UPDATED 2023 - 2032 TRANSMISSION SYSTEM DEVELOPMENT PLAN OF MONTENEGRO

- DRAFT -

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Countries:

Abbreviation	Country	ISO abbreviation
A	Austria	AT
AL, ALB	Albania	AL
BG, BUL	Bulgaria	BG
BiH, B&H	Bosna and Herzegovina	BA
GR	Greece	GR
CRO	Croatia	HR
I, IT, ITA	Italy	IT
MNE	Montenegro	ME
MK, MKD, FYROM	North Macedonia	MK
RO, ROM	Romania	RO
SLO, SI	Slovenia	SI
TR, TUR	Turkey	TR
UA, UKR	Ukraine	UA
RS, SRB	Serbia	RS

Other abbreviations:

ACER	The Agency for the Cooperation of Energy Regulators (ACER) of the European Union
AHP	Analytic Hierarchy Process
ATC	Available Transfer Capacity
BCE	Base Case Exchange
B/C	Benefit/Cost Ratio
CBA	ENTSO-E Cost Benefit Analysis Methodology
CEPA	Cambridge Economic Policy Associates
CGES	Transmission System Operator of Montenegro
OHL	Overhead line
EENS	Expected Energy Not Supplied
EPS	Electric power system
EMI	Electricity Market Initiative
EMS	Transmission System Operator of Serbia (Elektromreža Srbije)
EPCG	Electric Power Utility of Montenegro (Elektroprivreda Crne Gore)
ESO	Transmission System Operator of Bulgaria
ENTSO-E	The European Network of Transmission System Operators for Electricity

GTC	Grid Transfer Capacity
HPP	Hydroelectric power plant
HVDC	High-voltage direct current cable
IRR	Internal Rate of Return
SEE	Southeast Europe
KOSTT	Transmission System Operator of Kosovo
MKI	Ministry of Capital Investments of Montenegro
MEPSO	Transmission System Operator of Macedonia
sHPP	Small hydropower plant
NPP	Nuclear power plant
NOS (BiH)	Independent System Operator of Bosnia and Herzegovina
NPV	Net Present Value
NRL	No Realistic Limit
NTC	Net Transfer Capacity
TSO	Transmission system operator
OST	Transmission System Operator of Albania
PS Transformer	Phase-shift Transformer
ToR	Terms of Reference
SECI	The Southeast European Cooperative Initiative (project)
SEW	Social and economic wealth
RAE, Agency	Energy Regulatory Agency of Montenegro
TPP	Thermal power plant
TEL	Transmission System Operator of Romania
TERNA	Transmission System Operator of Italy
TR	Transformer
TS	Substation
TSO	Transmission System Operator
WB6	Western Balkan 6 countries (Albania, Bosnia and Herzegovina, Montenegro, Kosovo, North Macedonia and Serbia)

1 Legal framework for the adoption of the Development Plan

Pursuant to the Energy Law of Montenegro [1] the electricity transmission system operator is required to perform electricity transmission under conditions set out by the license according to the objectivity, transparency and non-discrimination principles. In order to play that role, the most important one, i.e. to fulfil requirements set before it during operation, pursuant to Article 112 of the Energy Law of Montenegro (Official Gazette of Montenegro no. 005/16, 051/17, 082/20), the electricity transmission operator is required to develop a ten-year transmission system development plan. This plan must be, to the greatest extent, harmonised with the planning documents of Montenegro, i.e. with the development plans of neighbouring transmission systems.

Accordingly, the transmission system operator submits annual investment plans prepared according to system user's needs, which shall be consistent with the ten-year transmission *system* development plan and spatial and planning documents.

The Transmission System Operator (hereinafter referred to as CGES) is authorised and responsible for technical criteria of planning and electricity consumption forecast, which are harmonised with technical standards laid down by the Transmission Grid Code [3] and the Energy Development Strategy **Error! Reference source not found.** in Montenegro, provided that every three years, a development plan for the next 10 years is prepared and submitted to the Energy Regulatory Agency for approval.

In addition, the Energy Regulatory Agency of Montenegro (ERA) has prescribed the Rules for Developing and Monitoring the Implementation of Ten-Year Development Plans of Electricity Transmission System [3] that determine the method and procedure of preparation, content, method and procedure of approval, the procedure of conducting a public discussion, as well as the method of monitoring the implementation of ten-year electricity transmission system development plans (hereinafter: development plan).

2 Methodological approach to drafting the Development Plan

The methodological approach to drafting the Plan implies a series of activities needed to be carried out in order for the Plan to lead to its purpose, which is system planning that allows a reliable and safe operation of the electric power system as well as the possibility of connection of new sources and consumers, in accordance with needs of new users.

The procedure itself for the development of the Plan has started with a series of activities by the TSO (CGES), principally with the aim of collecting data and informing transmission system users (CEDIS and EPCG) and competent state entities (MKI) on the time schedule of development of the Plan.

The methodological approach for drafting the Plan consists of the following components:

- Collecting data from transmission system users that include:
    - CEDIS,
    - EPCG,
    - Ministry of Capital Investments,
    - Direct consumers;
- Collection of data on development plans of neighbouring systems, or systems whose development projects may have an impact on CGES transmission network;
- Development of market and network scenarios of electricity exchange in the region;
- Identification of bottlenecks in the transmission network;
- Geography of total available power at points in the system free for the connection of new users (ΔGTC) based on the current state of the transmission network;
- Identification of necessary projects;
- Cost-benefit analysis (ENTSO-E CBA 3.0);
- Development plan for new projects.

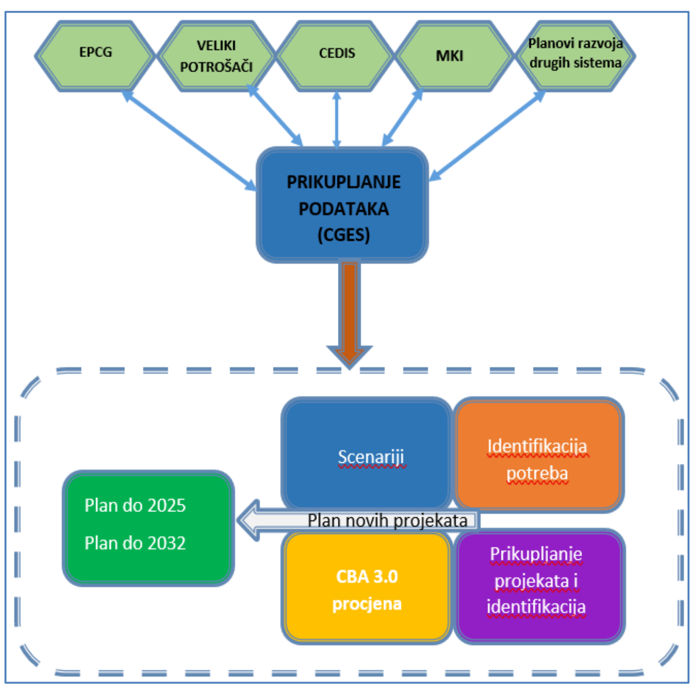


Figure 2-1 Methodological approach to drafting the Plan

Market analyses imply the calculation of socio-economic benefit from construction of new transmission facility, for society as a whole (including the region), where this benefit is a consequence of merging two price areas and the equalisation of prices between them, i.e. using generation units with lower generation costs. If some project of transmission system contributes to the equalisation of prices between two price areas, market analyses show how much impact this project has on society as a whole.

Based on electricity market models, characteristic hours (usually with maximum and minimum consumption, maximum and minimum commercial exchange at the border of CGES transmission system, with maximum and minimum transits) were selected based on which market models were developed.

Further analyses were done on market models that gave results in the form of need to reinforce the transmission system in order to satisfy the needs of the existing and new transmission system users in the safest and securest way.

Total benefits calculated in network and market analyses make the total benefit for society (by a new facility). The mentioned analyses are done to do an estimate of necessary investments and their cost-effectiveness during operation.

Then an investment plan was developed for each new project, which together with other investments (reconstructions, replacements of obsolete equipment, protection systems, surveillance systems, exchange and storage of data etc.) make a unique investment plan.

2.1 Methodology and criteria for transmission system planning

With the deregulation of the electric power sector and liberalisation of electricity market, instead of central management and planning, it appears a big number of competitive participants that act independently and whose coordination needs to be agreed at the higher level, or at the level of system possibilities and needs, whereby the major role should be given to transmission system operator. In such conditions, transmission system development planning becomes an extremely complex task in which planners must take into account a big number of unknowns and uncertainties in terms of technical, economic and regulatory constraints.

Transmission system development plans must prove sufficiently robust and adequate to satisfy a wide range of possible future states of the system. Therefore, it is no longer just desirable, but also necessary, that market analyses precede network analyses that will optimise the operation of the generation portfolio, make a plan for engagement of generation units, but also identify certain specific (non-characteristic) hours, for which it is necessary to do an analysis of the state of the system. Such practice of using both market and network analyses in drafting development plans is used also in processes of Pan-European transmission system development planning by ENTSO-E.

Of course, system specificities were also taken into account and an optimal way to fulfil both conditions was found, complying with the fact that ENTSO-E methodologies are made for an open electricity market.

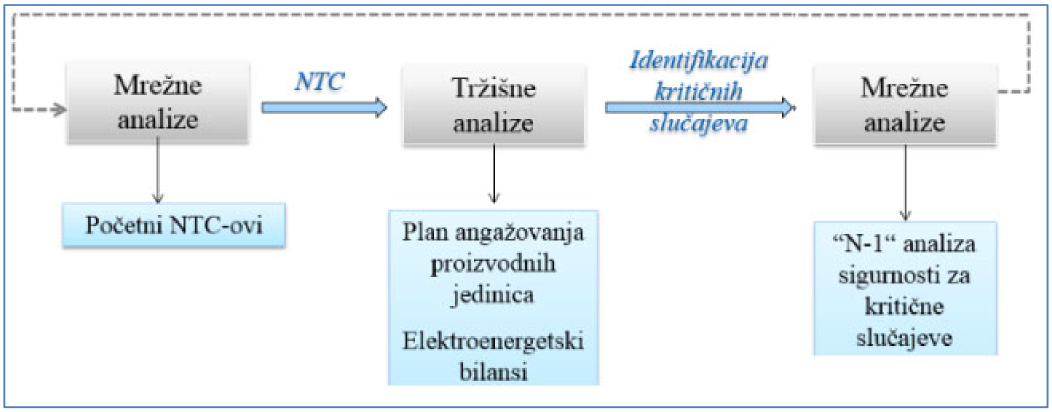


Figure 2-2 Interaction between market and network analyses

For certain projects, it was not possible to give a detailed analysis of benefits that could be monetized, but it was provided a rationale of needs for implementing such projects. Such projects include purchase of certain equipment, repairs of obsolete elements and similar.

In this analysis, a value of 10,000 €/MWh was taken for electricity not supplied (ENTSO-TYNDP 2020) observed from the perspective of the transmission system, while in the analysis of the connection of the distribution SSs, the price of 2.5 €/kWh was taken, as given in the CEDIS Technical and Economic Analysis (separate Annex).

Price of electricity from wind power plants in Montenegro amounts to 96 €/MWh.

For the price of losses and energy not supplied from other generation facilities (except WPPs Krnovo and Možura), the price obtained from market analyses based on expected opportunities in the system managing for a given year in the future was used. Namely, according to Article 9, Paragraph 6, as well as Article 28 of the Methodology for Setting Regulatory Allowed Revenue and Prices for Using the Electricity Transmission System [14], the price of electricity to cover justified losses is determined in the manner defined by law. Since the analyses within the subject Plan are based on simulations of the electricity market, as provided by the ENTSO-E guidelines [8], the prices of losses and techno-economic analysis are taken from the results obtained from market analyses.

Generally speaking, the ENTSO-E CBA methodology is applied on interstate projects (regional projects), or on internal projects having an impact on a certain region.

2.2 Electricity market simulations

Within market simulations, it has been optimised the operation of mixed hydro-thermal systems of Europe with the aim of maximising the well-being of the Pan-European electricity market, taking into account available energies from renewable sources, constraints in the transmission network, as well as market interactions between modelled countries. Analyses were conducted for 2025 and 2032 as average years.

Market simulations will be performed in the programme package Antares. The engagement of generation capacities shall be determined for all 8,760 hours, with the optimisation of total costs of operation of the overall modelled system and application of short-term marginal costs. During simulations, the commercial constraints of transmission (NTC) will be taken into account with the assumption of ideal market (without application of market power) and price inelastic consumption.

By the conducted simulations, the following output data of interest for network analyses are obtained for each year in each analysed year:

- engagement of natural units of Montenegro (8,760 hour values),
- import/export positions of Southeast Europe countries,
- commercial exchanges of Montenegro by borders.

Transmission network constraints between price areas are outlined through NTC values according to the latest data from ENTSO-E TYNDP 2022.

In the available SECI models for 2025 and 2030 (updated to 2032), depending on the area, generation plants are modelled as follows:

- by power plants for Albania, Bosnia and Herzegovina, Bulgaria, Greece, Croatia, Montenegro, Northern Macedonia, Romania, Serbia, Kosovo and Slovenia,
- by technologies for Austria, Czech Republic, Hungary, Italy, Poland and Slovakia,
- spot markets: Germany and Turkey.

2.3 Technical criteria and constraints in EPS operation

In addition to criteria and methodology described within Market Analyses, a summary of other criteria is given within this Chapter, which may be included in Technical Criteria, which are included in the Transmission Grid Code, CGES [3].

The planned construction, reconstruction and upgrade of transmission facilities must ensure preconditions for the development of generation and distribution capacities, electricity market developments and reliable and quality supply of electricity for the forecasted level of consumption.

For the identification of eventual problem and transmission system planning, TSO shall use the following planning criteria:

1. Technical criteria and constraints under normal operational conditions;
2. Technical criteria and constraints under difficult operational conditions;
3. Criteria for allowed short-circuit currents; and
4. Criteria for commissioning new network elements or reconstructing existing ones.

2.4 Assessment of candidates for construction by the CBA methodology

Impact of potential future transmission facilities is analysed through more criteria of cost-benefit analysis determined by ENTSO-E. According to this approach, scenarios of new transmission facilities are assessed through different benefit categories and compared according to their indicators. Indicators of benefit categories are a result of network and market analyses.

Pursuant to the Rules for developing and monitoring the implementation of ten-year development plans **Error! Reference source not found.** and ENTSO-E CBA 3.0 Methodology **Error! Reference source not found.** from 2020, the results of the study will show the following indicators on the basis of which projects/clusters (listed in accordance with the numeration of the Rules) will be evaluated:

1. K1 - Common and social economic benefit (it is used only for those internal projects that can have a significant cross-border impact such as interconnection projects or can solve internal bottlenecks, which leads to large internal benefits that are achieved by reducing the generation of redispatching costs [€/year];

   a. K1.1 Energy cost savings [€/year],
   b. K1.2 Gas emission cost savings [€/year],

2. K2 - Change in CO_2 emissions [t/year];
3. K3 - Integration of renewable energy sources [MW] or [MWh/year];
4. K4 - Non-CO2 emissions [t/year];
5. K5 - Network losses [MWh/year];
6. K6 - Adequacy [MWh/year];
7. K7 - Flexibility:
   a. K7.1 Balance energy exchange [ordinal scale],
   b. K7.2 Balance capacity exchange;
8. K8 – Stability:
   a. K8.1 Qualitative indicator,
   b. K8.2 Frequency stability,
   c. K8.3 Needs for no-load start-up services [€/year], and
   d. K8.4 Needs for voltage/reactive power management services;
9. K9 - Avoidance/postponement of remedial actions on existing elements [€];
10. K10 - Change in redispatching needs [€/year];
11. K11 - Robustness.

In addition to the listed cost-effectiveness ratios, two additional indicators are presented as expense-related indicators:

1. T1 CAPEX [€],
2. T2 OPEX [€/year].

Indicators of benefits from construction of certain projects were obtained by applying calculation WITH and WITHOUT project, whereby obtaining its impact of benefit on the transmission network and generally overall system of Montenegro. For cases where monetization of project benefit was not possible, its benefits were given descriptively.

ENTSO-E CBA methodology is applied in European practice on regional projects, or on internal projects having an impact on the region.

2.5 Maximum available connection capacity (ΔGTC)

Another important indicator of the readiness of the transmission network to receive new generation and consumption facilities is the grid maximum available connection capacity at the connection points of the transmission system, and within this Plan, an analysis was performed in accordance with the Transmission Grid Code and the current Methodology for Calculating Available Connection Capacities.

This Methodology determines the method of calculating the maximum available connection capacity at the existing connection points of the electricity transmission system that does not require further development of the system to permanently preserve the guaranteed transmission parameters.

The maximum available connection capacity (GTC – Grid Transfer Capacity) is the highest allowed exchange capacity at a connection point that does not require further development of the system to permanently preserve the transmission parameters guaranteed by the Transmission Grid Code.

The maximum available connection capacity for each connection point is set to be less than the value of the remaining theoretically free capacity and other constraints:

MAC=min (RTC, OO)[1]

[1] CGES reserves the right to, depending on the specific demands for connection by potential users of the network, make additional analyses of the possibility of connection at a certain point of the transmission network.

3 Scenario description

The European Energy Union Strategy, published by the European Commission in February 2015, emphasised the need for integrated governance to ensure that all energy activities at EU, national, regional and local levels contribute to the goals of the Energy Union. This will, by 2030, expand the scope beyond climate and energy policy to include all five key dimensions of the Energy Union: 1. Energy security, 2. Internal energy market, 3. Energy efficiency, 4. Decarbonisation and 5. Research, innovation and competitiveness.

The National Energy and Climate Plans (NECPs) should cover the period from 2021 to 2030, paving the way for achieving the agreed 2030 targets, upgrade on what each party needs to deliver concerning its policies and include a perspective by 2050 to ensure consistency with the long-term relevant policy objectives at EU and Energy Community level.

As a member of the United Nations, Montenegro, by ratifying the Paris Agreement, has committed itself to joining the international community aimed at reducing greenhouse gas emissions. In addition, as a member of the Energy Community and a candidate for EU membership, Montenegro has committed itself to meeting the objectives of the Energy Community and the European Union in the areas of renewable energy, energy efficiency and greenhouse gas emission reductions. In order to meet these obligations and achieve the set goals, Montenegro must harmonise and coordinate its energy and climate policy. Integrating environmental and climate change issues into ambitious development and energy policies and strategies is one of the country's biggest challenges in joining the European Union.

Bearing in mind that the Plan must in particular contain (among other things) elaborated scenarios in accordance with the NECP, it should be noted that the NECP is currently being drafted and it is not realistic to expect it to be in the official draft phase before the end of 2022. As the NECP is in the initial phase of development, no analysis has been done within this Plan according to the scenarios that would be included in this plan, so the results and input data of current studies were used within the subject Plan (**Error! Reference source not found.**, EMI project and other).

Earlier development plans (and the Strategy) envisaged the construction of hydropower plants on the river Morača, but in the subject Development Plan, HPPs on Morača are no longer relevant (according to the data provided by MKI).

The EPS model includes Montenegro as well as other European countries modelled with the following level of detail:

- Consumption: total consumption defined by medium hour loads.
- Conventional generation capacities (TPP, HPP): each power plant separately or power plants grouped by clusters with corresponding technical and economic parameters.
- Renewable energy sources (wind, solar energy): total available hour generation for each technology in accordance with hour CF factors, treated as “must run“ priority generation.
- Transmission constraints on interconnections defined by NTC values.

The source of data for Montenegro are questionnaires received from users of transmission system of Montenegro (EPCG, Ministry, investors, etc.), and for other European states relevant studies ERRA 2021, TYNDP 2020, as well as climate databases.

The scenarios for the development of new sources are contained through a market simulation defined based on the probability of sequential hourly simulation of electric power system operation applying the following simulations:

- application of the Monte Carlo method that includes different combinations of wind, sun, hydro generation as well as different changes in demand in respect of weather conditions (changes in

wind speed, hydrological conditions, temperature) and different levels of unavailability of thermal units due to failures or maintenance;
- hydro-thermal optimisation (optimal dispatching by the hour) to minimise system operation costs;
- compliance with characteristics and constraints in the transmission network (NTC or GTC constraints with direct load flow in accordance with PTDF factors).

3.1 Transmission system development objectives

The objective of the Development Plan is defined by Article 4 of the Rules for Developing and Monitoring the Implementation of Ten-Year Development Plans of Electricity Transmission System (hereinafter the Rules), which clearly stated that the Plan should show in detail the state of the transmission system in Montenegro in a year preceding the planning period, lay down the guidelines for its development according to system users' needs as well as necessary investments in accordance with the proposed transmission system development.

The backbone of this transmission network development planning is the Energy Law, i.e. those of its articles related to the Transmission Network Development Plan. It was pointed out that in drafting the Development Plan, the Energy Law places special emphasis on supporting the achievement of a number of long-term objectives, the most important of which is reliable, secure and quality electricity supply, which coincides with the mission of CGES.

<u>Objective 1 - Elimination of observed uncertainties in the past period</u>

At the beginning of analyses, the Development Plan aims to show in detail the state of the transmission system in Montenegro to identify bottlenecks that contribute to reduced electricity exchange, both within the same price zone and between different price areas, to enable uninterrupted trading in electricity. Therefore, the emphasis is not only on the development of the domestic electricity market but also the complete European electricity market.

At the 110 kV voltage level, except for projects of internal 110 kV network and solving of radially powered distribution transformer stations 110/x kV, in a transparent and non-discriminatory manner, CGES also plans and implements projects for connecting the transmission and distribution system, as well as projects for connecting facilities to the transmission system of Montenegro, which enables the placement of all volumes of electricity generated and its and its reliable and efficient transmission to customers, i.e. end consumers.

<u>Objective 2 - National system security</u>

The Development Plan must be based on the existing and planned generation and system load and contain measures guaranteeing the system capability to meet the needs for electricity transmission and long-term power supply security.

At the same time, the necessary enhancement and construction of new transmission system facilities are defined to timely initiate procedure relating to their designing, provision of funds, construction and commissioning.

<u>Objective 3 - Security of undisturbed electricity trade in the region</u>

The transmission systems of the countries in the SEE region are, compared to other ENTSO-E regions, less interconnected. In recent years, there has been a significant increase in new installed capacity in renewable sources, especially wind power plants, but also solar units.

Planned projects in the SEE region's transmission network (new facilities and reconstruction of existing facilities) over the next decade aim to increase security of supply, support the integration of renewable sources, couple electricity markets in the region and strengthen interconnections between transmission systems and increase available transmission capacities.

<u>Objective 4 - Proper planning in order to minimise capital investments in the transmission network</u>

First of all, it is necessary to take into account that during the preparation and selection of a technical solution, in a way that among the possible technical solutions that meet the requirements and constraints, the following is chosen:

- a solution that causes minimum investment costs in achieving objectives, and
- a solution that allows reducing total operation costs of operators or, if this is not possible, that causes the smallest increase in these costs.

The law clearly defines that the TSO maintains, modernises, improves and develops the electricity transmission system with clearly defined planning objectives:

- determines the technical and technological conditions for connecting electric power facilities, devices and plants into a single system;
- develops the transmission network by not limiting the purchase and sale of electricity within the technical-technological possibilities of the transmission system;
- plans the operation of the transmission system, in cooperation with the market operator and operators of other systems;
- resolves overloads of certain transmission system elements, taking into account the equal position of all transmission system users.

<u>Objective 5 - Proper planning in order to connect renewable energy sources and increase socio-economic benefits</u>

Grid planning must take into account different technologies (wind power plants, solar power plants, gas power plants, coal fired power plants, hydropower plants etc.) and energy that produce and which, with the aim of supplying certain consumption, must be transferred by using transmission system at small or big distance. Therefore, transmission grid planning refers to forecasting how much energy (and power) will be needed to satisfy consumption, while for planning and selection of transmission elements, it is important where this energy will be generated and consumed. Although transmission costs are considerably lower than generation costs, just a well-constructed transmission system allows optimal use of generation capacities and available energy, increasing energy efficiency and reducing total costs in the long term.

In the process of planning the development of the transmission system, the so-called "golden network", a network that will have no restrictions, but aims to develop a dynamic, flexible and robust network, adaptable to future changes in generation and consumption.

Within market simulations, it has been optimised the operation of mixed hydro-thermal systems of Europe with the aim of maximising the well-being of the Pan-European electricity market (not just the national market), taking into account available energies from renewable sources, constraints in the transmission network, as well as market interactions between modelled countries.

<u>Objective 6 - Connecting the European electricity market</u>

An important segment of the strategic transmission system development in the next ten years remains the construction of interconnections to neighbouring systems, primarily with Bosnia and Herzegovina, Serbia, Kosovo and Albania, which ensures a high level of security of consumer supply throughout Montenegro in the observed period. The project of connecting with BiH and Serbia with new 400 kV interconnections is part of the construction of the so-called Trans-Balkan Corridor, which aims to increase the capacity of the Western Balkans interconnection in the east-west and north-south directions, thus allowing the integration of renewable sources, primarily in Montenegro, and the delivery of energy to neighbouring countries.

<u>Objective 7 - Strategic directions of improvement and development in environmental protection</u>

Within this objective, it is necessary to first adjust your own operations for the purpose of the following activities:

- Management of hazardous materials (insulating oils);
- Construction of new "ecological" oil pits or reconstruction of existing ones;
- Introduction of new information technologies - GIS for the purpose of monitoring system parameters;
- Active participation in the harmonisation of legal regulations;
- Preparation of studies in the field of environmental protection;
- Energy efficiency projects - pilot projects; The installation of DLS devices for monitoring the load of critical ranges of lines replaces or delays their reconstruction, i.e. significantly less impact on the environment (magnetic radiation, etc).

4 Starting point for drafting the Plan

4.1 Energy balance in the previous period

Based on the available balance of electricity consumption in Montenegro for five years (2017-2021), as shown in Figure 4-1, it can be noticed a decrease in total consumption by 2021 (as a consequence of decrease in the consumption of large consumers).

Distribution consumption makes most of the electricity consumption, but the total electricity consumption to a significant degree is determined by consumption of three existing direct consumers: Aluminium Plant (KAP), Steel Mill and Railway Infrastructure of Montenegro (ŽICG). In the same period, distributive consumption in Montenegro increased by 2018, and after that, due to the COVID-19 pandemic, there was a significant decline of about 13.5%.

During 2021, there was a significant reduction in KAP's consumption, which in total affects the energy balance of Montenegro in the sense that it imports significantly less than in previous years.

When it comes to exchanges at borders, during the previous 3 years (Figure 4-2), the highest level of exchange was achieved with Bosnia and Herzegovina in 2020 of about 4.06 TWh of imports, as well as with Albania in the same year of about 2.6 TWh of exports. This leads to the conclusion that CGES' network was mainly used for electricity transit, which leads to a clear signal that it is necessary to think about new interconnections at these borders.

When it comes to the border with Italy (HVDC), electricity was mainly directed towards Italy, which resulted in a significant increase in transit compared to the period before 2019.

CGES does not take into account the distribution network in its network simulations (the distribution network model has not been processed), which is in line with the established practice of other ENTSO-E transmission network operators, unless a TSO specifically models the distribution network due to special needs and effects on the transmission system.

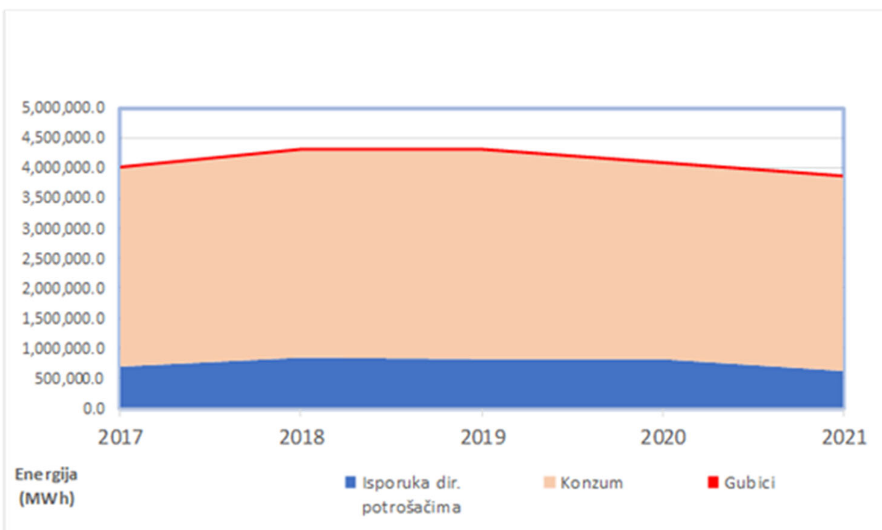


Figure 4-1: CGES consumption balance 2019-2021

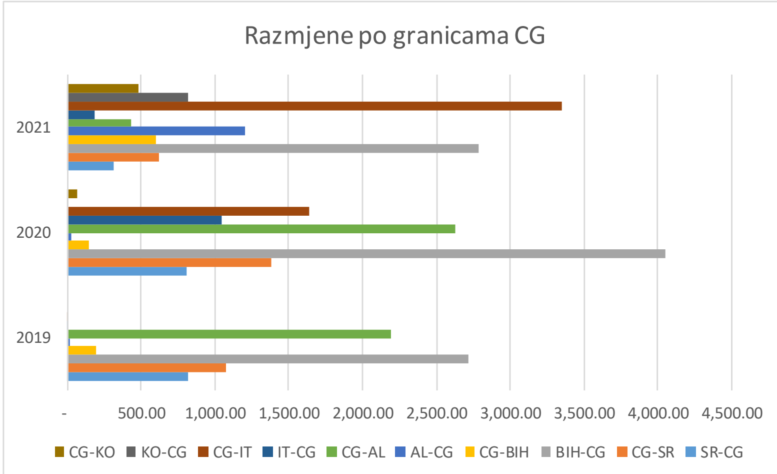


Figure 4-2: Graph overview of electricity exchange along the borders of Montenegro 2019-2021

Electricity consumption by large consumers is determined based on the consumption by KAP, Nikšić Steel Mill, Railway Infrastructure i.e. electric traction substations. The graph (Figure 4-3) shows realised values of consumption of large consumers from 2017 to 2021, where it is clear that KAP participates with dominant 90% in the total consumption of large consumers in recent years.

The greatest impact has the change in consumption by KAP, considering the high share in power and energy of the system as well.

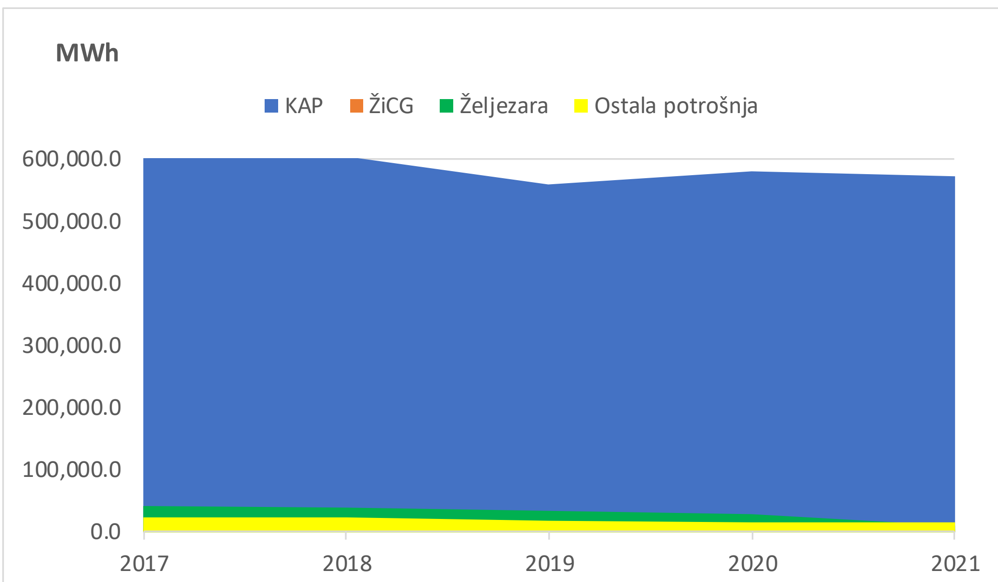


Figure 4-3: Graph overview of electricity consumed in Montenegro

KAP - Podgorica Aluminium Plant, which as of 2017 participated in total consumption in the range from 17% to 33% of total energy consumed (Figure 4-3), with a peak annual utilisation of 70-75 MW/h in 2018 and an average utilisation of about 70 MW. For all analyses within the subject Development Plan, the peak utilisation of KAP will be 10 MW.

Nikšić Steel Mill - the second-ranked direct consumer with a share of the total consumed electricity in the system annually significantly declines over the last two years. For the upcoming period, the peak hourly load is expected to be equal to that realised in 2021.

ŽICG - electric traction substations, including four facilities located in Bar, Trebješica, Podgorica, Mojkovac, have their share of 0.6% of total electricity consumption of the Montenegrin system, with an expected peak load of 6 MW, evenly distributed across the existing four electric traction substations.

