MEPSO

Investment and Development Division
Power system planning, analysis and connections

TEN YEAR NETWORK DEVELOPMENT PLAN FOR THE PERIOD 2020 – 2029

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Title:	TEN YEARS NETWORK DEVELOPMENT PLAN FOR THE PERIOD 2020-2029
Authors:	Power system planning, analysis and connections

Context

1. INTRODUCTION

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

MEPSO in 2016/2017 carried out a study on the development of the transmission network titled: "Concepts for the development of the transmission network in separate regions for long-term period" that represents a update/definition of the plans for the electricity transmission system (EPS), development as MEPSO's obligation in correspondence to the legislation in the country. Namely, the long-term vision for the development of the future 400 kV and 110 kV transmission network in the Macedonian EPS, shall be reconciled with the expected change in the load, taking into consideration the actual development plans by Elektrodistribucija, Power Plants of North Macedonia (ESM), as well as the connection of new users to the transmission network (new direct consumers and new producers of electric power).

The study is carried out by the use of a determinist approach including more scenarios, in whose terms are analyzed possible future working conditions. The scenarios are defined for different periods (years of 2020, 2025, 2030 and 204o) depending on variations like construction of power plants, system load, hydrology, engagement of the plants that use renewable energy sources (RRE – especially wind power plants, WPP), construction of power plants in the distribution network, etc. The final aim of the analysis of more scenarios is to fulfill the following basic principles:

- Achievement of acceptable security of electricity supply to consumers;
- Achievement of acceptable availability and capacity in the Macedonian transmission network for continual flow of the activities of all of the participants in the electricity market (producers, traders and suppliers, as well as other subjects);
- Enabling new consumers to connect to the transmission network under equal, transparent and undiscriminating non-discriminatory conditions;
- Integration of the power plants that use RES.

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

- Continually invest in the reconstruction and revitalization of the deteriorated elements of the transmission network;
- Invest in construction of new facilities in the transmission network (transmission lines, transformers (TR), information technology infrastructure, etc.) based on the criteria stated 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 electricity transmission, such as utilization of new conductors with low sag during revitalization and enlargement of transmission power in the existing transmission lines (OHLs), possible installation of assets based on power electronics (FACTS), possible installation of face shifting transformer (control over the active power flow), etc.
- Constantly promote and improve human resources because of obligatory participation in the European processes under ENTSO-E and participation in other international organizations (CIGRE, IEEE, etc.).

The greatest risks in the successful realization of the previously listed principles and planned activities are the uncertain flows in the economy, constraints on spatial and regional planning and ecological demands, insecurities in regards to the construction of new production facilities and insecurities with stable financing of all required activities.

MEPSO prepared a "Strategy for reconstruction/rehabilitation of the transmission network" in September 2019. Taking into consideration that the greater number of the transmission lines in the Macedonian transmission network were built 40-50 years ago, a great number of lines may be expected to be candidates for reconstruction/rehabilitation after 2020. Therein, when scheduling the undertakings on the lines, except for the lines' age, their significance for the safety of the transmission network operating shall be considered, as well. Hence, in this Strategy the focus is directed upon two key factors:

- Preparation of database with information for the condition of the functional components of the transmission lines, on whose basis were made the estimation of the condition and the matter of urgency about undertakings on certain transmission lines, which resulted in the priority list of undertakings; and
- Definition of the methodology in which throughout a procedure of optimization is created a schedule of undertakings set into specific periods (2025-2030, 2030-2035, 2035-2040), therefore the schedule was prepared as balanced as possible by giving priority to all the safety criteria for transmission system operation.

Therefore, the schedule for undertakings on the transmission lines in the periods of 2025-2030, 2030-2035, 2035-2040, was made by giving priority to the lines' condition and their systematic importance, as well. Additionally, a priority has been given to the recommendations arising from the already conducted development plans and studies in MEPSO. Moreover, the geographical connection with the lines has been assumed.

Although the average age of the transmission lines is relatively high and it is 42 years, the condition of almost 2/3 of them is estimated to behave above-average good, which indicates that they are properly maintained. The total investments for the three periods are 47.5 million euros, while the total length of all the lines suggested for reconstruction/rehabilitation is around 560 km. The average investment is 15.8 million euros, and the medium length is 187.5 km. The investments and lengths of the transmission lines are evenly divided into periods, in interval of ±10 % from the average value.

Ten years network development plan for the period from 2020 to 2029 represents an updated version of the analysis, and a result of both studies including a presentation of the condition of the realized projects, and projects that are in phase of implementation and necessary measures and investments that shall be taken in the upcoming 10 years.

2. Condition of the transmission network in 2019

The integration of producers and consumers is enabled by a well-developed transmission network with a large number of rings (contours) on two voltage levels: 110kV and 400kV.

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

Table 1. Length of transmission network by voltage level

Voltage level [kV]	110 kV	400 kV
Lenght [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 network. They form the 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 southwest region of the country. In addition, the 400 kV transmission lines are used for interconnection between the neighboring transmission systems. The transmission network of 110kV 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 centers. The connection between the 400kV and 110kV transmission networks is realized via the five substations: SS Skopje 4, SS Skopje 5, SS Bitola2, SS Dubrovo and SS Shtip.

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

On the northern side, towards Kosovo operates the 400 kV SS Skopje 5 - Firezaj (Uroshevac), and towards Serbia operates the 400 kV transmission line SS Shtip – SS Vranje 4. In the past, two transmission lines operated: 220 kV 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. Their reconstruction is not foreseen in the development plans, but only making use of the corridors for future construction of transmission lines.

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

Towards the eastern side, in 2009, it has started synchronized work for construction of 400 kV transmission line SS Shtip – SS Chervena Mogila in cooperation with the Bulgarian transmission system. Until then, an occasional electricity exchanges had been conducted between both of the systems in an "islanded" operation, using two 110kV transmission lines SS Kriva Palanka – SS Skakavica and SS Sushica - SS Petrich. Currently, both of the 110kV transmission lines are operating, but most of the time they work in island mode.

Figure 1. Condition of the transmission network in 2019

3. New INTERCONNECTION lines towards the neighbours

The benefits from the interconnections are reflected in incomes like a reduction of electricity losses, an increase of cross-border transmission capacity and increase of transits among the regional systems and equalization of difference in the electricity price in the region. Despite the above mentioned general benefits, there are other positive impacts that contribute to the social values, such as increased supply reliability, decreased investments in power production facilities for national system reserves, regional dispatching and reduced production costs, as well as generalization of the reactive power.

3.1 400 KV INTERCONNECTION TRANSMISSION LINE BITOLA (MK) – ELBASAN (AL)

The realization of Corridor 8 is of great significance to our state. Regarded from the geostrategic aspect, Corridor 8 is an integral part of one much larger and exclusively significant project that includes the exploitation of energetic sources from the Caspian region and from Central Asia. Therefore, a "Joint Statement for Energy Infrastructure Cooperation" was signed on 13 April 2005 in Sofia by the Ministers from the energetic domain 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 the power engineering viewpoint, the 400 kV interconnection Bitola (MK) – Elbasan (AL) represents the last part of the realization of the Corridor 8 (East-West) for transmission of electric power between Bulgaria, North Macedonia, Albania, and Italy. The part between Bulgaria and North Macedonia is completed, while the realization of the submarine cable between Italy and Montenegro is in process, and by now the first phase has been completed with an installed capacity of 600 MW out of the 1200 MW foreseen. The projects for 400 kV interconnection between Albania and Montenegro and between Albania and Kosovo are already in function.

Discerning the development of the Macedonian transmission network, the construction of a new 400/110 kV substation in the Ohrid - Struga region with in/out connection to the new 400 kV interconnection Bitola (MK) – Elbasan (AL) will solve the problems that exist in the south-western part of the transmission network.

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

The project is shown in Table 6, position 1 and 2.

3.1.1. Technical characteristics

The project 400 kV interconnection Bitola (MK) – Elbasan (AL) on the Macedonian territory:

1. 400 kV transmission line from SS Bitola 2 – Macedonian/Albanian border
2. 400/110 kV SS Ohrid
3. 400 kV transmission bay in SS Bitola 2

Table 3 shows the technical specification of the Macedonian part from the 400 kV interconnection Bitola (MK) –Elbasan (AL).

Table 3. Technical specifiction of 400 kV TL SS Bitola – Macedonian-Albanian border

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

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

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 it will be comprised of:

400 kV substation:	110 kV substation:
1. Coupling bay 2. OHLbay "SS Elbasan 3" 3. SS bay 1 4. Auxiliary SS bay 5. Auxiliary OHLbay 6. OHLbay "SS Bitola 2"	1. Coupling bay 2. OHLbay "SS Struga" 3. Auxiliary OHLbay 4. SS bay 1 5. OHLbay "SS Ohrid 1" 6. OHLbay "SS Ohrid 2" 7. OHLbay "SS Resen" 8. Auxiliary OHLbay 9. Auxiliary SS bay 10. Domestic needs

3.1.2. Financial and economic parameters

Study on the justification of 400 kV interconnection Bitola-Elbasan

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

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 investment value according to the *Study on the justification of 400 kV interconnection Bitola-Elbasan,* on the Macedonian part of the project is as follows:

1. 400 kV OHLfrom SS Bitola 2 - Macedonian/Albanian border	28,3 MEUR
2. SS 400/110 kV Ohrid	14,3 MEUR
3. 400 kV transmission bay in SS Bitola 2	0,85 MEUR
TOTAL	43,5 M EUR

The proposal for providing funds according to the *Study on the justification of the 400 kV interconnection Bitola-Elbasan* is as follows:

1. EBRD loan	37,25 MEUR
2. MEPSO's own funds	6,25 MEUR
TOTAL	43,5 M EUR

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

Grant

For 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 euro

  In the scope of this regional grant were prepared the following studies:

  - Study on the justification of the 400kV interconnection Elbasan (AL) – Bitola (MK),
  - Study on Environmental Impact Assessment of the 400 kV OHL SS Bitola 2 – Macedonian/Albanian border
  - Study on Environmental Impact Assessment of the 400 kV OHL SS Elbasan 3 – Albanian/Macedonian border

- WBIF grant for technical support (WB9-MKD-ENE-01) – 900.000 euro

  In the scope of this regional grant is prepared complete project documentation:

  - 400 kV transmission line from SS Bitola 2 – Macedonian/Albanian border
  - SS 400/110 kV Ohrid,

- 400 kV transmission bay SS Bitola 2,
- connecting 110kV OHLs to SS 400/110 kV Ohrid.

- WBIF investment grant (WB-IG00-MKD-ENE-01) – 12.000.000 euro

Loan

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

Main parameters:	EBDR loan No.46274
Signed:	10.12.2015
Loan:	37.000.000 EUR
Repayment period:	15 years including grace period of 3,5 years

Total funds (grant and loan)

The rate of progress and the allocation of funds are given in Table 5 and Table 6, position 1 and position 2 , in years and project components.

According to the source of financing the funds were allocated as follows:

Components	Summed values MEUR	Loan (MEUR)	Own Funds (MEUR)	Grant (MEUR)
400 kV interconnection OHL SS Bitola 2 – Macedonian/Albanian border	29,40	19,70	2,80	5,00
SS 400/110 kV Ohrid and new 400 kV OHL bay in SS Bitola 2	14,00	7,20	2,80	4,00

3.1.3 Project implementation

Completed activities:

- Preparation of Feasibility Study and Studies on environmental impact assessment (both for the Macedonian and Albanian part of the interconnection):
  - Financed by Grant I of WBIF: 800.000 euro (for the Macedonian part of the project 650.000 euro)
  - Final version: January 2013.
  - Prepared by: COWI (WBIF Consultant team).
- Approval for the Study on Environmental Impact Assessment.

  Issued on 27.07.2015, by the Ministry of Environment and Physical Planning after complemented entire procedure on assessment of the environmental effect of the project
- Research on vulnerable group fauna (birds and bets) across the corridor from the Macedonian part of the interconnection

  The research was carried out in a period of one year 2016-2017 on demand from the MOEPP

The Civil Engineering Institute Macedonia (GIM) - Skopje carried out the research

- Preparation of the complete project documentation

Financed by Grant II from WBIF approved in 2013: 899.098 euro.

It was designed by consultant/designer GEING-Skopje that has begun with the preparation in 2016

- Tender announcement: August 2019.
- At the tender were submitted 9 offers for the substation and 5 offers for the transmission line.

