimation, Dynamic Line Rating Study, and AM-Asset Management Study. The second component will prepare project and tender documentation for the chosen solution for development/upgrade of the network.

9. CONNECTIONS OF NEW USERS TO THE TRANSMISSION NETWORK

9.1. CONNECTION OF PRODUCTION CAPACITIES TO THE TRANSMISSION NETWORK

Based on the demands by the Ministry of Economy for construction of new photovoltaic power plants, MEPSO prepared and submitted a proposal for solutions for connection to the transmission network including information about the procedure for connection to the transmission network about:

- Photovoltaic power plants in the region of Kichevo with an installed power of 60 MW
- Photovoltaic power plants in the region of Municipality of Debarca with an installed power of around 50 MW.

9.1.1. Connection of WPP Bogoslovec

Wind power plant Bogoslovec is planned to consist of wind turbines with a total installed power of 36 MW, with an average annual generation of 83.659 GWh and 2324 equivalent hours for maximum generation; Table 14, position 1.

In order to connect WPP Bogoslovec to the transmission network, a 110/33 kV transformer station Bogoslovec shall be built, whose 110 kV switchyard will be built with a classic "H" scheme with one 40 MVA power transformer.

The 110/33 kV transformer station Bogoslovec will be bilaterally connected to the transmission grid with a 110 kV double-circuit transmission line connected to the existing 110 kV line TS Ovche Pole – SS Shtip 1 forming electrical connections of 110 kV such as SS Ovche Pole-SS Bogoslovec and SS Bogoslovec-SS Shtip 1.

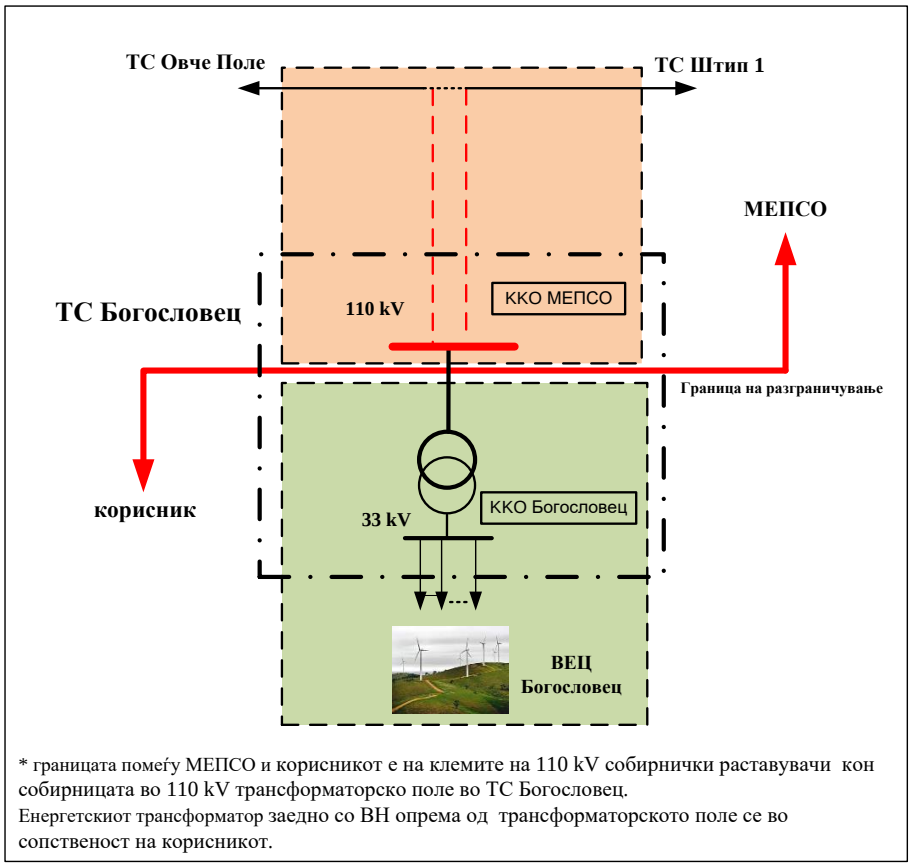


Figure 14. Connection of WPP Bogoslovec to the transmission network

As per the procedure for connection, a Contract for connection to the transmission network was signed; project documentation for the connection was prepared, revised, then supervised, and approved by MEPSO.

Further steps would be supervision of the construction of the connection to the transmission grid, energizing the connection and WPP Bogoslovec, possession of the part of the connection that owns MEPSO, and signing a Contract for use of the transmission grid.

9.1.2. Connection of WPP Demir Kapija

Construction of wind turbines with a total installed power of 34 MW with an average annual production of 80.4 GWh and 2233 equivalent hours in the maximum production is planned in the wind power plant Demir Kapija (Dren). The Investor requested a change of the existing connection so that there will be a connection of second phase WPP Dren 2, with a total installed power of 10 MW with an average annual production of 26.300 MWh and 2630 equivalent hours with maximum electric power production, Table 14, position 2.

For connection of WPP Demir Kapija (Dren) to the transmission grid and connection of the second phase WPP Dren 2, a 110/c kV transformer substation is necessary to be built in Demir Kapija that shall be unilaterally (radially) connected to the transmission grid with single-circuit 110 kV connection line towards SS Dubrovo.

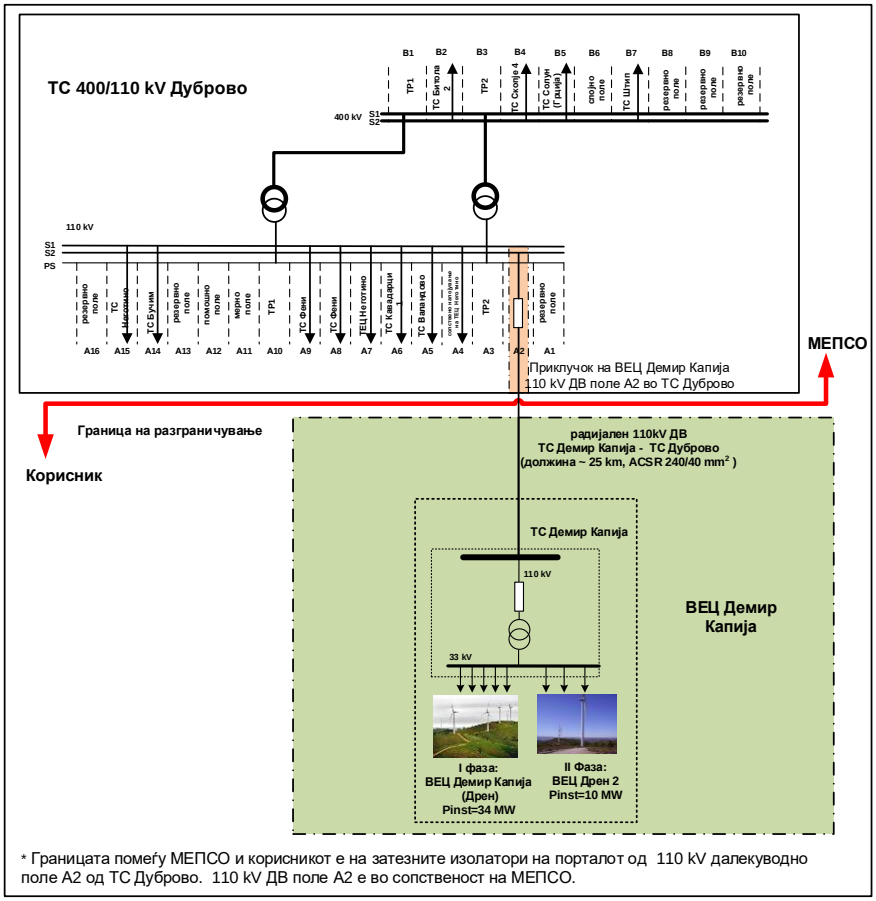


Figure 15. Connection of WPP Demir Kapija (Dren) and WPP Dren 2 to the transmission network

As per the procedure for connection, a Contract for connection to the transmission network was signed, and an Approval for connection of WPP Dren 2, a second phase of WPP Demir Kapija (Dren) to the transmission network was issued because of the changes into the technical parameters of WPP Demir Kapija.

Further steps would be supervision of the project documentation, supervision of the construction of the connection to the transmission grid, energizing the connection and WPP

Demir Kapija, possession of the part of the connection that owns MEPSO, and signing a Contract for use of the transmission grid.