Table 4-1: Realised consumption in the period 2017-2021 at the points of electricity takeover from the transmission system of CGES

Elektroenergetski objekti	2021						2020						2019						2018						2017					
	Zima			Ljeto			Zima			Ljeto			Zima			Ljeto			Zima			Ljeto			Zima			Ljeto		
	W_a (MWh)	Wr (Mvarh)	P_{max} (MW)	W_a (MWh)	Wr (Mvarh)	P_{max} (MW)	W_a (MWh)	Wr (Mvarh)	P_{max} (MW)	W_a (MWh)	Wr (Mvarh)	P_{max} (MW)	W_a (MWh)	Wr (Mvarh)	P_{max} (MW)	W_a (MWh)	Wr (Mvarh)	P_{max} (MW)	W_a (MWh)	Wr (Mvarh)	P_{max} (MW)	W_a (MWh)	Wr (Mvarh)	P_{max} (MW)	W_a (MWh)	Wr (Mvarh)	P_{max} (MW)	W_a (MWh)	Wr (Mvarh)	P_{max} (MW)
TE Pljevlja SP	5,111	4,319	7.47	4,098	3,571	4.42	5,085	4,221	10	4,077	3,553	4.72	4,346	4,079	4.58	4,317	3,899	4.69	5,565	4,594	9.65	4,199	3,798	10.92	5,437	4,594	7.95	4,359	3,798	4.7
ŽCG	9,353	4,956	7.13	9,772	5,818	7.27	9,393	4,977	7	9,814	5,843	7.36	9,337	4,495	7.85	10,545	5,560	7.77	9,949	5,272	8	10,394	6,189	8	9,949	5,272	7.58	10,394	6,189	7.73
KAP	324,471	171,070	65.8	317,598	127,159	65.8	264,225	166,794	64.2	258,628	126,313	62.7	307,854	186,117	78.7	301,118	214,143	84.8	345,128	181,961	70	337,818	135,255	70	345,128	181,961	70	337,818	135,255	70
Željezara Nikšić	3,814	2,265	5.08	1,199	744	4.42	18,242	10,835	38.5	15,832	9,822	39.8	22,127	11,847	42.6	21,072	12,035	38.3	4,057	2,409	5	1,275	791	5	4,057	2,409	5.4	1,275	791	4.7
TS Andrijevica	10,268	5,358	5.53	9,736	6,828	8.31	11,539	5,723	5.64	12,675	6,738	5.71	18,029	7,266	6.59	15,213	7,543	6.35	5,613	5,699	6.45	-7,210	7,263	6.86	10,921	5,699	5.88	10,356	7,263	8.84
TS Bar	89,083	21,721	38.5	90,625	30,520	47.3	88,791	21,453	34.4	86,556	30,177	40.3	94,836	24,757	38.9	89,729	34,117	46.9	92,853	23,104	39.45	100,198	32,463	49.47	94,755	23,104	40.96	96,395	32,463	50.26
TS Berane	40,614	10,420	18.3	33,574	12,544	24	33,291	9,993	16.7	30,675	11,947	15.6	47,236	11,020	18.9	34,419	13,444	16.4	39,889	11,083	17.12	26,221	13,343	16.13	43,199	11,083	19.47	35,711	13,343	25.55
TS Brezna	3,461	1,267	4.69	3,995	1,205	6.06	/	/	/	/	/	/	/	/	/	/	/	/	5,698	1,348	4.54	5,113	1,282	6.15	3,681	1,348	4.99	4,249	1,282	6.45
TS Ribarevine	49,958	15,900	19.1	44,561	17,700	22.9	49,683	14,968	18.3	41,933	16,293	15.6	53,021	16,537	19	43,860	18,169	16.4	47,245	16,912	16.61	40,722	18,827	16.21	53,139	16,912	20.29	47,398	18,827	24.39
TS Budva	102,326	17,505	44.5	132,943	33,803	70	97,156	14,180	47.2	126,591	33,844	60.3	101,495	17,444	47.8	127,424	36,853	70	109,673	18,619	48.68	147,500	35,955	72.58	108,841	18,619	47.34	141,407	35,955	74.49
TS Cetinje	42,819	9,556	20.8	35,548	12,432	19.8	46,211	10,739	23.5	31,138	11,271	17.8	54,951	13,736	23.2	36,812	14,138	18	46,263	10,165	19.40	33,442	13,224	16.43	45,545	10,165	22.08	37,811	13,224	21.11
TS Danilovgrad	32,107	16,701	13.4	30,403	18,070	16.2	24,715	13,127	12.2	23,807	16,407	10.4	32,039	15,826	12.9	28,373	17,869	13.1	35,555	17,764	13.52	29,936	19,220	12.86	34,151	17,764	14.2	32,339	19,220	17.2
TS Herceg Novi	82,924	21,619	37.8	80,458	29,420	40.1	86,147	23,763	35.2	79,636	30,715	35.1	93,370	28,084	36.9	83,791	34,584	39.3	87,015	22,995	34.51	88,127	31,292	41.17	88,203	22,995	40.16	85,581	31,292	42.7
TS Mojkovac	21,194	7,343	8.19	18,713	8,490	10.6	19,969	7,016	8.02	17,548	7,994	6.74	23,230	7,564	8.88	19,037	8,077	6.95	21,662	7,810	7.33	18,906	9,031	7.60	22,544	7,810	8.71	19,904	9,031	11.23
TS Nikšić - ukupno	111,600	36,705	47.5	76,677	36,151	35.3	124,673	42,062	42.3	94,431	43,576	33.5	138,029	45,512	48.3	101,161	47,471	42	88,584	39,042	30.02	69,965	38,452	29.09	118,705	39,042	50.57	81,558	38,452	37.54
TS Pljevlja 1 (sa ED Čajniče)	69,504	22,233	26.1	61,480	25,034	33.9	68,672	21,946	25.2	61,103	25,080	22.7	76,224	24,582	26.2	68,428	29,387	24	65,459	23,649	21.34	59,845	26,627	20.09	73,929	23,649	27.72	65,394	26,627	36.05
TS Podgorica 1	140,798	34,619	60.1	120,509	43,605	51.8	144,573	38,262	55.3	111,041	44,924	41.7	147,899	40,626	57.5	115,413	47,576	46.5	153,800	36,823	57.18	132,493	46,381	52.09	149,762	36,823	63.9	128,182	46,381	55.13
TS Podgorica 3	104,921	14,302	47.1	85,040	19,793	38.8	103,159	16,288	40.5	77,655	19,550	30	109,971	20,711	41.6	89,003	26,359	36.1	105,781	15,213	42.20	89,896	21,054	38.63	111,601	15,213	50.14	90,454	21,054	41.24
TS Podgorica 4	130,143	17,781	57.9	98,526	20,285	46.7	129,117	18,541	48.9	96,404	21,111	37	134,329	22,345	48.8	99,606	22,723	39.2	126,450	18,913	50.86	105,092	21,577	44.82	138,428	18,913	61.59	104,798	21,577	49.66
TS Podgorica 5	72,912	11,862	33.7	54,818	14,130	25.7	74,033	12,701	28.4	52,368	14,072	20.5	75,238	13,402	28.5	54,090	14,879	22.5	77,473	12,617	31.33	62,191	15,029	27.64	77,554	12,617	35.84	58,308	15,029	27.34
TS Tivat	82,259	15,661	42.3	77,984	20,463	35.9	101,413	20,384	36.3	91,289	26,073	38	101,550	22,201	37.8	85,683	27,019	38	67,234	16,658	32.16	67,271	21,766	26.14	87,496	16,658	45.01	82,948	21,766	38.21
TS Kotor	26,593	6,545	23.3	18,588	6,392	21.3	/	/	/	/	/	/	/	/	/	/	/	/	45,714	6,962	21.84	44,473	6,799	21.50	28,286	6,962	24.76	19,772	6,799	22.67
TS Kličevo	18,929	6,434	25	4,810	2,409	5.39	/	/	/	/	/	/	/	/	/	/	/	/	38,767	6,844	13.23	28,459	2,562	12.71	20,134	6,844	26.58	5,116	2,562	5.73
TS Ulcinj	41,349	14,688	15.3	53,058	23,262	33.4	39,769	12,254	18.5	49,439	20,965	30.2	41,502	14,085	16.7	48,409	21,894	33.9	44,001	15,624	20.29	59,221	24,743	37.77	43,982	15,624	16.26	56,435	24,743	35.53
TS Vilusi	3,043	2,292	1.22	2,880	2,608	1.59	2,949	2,086	1.14	2,806	2,505	1.17	2,951	2,006	1.23	2,874	2,375	1.07	3,402	2,438	1.30	3,205	2,774	1.29	3,237	2,438	1.3	3,064	2,774	1.69
TS G.Mrke	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	3,436	3,264	2.39	4,394	4,175	2.17	/	/	/	/	/	/
TS Uvac	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	1,347	1,280	0.67	1,780	1,691	0.64	/	/	/	/	/	/
VE Krnovo	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	297	282	0.45	349	331	0.41	/	/	/	/	/	/
TS Virpazar	20,705	6,256	9.9	24,254	7,791	13.6	20,044	5,643	10.1	22,308	7,975	11.4	21,036	6,703	10.7	17,973	6,699	11.8	21,240	6,654	10.22	25,744	8,287	13.53	22,023	6,654	10.53	25,798	8,287	14.44

* distribuirana proizvodnja veća od ukupne potrošnje

4.2 Share of the installed generation capacities by generation category

This Chapter presents an overview of technical features of the existing generation facilities of the Montenegrin EPS and the share of generation by individual generation categories.

HPP Perućica - the oldest facility of the Montenegrin EPS that was put into operation in 1960.

The main technical features of HPP Perućica are as follows:

- Installed capacity 330 MVA (307 MW 5x38MW and 2x58.5MW);
- Seven generating units with horizontally mounted synchronous generators.

The eighth generating unit with the capacity of 65 MVA is planned to be installed for which all conveyance and outfall features were built along with ancillary and common drive mechanisms and a place defined for the installation into the power house.

HPP Piva - a hydroelectric reservoir power plant with one of the largest concrete arch dam in the world has been operating since 1976.

The main technical features of HPP Piva are as follows:

- Installed capacity of 360 MVA (342 MW - 3×114 MW).

TPP Pljevlja is a condensation thermal power plant designed with two blocks of 210 MW. Water reservoir along with all auxiliary, technical and control-administration facilities (except for decarbonisation and re-circular cooling system) were designed for two blocks, but currently there is only one block.

The main technical features of TPP Pljevlja are as follows:

- Installed capacity of the power plant is 225 MW;
- After the performed reconstruction (2009), technological repairs and improvements of the whole plant, annual generation goes even beyond 1400 GWh.

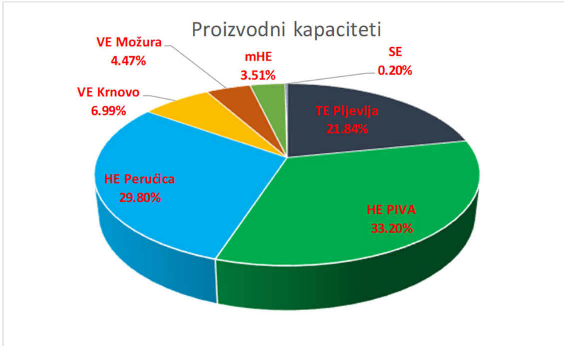
TPP Pljevlja is a base power plant in the Montenegrin EPS, and its significance is reflected in coverage of constant load diagram.

WPP Krnovo - WPP Krnovo has been in operation since 2017, with the total installed capacity of 72 MW and annual generation of about 200 GWh.

WPP Možura - WPP Možura has been in operation since 2018. The total installed capacity of 23 wind turbines is 46 MW, with a planned annual generation of 100 GWh.

Small HPPs - In Montenegro, there are 38 small hydropower plants (sHPP) connected to the distribution network with a total approved capacity of 64.71 MVA (calculated with the approved capacity to which the 400 kVA sHPP Pecka is limited to).

Apart from them, there are five solar power plants operating in the power system, with a total installed capacity of 2.235 MW.



Generation capacities of Montenegro 2021 Annual generation of Montenegro 2021

Figure 4-4: Distribution of annual capacity/generation in 2021 by power plants

4.3 Share of electricity generated by generation category

The diagram (Figure) shows annual generation in the Montenegrin EPS by power plant type in the period 2017-2021. It can be concluded from the diagram that on average over 60% of annual generation in the Montenegrin EPS comes from hydropower plants (provided that the generation in 2017 was lower than 50% due to a poor hydrological situation).

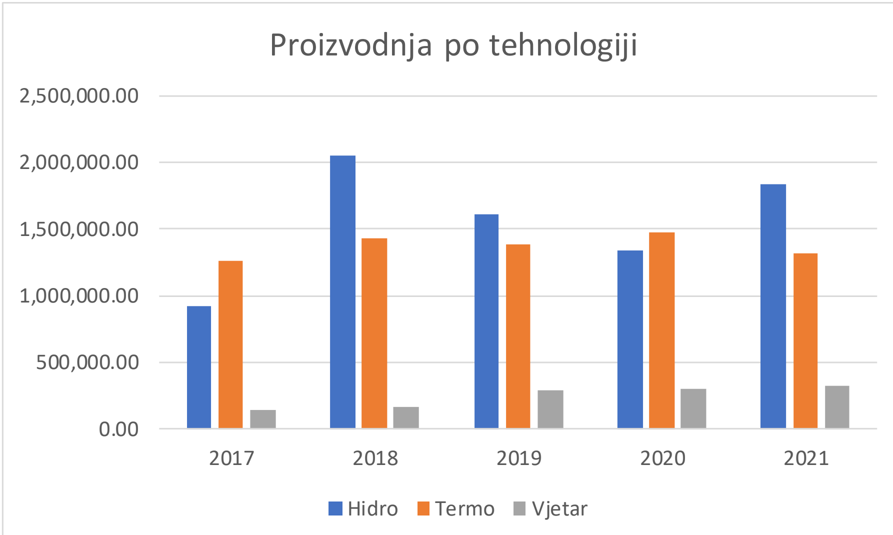


Figure 4-5: Generation of the Montenegrin EPS by power plant type in the period 2017-2021

Having in mind a high percentage of annual generation from hydropower plants, we can conclude that the Montenegrin EPS has been in deficit mainly in summer months having poor hydrology and high consumption, especially in Podgorica and at the seaside.

The exception is the last year of the considered period during which Montenegro achieved an electricity surplus. Due to favourable weather conditions, the generation of HPP Piva and HPP Perućica is considerably higher in comparison with the past two years. On the other hand, generation of TPP Pljevlja was slightly lower in the past year, in comparison with previous years. WPP Krnovo and WPP Možura certainly contribute to the electricity surplus. Their share in total generation in 2021 was about 9.2%.

4.4 Available connection capacities by points in the system (ΔGTC)

This Chapter outlines the maximum available capacity calculated at the connection point (GTC - Grid Transfer Capacity). This capacity represents the maximum allowed power of exchange at the connection point, which does not require further development of the system in order to permanently preserve the transmission parameters guaranteed by the Transmission Grid Code. In this way, the maximum available capacity (MAC) was obtained at the connection points of the transmission system for 110 kV and 400 kV busbars in facilities owned by CGES. Connection to the 220 kV voltage level has been eliminated in the process of considering other constraints, bearing in mind the position from the Energy Development Strategy of Montenegro by 2030: *For the period after 2020, it is necessary to study the consequences of the eventual abandonment of the 220 kV voltage level in the transmission network*. Considering that other parts of the region of Southeast Europe are considering abandoning the 220 kV voltage level, no assessment for this voltage level has been made within these analyses[2].

The maximum available capacity at a connection point is the highest allowed exchange capacity at a connection point that does not require further development of the system to permanently preserve the guaranteed transmission parameters, and this value is considered to be indicative.

The capacity values in the table indicate the possibility of connecting a new user to the system at the current time at a given point. In practice, it is expected that the connection of a new user can be carried out techno-economically more efficiently along the routes of existing lines.

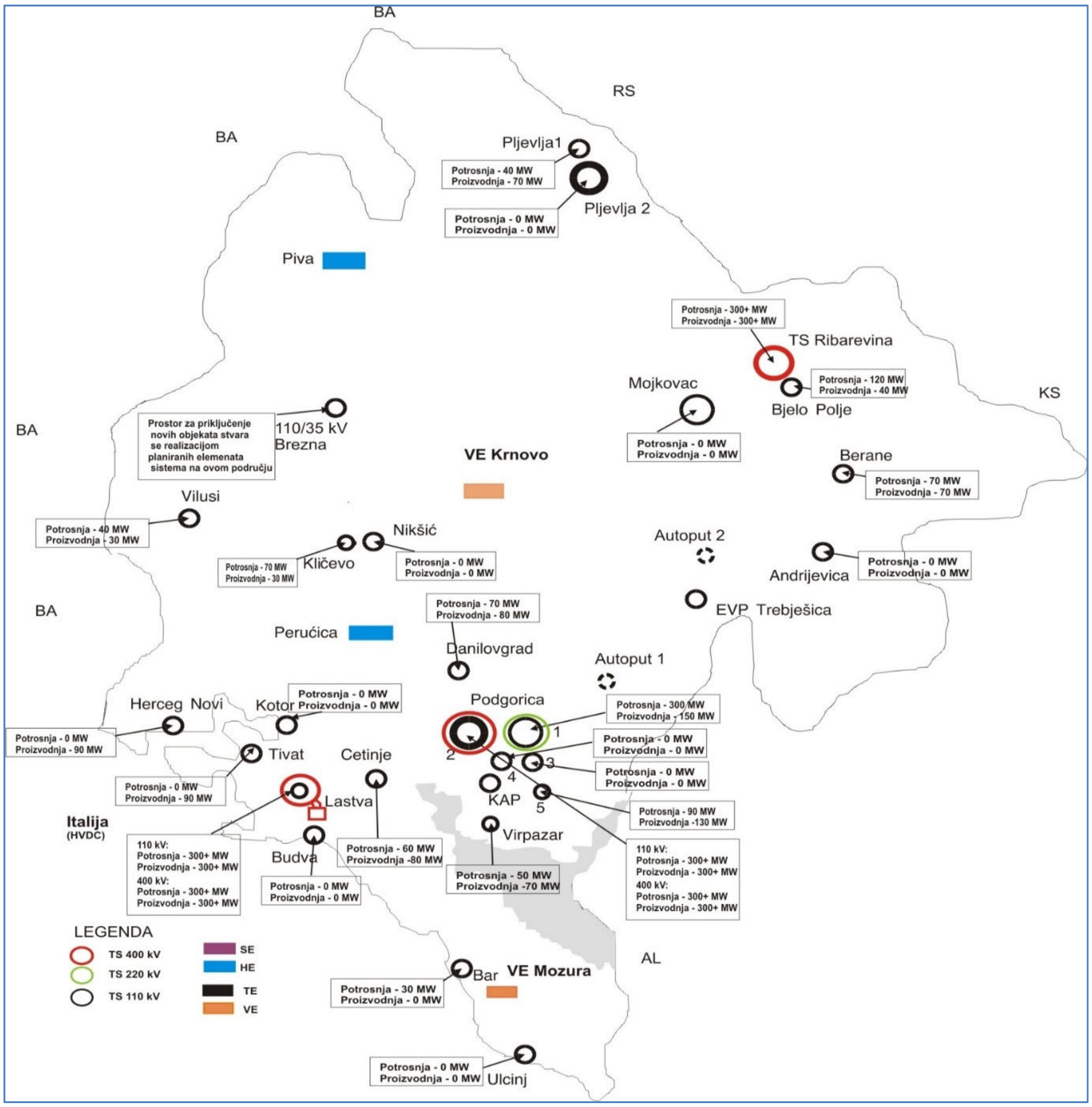


Figure 4-6: Geographical overview of the total available capacity by points in the system free for connection of new users

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2 Values shown the tables are informative and depending on the needs and requests for connection, accurate analyses will be performed for each SS individually.

Table 4-2: Overview of the available connection capacity by points in the CGES system

Point	Direction	MAC 110 kV	MAC 220 kV	MAC 400 kV	Comment
Bar	*Consumption*	**30**			The request for connection of generation in this area is being considered, thus there is no room for an indication of additional generation capacity.
	Generation	**0**			
Budva	*Consumption*	**0**			There are no spare bays and it is not possible to expand the substation.
	Generation	**0**			
Cetinje	*Consumption*	**60**			
	Generation	**80**			
Danilovgrad	*Consumption*	**70**			
	Generation	**80**			
Herceg Novi	*Consumption*	**0**			There is no space to connect new consumption at the moment.
	Generation	**90**			
Tivat	*Consumption*	**0**			There is no space to connect new consumption at the moment.
	Generation	**90**			
Kotor	*Consumption*	**0**			There are no spare bays and it is not possible to expand the substation.
	Generation	**0**			
Ulcinj	*Consumption*	**0**			The node does not meet the N-1 security criterion in the basic case.
	Generation	**0**			
Lastva	*Consumption*	**300+**		**300+**	
	Generation	**300+**		**300+**	
Podgorica 1	*Consumption*	**300+**	**300+**		
	Generation	**150**	**150**		
Podgorica 2	*Consumption*	**300+**		**300+**	
	Generation	**300+**		**300+**	
Podgorica 3	*Consumption*	**0**			There are no spare bays and it is not possible to expand the substation.
	Generation	**0**			
Podgorica 4	*Consumption*	**0**			It is not recommended to connect new lines to this facility.
	Generation	**0**			
Podgorica 5	*Consumption*	**90**			

	Generation	**130**			
Vilusi	*Consumption* *Generation*	**40** **30**			A prerequisite for all new connections is the elimination of the existing T-connection and the construction of 110 kV busbars in the plant.
Nikšić 1	*Consumption* *Generation*	**0** **0**			There is no possibility of further expansion.
Nikšić 2	*Consumption* *Generation*	**70** **30**			Connection space is available but the only remaining 110 kV bay is preliminarily reserved.
Brezna	*Consumption* *Generation*	**0** **0**			The space for connecting new facilities is created by implementing the planned system elements in this area.
Mojkovac	*Consumption* *Generation*	**0** **0**			There are no spare bays and it is not possible to expand the substation.
Andrijevica	*Consumption* *Generation*	**0** **0**			There are no spare bays and it is not possible to expand the substation.
Berane	*Consumption* *Generation*	**70** **70**			
Ribarevine	*Consumption* *Generation*	**120** **140**		**300+** **300+**	
Pljevlja 1	*Consumption* *Generation*	**40** **70**			Values will be available after the ongoing reconstruction and expansion are completed.
Pljevlja 2	*Consumption* *Generation*	**0** **0**		**0** **0**	Spare bays are reserved in order to implement already initiated projects, and currently there is no possibility of additional expansion of the substation.
Virpazar	*Consumption* *Generation*	**50** **70**			

4.5 Overview of electricity transmission infrastructure

This Chapter shows the state of the transmission network of Montenegro, its age, possibility of extension, as well as the future status of certain facilities from the aspect of abandoning some solutions (it primarily refers to facilities the rehabilitation of which is in progress).

For each transmission system element are given its main features, necessary for further analysis.

The current topology of the transmission system (late 2021) is shown in the Figure 4-7.

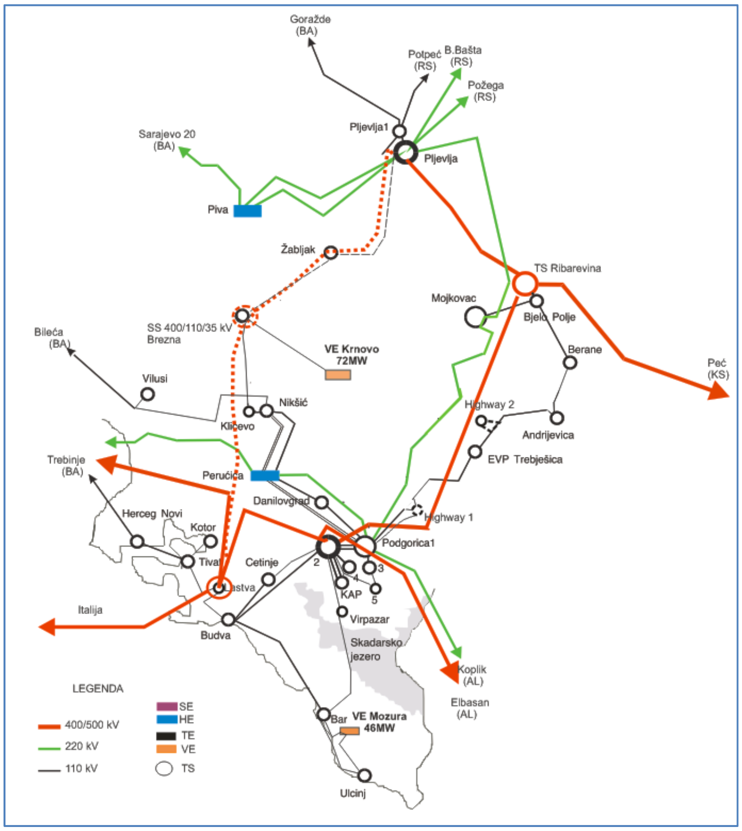


Figure 4-7: Transmission grid of CGES

4.5.1 Overhead lines

Within the transmission system there are overhead lines of voltage level 110, 220 and 400 kV. All overhead lines are made of Al/Fe material, except overhead lines 110 kV Vilusi-Nikšić, Vilusi Bileća and Vilusi-Vilusi KT that are made of material Cu 120 mm2. Most of them are 110 kV overhead lines, which at the same time are the ones with the highest load regardless of time of day or year.

About 50% of total capacities of overhead lines consists of 100 kV overhead lines, of which more than half are overhead line with section Al-Fe150/25 mm2 with capacity of 470A (89MVA). Most of these overhead lines was constructed in the coastal area of Montenegro whereby, due to increased load (particularly in the future) they automatically impose themselves as first candidates for reconstruction (replacement).

Here is important to note that during replacement of overhead line wires, of the same type but higher transmission capacity, it will have to be replaced also towers and complete suspension equipment (as well as equipment in switchgears), which practically means construction of a new overhead line. The advantage of this approach is that the existing routes will be used to the fullest extent. The list of lines is given in the tables below (Table i Table).

Figure 4-8 – Lengths of overhead lines in the transmission network

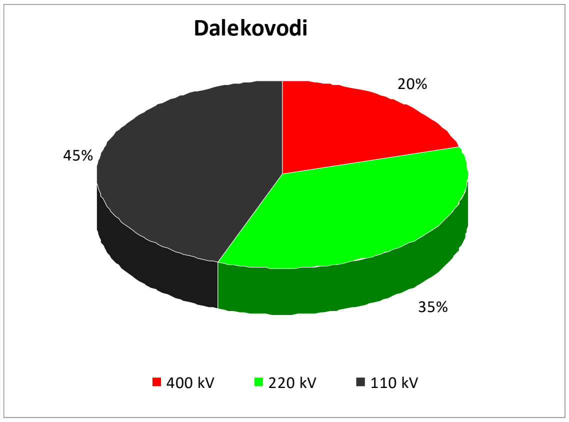


Figure 4-9 – Capacities of overhead lines in the transmission network

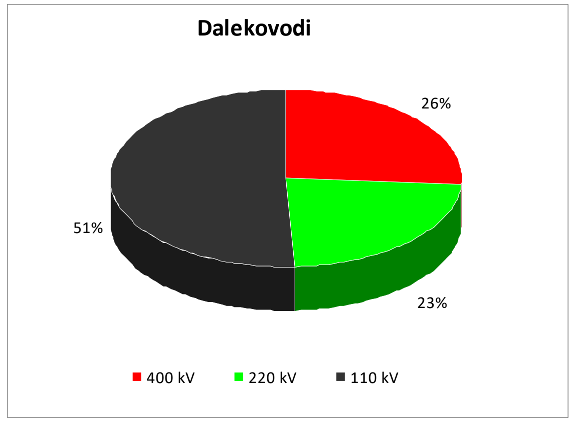


Table 4-3: Data on overhead lines of voltage level 400, 220 and 110 kV of the transmission system of CGES

Voltage level (kV)	No.	OHL	Circuit	Length		material	Cross-section	R1		X1		B1		Sn	In
				in MNE	total			in MNE	total	in MNE	total	in MNE	total		
				(km)			(mm^2/phase)	(ohm/phase)		(ohm/phase)		(μF/phase)		(MVA)	(A)
400	1	Lastva - Trebinje	1	67.0	95	Al-Fe	(2x490/65)-5	1.80516	2.62836	20.9374	30.4854	0.658836	0.959282	1330.2	1920
	2	Lastva - Podgorica 2	1	66.0	66.0	Al-Fe	(2x490/65)-5	2.51958	2.51958	29.2237	29.2237	0.91958	0.91958	1330.2	1920
	2	Ribarevine - Podgorica 2	1	85.1	85.1	Al-Fe	(2x490/65)-5	2.51958	2.51958	29.2237	29.2237	0.91958	0.91958	1330.2	1920
	3	Ribarevine – Pljevlja	1	54.8	54.8	Al-Fe	(2x490/65)-5	1.61112	1.61112	18.6868	18.6868	0.588016	0.588016	1330.2	1920
	4	Ribarevine - Peć 3	1	53.1	65	Al-Fe	(2x490/65)-5	1.56114	1.911	18.1071	43.6821	0.569775	1.374542	1330.2	1920
	5	Podgorica 2 - Tirana 2	1	29.3	156	Al-Fe	(2x490/65)-5	0.8614	4.586	9.991	53.196	0.317578	1.673915	1330.2	1920
220	1	Pljevlja 2 - HE Piva 264	1	40.4	50.1	Al-Fe	490/65	2.8884	2.8884	21.2646	21.2646	0.423244	0.423244	381.1	1000
	2	Pljevlja 2 - HE Piva 265	2	40.0	49.7	Al-Fe	490/65	2.8768	2.8768	21.1792	21.1792	0.421544	0.421544	381.1	1000
	3	Piva - Lukavica (Buk Bijela)	1	11.0	25	Al-Fe	490/65	1.3572	1.45	9.9918	10.675	0.198874	0.212472	381.1	1000
	4	Pljevlja 2 – Požega	1	14.1	92	Al-Fe	360/57	1.128	7.36	6.1476	40.112	0.116692	0.761397	274.4	720
	5	Podgorica 1 - HE Perućica	1	34.1	34.1	Al-Fe	360/57	2.728	2.728	14.8676	14.8676	0.282214	0.282214	274.4	720
	6	HE Perućica – Trebinje	1	42.5	63.2	Al-Fe	360/57	3.4	5.056	18.53	27.5552	0.351732	0.523047	274.4	720
	7	Podgorica 1 – Mojkovac	1	72.3	72.3	Al-Fe	360/57	5.816	5.816	31.6972	31.6972	0.601669	0.601669	274.4	720
	8	Mojkovac - Pljevlja 2	1	81.6	81.6	Al-Fe	360/57	6.48	6.48	35.316	35.316	0.670361	0.670361	274.4	720
	9	B.Bašta - Pljevlja 2	1	15.7	97.2	Al-Fe	360/57	1.256	7.776	6.8452	42.3792	0.129934	0.804433	274.4	720
	10	Podgorica 1 – Koplik	1	21	65.6	Al-Fe	360/57	1.68	3.0224	9.156	16.427	0.172549	0.322785	274.4	720
110	1	Podgorica 1 - HE Perućica	1	32.6	32.6	Al-Fe	240/40	3.9446	3.9446	13.0726	13.0726	0.295742	0.295742	122.9	645
	2	Podgorica 1 - HE Perućica	2	32.6	32.6	Al-Fe	240/40	3.9446	3.9446	13.0726	13.0726	0.295742	0.295742	122.9	645
	3	Podgorica 1 – Danilovgrad	1	17.6	17.6	Al-Fe	150/25	3.3792	3.3792	7.3392	7.3392	0.152381	0.152381	89.5	470
	4	Podgorica 1 - Podgorica 2	1	5.8	5.8	Al-Fe	(2x240/40)-5	0.35148	0.35148	1.8328	1.8328	0.067386	0.067386	245.8	1290
	5	Podgorica 1 - Podgorica 2	2	5.9	5.9	Al-Fe	(2x240/40)-5	0.35754	0.35754	1.8644	1.8644	0.068548	0.068548	245.8	1290
	6	Podgorica 2 - Podgorica 4	1	3.5	3.5	Al-Fe	240/40	0.4235	0.4235	1.4035	1.4035	0.031751	0.031751	122.9	645
	7	Podgorica 1 - Podgorica 3	1	3.9	3.9	Al-Fe	240/40	0.4719	0.4719	1.5639	1.5639	0.03538	0.03538	122.9	645
	8	Podgorica 1 – Trebješica	1	36.1	36.1	Al-Fe	150/25	6.9312	6.9312	15.0537	15.0537	0.312555	0.312555	89.5	470
	9	Podgorica 2 – Virpazar	1	30.0	30.0	Al-Fe	150/25	5.51	5.51	11.967	11.967	0.248485	0.248485	89.5	470
	10	Virpazar- Bar	1	16.4	16.4	Al-Fe	150/25	3.283	3.283	7.13	7.13	0.148052	0.148052	89.5	470
	11	Podgorica 2 - Budva	1	36	36	Al-Fe	150/25	7.296	7.296	15.846	15.846	0.329005	0.329005	89.5	470

Table 4-4 (sequence): Data on overhead lines of voltage level 400, 220 and 110 kV of the transmission system of CGES

Voltage level (kV)	No.	OHL	Circuit	Length		material	Cross-section	R1		X1		B1		Sn	In
				In MNE	total			In MNE	total	In MNE	total	In MNE	total		
				(km)			(mm²/phase)	(ohm/phase)		(ohm/phase)		(µF/phase)		(MVA)	(A)
110	12	Podgorica 2 - Cetinje	1	31.7	31.7	Al-Fe	240/40	3.835	3.835	12.711	12.711	0.287577	0.287577	122.9	645
	13	Bar – Možura	1	17.0	17.0	Al-Fe	150/25	3.2832	3.2832	7.1307	7.1307	0.148127389	0.148127389	89.5	470
	14	Možura - Ulcinj	1	7.1	7.1	Al-Fe	150/25	1.344	1.344	2.919	2.919	0.060636943	0.060636943	89.5	470
	15	Bar - Budva	1	33.4	33.4	Al-Fe	150/25	6.4128	6.4128	13.9278	13.9278	0.289178	0.289178	89.5	470
	16	Budva - Cetinje	1	11.5	11.5	Al-Fe	150/25	2.400	2.400	5.2125	5.2125	0.108225	0.108225	89.5	470
	17	Budva - Lastva	1	6.0	6.0	Al-Fe	150/25	1.1520	1.1520	2.5022	2.5022	0.051970	0.051970	89.5	470
	18	Lastva - Tivat	1	11.9	11.9	Al-Fe	150/25	2.2848	2.2848	4.9622	4.9622	0.103082	0.103080	89.5	470
	19	Tivat - Herceg Novi	1	20.7	20.7	Al-Fe	150/25	3.9744	3.9744	8.6319	8.6319	0.179221	0.179221	89.5	470
	20	Herceg Novi - Trebinje	1	15.6	30.8	Al-Fe	150/25	2.976	5.9136	6.4635	12.8436	0.134199	0.266667	89.5	470
	21	Danilovgrad - HE Perućica	1	17.1	17.1	Al-Fe	150/25	3.2832	3.2832	7.1307	7.1307	0.148052	0.148052	89.5	470
	22	HE Perućica - Nikšić	1	12.8	12.8	Al-Fe	240/40	1.5488	1.5488	5.1328	5.1328	0.116119	0.116119	122.9	645
	23	HE Perućica - Nikšić	2	12.8	12.8	Al-Fe	240/40	1.5488	1.5488	5.1328	5.1328	0.116119	0.116119	122.9	645
	24	HE Perućica - Nikšić	3	13.5	13.5	Al-Fe	240/40	1.6335	1.6335	5.4135	5.4135	0.12247	0.12247	122.9	645
	25	Nikšić - Vilusi KT	1	37.4	37.4	Cu	120	5.797	5.797	16.3064	16.3064	0.333334	0.333334	89.4	470
	26	Vilusi KT - Bileća	1	13.8	17.7	Cu	120	2.139	2.7435	6.0168	7.7172	0.122995	0.157754	89.4	470
	27	Vilusi KT - Vilusi	1	0.5	0.5	Al-Fe	150/25	0.096	0.096	0.2085	0.2085	0.004329	0.004329	89.5	470
	28	Trebješica - Andrijevica	1	30.8	30.8	Al-Fe	150/25	5.913	5.6064	12.844	12.1764	0.26675	0.26675	89.5	470
	29	Andrijevica - Berane	1	17.1	17.1	Al-Fe	150/25	3.436	3.436	7.464	7.464	0.155233	0.155233	89.5	470
	30	Berane - Ribarevine	1	21.1	21.1	Al-Fe	150/25	4.0512	4.0512	8.7987	8.7987	0.182684	0.182684	89.5	470
	31	Ribarevine - Mojkovac	1	14.0	14.0	Al-Fe	150/25	2.688	2.688	5.838	5.838	0.121212	0.121212	89.5	470
	32	Pljevlja 1 - Pljevlja 2	1	2.8	2.8	Al-Fe	240/40	0.3388	0.3388	1.122	1.122	0.024242	0.024242	122.9	645
	33	Pljevlja 1 - Potpeć	1	8.2	28.3	Al-Fe	150/25	1.5744	5.4336	3.4194	11.8011	0.070996	0.245022	89.5	470
	34	Podgorica 2 - KAP	1	8.1	8.1	Al-Fe	(2x240/40)-5	0.49086	0.49086	2.5596	2.5596	0.094108	0.094108	245.8	1290
	35	Podgorica 2 - KAP	2	8	8	Al-Fe	(2x240/40)-5	0.4848	0.4848	2.528	2.528	0.092946	0.092946	245.8	1290
	36	Podgorica 2 – Podgorica 5	1	11.7	11.7	Al-Fe	240/40	1.4399	1.4399	4.7719	4.7719	0.1080247	0.1080247	122.9	645
	37	Kličevo - Nikšić	1	3.7	3.7	A2XS(FL)2Y	3x(1x1000) Al	0.09922	0.09922	0.363	0.363	0.73527	0.73527	141	740
	38	Podgorica 3 - Podgorica 5	1	3.0	3.0	A2XS(FL)2Y	3x(1x1000) Al	0.08954	0.08954	0.33033	0.33033	0.668451	0.668451	141	740
	39	Tivat - Kotor	1	5.9	5.9	Al-Fe	240/40	0.907500	0.907500	3.008060	3.008060	0.043669	0.043669	122.9	470
	40	Brezna – Kličevo	1	32.0	32.0	Al-Fe	240/40	3.533200	3.533200	11.709170	11.709170	0.265171	0.265171	122.9	470

4.5.2 Transformers 400, 220 and 110 kV

The following substations are currently in operation in the EPS of Montenegro:

- one SS 400/220/110 kV (SS Pljevlja 2),
- one SS 400/110 kV (SS Podgorica 2),
- two SSs 400/110/35 kV (SS Ribarevine and SS Lastva),
- two SSs 220/110/35 kV (SS Podgorica 1 and SS Mojkovac),
- fifteen SSs 110/35 kV (SS H. Novi, SS Tivat, SS Budva, SS Bar, SS Ulcinj, SS Virpazar, SS Nikšić, SS Vilusi, SS Danilovgrad, SS Pljevlja 1, SS Cetinje, SS Berane, SS Andrijevica, SS Kotor and SS Brezna),
- four SSs 110/10 kV: SS Kličevo, SS Podgorica 3, SS Podgorica 4 and SS Podgorica 5.