Following steps:

- Evaluation of bids and selection of the most suitable bidder for execution of all the components of the project.
- Signing a Contract for construction with the most suitable bidder and commissioning.
- Start of the expropriation procedure and resolution of the property and legal relations of land on which the 400 kV OHL and SS Ohrid shall be built.

The project is expected to be completed by 2022.

4. MEASURES AND INVESTMENTS IN THE PERIOD FROM 2020-2029

Generally, the transmission network in the power supply operates with satisfying characteristics as safety, reliability, and security of supply.

Possible disturbances in the safety of the operation for short-term period will be solved with re-dispatching of the production and/or with system unloading, with small undertakings on the network and with completion of the already started projects, while for the long-term period they will be solved with the accomplishment of new projects..

4.1. NORTHERN REGION OF THE TRANSMISSION NETWORK

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

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

In order to reduce the short-circuit currents of 110 kV busbars in SS Skopje 1 and SS Skopje 4, sectioning of busbars shall be done. Those plants have a double system of busbars (more complicated design), and great flexibility in the system operation is possible, more precisely, every element (transmission line, transformer) may be connected to one of the two busbar systems. While sectioning, the selection of elements that will be connected to the individual sections is important, and there are several modes of 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 with satisfactory safety of the system for the N-1 criterion. The study analysis for the implementation of the measure is given in Table 6, position 39.

4.2. WESTERN REGION OF THE TRANSMISSION NETWORK

In the north-western part of the transmission network, in process of realization is the project for 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. MEPSO will undertake actions to complete the construction of the third section from SS Polog to SS Tetovo 1 in 2020, and with that, the construction of the double-circuit transmission line from HPP Vrtutok to SS Tetovo will be completed. This project is shown in Table 6, position 7.

To surpass ultimate design loads, which occur when there is an outage at 110 kV OHL Vrutok – Tetovo 1, in the Study on transmission network development, it is suggested connection of the already existing 110 kV OHL Vrutok – Skopje 1 via in/out principle in SS Tetovo 1, so additional reconfiguration in the Polog region and new connections will be formed: HPP Vrutok – SS Tetovo1 and SS Tetovo 1 – SS Skopje 1. This undertaking is expected to be executed from 2020-2024. This project is shown in Table 6, position 3.

Regarding voltage quality in the transmission network and the security of supply, the construction of 400/110 kV SS Ohrid in the south-western region of the transmission network is of great importance, and it is expected to be completed until 2022. Without its construction and active participation of the power plants in the voltage 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). While 400/110 kV SS Ohrid is not built yet, it is necessary the power plants in the south-western region HPP Vrutok, HPP Globochica, and HPP Shpilje to participate actively in the regulation of the voltages, and reactive power flows.

Calculations from the stability analysis (N-1 criterion) in the Study on transmission network development indicate that in the western region when there is high hydrology (with maximal

engagement of HPP Kozjak and HPP Sv. Petka and high engagement of TPP Oslomej), and regimes with single power outages, 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%). A middle-term solution of the overload problem in the western region is foreseen with the reconstruction/revitalization of the whole 110 kV Gostivar - Oslomej – Kichevo – Sopotnica – Bitola 1 via utilization of conductors with high ampacity ("hot" conductors) and low sag (AAAC). This reconstruction/revitalization is planned to be completed in the period from 2020-2023. 110kV TPP Oslomej- Kichevo – Sopotnica – Bitola is built in 1960 and has ACSR 150/25 mm2, 93 MVA types of conductors. This project is presented in Table 6, position 14.

The long-term solution of the problem with overload in the western region is foreseen with additional reconstruction/revitalization of the 110 kV SS Polog – HPP Vrutok – HPP Shpilje – HPP Globochica – SS Struga with utilization of conductors with high ampacity ("hot" conductors) and low sag (AAAC). This reconstruction/revitalization is planned to be carried out in the period after 2030. The line 110 kV SS Polog – HPP Vrutok – HPP Shpilje – HPP Globochica - SS Struga is built in the period 1964-1970 and has ACSR 240/40 mm2, 121 MVA types of conductors. This project is presented in Table 6, position 16.

4.3. EASTERN REGION OF THE TRANSMISSION NETWORK

In the eastern region in the middle term period appears an overload of the 110 kV transmission lines and very low voltages in regimes with power outages (N-1 criterion). In order to ensure secure system operation, simultaneously taking into consideration the announced connections of the wind power plants in the southeast region, in the middle-term period, as a variant, it is suggested construction of 110 kV double-circuit transmission lines with high ampacity ("hot" conductors) and low sag (AAAC) during the reconstruction of the existing 110 kV OHL: SS Dubrovo –SS Valandovo and SS Valandovo – SS Strumica 2 - SS Strumica 1. Another variant is an upgrade of the network with a new 400/110 kV substation in the region, which enables the potential construction of a second 400 kV interconnection towards Bulgaria. The optimal solution shall be defined in the Study 7.4. This project is presented in Table 6, position 15.

To overcome low voltage conditions in the eastern region in the long-term period installation of compensational device (reactive power source) in 110kV SS Kochani with minimal power of 25 Mvar is foreseen.

Due to power load increase in the middle-term and long-term period in the south-eastern region and due to distorted safety in the N-1 criterion system operation, a new 400/110 kV SS Kumanovo is necessary to be built, the 110 kV transmission lines to be split and the loads to be redistributed among 110kV SS Kumanovo 1, 110 kV SS Kumanovo 2 and the new 110 kV SS Kumanovo 3. This project is presented in Table 6, position 4.

5. 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 network planning. Unreliable and older plants may endanger the reliability and safety of the whole 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 reliability and safety in the system.

Transmission facilities and equipment (overhead transmission lines, cables, substations, protective systems, systems for control and management, measurement systems, telecommunication installations, etc.) are aging during their operation. Every transmission facility and equipment has its own life expectancy. The transmission equipment is expected to operate according to the said characteristics during their life expectancy without a major number of errors and problems. The life expectancy for the same type of equipment may be changed over a broad span due to various factors such as climate conditions, operational conditions, and fabric characteristics. 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 following the declared characteristics until that is possible because of its age.

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

- Increase of the operational safety of the plants;
- Decrease in the amortization rate of the equipment installed in the transmission bays in the 110 kV substations;
- Significant decrease in the number of outages in the transmission lines, thus decrease of the interruption of power supply among the consumers;
- Increase in the level of uninterrupted power supply to the consumers;
- Reduction in price for maintenance and reduction of the problems by administrating the old transmission lines;
- Enhance the power quality at transmission system level
- Improvement of the employees and environment safety

5.1. RECONSTRUCTION AND REVITALIZATION OF TRANSMISSION LINES

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

5.1.1. Reconstruction of transmission lines

The reconstruction of the 110 kV transmission lines has begun and is financed by a loan from EBRD (44114), and it is presented in the following table as component 4:

Table 4. Reconstruction of the 110 kV transmission lines in the period from 2020 to 2029 (positions from 8 to 13 in Table 6)

Transmission line	Length (km)	Year of construction	Activities in 2019
SS Shtip – SS Probishtip	25.2	1972	In process of construction
SS Skopje 4 – SS Petrovec - SS Veles	37	1953	In process of design-build
SS Veles - SS Ovche Pole	21	1960	In process of design-build
SS Ovche Pole – SS Shtip	17.9	1960	In process of design-build
SS Bitola 1 – SS Prilep 1	33.7	1963	In process of design-build
SS Bunardjik – SS Miladinovci 1	17	1971	Change of route

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

Table 5. Reconstruction/revitalization of 110 kV transmission lines in the period from 2020 to 2029 (Table Table 6, positions 6 and from 14 to 16)

Transmission line	Length (km)	Year of construction	Undertaking
2x110 kV OHL Section Vapila – SS Ohrid1	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 Dubrovo –SS Valandovo	39,3	1971	Double-circuit OHLwith new conductor AAAC
SS Valandovo – SS Strumica 2 – SS Strumica 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	

5.1.2. Revitalization of Transmission Lines

The maintenance plans for the transmission network forsee continual rehabilitation of the existing transmission lines of MEPSO by replacement of the fittings, suspension equipment, earth wires, as well as replacement of the existing conductors with a new type of wires with better characteristics compared to the contemporary one, Table 6, position 5.

5.2. RECONSTRUCTION AND REVITALIZATION OF THE SUBSTATIONS

The reconstruction and revitalization of the equipment in the substations come as a result of real technical needs identified from different aspects:

- Equipment older than 30 years and inability to supply spare parts,
- Impeded maintenance of the equipment,
- Bad operational equipment parameters that are in function,
- Impeded management of the equipment,
- Risk to the employees and environment during manipulation with the equipment.

An analysis had been made for the condition of the 400/110 kV power transformers founded on the results from the "periodical surveys", operation surveillance, and laboratory testing. Based on these analyses, in the long-term period, one power transformer in SS Skopje 4 and SS Dubrovo is foreseen to be replaced. Such replacements of power transformers are shown in the positions 20 and 22 in Table 6.

Procurement and implementation of one power transformer in SS Bitola 2 has already begun and will be completed in 2020. This replacement of the power transformer is shown in Table 6, position 24.

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 arresters) and replacement of the auxiliary equipment (relay protection, remote control and management systems, supply, electric energy measurement) continues with an aim to increase the stability and reliability in the substations and the transmission system in the Republic of North Macedonia.

Because of the old age of the buildings (control buildings/rooms/facilities, fences, etc.) at the site of the substations, in continuity are undertaken works for their rehabilitation. The rehabilitation of the command buildings/rooms/facilities is also carried out for the improvement of energy efficiency.

The reconstruction and revitalization in the substations is carried out in several projects/packages:

5.2.1. Reconstruction in Switchyard Kratovo

The reconstruction of the switching station in Kratovo includes execution of 3 transmission bays, a new 100 kV busbars and reconstruction of the secondary circuits using the newest digital technology. This project is presented in Table 6, position 18.

5.2.2. Revitalization of SS Dubrovo

By the revitalization of 110 kV plant in SS Dubrovo, the old primary and auxiliary equipment (that has been in function since 1977) will be replaced, in Table 6, position 21. This complex project includes replacement of the primary equipment (circuit breakers, disconnectors, power and voltage metering substations) as well as revitalization of the secondary equipment of 400 kV and 110 kV voltage level that includes distribution and installation of relay protection systems, remote control and management, AC/DC supply and complete revitalization of the electric power measuring system.

5.2.3. Revitalization of four substations (SS Skopje 4, SS Bitola 2, SS Valandovo, HPP Oslomej)

In these substations, part of the high-voltage equipment and part of the secondary equipment will be replaced, Table 6, positions 19, 23, 25 and 26.

5.2.4. Relay protection (HPP Tikvesh, HPP Vrutok, HPP Globochica, HPP Shpilje)

In the substations that are connected to power plants, replacement of the relay equipment is in process; Table 6, position 27.

5.2.5. Revitalization of SS Prilep 1

The revitalization of SS Prilep 1 covers replacement of part of the high-voltage equipment and the secondary equipment; Table 6, position 28.

5.2.6. Revitalization of SS Veles and SS Kavadarci 1

In this project is planned replacement of part of the high-voltage equipment and the auxiliary equipment in SS Veles and SS Kavadarci 1 and installation of already procured equipment for DC supply and AC/DC distribution system in 4 substations, Table 6, position 29.

6. MODERNISATION OF THE TRANSMISSION SYSTEM

6.1. TELECOMMUNICATION EQUIPMENT AND REMOTE MONITORING OF THE TRANSFORMER SUBSTATIONS

AD MEPSO has built its telecommunication infrastructure for telecommunication link with the power facilities. This infrastructure is comprised of optical fiber integrated in the ground wires (OPGW) of the transmission lines and telecommunication equipment. The optical grid integrated in the ground wires of the transmission lines is shown in the following Figure:

Figure 3. OPGW ground wire cross transmission lines in the transmission network

This project includes supply and installment of TC equipment for construction of a new network for transmission of System for supervision and control, measurement of the electricity, relay protection, LAN and WAN network, telecommunication lines, Table 6, position 31.

The telecommunication equipment is the basis for receiving "real-time" data for SCADA/EMS system[1] and interconnection with the neighbouring countries, and data connection with all MEPSO's locations, as well. In order to modernize the whole telecommunication equipment, MEPSO shall offer a new systematic solution i.e. installation of DWDM[2] equipment.

[1] Supervisory control and data acquisition system for real time monitoring

[2] DWDM is a technology that merges - multiplexes - data signals from different sources so that they can share an optical fiber pair while maintaining complete separation of data sources.