9.1.3. Connection of WPP Miravci

The wind turbines planned for the wind power plant Miravci shall be of total installed capacity of 14 MW, with an average annual generation of 40 GWh, Table 14, position 3.

To connect WPP Miravci to the transmission grid, a 110/20 kV transformer substation Miravci shall be built which will be unilaterally (radially) connected to the transmission grid with a single-circuit 110 kV connection line towards SS Valandovo.

The procedure for connecting to the transmission network shall continue providing financing construction.

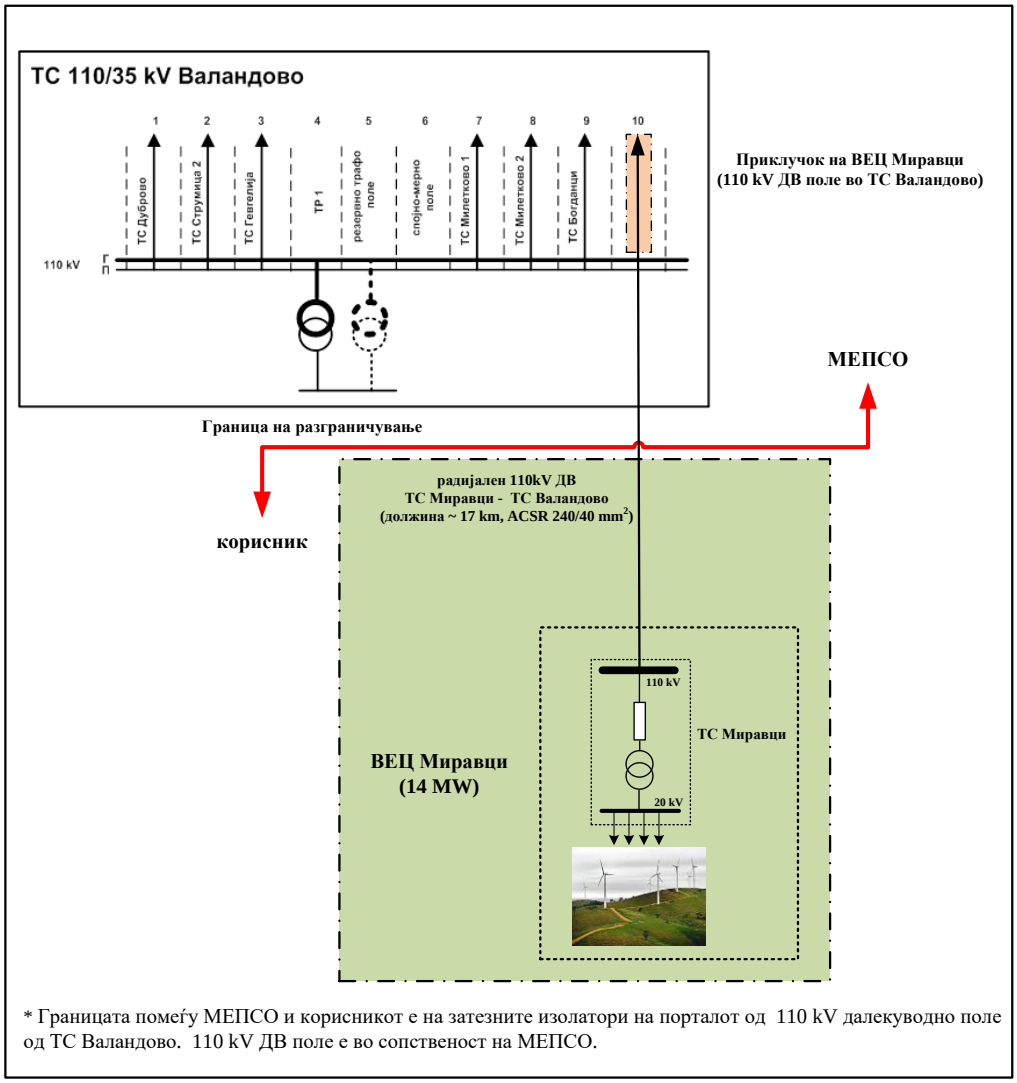


Figure 16. Connection of WPP Miravci to the transmission network

Further steps would be signing a Contract for connection to the transmission; supervision of the project documentation, supervision of the construction of the connection to the transmission grid, energizing the connection and WPP Miravci, possession of the part of the connection that owns MEPSO, and signing a Contract for use of the transmission grid.

9.1.4. Connection of WPP Krushevo and PVPP Krushevo

The installed capacity of WPP Krushevo is 20 MW with an annual production of electric power of around 60 GWh. The installed capacity of PVPP is 8 MW with an annual production of electric power around 10.66 GWh, Table 14, position 4.

The Figure below is a geographical view of WPP Krushevo and PVPP Krushevo.

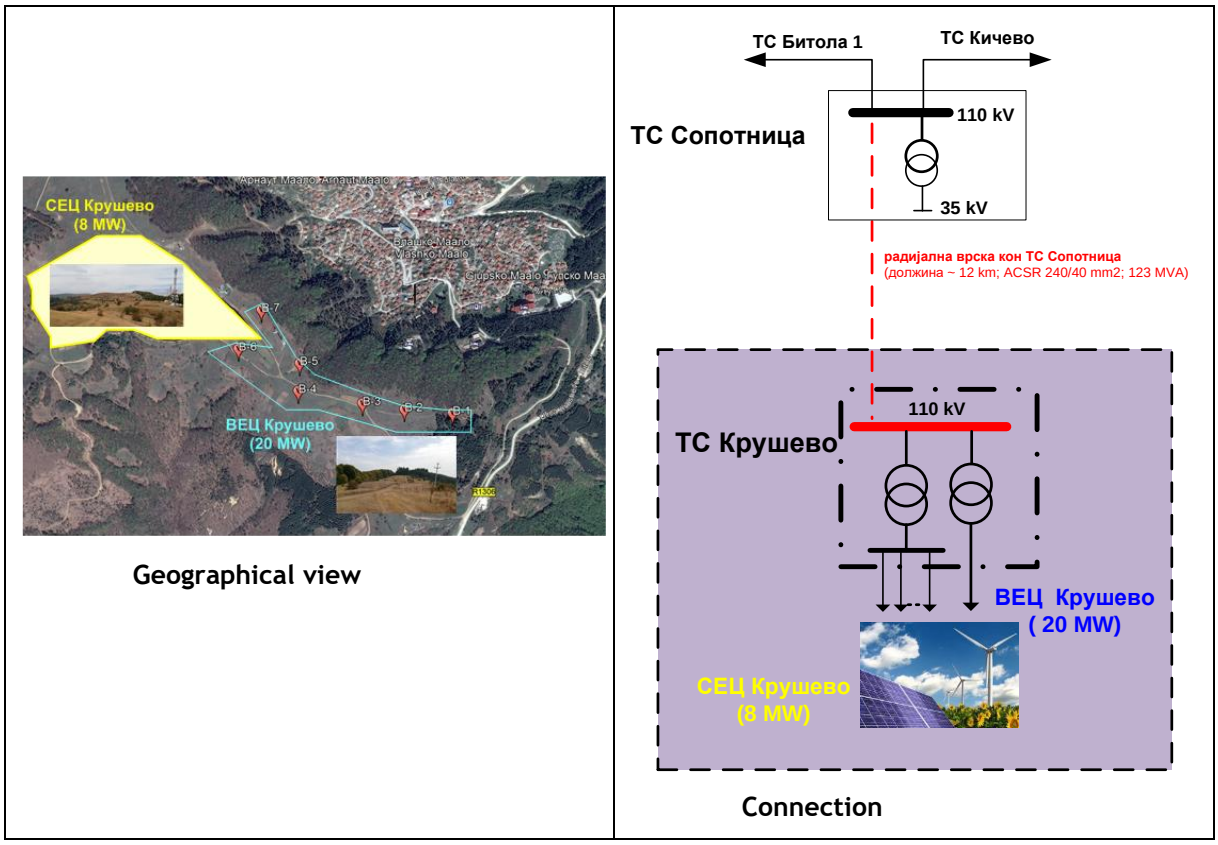


Figure 17. Location and connection to the transmission network of WPP Krushevo and VPVV Krushevo

WPP Krushevo and PVPP Krushevo will be connected to the transmission network via 110/x kV transformer substation SS Krushevo. The Study foresees the connection to be carried out via single-circuit (radial) 110 kV line to SS Sopotnica. The distance between the SS Sopotnica and transformer substation Krushevo is approximately 12 km.