The largest SS is 400/220/110 kV SS Pljevlja 2 (2x400 MVA + 1x125 MVA).

On 400 kV voltage level it is connected with SS Ribarevine, and on 220 kV voltage level with HPP Piva and TPP Pljevlja, and with SS 220/110 kV/35 kV Mojkovac, as well as the electric power system of Serbia (SS Bajina Bašta and SS Požega). SS 110/35 kV Pljevlja 1 is supplied through transformation 220/110 kV.

The next substation with installed power of transformation of 600 MVA (2x300MVA, one of which was replaced in 2021) is SS 400/110 kV Podgorica 2, as a part of the most important supply node in EPS Montenegro.

It is connected to SS Ribarevine, SS Lastva at 400 kV voltage level and to SS Tirana in Albania. Additionally, it is connected to SS 220/110 kV Podgorica 1 as well as to SS 110/35 kV Virpazar and SS 110/35 kV Budva via two 110 kV overhead lines. It supplies SS Podgorica 4, SS Podgorica 5, SS Cetinje and KAP via 110 kV connections.

SS Lastva was commissioned in 2019 with installed capacity of 1x300 MVA and represents an important hub for supplying the coastal part of Montenegro. Over 400 kV voltage level is connected with one connection to SS Podgorica 2 and the other to SS Trebinje (BiH). At 110 kV voltage level it is connected to SS Tivat and SS Budva (110 kV OHL Budva – Tivat was diverted to SS Lastva by input/output principle). With two short 400 kV connections it is connected to the converter plant (TERNA) and further via 500 kV HVDC to Italy (one cable pole of 600 MW capacity).

Distribution consumers in Montenegro are supplied through transformer stations of 110/35 kV and 110/10 kV. Two transformers are installed in the most of switchgears, and very often of different installed capacities.

All transformers are three-winding, where the third winding is a compensation one.

The list of transformers is given in the Table 4-5.

Table 4-5: Data on transformers of the transmission system of CGES

Objekat	Prenosni odnos (kV/kV)	Oznaka	Nominalna snaga (MVA)	Step. regul.(+/-) %	Sprega	Proizvođač	Godina Proizvodnje	Godina Ugradnje	uk 1-2 (%)	uk 1-3 (%)	uk 2-3 (%)	Pfe (kW)	Pcu (kW)	R (Ω)	X (Ω)	In1 (A)	In2 (A)	In3 (A)
Pljevlja 2	400/231/31.5	T1	400	5	YNaOd5	Rade Končar	1982	1991	11.93	13.37	9.72	127.1	594.5	0.59	47.2	577	1000	1833
		T2	400	5	YNaOd5	Rade Končar	1984	1991	11.8	13.27	9.88	131.8	615.5	0.62	47.2	577	1000	1833
Podgorica 2	400/115/31.5	T2	300	17	YNaOd5	CHINT	2020	2021	12.25	14	9.3	129.7	619.1	1.1	65.33	433	1506	1833
		T1	300	17	YNaOd5	CHINT	2015	2016	12.34			71.69	539.29	0.96	65.82	433	1506	1833
Ribarevine	400/115/10.5	T1	150	+10%, -8%	Yy0d5	Siemens	2010	2010	12.22	-	-	49.11	388.5	1.1	130.4	216.5	753.1	2749.3
Lastva	400/115/31.5	T1	300		YNaOd5	CHINT	2017	2017	12.39			71.8	540.4	0.96	65.82	433	1506	1833
Lastva	400/115/31.5	T2	300		YNaOd5	CHINT	2020	2021	12.39			71.8	540.4	0.96	65.82	433	1506	1833
Podgorica 1	220/115/10.5	T1	150	12x1.25	YNaOd5	Končar-Siemens	2012	2012	10.64	11.24	6.36	41	282	0.61		393.6	753	2749.3
	220/115/10.5	T2	150	12x1.25	YNaOd5	Rade Končar	1972	1973	10.22	13.13	8.66	52.46	428.2	0.92	32.9	394	754	2750
Mojkovac	220/115/10.5	T1	150	12x1.25	YNaOd5	Elta	1975	1977	10.53	11.73	7.43	59.4	371.08	0.8	33.97	393.7	753	2749
HE Perucica	220/110/6.3	T1	125	6x2	Yy0d5	SSSR		1981	10.1	15.2	9.55							
Pljevlja 2	220/115/10.5	T1	125	6x2	YNa0d5	SSSR	1979	1984	10.51	19.7	31.6	80.2	295	0.91	40.7	313	595	3333
Podgorica 1	110/36.75/10.5	T4	63	10x1.5	YNynOd5	ETRA	2005	2015	10.44			36	178	0.54	20	330.7	989.7	1154.7
		T5	63	10x1.5	YNynO(d5)	ETRA	2005	2005	10.32	-	-	37.36	179.97	0.55	19.82	330.7	989.7	1154.7
Podgorica 3	110/10.5/10.5	T2	40	10x1.5	YNynOd5	Končar D&ST	2013	2013	11.04			19.32	114.3	0.86	33.39	210	2199.4	428.6
		T1	31.5	12x1.33	YNynOd5	Minel	2001	2001	10.41	5.77	1.6	25.59	165.61	2.13	39.98	166	1732	578
Podgorica 4	110/10.5/10.5	T1	40	10x1.5	YNynOd5	ETRA	2005	2008	10.57	-	-	27.04	113.93	0.86	31.97	209.9	2199.4	742.3
		T2	40	10x1.5	YNynOd5	ETRA	2005	2008	10.6	-	-	27.95	113.66	0.86	32.06	209.9	2199.4	742.3

Objekat	Prenosni odnos (kV/kV)	Oznaka	Nominalna snaga (MVA)	Stop. regul. (+/-) %	Sprega transformat.	Proizvođač	Godina		uk 1-2	uk 1-3	uk 2-3	Pfe	Pcu	R	X	In1	In2	In3
							Proizvodnje	Ugradnje	(%)	(%)	(%)	(kW)	(kW)	(Ω)	(Ω)	(A)	(A)	(A)
Danilovgrad	110/36.75/10.5	T1	20	10x1.5	YNynOd5	Rade Končar	1959	1982	10.63	4.78	1.18	44.2	111	3.36	64.31	105	314.2	333
Nikšić		T2	63	10x1.5	YNynOd5		2009	2009	10.27	-	-	39.01	184.29	0.56	19.72	330.7	989.7	-
		T1	40	10x1.5	YNynOd5	ETRA	2015	2015	10.48			24.58	113.24	0.86	31.71	209.9	628.4	
		T3	63	10x1.5	YNynOd5	Rade Končar	1979	1979	11.03	11.1	6.74	54.9	302.89	0.92	21.14	330.7	989.7	1924.5
		T4	63	10x1.5	YNynOd5	Rade Končar	1979	1979	11.23	12.13	7.64	52.04	314.39	0.96	21.56	330.7	989.7	1924.5
Herceg Novi		T1	40	10x1.5	YNynO(d5)	ETRA	2004	2005	10.14	11.1	9.89	27.38	114.03	0.86	30.67	209.9	628.4	742.3
		T2	40	10x1.5	YNynO(d5)	ETRA	2005	2005	10.12	11,'09	9.89	27.64	114.42	0.86	30.61	209.9	628.4	742.3
Tivat		T1	20	10x1.5	YyOd5	Minel	1981	1981	10.43	-	-	21.27	116.63	3.53	63.1	105	314.2	357.8
		T2	63	10x1.5	YNynOd5	ETRA	2011	2011	10.3	-	-	32.77	190.81	0.58	19.78	330.7	989.7	-
Budva		T1	40	10x1.5	YNynO(d5)	ETRA	2004	2005	10.08	-	-	27.18	114.16	0.86	30.49	209.9	628.4	742.3
		T2	63	10x1.5	YNynOd5	ETRA	2009	2009	10.21	-	-	39.26	184.25	0.56	19.6	330.7	989.7	-
Bar		T1	40	10x1.5	YNynO(d5)	ETRA	2004	2005	10.1	11.1	9.89	26.99	114.1	0.86	30.55	209.9	628.4	742.3
		T2	40	10x1.5	YNynO(d5)	ETRA	2005	2005	10.06	11.09	9.88	26.41	113.93	0.86	30.55	209.9	628.4	742.3
Ulcinj		T1	31.5	10x1.5	YNynO(d5)	Minel	1979	2015	10.43	-	-	27.71	125.76	2.13	39.85	165.3	494.9	333.3
		T2	20	10x1.5	YNynO(d5)	Energoinvest	1986	1986	10.7			21.09	101.25	3.06	64.73	104.9	314	367
Cetinje		T1	20	10x1.5	YNynO(d5)	Elta	1977	1979	10.76	-	-	20.48	99.08	3.01	65.09	84	251.4	170
		T2	31.5	10x1.5	YNynO(d5)	Minel	2001	2001	10.3	-	-	24.96	152.07	1.85	62.31	165	495	577
Pljevlja 1		T1	20	10x1.5	YNynO(d5)	Minel	1981	1987	10.38	-	-	20.19	113.99	3.45	62.79	105	314.2	357.4
		T2	40	10x1.5	YNynO(d5)	ETRA	2004	2005	10.12	-	-	26.9	114.29	0.86	30.61	209.9	628.4	742.3
Ribarevine		T1	20	10x1.5	YNynO(d5)	Elin-Minel	1977/1990	1983	10.95			15.07	141.97	3.1	66.24	105	314	367
		T2	20	10x1.5	YNynO(d5)	Minel	1997	1999	10.43	-	-	19.92	102.83	3.11	63.1	105	314	357.4
Mojkovac		T1	20	10x1.5	YNynO(d5)	Minel	1981/2007	2012	10.4	-	-	20.1	118	3.75	64.37	105	314	357.4
		T3	20	10x1.5	YNynO(d5)	ABB	2015	2015	10.82			14.98	76.04	2.3	65.44	105	314.2	366.6
Berane		T1	20	10x1.5	YNynO(d5)	Rade Končar	1963	1964	10.9	8.9	5.3	43.26	114.33	3.46	65.94	105	314	357.4
		T2	20	10x1.5	YNynO(d5)	Elta-Minel	1964	1964/80	10.58	5.77	1.79	26.08	108.93	3.3	64	105	314.2	366.6
Andrijevica		T1	10	10x1.5	YNynO(d5)	Rade Končar	1961	1988	10.98	4.85	1.18	21.98	63.88	7.73	132.86	52.5	157	275
		T2	20	10x1.5	YNynO(d5)	ETRA	2009	2011	10.58	-	-	12.18	77.06	2.33	64	105	314.2	-
Vilusi		T1	10	12x1.33	YNynO(d5)	Minel	1985	1986	10.62	-	-	11.35	58.69	7.1	128.5	52.5	157	-
Podgorica 5	110/10.5/10.5	T1	31.5	10x1.5	YNynOd5	Energoinv.	1988	88/2010	11.43	-	-	28.03	145.5	1.77	43.9	165	1732	-
	110/10.5/10.5	T2	31.5	10x1.5	YNynOd5	Energoinv.	1988	88//2010	11.5	-	-	28.5	144	1.76	44.17	165	1732	-
Virpazar	110/36.75/10.5	T1	20	10x1.5	YNynOd6	Elta	1977	88/2009	10.93	-	-	19.62	102.8	3.1	66.12	84	251.4	170
	110/36.75/10.5	T2	20	10x1.5	YNynOd7	Elta	1972	88/2009	10.81	-	-	19.72	117.55	3.55	65.4	84.08	251.7	294.5
Kotor	110/36.75/10.5	T1	20	10x1.5	YNynOd8	Rade Končar	1990	2013	11.05			22.1	137.5	4.16	66.85	104.97	314.2	333
	110/36.75/10.5	T2	20	10x1.5	YNynOd9	ABB	2015	2015	10.74			14.96	75.23	2.27	64.96	105	314.2	366.6
Brezna	110/36.75/10.5	T1	20	10x1.5	YNynOd8	Rade Končar	-	2016	11.05			22.1	137.5	4.16	66.85	104.97	314.2	333
Kličevo	110/36.75/10.5	T1	31.5	10x1.5	YNynOd10	ABB	2015	2015		5.77	1.6	25.59	165.61	2.13	39.98	166	1732	578
	110/36.75/10.5	T2	31.5	10x1.5	YNynOd11	ABB	2015	2015		5.77	1.6	25.59	165.61	2.13	39.98	166	1732	578

4.6 Overview of the need for remedial actions on the existing elements during the planning period

4.6.1 Overhead lines

The area of Montenegro is powered through a relatively well-built transmission system network (especially 110 kV lines), but the problem of safe and high-quality power supply of certain parts is significantly pronounced during the summer months. The basic parameter that characterizes the state of the existing transmission system network, especially the part of network through which the Montenegrin coastal area is supplied, is the age of the transmission system facilities, i.e. the equipment installed therein, and therefore obsolescence and depreciation of the same.

Criterion (N-1), when concerning power supply from the transmission system, is not satisfied during the summer season on the Montenegrin coast, because in case of failure of any of 110 kV overhead lines that supply the coastal area, with peak load, there is overloads on other lines, whereby the most pronounced problem of lack of criterion (N-1) refers to the area of Ulcinj and Kotor.

Stresses of the overhead line equipment from overvoltages caused by lightning impulse are very pronounced due to the karst terrain in the central and southern parts of Montenegro due to which, most commonly, insulators are damaged, then somewhat less protective and conductive ropes. These failures do not, however, have a lasting impact on the general state of the overhead line, as they are immediately eliminated by replacing the insulator by connecting it, or by replacing the conductor.

Amount the important reconstructions that should be completed by 2025, the focus is on the reconstructions of the following elements:

- Reconstruction of OHL 110 kV Podgorica 2 – Virpazar,
- Reconstruction of OHL 110 kV Podgorica1 - ETP Trebješica – Andrijevica,
- Reconstruction of OHL 110 kV Bar – Ulcinj,
- Reconstruction of OHL 110 kV Nikšić - Bileća (Vilusi),
- Replacement of HV equipment in transformer stations,
- Reconstruction of busbars in SS Budva[3],
- Reconstruction of OHL 110 kV Bar - Budva.

Reconstructions of OHL 110 kV Podgorica 2-Virpazar, OHL 110 kV Bar-Ulcinj and OHL 110 kV Bar-Budva are extremely critical with regard to supplying the southern part of the Montenegrin coast, so bearing in mind the aforesaid and the fact that during the preparation of the Plan these reconstructions were in progress, it can be concluded that they need to be completed as soon as possible so as not to jeopardise the supply of consumers.

Nikšić - Vilusi - Bileća (part on BiH territory is already in the process of reconstruction and increasing the cross section to 240/40mm2, in Montenegro, one part is being reconstructed to prepare the towers to accept the increased capacity of overhead lines, but still the cross section of conductors is not increased).

[3] Instead of this investment, the candidate investment was the Construction of SS 110/10 kV Bečići - the abandonment of the investment in question will be final after obtaining the consent of ERA for the project Construction of SS 110/10 kV Bečići.

4.6.2 Transformers

As mentioned in the previous chapters, distribution consumers are supplied from 19 substations 110/35kV and four 110/10 kV, with total installed transformation power of 1421.5 MVA. Transformer stations are constructed with two transformer units (for distribution consumers) except for Danilovgrad, Vilusi and Brezna where one transformer unit is installed.

Very intensive development in past years of certain areas of Montenegro, especially of the Montenegrin coast, have caused an increase in peak power consumption, especially in summer, during the tourist season.

In parallel with the replacement of transformers, it was also replaced a part of the HV equipment, protection and control equipment, technical and operational characteristics of which were proved to meet no requirements of safe operation.

Considering the aforementioned, it can be concluded that conditions of the transformer stations are such to meet the needs of electricity consumers.

However, it is necessary to emphasize that for the purpose of reliable and safe power supply of certain areas it is necessary to replace individual existing transformers with higher power units, as follows:

- SS Ulcinj,
- SS Budva, and
- SS Podgorica 4.

Alternatively, depending on the needs and requirements of the users of the transmission system of Montenegro, primarily CEDIS, the construction of new SSs may be required.

At the same time, it should be emphasised that by increasing the transformer power, the short-circuit currents on the low-voltage side of the transformer and the corresponding busbars in the distribution network are also increased, so additional measures should be envisaged in order to protect the equipment on the medium-voltage and low-voltage side of the Montenegrin EPS.

The problem is addressed in detail in the Study **Error! Reference source not found.**.

The following table contains a list of required remedial actions on the existing elements during the planning period:

Table 4-6: Overview of required remedial actions on the existing CGES elements

Required remedial actions on the existing elements, the implementation of which is planned to begin during the first regulatory period, or the implementation of which began before the period to which the Plan refers				
No.	ID No.	Investment title	Commencement year	Completion year
1	IPR009	Reconstruction of OHL 110 kV Lastva - Budva	2013	2024
2	IPR089	Reconstruction of OHL 110 kV Podgorica - Danilovgrad - Perućica	2020	2023
3	IPI018	Reconstruction and extension of SS 110/35kV Pljevlja 1	2019	2023
4	IPR034	Replacement of HV equipment in transformer stations	2016	2023
5	IPR006a	Reconstruction of the protection system	2016	2023

6	IPR098	Reconstruction of OHL 110 kV Bar – Možura - Ulcinj	2023	2024
Required remedial actions on the existing elements, the implementation of which is planned to begin after the first regulatory period				
1	IPRXXX	Reconstruction of OHL 110 kV Podgorica1 – ETP Trebješica – Andrijevica	2026-2032	
2	IPRXXX	Reconstruction of OHL 110 kV Bar – Možura -Ulcinj – increasing throughput	2026-2032	
3	IPRXXX	Reconstruction of OHL V 110 kV Bar – Budva – increasing throughput	2026-2032	
4	IPRXXX	Reconstruction of OHL 110 kV Podgorica 2 - Virpazar – increasing throughput	2026-2032	
5	IPRXXX	Reconstruction of OHL 110 kV Nikšić – Bileća (Vilusi)	2026-2032	

5 Identifying needs

5.1 Consumption forecast

Based on the adopted scenarios of peak load growth in distribution areas from the Updated Development Plan 2020-2029 **Error! Reference source not found.**, as well as on the plan of the forecasted power of KAP and of other large transmission grid consumers (data obtained from the network users), an overview of total forecast growth in peak load for Montenegro according to the analysed years is given in Figure 5-1 and the total growth of electricity consumption in Montenegro, which includes consumers connected to 110 kV, as well as the tourist complexes Porto Montenegro and Luštica, in Figure 5-1.

The consumption forecast by individual SS is shown in **Error! Reference source not found.**[4].

It should be noted here that the total consumption, compared to the forecasts in the previous plans, has been reduced by the expected (and planned) drop in KAP consumption (from 85 MW to 10 MW).

As for the characteristic winter regime maximum, the following can be concluded:

- Annual average growth of 2.46% in the period 2022-2025 due to the entry into operation of substations for powering a highway infrastructure on the Smokovac - Mateševo section;
- In the period 2026-2032, the average annual growth of peak load is 1.5% due to the entry into operation of substations for powering a highway infrastructure on the Bar-Podgorica section, thereby the given growth reflects a consumption growth on key 110/x kV nodes.

As for the characteristic summer regime maximum, the following can be concluded:

- A sudden peak load growth with an annual increase of 2.83% in the period 2023-2025 due to the entry into operation of hotel complexes and substations for powering a highway infrastructure on the Smokovac - Mateševo section;
- In the period 2026-2032, the average annual growth of peak load is 1.54% due to the entry into operation of substations for powering a highway infrastructure on the Bar-Podgorica section. In this case, it is necessary to pay attention to the tourist season that has a considerable impact on the summer peak load.

[4] The consumption forecast by individual SSs is taken from the data provided by CEDIS.

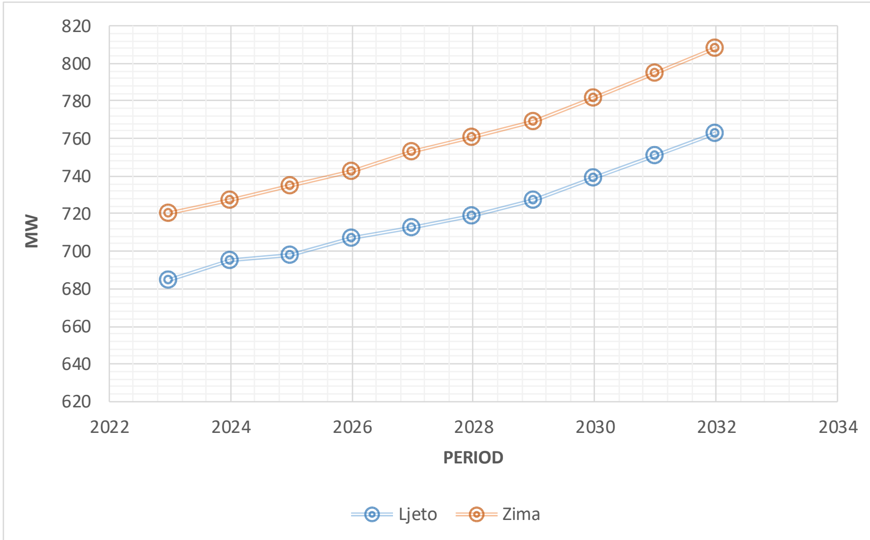
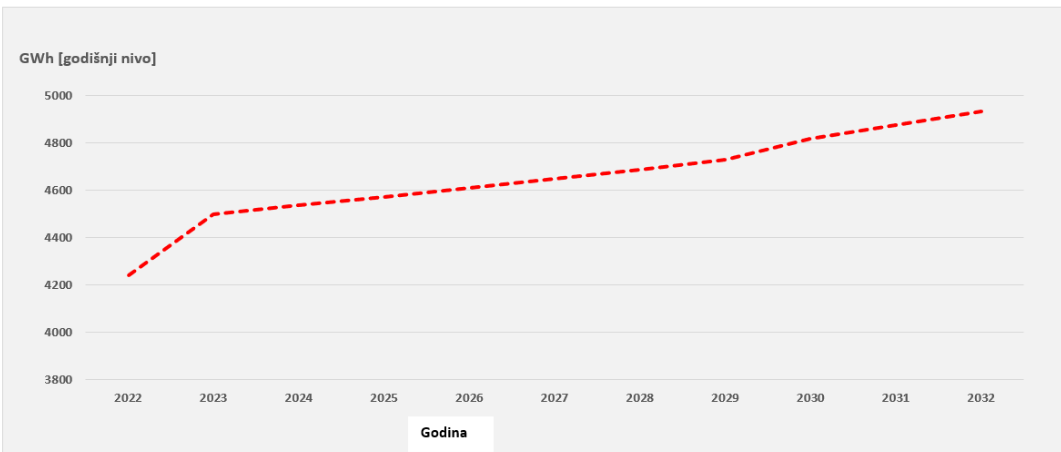


Figure 5-1: Peak power growth in EPS Montenegro 2023 - 2032



period	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
GWh [godišnji nivo]	4238.21	4497.79	4534.43	4571.07	4609.34	4647.62	4686.47	4725.89	4817.5132	4873.8823	4930.2513

Figure 5-2: Net consumption growth in the EPS of Montenegro 2023 – 2032

Table 5-1: Electricity consumption forecast for 110/X kV nodes (CEDIS energy takeover points from the transmission system) and forecasted peak active and reactive loads for the horizon years 2025 and 2032

Elektroenergetski objekat	2023						2025						2032					
	Zima			Ljeto			Zima			Ljeto			Zima			Ljeto		
	W_a (MWh)	P_{max} (MW)	Q (MVar)	W_a (MWh)	P_{max} (MW)	Q (MVar)	W_a (MWh)	P_{max} (MW)	Q (MVar)	W_a (MWh)	P_{max} (MW)	Q (MVar)	W_a (MWh)	P_{max} (MW)	Q (MVar)	W_a (MWh)	P_{max} (MW)	Q (MVar)
TS Andrijevica	18,495.60	7.14	2.08	15,584.80	6.87	2.25	18,059.57	6.60	1.93	15,412.55	6.36	2.25	18,317.20	7.14	2.08	16,192.00	6.87	2.25
TS Bar	101,662.98	50.22	14.65	103,674.09	53.99	15.75	104,117.53	51.43	15.00	106,177.20	55.29	16.13	110,516.32	54.59	15.92	112,702.57	58.69	17.12
TS Berane	48,499.44	26.38	7.69	35,247.81	16.80	4.90	48,888.21	26.59	7.76	35,530.36	16.93	4.94	49,873.83	27.13	7.91	36,246.67	17.27	5.04
TS Brezna	6,983.24	6.53	1.90	6,043.20	5.37	1.57	6,983.24	6.53	1.90	6,043.20	5.37	1.57	6,983.24	6.53	1.90	6,043.20	5.37	1.57
TS Ribarevine	56,093.19	25.18	7.34	49,082.09	16.76	4.89	56,542.84	25.38	7.40	49,475.53	16.89	4.93	57,682.78	25.89	7.55	50,472.99	17.23	5.03
TS Budva	122,313.59	78.84	22.99	149,901.40	80.81	23.57	125,762.34	81.06	23.64	154,128.02	83.09	24.23	134,815.68	86.89	25.34	165,223.33	89.07	25.98
TS Cetinje	47,586.26	23.38	6.82	41,012.23	21.34	6.22	48,769.76	23.96	6.99	42,032.24	21.87	6.38	51,257.51	25.18	7.34	39,992.23	22.98	6.70
TS Danilovgrad	35,465.21	14.75	4.30	33,583.46	17.86	5.21	36,393.30	15.13	4.41	34,462.31	18.33	5.35	38,821.18	16.14	4.71	36,761.36	19.55	5.70
TS Herceg Novi	95,317.52	43.40	12.66	92,483.43	46.14	13.46	97,426.04	44.36	12.94	94,529.26	47.16	13.76	102,903.66	46.85	13.67	99,844.01	49.82	14.53
TS Mojkovac	23,492.28	8.99	2.62	20,590.96	11.59	3.38	23,028.25	8.81	2.57	20,184.23	11.36	3.31	23,492.28	8.99	2.62	20,590.96	11.59	3.38
TS Nikšić	127,483.84	53.13	15.50	84,935.55	39.44	11.50	129,073.34	53.79	15.69	85,994.55	39.93	11.65	132,332.60	55.15	16.09	88,166.02	40.94	11.94
TS Pljevlja 1	78,763.58	38.73	11.30	70,443.74	27.15	7.92	80,722.48	74.28	21.67	72,195.73	27.83	8.12	84,840.14	77.30	22.55	75,878.43	26.48	7.72
TS Podgorica 1	165,439.61	71.40	20.82	145,577.01	56.74	16.55	172,123.37	74.28	21.67	151,458.32	59.03	17.22	190,038.10	82.01	23.92	167,222.23	65.17	19.01
TS Podgorica 3	118,921.07	54.13	15.79	100,080.16	44.52	12.98	122,033.12	55.54	16.20	102,699.16	45.68	13.32	130,174.20	59.25	17.28	109,550.44	48.73	14.21
TS Podgorica 4	148,969.57	68.14	19.88	118,291.43	51.82	15.12	154,380.74	70.62	20.60	122,588.25	53.71	15.66	168,784.29	77.21	22.52	134,025.59	58.72	17.13
TS Podgorica 5	79,762.11	31.21	9.10	59,153.02	22.80	6.65	85,926.45	33.62	9.81	63,724.60	24.56	7.16	92,567.18	36.22	10.56	68,649.49	26.46	7.72
TS Tivat	60,676.04	26.62	7.76	62,972.08	28.34	8.26	62,263.87	40.92	11.94	64,620.00	36.68	10.70	66,417.63	31.37	9.15	68,930.93	31.68	9.24
TS Kotor	52,168.70	21.66	6.32	48,947.68	23.24	6.78	53,533.90	22.22	6.48	50,228.59	23.85	6.96	57,105.26	23.71	6.91	53,579.45	25.44	7.42
TS Kličevo	13,192.66	7.31	2.13	13,406.98	3.04	0.89	13,404.58	7.43	2.17	13,622.35	3.08	0.90	13,949.42	7.73	2.25	14,176.03	40.94	11.94
TS Ulcinj	49,911.18	29.98	8.74	62,225.47	39.70	11.58	51,927.59	31.19	9.10	64,739.38	41.30	12.05	57,332.25	34.44	10.04	71,477.51	45.60	13.30
TS Vilusi	3,321.98	1.74	0.51	3,147.20	1.18	0.34	3,348.53	1.75	0.51	3,172.35	1.19	0.35	3,402.43	1.78	0.52	3,223.41	1.21	0.35
TS Virpazar	23,149.83	14.85	4.33	26,174.54	12.56	3.66	23,334.84	14.97	4.37	26,383.72	12.66	3.69	23,710.44	15.21	4.44	26,808.40	12.86	3.75

5.1.1 Distribution system development needs

Within this Chapter, an analysis of the connection of new SS 110/x kV was performed, for the construction of which a request was sent by CEDIS. The analysis includes the construction of the following plants:

Table 5-2 – New SSs 110/x kV up to 2025[5]

New SSs 110/x kV			
Facility	**Transformer installed capacity (MVA)**	**Transmission ratio TR (kV/kV)**	**Expected commissioning year**
SS 110/10 kV Podgorica 7	2x31.5 MVA	110/10	2025
SS 110/10 kV Bečići[6]	2x40 MVA	110/10	2025
SS 110/35 kV Žabljak	2x20 MVA	110/35	2024
SS 110/35 kV Radovići (Luštica)	2x40 MVA	110/35	2024
110/10 kV Podgorica 6	2x40 MVA	110/10	2025
110/10 kV Podgorica 8	2x31.5 MVA	110/10	2025
110/35 kV Bijela	2x20 MVA	110/35	2025

As can be seen from the Table 5-2, it is estimated as technically feasible to implement the projects of SS Podgorica 7, SS Žabljak and SS Radovići (Luštica) in the next five years (approved by ERA), while for SS Bečići, CEDIS and CGES expressed mutual readiness for the project implementation to start within the regulatory framework.