This solution shall optimize the utilization of the optical wires, and at the same time will provide encryption on a physical level, which is the most acceptable for MEPSO, because of the on-time reception and complete protection of the information that will be transported. The system shall offer additional interfaces for inner and outer connection with other systems and entities.

Using DWDM, MPLS-TP and IP/MPLS, MEPSO will have a consistent way of security, solving problems, and control over its network.

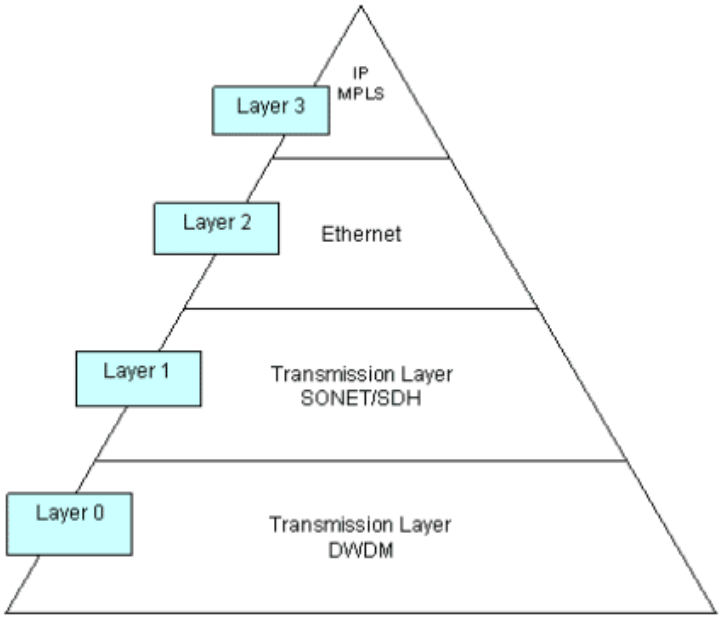


Figure 4. Structure of telecommunication equipment of MEPSO

6.2. UNDERGROUND FACILITY FOR OPTICAL CONNECTION

The underground facility for optical connection shall be done in order to connect NDC to SS Gjorche Petrov and TETO.

The preliminary activities are in progress. The realization is expected to begin, Table 6, position 32.

6.3. BALKAN DIGITAL HIGHWAY

The accessibility of the broadband infrastructure is considered a significant baseline of the economic and social development of a country. As an acknowledgment of this in 2012, the EU adopted Digital Agenda for Europe that is updated by the European Gigabit Society in 2015. Consequently, the broadband infrastructure deployment became the main priority for the region of the Western Balkan, as well.

The exchange of infrastructure (that may be reached with a contract between two or more transmission system operators (TSO)) is an efficient way to reduce the expanses for deployment of the broadband communication networks, to gain better connection, it helps to protect the environment, to decrease the consumption of resources and to increase energy efficiency.

Regarding the advantages, The World Bank formed initiative Balkan Digital Highway for research and upgrade of the possibilities for infrastructure sharing in Western Balkan. The initiative conducted numerous feasibility studies to:

- investigate the possibilities for use of the capacity surplus of the existing network fibers (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 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 as 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.

The assessments indicate that only 35% of the total capacity is used of all network fibers of the transmission network operators in the region. In that manner, the infrastructure sharing may be considered as "win-win": the government gains by saving public funds and avoidance of unnecessary doubling of the infrastructure, the utilities gain by decrease of the expenses for installation of infrastructure that is necessary for them (for example distribution of smart grids, etc.) and the telecommunication operators gain optimization of their own networks so as to focus on providing an access to difficult reachable areas and straightening of the retail business.

The Balkans Digital Highway Initiative will provide improvement of the wholesale access to the fast broadband services on national and regional level of the participant countries by establishing regional network for broadband network, via OPGW infrastructure; Table 6, position 33.

In each country, the project will finance:

1. Identified segments and equipment of the OPGW network in the nodes of the backbone and international part of the TSOs' networks. Precisely, the project will finance CAPEX investments for upgrade of the existing SDH equipment of the active telecommunication equipment DWDM, MPLS-TP and IP-MPLS, enabling them obtainment of modern telecommunication services (for example x Gbps capacities).The exact scope of investments that shall be conducted within each TSO will be identified through feasibility studies.

2. The modalities of co-operation between TSOs, including but not limited to carrying out mutual strategic approach, branding, integrated marketing, business arrangements and internal reorganization, shall be identifies through feasibility studies.

The project shall be carried out via national sub-projects.

The structure of the Project components will be based on the results from the feasibility studies (FS) and other project documentation, subject to this current application for grant from WBIF, and it is planned to be co-financed through the WBIF application for investment grants (INV GAF).

The studies before the feasibility estimated the initiative as potentially viable, useful for the TSOs demand, especially from the local Internet service providers' point of view (internet providers). The technical inventory of the current OPGW capacity surplus of the power networks in Western Balkan gives clear potential for infrastructure sharing on national and cross-border level, while those actual networks may be a good start point for further development. If they are made technologically uniformed and mutually connected, a unique optical tape may be created through high-voltage transmission lines, which is informally called "Balkan Digital Highway".

6.4. WIDE AREA MONITORING SYSTEM – WAMS

The wide area monitoring system (WAMS) enables on time detection of the aberrance from the operative safety margin. WAMS is based on measuring technology for phasor voltages and currents in real time at the same time (GPS synchronized).

This project shall form a system for obtainment of exact data about possible disturbances in the synchro-connected transmission system in real time and shall enable realization of proper activities for correction.

The aims of this project are: determination of optimal locations for installation of the wide area monitoring units in order to manage the transmission network stability issues with provision of high qualitative monitoring in real time, installation of the wide area monitoring units with the necessary

technical characteristics and installation of the central unit in the National Dispatcher Center with dynamic functions for stability monitoring.

The project is component of *Smart Grid Improvements;* Table 6, position 34.

6.5. DLR - DYNAMIC LINE RATING

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

To determine the economic viability of the DLR technology implementation, MEPSO shall firstly carry out initial researches in the frameworks of the study 7.4 with which will confirm the optimal transmission lines and routes to which the DLR technology shall be implemented.

The project is presented in Table 6, position 35.

6.6. SPECIAL SOFTWARE AND HARDWARE PACKAGE FOR MAINTENANCE OF THE TRANSMISSION NETWORK

Due to the needs of the interactive on-line operation and improvement of the efficiency, time, accuracy and scope of completed works for the transmission lines, a specific software and hardware package for maintenance of the transmission network are planned to be procured.

The specific software package is intended for planning, monitoring, operation, collection and processing of data related to maintenance of the transmission lines.

In order to function the specific software, a database for the transmission lines is planned to be formed, which will contain all the necessary data related to lines (types of towers, plates, heights, insulation types, conductors and earth wires, coordinates, access roads, etc.).

MEPSO will firstly carry out initial researches within the study 7.4 framework to determine the economic viability of the implementation of the specific software package.

The project is presented in Table 6, position 36.

7. REASEARCH ON THE POWER TRANSMISSION SYSTEM

Following the progressive goals for the development of the power transmission systems and obligations arising from the European regulations, MEPSO tends independently or as a member of regional and European projects to keep pace with progressive researches.

To that end, in its ten-year network development plan, MEPSO presents ongoing and future research that will guide the modern development of the power transmission system and modern functionality of the company.

7.1. 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 6, position 37.

The main goals 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.

7.2. TRINITY

TRINITY (TRansmission system enhancement of regIoNal borders by means of IntelIIgenT 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 6 position 38.

The main goals 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 – center for optimization and control of RES on 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 centers.

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, participates the Faculty of Technical Sciences Bitola.

7.3. REGIONAL FEASIBILITY STUDY ON VOLTAGE PROFILE IMPROVEMENT

The appearance of high voltages in certain operational regimes is an actual 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 commissioning of 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 6, position 42. 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.

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

According to the development plans, the current demands and the shown interest for connection to the transmission network, in the southeast part is expected concentration of more wind power plants, part of the hydropower plants from the Vardar Valley Project, as well as big industrial consumers. Certain researches in ENTSO-E showed that, in the long term, it might be expected necessity of a second 400 kV interconnection between North Macedonia and Bulgaria.

Additionally, 100 kV connection Dubrovo – Valandovo – Strumica 2 – Strumica 1 on the midterm horizon shall be a candidate for reconstruction because of the aging of the equipment. In the studies on network development and integration of renewable energy resources, a pragmatic solution for construction of new double-circuit 110 kV transmission line is suggested on the route Dubrovo – Valandovo – Strumica with new conductors with high ampacity ("hot" conductors) and low sag (AAAC).

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

MEPSO plans collaboration on a separate study in which will be investigated different variants for development/upgrade of the grid and will be made technical and economic optimization; in Table 6, position 43. Despite the already reviewed solutions, there will be researched variants with new 400/110 kV substation as well as interconnection from that region towards neighboring Bulgaria.

7.5. STUDY ON OPTIMAL UTILIZATION OF THE DOUBLE-CIRCUIT BUSBARS IN THE SUBSTATIONS

All 400/110 kV substations in the Macedonian transmission network (Skopje 4, Skopje 5, Shtip, Dubrovo and Bitola 2) are equipped with two systems of major busbars. These substations work in such a manner that all transmission lines and transformer bays are connected only to one busbar system and at two voltage levels, while the other system serves as a reserve. This type of operation does not use the potentiality for flexibility and enlarged reliability offered by the double busbars.

As a result of the transmission network development in the region of Skopje, short-circuit currents reach high values close to the nominal parameters of the high-voltage equipment. With an additional connection of new consumers and construction of new 110 kV transmission lines, short-circuits will surpass the equipment parameters.

The topology of the 110 kV network has the greatest impact on the value of the short-circuit currents. A simple change in the topology may be reached by grouping the feeders from different 110 kV sections from the double busbars within substations Skopje 1 and Skopje 4. Sectioning of 110 kV busbars is compulsory for dealings of high short-circuit currents.

On the other hand, grouping all 400 kV feeders in only one busbar jeopardizes the supply safety. An example for this is the very important 400 kV distribution plant in 400/110 kV SS Bitola 2, where both of the generators, both of the network transformers, both of the inner 400 kV transmission lines and one 400kV interconnecting transmission line are connected to only one 400 kV busbar system. In case of failure of the busbars appears simultaneous loss of the total production and exclusion of the all 400 kV transmission lines that would evoke partial or complete breakdown of the transmission system of the Republic of North Macedonia.

The planned Study on optimal utilization of the double busbar within substations, should analyze various operational regimes of the system and define proper topology for 110 kV and 400 kV busbars in 400/110 kV substations, Table 6, position 39. Additionally, appropriate managing procedures for the realization of the integrated operations shall be defined, as well as appropriate adjustment of the protection units.

7.6. NETWORK DEVELOPMENT STUDY

The Study on the transmission network development is part of the 10-year development plan for Europe's transmission network accepted by the European Network of Transmission System Operators ENTSO-E, as well as basis for the preparation of the national plan for development of the transmission system in a period of ten years.

This Study is a strategic document, and at the same time, 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 that defines different scenarios for the development of the conditions and requirements of the transmission system of the country.

As the new Strategy is expected to be published by the end of 2019, MEPSO will begin to prepare the Study in 2020, Table 6, position 40.

7.7. ACTION FOR POWER GRID STRENGTHENING TO SUPPORT RENEWABLE ENERGY PROJECTS IN NORTH MACEDONIA

The basic technical limitations for RES integration in the transmission network are in the supply of system reserves and the problems with the production changes balance and consumption in the transmission system. An extraordinary challenge is the wind power plants and the photovoltaic power plants (PVPP) because of their unpredictable way of production and the potential capacities.

The Study on reinforcement of the grid for RES integration will give a preview on the technical measures and investments for support of the installation of large RES capacities in the Macedonian transmission system, Table 6, position 41. The Integration of RES in the Republic of North Macedonia will be review regarding the following:

- Identification of different types of RES (locations, installed capacities) that are used or will be used in the country, with an emphasis on WPP and PVPP.
- Assessment of the expected changes in the production by the RES power plants on yearly, seasonally, daily and hourly level.
- Assessment of RES impact on electricity consumption and loads considered on system level as a whole and transmission network..
- Analysis of the possible technical limitation of the transmission network operation due to RES integration.
- Assessment of the necessary additional services within the transmission system in case of different levels of RES integration.
- Recommendations for technical measures and systems for integration of RES.