By the procedure for connection, the Investor had prepared and approved a Study for connection of WPP and PVPP Krushevo to the transmission network. The invoice for the Study was issued, but it has not acted upon the same.

Further steps would be payment of the Study for connection; issuance of Approval for connection; signing a Contract for connection to the transmission network; supervision of the project documentation; supervision of the construction of the connection to the transmission grid; energizing the connection WPP Krushevo and PVPP Krushevo; possession of the part of the connection owned by MEPSO; and signing a Contract for the use of the transmission network.

9.1.5. Connection of WPP Oslomej 1 and 2 PVPP Oslomej (PPP)

AD ESM submitted a request for a new PVPP Oslomej with an installed power of 2x50 MW, besides the already planned PVPP Oslomej 2 and 3 with an installed power of 2x10 MW, in December 2019. The project will be carried out with a public-private partnership (PPP).

MEPSO submitted to AD ESM the integral analysis for connection of solar plants SPP Oslomej to the transmission network. Based on that analysis, AD ESM conveyed information that AD

ESM will build PVPP Oslomej 1 (10 MW) and PVPP Oslomej 2 (10 MW) in their ownership in Oslomej. PVPP Oslomej 1 and 2 will be connected to a 35 kV network owned by AD ESM.

For the remaining installed capacity of 80-100 MW in one or two PVPP, which will be realized via PPP, AD ESM asked for a way of connection and connection point at the transmission network.

On February 11, 2020, MEPSO submitted a response including a proposal for a method of connection and connection point at the transmission network for PVPP Oslomej (PPP).

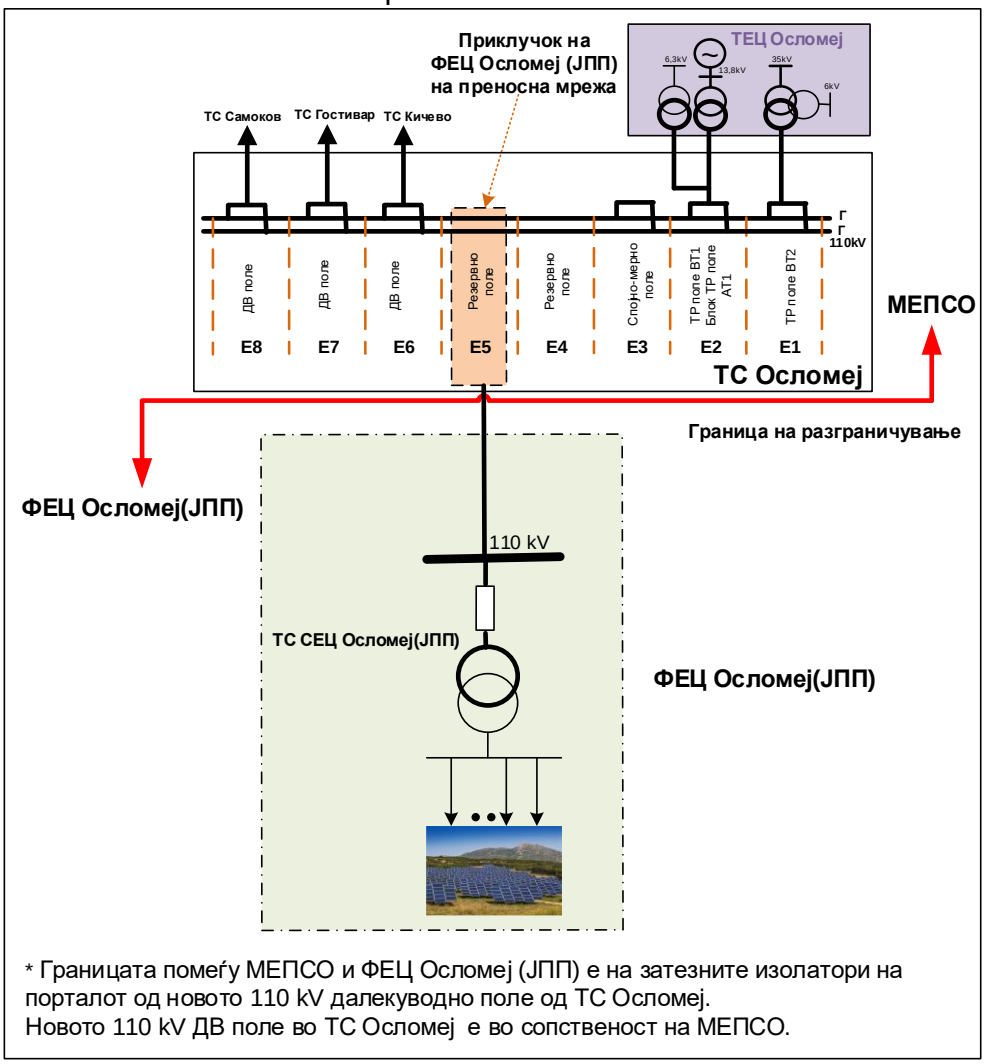


Figure 17. Proposal-connection point of PVPP Oslomej (PPP)

Further steps would include a request for connection of PVPP Oslomej (PPP); preparation of complete Study for connection to the transmission network; issuance of Approval for connection to the transmission network; signing a Contract for connection; supervision of the project documentation; supervision of the construction of the connection to the transmission grid; energizing the connection and mine; possession of the part of the connection that owns MEPSO; and signing a Contract for the use of the transmission network.

9.1.6. Connection of PVPP Bitola

AD ESM plans construction of two solar power plants, PVPP Bitola 1 (10 MW) and PVPP Bitola 2 (10 MW), with a total installed capacity of 20 MW. MEPSO prepared analysis for connection of the power plants in Bitola. PVPP Bitola 1 and 2 are connected to the existing SS Suvodol owned by AD ESM, which is connected to the transmission network in SS Bitola 2 through 110 kV TL.

AD ESM submitted an additional request for connecting a new PVPP Bitola 3 (40 MW) and PVPP Bitola 4 (100 MW). The analysis for the total evacuation of PVPP in the region of Bitola (REK Bitola) is in preparation, on the threshold of the transmission network with possible solutions for connection to the transmission network.

Further steps would include adoption of the Analyses for connection to the transmission network; preparation of complete Study for connection to the transmission network; issuance of Approval for connection to the transmission network; signing a Contract for connection; supervision of the project documentation; supervision of the construction of the connection to the transmission grid; energizing the connection and mine; possession of the part of the connection that owns MEPSO; and signing a Contract for the use of the transmission network.

9.1.7. Connection of PVPP Tikvesh

AD ESM plans construction of new PVPP Tikvesh with an installed capacity of 100 MW near the dam HPP Tikvesh.

AD ESM submitted an additional request for connection of new PVPPs Tikvesh. The analysis for the total evaluation of PVPP Tikvesh is in preparatory process, on the threshold of the transmission network with possible solutions for connection to the transmission network.

Further steps would include adoption of the Analyses for connection to the transmission network connection to the transmission grid; preparation of complete Study for connection to the transmission network; issuance of Approval for connection to the transmission network; signing a Contract for connection; supervision of the project documentation; supervision of the construction of the connection; energizing the connection and mine; possession of the part of the connection that owns MEPSO; and signing a Contract for the use of the transmission;

9.2. CONNECTION OF DISTRIBUTION SUBSTATIONS TO THE TRANSMISSION NETWORK

9.2.1. Connection of Second Transformer in SS Ovche Pole

Elektrodistribucija DOOEL–Skopje submitted a request for a change of the connection with installation of a second power transformer at the existing substation SS Ovche Pole, in the Municipality of Sveti Nikole because within the municipality territory is planned to be built several photovoltaic power plants with different capacity as part of the Solar PV and Wind PP Support Programme in the Republic of North Macedonia by the Ministry of Economy, financed by the European Bank for Reconstruction and Development (EBRD). The total installed capacity of those power plants is foreseen to be 25 MW.

A new additional (second) transformer 110/10(20) kV/kV with a capacity of 40 MWA needs to be installed in 110/35/10 kV/kV/kV SS Ovche Pole, to connect the new photovoltaic power plants with a total installed capacity of 25 Mw, in the village of Azembegovo, Municipality of Sveti Nikole, Table 14, position 7.