The construction of other SSs will be planned depending on the consumption growth and its geographical distribution.

As for the period 2026-2032, the list of new transformer stations for which CEDIS has expressed interest and need is given in the following table.

Table 5-3: New SSs 110/x kV 2026-2032

New SSs 110/x kV			
Facility	Installed power of the transformer (MVA)	Transmission ration TR (kV/kV)	Expected year of commissioning
SS 110/10 kV Podgorica 6	2x40 MVA	110/10	2032
SS 110/10 kV Podgorica 8	2x31.5 MVA	110/10	2032
110/10 kV Tuzi	2x20 MVA	110/10	2032

[5] *Request for constructing new SSs as demanded by CEDIS*

[6] *Techno-economic analysis submitted by CEDIS*

SS 110/35 kV (20 kV) kV Golubovci	2x20 MVA	110/35(20)	2032

Of the new transmission system facilities whose implementation was foreseen in the period covered by the Plan, and after the first regulatory period (Table 5-3), ERA only approved the project of construction of SS 110/35 kV Buljarica, while the other facilities from the table were not yet considered in terms of approval of the said authority.

5.2 Generation forecast

The construction of new generation facilities in the EPS Montenegro as well as the reality of their implementation should be observed while considering the following facts:

- large untapped hydropower potential,
- expansion of renewable energy construction in the region,
- implementation of the project of connecting the systems of Montenegro and Italy via submarine DC cable, and thus connecting the electricity markets of Southeast Europe and Italy.

Considering the abovementioned, it is quite realistic to expect a significant number of new generation facilities in Montenegro, especially after the commissioning of DC cable (December 2019). Accordingly, one of the tasks of this document is to give transmission system development direction in terms of generation. The starting point for planning the construction of new transmission capacities is the Energy Development Strategy of Montenegro, and official documents obtained from the competent Ministry of Montenegro in accordance with currently available information on the existing status of each project, as well as the certainty of its construction or concession.

The connection of new power plants is defined according to already developed and adopted studies and analyses, by adopting sustainable solutions, and serve to achieve goals for further development of the power system and cause minimal investment costs.

The following table (Table) shows a list of new generation facilities submitted by relevant institutions in Montenegro (EPCG and MKi).

Table 5-4: List of generation facilities up to 2025

CGES up to 2025			
Large hydropower plants			
Facility	Installed capacity [MW]	Planned annual generation [GWh]	Commissioning year
HPP Perućica - A8 unit	58.5	50	2024
Wind power plants			
Facility	Installed capacity [MW]	Planned annual generation [GWh]	Commissioning year
WPP Brajići	100.8	250	2025
WPP Gvozd	54.6	150	2023
Solar power plants			

Facility	Installed capacity [MW]	Planned annual generation [GWh]	Commissioning year
SPP Briska Gora	I phase 50	90	2023
SPP Velje Brdo	I phase 50	80	2024
SPP Vilusi I	30	45	2024
SPP Slano	39 (50)	(60)	2023
Small hydropower plants			
Facility	Installed capacity [MW]	Planned annual generation [GWh]	Commissioning year (2021-2023)
sHPP Bjelojevićka 1, at Bjelojevićka watercourse, Mojkovac Municipality	0.92	2.32	2023
sHPP Bjelojevićka 2, at Bjelojevićka watercourse, Mojkovac Municipality	2.250	5.59	2023
sHPP Otilovići	3.06	11.5	2024

Table 5-5: List of generation facilities 2026-2032

CGES 2023-2032			
Large hydropower plants			
Facility	Installed capacity [MW]	Planned annual generation [GWh]	Commissioning year
HPP Komarnica	171.9	213	2028
HPP Boka	290		2030
HPP Kruševo	90-120	235	2030
Wind power plants			
Facility	Installed capacity [MW]	Planned annual generation [GWh]	Commissioning year
Solar power plants			
Facility	Installed capacity [MW]	Planned annual generation [GWh]	Commissioning year
SPP Briska Gora	II phase 200	360	2026
SPP Velje Brdo	II phase 100	160	2026
SPP Dragalj/Vilusi II	80-150	140 -	2026
SPP Čevo	100	Not decided	Not decided

Small hydropower plants are modelled according to the principle of equivalent tank, while solar panels have been made equivalent through negative consumption.

The thermal power plants used in the modelling are the following[7]:

Rehabilitation/revitalization of the existing				
Facility	Installed power (MW)			Commissioning year of the rehabilitated unit
TPP Pljevlja G1	2018	2021-2023	2023-2032	
	225	225	225	

The construction of a second block has not been envisaged in the EPCG Plan, so the analyses will take into account only one block is constantly in operation.

5.3 Cross-border projects

This Chapter outlines a brief overview of new projects of transmission system operators of neighbouring countries (including HOPS - Transmission System Operator of Croatia), which may have an impact on changes in power flows in the region and security of the transmission system of Montenegro. Information on these data is taken from the latest version of TYNDP 2020 ENTSO-E, i.e. national development plans.

In February 2020, a call was launched for the third selection procedure, Projects of the Energy Community Interest (PECI) and Projects of Mutual Interest (PMI). Project promoters working on the implementation of energy infrastructure projects in the categories defined by the adopted Regulation 347/2013 Annex I/1-2-3 (electricity transmission, storage, smart grid; gas transmission, storage, LNG/CNG infrastructure; oil transmission and storage) could submit their projects to the Secretariat of the Energy Community by 28 February 2020 at the latest.

The following subchapters provide lists of CGES-led projects, which are on the ENTSO-TYNDP and PECI/PMI lists.

5.3.1.1 Projects on the ENTSO-E TYNDP list

The following projects relating to the CGES activities are on the ENTSO-E project list:

- 400 kV OHL Pljevlja – Bajina Bašta (RS) – Višegrad (BA) – Trans-Balkan Corridor,
- HVDC Montenegro – Italy II pole line (600 MW),
- 400 kV OHL Lastva – Pljevlja.

400 kV OHL Pljevlja - Bajina Bašta (RS) - Višegrad (BA) is included in a large investment project called Trans-Balkan Corridor stretching from central Serbia (SS Kragujevac 2 and SS Kraljevo 3) and western Serbia (SS Obrenovac and SS Bajina Bašta) all the way to SS Višegrad in Bosnia and Herzegovina and SS Lastva (via SS Pljevlja) in Montenegro. The project aims to increase both transmission capacity within the transmission system of Montenegro and transmission capacity at the borders between these countries. This project is closely associated with the Italy-Montenegro and Central Balkan Corridor projects. **The commissioning is planned after 2025.**

The second pole line (600 MW), or the interconnection project of Italy and Montenegro, includes a new HVDC submarine cable between Villanova (Italy) and Lastva (Montenegro) and DC converter stations. The second HVDC module (600 MW) of the Italy-Montenegro interconnection project is strictly correlated with the Trans-Balkan Corridor, thus significantly contributing to the use of transmission capacity between Italy and the countries of Southeast Europe.

[7] *Data obtained from EPCG*

OHL 400 kV Pljevlja - Lastva is in the phase of completion of works.

Table 5-6: ENTSO-E TYNDP project list

Ime projekta	God.ulaska u pogon	Status	Progers investicije	Tip elementa	TS1	TS2	Type of HVDC	Dužina (km)	CAPEX (MEUR)	OPEX (MEUR)
HVDC ME-IT (drugi pol)	2026	izgradnja	odložen	HVDC	Villanova (IT)	Lastva (ME)	Bipolar	445	362	0.7
400kV DV in RS-ME	2026	Izdavanje dozvola	odložen	AC	Bajina Basta (RS)	Pljevlja (ME)	None	100	44.4	0.53
400 kV DV Lastva - Pljevlja	2019	izgradnja	odložen	AC	SS Lastva	SS Pljevlja	None	151	67.5	1.35

5.3.1.2 Projects on the PECI/PMI list

As part of the PECI list, the 400 kV OHL Pljevlja - Bajina Bašta (RS) - Višegrad (BA) was nominated.

5.3.1.3 Review of development plans of neighbouring countries

This Chapter outlines a brief overview of new projects of transmission system operators of neighbouring countries (including HOPS - Transmission System Operator of Croatia), which may have an impact on changes in power flows in the region and security of the transmission system of Montenegro. Information on these data is taken from the latest version of TYNDP 2020 ENTSO-E, i.e. the national development plans.

Albania:

- **SS 400/220 kV Vau Dejes** near the existing 220/110 kV, the commissioning is expected by **2030,**
- **400 kV OHL Rrashbul - Fier**, the commissioning is expected by **2030,**
- **400 kV OHL Arachtos (GR) - Fier (AL)**, the commissioning is expected by **2030.**

Of these three projects, it is certain that the construction of SS 400/220 kV Vau Dejes will have a significant impact on increasing transit through the Montenegrin power system.

Bosnia and Herzegovina:

- **400 kV OHL Bajina Bašta (RS) - Višegrad**, according to the current development plan (Long-term transmission system development plan 2018-2027) dated December 2017, the commissioning of this overhead line is expected in 2023, but according to available data from TYNDP the expected year is shifted to **2024**;
- **400 kV OHL Višegrad - Bistrica (RS) - Pljevlja (ME)**, according to the current development plan (Long-term transmission system development plan 2018-2027) dated December 2017, the commissioning of this overhead line is expected after **2027**.

In addition to the above transmission network facilities that may have an impact on the transmission network of Montenegro, it should be noted that the Indicative Plan for Development of Production Facilities of B&H 2022 - 2031 includes the construction of HPP Dabar with connecting lines, located in Eastern Herzegovina. The power plant will be connected to the 220 kV OHL Trebinje - Mostar, but it will most likely not be completed before 2025. Due to its electrical proximity to the Montenegrin power system, the production of this power plant is expected to affect the flow of power on the border Montenegro - Bosnia and Herzegovina.

Croatia period 2019-2028:

- **400 kV OHL Banja Luka (BA) - Lika**, new 400 kV interconnection between HR and B&H,
- **400 kV OHL Brinje - Lika**, 400 kV overhead line that replaces the section of the existing OHL 220 kV Brinje - Konjsko,
- **OHL 400 kV Lika - Velebit**, 400 kV overhead line that replaces the section of the existing OHL 220 kV Brinje - Konjsko,
- **Cirkovce (SI) - Heviz (HU), Žerjavinec (HR)** (New 400 kV interconnection between HR and SI, and HR and HU),
- **OHL 400 kV Velebit - Konjsko**, 400 kV overhead line that replaces the section of the existing OHL 220 kV Brinje - Konjsko,
- **OHL 400 kV TPP Tuzla (BA) - Đakovo,**
- **OHL 400 kV TPP Tuzla (BA) - Gradačac (BA) - Đakovo,**
- **400 kV OHL Ernestinovo - Sombor (RS)**, new 400 kV interconnection between HR and Serbia, the commissioning is expected in **2035**.

Of the listed projects within the responsibility of HOPS, there is not a single project that can directly affect the Montenegrin power system.

Italy period 2020-2031:

The transmission network of the Italian Transmission System Operator (TERNA) has no significant impact on the CGES transmission system, due to the fact that they are connected by HVDC cable, which can be treated as consumption with regard to the Montenegrin power system. Among the most significant projects, which are planned by the Italian transmission network operator, the following reinforcements stand out:

- **HVDC 500 kV Lastva (ME) - Villanova (IT)**, the second pole of the HVDC cable, whose year of completion has not yet been precisely defined;
- **HVDC 500 kV Sicily (IT) - Tunis**, HVDC 600 MW;
- **400 kV OHL Codrongianos (IT) - Lucciana (Corsica, FR) - Suvereto (IT), currently known as SACOI 3;**
- **HVDC Salgareda (IT) - Divača (SI)**, 1000 MW.

Depending on the electricity deficit/surplus in Western Europe, the increased exchange at the Italy - Western Europe border is expected to affect the load on the ME - IT HVDC cable.

Kosovo:

- **SS 400/220/110 kV Prizren 4,** new SS connected according to input/output to 400 kV OHL Kosovo B - Tirana (AL).

Serbia:

- Interconnecting double **OHL 400 kV Pančevo - Resica (RO)**, the commissioning planned after 2022 (due to works on the Romanian side, it is currently operating under 110 kV voltage);
- Interconnecting double **OHL 400 kV Niš - Sofia 2 (BG)**, the commissioning planned after 2030;
- Interconnecting double **OHL 400 kV Leskovac - Bobov Dol (BG)**, the commissioning planned after 2030;
- **OHL 2x400 kV HPP Đerdap 1 - Portile de Fier (RO)**, after 2030;
- **OHL 400 kV Kragujevac 2 - Kraljevo 3**, with upgrading the voltage level in SS Kraljevo 3 to 400 kV. The commissioning is expected after **2021**;

- Double **OHL 400 kV Obrenovac - Bajina Bašta**, with upgrading the voltage level in SS Bajina Bašta to 400 kV. According to the development plan (Transmission System Development Plan of the Republic of Serbia 2019-2028) dated October 2019, the commissioning is expected in 2025. Besides, according to available data from TYNDP 2018, the expected year is **2025**;
- **OHL 400 kV Bajina Bašta - Višegrad (BA)**, according to the development plan (Transmission System Development Plan of the Republic of Serbia 2019-2028) dated October 2019, the commissioning of this overhead line is expected after 2025. Besides, according to available data from TYNDP 2018, the expected year is **2025**;
- **400 kV OHL Bajina Bašta - Bistrica - Pljevlja (ME)**, according to the development plan (Transmission System Development Plan of the Republic of Serbia 2019-2028) dated October 2019, the commissioning of this overhead line is expected after **2025**.

Among the abovementioned projects within the responsibility of EMS, we should single out the **400 kV OHL Bajina Bašta - Bistrica** (the place where the switchgear will be built) **- Pljevlja (ME)** project which includes a double circuit line from SS Bajina Bašta, where one branch would go to SS Višegrad and the other towards SS Bistrica (RS) and further towards SS Pljevlja.

Namely, as a sequel to this project, EMS took into consideration another project, and that is the 110 kV OHL Tutin - state border (SS Rožaje (ME)).

Each of these projects can potentially lead to an increase in exchanges at HVDC ME - IT, thus their modelling and analysis of power flows in the Montenegrin power system should be taken into account in the calculation of NTCs at the above borders.

6 System analyses

System analyses within the subject Plan were performed according to the recommendations from the Transmission Grid Planning Rules [4], with certain changes in terms of adjusting the needs and capabilities of CGES:

- Dynamic stability analyses were performed for 2025, as the target year for the implementation of the Investment Plan, but also as a year until which the parameters of individual generation facilities can be determined with sufficient accuracy, which are crucial for creating dynamic power system models.
- Analysis of general indicators of electricity supply quality are analyses performed at the operational level by the 25th of the month for the previous month, as well as at the annual level (Article 7 of the Rules on minimum quality requirements of electricity delivery and supply [5]). They have not been specifically processed within the framework of the Plan.

6.1 Analyses for 2021

6.1.1 Analysis of power flows and system elements loads

Within this Chapter, two critical regimes are analysed:

- Maximum transit regime (in order to consider the system load); and
- Minimum load mode (in order to consider voltage-reactive problems).

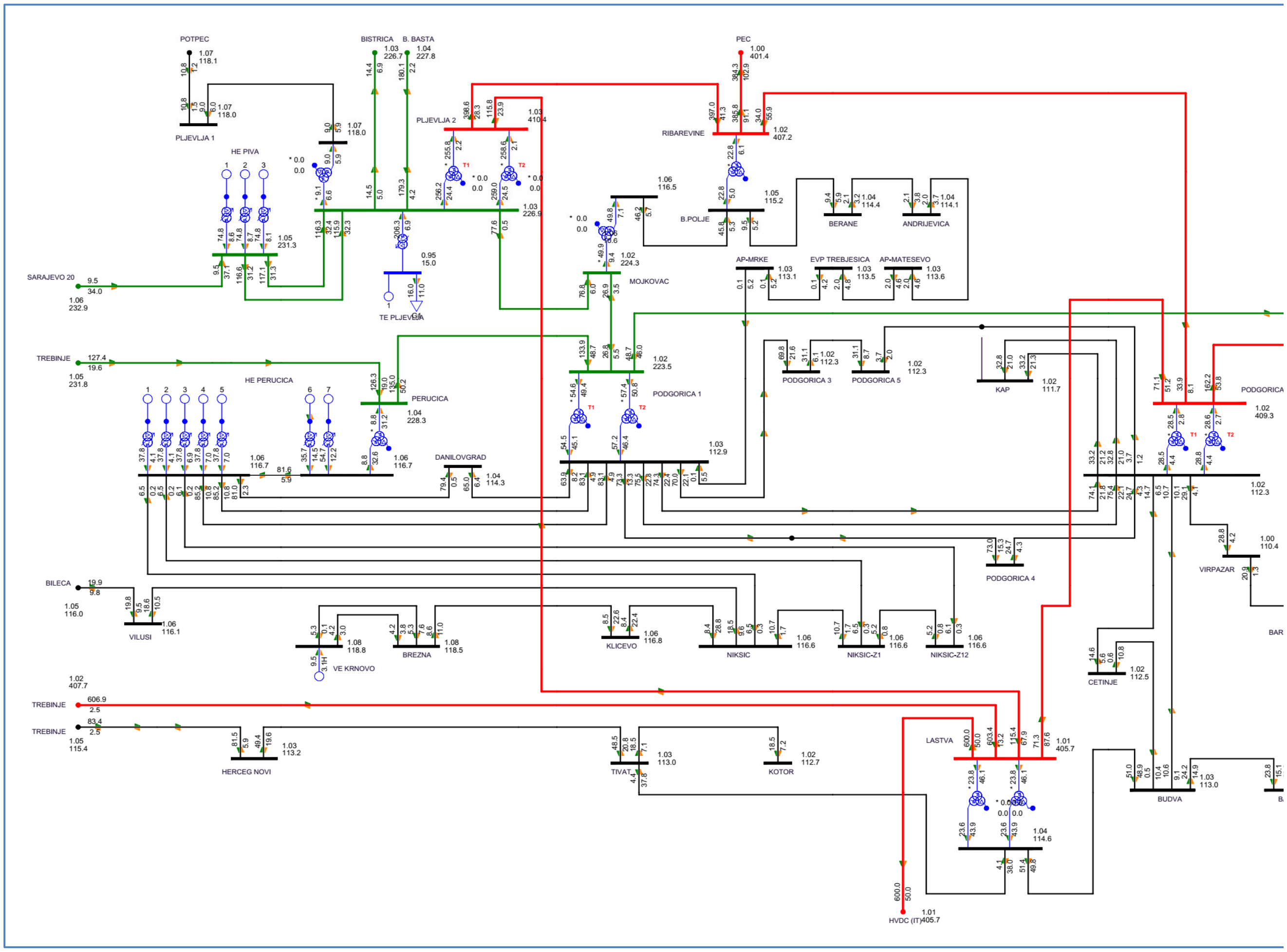


Figure i Figure (Addendum **Error! Reference source not found.**) show power flows at the border of Montenegro, as well as voltage conditions in the Montenegrin power system for the analysed regime

High transits are characterised by the full HVDC capacity and high import from the Albanian system. We note that energy comes from the EPS of Bosnia and Herzegovina as a consequence of strong generation node in Herzegovina (TPP Gacko, HPP Trebinje, HPP Dubrovnik), and import to the Albanian system, with CGES being a significant transit country for electricity. The topological structure of the 400 kV network in that part of the region is practically such that there is a 400 kV connection between Trebinje (BA) and Tirana (AL), over the 400 kV network of Montenegro.

The full topology analysis was performed and the results show that the most loaded element is the 110 kV OHL Budva - Lastva which is loaded with 128% of its thermal limit (470 A, Al/Fe 150/25 mm2).

Due to the high load, the 110 kV OHL Budva - Lastva must be disconnected in normal topology under the regime of energy import from Italy.

6.1.2 Analyses of voltage-reactive conditions

In the period of low loads, higher voltages are observed mainly in the vicinity of generation facilities and in parts of lightly loaded network of 220 and 400 kV voltage level, which results in reactive energy generation and additional voltage increase. The problem is primarily noticed in SS Lastva, when voltages are above the allowed values at 400 kV voltage level (it can be seen from the figure that the voltage value for the minimum load of the transmission network goes up to 439 kV).

Generally speaking about voltage-reactive problems, high voltages are observed in all 400 and 220 kV nodes of the transmission networks of Montenegro and Bosnia and Herzegovina.

6.1.3 Analysis of short-circuit currents

Short-circuit current calculation was made for the winter maximum regime. In the given regime, in the system of Montenegro and the surrounding systems, the largest number of power plants is in operation, which gives the maximum values of the short-circuit current.

The short-circuit current calculations were made in accordance with IEC 60909 international standard, whereby for the calculation of the maximum value of short-circuit current, the coefficient for increasing the voltage by nodes is assumed to be 1.1.

A detailed calculation of short-circuit currents (at all voltage levels in the transmission network, as well as on the low-voltage busbars in the facilities belonging to CGES to which users are connected) was made through a separate study that provided measures for reducing them **Error! Reference source not found.**.

The highest expected values in SS 110 kV Podgorica 1 and Podgorica 2 are:

2021

SS Podgorica 1: I_{3pks} - 24,992 A **I_{1pks} - 28,775 A**

SS Podgorica 2: I_{3pks} - 26,065 A **I_{1pks} - 29,449 A**

6.1.4 Dynamic system stability analysis

The dynamic stability test was performed by analysing transient stability. The transient stability analysis is performed by analysing the angle of the generator rotor for major disturbances.

Frequency stability analyses are performed for systems that are not well-connected, where an outage of some of the links could lead to isolated system operation, thus leading to a significant reduction/increase in frequency below/above the allowable values. Given the good interconnectivity between the Montenegrin system and its neighbours, such analyses did not need to be done in this study.

Dynamic analysis models were created on the basis of models from individual studies ([13], [19], [20] and [21]), then updated according to the proposed CGES development plan by 2025.

Fault simulations were carried out for all major elements of the transmission system, including overhead lines that connect power plants with the rest of the transmission system. The fault time was 100 ms, after which the fault was cleared by switching off the element affected by the fault.

In all cases, the responses showed that the system was stable, or that the system, after disturbance, reached a new stationary state without any additional or cascading outages.

Besides, the calculation of critical clearing time (CCT - Critical Clearing Time) was performed within the transient stability analysis. Analyses of the most critical cases were performed within the simulations needed to determine the critical fault clearance time because the faults observed on the busbars are such that the clearance of faults implies tripping the busbars and all converging branches. The cases of actions of the second degree of distant protection in adjacent nodes were practically simulated.

6.1.4.1 Simulation of faults in the selected tie power lines

This Chapter outlines the results of simulation of faults on selected tie power lines. A fault was simulated on the side of the power plant for 100 ms, after which the fault was cleared by the distant protection or by switching off the overhead line.

Simulations of the following faults are shown for the winter maximum regime:

- short circuit at the initial end of the 220 kV overhead line Pljevlja - Mojkovac and outage of the overhead line;
- short circuit at the initial end of the 220 kV overhead line Piva - Pljevlja (2) and outage of the overhead line;
- short circuit at the initial end of the 110 kV overhead line Perućica - Podgorica 1 (1) and outage of the overhead line.

Simulations of the following faults are shown for the summer maximum regime:

- short circuit at the initial end of the 220 kV overhead line Pljevlja - Mojkovac and outage of the overhead line;
- short circuit at the initial end of the 220 kV overhead line Piva - Sarajevo 20 (B&H) and outage of the overhead line;
- short circuit at the initial end of the 110 kV overhead line Perućica - Danilovgrad and outage of the overhead line.

Generator responses to the observed faults are shown in Figures in the Chapter 11.2.

6.1.4.2 Calculation of critical clearing time

The Critical Clearing Time (CCT), compared to the real critical clearing time, provides a good estimate of the transient stability reserve in the Montenegrin system.

The critical clearing time was determined by simulating the faults causing the node and all incidental branches to fail. Thus, the most critical situations were simulated, where there was no response from distant protection in the first degree (stuck breaker contacts, no response of protective devices, etc.), but the distant protection in adjacent nodes was triggered in the second or third degree switching off the tie lines.

In addition, cases of transient faults in the busbars were examined, i.e. faults where they disappear (e.g. arc suppression) before action of protection.

Calculations were made for the year 2025, for which there were available dynamic models of neighbouring systems.

The calculation results are shown in the following table.

Table 6-1: Critical clearing time (CCT) in non-production nodes

Fault in node	Un [kV]	Description of simulation	Winter maximum CCT [ms]	Summer maximum CCT [ms]	Adopted CCT [ms]
SS Podgorica 2	400	Fault cleared by busbar tripping	550	680	550
		Transient fault	550	680	550
SS Lastva	400	Fault cleared by busbar tripping	550	690	550
		Transient fault	530	680	530
SS Pljevlja	400	Fault cleared by busbar tripping	530	470	470
		Transient fault	520	430	430

SS Ribarevine	400	Fault cleared by busbar tripping	> 1 000	> 1 000	> 1 000
		Transient fault	> 1 000	> 1 000	> 1 000
SS Mojkovac	220	Fault cleared by busbar tripping	> 1 000	> 1 000	> 1 000
		Transient fault	> 1 000	> 1 000	> 1 000
SS Podgorica 1	220	Fault cleared by busbar tripping	> 1 000	> 1 000	> 1 000
		Transient fault	> 1 000	> 1 000	> 1 000
SS Perućica	220	Fault cleared by busbar tripping	> 1 000	> 1 000	> 1 000
		Transient fault	> 1 000	> 1 000	> 1 000
SS Pljevlja	110	Fault cleared by busbar tripping	660	1 000	660
		Transient fault	670	1 000	670

Such faults, along with busbar tripping, were not simulated for the nodes to which power plant units are connected (220 kV busbars in HPP Piva and SS Pljevlja 2, as well as 110 kV busbars in HPP Perućica), because the tripping of the busbars would automatically mean switching off power units from the network.

Accordingly, in order to estimate the transient stability reserve, three-phase short circuits were simulated at the ends of all 400 kV and 220 kV overhead lines (faults in plants on the territory of Montenegro were analysed for the interconnective overhead lines) and 110 kV overhead lines connected to HPP Perućica. The critical clearing time was calculated for both observed regimes, and the lower values were taken as the final value.

The results showed that the lowest values of the critical clearing time were obtained for the faults in the branches converging on the busbars to which the power units are also connected, more precisely for the faults on the power plant side. The most critical values were obtained for the faults in the 220 kV lines converging on the SS Pljevlja 2 for which the critical clearing time was about 240 ms, as well as for the faults in the 110 kV lines converging on HPP Perućica for which the critical clearing time was about 220 ms.

Table 6-2: Critical clearing time (CCT) of overhead lines

Overhead line	Un [kV]	Fault in the mode	Winter max CCT [ms]	Summer max CCT [ms]	**CCT [ms]**
Podgorica 2 - Tirana (AL)	400	Podgorica 2	530	630	**530**
Podgorica 2- Lastva	400	Podgorica 2	520	640	**520**
Lastva - Trebinje (BiH)	400	Podgorica 2	520	640	**520**
Ribarevine - Peć (KS)	400	Ribarevine	> 1000	> 1000	**> 1000**
Pljevlja - Ribarevine	400	Pljevlja	510	440	**440**
		Ribarevine	> 1000	> 1000	**> 1000**
Podgorica 2 - Ribarevine	400	Podgorica 2	520	630	**520**
		Ribarevine	> 1000	> 1000	**> 1000**
Pljevlja - Požega (RS)	220	Pljevlja	250	250	**250**
Podgorica 1 - Koplic (AL)	220	Podgorica 1	> 1000	> 1000	**> 1000**
Piva - Sarajevo 20 (BiH)	220	Piva	330	300	**300**
Perućica - Trebinje (BiH)	220	Perućica	> 1000	> 1000	**> 1000**
Pljevlja - Bajina Bašta (RS)	220	Pljevlja	250	250	**250**
Perućica - Podgorica 1	220	Perućica	> 1000	> 1000	**> 1000**

		Podgorica 1	> 1000	> 1000	**> 1000**
Piva - Pljevlja (1)	220	Piva	360	320	**320**
		Pljevlja	250	250	**250**
Piva - Pljevlja (2)	220	Piva	360	320	**320**
		Pljevlja	240	240	**240**
Mojkovac - Podgorica 1	220	Mojkovac	> 1000	> 1000	**> 1000**
		Podgorica 1	> 1000	> 1000	**> 1000**
Mojkovac - Pljevlja	220	Mojkovac	> 1000	> 1000	**> 1000**
		Pljevlja	240	240	**240**
Pljevlja (1) - Pljevlja (2)	110	Pljevlja (1)	650	> 1000	**650**
Pljevlja (2) - Zamršten (RS)	110	Pljevlja (2)	590	790	**590**
Danilovgrad - Perućica (A)	110	Perućica (A)	220	270	**220**
Perućica (A) - Nikšić (1)	110	Perućica (A)	220	270	**220**
Perućica (A) - Nikšić (2)	110	Perućica (A)	220	270	**220**
Perućica (B) - Nikšić (3)	110	Perućica (B)	220	270	**220**
Perućica (B) - Podgorica 1 (1)	110	Perućica (B)	220	270	**220**
Perućica (B) - Podgorica 1 (2)	110	Perućica (B)	220	275	**220**

6.1.5 Analysis of losses

The analysis of losses was carried out on the basis of data collected during 2021.
The following table shows the losses in 2021.

Table 6-3: Losses in the transmission network of Montenegro during 2021

Energy [MWh] / Year	2020	2021
Energy at the entrance to the transmission system	9.096.499	8.867.258
Generation at the power plant gate	3.123.734	3.480.567
Total losses in the transmission system	163.589	158.412
Total consumption [MWh]	3.075.039	3.219.901
Ratio of losses and total energy [%]	**1.80**	**1.79**

The value of losses depends on several factors, including the large transit going through the Montenegrin transmission system towards the Albanian, and through the submarine cable towards the Italian power system, as well as the specific layout of generation facilities and consumer centres in Montenegro.

Namely, the table shows the energy that enters the transmission system, and starting from 2020, compared to the period before the commissioning of the cable, its increase is over 40%. The rate of losses shows the dependence of the same on the total energy entering and leaving the system, so that we can see a trend of their reduction compared to the period before 2020.

6.1.6. Analysis of transmission capacity and congestions

Individual outages of elements of the transmission system of Montenegro in the modelled regime of maximum transit (including import from Italy via the HVDC cable up to 600MW) lead to overload within the Montenegrin system and thus to the disturbance of the normal operating regime of the EPS of Montenegro.

In the analysis of N-1 security, a large number of overloads of elements over 100% is observed, primarily in the 220 kV network. It should be noted that due to the large overload of 110 kV OHL Budva - Lastva must be disconnected in normal topology.

Analyses of cascading outages and simulations of faults with protection relay activation have revealed the following critical situations from the security of the power system of Montenegro:

Outage of 400 kV OHL **Trebinje (BA) - Lastva**, leads to the overload regime of the entire 220 kV section of Trebinje (BA) - HPP Perućica - Podgorica 1 - Vau Dejes (AL).

Outage of 400 kV OHL **Lastva - Podgorica 2** leads to the overload regime of the entire 220 kV section of Trebinje (BA) - HPP Perućica - Podgorica 1 - Vau Dejes (AL), all 110 kV OHLs between HPP Perućica and Podgorica 1, as well as OHL 110 kV Tivat - Lastva.

Outage of 400 kV OHL **Podgorica 2 - Tirana** (AL), leads to the overload regime of the entire 220 kV section of Trebinje (BA) - HPP Perućica - Podgorica 1 - Vau Dejes (AL). In this case, due to the overload, level II of overload protection is activated on OHL Podgorica 1 - Vau Dejes and its automatic disconnection after 20 seconds occurs. After this disconnection, the system resumes its normal operation.

The interconnection 220 kV OHL Podgorica 1 - Vau Dejes (AL) is overloaded in the event of multiple outages of 400 kV lines in the region (Pljevlja - Ribarevine - Peja - Kosovo B, Tirana - Elbasan, Kragujevac - Obrenovac). In all cases, level I overload protection would activate, dispatchers have 20 minutes to take corrective action to restore the system from a disturbed state to a normal or transient state.

Outage of 220 kV OHL HPP Perućica - Podgorica 1 would result in an overload of a parallel 110 kV section between Perućica and Podgorica 1. Also, the outage of one of two 110 kV OHL HPP Perućica - Podgorica 1 leads to overloading of the 110 kV OHL HPP Perućica - Danilovgrad - Podgorica 1.

Of the projects that stand out in terms of solving the identified problems, it is necessary to point out the following (they are elaborated below):

- Reconstruction of SS Budva (installation of busbar breaker);
- Reconstruction of 110 kV OHL Perućica-Danilovgrad-Podgorica 1.