8. CONNECTION OF NEW USERS TO THE TRANSMISSION NETWORK

8.1. CONNECTION OF GENERATION CAPACITIES TO THE TRANSMISSION NETWORK

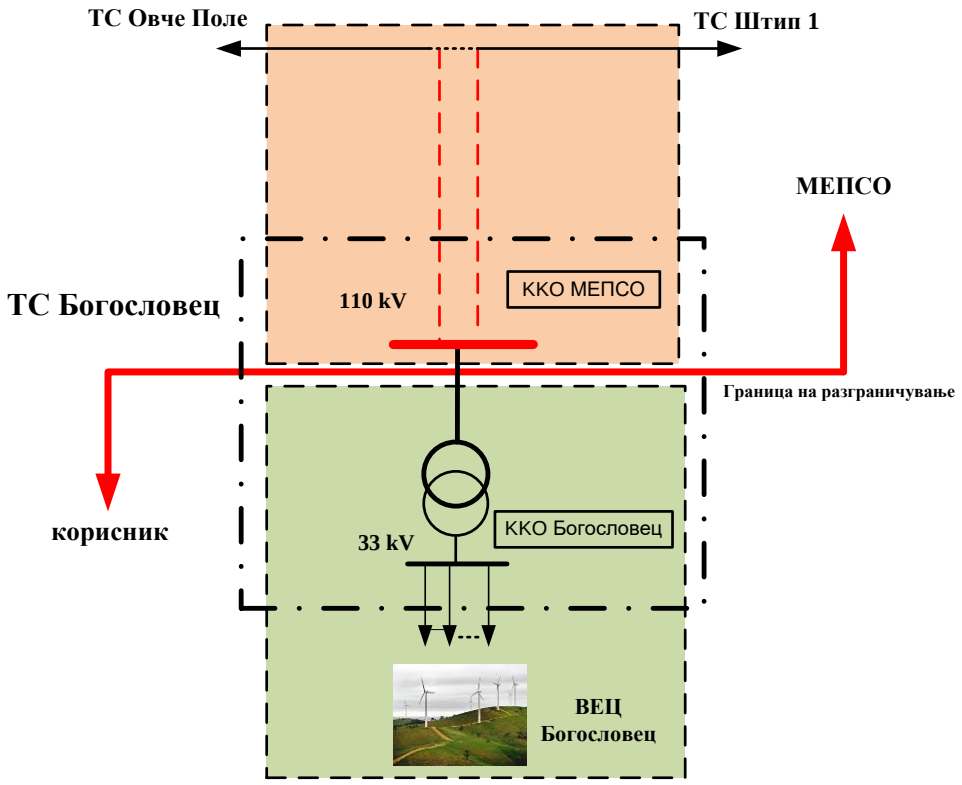
8.1.1. Connection of WPP Bogoslovec

In the wind power plant Bogoslovec ten wind turbines are planned to be built with a total installed power of 36 MW and an average annual generation of 83.659 GWh and 2324 MW equivalent hours for maximal generation, Table 8, position 1.

For connection of WPP Bogoslovets to the transmission network shall be built a 110/33 kV substation, whose 110 kV switchyard will be built with classic "N" (H in Cyrillic) scheme with one 40 MVA power transformer.

The 110/33 kV substation Bogoslovec will be bilaterally connected to the transmission network with 110 kV double-circuit transmission line to the existing 110 kV line SS Ovche Pole – SS Shtip 1 forming electrical 110 kV connections SS Ovche Pole - SS Bogoslovec and SS Bogoslovec - SS Shtip 1.

In accordance with the procedures for connection, a Study on connection has been done and Approval for connection of WPP Bogoslovec to the transmission network has been issued.



* границата помеѓу МЕПСО и корисникот е на клемите на 110 kV собирнички раставувачи кон собирницата во 110 kV трансформаторско поле во ТС Богословец.
Енергетскиот трансформатор заедно со ВН опрема од трансформаторското поле се во сопственост на корисникот.

Figure 5. Connection of WPP Bogoslovec to the transmission network

Following steps are: signing a Contract for connection to the transmission network, supervision of the project documentation, supervision of the connection to the transmission network during construction, energizing the facility and WPP Bogoslovec, operational acceptance of part of the connection that is MEPSO's property, and signing a Contract for use of the transmission network.

8.1.2. Connection of WPP Demir Kapija

The plan for the WPP Demir Kapija includes construction of ten 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 maximal production, Table 8, position 2.

For connection of WPP Demir Kapija to the transmission network, a 110/x kV SS Demir Kapija is necessary to be built that shall be unilaterally (radially) connected to the transmission network with single-circuit 110 kV transmission line towards SS Dubrovo.

Following the procedure for connection, a Study on connection was prepared, and an Approval for connection of WPP Demir Kapija to the transmission network was issued.

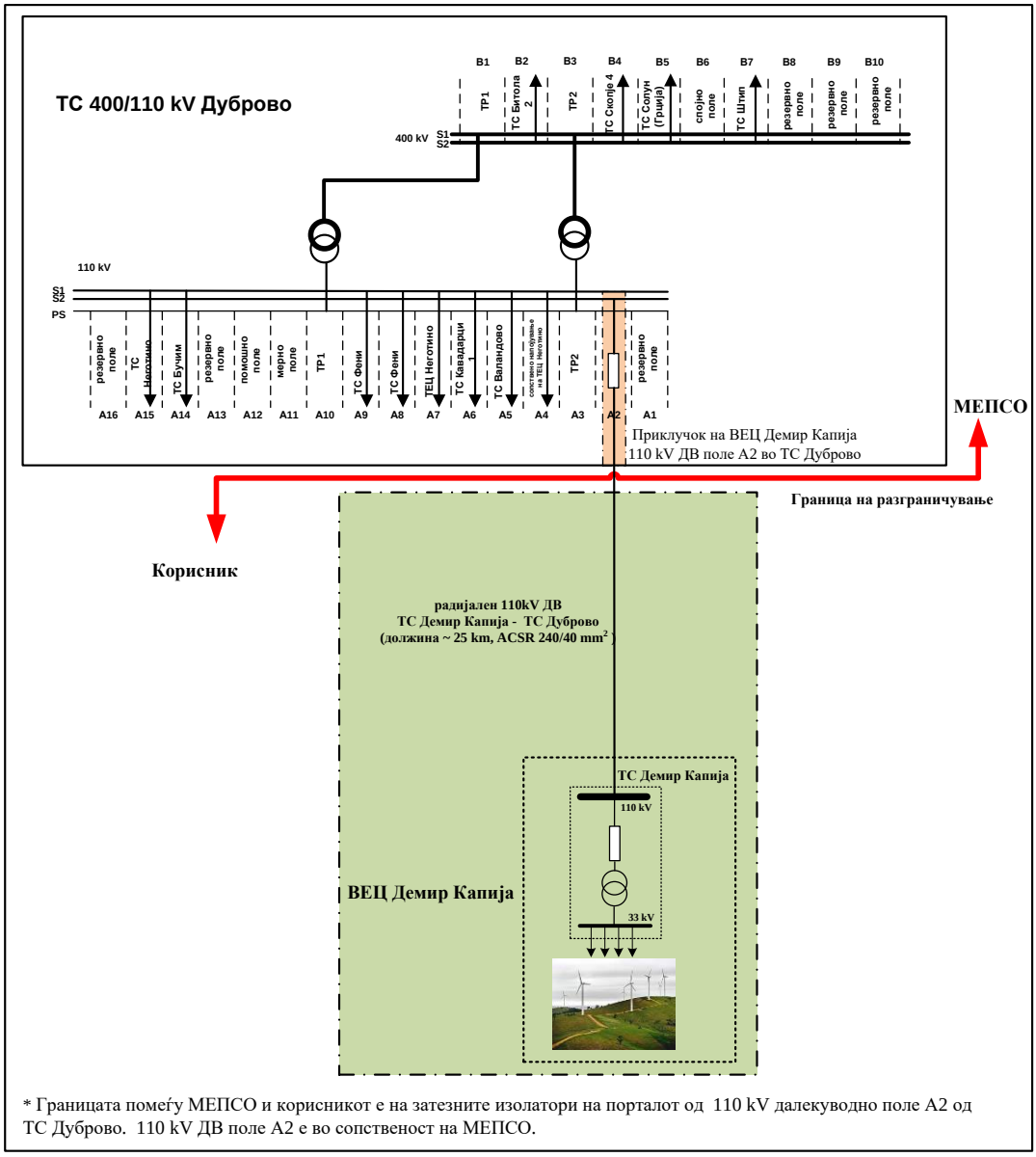


Figure 6. Connection of WPP Demir Kapija to the transmission network

Following steps are: signing a Contract for connection to the transmission network, supervision of the project documentation, supervision of the connection to the transmission network during construction, energizing the facility and WPP Demir Kapija, operational acceptance of part of the connection that is MEPSO's property, and signing a Contract for use of the transmission network.

8.1.3. Connection of WPP Miravci

In the wind power plant Miravci, wind turbines with a total installed capacity of 14 MW, and an average annual generation of 40 GWh are planned to be built, Table 8, position 3.

For connection of WPP Miravci to the transmission network, a 110/20 kV SS Miravci shall be built, which will be unilaterally (radially) connected to the transmission network with single-circuit 110 kV transmission line towards SS Valandovo.

Following the procedure for connection, a Study for connection of WPP Miravci to the transmission network was prepared.

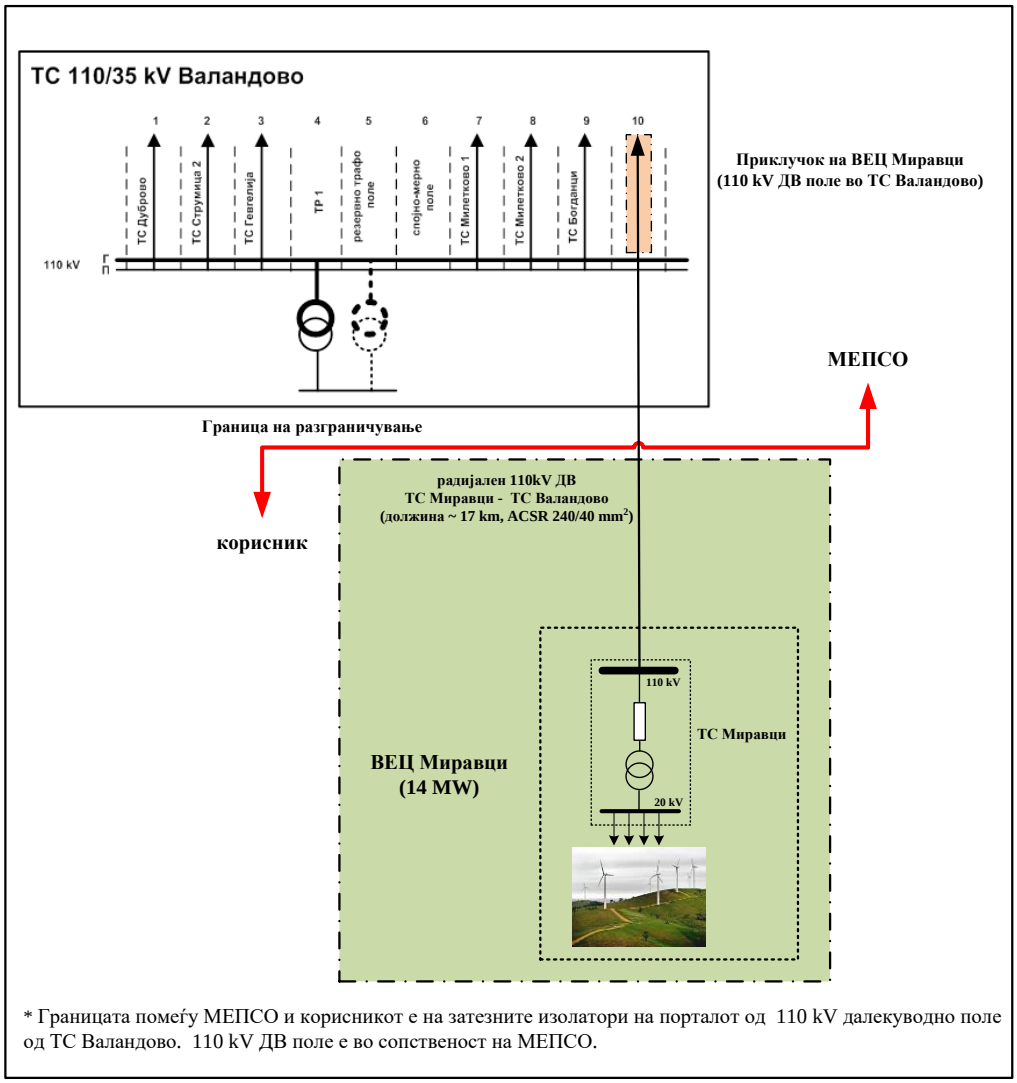


Figure 7. Connection of WPP Miravci to the transmission network

Following steps are: issue of Approval for connection to the transmission network, signing a Contract for connection to the transmission network, supervision of the project documentation, supervision of the connection to the transmission network during construction, energizing the facility and WPP Miravci, operational acceptance of part of the connection that is MEPSO's property, and signing a Contract for use of the transmission network.