In compliance with the procedure for connection, the following activities were undertaken: approval of the equipment for realization of the connection, participation in the FAT of disconnectors, metering transformers, and metering equipment cabinet, and supervision of

the construction works as well as the implementation of the equipment.

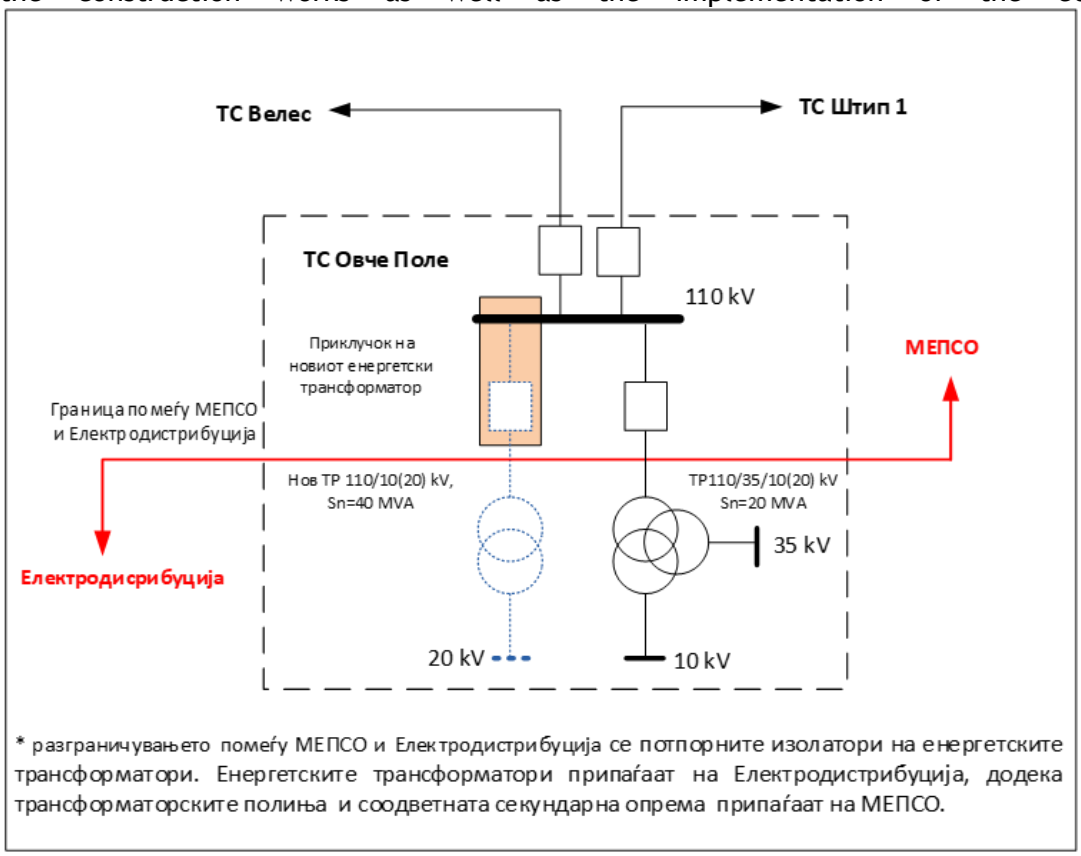


Figure 18. Connection of second transformer in SS Ovche Pole

Further steps would be signing a Contract for connection to the transmission; supervision of the project documentation, supervision of the construction of the connection to the transmission grid, energizing the connection, possession of the part of the connection that owns MEPSO, and signing a Contract for use of the transmission grid.

9.3. CONNECTION OF INDUSTRIAL CONSUMERS TO THE TRANSMISSION NETWORK

9.3.1. Connection of Cranfield Foundry

To connect Cranfield Foundry to the transmission network, substation 110/20 kV Neokazi was built in the industrial zone Probishtip, whose 110 kV switchyard has two main busbars connected via coupling bay with two power transformers of 20 MVA, Table 14, position 5. SS Neokazi is connected to the transmission network via double-circuit 110 kV transmission line to the existing 110 kV transmission line SS Shtip 1 – SS Probishtip forming electrical 110 kV links SS Shtip 1 – SS Neokazi and SS Neokazi – SS Probishtip.

According to the procedure for connection, a Contract for connection to the transmission network was signed, supervision of the construction of SS Neokazi and the 2x110 kV transmission line was done, SS Neokazi was bilaterally connected and set into operation, and a Contract for use of the transmission network was signed.

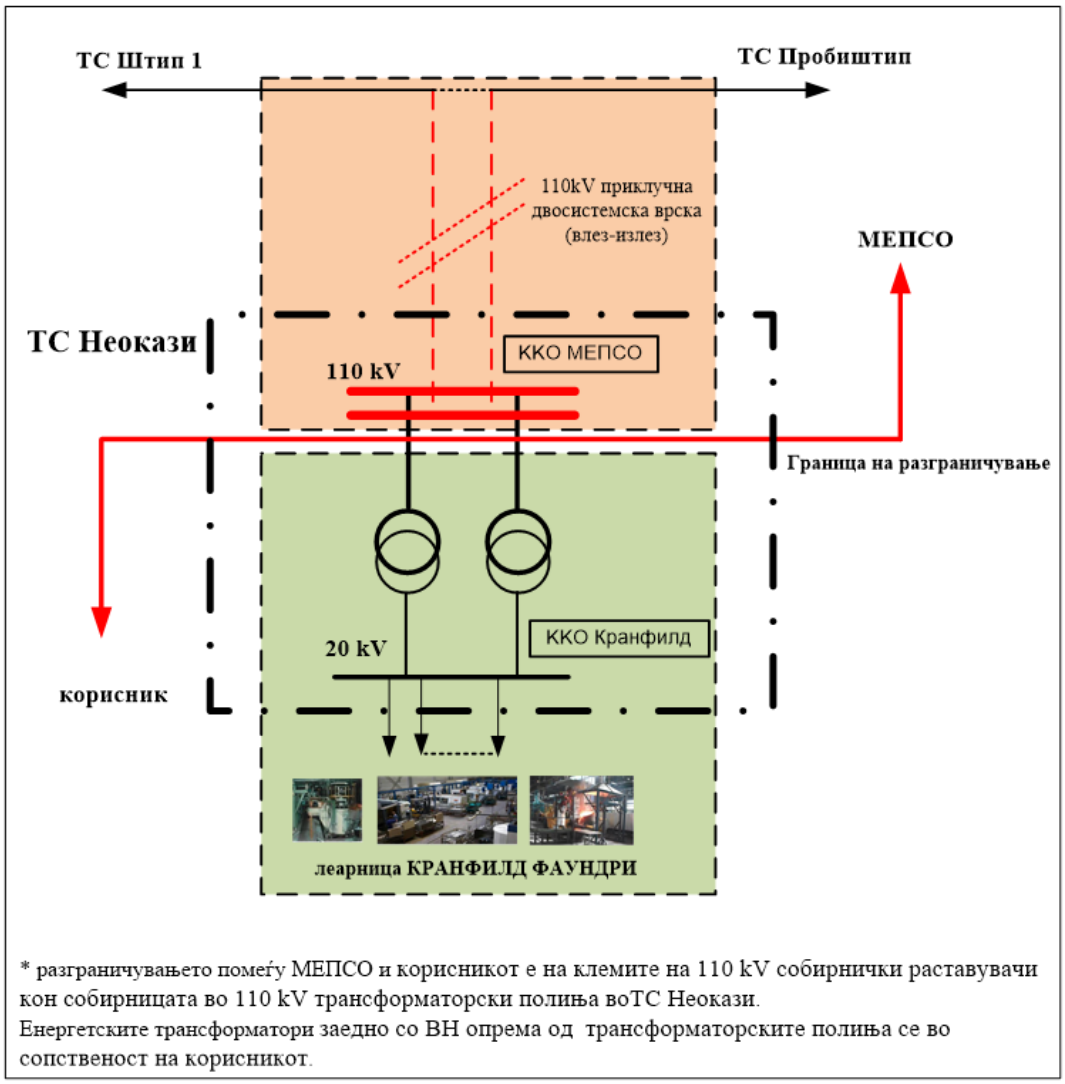


Figure 19. Connection of Cranfield Foundry

Further steps would be a removal of the final remarks from the supervision, payment of the supervision, possession of the part of the connection that owns MEPSO.