Table 6-3: Analysis of the N-1 security criterion of transmission system of the EPS of Montenegro

ISPAD ELEMENTA	PREOPTEREĆEN ELEMENT	Termička Granica (MVA)/(A)	Tok po Elementu (MVA)/(A)	Zaštita od preopterećenja (A) I Stepen / II Stepen	Strujno Opterećenje (%)
/	110kV DV Budva - Lastva	89.5 / 470	119.1 / 601.3	450 / 500	128
400kV DV Trebinje (BA) - Lastva	220kV DV HE Perucica - Podgorica 1	274.4 / 720	322.1 / 833.9	720 / 900	115.8
	110kV DV Danilovgrad - HE Perucica	89.5 / 470	99.5 / 495.1	- / -	105.4
	220kV DV HE Perucica - Trebinje (BA)	274.4 / 720	344.2 / 874.2	720 / 940	121.4
	220kV DV Podgorica 1 - Vau Dejes (AL)	274.4 / 720	294.2 / 761.9	720 / 900	105.8
	110kV DV Herceg Novi - Trebinje (BA)	89.5 / 470	101.7 / 527.5	- / -	112.3
400kV DV Lastva - Podgorica 2	220kV DV HE Perucica - Podgorica 1	274.4 / 720	451.3 / 1188.9	720 / 900	165.1
	110kV DV Danilovgrad - HE Perucica	89.5 / 470	129 / 663.3	- / -	141.2
	110kV DV Danilovgrad - Podgorica 1	89.5 / 470	114.2 / 602.2	- / -	128.2
	110kV DV HE Perucica - Podgorica 1	122.9 / 645	143.3 / 737.3	- / -	114.3
	110kV DV Lastva - Tivat	89.5 / 470	109.6 / 544.4	- / -	115.9
	220kV DV HE Perucica - Trebinje (BA)	274.4 / 720	495.5 / 1305.6	720 / 940	181.3
	220kV DV Podgorica 1 - Vau Dejes (AL)	274.4 / 720	348.8 / 934.7	720 / 900	129.8
	110kV DV Bileća (BA) - Nikšić	89.4 / 469	96.2 / 494.1	- / -	105.3
400kV DV Podgorica 2 - Tirana (AL)	220kV DV HE Perucica - Podgorica 1	274.4 / 720	317.2 / 820.9	720 / 900	114
	220kV DV HE Perucica - Trebinje (BA)	274.4 / 720	295.2 / 748.2	720 / 940	103.9
	220kV DV Podgorica 1 - Vau Dejes (AL)	274.4 / 720	471.9 / 1221.3	720 / 900	169.6
400kV DV Pljevlja 2 - Ribarevine	220kV DV Podgorica 1 - Vau Dejes (AL)	274.4 / 720	289.6 / 745.3	720 / 900	103.5
400kV DV Ribarevine - Peć		274.4 / 720	318.7 / 808	720 / 900	112.2
400kV DV Kragujevac - Obrenovac		274.4 / 720	282.3 / 725.2	720 / 900	100.7
400kV DV Peć - Kosovo B		274.4 / 720	284.7 / 723	720 / 900	100.4
400kV DV Tirana (AL) - Elbasan (AL)		274.4 / 720	287 / 735.2	720 / 900	102.1
220kV DV HE Perucica - Podgorica 1	110kV DV Danilovgrad - HE Perucica	89.5 / 470	121.8 / 598.9	- / -	127.5
	110kV DV Danilovgrad - Podgorica 1	89.5 / 470	106.5 / 537.9	- / -	114.5
	110kV DV HE Perucica - Podgorica 1	122.9 / 645	128.9 / 662.5	- / -	102.7
110kV DV HE Perucica - Podgorica 1	110kV DV Danilovgrad - HE Perucica	89.5 / 470	114 / 559.9	- / -	119.2
	110kV DV Danilovgrad - Podgorica 1	89.5 / 470	99.5 / 500.3	- / -	106.5

6.1.7 Analysis of general indicators of quality electricity delivery

In order to encourage transmission system operators to achieve and maintain the level of general and individual indicators of minimum quality of electricity supply, the Agency Board has established Rules on minimum quality of electricity delivery and supply (**Error! Reference source not found.**), which specify minimum quality of electricity delivery and supply, which is based on the following criteria:

- quality of services,
- uninterruptible power supply,
- quality of electricity voltage.

The most important indicator of the quality of transmission system operation is AIT (Average Interruption Time) which provides information on the average duration of power outages for customers, parts of distribution systems and closed distribution systems connected to the transmission system, expressed in minutes per year. In terms of transmission system operation, it is desirable that the values of AIT parameters be as low as possible.

With regard to the number of transient failures of overhead lines, it must be emphasized that the size of this parameter depends on a large number of factors, and that this trend does not necessarily occur due to poor condition of system elements, but may be due to climatic conditions such as thunderbolt near the overhead line in the year in question. Such phenomena, widely recognized as risky for adequate operation of the transmission system, are not sufficiently predictable, which lead to a short-term reduction in the insulation level of equipment, and, consequently, to more favourable conditions for transient failures.

AIT values for 2021 are presented in the following diagram:

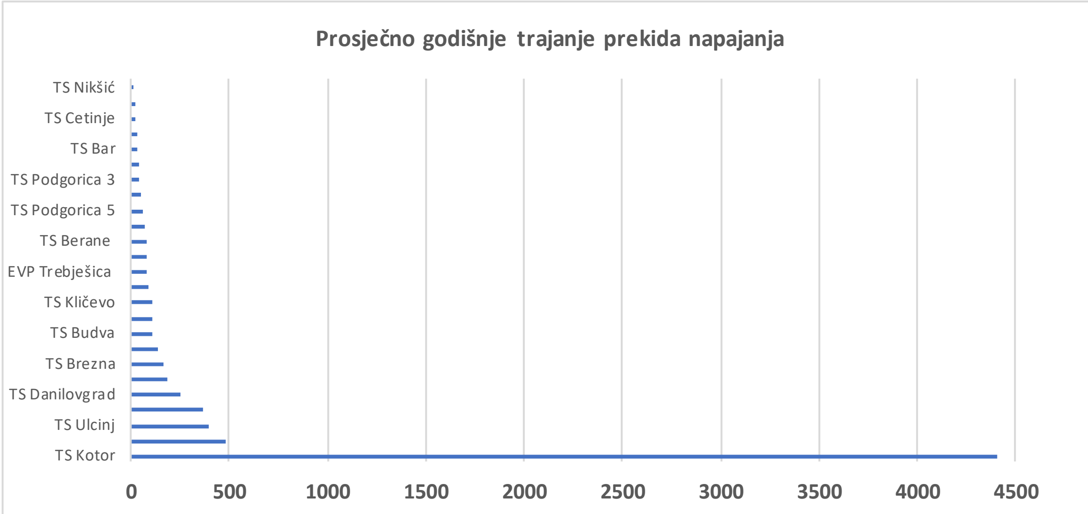


Figure 6-1: Average Interruption Time in 2021

From the diagram it can be seen that SS Kotor had the longest average period of interruption of about 4,400 minutes, which was recorded in April. The shutdown was planned due to urgent works to replace the equipment and lasted for 12 days.

Of the other transformer stations, the longest failure periods were recorded in SS Ulcinj and SS Danilovgrad, which is a consequence of the age of 110 kV power lines and switching equipment of the plant.

No failures that would lead to power outages were recorded in other plants because of good maintenance and timely remedial actions at the plants.

6.1.8 Situation in 2021 - Conclusion:

Generally, having analysed current state of network, regardless of operational regimes, the following problems should be solved:

1. More reliable power supply of the coastal area of Montenegro, in particular Herceg Novi and Ulcinj (connected via single line to the transmission network), which are practically one-sidedly supplied from the system of Montenegro (from the other side Herceg Novi is supplied with power from the system of Bosnia and Herzegovina).
2. During the operation of the HVDC ME-IT cable, problems were noted in the regime when Italy exports to Southeast Europe. The direction of the exchange on the HVDC cable from Italy causes the 110 kV network in the coastal part of Montenegro (on the stretch from Lastva to Budva and Bar) to be extremely loaded, so it is necessary to perform the sectioning of busbars in SS Budva and increase the capacity of the lines from Lastva to Budva and further to Bar and Ulcinj. Therefore, it is necessary to plan the reconstruction of the 110 kV network on the mentioned stretch.
3. Following the shutdown of the Aluminium Smelter Mostar (BiH), poor hydrological situation in the region (it is often the case that few generating units in the region are connected), as well as limited possibilities of the transmission system operators in the region when it comes to reactive energy management led to voltage increase across all transmission networks in the region of interest of CGES operation, especially at the 400 kV voltage level. It is necessary to install a shunt reactor with a 250 MVAr capacity in SS Lastva for greater flexibility and engagement of the device (for fixed shunts, an order is given for switching the device on or off, while the variable shunts set the desired degree depending on need).

4. SS Kotor has one-sided supply from the transmission system (from SS Tivat), so at least one connection has to be provided, in order to meet the N-1 security criterion. Another connection planned and proposed in the Plan is 110 kV OHL Lastva - Kotor, which solves this problem and will be in operation until 2025.
5. Constant suppressing of generation capacity from HPP Perućica towards SS Podgorica 1 through 110 kV overhead lines HPP Perućica - Podgorica 1 (double-circuit on the same towers) and HPP Perućica - Danilovgrad - Podgorica 1 (Al/Fe 470A, cross-section 150/25 mm2), which are loaded with over 50% of its thermal limit in full network topology and availability of all elements of transmission system. This is caused because only a small portion of energy generated in HPP Perućica goes through TR 220/110 HPP Perućica into the 220 kV network. Construction of 110 kV OHL Vilusi - Herceg Novi and reconstruction of 110 kV OHL Perućica - Danilovgrad - Podgorica will solve this overload problem.
6. All 110 kV OHLs in the coastal area of Montenegro are old with conductors 150/25 mm2 and thermal limit of 470 A (89MVA). Since the towers are designed to bear wires of the existing cross-section, it is not possible to replace only the existing wires with the wires of larger cross-section, but the existing towers will have to be replaced as well by towers that can bear wires of larger cross-section. Construction of SS Radovići, increase of the existing line capacities, as well as 110 kV OHL Vilusi - Herceg Novi and Kotor - Tivat, with the already installed in SS Lastva, will completely solve this problem.
7. It is necessary to solve the problem of T-junction in SS Vilusi, including reconstruction of the substation with associated overhead lines (overhead lines Cu 120 mm2 transmission capacity 76MVA) as envisaged through the construction project 110 kV OHL Vilusi - Herceg Novi.
8. The critical point of supply of the coast is SS Budva in which there is no possibility to sectionalize the 110 kV network, nor the possibility, for now, to extend this substation (another busbar system would be necessary, because the plan currently has only one). It is proposed to install a busbar breaker.
9. The analysis of power losses in the selected regimes has shown that the level of losses depends on the transit of electricity, which should be taken in consideration now when HVDC Montenegro-Italy is in operation. All losses resulting from the transit of electricity to other transmission system operators will be recovered by the ENTSO-E ITC mechanism, the member of which is CGES. It is not expected that the total losses in relation to the available energy exceed 1.8-2.1%.
10. Regarding the values of short-circuit currents in the transmission network, they are separately elaborated through the study Analysis of short-circuit currents in the transmission network of Montenegro **Error! Reference source not found.**. Currently, the highest observed values of short-circuit currents are in SS Podgorica 1 (I3pks 25 kA and I1pks 28,8 kA) and SS Podgorica 2 (I3pks 26 kA and I1pks 29,5 kA).

6.2 Analyses for 2025

Analyses for 2025 - market simulation results

This Chapter, inter alia, analyses development of the electricity market from the point of the price zone coupling of certain regions of Europe.

Basic analyses within this study rely on the data from:

- ENTSO database;
- PEMDDB (2020-Expected Progress, 2030-Vision 1);
- Official documents of the transmission and production companies of the countries in the region;
- ERAA 2021.

Growth rates for the realistic scenario for most countries are calculated according to annual consumption in 2021 and forecasted consumption for year 2032. The growth rates so determined were applied to the medium-sized load from 2021 and thus the consumption was determined for years 2025 and 2032.

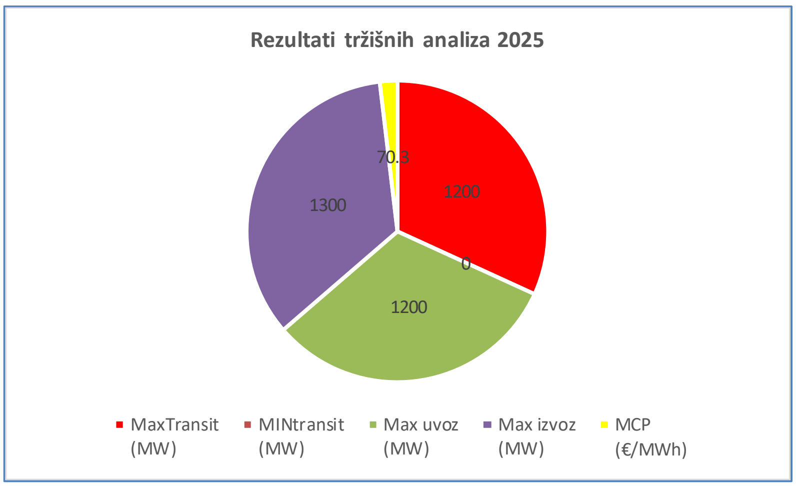


Figure 6-2: Market analyses results for Montenegro in 2025

Figure shows the basic results of market analyses for 2025. The average annual marginal price is around 70 €/MWh, while the maximum expected transit is around 1200 MW/hour (import and export imply energy that entered /left the system). Market results were used to create network models of the Southeast Europe region.

6.2.1 Analysis of power flows and system elements loads

The implementation of the following development projects is underway, the completion and commissioning of which is expected in the next regulatory period (possibly with some delay) and which are considered in the transmission network model for 2025[8]:

- 400 kV OHL Lastva – Pljevlja,
- 110/35 kV OHL Žabljak,
- 110 kV OHL Brezna - Žabljak – Pljevlja,

[8] Approved by the Agency [1], but does not prejudge the year of commissioning.

- SS Buljarica,
- SS Podgorica 7,
- Of the projects nominated by CEDIS, it is estimated as technically feasible to implement the Bečići SS project in the next five years (the first regulatory framework envisages the implementation of SS Podgorica 7, SS Žabljak and SS Buljarica). The construction of other SSs will be planned depending on the increase in consumption and its geographical distribution. SS Bečići was analysed as part of the transmission network development (analysis shown in Addendum 11.4.1).

Based on the input data obtained from the relevant institutions in the coming period, the following generation facilities are expected (analysed in market and network analyses)[9]:

- **WPP Gvozd 54.6 MW** - connection of new 110 kV OHL to the existing SS 110/33 kV Krnovo and SS 110 / 35kV Nikšić.
- **SPP Briska Gora 50 MW** - in Phase I (50MW) is connected via 110 kV OHL, about 12 km long, cross section of 2x240 mm2, to SS Ulcinj**.**
- **SPP Velje Brdo** - Phase I, as mentioned earlier, envisages the connection of 50MW capacity to the transmission network and the analysis was made for the connection to 110 kV OHL Podgorica 1 - Podgorica 2 on the input/output basis**.**
- **SPP Vilusi I 30 MW** - connection to SS Vilusi at 110 kV**.**
- **SPP Slano 50 MW** - connection to 110 kV OHL Nikšić-Vilusi on the input/output basis**.**
- **HPP Perućica G8 58.5 MW** - to the existing facility of HPP Perućica.
- **WPP Brajići 100.8 MW**[10] **-** connection to SS Bečići.

Power flows and voltage profiles in the Montenegrin transmission grid have shown the following:

- In winter maximum regime:
  - 220 kV OHL Pljevlja (ME) - Bajina Bašta (RS), loaded with 97% of its thermal limit;
  - 110 kV OHL Kličevo - Brezna loaded with 91% of its thermal limit (directly resulting from the installed capacities of generation facilities) as a result of utilization of WPP Krnovo and small hydropower plants, whereby the energy from these generation facilities is naturally transferred in the direction of Kličevo or towards the centre of consumption;
  - 110 kV OHL Herceg Novi (ME) - SS Trebinje (BA) loaded with 81% of its thermal limit.
- In summer maximum regime:
  - 220 kV OHL Pljevlja (ME) - Bajina Bašta (RS) loaded with 96% of its thermal limit;
  - 110 kV OHL Kličevo - Brezna loaded with 91% of its thermal limit;
  - 110 kV OHL Herceg Novi (ME) - SS Trebinje (BA) loaded with 85% of its thermal limit.

[9] Except for WPP Gvozd, connection method of which was elaborated in a special Connection Study, the connection methods of new generation facilities are informative and will be treated in special studies, after receiving official connection requests.

[10] It was considered for the year 2025 due to the great uncertainty regarding obtaining location permits in the next 3 years but was analysed for the year 2032 as a more critical case of network load.

6.2.2 Analysis of voltage-reactive conditions

In the period of low loads, as well as for 2021 and 2025 higher voltages are observed mainly in the vicinity of generation facilities and in parts of lightly loaded network of 220 and 400 kV voltage level, which results in reactive energy generation and additional voltage increase. The problem is primarily noticed in SS Lastva, when voltages are above the allowed values at 400 kV voltage level. If a compensator is installed in SS Lastva, it is possible to bring the voltages within the allowed limits, but it also depends on the neighbouring systems and their voltage regulation.

Installation of the shunt reactor is planned after 2025, but the need for its installation has been seen through other analyses and studies [22].

Generally speaking about voltage-reactive problems, high voltages are observed in all 400 and 220 kV nodes of the transmission networks of Montenegro and Bosnia and Herzegovina.

6.2.3 Analysis of short-circuit currents

An increase in the short-circuit current values is obvious in almost all transformer stations. The most vulnerable ones are SS Podgorica 1 and Podgorica 2 with extremely high values in 2025 and 2032 (in 2032 they are at the limits of the value of installed 110 kV switchgear equipment of 31.5 kA, which is located in most 110 kV SSs).

The highest expected values in SS 110 kV Podgorica 1 and Podgorica 2 are:

<u>2025</u>

SS Podgorica 1: I_{3pks} - 27,660 A **I_{1pks} - 30,321 A**

SS Podgorica 2: I_{3pks} - 31,725 A **I_{1pks} - 33,835 A**

6.2.4 Dynamic system stability analysis

The dynamic stability test was performed by analysing transient stability. The transient stability analysis is performed by analysing the angle of the generator rotor for major disturbances.

Frequency stability analyses are performed for systems that are not well-connected, where an outage of some of the links could lead to isolated system operation, thus leading to a significant reduction/increase in frequency below/above the allowable values. Given the good interconnectivity between the Montenegrin system and its neighbours, such analyses did not need to be done in this study.

Likewise, voltage stability is separately tested for systems where voltage may collapse, most often as a result of high power transit. Such analyses have already been done in the Defence Plan (the results of the latest Defence Plan showed that the Montenegrin power system did not face problems of voltage instability and voltage collapse, and that voltage may collapse only due to large imports of the Montenegrin power system which significantly exceeds the current needs of the system and the available transmission capacities on the border overhead lines towards the neighbours **Error! Reference source not found.**).

Dynamic analysis models were created on the basis of models from individual studies ([13], [19], [20] and [21]), then updated according to the proposed CGES development plan by 2025.

The analysis of transient stability was performed in accordance with the requirement of CGES on the operating conditions of the system in disturbed operating regimes from the Transmission Grid Code ([3]).

Three-phase short-circuits (so-called metal short-circuits) were simulated on the busbar side (in the case of lines, short-circuits were simulated on the output/input gantry, and in the case of transformers, short-circuits were simulated on the conductive insulators at the entry to the transformers).

Fault simulations were carried out for all major elements of the transmission system, including overhead lines that connect power plants with the rest of the transmission system. The fault time was 100 ms, after which the fault was cleared by switching off the element affected by the fault.

In all cases, the responses showed that the system was stable, or that the system, after disturbance, reached a new stationary state without any additional or cascading outages.

Besides, the calculation of critical clearing time (CCT - Critical Clearing Time) was performed within the transient stability analysis. Analyses of the most critical cases were performed within the simulations needed to determine the critical fault clearance time because the faults observed on the busbars are such that the clearance of faults implies tripping the busbars and all converging branches. The cases of actions of the second degree of distant protection in adjacent nodes were practically simulated.

6.2.4.1 Simulation of faults in the selected tie power lines

A fault was simulated on the side of the power plant for 100 ms, after which the fault was cleared by the distant protection or by switching off the overhead line.

Simulations of the following faults are shown for the winter maximum regime:

- short circuit at the initial end of the 220 kV overhead line Pljevlja - Mojkovac and outage of the overhead line;
- short circuit at the initial end of the 220 kV overhead line Piva - Pljevlja (2) and outage of the overhead line;
- short circuit at the initial end of the 110 kV overhead line Perućica - Podgorica 1 (1) and outage of the overhead line.

Simulations of the following faults are shown for the summer maximum regime:

- short circuit at the initial end of the 220 kV overhead line Pljevlja - Mojkovac and outage of the overhead line;
- short circuit at the initial end of the 220 kV overhead line Piva - Sarajevo 20 (B&H) and outage of the overhead line;
- short circuit at the initial end of the 110 kV overhead line Perućica - Danilovgrad and outage of the overhead line.

Generator responses to the observed faults are shown in Figures in the Chapter 11.2.

6.2.4.2 Calculation of critical clearing time

The Critical Clearing Time (CCT), compared to the real critical clearing time, provides a good estimate of the transient stability reserve in the Montenegrin system.

The critical clearing time was determined by simulating the faults causing the node and all incidental branches to fail. Thus, the most critical situations were simulated, where there was no response from distant protection in the first degree (stuck breaker contacts, no response of protective devices, etc.), but the distant protection in adjacent nodes was triggered in the second or third degree switching off the tie lines.

In addition, cases of transient faults in the busbars were examined, i.e. faults where they disappear (e.g. arc suppression) before action of protection.

Calculations were made for the year 2025, for which there were available dynamic models of neighbouring systems.

The calculation results are shown in the following table.

Table 6-4: Critical clearing time (CCT) in non-production nodes

Fault in node	Un [kV]	Description of simulation	Winter maximum CCT [ms]	Summer maximum CCT [ms]	Adopted CCT [ms]
SS Podgorica 2	400	Fault cleared by busbar tripping	570	680	570
		Transient fault	560	680	560
SS Lastva	400	Fault cleared by busbar tripping	560	690	560
		Transient fault	540	680	540
SS Pljevlja	400	Fault cleared by busbar tripping	540	480	480
		Transient fault	520	440	440
SS Ribarevine	400	Fault cleared by busbar tripping	> 1 000	> 1 000	> 1 000
		Transient fault	> 1 000	> 1 000	> 1 000
SS Mojkovac	220	Fault cleared by busbar tripping	> 1 000	> 1 000	> 1 000
		Transient fault	> 1 000	> 1 000	> 1 000
SS Podgorica 1	220	Fault cleared by busbar tripping	> 1 000	> 1 000	> 1 000
		Transient fault	> 1 000	> 1 000	> 1 000
SS Perućica	220	Fault cleared by busbar tripping	> 1 000	> 1 000	> 1 000
		Transient fault	> 1 000	> 1 000	> 1 000
SS Pljevlja	110	Fault cleared by busbar tripping	660	1 000	660
		Transient fault	670	1 000	670

Such faults, along with busbar tripping, were not simulated for the nodes to which power plant units are connected (220 kV busbars in HPP Piva and SS Pljevlja 2, as well as 110 kV busbars in HPP Perućica), because the tripping of the busbars would automatically mean switching off power units from the network.

Accordingly, in order to estimate the transient stability reserve, three-phase short circuits were simulated at the ends of all 400 kV and 220 kV overhead lines (faults in plants on the territory of Montenegro were analysed for the interconnective overhead lines) and 110 kV overhead lines connected to HPP Perućica. The critical clearing time was calculated for both observed regimes, and the lower values were taken as the final value (**Error! Reference source not found.**).

The results showed that the lowest values of the critical clearing time were obtained for the faults in the branches converging on the busbars to which the power units are also connected, more precisely for the faults on the power plant side. The most critical values were obtained for the faults in the 220 kV lines converging on the SS Pljevlja 2 for which the critical clearing time was about 250 ms, as well as for the faults in the 110 kV lines converging on HPP Perućica for which the critical clearing time was about 220 ms.

Table 6-5: Critical clearing time (CCT) of overhead line

Overhead line	Un [kV]	Fault in the node	Winter max CCT [ms]	Summer max CCT [ms]	**CCT [ms]**
Podgorica 2 - Tirana (AL)	400	Podgorica 2	535	635	**535**
Podgorica 2- Lastva	400	Podgorica 2	525	645	**525**

Lastva - Trebinje (BiH)	400	Podgorica 2	525	645	**525**
Ribarevine - Peć (KS)	400	Ribarevine	> 1000	> 1000	**> 1000**
Pljevlja - Ribarevine	400	Pljevlja	515	440	**440**
		Ribarevine	> 1000	> 1000	**> 1000**
Podgorica 2 - Ribarevine	400	Podgorica 2	525	635	**525**
		Ribarevine	> 1000	> 1000	**> 1000**
Pljevlja - Požega (RS)	220	Pljevlja	250	250	**250**
Podgorica 1 - Koplic (AL)	220	Podgorica 1	> 1000	> 1000	**> 1000**
Piva - Sarajevo 20 (BiH)	220	Piva	330	305	**305**
Perućica - Trebinje (BiH)	220	Perućica	> 1000	> 1000	**> 1000**
Pljevlja - Bajina Bašta (RS)	220	Pljevlja	250	250	**250**
Perućica - Podgorica 1	220	Perućica	> 1000	> 1000	**> 1000**
		Podgorica 1	> 1000	> 1000	**> 1000**
Piva - Pljevlja (1)	220	Piva	360	320	**320**
		Pljevlja	250	250	**250**
Piva - Pljevlja (2)	220	Piva	360	325	**325**
		Pljevlja	250	250	**250**
Mojkovac - Podgorica 1	220	Mojkovac	> 1000	> 1000	**> 1000**
		Podgorica 1	> 1000	> 1000	**> 1000**
Mojkovac - Pljevlja	220	Mojkovac	> 1000	> 1000	**> 1000**
		Pljevlja	250	250	**250**
Pljevlja (1) - Pljevlja (2)	110	Pljevlja (1)	660	> 1 000	**660**
Pljevlja (2) - Zamršten (RS)	110	Pljevlja (2)	600	795	**600**
Danilovgrad - Perućica (A)	110	Perućica (A)	220	275	**220**
Perućica (A) - Nikšić (1)	110	Perućica (A)	220	275	**220**
Perućica (A) - Nikšić (2)	110	Perućica (A)	220	275	**220**
Perućica (B) - Nikšić (3)	110	Perućica (B)	220	275	**220**
Perućica (B) - Podgorica 1 (1)	110	Perućica (B)	220	275	**220**
Perućica (B) - Podgorica 1 (2)	110	Perućica (B)	220	275	**220**

6.2.5 Analysis of losses

The analysis of losses was elaborated through the analysis and comparison of losses in 2025 in the analysed regimes (winter and summer maximum), compared to calculated losses in 2018. Consumption compared to 2018 has increased by the consumption of tourist complexes.

The following table shows the losses in 2025.

Table 6-6: Ratio between the power of losses and consumption for the characteristic hours in 2025[11]

Summer 2025				Winter 2025			
Generation	Consumption	Losses*		Generation	Consumption	Losses*	
MW	MW	MW	%	MW	MW	MW	%
606	610	16.43	2.69	769	702	22.1	3.14

*** including also the HVDC (as consumption of 6000 MW), the capacity of consumption is 1370 MW in summer and 1402 MW in winter, so losses amount to 1,5% in summer and 2% in winter**

Total losses in the EPS of Montenegro amount to about 22.1 MW for the winter and 16.43 MW for the summer regime, which amounts to 3.14% and 2.7%, respectively, in relation to the total consumption of Montenegro.

Making comparison with losses from 2021, they are expected to increase in percentages of total load as well as in absolute value, which is mainly the result of the expected increase of electricity transit.

The losses caused by the increase in transit will be compensated through the ITC mechanism within the ENTSO-E calculation of costs for loss coverage (ENTSO-E Inter TSOs Compensation Mechanism) so that the level of losses caused by internal transits will remain at approximately same level, while the construction of new elements of the transmission system and new generation capacities could reduce them.

Loss calculation based on 8,760 hour models for 2025 has shown that losses are at the level of 2017 and amount to 150,541.7 MWh[12].

6.2.6 Transmission power and congestion analysis

With regard to the import of electricity from the direction of Italy, 110 kV overhead lines from Budva are critically loaded because SS Lastva at the 400 kV voltage level behaves as a 600 MW power generator (or less, depending on the exchange programme on the cable) and directly pushes energy to the 100 kV grid, thereby loading the direction to SS Budva and further to the maximum limit (this topic is separately elaborated through the 2020 CGES Defence Plan).

As a solution to the identified problems, the following reconstructions, operational measures and construction of transmission elements are proposed (Table):

Table 6-7: Analysis of reinforcements and elimination of identified uncertainties in the transmission network of Montenegro

2025				
Element outage/network problem	Overloaded element	Load [%]	Load relief measure	Development measure
Import from Italy on 600 MW HVDC (Base case)	110 kV OHL Budva - Bečići - Buljarica	237	Busbar sectioning in SS Budva	Reconstruction of 110 kV OHL Budva - Bečići - Buljarica - Bar - Ulcinj
Outage of 110 OHL kV Perućica - Podgorica	110 kV OHL Perućica-Danilovgrad	110	Busbar sectioning in HPP Perućica	Reconstruction of 110 kV OHL Podgorica - Danilovgrad - HPP Perućica

11 The costs of losses incurred by cross-border transits are reimbursed from the ITC mechanism.

12 Including losses on 110/x kV transformers .

				Construction of SS 400/110 kV Brezna
110 kV OHL Bar-WPP Možura	**Consumption outage in SS Ulcinj and WPP Krnovo/SPP Briska Gora**	**-**	**-**	**Construction of another 110 kV link from SPP Briska Gora (SS Ulcinj) to SS Virpazar**
110 kV OHL Kotor-Tivat	**Outage of part of consumption in SS Kotor**	**-**	**-**	**Construction of 110 kV OHL Lastva - Kotor**
400 kV OHL Trebinje (BA) - Lastva (ME)	**Voltages over 420 kV**	**-**	**-**	**Installation of a shunt reactor 250 MVAr in SS Lastva**
400 kV OHL Trebinje (BA) - Lastva (ME)	**Herceg Novi (ME) - Trebinje (BA) Herceg Novi - Tivat**	**130**	**Change of grid switching state in the area of H. Novi**	**Reconstruction of 110 kV OHL Lastva - Tivat Construction of 110 kV OHL Lastva-Kotor**
High grid voltages in the Lastva region	**Voltages over 420 kV**	**-**	**-**	**Installation of a 250 MVAr shunt reactor in SS Lastva**

6.2.7 Analysis of general indicators of quality electricity delivery

In order to improve the quality electricity delivery and supply, which is based on the Rules (**Error! Reference source not found.**), in the regulatory period until 2025 CGES will begin a series of activities to build new and reconstruct old elements of the transmission network that will provide a high degree of reliability of certain elements of the transmission system, and above all:

- Reconstruction of 110 kV OHL Podgorica – Danilovgrad - Perućica,
- Reconstruction of 110 kV OHL Lastva - Budva,
- Reconstruction of part of 110 kV OHL Nikšić – Bileća (Vilusi),
- Revitalization of 110 kV OHL Bar – Možura – Ulcinj,
- Construction of 110 kV OHL Lastva – Kotor.

Taking into account the previously mentioned reinforcements and reconstructions, a significant reduction in the number of outages and unavailability of certain elements of the transmission network is expected, primarily:

- SS Kotor,
- SS Budva,
- SS Ulcinj,
- SS Bar,
- SS Vilusi, and
- SS Danilovgrad.

With regard to other facilities of the high-voltage network, the reduction of undelivered electricity can be expected after the implementation of a number of measures, in terms of reinforcement and reconstruction of the transmission network in the period after 2025.

For 2025, the expected values of AIT (taking into account the experiences with existing SSs that are either bidirectionally supplied or reconstructed) are presented in the following diagram:

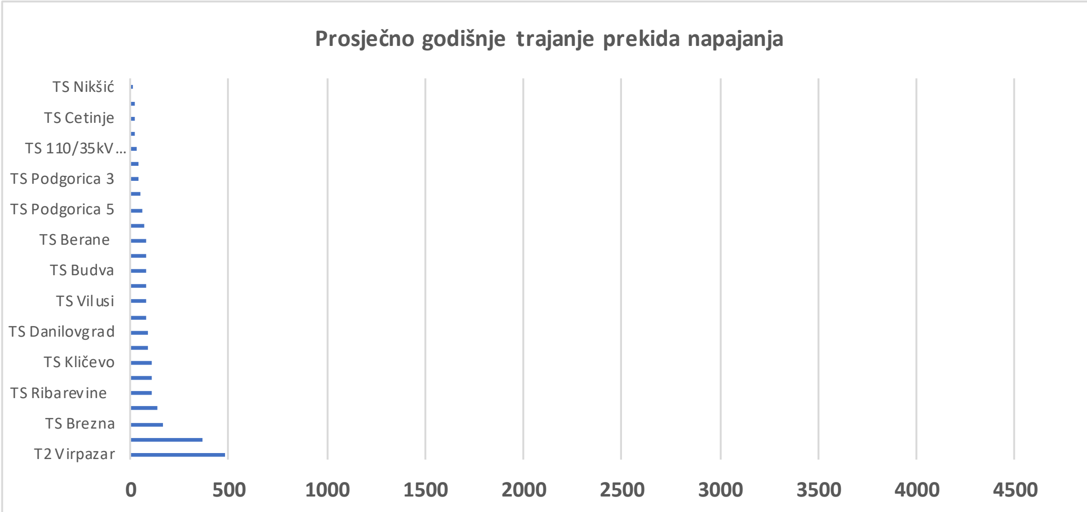


Figure 6-3: Average Interruption Time in 2025

It is very important to emphasise that the size of the reliability parameters of individual elements depends also on other impacts, primarily climatic conditions, such as thunderstorms, high/low temperatures that are risky for adequate operation of the transmission system and not sufficiently predictable leading to short-term reduction of the insulation level of equipment and more favourable conditions for the occurrence of transient failures.