8.1.4. Connection of WPP Krushevo and PV 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 PV is 8 MW with an annual production of electric power of around 10.66 GWh, Table 8, position 4 .

In the following picture is shown the geographic location of WPP Krushevo and PV Krushevo.

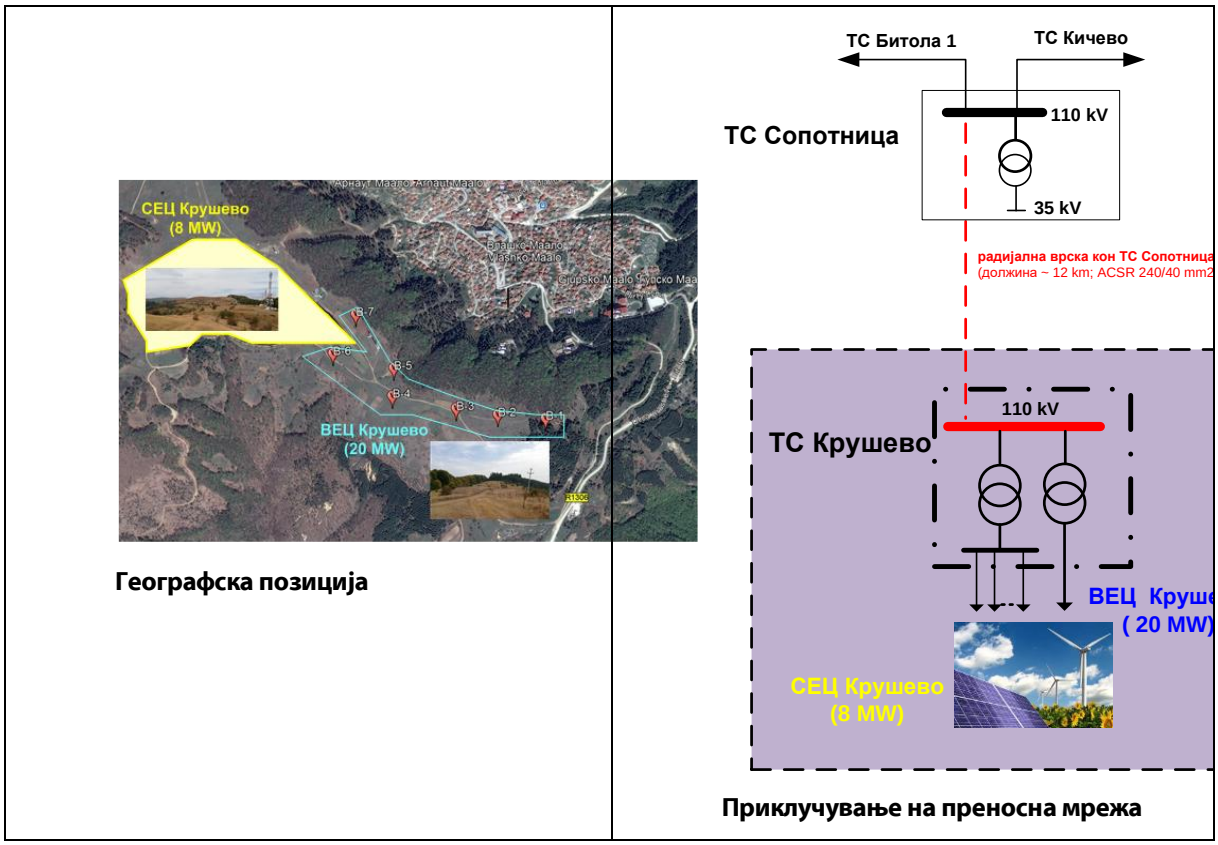


Figure 8. Position and connection to the transmission network of WPP Krushevo and TPP Krushevo

The connection of WPP Krushevo and PV Krushevo to the transmission network shall be realized via 110/x kV SS Krushevo, whose position is planned to be on the location of PV Krushevo.

Following the procedure for connection to the transmission network, a Study for connection of WPP Krushevo and PV Krushevo to the transmission network was prepared.

In the Study is foreseen the connection to the transmission network to be carried out via unilateral (radial) 110 kV line to 110 kV SS Sopotnica, with length of around 12 km from the regional substation Krushevo.

Following steps are: issue of Approval for connection, signing of a Contract for connection to the transmission network, supervision of the project documentation, supervision of the construction of the connection to the transmission network, energizing the connection WPP and PV Krushevo, operational acceptance of the connection part which is MEPSO's property and signing Contract for use of the transmission network.

8.1.5. Connection of PV Oslomej 2 and 3

AD Power Plants of North Macedonia (AD ESM) plans construction of two solar power plants PV Oslomej 2 and 3 with an installed power of 10 MW of each i.e. total installed power of 20 MW. This project for construction of new solar power plants is a sequel of the project for construction of PV Oslomej 1 with the utilization of land owned by AD ESM at the locality where the former coalmine and coal waste dumpsite existed.

The connection of PV Oslomej to the transmission network will be carried out through construction of a new regional SS 110/35 kV TPP Oslomej, near (or at the same site) SS 35/6.3 Mine Oslomej, which will connect to SS Oslomej via new OHL 110 kV SS PV Oslomej – SS Oslomej.

Following the procedure for connection an Analysis for connection to the transmission network has been prepared.

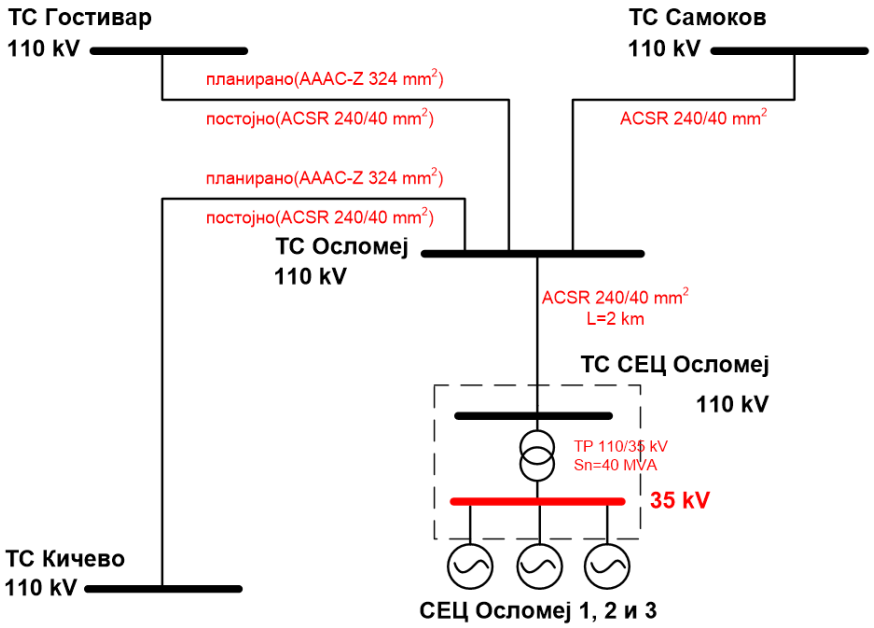


Figure 9. Connection of TPP Oslomej to the transmission network

Following steps are: adoption of the Analysis for connection to the transmission network, preparation of complete Study for connection to the transmission network, issue of Approval for connection, signing of a Contract for connection to the transmission network, supervision of the project documentation, supervision of the construction of the connection to the transmission network, energizing the connection and the mine, operational acceptance of the connection part which is MEPSO's property and signing Contract for use of the transmission network.

8.1.6. Connection of TPP Bitola 1 and 2

AD Power Plants of MK (ESM) plans construction of two solar power plants, PV Bitola 1 and PV Bitola 2 (TPP Bitola 1 and 2) with an installed capacity of 10 MW each i.e. total installed capacity of 20 MW. This project for construction of solar power plants is suggested due to the favourable conditions (the land is MEPSO's ownership), and the location is situated near the existing thermal power plant, on short distance to the local transformer substations and road infrastructure.

For connection of PV Bitola to the transmission network are reviewed the following two variants:

- Variant 1: construction of a new regional transformer substation SS 110/35 kV PV Bitola near SS 400/110 kV Bitola 2, which will connect to SS Bitola 2 with a new OHL110 kV SS PV Bitola – SS Bitola 2.
- Variant 2: installation of a new switchyard 110/35 kV with installed power of 40 MVA in SS Bitola 2, while the connection of PV Bitola 1 and 2 to SS Bitola 2 shall be carried out via distributive overhead line.

The distance from the location of the connection of PV Bitola 1 and 2 to SS Bitola 2, for both offered solutions, is around 2 km.

Following the procedure for connection an Analysis for connection to the transmission network has been prepared.

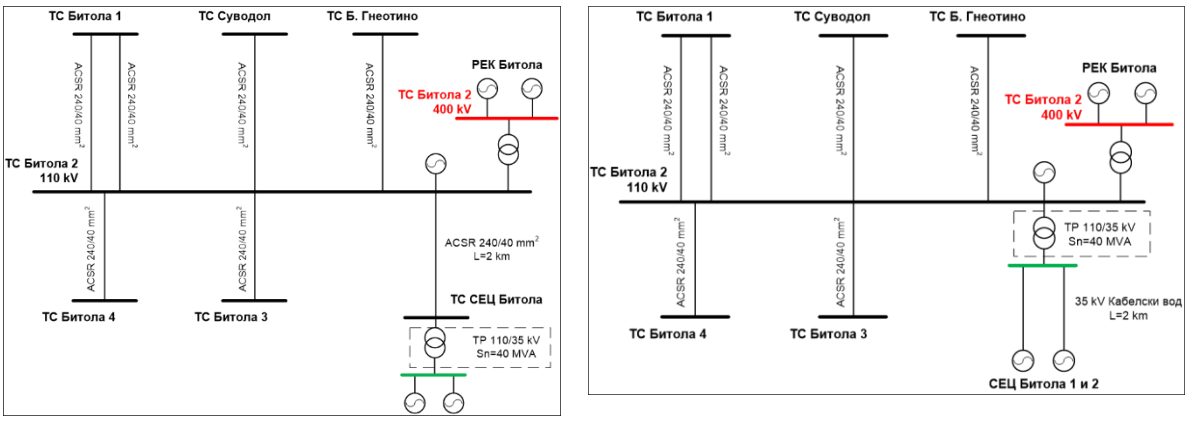


Figure 10. Connection of TPP Bitola to the transmission network

Following steps are: adoption of the Analysis for connection to the transmission network, preparation of complete Study for connection to the transmission network, issue of Approval for connection, signing of a Contract for connection to the transmission network, supervision of the project documentation, supervision of the construction of the connection to the transmission network, energizing the connection and the mine, operational acceptance of the connection part which is MEPSO's property and signing Contract for use of the transmission network

8.2. CONNECTION OF DISTRIBUTION SUBSTATIONS TO THE TRANSMISSION NETWORK

Requests for replacement of the existing connections were submitted:

- SS Jug Nova - due to the radial connection to new 110/35(20)/10 kV SS Centralna and revitalization of 2x110 kV line SS Skopje 4 – SS Jug Nova
- SS Gevgelija - due to radial connection to new WPP EUROUNG (33 MW)

MEPSO made analyses for alteration of the existing connections:

- Analysis to modify the SS Jug Nova connection to the transmission network
- Analysis to modify the SS Gevgelija connection to the transmission network.

In the Analyses has been confirmed that the changes in the existing connections to the transmission network to SS Jug Nova and SS Gevgelija will not jeopardize the security of the transmission system.

8.2.1. Connection of a second transformer to SS Ovche Pole

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

For the needs of connection of solar power plants (PV) with total installed capacity of 25 MW, in the village of Azambegovo, municipality of Sveti Nikole, it is necessary to be installed additionally (second) transformer 110/10(20) kV/kV with a capacity of 40 MVA in 110/35/10 kV/kV SS Ovche Pole, Table 8, position 7.