9.3.2. Connection of IMG Trade

The connection of IGM Trade to the transmission grid is planned to be realized via tapping (in/out) the existing 110 kV line SS Kavadarci – HPP Tikvesh, hence the section is positioned 650 m from the existing SS Kavadarci 1. The existing transmission line SS Kavadarci – HPP Tikvesh is commissioned by conductors from type ACSR 240/40 mm2, with a continuous permissible loading of 647 A/123 MVA, Table 14, position 6.

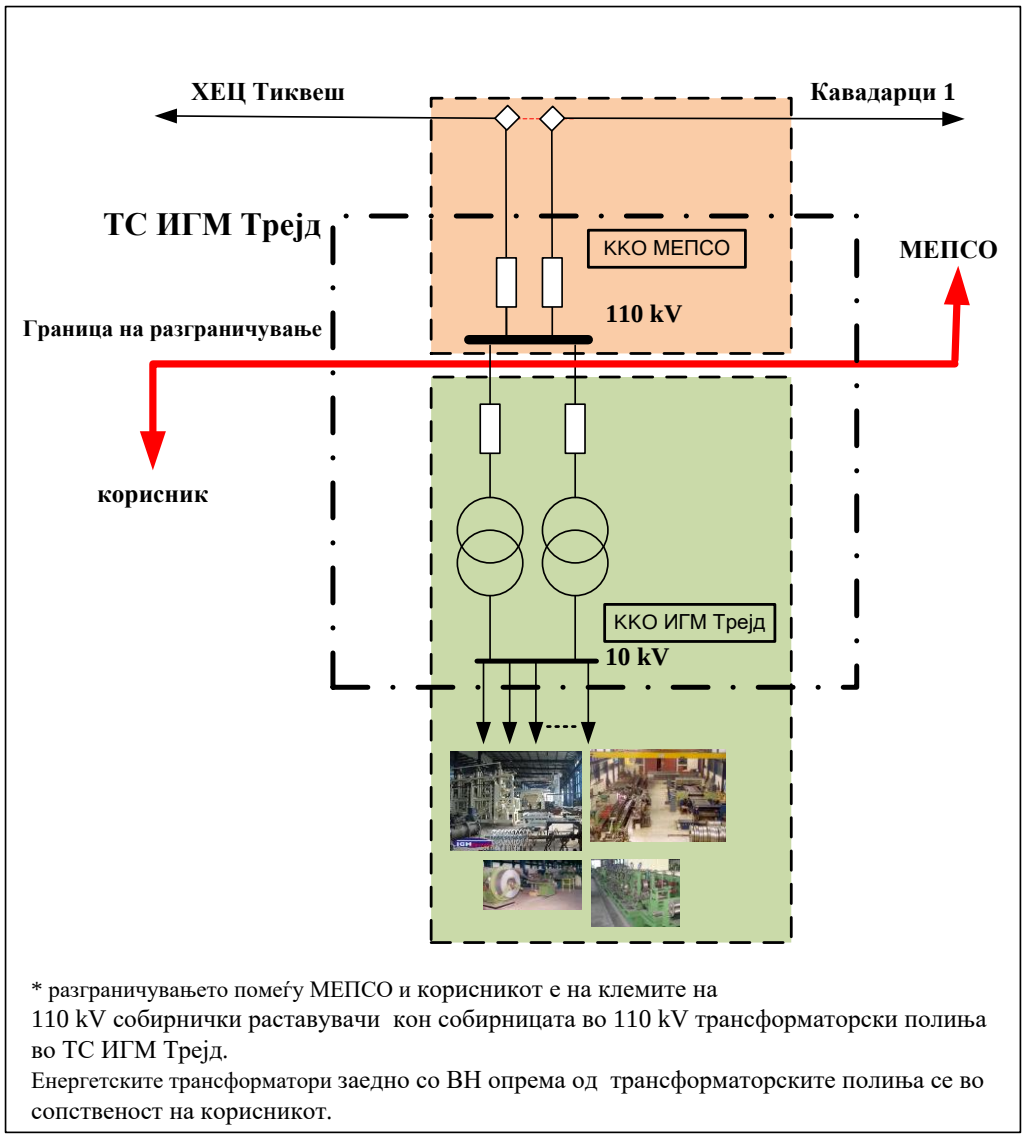


Figure 20. Connection of IGM Trade to the transmission network

In compliance with the procedure for connection, a Contract for connection to the transmission network was signed, while the preparation and supervision of the technical documentation are in the final phase.

Further steps would include finalization of the supervision of the project documentation, supervision of the construction of the connection, energizing of the connection and factory, possession of the part of the connection that owns MEPSO, and signing a Contract for use of the transmission grid.

9.3.3. Connection of Deposit Plavica – Kratovo

The connection with the Plavica deposit is foreseen to be realized via tapping (in/out) of the existing 110 line SS Probishtip –Kratovo switchyard.

The connection will be carried out through construction of a new double-circuit 110 kV transmission line with conductors Al/Fe 240/40 mm^2 (permissible loading of 645 A e.i. permissible capacity of 123 MVA) on the section from SS Plavica to the existing 110 kV TL SS Probishtip –Kratovo Switchyard. The length of the double-circuit section is estimated to be 2.7 km.

According to the procedure for connection, a Study for connection to the transmission network was prepared.

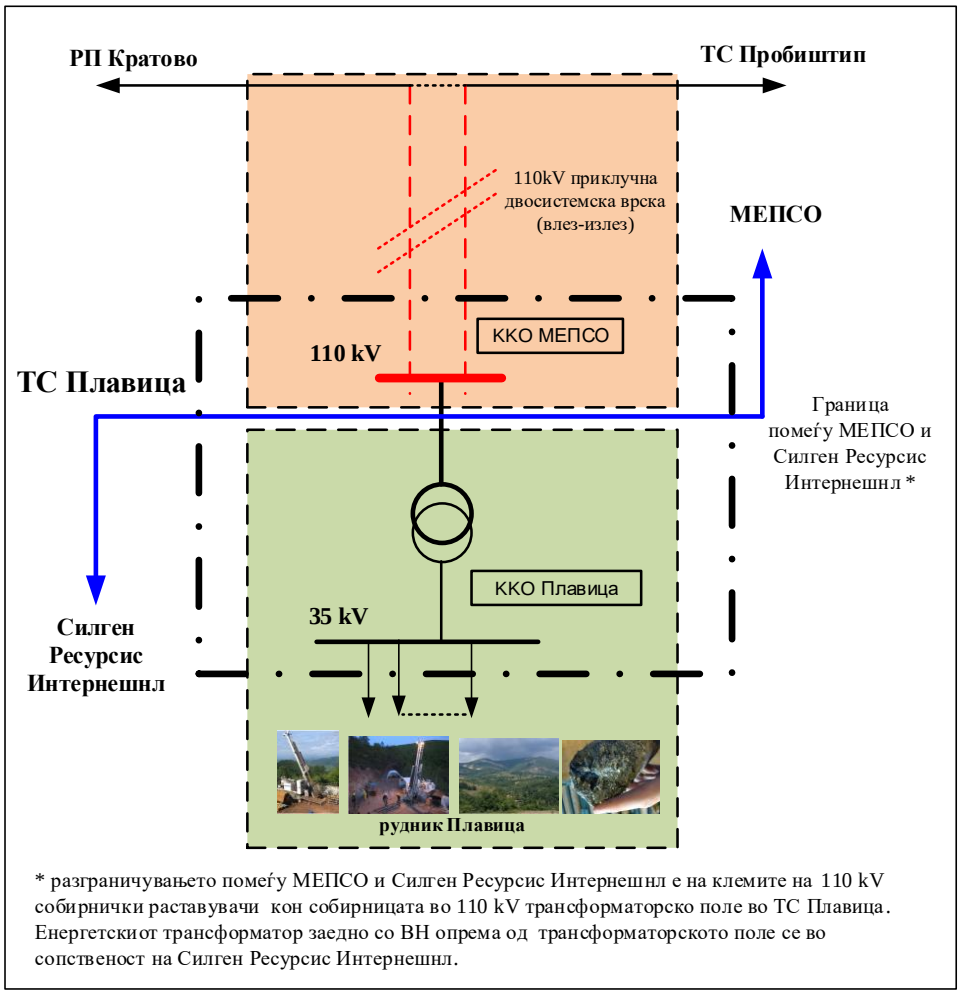


Figure 21. Connection of Plavica – Kratovo Deposit

Further steps would be approval of the Study for connection to the transmission network, issuance of Approval for connection to the transmission network, signing Contract for connection to the transmission network, supervision of the construction of the connection, energizing of the connection and depository, possession of the part of the connection that owns MEPSO, and signing a Contract for the use of the transmission grid.