6.3 Analyses for 2032

Market simulation results - 2032

Figure 6-4: Market analyses results for Montenegro in 2032

shows the basic results of market analyses for 2025. The average annual marginal price on the Montenegrin market is around 100.3 €/MWh, while the maximum expected transit is around 1500 MW/hour (import and export imply energy that entered /left the system). Market results were used to create network models of the Southeast Europe region.

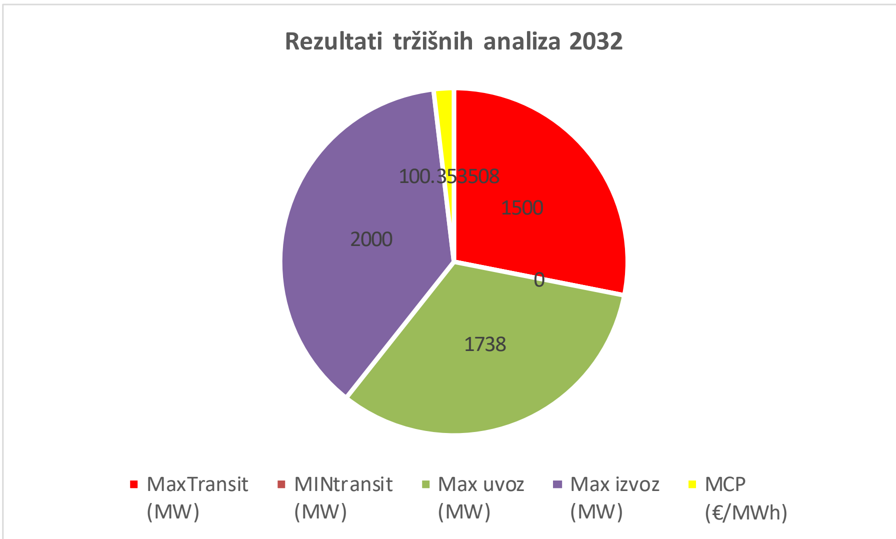


Figure 6-4: Market analyses results for Montenegro in 2032

By analysing commercial exchanges along the borders of Montenegro, it can be concluded as follows:

- ✓ Bosnia and Herzegovina: the dominant direction of trade from B&H to Montenegro, which is largely due to the export of B&H towards the cable and the Italian market, and to a lesser extent from own import needs of Montenegro, due to the cable capacity increase compared to 2025, the imports from Bosnia and Herzegovina increased by almost 0.5 TWh.
- ✓ Serbia: the dominant direction of exchange is towards Montenegro.
- ✓ Kosovo: the dominant direction of exchange is towards Montenegro which, as in the case of B&H, originates from exports through Montenegro to Italy, and to a lesser extent due to own needs of Montenegro. Despite the change in cable capacity, the expected export is at a similar level as in 2025.
- ✓ Italy: the dominant direction of exchange is towards Italy, caused by import needs and higher prices in Italy compared to the region of Southeast Europe. The increase in exports through cable increases by about 28%, i.e. 2,5 TWh compared to 2025. This is enabled by higher imports from the B&H price zone, lower exports to Albania, but also surpluses in the generation in Montenegro in relation to domestic needs.
- ✓ Albania: the dominant direction of exchange is still from Montenegro to Albania, as a result of the export transit to Greece and Albania, however, this export is reduced by about 360 GWh, as most of electricity due to higher prices goes to Italy.

6.3.1 Analysis of power flows and system elements loads

Based on the input data obtained from the relevant institutions, the following generation facilities are expected in the coming period (analysed in market and network analyses):

- **SPP Briska Gora phase II 200 MW** - connection by construction of a new 110 kV OHL, with a capacity of 245 MVA, to SS Virpazar, including the reconstruction of the existing 110 kV OHL Virpazar - Podgorica 2 to 245 MVA.
- **SPP Velje Brdo phase II 100 MW** - connected to the transmission network by input/output system on 110 kV OHL Podgorica 1 - Podgorica 2.
- **SPP Dragalj/Vilusi II 80-150 MW** - connection to SS Vilusi on 110 kV.
- **SPP Čevo 100 MW** - connection on the input/output basis on 400 kV OHL Trebinje - Podgorica.
- **WPP Brajići 100.8MW**[13] - connection to SS Bečići.
- **HPP Komarnica 171. MW** - connection to SS Brezna 400/110 kV.
- **HPP Boka 290 MW** - connection to 400 kV OHL Trebinje - Lastva[14].
- **HPP Kruševo 120 MW** - connection to 400 kV OHL Sarajevo 20 (BA) - Brezna[15].

As for distribution transmission facilities, the following SSs were modelled:

- **110/35 kV Kolašin (Drijenak)** - commissioning of 110 kV OHL Mojkovac - Kolašin (now operating under 35 kV voltage) under 110 kV voltage.
- **110/10 kV SS Igalo** - connected on the input/output basis to 110 kV OHL Herceg Novi - Trebinje (BA).
- **110/35 kV Podgorica 6** - cutting the cable Podgorica 1 - Podgorica 4 and diversion to Podgorica 6.
- **110/35 kV Podgorica 8** - on the input/output basis to 110 kV OHL Podgorica 1 - Podgorica 3.
- **110/35 kV SS Bijela** - connected on the input/output basis to 110 kV OHL Herceg Novi - Tivat.
- **110/10 kV Tuzi** - connection to SS Podgorica 1, then another line to SS Podgorica 5.

6.3.2 Analysis of voltage-reactive conditions

In the period of low loads, as well as for 2025, higher voltages are noted mainly in the vicinity of generation facilities and parts of the lightly loaded network of 220 and 400 kV voltage levels, which results in reactive energy generation and additional voltage increase. The problem is primarily noted in SS Lastva when voltages are above the allowed values at the 400 kV voltage level. If a compensator is installed in SS Lastva, it is possible to bring the voltages within the allowed limits, but it also depends on the neighbouring systems and their voltage control.

Generally speaking about voltage-reactive problems, high voltages are noted in all 400 and 220 kV hubs of the transmission network of Montenegro and Bosnia and Herzegovina.

6.3.3 Analysis of short-circuit currents

As for the previous two timeframes, the highest expected values in SS 110 kV Podgorica 1 and Podgorica 2 amount to:

13 It was not taken into account in 2025 due to the great uncertainty regarding obtaining location permits in the next 3 years.

14 Due to the large capacity of the power plant, and the insufficient capacity of the transmission network, the power plant was connected to cause as few as possible problems in the system. It will be elaborated through the Connection Study, if an application for connection is submitted.

15 If a decision on a new ME-BA interconnection is made.

2032

SS Podgorica 1: I_{3pks} - 31,331 A **I_{1pks} - 35,914 A**

SS Podgorica 2: I_{3pks} - 32,244 A **I_{1pks} - 36,045 A**

Therefore, it is recommended to propose in one of the detailed analyses a solution that will limit the values of short-circuit currents throughout the transmission network.

The following solutions may be proposed:

- network sectioning at the 110 kV voltage level,
- installation of low ohm resistance in order to reduce short-circuit currents,
- replacement of equipment where feasible and profitable,
- estimation of the probability of failures occurring at the moment of utilization of all (or a large number) generation units in Montenegro and the surrounding area.

When building new 110/x kV substations, it is necessary to install transformers with significantly higher short-circuit voltage in order to limit short-circuit currents at the distribution voltage level[16].

Detailed values of short-circuit currents are shown in the Addendum **Error! Reference source not found.**.

6.3.4 Dynamic system stability analysis

Having in mind that there are currently no reliable models of Southeast European systems for dynamic analysis (SECi dynamic models for 2030 are under development at the time of drafting this Plan), this Chapter provides only a qualitative overview of the expected parameters of transient stability.

Having in mind that new interconnections to Bosnia and Herzegovina and Serbia are expected to be put into operation in the period from 2025 to 2032, it is realistic to expect that the values of dynamic indicators of stability of the Montenegrin power system will be higher than in 2025. This is supported by the fact that all conventional sources in the Montenegrin power system, the southern part of Bosnia and Herzegovina and the Albanian power system (primarily all hydropower plants which are in operation in 2025) are in operation in 2032, which significantly affects faster clearing time of the affected element.

The lowest values of the critical clearing time were obtained for the faults in the branches converging on the busbars to which the power units are also connected, more precisely for the faults on the power plant side. The most critical values were obtained for the faults in the 220 kV lines converging on the SS Pljevlja 2 for which the critical clearing time was about 250 ms in 2025, where higher values can be expected in 2032 due to the new interconnection to Bosnia and Herzegovina and Serbia, i.e. lower critical values.

With regard to the faults in the 110 kV lines converging on HPP Perućica for which the critical clearing time was about 220 ms in 2025, it can be expected that in the worst case the values will remain at the same level.

[16] For SS Bečići, the value of short-circuit voltage at 110/35 kV transformer will be determined through a special study, in order to limit short-circuit currents to a value acceptable to CEDIS.

6.3.5 Analysis of losses

The analysis of losses was elaborated through the analysis and comparison of losses in 2032 in the analysed regimes (winter and summer maximum), compared to calculated losses in 2025. It should be noted that the increase in consumption includes the entry into operation of tourist complexes Luštica, Porto Montenegro, Highway, etc. The forecast of the increase in the peak load of transformer stations (excluding "direct consumers") is about 1.5% annually.

The following table shows the losses in 2032 calculated in the analysed regimes.

Table 6-8: Ratio between the power of losses and consumption for the characteristic hours in 2032[17]

Summer 2032				Winter 2032			
Generation	Consumption	Losses*		Generation	Consumption	Losses*	
MW	MW	MW	%	MW	MW	MW	%
487	802	36.5	4.55	992	844	43	5.09

*** including also the HVDC (as consumption of 1000 MW), the capacity of consumption is 2002 MW in summer and 2044 MW in winter, so losses amount to 1,8% in summer and 2,1% in winter**

Total losses in the EPS of Montenegro amount to about 43.0 MW for the winter and 36.5 MW for the summer regime, which amounts to 5.1% and 4.5%, respectively, in relation to the total consumption of Montenegro.

Making comparison with the losses from 2025, it can be expected an increase of the absolute value of losses, which is primarily due to the increase in electricity transit, provided that the level of losses in relation to **the available energy (with the HVDC**) in the system could be considered to be the same as in the period 2020-2025 (**about 2%**).

As with the case of 600 MW capacity transit over the cable, here the losses caused by the increase in transit to 1000 MW will be also compensated through the ITC mechanism within the ENTSO-E calculation of costs for covering losses (Inter TSO Compensation Mechanism), and will not affect the increase in the costs of CGES' operation.

The calculation of losses based on 8760 hour models for 2032 showed that a significant increase in losses can be expected compared to 2025, as a result of the entry of the second pole of the HVDC and amount to 230,611 MWh[18], which is about 5.7% of Montenegro's consumption.

6.3.6 Transmission Power and Congestion Analysis

In the analysis of N-1 security for winter and summer regime, overloads of over 100% of two elements in the transmission network of the Montenegrin EPS are noted. These are 110 kV OHL Trebinje (BA) - Herceg Novi and Herceg Novi - Tivat, during the outage of 400 kV overhead line Trebinje (BA) - Lastva.

The problem of the mentioned overload is a consequence of the operation of these overhead lines in parallel, i.e. 110 kV connection Lastva - Tivat - Herceg Novi - Trebinje (BA) and 400 kV connection Lastva - Trebinje (BA) and is resolved by changing the switching state in the 110 kV network.

At the same time, the high level of load of the 400 kV OHL from the direction of Trebinje contributes to the fact that a good part of the energy, in case of its outage, "spills over" to the 110 kV network and leads to overload from the direction of Trebinje.

[17] The costs of losses incurred by cross-border transits are reimbursed from the ITC mechanism.

[18] Losses on 110/x kV transformers are not included.

For the rest of the network of CGES, it can be stated that it meets the security criteria envisaged by the Transmission Grid Code of CGES [3], provided that all proposed solutions in the previous period are implemented by 2032.

As a solution to the identified problems, the following reconstructions, operational measures and construction of transmission elements are proposed (**Error! Reference source not found.**).

Table 6-9: Analysis of reinforcements and elimination of identified uncertainties in the transmission network of Montenegro

2032				
Element outage/ network problem	Overloaded element	Load [%]	Load relief measure	Development measure
Import from Italy on HVDC 1200 MW (Base case)[19]	220 kV OHL Pljevlja – Bajina Bašta (RS)	267	Reduction of the exchange power on the HVDC	400 kV OHL Pljevlja 2 - Bajina Bašta (RS), or 400 kV Brezna – Sarajevo 20 (BA)
TR 1 31.5 MVA in SS Ulcinj	TR 2 31.5 MVA in SS Ulcinj	118	Consumption reduction	Increasing the capacity of transformers in SS Ulcinj
110 kV OHL Virpazar - Podgorica 2	OHL Virpazar - Bar	110	Suppression of generation of SPP Briska Gora	Construction of 110 kV OHL Podgorica 5 - SS Virpazar
110 kV OHL SPP Briska Gora - Ulcinj (Virpazar)	110 kV OHL SPP Briska Gora - Ulcinj (Virpazar)	150	Reduction of generation of SPP Briska Gora	Construction of 110 kV interconnection (245 MVA) towards Albania
400 kV Trebinje (BA) - Lastva (ME)	Herceg Novi (ME) - Trebinje (BA) Herceg Novi – Tivat	110		Construction of 110 kV OHL Vilusi - Herceg Novi

Of the above projects, in order to couple the electricity market and connect renewable sources, two new potential interconnections stand out, towards Bosnia and Herzegovina and Albania:

- 400 kV Brezna – Sarajevo 20 (BA)

In late 2019, one pole of the HVDC link between Montenegro and Italy was commissioned, with the capacity of the laid cable of 600 MW. The agreement between the two transmission network operators CGES (Montenegro) and TERNA (Italy) envisages the laying of the second pole of the cable in the future, i.e. the commissioning of both poles (1200 MW), which will further burden the Montenegrin transmission network through increase in transit and power flows, both on the 400 kV and the 110 kV network.

The degree of implementation of new interconnections towards neighbouring systems depends on the possibility to implement them at a given moment and thus enable increased exchange of electricity through the electricity system of Montenegro, primarily for the needs of import/export, but also to couple the electricity markets of the Southeast Europe region, enabling increased benefits to consumers and producers of electricity.

The connection from Montenegro towards Serbia depends on the pace of construction and reconstruction of the existing infrastructure in the western part of Serbia, i.e. the construction of hundreds of kilometres of the new 400 kV network in the next 5 years, which is envisaged by the Development Plan of EMS (Transmission System Operator of Serbia).

[19] In line with ENTSO-E TYNDP 2020, commissioning of the second pole line HVDC ME-IT is postponed beyond 2025.

According to the latest information, EMS has started activities on the implementation of Section IV of the Trans-Balkan Corridor, but for its implementation, it is necessary to complete Section III 400 kV Obrenovac (RS) - Bajina Bašta (RS).

On the other hand, significant new infrastructure has been built on the territory of Montenegro, which is ready for full utilisation and connection to neighbouring systems, primarily for the purpose of implementing Section IV of the Trans-Balkan Corridor, i.e. the connection towards Serbia.

The second 400 kV interconnection from the systems of Montenegro and Bosnia and Herzegovina would enable the elimination of congestion on the border with BiH (conditionally also towards Serbia, due to the electrical connection of these three systems). This operation regime should further encourage the full use of energy potentials of Montenegro, Bosnia and Herzegovina, but also other neighbouring systems for which a strong connection with the Italian electricity market should offer a reliable investment signal and guarantee the profitability of investments in electricity generation.

- 110 kV OHL SPP Briska Gora – Dajc (AL)

The position of Albania and Montenegro in Southeast Europe provides favourable conditions for it to act as a region of "electricity channelling" (from Italy/Montenegro to Central Europe and vice versa), which requires new requirements for constructing a stable and secure transmission network.

Further development of the South East Europe (SEE) regional electricity market in accordance with the Energy Community Treaty and the expected opening of local electricity markets in both countries, with the need to meet the EC's targets for RES implementation in Montenegro (ME) and Albania (AL), which further implies the need to further strengthen internal and interconnection links.

The geographical characteristics of Montenegro and Albania, as well as the energy policy of diversification of conventional electricity sources and the revised legal framework of both countries paved the way for the construction and connection of an increasing number of renewable energy plants (wind and photovoltaic energy).

There are many new private investors who have expressed interest in implementing new RES projects near the border between the two countries, with the intention of exporting generation to the rest of Southeast Europe, i.e. the Italian electricity market.

The planned solar generation in Montenegro (Briska Gora), which will be constructed near the border with Albania (2023-2026) and which will significantly affect the development of new RES in the region, is of particular importance for this project. The effect and connections with SS Briska Gora will therefore have to be included in the scope of a future study with a special impact on security of supply in the region of southern Montenegro and northern Albania.

The geographical overview of the region of interest is given in the Figure 6.4.

The project includes the construction of a new double-circuit 110 kV overhead line between Montenegro and Albania (capacity 245 MVA), including the construction of the necessary 110/x kV substations (Kosmac (AL), SS Briska Gora (ME) and Ulcinj (ME)[20]). The diagram is shown in the following figure.

[20] It implies the reconstruction of SS Ulcinj and the construction of SPP Briska Gora, if in the meantime 110 kV OHL Ulcinj - Briska Gora - Virpazar is not implemented.

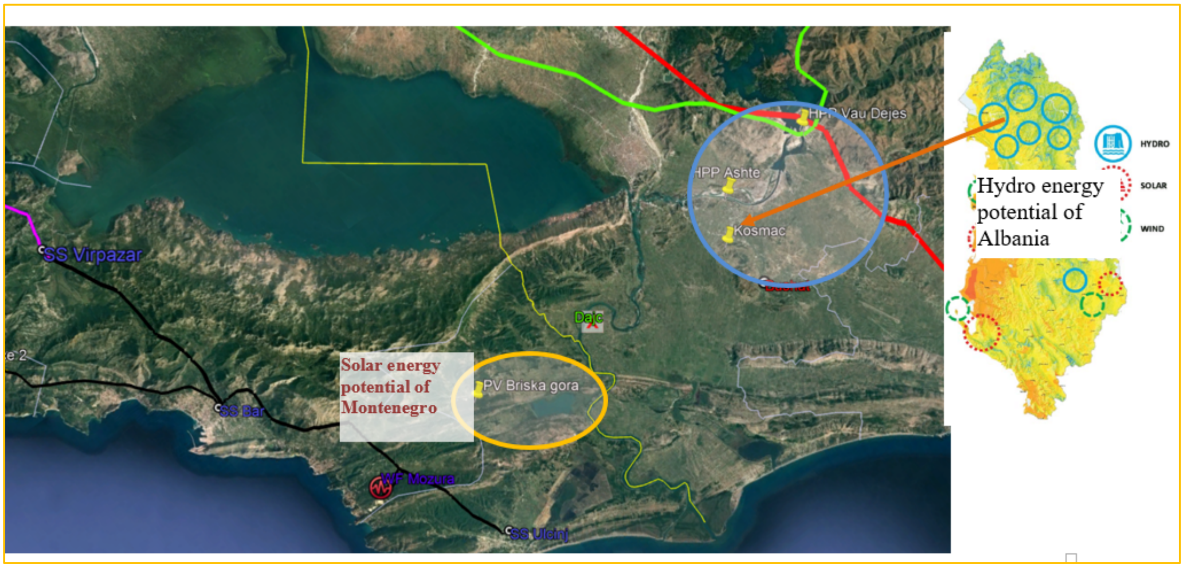


Figure 6-5: Geographical overview of the region between Montenegro and Albania with RES capacities

Having in mind the following facts:

- the average age of 220 kV overhead lines and transformers 220/110 kV will be 56 years in 2032,
- the reliability of the 220 kV transmission system has been already significantly reduced,
- parallel operation of 400 and 220 kV networks connecting virtually the same parts of the system and representing constraints in the transit of energy through the transmission system of Montenegro reducing cross-border transmission capacities,
- almost certain upgrade of 220 kV network in western Serbia to the 400 kV voltage level (expected completion by 2025).

It is necessary to give recommendations and guidelines for the future of the 220 kV network in Montenegro, or to answer the question of whether and how it is possible to abandon the 220 kV network. The issue of the possible abandonment of the 220 kV network is very complex and requires detailed analysis of the various characteristic conditions of the network to detect possible problems that can arise, and therefore, this Chapter outlines one scenario of possible abandonment of the 220 kV network in phases. The gradual abandonment of the 220 kV voltage level would be performed in phases in accordance with the dynamics of the possibility of disconnection and termination of operation of the 220 kV interconnection overhead lines (agreement with neighbouring transmission system operators), as well as the dynamics of the construction of certain transmission system elements having a significant impact on the implementation of the entire project.

The whole project requires a more detailed analysis, but it should be emphasised that in the characteristic regimes for 2032, no major network problems were identified in the case of the above-described abandonment of the 220 kV network, except for the aforementioned reinforcements in the 110 kV network in the direction of Bijelo Polje - Mojkovac unless another 400 kV overhead line in this direction that would connect SS Pljevlja and SS Podgorica 1 is constructed.

The perspective of the construction of new interconnections towards Bosnia and Herzegovina and Albania (in light of strengthening links towards neighbouring systems):

- ✓ New 400 kV interconnection Montenegro - Albania. Namely, according to the transmission system development plan, after 2021, OST plans to build a 400/220 kV transformation that would be connected to 400 kV overhead line Podgorica - Tirana, in the section between Tirana and Vau Dejes (in SS Komen, 21 km from Vau Dejes). Based on limited information related to the current initiative, the following can be analysed: to remove 220 kV overhead line Podgorica-Koplik-Vau Dejes and instead of it construct a new 400 kV overhead line, or a similar combination.

- ✓ New 400 kV interconnection Montenegro - Bosnia and Herzegovina. Considering that the studies conducted in the past few years have shown that the expected direction of capacity import to Montenegro is from Bosnia and Herzegovina, because this system is the first neighbouring system with the expected energy surplus as long as 2016, it was logical to assume that their capacity surplus will be transferred to Montenegro towards the HVDC cable. One of the proposals for the analysis is a new interconnection overhead line that would connect one of the existing 400 kV switchyards, or the future switchyard 400 kV Brezna in Montenegro, with the neighbouring connection point 400 kV (existing or planned) in BiH, where SS Sarajevo 20 (BiH) is the most logical option. The integration of this overhead line would require the dismantling of the 220 kV section of the overhead line Piva - Sarajevo 20 and the use of the 400 kV section from the location in BiH where the construction of HPP Buk Bijela was previously planned.

6.3.7 Analysis of general indicators of quality electricity delivery

With regard to indicators of the quality electricity delivery until 2032, a significant reduction in the number is expected as a result of the reconstruction, revitalization and construction of a number of transmission capacities, primarily:

- Construction of 110 kV OHL Vilusi - Herceg Novi,
- Construction of 110/10 SS kV Bečići,
- SS 400/110/35 kV Brezna,
- Construction of 400 kV OHL Pljevlja 2 - B.Bašta – Višegrad,
- Construction of 110 kV OHL Virpazar - Briska Gora – Ulcinj,
- Construction of a series of transformer stations in the area of Podgorica and the coastal part of Montenegro.

Taking into account the previously mentioned reinforcements and reconstructions, a significant reduction in the number of outages and unavailability of certain elements of the transmission network is expected, primarily:

- SS Brezna,
- SS Podgorica 3,
- SS Podgorica 5,
- SS Kličevo.

For 2032, the expected values of AIT (taking into account experiences with existing SSs that are either bidirectionally supplied or reconstructed) are presented in the following diagram:

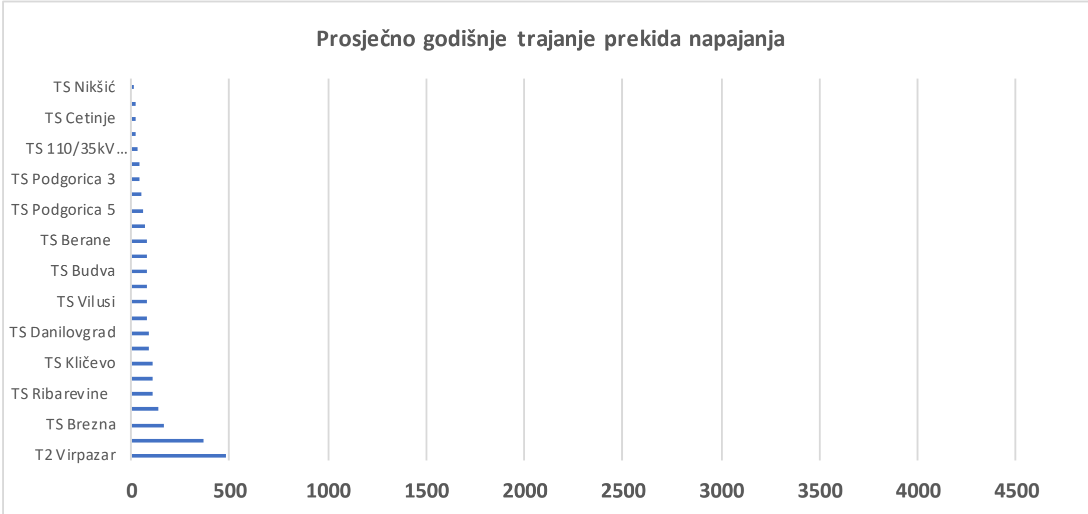


Figure 6-6: Average Interruption Time in 2032

Of course, one should refrain from assessing the condition of the network for 10 years and possible unplanned and sudden failures due to causes beyond the control of CGES' Maintenance Department.

7 Necessary investments in the planning period

7.1 Overview of necessary new system elements and remedial actions on existing elements

CGES' Investment Plan for the period 2023-2025 contains significant projects for the development of the electricity transmission system, aimed at providing safer, more reliable and better quality electricity transmission services, as well as providing conditions for the connection of new generation facilities.

Pursuant to Article 10 of the Rules, the investments presented in the Investment Plan 2023-2025 can be divided into investments in the construction of new or remedial actions on existing electricity transmission infrastructure, investments in telecommunications and control infrastructure, investments resulting from the need to replace elements whose service life has endangered their safe operation, investments so-called smart grid projects aimed at optimal operation of the transmission system, as well as investments implemented by other investors, for which an infrastructure repurchase program has been prepared. Besides, in accordance with Article 10 of the Rules, the Investment Plan in question contains funds intended for the implementation of investments that cannot be foreseen in the year of submission of the application for approval of the investment plan, i.e. investments whose implementation may become necessary during the planning period due to unforeseen circumstances (Contingency Plan).

Part of the investments within the Plan has been already included in previous CGES plans and the Agency's decisions. The Investments are divided into programs and projects as shown in Table 7-1, which contains the list of necessary investments in the planning period until 2032.

Table 7-1: Overview of necessary new transmission network elements and remedial actions on existing ones

INVESTMENTS WHOSE IMPLEMENTATION IS PLANNED TO BEGIN DURING THE FIRST REGULATORY PERIOD OR WHOSE IMPLEMENTATION BEGAN BEFORE THE PERIOD TO WHICH THE PLAN REFERS					
NO.	ID NUMBER	INVESTMENT TITLE	NEW ELEMENTS or INTERVENTIONS ON EXISTING ELEMENTS	BEGINNING OF IMPLEMENTATION	END OF IMPLEMENTATION
1	IPR009	Reconstruction of OHL 110 kV Lastva - Budva	intervention on existing element	2013	2024
2	IPR089	Reconstruction of OHL 110 kV Podgorica - Danilovgrad - Perućica	intervention on existing element	2020	2023
3	IPI018	Reconstruction and extension of SS 110/35kV Pljevlja 1	intervention on existing element	2019	2023
4	IPR034	Replacement of HV equipment in transformer stations	intervention on existing element	2016	2023
5	IPR006a	Reconstruction of protection system	intervention on existing element	2016	2023
6	IPR098	Rehabilitation of OHL 110 kV Bar - Možura - Ulcinj	intervention on existing element	2023	2024
7	IPI006b	Construction of OHL 400 kV Čevo - Pljevlja	new element	2013	2023

8	IPI019	SS 400/110/35 kV Brezna	new element	2016	2026
9	IPI009	Construction of OHL 400 kV Pljevlja2 - Bajina Bašta - Višegrad	new element	2012	2026
10	IPI015	Construction of OHL 110 kV Virpazar - Briska Gora - Ulcinj	new element	2018	2027
11	IPI058	Installation of shunt reactor 250 MVAr in SSS Lastva	new element	2020	2023
12	IPI030	Construction of SS 110/35 kV Luštica and connection to 110 kV network	new element	2015	2024
13	IPI013	Construction of SS 110/35 kV Žabljak	new element	2012	2024
14	IPI055	Construction of SS 110/10 kV Podgorica 7 and connection to 110 kV network	new element	2021	2025
15	IPI056	Construction of SS 110/35 kV Buljarica and connection to 110 kV network	new element	2021	2026
16	IPI017	Construction of OHL 110 kV Lastva - Kotor	new element	2013	2024
17	IPI016	Construction of OHL 110 kV Vilusi - Herceg Novi	new element	2013	2027
18	IPI060	Construction of SS 110/10 kV Bečići	new element	2023	2025
INVESTMENTS WHOSE IMPLEMENTATION IS PLANNED TO BEGIN AFTER THE FIRST REGULATORY PERIOD					
19	IPIXXX	Construction of OHL 400 kV Brezna - Sarajevo	new element	2026-2032	
20	IPIXXX	Construction of OHL 110 kV Ulcinj - Briska Gora - Kosmač	new element	2026-2032	
21	IPIXXX	Construction of SS 110/35 kV Kolašin (Drijenak)	new element	2026-2032	
22	IPIXXX	Construction of SS 110/35 kV V. Plaža and connection to transmission network	new element	2026-2032	
23	IPIXXX	Construction of 110/10 kV Igalo	new element	2026-2032	
24	IPIXXX	Construction of 110/10 kV Podgorica 6	new element	2026-2032	
25	IPIXXX	Construction of 110/10 kV Podgorica 8	new element	2026-2032	
26	IPIXXX	Construction of 110/35 kV Tuzi	new element	2026-2032	
27	IPIXXX	Construction of 110/35 kV Golubovci	new element	2026-2032	
28	IPIXXX	Construction of 110 kV OHL Podgorica 5 - Virpazar	new element	2026-2032	

29	IPRXXX	Reconstruction of OHL 110 kV Podgorica 1 - ETP Trebješica - Andrijevica	new element/intervention on existing element [21]	2026-2032
30	IPRXXX	Reconstruction of OHL 110 kV Bar - Možura - Ulcinj - increasing throughput	new element/intervention on existing element [22]	2026-2032
31	IPRXXX	Reconstruction of OHL 110 kV Bar - Budva - increasing throughput	new element/intervention on existing element [23]	2026-2032
32	IPRXXX	Reconstruction of OHL 110 kV Podgorica 2 - Virpazar - increasing throughput	new element/intervention on existing element [24]	2026-2032
33	IPRXXX	Reconstruction of OHL 110 Nikšić - Bileća (Vilusi)	new element/intervention on existing element 25	2026-2032
33	IPIXXX	Installation of synchronous compensator		2026-2032

7.2 Overview of unnecessary remedial actions on existing elements during the planning period

The planned new project for the construction of the 110/10 kV Bečići substation, as well as the installation of busbar breaker in SS Budva as a quick solution (in progress), created preconditions for abandoning the expensive investment in the 110 kV busbar reconstruction in Budva (GIS design), which was included in the previous plan.

Table 7-2: Overview of investments in existing elements being postponed

NO.	Investments in remedial actions on existing elements being postponed	Investments due to which remedial actions on existing elements are postponed
1	Reconstruction of busbars in SS 110/35 kV Budva	Construction of SS 110/10 kV Bečići

[21] Depending on further analyses and conducted studies, it will be defined whether a completely new system element will be constructed or whether the necessary reconstruction will be carried out on the existing element.

[22] Depending on further analyses and conducted studies, it will be defined whether a completely new system element will be constructed or whether the necessary reconstruction will be carried out on the existing element.

[23] Depending on further analyses and conducted studies, it will be defined whether a completely new system element will be constructed or whether the necessary reconstruction will be carried out on the existing element.

[24] Depending on further analyses and conducted studies, it will be defined whether a completely new system element will be constructed or whether the necessary reconstruction will be carried out on the existing element.

[25] Depending on further analyses and conducted studies, it will be defined whether a completely new system element will be constructed or whether the necessary reconstruction will be carried out on the existing element.