Following the procedure for connection to the transmission network, Approval for connection to the transmission network was issued.

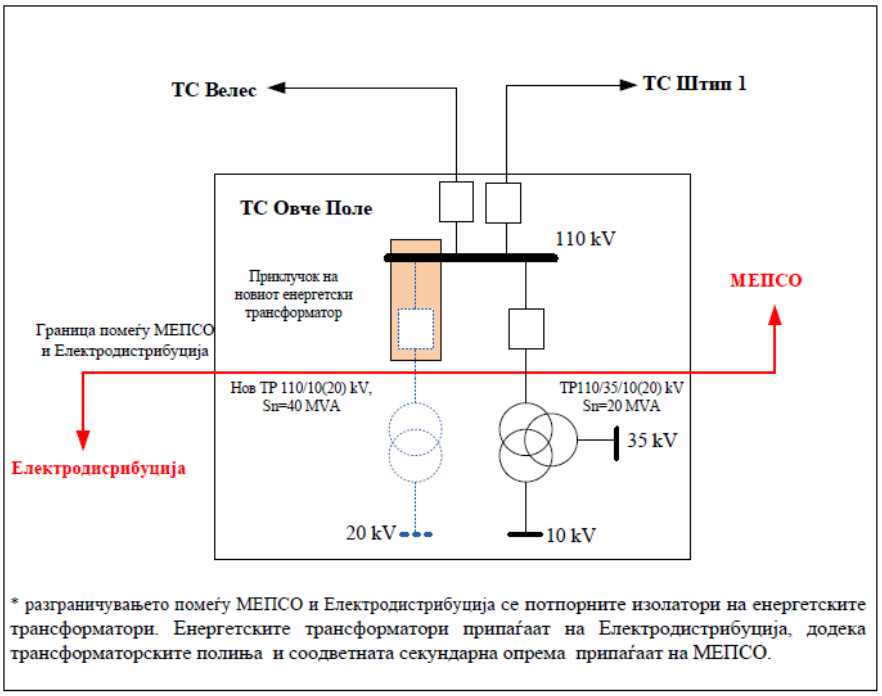


Figure 11. Connection of a second transformer to SS Ovche Pole

Following steps are: signing a Contract for connection to the transmission network, supervision of the project documentation, supervision of the connection to the transmission network during construction, energizing the facility, operational acceptance of part of the connection that is MEPSO's property, and signing a Contract for use of the transmission network.

8.3. CONNECTION OF INDUSTRIAL CONSUMERS TO THE TRANSMISSION NETWORK

8.3.1. Connection of Cranfield Foundry

110/20 kV systematic substation Neokazi shall be built for the connection of Cranfield Foundry to the transmission network. It shall be located in the industrial zone Probishtip and its 110 kV switchyard is consisted of two main busbars connected to coupler bay with two power transformers of 20 MVA. SS Neokazi will be bilaterally connected to the transmission network with a double-circuit 110 kV transmission line connected to the existing 110 kV line SS Shtip 1 – SS Probishtip, thus forming 110 kV tie lines SS Shtip 1 – SS Neokazi and SS Neokazi – SS Probishtip.

According to the procedure for connection, a Study on connection is made and an Approval for connection of Cranfield Foundry to the transmission network was issued.

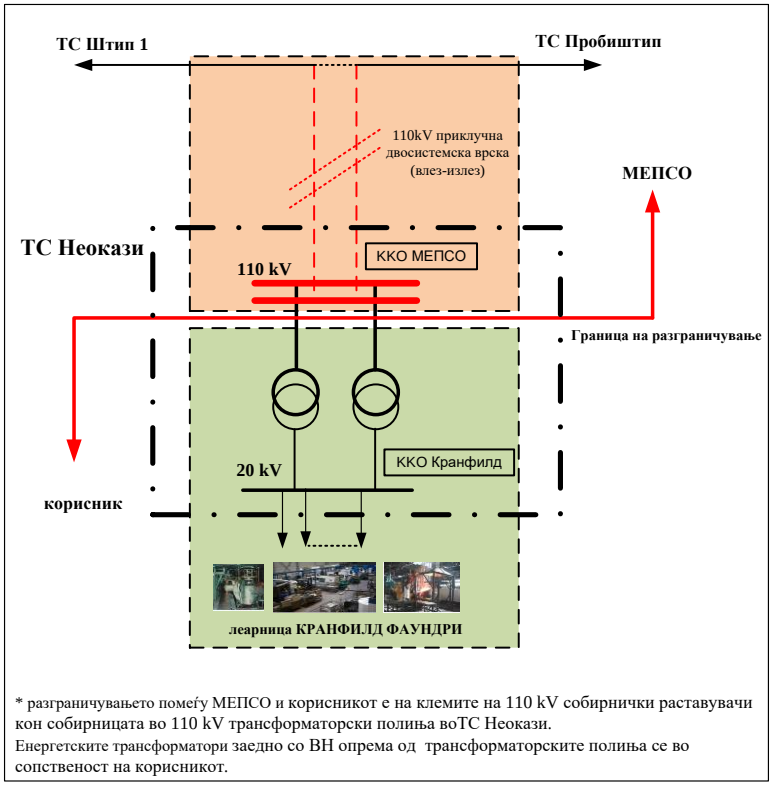


Figure 12. Connection of Cranfield Foundry to the transmission network

Following steps are: signing a Contract for connection to the transmission network, supervision of the project documentation, supervision of the connection to the transmission network during construction, energizing the facility and the foundry, operational acceptance of part of the connection that is MEPSO's property, and signing a Contract for use of the transmission network.

8.3.2. Connection of IGM Trade

The connection of IGM Trade to the transmission network is planned to be realized via input-output of the existing 110 kV transmission 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 load of 647 A/123 MVA.

Following the procedure for connection, a Study on connection was prepared.

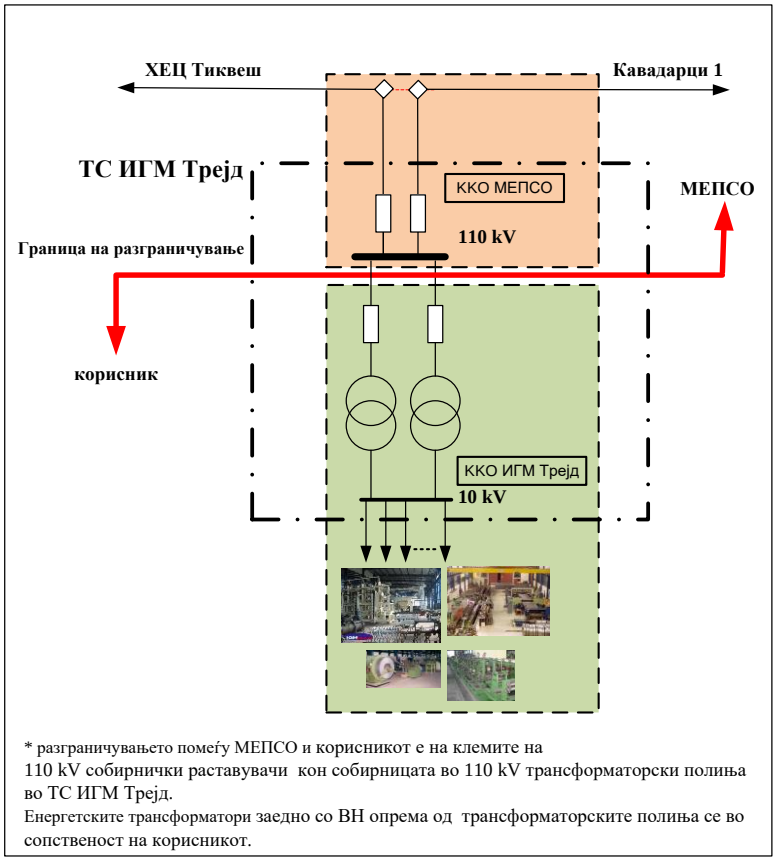


Figure 13. Connection of IGM Trade

Following steps are: signing a Contract for connection to the transmission network, supervision of the project documentation, supervision of the connection to the transmission network during construction, energizing the facility and the factory, operational acceptance of part of the connection that is MEPSO's property, and signing a Contract for use of the transmission network.

8.3.3. Connection of mine Plavica – Kratovo

The connection of the mine Plavica is planned to be carried out via input-output of the existing 110 kV OHL SS Probishtip - switchyard Kratovo. The connection will be made by construction of a new 110 kV double-circuit transmission line with Al/Fe 240/40 mm^2 conductors (permanent permissible load of 645 A i.e. permissible capacity of 123 MVA), on the line from SS Plavica to the existing 110 kV OHL SS Probishtip - switchyard Kratovo. The length of the new double-circuit section is estimated at around 2.7 km.

Following the procedure for connection, an Analysis for connection to the transmission line was prepared.

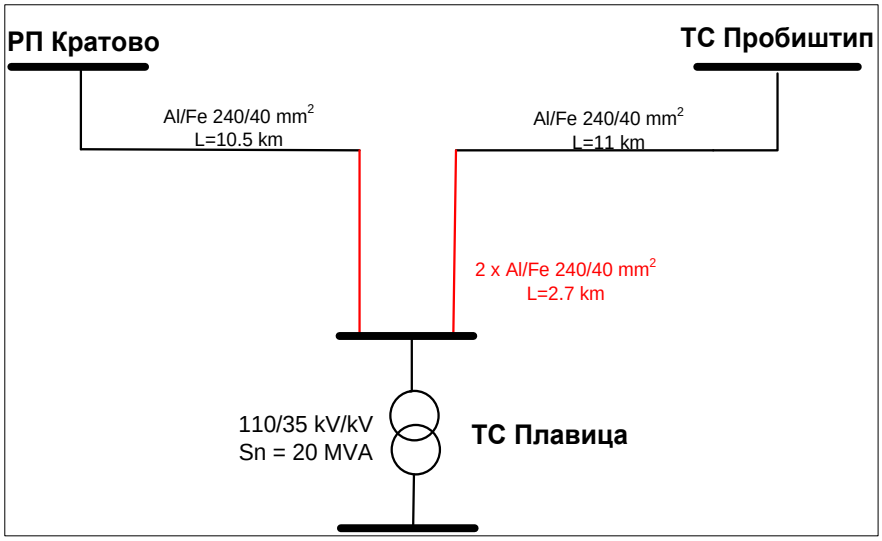


Figure 14. Connection of deposit Plavica – Kratovo to the transmission network

Following steps are: preparation of complete Study on connection to the transmission network, , issue of Approval for connection, signing of a Contract for connection to the transmission network, supervision of the project documentation, supervision of the construction of the connection to the transmission network, energizing the connection and the deposit, operational acceptance of the connection part which is MEPSO's property and signing Contract for use of the transmission network.

9. REALIZATION OF PROJECTS IN THE PERIOD FROM 2019 TO 2029

Taking into consideration all the changes foreseen in the period from 2019 to 2029, related to the construction of new facilities in the Macedonian electric transmission system and the neighbouring systems (new interconnections in the region, connection of new consumers and producers to the Macedonian transmission network, as well as reconstruction and rehabilitation of the transmission network facilities), from the development analyses occurred solutions that have to be implemented in the Macedonian transmission network in order to ensure safe and reliable operation of the electric transmission system.

Table 6 gives a timeframe for the realization of new transmission projects, facilities for reconstruction/revitalization, modernization and researches in the electric transmission system, which shall be implemented in the period from 2020 to 2029.

In Table 6 is given the value of the projects by year, in whose values are included funds of current loans and grants from international financial institutions and MEPSO's funds.