10. PROJECTS REALIZATION IN THE PERIOD 2021 - 2030

Taking into consideration all the changes foreseen in the period from 2021 to 2030, in terms of construction of new facilities in the Macedonian power system and the neighbouring systems (new interconnections in the region, connection of new consumers and producers to the Macedonian transmission grid, as well as reconstruction and rehabilitation of the transmission grid facilities), the development analyses gave solutions that have to be implemented in the Macedonian transmission grid in order to ensure secure and reliable operation of the power system.

Table 12 gives the time frame for the realization of new transmission projects, facilities for reconstruction/revitalization, modernization, and researches in the power system, which shall be implemented in the period from 2021 to 2030.

The Table also shows the value of the projects by years, including funds from current loans and grants from international financial institutions and MEPSO's funds.

Table 10. Timeframe and dynamic allocation of investments for period 2021-2030

No.	Projects	Budget Contract (MEUR)	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Realization (MEUR) loan	MEPSO	grant	Total
Interconnection lines																
1	400 kV interconnection transmission line TC Битола 2 – Macedonian/Albanian border	16.54	8.87	4.83	0.15								10.59	0.00	3.26	13.85
New transmission lines and substations																
2	400/110 kV Substation in SS Ohrid and new 400 kV TL bay in SS Bitola 2	16.32	5.78	5.21	1.88								11.37	0.00	1.50	12.87
3	Connection of 110 kV TL: HPP Vrutok - SS Skopje 1 in one substation from the region of Polog	5.10	0.10	0.10	0.60	3.00	1.30						0.00	5.10	0.00	5.10
4	Construction of SS 400/110 kV Kumanovo (1 x 300 MVA)	15.10				0.05	0.05	3.00	3.00	3.00	3.00	3.00	9.06	6.04	0.00	15.10
Revitalization/reconstruction of 110 kV transmission lines																
5	Revitalization of 110 kV transmission lines	3.00	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.00	7.00	0.00	7.00
6	Revitalization of TL 2x110kV section Vapila - SS Ohrid 1	0.58	0.38	0.20									0.00	0.58	0.00	0.58
7	Reconstruction of 110 kVTLs on Vrutok - Tetovo route	0.38	0.28	0.13									0.41	0.00	0.00	0.41
8	Reconstruction of 110 kV TL SS Bunardjik – SS Miladinovci	1.20	0.60	0.60									0.80	0.40	0.00	1.20
9	Reconstruction of 110 kV TL SS Veles - SS Ovche Pole	1.81	1.71										1.14	0.57	0.00	1.71
10	Reconstruction of 110 kV TL SS Ovche Pole - SS Shtip	1.41	1.19										1.02	0.17	0.00	1.19
11	Reconstruction off 110 kV TL SS Bitola 1 – SS Prilep	3.92	3.22										1.71	1.51	0.00	3.22
12	Reconstruction of 110 kV TL SS Skopje 4 –SS Petrovec - SS Veles	2.91	2.81										2.61	0.20	0.00	2.81
13	Reconstruction of TL 110 kV Gostivar (Bukovikj) - TPP Oslomej - Kichevo - Sopotnica - Bitola 1 (length ≈ 100 km AAAC)	2.37	0.10	1.09	1.19								0.17	2.20	0.00	2.37
14	Strneghtening of the network in the southeast region option 1: Double-circuit 110 kV line Dubrovo- Strumica length ≈ 57,5 km, AAAC-Z) or option 2: 400/110 kV SS in Strumica (300 MVA)	7.1-25.0		0.50	1.30	2.00	3.30						3.96	1.32	1.82	7.10
15	Reconstruction of TL 110 kV Polog -HPP Vrutok - HPP Shpilje - HPP Globochica - Struga (length ≈ 100 km, AAAC)	7.95							0.25	0.25	0.50	1.00	1.20	0.80	0.00	2.00
Revitalization/reconstruction of substations																
16	Revitalization of substations	13.00	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	0.00	13.00	0.00	13.00
17	HV equipment- disconnectors	0.93	0.93										0.28	0.65	0.00	0.93
Reconstruction/upgrade of Switchyard Kratovo																
18	Construction of 110 kV transmission bays, complete reconstruction and digitalization of the switchyard	0.70	0.10	0.25	0.35								0.60	0.10	0.00	0.70
Revitalization of SS Skopje 4																
19	HV equipment (*circuit-breakers.disconnectors, measurement transformers), cabinets*	4.80	1.40										0.00	1.40	0.00	1.40
20	Supports and foundations for 400 kV switchyard		0.22										0.00	0.22	0.00	0.22
21	Power transformer (5-SK4-1TA*)	2.50								0.50	2.00		0.00	2.50	0.00	2.50
Revitalization of SS Dubrovo																
22	Power Transformer (3-DUB-1TA)	2.50						0.50	2.00				0.00	2.50	0.00	2.50
23	HV equipment - disconnectors	2.00	1.00	1.00									2.00	0.00	0.00	2.00
Revitalization of SS Bitola 2																
24	HV equipment (110 kV circuit-brakers), secondary equipment	1.00	0.10										0.00	0.10	0.00	0.10
25	HV equipment (400 kV and 110 kV disconnectors, measurement transformers)	2.70	1.32	0.57	0.57								0.56	1.90	0.00	2.46
Revitalization of SS Kochani																
26	Shunt compensation in 110 kV SS Kochani (25 Mvar)	0.75								0.15	0.60		0.00	0.75	0.00	0.75
Revitalization of SS Veles and SS Kavadarci 1																
27	Adaptation, procurment and installation of primary equipment, installation of SACS, protection and DC supply	0.61	0.51										0.00	0.51	0.00	0.51
Revitalization/reconstruction of control systems in substations																
Reconstruction and modernization of the control system in SS Samokov																
28	Installation of supervision and control systemin SS Samokov based on SCADA platform and Bay Control Units (BCU)	0.20	0.15	0.05									0.00	0.20	0.00	0.20
Reconstruction and modernization of the control system in SS Strumica 1																
29	Installation of supervision and control system	0.25	0.05	0.20									0.00	0.25	0.00	0.25
Reconstruction and modernization of the control system in SS Sushica																
30	Installation of supervision and control system	0.20		0.20									0.00	0.20	0.00	0.20

No.	Projects	Budget Contract (MEUR)	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Realization (MEUR) loan	MEPSO	grant	Total
Modernization of the power system																
31	Telecommunication equipment and remote monitoring of substations	5.00	2.05	2.95									2.95	2.05	0.00	5.00
32	Underground installation of optic fiber cable	0.20	0.20										0.15	0.05	0.00	0.20
33	Balkan Digital Highway	5.80	0.80	3.25	1.75								1.50	2.50	1.80	5.80
34	Procurement and installation of OPGW in 400 kV TL Skopje 4 - Bitola 2	1.80		0.18	1.62								0.00	1.80	0.00	1.80
35	Smart Grid: DLR - Dynamic Line Rating	1.23		0.03	0.20	1.00							0.00	1.23	0.00	1.23
36	Voltage regulation technology	2.80					0.80	2.00					0.00	2.24	0.56	2.80
37	Procurement and installation of new SCADA/EMS system	3.30	0.15	0.65	1.50	1.00							3.30	0.00	0.00	3.30
38	Data Room	0.14	0.03	0.11									0.00	0.14	0.00	0.14
39	ENTSO-E Electronic Highway in NDC and BDC	0.10	0.02	0.08									0.00	0.10	0.00	0.10
40	Smart Maintenance and Asset managment	0.90	0.65	0.25									0.90	0.00	0.00	0.90
Studies on the power system																
41	CROSSBOW	0.18	0.05										0.00	0.00	0.05	0.05
42	TRINITY	0.80	0.02	0.02	0.02								0.00	0.00	0.06	0.06
43	Regional feasibility study on voltage profile improvement	0.80	0.20										0.00	0.00	0.20	0.20
44	Study on transmission grid development	0.08	0.08										0.00	0.08	0.00	0.08
45	Action plan for power grid strengthening to support renewable projects in North Macedonia	0.48	0.40										0.00	0.00	0.40	0.40
46	Study on optimal configuration of the transmission network in the southeast region	0.78	0.60	0.13									0.00	0.00	0.73	0.73
		142.22	38.06	24.58	13.13	9.05	7.45	7.50	7.25	5.90	8.10	6.00	56.28	60.36	10.38	127.01

Projects financed with loan, investment grant and grant for Smart Grid (EBRD/EPSO funds

Projects financed from loan EBRD 44114 and MEPSO funds

Grant WBIF

Grant EBRD & WB

Grant HORIZON 2020

Loan EIB

11. COMPLEX ENERGY PROJECTS IMPLEMENTATION

This year's publication of the Power system development plan for ten years has also confirmed the goals and vision for the development of the Macedonian transmission grid. The trend for the realization of the projects is satisfactory with several delays, mainly because of the complex administrative procedures and adjustment of the local urban and sociological conditions, but an additional impact has the Covid-19 pandemic. The plan includes a redefinition of some priorities, and it includes several new projects identified in the planning cycle from the last year.