7.3 Overview of other electricity transmission system investment needs

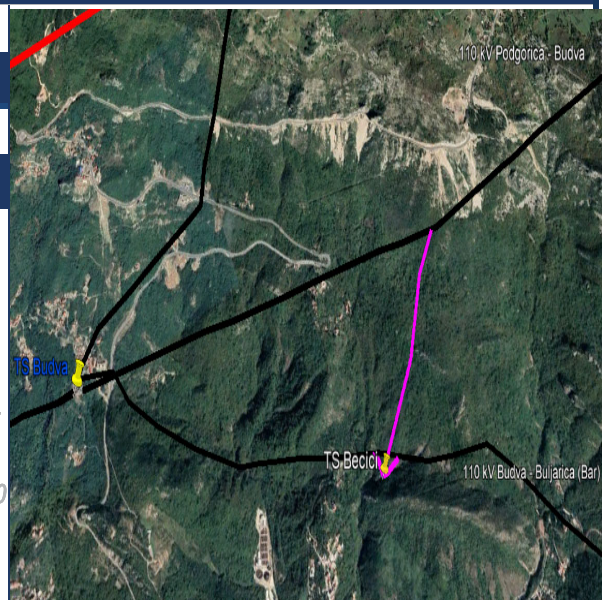
All investments that are not treated by subchapters 7.1 and 7.2, and which are forecasted in the 2023 – 2025 Investment Plan, can be classified in one of the following categories: control infrastructure, telecommunications infrastructure, smart grid projects, i.e. smart networks whose objective is the optimal operation of the transmission system, investments implemented by other investors and for which an infrastructure purchase programme was developed, as well as investments in the group "other" that contribute to the improvement of the core activity of CGES.

Certain funds are envisaged for the implementation of investments that could not be foreseen at the time of the preparation of the plan for the first regulatory period, i.e. for unforeseen interventions in the period in question, so in addition to the above, we can also talk about the category of unforeseen investments, which by their nature also represent investments in the transmission system.

8 Technical and economic analyses

Below are technical and economic analyses of new infrastructure projects (Construction of SS 110/10 kV Bečići, Revitalization of OHL 110 kV Bar - Možura and OHL 110 kV Možura - Ulcinj, Procurement of autotransformer 220/110 kV, 150 MVA in SS Podgorica 1 and Procurement of autotransformer 220/110 kV, 150 MVA in SS Mojkovac), i.e. for infrastructure projects where the technical solution was changed (Construction of 110 kV OHL Virpazar - Briska Gora - Ulcinj).

Construction of SS 110/10 kV Bečići

INVESTMENT	GEOGRAPHICAL LOCATION*
Construction of SS 110/10 kV Bečići	
INVESTMENT ID NUMBER	
IPI060	
DESCRIPTION OF ENGINEERING DESIGN	
The development plan includes a new investment in the construction of new electricity infrastructure, the construction of which is planned to begin in the first three years. *Examining the request of CEDIS for building new 110 / x kV substations, a new investment in the construction of SS 110/10 kV Bečići was proposed. According to the information obtained from CEDIS, the proposed SS 110/10 kV Bečići would replace several 35/10 kV substations that would need to be built. The 110/10 kV Bečići substation would also take over part of the consumption of the city of Budva (several 10 kV cables would be planned to be laid towards Budva). According to a CEDIS analysis conducted for July and August, the new SS would take up 27.6% of energy.* *Bearing in mind that the location is relatively close to the 110 kV overhead lines Podgorica 2 - Budva and Bar - Budva, the engineering design proposes the connection of both overhead lines to the new substation. The Bečići substation would have two busbar systems. The new substation would provide greater flexibility of power evacuation in different directions, the possibility of supplying SS Budva and SS Bečići with power from three directions, the possibility of separating the areas of Bar and Ulcinj and their power supply through the OHLs Podgorica-Bečići and Podgorica-Virpazar and the possibility of connecting WPP Brajići to SS Bečići.*	

BEGINNING OF CONSTRUCTION	END OF CONSTRUCTION
2023	2025
☒ Project	☐ Program

INVESTMENT CATEGORY

Electricity transmission infrastructure - construction

OBJECTIVE(S) OF THE DEVELOPMENT PLAN TO BE ACHIEVED BY INVESTMENT

C1 Eliminating observed uncertainties in the past period

C2 Security of the national system

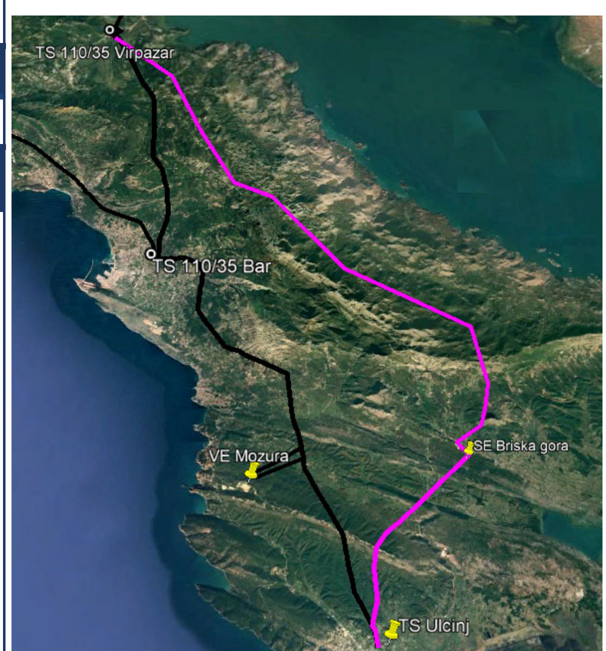
C5 Proper planning aimed at connecting renewable sources of electricity and increasing socio-economic benefits

C7 Strategic directions of improvement and development for the purpose of environmental protection

BENEFITS	
K1 Socio-economic benefit (€/year)	
K1.1 Energy cost savings (€/year)	**0**
K1.2 Gas emissions cost savings (€/year)	**1,242,500**
K2 Change in CO2 emissions (t/year) and (€/year)	177,500 t/year 1,242,500 €
K3 RES integration (MW) or (MWh/year)	100.3
K4 Non CO2 emissions (t/year)	Nox CO SOx 59 11 148
K5 Network losses (MWh/year)	1
K6 Adequacy [MWh/year]	No impact
K7 Flexibility 4	
K7.1 Balance energy exchange [ordinal scale]	No impact
K7.2 Exchange of balancing capacities [max 200 words]	No impact
K8 Stability	
K8.1 Qualitative indicator [ordinal scale]	No impact

K8.2 Frequency stability [max 200 words]	No impact
K8.3 No-load activation services [€/year] and [max 200 words]	No impact
K8.4 Voltage/reactive power control services [max 200 words]	No impact
K9 Avoidance/postponement of remedial actions on existing elements [€]	Avoiding the reconstruction of busbars in SS 110/35 kV Budva (GIS technology) 2,280,000 €
K10 Changing needs for redispatching [€/year]	No impact
K11 Robustness [ordinal scale]	8
EXPENSES	
T1 CAPEX [€]	7,500,000.0
T2 OPEX [€]/year	112,500.0

Construction of 110 kV OHL Virpazar - Ulcinj

NAME OF INVESTMENT	GEOGRAPHICAL LOCATION*
Construction of 110 kV OHL Virpazar - Ulcinj	
INVESTMENT IDENTIFICATION NUMBER	
IPI015	
DESCRIPTION OF TECHNICAL SOLUTION	
The area of the city of Ulcinj is supplied from SS 110/35kV Ulcinj via one 110 kV and one 35 kV overhead line from SS 110/35 kV Bar (used only in emergency situations and very limited transmission power). The construction of the 110 kV overhead line Virpazar - Ulcinj would enable bi-directional power supply to SS Ulcinj, which would ensure the n-" criterion of power supply security and thereby increase the level of consumption supply. *Scope of work:* *- construction of a new 110 kV overhead line Al/Fe 2x240/40 mm2 Virpazar-Ulcinj* *- construction of a new 110 kV overhead line bay in SS Ulcinj,*	

- construction of a new 110 kV overhead line bay in SS Virpazar

The main objectives of the project:

- loss reduction,

- reliable supply of consumption in the region of Ulcinj and Bar,

- improvement of voltage-reactive conditions,

- load shedding of existing 35/10 kV transformations,

- ensuring n-1 security criterion in the vicinity of SS Ulcinj, at 110 kV voltage level

- enabling the connection of new RES in the full planned capacity

BEGINNING OF CONSTRUCTION	END OF CONSTRUCTION
2018	*2027*

☒ **Project** ☐ **Programme**

INVESTMENT CATEGORY

Electricity transmission infrastructure - construction

(OBJECTIVE(S) OF THE DEVELOPMENT PLAN WHOSE ACHIEVEMENT IS SUPPORTED BY THE INVESTMENT

Objective 1 Eliminating observed uncertainties in the past period

Objective 2 Security of the national system

Objective 5 Proper planning aimed at connecting renewable sources of electricity and increasing socio-economic benefits

BENEFITS	
K1 Socio-economic benefit (€/year)	**0**
K1.1 Energy cost savings (€/year)	**640,200**
K1.2 Gas emissions cost savings (€/year)	26,500 t/year 715,200 €
K2 Change in CO2 emissions (t/year) and (€/year)	50
K3 RES integration (MW) or (MWh/year)	Nox CO SOx 39 07 75

K4 Non CO2 emissions (t/year)	7,700
K5 Network losses (MWh/year)	No impact
K6 Adequacy [MWh/year]	
K7 Flexibility 4	No impact
K7.1 Balance energy exchange [ordinal scale]	No impact
K7.2 Exchange of balancing capacities [max 200 words]	No impact
K8 Stability	-
K8.1 Qualitative indicator [ordinal scale]	No impact
K8.2 Frequency stability [max 200 words]	No impact
K8.3 No-load activation services [€/year] and [max 200 words]	No impact
K8.4 Voltage/reactive power control services [max 200 words]	No impact
K9 Avoidance/postponement of remedial actions on existing components [€]	No impact
K10 Changing needs for redispatching [€/year]	No impact
K11 Robustness [ordinal scale]	8
EXPENSES	-
T1 CAPEX [€]	10,000,000.00
T2 OPEX [€]/year	150,000.0

Revitalization of 110 kV OHL Bar - Možura and 110 kV OHL Možura - Ulcinj

NAME OF INVESTMENT

Revitalization of 110 kV OHL Bar - Možura and 110 kV OHL Možura - Ulcinj

INVESTMENT IDENTIFICATION NUMBER

IPR098

DESCRIPTION OF TECHNICAL SOLUTION

Revitalization of 110 kV OHL Bar - Možura and 110 kV OHL Možura - Ulcinj includes the procurement of Al/Fe 150/25 mm2 conductors, jointing and suspension equipment and glass insulators, as well as the execution of works on the installation of the said equipment.

In the previous period, the upper suspension systems on these overhead lines suffered problems. More specifically, on the cross-arms of certain 110 kV Bar - Možura overhead line towers, the panels on which the upper suspensions were mounted were damaged. In the previous period, this problem was solved. In addition, a drone recording with thermal imaging cameras was performed on this overhead line, which revealed dilapidation of the jointing and suspension equipment, therefore, in order to increase the reliability of these overhead lines, it is necessary to replace them on all towers. Besides, in order to complete the revitalization of this overhead line, and thus ensure reliable power supply to the Ulcinj Municipality, it is necessary to replace the conductor that has been in operation for almost 40 years.

Due to the conditions relating to the power supply of the consumption area of the Ulcinj Municipality, works are planned to be executed in the period from early April to the end of May or from early October to the end of November.

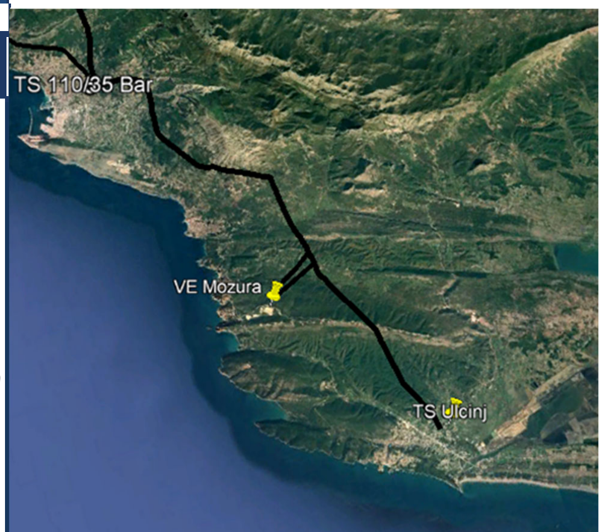
BEGINNING OF CONSTRUCTION END OF CONSTRUCTION4

2023	2024

☒ **Project** ☐ **Programme**

INVESTMENT CATEGORY

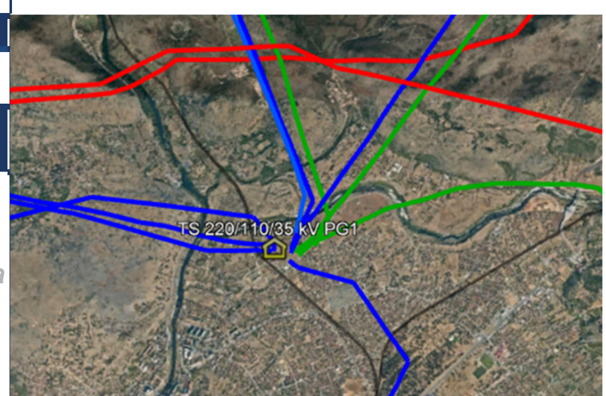
GEOGRAPHICAL LOCATION *



Electricity transmission infrastructure	
OBJECTIVE(S) OF THE DEVELOPMENT PLAN WHOSE ACHIEVEMENT IS SUPPORTED BY THE INVESTMENT	
Objective 1 - Eliminating observed uncertainties in the past period *Objective 5 - Proper planning aimed at connecting renewable sources of electricity and increasing socio-economic benefits*	
BENEFITS	
K1 Socio-economic benefit (€/year)	**Due to the fact that the project does not affect the change of SEW (ENTSO-E CBA 3.0), there is no special benefit in terms of this type of benefit (in the same price range as the rest of Montenegro)**
K1.1 Energy cost savings (€/year)	**0**
K1.2 Gas emissions cost savings (€/year)	**438,200**
K2 Change in CO2 emissions (t/year) and (€/year)	62,599.82 t/year 438,200 €/year
K3 RES integration (MW) or (MWh/year)	46 MW (WPP Možura)
K4 Non CO2 emissions (t/year)	Nox CO SOx 27 5 70
K5 Network losses (MWh/year)	No impact
K6 Adequacy [MWh/year]	No impact
K7 Flexibility 4	-
K7.1 Balance energy exchange [ordinal scale]	No impact
K7.2 Exchange of balancing capacities [max 200 words]	No impact
K8 Stability	-
K8.1 Qualitative indicator [ordinal scale]	No impact
K8.2 Frequency stability [max 200 words]	No impact

K8.3 No-load activation services [€/year] and [max 200 words]	No impact
K8.4 Voltage/reactive power control services [max 200 words]	No impact
K9 Avoidance/postponement of remedial actions on existing components [€]	No impact
K10 Changing needs for redispatching [€/year]	No impact
K11 Robustness [ordinal scale]	4
EXPENSES	-
T1 CAPEX [€]	700,000
T2 OPEX [€]/year	-

Procurement of 220/110 kV autotransformer, 150 MVA in SS Podgorica 1

NAME OF INVESTMENT	GEOGRAPHICAL LOCATION*
Procurement of 220/110 kV autotransformer, 150 MVA in SS Podgorica 1	
INVESTMENT IDENTIFICATION NUMBER	
IPR101	
DESCRIPTION OF TECHNICAL SOLUTION	
Project implementation includes the procurement and installation of a 220/110 kV power transformer, 150 MVA in SS Podgorica 1. *Autotransformer marked T2 in regular operation in SS 220/110/35 kV Podgorica 1, made by Rade Končar, f. no. 337014, type TARZ 150000/245s, rated voltage 220000/115000/10500 V, power 150 MVA, was manufactured in 1972. Although the revitalization of the insulation system of this ATR was carried out in 2019, the ageing of the cellulose insulation as well as the*	

complete sealing of the ATR is questionable, and consequently this ATR can remain in operation for a maximum of 5 years.
Implementation of investment will provide:
- higher operational readiness of substations,
- more reliable and safer operation of the transmission network and the plants themselves,
- reliable and secure power supply to consumers of the Podgorica area,
- more reliable and safer operation of the entire power system of Montenegro.

BEGINNING OF CONSTRUCTION END OF CONSTRUCTION	
2024	*2024*
☒ Project	☐ Programme

INVESTMENT CATEGORY

Electricity transmission infrastructure

OBJECTIVE(S) OF THE DEVELOPMENT PLAN WHOSE ACHIEVEMENT IS SUPPORTED BY THE INVESTMENT

Objective 1 Eliminating observed uncertainties in the past period

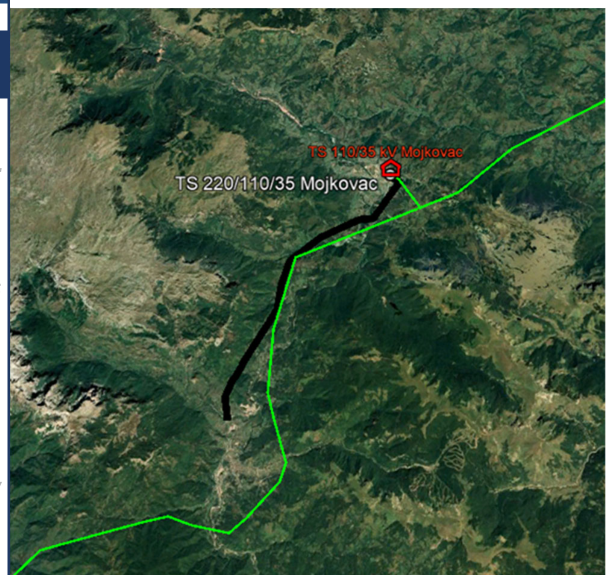
Objective 2 Security of the national system

Objective 4 – Proper planning aimed at minimizing capital investments in the transmission grid

BENEFITS	
K1 Socio-economic benefit (€/year)	
K1.1 Energy cost savings (€/year)	**0**
K1.2 Gas emissions cost savings (€/year)	**0**
K2 Change in CO_2 emissions (t/year) and (€/year)	0
K3 RES integration (MW) or (MWh/year)	0
K4 Non CO_2 emissions (t/year)	0
K5 Network losses (MWh/year)	612

K6 Adequacy [MWh/year]	No impact
K7 Flexibility 4	
K7.1 Balance energy exchange [ordinal scale]	No impact
K7.2 Exchange of balancing capacities [max 200 words]	
K8 Stability	No impact
K8.1 Qualitative indicator [ordinal scale]	No impact
K8.2 Frequency stability [max 200 words]	No impact
K8.3 No-load activation services [€/year] and [max 200 words]	No impact
K8.4 Voltage/reactive power control services [max 200 words]	No impact
K9 Avoidance/postponement of remedial actions on existing components [€]	No impact
K10 Changing needs for redispatching [€/year]	2
K11 Robustness [ordinal scale]	
EXPENSES	2,200,000
T1 CAPEX [€]	33,000
T2 OPEX [€]/year	

Procurement of 220/110 kV autotransformer, 150 MVA in SS Mojkovac

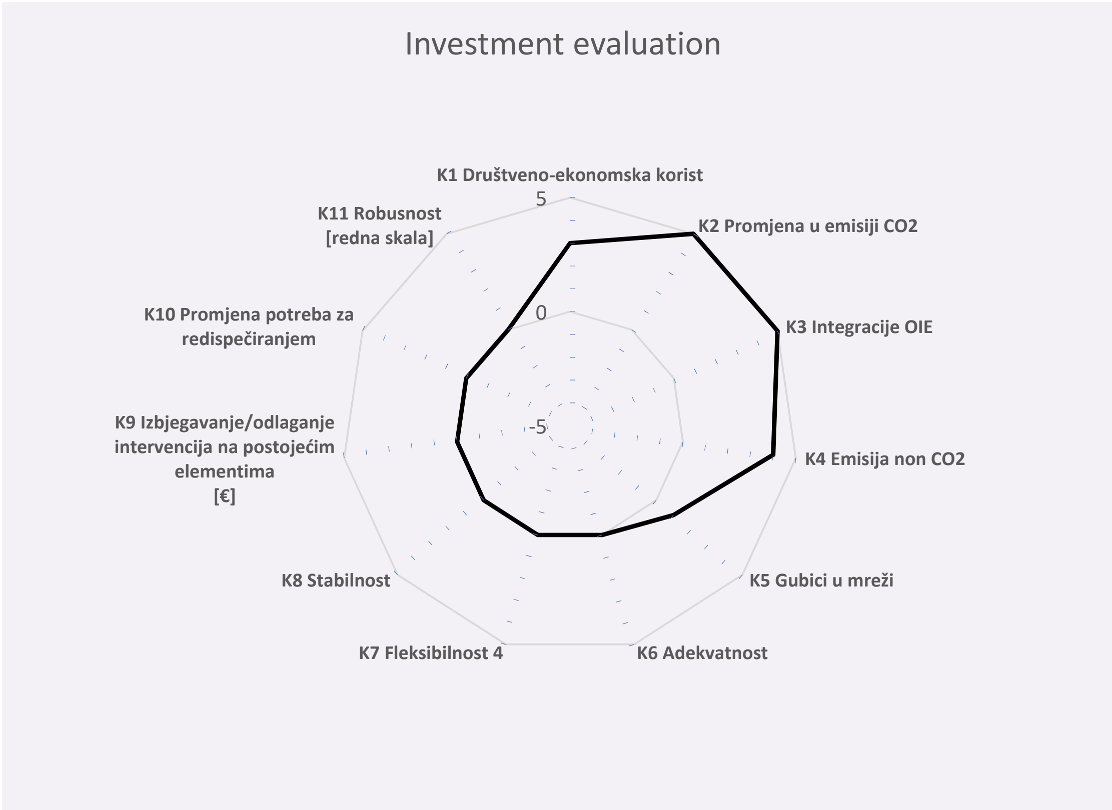
NAME OF INVESTMENT	GEOGRAPHICAL LOCATION*
Procurement of 220/110 kV autotransformer, 150 MVA in SS Mojkovac	
INVESTMENT IDENTIFICATION NUMBER	
IPR102	
DESCRIPTION OF TECHNICAL SOLUTION	
Project implementation includes the procurement and installation of a 220/110 kV power transformer, 150 MVA in SS Mojkovac. Autotransformer marked T2 in regular service in SS 220/110/35 kV Mojkovac, made by "Elta Łódź", factory no. 143141, type AFR 150000/245s, rated voltage 220000/115000/10500 V, power 150 MVA, was manufactured in 1975. *The latest test results of this ATR from August 2021 indicate the possible existence of thermal failure in the lower temperature range. The ratio of carbon(IV)oxide gases to carbon(II)oxide indicates the decomposition of cellulose insulation due to overheating. The general condition of this ATR, especially when it comes to sealing, is quite questionable, and consequently, ATR is considered unreliable.* *For these reasons, it is necessary to plan the procurement of a new ATR in this facility in the next two years. Implementation of investment will provide:* *- higher operational readiness of substations,* *- more reliable and safer operation of the transmission network and the plants themselves,* *- reliable and secure power supply to consumers of the Mojkovac area,* *-more reliable and safer operation of the entire power system of Montenegro.*	
BEGINNING OF CONSTRUCTION END OF CONSTRUCTION	
2023 *2025*	
☒ Project ☐ Programme	
INVESTMENT CATEGORY	
Electricity transmission infrastructure	
OBJECTIVE(S) OF THE DEVELOPMENT PLAN WHOSE ACHIEVEMENT IS SUPPORTED BY THE INVESTMENT	
Objective 1 Eliminating observed uncertainties in the past period *Objective 2 Security of the national system* *Objective 4 – Proper planning aimed at minimizing capital investments in the transmission grid*	

BENEFITS	
K1 Socio-economic benefit (€/year)	-
K1.1 Energy cost savings (€/year)	**0**
K1.2 Gas emissions cost savings (€/year)	0
K2 Change in CO2 emissions (t/year) and (€/year)	0
K3 RES integration (MW) or (MWh/year)	0
K4 Non CO2 emissions (t/year)	0
K5 Network losses (MWh/year)	936
K6 Adequacy [MWh/year]	No impact
K7 Flexibility 4	-
K7.1 Balance energy exchange [ordinal scale]	No impact
K7.2 Exchange of balancing capacities [max 200 words]	No impact
K8 Stability	No impact
K8.1 Qualitative indicator [ordinal scale]	No impact
K8.2 Frequency stability [max 200 words]	No impact
K8.3 No-load activation services [€/year] and [max 200 words]	No impact
K8.4 Voltage/reactive power control services [max 200 words]	No impact

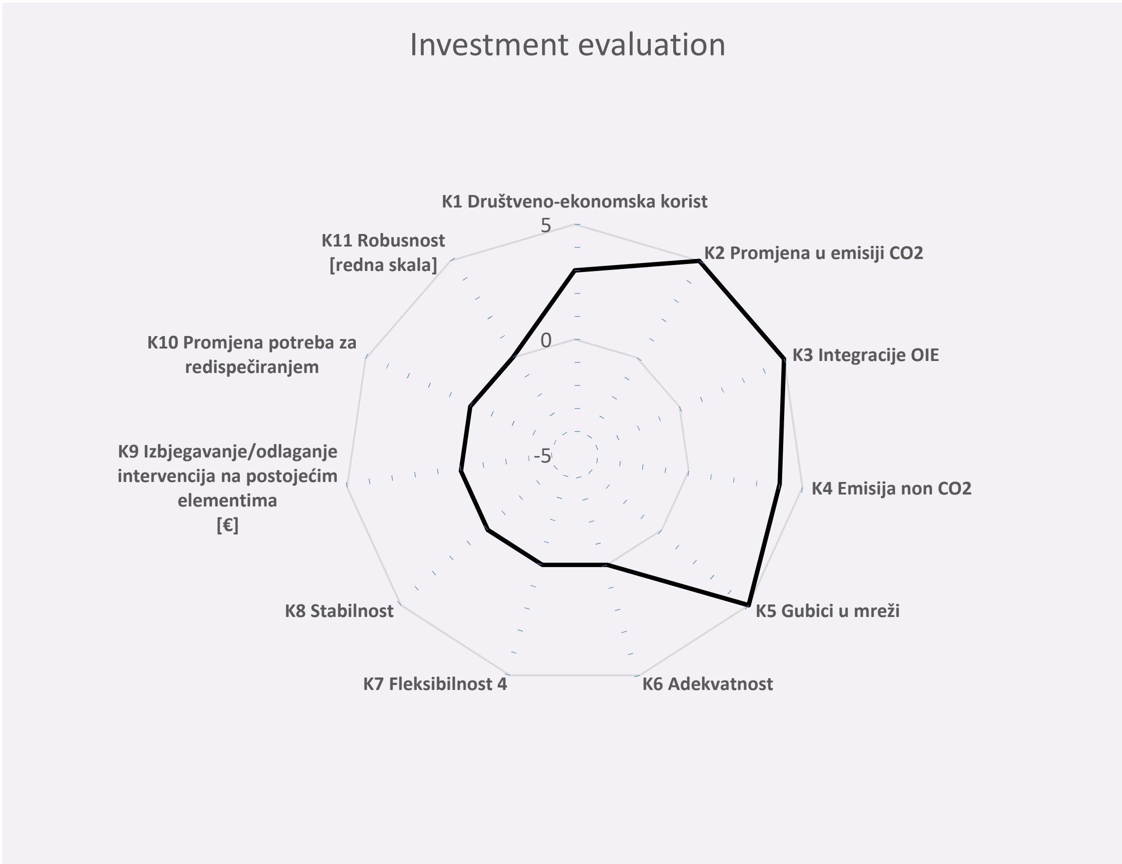
K9 Avoidance/postponement of remedial actions on existing components [€]	2
K10 Changing needs for redispatching [€/year]	No impact
K11 Robustness [ordinal scale]	2
EXPENSES	
T1 CAPEX [€]	2,200,000
T2 OPEX [€]/year	33,000

9 Illustration of a comprehensive investment evaluation

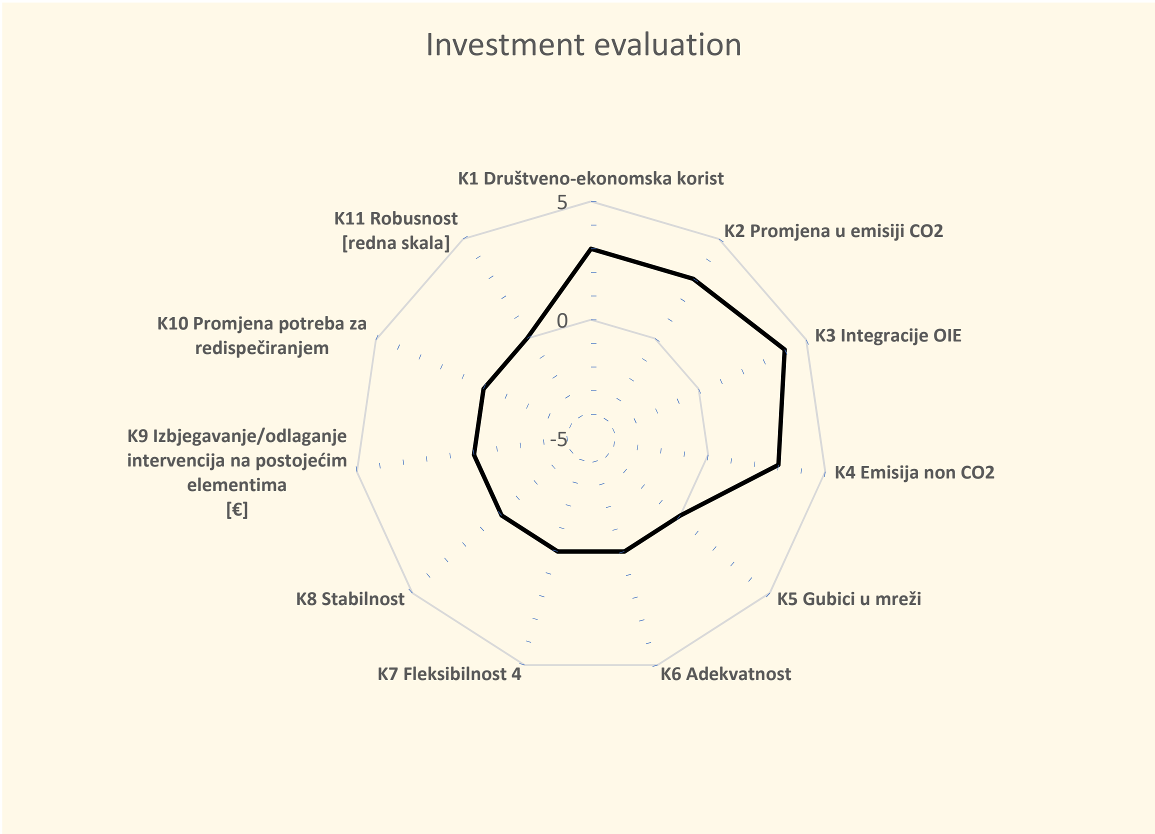
9.1 SS 110/10 kV Bečići



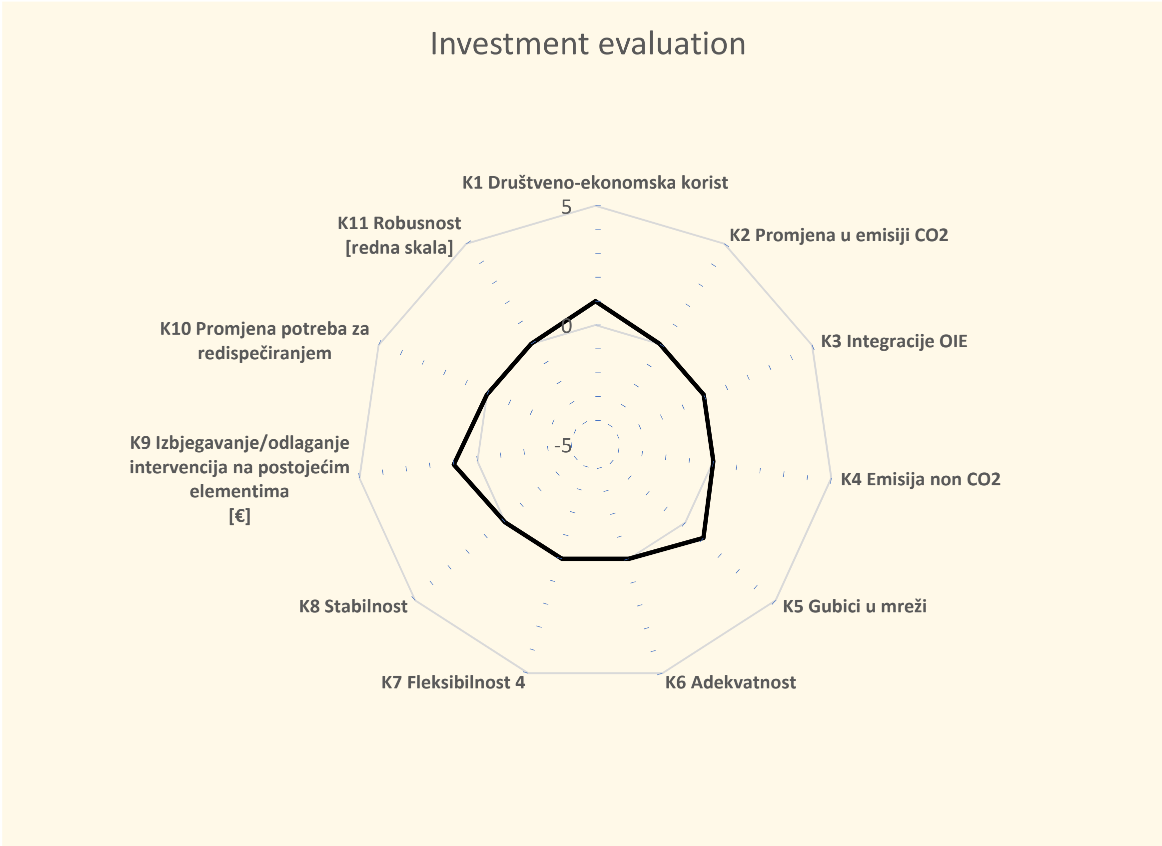
9.2 Construction of 110 kV OHL Virpazar - Ulcinj



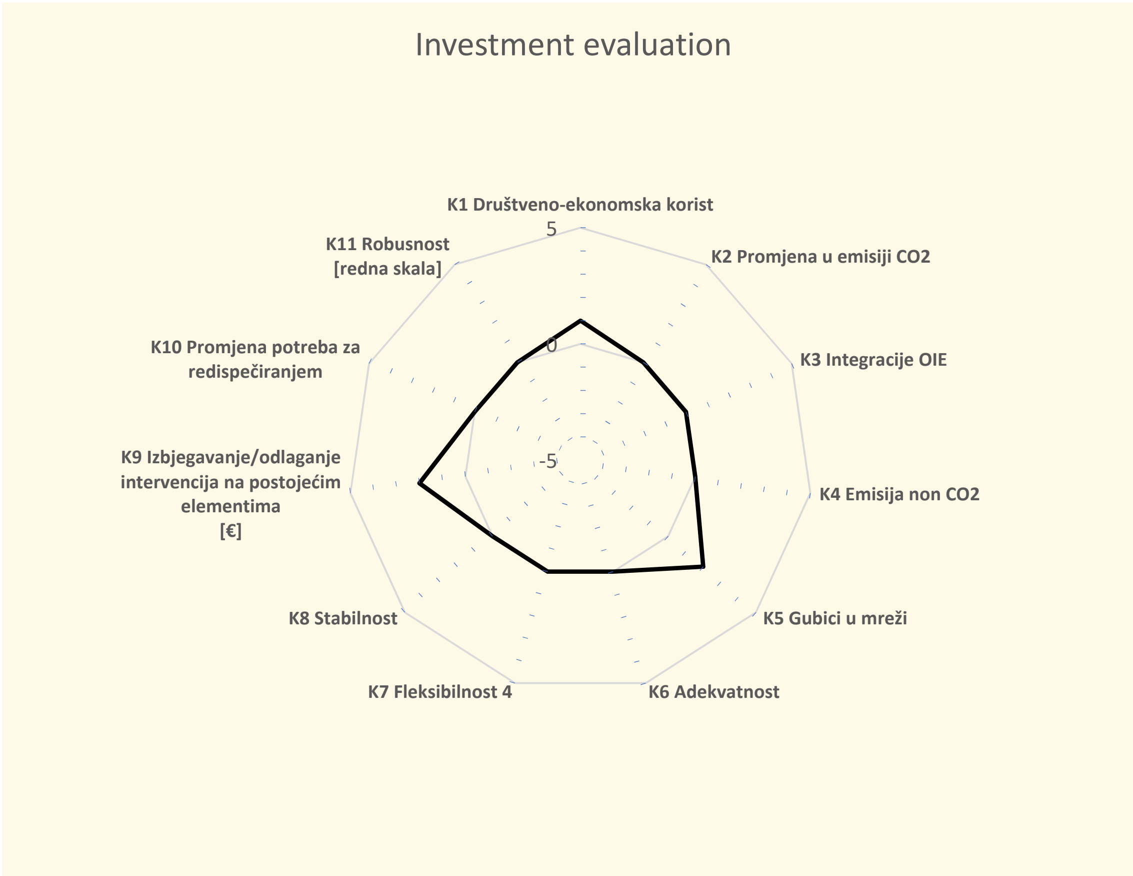
9.3 Revitalization of 110 kV OHL Bar - Možura and 110 kV OHL Možura - Ulcinj



9.4 Procurement of 220/110 kV autotransformer, 150 MVA in SS Podgorica 1



9.5 9.4 Procurement of 220/110 kV autotransformer, 150 MVA in SS Mojkovac



Prepared by	Proposed by
Director of Development and Investment Sector	Executive Director
Dragan Perunović, BScEE	Ivan Asanović, BScEE

10 Literature and input data

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11 Addendum

11.1 Addendum – Input data used to analyse market effects

The new facilities planned by the end of 2032, which are also part of the modelling process are given below.