Table 6. Time schedule and dynamic investment plan by years for period 2020-2029

No.	Projects	Budget Contract (MEUR)	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	Realization (MEUR) Total
Interconnections													
1	400 kV interconnection line SS Bitola 2 – Macedonian/Albanian border	29.40	8.15	10.69	8.17								27.01
New transmission lines and transformer substations													
2	Transformer substation 400/110 kV SS Ohrid and new 400 kV OHL bay SS Bitola 2	14.00	4.12	5.49	4.12								13.72
3	Connection of 110 kV OHL HPP Vrutok - SS Skopje 1 in a transformer substation in the region of Polog	5.10	0.10	0.10	0.60	3.00	1.30						5.10
4	Costruction of SS 400/110 kV Kumanovo (1 x 300 MVA)	15.00							3.00	4.50	4.50	3.00	15.00
Revitalization/ reconstruction of 110 kV lines													
5	Revitalizations of 110 kV lines	3.00	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	3.00
6	Revitalization of OHL 2x110kV section Vapila - SS Ohrid 1	0.58	0.38	0.20									0.58
7	Reconstruction of 110 kV OHLs section Vrutok - Tetovo	0.54	0.54										0.54
8	Reconstruction of 110 kV OHL SS Shtip - TC Probishtip	2.45	0.42										0.42
9	Reconstruction of 110 kV OHL SS Bunardzik - SS Miladinovci	1.20	0.60	0.60									1.20
10	Reconstruction of 110 kV OHL SS Veles - SS Ovche Pole	1.81	1.15	0.01									1.16
11	Reconstruction of 110 kV OHL SS Ovhe Pole - SS Shtip	1.41	1.01										1.01
12	Reconstruction of 110 kV OHL SS Bitola 1 – SS Prilep	3.92	3.03	0.20									3.23
13	Reconstruction of 110 kV OHL SS Skopje 4 –SS Petrovec - SS Veles	2.99	2.16	0.15									2.31
14	Reconstruction of OHL 110 kV Gostivar (Bukovikj) - TPP Oslomej - Kichevo - Sopotnica - Bitola 1 length ≈ 100 km AAAC)	3.10	0.10	0.20	2.00	0.80							3.10
15	Reinforcement of the grid in the southeast region variant 1:Double-circuit 110 kV OHL to Strumica length ≈ 57,5 km, AAAC-Z) or variant 2: 400/110 kV SS in Strumica (300 MVA)	7.1-25.0		0.20	0.30	1.30	2.00	3.30					7.10
16	Reconstruction of OHL 110 kV Polog - HPP Vrutok - HPP Shpilje - HPP Globochica - Struga length ≈ 100 km, AAAC)	7.95								0.25	0.25	0.50	1.00
Revitalization /Reconstruction of transformer substations													
17	Revitalization of transformer substations	14.20	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42	14.20
Reconstruction/upgrade of swichyard Kratovo													
18	Construction of 110 kV transmission bays, complete Reconstruction and digitalization of the switchyard	0.70	0.10	0.25	0.35								0.70
Revitalization of SS Skopje 4													
19	High-voltage equipment (breakers, disconnectors, measurement transformer), transformers), control panels	4.80	2.00	0.34									2.34
20	Energy transformer (5-СК4-1ТА)	2.50									0.50	2.00	2.50
Revitalization of SS Dubrovo													
21	High-voltage equipment *(breakers,disconnectors, measurement transformers), auxiliary equipment (relay protection, SCADA, measurement transformers) , rectifiers for 220 DC system*	4.62	0.24										0.24
22	Power transformer (3-ДУБ-1ТА)	2.50							0.50	2.00			2.50
Revitalization of SS Bitola 2													
23	Нигh-voltage equipment (*110 kV breakers*), auxiliary equipment	1.00	0.32	0.10									0.42
24	Energy transformer	2.40	2.40										2.40
Revitalization of SS Valandovo													
25	BH equipment (*measurement transformers, breakers and disconnector*)	0.77	0.18										0.18
Revitalization of SS in TPP Oslomej													
26	BH equipment *(diconnectors breakers measurement transformers)*	0.63	0.21										0.21
Revitalization of SS in HPP Tikvesh, HPP Vrutok, HPP Globochica and HPP Shpilje													
27	Secondary equipment *(relay protection)*	0.63	0.19										0.19
Revitalization of SS Prilep 1													
28	High-voltage equipment (diconnectors breakers measurement transformers), secondary equipment (*relay protection, SCADA, measuring transformers) rectifiers for 220 DC system measuring unit*)	1.12	0.26										0.26
Revitalization of SS Veles and SS Kavadarci 1													
29	Adaptation, supply and installation of the primary equipment, installation of SACS, Protection and DC supply	0.54	0.34	0.20									0.54
Revitalization of SS Kochani													
30	Shunt compenzation in 110 kV SS Kochani (25 Mvar)	0.75									0.15	0.60	0.75

No.	Projects	Budget Contract (MEUR)	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	Realization (MEUR) Total
Modernization of the transmission system													
31	Telecommunication equipment and remote monitoring of the transformer substations	5.00	**2.05**	**2.95**									**5.00**
32	Underground facility for optical connection	0.20	**0.20**										**0.20**
33	Balkan Digital Highway	5.80	**0.80**	**3.25**	**1.75**								**5.80**
34	Wide Area Monitoring System-WAMS	0.15	**0.15**										**0.15**
35	DLR - Dynamic Line Rating	1.23	**0.03**	**0.20**	**1.00**								**1.23**
36	Special software and hardware package for maintenance of the transmission grid	0.27	**0.03**	**0.05**	**0.19**								**0.27**
Research on Power Transmission System													
37	CROSSBOW	0.18	**0.05**	**0.05**									**0.10**
38	TRINITY	0.80	**0.02**	**0.02**	**0.02**	**0.02**							**0.08**
39	Study on Optimal Utilization of the Double-circuit Busbars in the Substations	0.02	**0.02**										**0.02**
40	Transmission Network Development Study	0.08	**0.02**	**0.06**									**0.08**
41	Action Plan for Power Grid Strengthening to Support Renewable Eenergy Projects in North Macedonia	0.08	**0.08**										**0.08**
42	Study on Voltage Profile Improvement of the Smart Grid	0.60	**0.60**										**0.60**
43	Strengthening the Transmission Network in the Southeast Region of North Macedonia	0.25	**0.25**										**0.25**
		151.37	**33.99**	**27.03**	**20.22**	**6.84**	**5.02**	**5.02**	**5.22**	**8.47**	**7.12**	**7.82**	**126.75**

Projects financed by loans, investment grants and Smart Grid grant (EBRD 46274) and AD MEPSO own funds
Projects financed by loans EBRD 44114 and AD MEPSO own funds
Grant WBIF
Grant EBRD
Grant HORIZON 2020

10. COMPLEX IMPLEMENTATION OF ENERGY PROJECTS

This year's publication of the ten years development plan for the transmission system reconfirmed the goals and the vision of the Macedonian transmission system. The rate of progress of the projects is on a satisfying level with certain delays, firstly because of the complex administrative procedures and adjustments to the local spatial and sociological conditions. In the plan are redefined certain priorities as well, and includes several new projects identified in the planning cycle from the last year.

The comparison of the budget, as well as the foreseen dynamic of activities and costs in the new plan (publication 2019), with the previous development plan for the transmission network (publication 2018), is given in Table 7. Regarding the projects that have different dynamics and costs, there is an explication for the difference in price and time of their realization. Later in the text are stated the important differences.

The structure of the expenses for the 400 kV interconnection line Bitola (MK) – Elbasan (AL), position 1, and 400/100 kV substation Ohrid, position 2, is updated according to the completed project and tender documentation, and procurement plans.

For the connection project of the 110 kV OHL HPP Vrutok – SS Skopje 1 in one transformer substation in the region of Polog, position 3, the time for completion is prolonged for a year because of the specifics of the terrain and the difficulties in determination of an access corridor.

For the long-term project for the construction of the 400/110 kV substation Kumanovo, position 4, the investment price is updated for 15 million euros, in accordance with current equipment prices, design and built of this type of facility.

The realization of the project for reconstruction of the 110 kV OHL SS Shtip – SS Probishtip, position 8, has begun in 2018. The price is updated in accordance with the signed contract, and in the development plan (2019) are presented only the funds for 2020.

For the project for reconstruction of the 110 kV transmission lines for the supply of SS Miladinovci, position 9, a new route is suggested to achieve rational execution. The new connection point of the 110 kV transmission line towards Miladinovci will be SS Bunardjik, instead of SS Skopje 1.

For the ongoing projects for the reconstruction of the 110 kV lines, position 10-13, in the previous development plan (2018) were used investment prices, while the contracts were signed at the end of 2018. The realization has started in 2019. The costs and the dynamic of activities were updated in accordance with the signed contracts and the construction plans, while in coordination with the bank. In the new development plan (2019), the price was updated following the contracts, and the dynamic of expenses is presented from 2020 onwards.

The plan for the new projects for reconstruction/rehabilitation of the 110 kV lines has certain changes. Regarding the priority corridor Gostivar (Bukovikj) – TPP Oslomej – Kichevo – Sopotnica – Bitola 1, position 14, the time for completion was prolonged for a year because of the procedure for optimization during designing. The commission of the project for reinforcement of the network in the southeast region (from Dubrovoto to Strumica), position 15, is planned 3 years prior due to increased interest in the construction of RES in the SEE region. The investment prices for two variants are given, and depending on the results from the Study (position 43), the costs will be determined.

For the project for reconstruction of the 110 kV OHL Polog – HPP Vrutok – HPP Shpilje – HPP Globochica – Struga, position 16, the investment price is updated following the current prices of equipment, design and built of this type of facilities, and in the plan are given the funds for 2027-2029.

The prices and dynamic of activities of the ongoing revitalization of substations are updated according to the signed contracts and actual plans for realization; the dynamic of costs is presented from 2020 onwards.

Table 7. Comparison between projects in the development plan (2019) in regards of the development plan (2018)

No.	Projects	Budget Contract (MEUR)	Development plan (2019)	Development plan (2018)	Explanation about the costs difference or the time for commencement
Интерконективни врски					
1	400 kV interconnection line SS Bitola 2 – Macedonian/Albanian border	29.40	**27.01**	**29.31**	Costs structure is updated following the completed project and tender documentation and the procurement plans.
New transmission lines and transformer substations					
2	Transformer substation 400/110 kV SS Ohrid and new 400 kV OHL bay SS Bitola 2	14.00	**13.72**	**17.61**	Costs structure is updated following the completed project and tender documentation and the procurement plans.
3	Connection of 110 kV OHL HPP Vrutok - SS Skopje 1 in a transformer substation in the region of Polog	5.10	**5.10**	**5.10**	The completion time is prolonged for a year due to the specifics of the terrain, and the difficulties during tracing the access corridor.
4	Costruction of SS 400/110 kV Kumanovo (1 x 300 MVA)	15.00	**15.00**	**8.60**	The investment cost is updated in accordance with the actual prices of equipment, design and built of this type of facility.
Revitalization/ reconstruction of 110 kV lines					
5	Revitalizations of 110 kV lines	3.00	**3.00**	**3.00**	
6	Revitalization of OHL 2x110kV section Vapila - SS Ohrid 1	0.58	**0.58**	**0.58**	
7	Reconstruction of 110 kV OHLs section Vrutok - Tetovo	0.54	**0.54**	**0.54**	
8	Reconstruction of 110 kV OHL SS Shtip - TC Probishtip	2.45	**0.42**	**1.92**	The realization of the project has begun in 2018, the cost is updated according to the signed Contract, and in the development plan (2019) are given the funds for 2020.
9	Reconstruction of 110 kV OHL SS Bunardzik - SS Miladinovci	1.20	**1.20**	**3.20**	A new route is suggested as per rational execution; the newconnection point of the 110 kV OHL towards Miladinovci will be SS Bunardzik.
10	Reconstruction of 110 kV OHL SS Veles - SS Ovche Pole	1.81	**1.16**	**3.19**	In the development plan (2018) are used investment costs, while the contracts were signed at the end of 2019. The execution has stared in 2019. The costs and rate of progress were updated as per thesigned contracts and construction plans in coordination with the Bank. In the development plan (2019) the price was updated as per the contracts and the dynamic of costs given from 2020 onwards.
11	Reconstruction of 110 kV OHL SS Ovhe Pole - SS Shtip	1.41	**1.01**	**2.88**	
12	Reconstruction of 110 kV OHL SS Bitola 1 – SS Prilep	3.92	**3.23**	**4.23**	
13	Reconstruction of 110 kV OHL SS Skopje 4 –SS Petrovec - SS Veles	2.99	**2.31**	**4.03**	
14	Reconstruction of OHL 110 kV Gostivar (Bukovikj) - TPP Oslomej - Kichevo - Sopotnica - Bitola 1 length ≈ 100 km AAAC)	3.10	**3.10**	**3.10**	The completition time is postponed for a year due to the optimization procedure during designing.
15	Reinforcement of the grid in the southeast region variant 1:Double-circuit 110 kV OHL to Strumica length ≈ 57,5 km, AAAC-Z) or variant 2: 400/110 kV SS in Strumica (300 MVA)	7.1-25.0	**7.10**	**5.24**	The commencement of the project is planned 3 years earlier due to the increased interest for construction of RES in th SEE region. Unvestment costs were given about two variants, the costs wil be determined depending on the results from the Study (No.43).
16	Reconstruction of OHL 110 kV Polog - HPP Vrutok - HPP Shpilje - HPP Globochica - Struga length ≈ 100 km, AAAC)	7.95	**1.00**	**9.06**	The investment cost is updated following the actual prices of equipment, design and built of this type of facility, and in the plan ae given the funds for 2027-2029.
Revitalization /Reconstruction of transformer substations					
17	Revitalization of transformer substations	14.20	**14.20**	**14.20**	
Reconstruction/upgrade of swichyard Kratovo					
18	Construction of 110 kV transmission bays, complete Reconstruction and digitalization of the switchyard	0.70	**0.70**		New project for upgrade of switchyard Kratovo.
Ревитализација на ТС Скопје 4					
19	High-voltage equipment (breakers, disconnectors, *measurement transformers),* control panels	4.80	**2.34**	**4.36**	The costs and the rate of progress are updated according to the signed contracts and current plans for execution; the dynamic of costs are given from 2020 onwards.
20	Power transformer (5-СК4-1ТА)	2.50	**2.50**	**2.50**	
Revitalization of SS Dubrovo					
21	High-voltage equipment (breakers,disconnectors, measurement transformers), auxiliary equipment (relay protection, SCADA, measurement transformers), rectifiers of 220 DC systems)	4.62	**0.24**	**1.41**	
22	Power transformer (3-ДУБ-1ТА)	2.50	**2.50**	**2.50**	
Revitalization of SS Bitola 2					
23	High-voltage equipment (*110 kV breakers),* secondary equipment	1.00	**0.42**	**0.93**	
24	Power transformer	2.40	**2.40**	**2.40**	
Revitalization of SS Valandovo					
25	BH equipment (measurement transformers, breakers and disconnector)	0.77	**0.18**	**0.70**	
Revitalization of SS in TPP Oslomej					
26	BH equipment (diconnectors breakers measurement transformers)	0.63	**0.21**	**0.57**	
Revitalization of SS in HPP Tikvesh, HPP Vrutok, HPP Globochica and HPP Shpilje					
27	Secondary equipment (relay protection)	0.63	**0.19**	**0.56**	
Revitalization of SS Prilep 1					
28	High-voltage equipment (breakers,disconnectors, measurement transformers), auxiliary equipment (relay protection, SCADA, measurement transformers), исправувачи на 220 DC систем)	1.12	**0.26**	**1.01**	
Revitalization of SS Veles and SS Kavadarci 1					
29	Adaptation. Supply and installation of the primary equipment, installation of SACS, Protection and DC supply	0.54	**0.54**	**0.52**	
Revitalization of SS Kochani					
30	Shunt compenzation in 110 kV SS Kochani (25 Mvar)	0.75	**0.75**	**0.75**	