In Table 13, there is a comparison between the budget, the foreseen dynamic of activities, and expenses from the new plan (publication 2020) with the previous plan for the development of the power system (publication 2019). About the projects, which have different dynamics, and costs there is an explication regarding the price difference or realization period. Below are the important differences.

The price structure for the 400 kV interconnection Bitola (MK) – Elbasan (AL), position 1 and 400/110 kV SS Ohrid, position 2 is amended as per the completed project documentation, procurement plans, and signed contracts for construction. As a consequence of the pandemic and inability to unimpededly do the construction works, the project is prolonged until 2023.

The reconstruction of the 110kV TLs section Vrutok-Tetovo is postponed for 2021 because an extension of the building permit is needed. MEPSO made an optimization of its funds that will be used for this reconstruction.

The period for the realization of the project for revitalization of OHLs 2x110 kV section Vapila –SS Ohrid 1, position 6 is postponed for a year due to optimization and a new call for public procurement for construction design.

The duration of the project for reconstruction of the 110 kV OHL SS Bunardjik – SS Miladinovci, position 8, was extended until 2022, following the change of the route for the project for reconstruction of the 110 kV OHL SS Bunardjik – SS Miladinovci, position 8, a need for new approval for the route from MOEPP, as well as preparation of a new elaborate for Environmental Impact Assessment.

Regarding the ongoing projects for reconstruction of the 110 kV OHLs (positions 9 and 12), there are signed annexes to the contracts for extension of the duration of the projects for 18 months, without financial implications. The reconstruction of the 110 kV OHLs is prolonged for a year due to stagnation with the construction works.

The plan for reconstruction/revitalization of 110 kV lines also undergoes several changes. Regarding the priority corridor Gostivar (Bukovikj) – TPP Oslomej – Kichevo – Sopotnica – Bitola 1, position 13, the realization period has been postponed for one year because of the optimization procedure during designing. The Contract for designing is waiting to be signed. The kickoff of the project for strengthening of the southeast region (from Dubrovo to Strumica), position 14 is prolonged for a year since the results from the Study (position 46) that will direct which variant shall be implemented are still not delivered, based on which the costs will be determined.

The project reconstruction of Kratovo Switchyard is postponed for a year due to the optimization procedure for designing.

The projects for modernization of the power system (position 31-33), are prolonged for a year in account of the time framework for implementation of the projects and stagnation in the construction works because of the pandemic.

The implementation of the project for DNL (position 35) is prolonged for two years due to researches.

Table 11. Comparison of the projects in the development plan (2020) to the projects in the development plan (2019)

No.	Projects	Budget	Development plan (2020)	Development plan (2019)	Clarification of the difference in price and realization period 2019 vs.2020
Interconnections					
1	400 kV interconnection line SS Bitola 2 –Macedonian/Albanian border	29.40	**13.85**	**27.01**	The difference in price is for to the following reasons: 1. The contract price is lower for around €10 million than the budget price. 2. The realized costs from 2020 are not shown. The project continues in 2023.
New Transmission Lines and Substations					
2	400/110 kV Substation in SS Ohrid and new 400 kV TL bay in SS Bitola 2	14.00	**12.87**	**13.72**	The structure of the costs is updated as per the performance plan. The project continues in 2023.
3	Connection of 110 kV TL: HPP Vrutok - SS Skopje 1 in one substation from the region of Polog	5.10	**5.10**	**5.10**	The realization period is postponed for one year due to the specificity of the terrain and obsticles regarding the choice of access road.
4	Construction of 400/110 kV Kumanovo (1 x 300 MVA)	15.00	**15.10**	**15.00**	The investment price and implementation period are updated as per the current prices for equipment, designing and construction of facilities of this type.
Revitalization/Reconstruction of 110 kV Transmission Lines					
5	Revitalization of 110 kV lines	3.00	**7.00**	**3.00**	
6	Revitalization of TL 2x110kV section Vapila - SS Ohrid 1	0.58	**0.58**	**0.58**	The realization period is postponed for one year due to optimization and improvement of the public procurement for designing.
7	Reconstruction of 110 kV TLs - route Vrutok - Tetovo	0.41	**0.41**	**0.54**	The realization period is postponed for one year, until issuance of an extension of the construction permit.
8	Reconstruction of 110 kV TL SS Bunardjik - SS Miladinovci	1.20	**1.20**	**1.20**	New route is suggested considering rational performance; the new connection point of the 110 kV TL towards Miladinovci will be SS Bunardjik.
9	Reconstruction of 110 kV TL SS Veles - SS Ovche Pole	1.81	**1.71**	**1.16**	Anex 2 to the Contract for extention of the project for 18 months was prepared. The project continues without modification of price; permits and approvals are pending.
10	Reconstruction of 110 kV TL SS Ovche Pole - SS Shtip	1.41	**1.19**	**1.01**	The project shall be completed with delay of several months.
11	Reconstruction of 110 kV TL SS Bitola 1 - SS Prilep	3.92	**3.22**	**3.23**	
12	Reconstruction of 110 kV TL SS Skopje 4 – SS Petrovec 0 SS Veles	2.99	**2.81**	**2.31**	
13	Reconstruction of SS 110 kV Gostivar (Bukovikj) - TPP Oslomej - Kichevo - Sopotnica - Bitola 1 (length ≈ 100 km AAAC)	3.10	**2.37**	**3.10**	The realization period is postponed for a year due to optimization of the designing procedure.
14	Strenghtening of the network in the southeast region option 1: Double-circuit 110 kV line Dubrovo- Strumica length ≈ 57,5 km, AAAC-Z) or option 2: 400/110 kV SS in Strumica (300 MVA)	7.1-25.0	**7.10**	**7.10**	
15	Reconstruction of TL 110 kV Polog - HPP Vrutok - HPP Shpilje - HPP Globochica - Struga (length ≈ 100 km, AAAC)	7.95	**2.00**	**1.00**	
Revitalization/Reconstruction of Transformer Substations					
16	Revitalization of Substations	14.20	**13.00**	**14.20**	
17	HV equipment- disconnectors	0.93	**0.93**		New project for procurement of disconnectors in several substations.
Reconstruction/Upgrade of Swithyard Kratovo					
18	Construction of 110 kV transmission bays, complete reconstruction and digitalization of the switchyard	0.70	**0.70**	**0.70**	The realization period is postponed for a year due to optimization of the procedure for designing.
Revitalization of SS Skopje 4					
19	HV equipment (*diconnectors, circuit-breakers, measurment transformers*) cabinets	4.80	**1.40**	**2.34**	
20	Supports and foundations for 400 kV switchyard	0.22	**0.22**		New project for supports and foundation.
21	Power Transformer (5-SK4-1TA)	2.50	**2.50**	**2.50**	
Revitalization of SS Dubrovo					
22	Power transformer (3-DUB-1TA)	2.50	**2.50**	**2.50**	
23	HV equipment- disconnectors	2.00	**2.00**		New project for procurement of disconnectors.
Revitalization of SS Bitola 2					
24	HV equipment (110 kV disconnectors), secondary equipment	1.00	**0.10**	**0.42**	
25	HV equipment (400 kV and 110 kV disconnectors, measurment transformers)	3.18	**2.46**		New tender for replacement of the high-voltage equipment.
Revitalization of SS Kochani					
26	Shunt compensation in 110 kV SS Kochani (25 Mvar)	0.75	**0.75**	**0.75**	
Revitalization of SS Veles and SS Kavadarci					
27	Adaptation, procurment and installation of primary equipment, installation of SACS, protection and DC supply	0.51	**0.51**	**0.54**	
Revitalization/reconstruction of control systems in substations					
Reconstruction and modernization of the control system in SS Samokov					
28	Installation of supervision and control systemin SS Samokov based on SCADA platform and Bay Control Units (BCU)	0.20	**0.20**		
Reconstruction and modernization of the control system in SS Strumica 1					
29	Installation of supervision and control system	0.25	**0.25**		Installation of supervision and control system
Reconstruction and modernization of the control system in SS Sushica					
30	Installation of supervision and control system	0.20	**0.20**		

No.	Projects	Budget	Development plan (2020)	Development plan (2019)	Clarification of the difference in price and realization period 2019 vs.2020
Modernization of the power system					
31	Telecommunication equipment and remote monitoring of substations	5.00	5.00	5.00	
32	Underground installation of optic fiber cable	0.20	0.20	0.20	Projects are postponed for a year due to the change of the time frame for implementation of the projects and stagnation in the construction activities.
33	Balkan Digital Highway	5.80	5.80	5.80	
34	Procurement and installation of OPGW in 400 kV TL Skopje 4 - Bitola 2	1.80	1.80		OPGW of 400 kV TL Skopje 4 - Bitola 2
35	Smart Grid: DLR - Dynamic Line Rating	1.23	1.23	1.23	Projects are prolonged because of research studies.
36	Device for voltage profile correction	2.80	2.80		Device procured as a result of theRegional feasibility study on voltage profile improvement.
37	Procurement and installation of SCADA/EMS system	3.30	3.30		New SCADA/EMS system
38	Data Room	0.14	0.14		Providing high-level protection of the equipment and data also increase the accessibility of the data center of the systems for supervision and control in TSO.
39	ENTSO-E Electronic Highway in NDC and BDC	0.10	0.10		New Electronic Highway system for sacure exchange of data.
40	Smart Maintenance and Asset management	0.90	0.90		System for maintenance and management of the equipment.
Studies on the power system					
41	CROSSBOW	0.18	0.05	0.10	
42	TRINITY	0.80	0.06	0.08	
43	Regional feasibility study on voltage profile improvement	0.80	0.20	0.60	Additional researches for complete realization of the project are required.
44	Study on transmission grid development	0.08	0.08	0.08	
45	Studies on integration of RES	0.08	0.40	0.08	New study for development of the generation capacities and RESintegrationin Western Balkan finnaced by the World Bank.
46	Study on optimal configuration of the transmission network in the southea	0.25	0.73	0.25	The study is in process of preparation within the framework of WBIF grant for technical support and will have greater scope of activities; more options, project and tender documentationfor
Deleted/Postponed Projects and Activities					
	Study on optimal utilization of the double-circuit busbars in the substations is of lower priority				Postponed

New projects in the development plan:

- Procurement of high-voltage equipment (disconnectors) in 13 substations financed by EBRD, position 17;
- Procurement of high-voltage equipment (disconnectors) in SS Dubrovo, position 23;
- New project for replacement of high-voltage equipment (400 kV and 110 kV disconnectors, measurement transformers) in SS Bitola 2, position 25;
- Installation of SCADA system in SS Samokov, SS Strumica 1 and SS Sushica, positions 28-30;
- New project for procurement and installation of OPGW of 400 kV TL Skopje 4 – Bitola 2, position 34;
- Project for procurement of voltage profile compensator, position 36;
- Project for procurement and installation of new SCADA/EMS system, position 37;
- Project for unification of all systems in MEPSO in Data Room, position 38;
- Project for ENTSO-E Electronic Highway, position 39;
- Procurement of Smart Maintenance and Asset Management, position 40;
- Least Cost Generation Planning and Variable Renewable Energy Grid Integration Analysis, position 45.

The Study on optimal utilization of the double-circuit busbars in the substations is of lower priority, consequently it is postponed.

12. COSTS FOR CONNECTION OF NEW USERS

Table 12. Table of the costs for connection to the transmission network

No.	Connections	Documents defining and determining the costs for connection to the transmission network	Costs for connection			
			Fixed costs		*Variable costs**	
			Costs:	Value (denars excluding VAT)	Costs:	Value (euro excluding VAT)
1	**WPP Bogoslovec**	Study for connection to the transmission network, prepared on 25 April 2017 Anex to the Study for connection to the transmission network, prepared on 05 June 2018 Approval for connection to the transmission network, issued on 21 June 2018	1. Study for connection to the transmission netwo 2. Approval of technical documentation 3. Construction supervision 4. Compliance testing	1,650,090.00 55,003.00 16.500,90 x T** as per the actual costs	Connection to the transmission network comprised of: 1. Connected 2x110 kV line 2. 110 kV switchyard and Control Building of MEPSO in SS Bogoslovec 3. Completing the equipment in the 110 kV TL bays in SS Ovche Pole and SS Shtip 1	2,278,000.00
2	**WPP Demir Kapija**	Study for connection to the transmission network, prepared on 19 June 2018 Approval for connection to the transmission network, issued on 19 July 2018 Agreement for connection of WPP Bogoslovec to the transmission network, signed on 25 November 2019	1. Study for connection to the transmission netwo 2. Approval of technical documentation 3. Construction supervision 4. Compliance testing	1,644,780.00 54,826.00 16.447,80 x T** as per the actual costs	Connection to the transmission network comprised of 110 kV TL bay in SS Dubrovo.	325,000.00
3	**WPP Miravci**	Study for connection to the transmission network, prepared on 01 August 2019 Approval for connection to the transmission network; issued on 04 November 2019	1. Study for connection to the transmission netwo 2. Approval of technical documentation 3. Construction supervision 4. Compliance testing	1,644,780.00 54,826.00 16,447.80 x T** as per the actual costs	Connection to the transmission network comprised of 110 kV TL bay in SS Valandovo	325,000.00
4	**WPP Krushevo and SPP Krushevo**	Study for connection to the transmission network, prepared on 30 August 2019	1. Study for connection to the transmission netwo 2. Approval of technical documentation 3. Construction supervision 4. Compliance testing	1,717,680.00 57,256.00 17,168.80 x T** as per the actual costs	Connection to the transmission network comprised of 110 kV TL bay in SS Sopotnica.	325,000.00
5	**Direct onsumer CRANFIELD FOUNDRY**	Study for connection to the transmission network, prepared on 17 November 2015 Anex to the Study for connection to the transmission network, prepared on 03 September 2018 Approval for connection to the transmission network, issued on 04 September 2018	1. Study for connection to the transmission netwo 2. Approval of technical documentation 3. Construction supervision 4. Compliance testing	547,770.00 54,777.00 16.447,80 x T** as per the actual costs	Connection to the transmission network comprised of: 1. Connected 2x110 kV line 2. 110 kV switchyard and Control Building of MEPSO in SS Neokazi 3. Completing the equipment of 110 kV TL bay in SS Probishtip	1,804,000.00
6	**Direct consumer IGM Trade**	Study for connection to the transmission network, prepared on 05 March 2018 Approval for connection to the transmission networ, issued on 29 March 2019 Agreement for connection of IGM Trade, signed on 09 September 2020	1. Study for connection to the transmission netwo 2. Approval of technical documentation 3. Construction supervision 4. Compliance testing	548,260.00 54,826.00 16.447,80 x T** as per the actual costs	Connection to the transmission network comprised of: 1. 110 kV connection line 2. 110 kV Switchyard and Control Building in SS IGM Trade 3. Completing the equipment of 110 kV TL bay in SS Kavadarci and HPP Tikvesh	892,000.00
7	**Second TR in SS Ovche Pole**	Study for connection to the transmission network, prepared in August 2017 Approval for connection to the transmission network, issued on 03 October 2019	1. Study for connection to the transmission netwo 2. Approval of technical documentation 3. Construction supervision 4. Compliance testing	286,280.00 57,256.00 17,176.80 x T** as per the actual costs	Connection to the transmission network comprised of 110 kV TL bay in SS Ovche Pole	325,000.00

* - Variable costs are estimated costs. If a difference appears between the given estimated costs and actual costs, the Investor is obliged to pay the actual costs.

** - T- planned and realized time of construction in case of extension of the planned time. time планирано или реализирано време на градба во случај на продолжување на планираното време

13. CONFIGURATION OF THE TRANSMISSION GRID IN 2030

Figure 22. Macedonian transmission grid in 2030