No.	Projects	Budget Contract (MEUR)	Development plan (2019)	Development plan (2018)	Explanation about the costs difference or the time for commencement
Modernization of the transmission system					
31	Telecommunication equipment and remote monitoring of the transformer substations	5.00	**5.00**	**4.79**	The cost and dynamic are updated following the plans for supply and installation.
32	Underground facility for optical connection	0.20	**0.20**	**0.20**	The commencement period is postponed for a year due to terrain problems.
33	Balkan Digital Highway	5.80	**5.80**		*Студија за развој на оптичка и телекомуникациска мрежа и проценка на вкупни трошоци за интегрирање во национален широко појасен план и Проектот за ревитализација на телекомуникациска мрежа* се надградени во регионален проект за креирање „дигитален автопат", финансиран преку WBIF и координиран од Светска Банка.
34	Wide Area Monitoring System-WAMS	0.15	**0.15**	**0.15**	Цената и динамиката е ажурирана според плановите за набавка и инсталација.
35	DLR - Dynamic Line Rating	1.23	**1.23**	**0.60**	New smart grid project as part of the Implementation of new technologies in the transmission grid; the project is needed for optimal utilization of the existing capacity of the transmission lines.
36	Special software and hardware package for maintenance of the transmission grid	0.27	**0.27**	**0.20**	The cost and dynamic are updated following the plans for supply and installation.
Research on Power Transmission System					
37	CROSSBOW	0.18	**0.10**	**0.15**	The costs are updated in in accordance to the planned undertakings in 2020 and 2021.
38	TRINITY	0.80	**0.08**	**0.08**	New scientific and research project financed by Horizon2020.
39	Study on Optimal Utilization of the Double-circuit Busbars in the Substations	0.02	**0.02**	**0.02**	The commencement period is shortened as to faster concept implementaton.
40	Transmission Network Development Study	0.08	**0.08**		Preparation of a new Transmission Grid Development Study based on the new Energy Development Strategy.
41	Action Plan for Power Grid Strengthening to Support Renewable Eenergy Projects in North Macedonia	0.08	**0.08**		New study financed by EBRD because of the actuality of the RES integration.
42	Study on Voltage Profile Improvement of the Smart Grid	0.60	**0.60**	**0.60**	The Study is expected to be completed at the beginning of 2020.
43	Strengthening the Transmission Network in the Southeast Region of North Macedonia	0.25	**0.25**	**0.03**	The Study will be carried out as part of the WBIF Grant for technical support and and will have enlarged scope of work: more variants, project and tender documentation for optimal variant.
Cancelled/posteponed projects and undertakings in the new development plan					
	Reconstruction/revitalization of 110 kV OHL SS Kavadarci -HPP Tikvesh				By the Strategy for reconstruction/revitalization of the transmission grid, these reconstructions have a lower priority for realization and are excluded from the 10-year period.
	Reconstruction/revitalization of 110 kV OHL SS Gj. Petrov –SS Skopje1				
	Study for tower testing station				The project is delayed.
	Study for Procedures and Technologies for Organization, Operation and Planning in MEPSO				The study is delayed.
	Investigation of Potential Increase of the Bidirectional Transfer Capacity in the MK-GR Border				The results of the new calculations for system requirements by ENTSO-E TYNDP2020 are expected.
	Projects financed by loans, investment grants and Smart Grid grant (EBRD 4650's own funds				
	Projects financed by loans EBRD 44114 and AD MEPSO's own funds				
	Grant WBIF				
	Grant EBRD				
	Grant HORIZON 2020				

The Study on development of the optical and telecommunication network and the assessment of the total costs for integration in the national broadband plan and the *Project for Revitalization of the telecommunication network* foreseen in the former development plan (2018), in the new plan (2019) are upgraded in regional project for building "digital highway", financed via WBIF and coordinated by the World Bank, position 33.

The WBIF framework for technical support provides funds for completion of the *Strengthening the transmission network in the southeast region of North Macedonia*, which shall consider all aspects, shall define the optimal variant and shall speed up the execution of the project, position 43. The Study will have wider scope of work: more variants, project and tender documentation for optimal variant and concepts for implementation of the smart grid.

The new projects identified in the development plan are:

- New project for an upgrade of Switchyard Kratovo, position 18. That is the only facility within the transmission network in which the transmission bays are not completely formed.
- System for DLR – Dynamic Line Rating, position 35. The case is a new smart grid project within the initiative for change of new technologies in the transmission network; the project is necessary for optimal use of the existing capacity of the transmission lines.
- TRINITY, position 38: a new scientific researching project financed by Horizon 2020.

Preparation of a new *Study on transmission network development* is foreseen, position 40, based on the new *Strategy for Energy Development*.

Moreover, taking into consideration the popularity of the renewable energy resources integration, EBDR expressed an interest to finance the new Action plan for power grid strengthening to support renewable energy projects in North Macedonia.

According to the *Strategy for reconstruction/revitalization of the transmission network*, the projects from the former development plan (2018), which are listed below, have lower priority for realizations and are not considered in the ten-year development plan:

- reconstruction/revitalization of 110 kV OHL SS Kavadarci -HPP Tikvesh and
- reconstruction/revitalization of 110 kV OHL SS Gj. Petrov – SS Skopje 1.

Investigation of the potential increase of the bidirectional transfer capacity in the MK-GR border is delayed and will continue depending on the results from the new calculations for system needs of ENTSO-E TYNDP 2020.

Other projects that are delayed are the *Study for tower testing station* and the *Study for procedures and technologies for organization, operation and planning in MEPSO*.

11. COSTS FOR CONNECTION TO THE TRANSMISSION NETWORK OF NEW USERS

Table 8. Price schedule for connection to the transmission network

No.	Connections	Defined and approved documents connection costs to the transmission grid	Connection costs			
			Fixed costs		*Variable costs**	
			Costs for:	amount (MKD without VAT)	Costs for:	amount (MKD without VAT)
1	**VPP Bogoslovec**	Study on connection to the transmission grid prepared: 25.04.2017 Annex to the Study on connection to the transmission grid prepared: 05.06.2018 Approval for connection to the transmission grid issued: 21.06.2018	1. Study on connection to the transmission grid	1,650,090.00	transmission grid comprised of: 1. Connected 2x110kV line 2. 110kV switchyard and MEPSO's Control and Command Building in SS Bogoslovec 3. Equipping of the 110kV	2,278,000.00
			2. Approval of technical documentation	55,003.00		
			3. Construction supervision	16.500,90 x T**		
			4. Compliance testing	in accordance with the real costs		
2	**VPP Demir Kapija**	Study on connection to the transmission grid prepared: 19.06.2018 Approval for connection to the transmission grid issued: 19.07.2018	1. Study on connection to the transmission grid	1,644,780.00	Connection to the transmission grid comprised of: 1. 110 kV transmission bay in SS Dubrovo	325,000.00
			2. Approval of technical documentation	54,826.00		
			3. Construction supervision	16.447,80 x T**		
			4. Compliance testing	in accordance with the real costs		
3	**VPP Miravci**	Study on connection to the transmission grid prepared:: 05.2019	1. Study on connection to the transmission grid	1,644,780.00	Connection to the transmission grid comprised of: 110 kV transmission bay in SS Valandovo	325,000.00
			2. Approval of technical documentation	54,826.00		
			3. Construction supervision	16,447.80 x T**		
			4. Compliance testing	in accordance with the real costs		
4	**VPP Krushevo and TPP Krushevo**	Preliminary study on connection to the transmission grid prepared: 07.2019	1.Study on connection to the transmission grid	1,717,680.00	Connection to the transmission grid comprised of: 110 kV transmission bay in SS Sopotnica	325,000.00
			2. Approval of technical documentation	57,256.00		
			3. Construction supervision	17,168.80 x T**		
			4.Compliance testing	in accordance with the real costs		
5	**Direct user Cranfield Foundry**	Study on connection to the transmission grid prepared: 17.11.2015 Annex to the study on connection to the transmission grid prepared: 03.09.2018 Approval for connection to the transmission grid issued: 04.09.2018	1. Study on connection to the transmission grid	547,770.00	transmission grid comprised of: 1. Connected 2x110kV OHL 2. 110 kV Switchyard and MEPSO's Control and Command Building in SS Neokazi 3. Equipping of 110kV Transmission bay in SS	1,804,000.00
			2. Approval of technical documentation	54,777.00		
			3. Construction supervision	16.447,80 x T**		
			4. Compliance testing	in accordance with the real costs		
6	**Direct user IGM Trade**	Study on connection to the transmission grid prepared: 02.2018 Approval for connection to the transmission grid issued: 26.03.2019	1. Study on connection to the transmission grid	548,260.00	Connection to the transmission grid comprised of: 1. Connection 110 kV lines 2. 110 kV swithcyard and Control and Command Building in SS IGM Trade 3. Equipping of 110 kV transmission bays in SS Kavadarci 1 and HPP Tikvesh	892,000.00
			2.Approval of technical documentation	54,826.00		
			3. Construction supervision	16.447,80 x T**		
			4.Compliance testing	in accordance with the real costs		
7	**second transformer in SS Ovche Pole**	Study on connection to the transmission grid prepared: 08.2017 Approval for connection to the transmission grid issued: 03.10.2019	1. Study on connection to the transmission grida	286,280.00	Connection to the transmission grid comprised of:110 kV transmission bay in Ovche Pole	325,000.00
			2. Approval of technical documentation	57,256.00		
			3. Construction supervision	17,176.80 x T**		
			4. Compliance testing	in accordance with the real costs		

12. CONFIGURATION OF THE TRANSMISSION NETWORK IN 2029

Figure 15. Transmission network in 2029