Table 11-1 Generation facilities by 2032

CGES 2023-2032			
Large hydropower plants			
Facility	Installed capacity [MW]	Planned annual generation [GWh]	Commissioning year
HPP Komarnica	171.9	213	2028
HPP Perućica – Power unit A8	58.5	50	2024
HPP Boka	290		2030
HPP Kruševo	90-120	235	2030
Wind power plants			
Facility	Installed capacity [MW]	Planned annual generation [GWh]	Commissioning year
WPP Brajići	100.8	250	2025
WPP Gvozd	54	150	2023
Solar power plants			
Facility	Installed capacity [MW]	Planned annual generation [GWh]	Commissioning year
SPP Briska Gora	I phase 50	90	2023
	II phase 200	360	2026
SPP Velje Brdo	I phase 50	80	2024
	II phase 100	160	2026
SPP Vilusi I	30	45	2024
SPP Dragalj/Vilusi II	80-150	140 -	2026
SPP Čevo	100	Not decided	Not decided
SPP Slano	39 (50)	(60)	2023
Small hydropower plants			

Facility	Installed capacity [MVA]	Planned annual generation [GWh]	Commissioning year (2021-2023)
Small HPP Bjelojevićka 1 on the watercourse Bjelojevićka, Municipality of Mojkovac	0.92	2.32	2022
Small HPP Bjelojevićka 2 on the watercourse Bjelojevićka, Municipality of Mojkovac	2.250	5.59	2022
Small HPP Otilovići	3.06	11.5	2024

Small hydro power plants are modelled based on equivalent reservoir, while solar panels are made equivalent through negative consumption.

The thermal power plants used in the modelling are as follows[26]:

Rehabilitation/revitalization of the existing				
Facility	Installed power (MW)			Commissioning year of the rehabilitated unit
TPP Pljevlja G1	2018	2021-2023	2023-2032	
	225	225	225	

Since the construction of Unit 2 is not included in the EPCG plan, the analyses will take into account that only one Unit is constantly in operation.

Hydropower plants are as follows:

Br	Hidroelektrana	Tip elektrane: sa nedeljnom akumulacijom, sezonskom akumulacijom, protočna itd…	Jedinica	Van pogona	Nominalna snaga [MW]	Tehnički minimum [MW]	Velčina rezervoara[GWh]
1	HPP Piva	Sezonska akumulacija	3	-	114	70	270
				-	114	70	
				-	114	70	
2	HPP Perucica	Sezonska akumulacija	1	-	38	7	190
			2	-	38	7	
			3	-	38	7	
			4	-	38	7	
			5	-	38	7	
			6	-	58.5	12	
			7	-	58.5	12	
			8	-	58.5	12	

[26] *Data obtained from EPCG*

11.2 Simulation of faults in the selected tie power lines

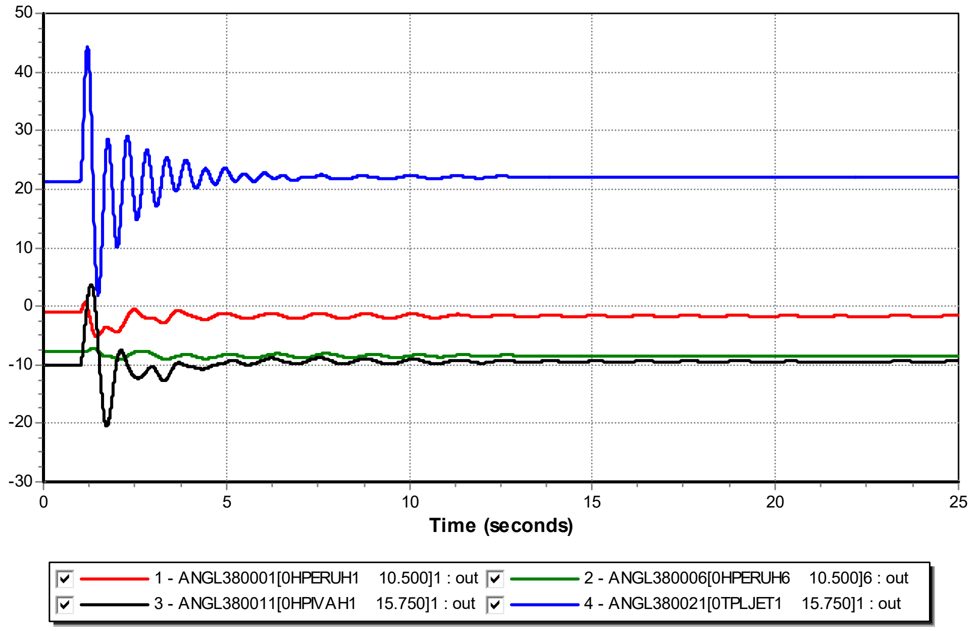

Figure 11-1: Generator angles in case of failure and outage of 220 kV OHL Pljevlja - Mojkovac, winter maximum regime in 2021

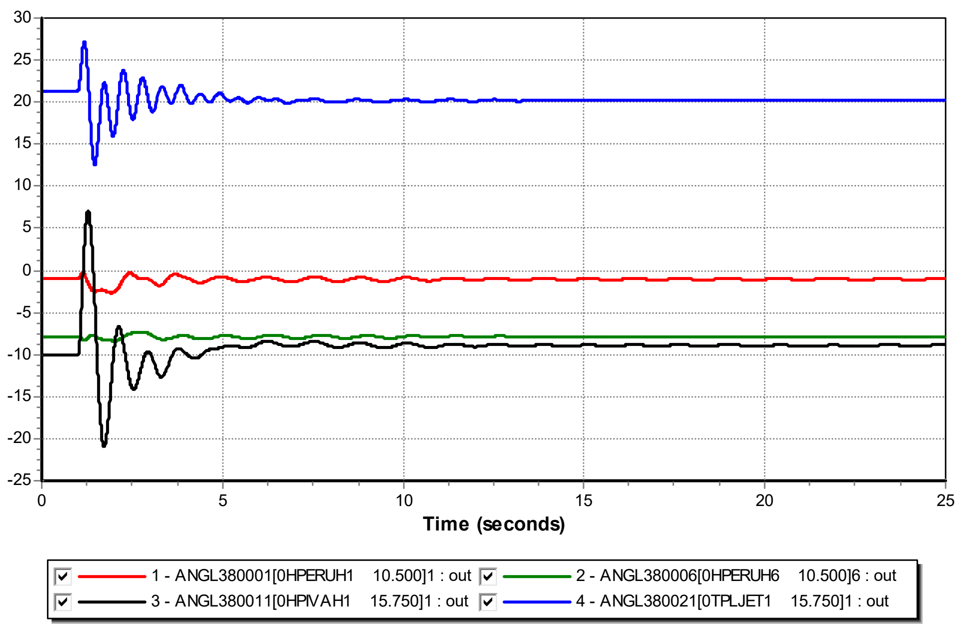

Figure 11-2: Generator angles in case of failure and outage of 220 kV OHL Pljevlja - Piva, winter maximum regime in 2021

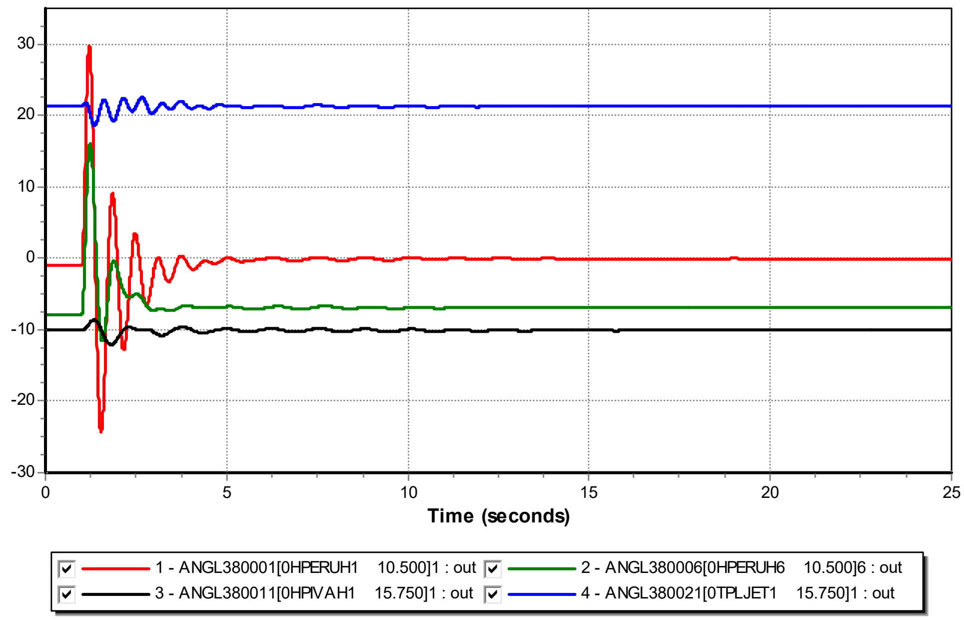

Figure 11-3: Generator angles in case of failure and outage of 110 kV OHL Perućica – Podgorica 1 (1), winter maximum regime in 2021

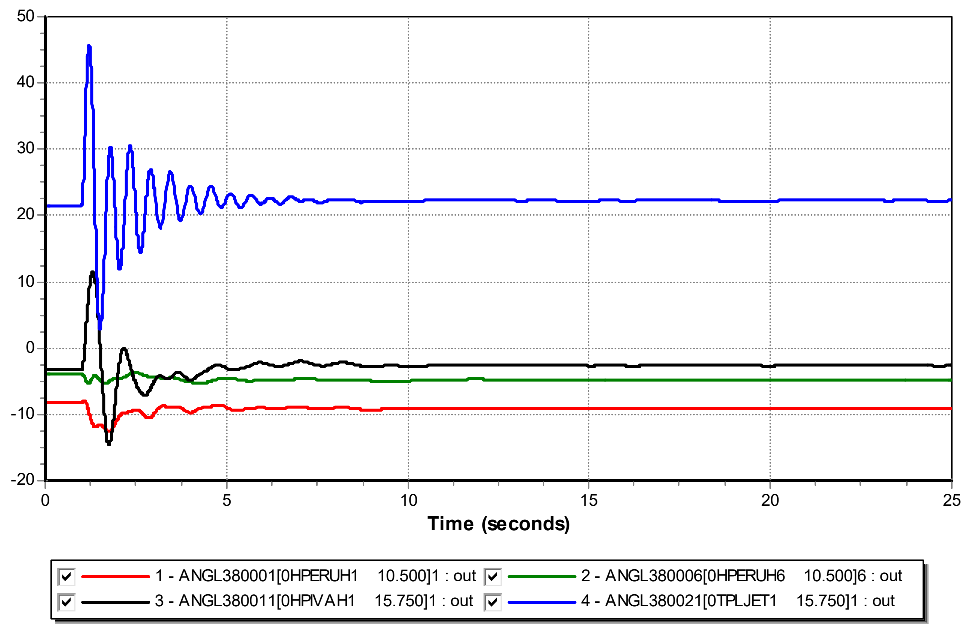

Figure 11-4: Generator angles in case of failure and outage of 220 kV OHL Pljevlja-Mojkovac, summer maximum regime in 2021

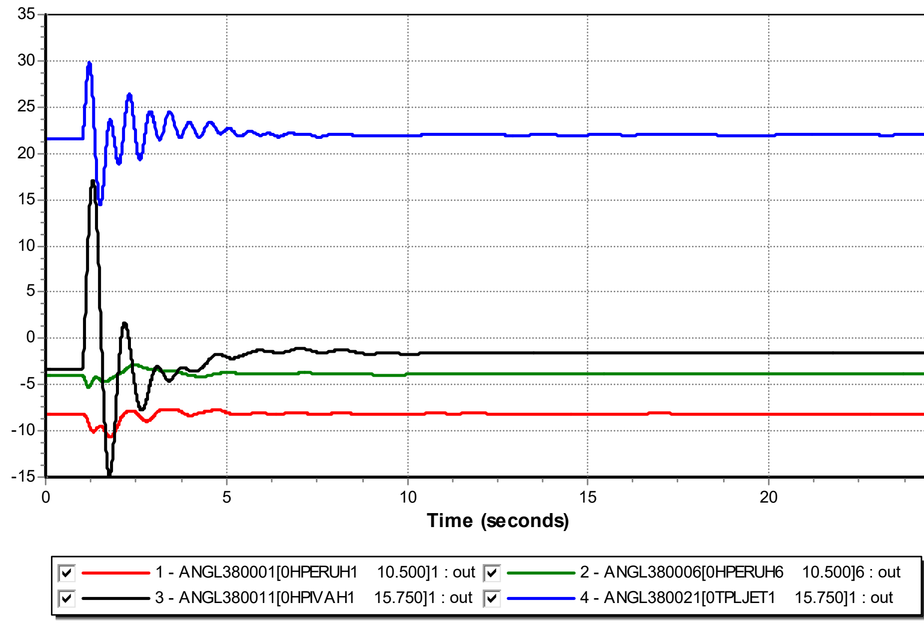

Figure 11-5: Generator angles in case of failure and outage of 220 kV OHL Piva – Sarajevo 20 (BiH), summer maximum regime in 2021

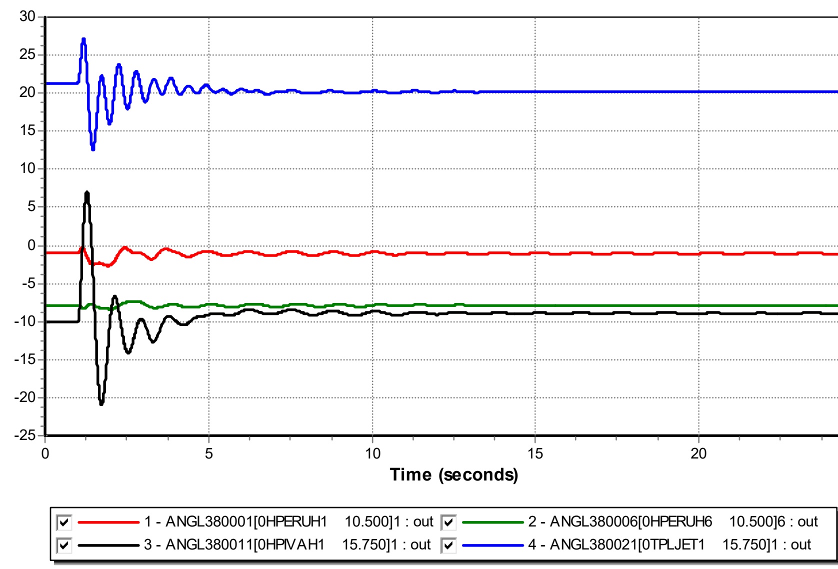

Figure 11-6: Generator angles in case of failure and outage of 220 kV OHL Pljevlja - Piva, winter maximum regime in 2025

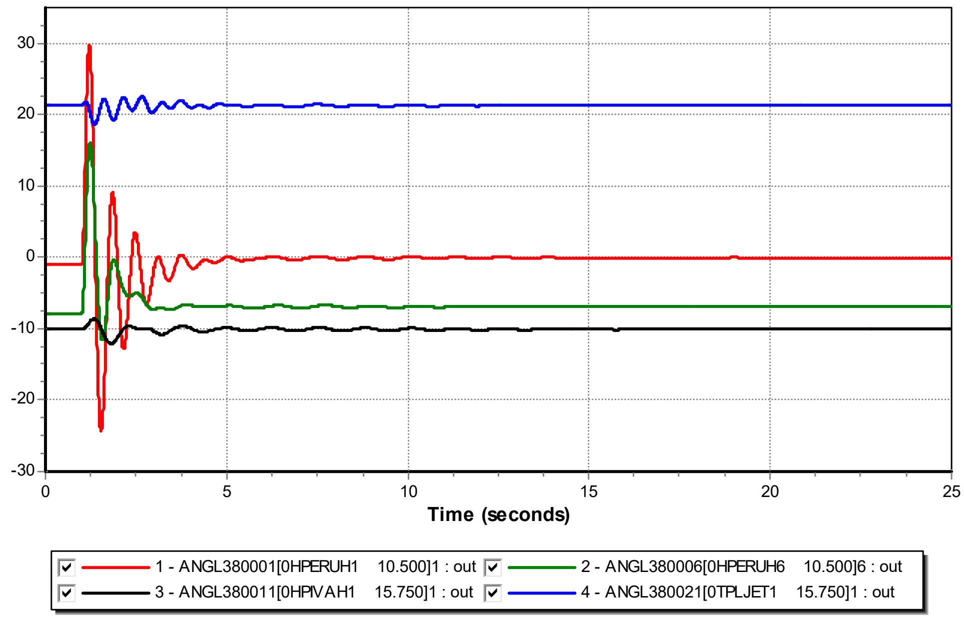

Figure 11-7: Generator angles in case of failure and outage of 110 kV OHL Perućica - Podgorica 1 (1), winter maximum regime in 2025

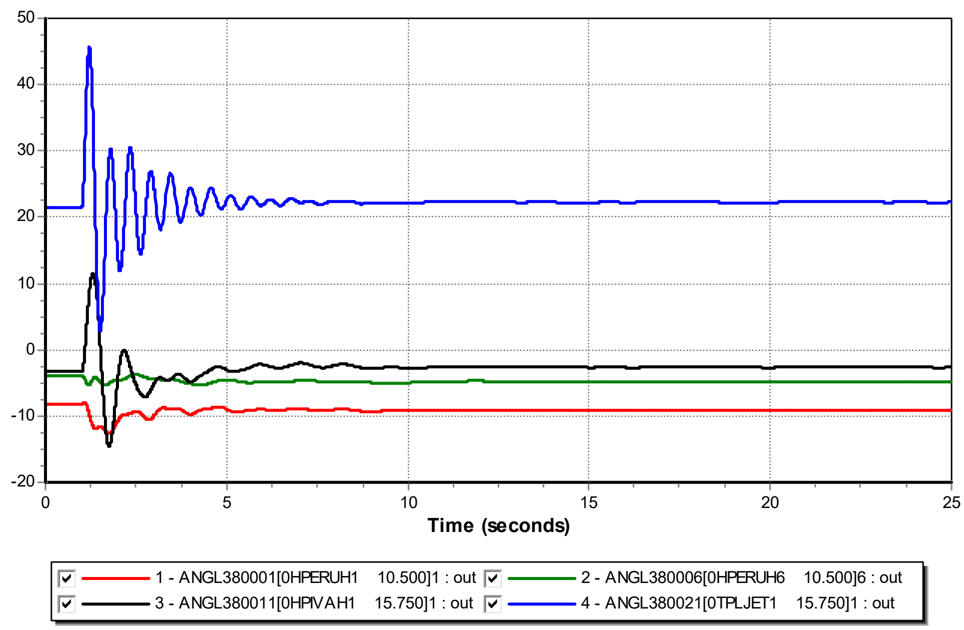

Figure 11-8: Generator angles in case of failure and outage of 220 kV OHL Pljevlja - Mojkovac, summer regime in 2025

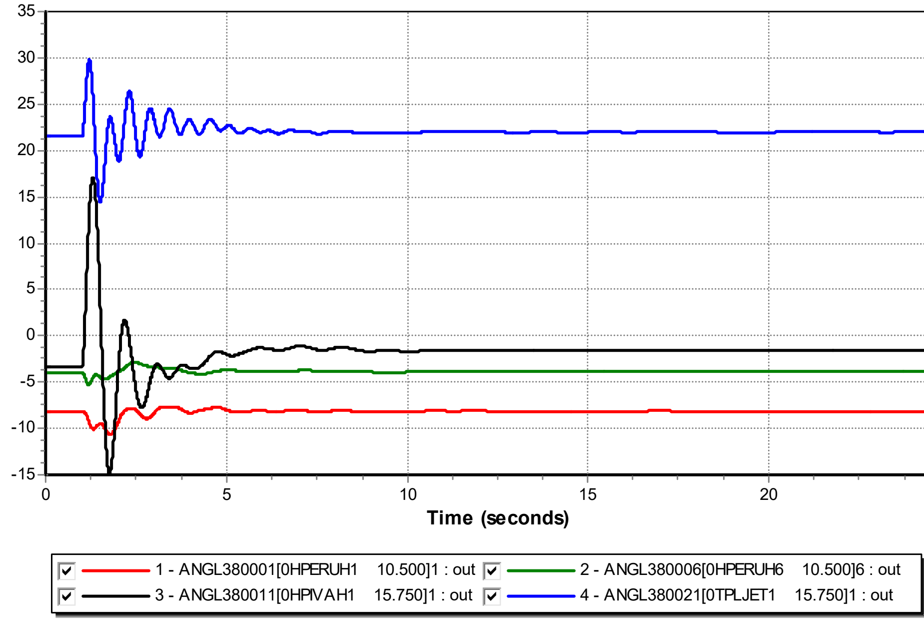

Figure 11-9: Generator angles in case of failure and outage of 220 kV OHL Piva - Sarajevo 20 (BiH), summer regime in 2025

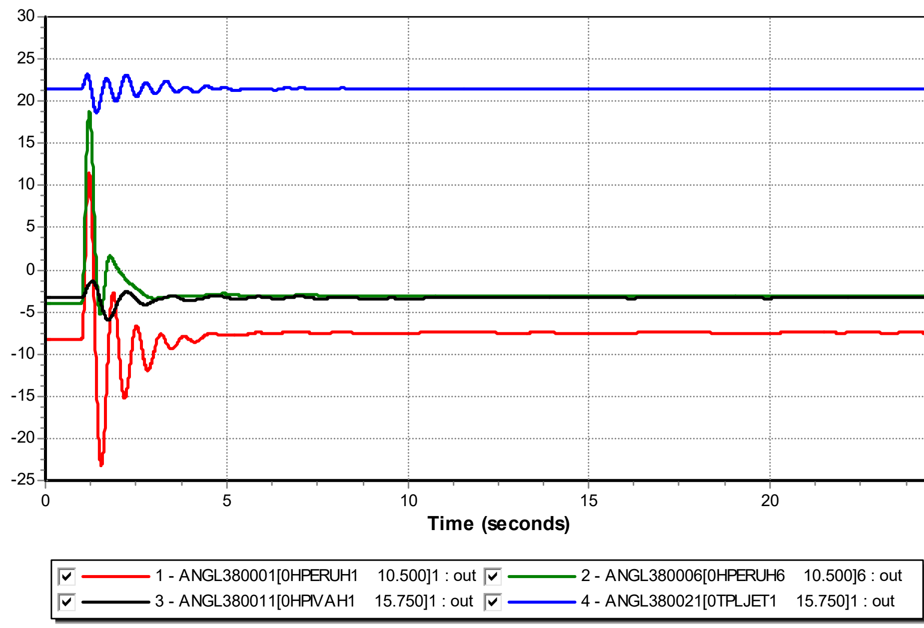

Figure 11-10: Generator angles in case of failure and outage of 110 kV OHL Perućica - Danilovgrad, summer regime in 2025

11.3 Calculation of short-circuit current values

Table 11-2: Short-circuit current values 2021

Čvor		2021					
		Tropolni			Jednopolni		
Naziv	Vn [kV]	I''_{3p} [kA]	I'_{3p} [kA]	I_{3p} [kA]	I''_{3p} [kA]	I'_{3p} [kA]	I_{3p} [kA]
Brezna	400						
Lastva	400	9.324	9.177	8.531	9.374	9.324	9.091
Pljevlja 2	400	9.254	8.892	7.478	8.802	8.689	8.185
Podgorica 2	400	12.402	11.895	9.625	11.779	11.623	10.794
Ribarevine	400	11.851	11.372	9.403	10.573	10.442	9.813
HE Perućica	220	9.417	9.158	7.972	8.144	8.078	7.739
HE Piva	220	11.948	10.913	8.909	12.233	11.850	10.958
Mojkovac	220	7.143	7.021	6.450	5.936	5.908	5.765
Pljevlja 2	220	18.996	17.764	13.911	20.589	20.085	18.187
Podgorica 1	220	12.242	11.867	10.163	11.395	11.284	10.715
Andrijevica	110	4.681	4.657	4.530	3.893	3.887	3.857
Bar	110	5.316	5.281	5.092	5.811	5.796	5.718
Bar 2	110						
Bečići	110						
Berane	110	5.514	5.482	5.312	4.912	4.903	4.857
Bijela	110						
Bijelo Polje	110	9.736	9.636	9.134	10.757	10.716	10.502
Brezna	110	3.989	3.936	3.708	3.338	3.326	3.269
Budva	110	8.631	8.536	8.037	9.141	9.105	8.908
Buljarica	110						
Cetinje	110	7.605	7.532	7.145	7.376	7.353	7.225
Danilovgrad	110	10.616	10.369	9.299	8.448	8.396	8.144
Herceg Novi	110	5.862	5.808	5.522	6.088	6.068	5.959
Igalo	110						
KAP	110	17.588	17.200	15.324	15.432	15.330	14.793
Kličevo	110	11.169	10.772	9.246	11.563	11.418	10.789
Kolašin	110						
Kotor	110	5.201	5.165	4.965	5.456	5.442	5.366
Lastva	110	18.982	18.771	17.826	21.887	21.793	21.354
Luštica	110						
Mateševo	110						
Mojkovac	110	8.606	8.526	8.121	9.436	9.403	9.234
Možura	110						
Mrke	110						
Nikšić	110	12.666	12.159	10.254	13.888	13.679	12.789
Nikšić - Željezara	110	12.666	12.159	10.254	13.888	13.679	12.789
Pljevlja 1	110	7.119	6.984	6.600	7.420	7.370	7.222
Pljevlja 2	110	7.461	7.321	6.907	7.905	7.852	7.687
Podgorica 1	110	24.992	24.117	20.281	28.775	28.380	26.420
Podgorica 2	110	26.065	25.219	21.379	29.449	29.082	27.204
Podgorica 3	110	17.886	17.446	15.388	18.397	18.239	17.427
Podgorica 4	110	18.613	18.219	16.302	17.082	16.970	16.373
Podgorica 5	110	17.212	16.806	14.896	17.334	17.195	16.475
Podgorica 6 (I)	110						
Podgorica 6 (II)	110						
Podgorica 7	110						
Podgorica 8	110						
SE Briska gora	110						
SE Slano	110						
SE Velje brdo	110						
SE Dragalj	110						
SE Čevo	110						
Tivat	110	6.151	6.100	5.823	6.837	6.816	6.696
Trebješica	110	5.231	5.198	5.025	3.667	3.662	3.633
Tuzi	110						
Ulcinj	110	2.908	2.898	2.840	3.113	3.109	3.087
VE Brajići	110						
VE Gvozd	110						
VE Krnovo	110	3.630	3.598	3.474	3.923	3.911	3.861
Vilusi	110	6.206	6.125	5.742	4.765	4.749	4.669
Virpazar	110	6.043	5.998	5.757	5.703	5.690	5.615
Žabljak	110						

Table 11-3: Short-circuit current values 2025

Čvor		2025					
		Tropolni			*Jednopolni*		
Naziv	Vn [kV]	I''_{3p} [kA]	I'_{3p} [kA]	I_{3p} [kA]	I''_{3p} [kA]	I'_{3p} [kA]	I_{3p} [kA]
Brezna	400						
Lastva	400	9.920	9.763	9.076	9.973	9.919	9.671
Pljevlja 2	400	10.965	10.713	9.645	10.373	10.297	9.943
Podgorica 2	400	10.988	10.704	9.457	11.347	11.244	10.748
Ribarevine	400	12.085	11.806	10.424	11.043	10.964	10.531
HE Perućica	220	9.807	9.638	8.969	7.484	7.451	7.311
HE Piva	220	12.383	11.479	10.084	12.204	11.897	11.354
Mojkovac	220	7.226	7.149	6.819	5.975	5.958	5.879
Pljevlja 2	220	21.247	20.431	17.822	22.674	22.356	21.224
Podgorica 1	220	12.675	12.379	11.173	11.661	11.576	11.199
Andrijevica	110	4.695	4.679	4.603	3.898	3.895	3.877
Bar	110	7.335	7.299	7.131	7.580	7.567	7.506
Bar 2	110	14.190	14.051	13.396	16.694	16.629	16.315
Bečići	110	8.912	8.863	8.633	7.887	7.874	7.812
Berane	110	5.525	5.505	5.404	4.917	4.911	4.884
Bijela	110						
Bijelo Polje	110	9.771	9.710	9.410	10.792	10.768	10.642
Brezna	110	8.134	8.005	7.553	7.372	7.336	7.204
Budva	110	16.839	16.726	16.285	16.488	16.452	16.309
Buljarica	110	8.488	8.441	8.222	7.512	7.499	7.440
Cetinje	110	10.175	10.103	9.774	9.028	9.009	8.920
Danilovgrad	110	11.264	11.034	10.215	8.723	8.676	8.498
Herceg Novi	110	7.557	7.523	7.363	7.295	7.284	7.233
Igalo	110						
KAP	110	18.793	18.480	17.170	16.256	16.177	15.825
Kličevo	110	13.428	12.974	11.536	13.436	13.282	12.740
Kolašin	110						
Kotor	110	14.198	14.088	13.582	13.909	13.874	13.706
Lastva	110	20.193	19.970	18.963	23.284	23.184	22.717
Luštica	110	15.073	14.950	14.383	14.864	14.824	14.634
Mateševo	110	4.996	4.976	4.883	3.535	3.531	3.516
Mojkovac	110	8.647	8.597	8.363	9.463	9.443	9.348
Možura	110	3.984	3.974	3.926	4.401	4.397	4.377
Mrke	110	11.495	11.368	10.826	8.512	8.489	8.385
Nikšić	110	15.241	14.651	12.820	16.243	16.014	15.223
Nikšić - Željezara	110	15.241	14.651	12.820	16.243	16.014	15.223
Pljevlja 1	110	8.846	8.803	8.604	8.822	8.808	8.741
Pljevlja 2	110	9.024	8.977	8.767	9.164	9.148	9.074
Podgorica 1	110	27.660	26.889	23.927	31.725	31.381	29.939
Podgorica 2	110	30.321	29.722	29.722	33.835	33.584	33.584
Podgorica 3	110	19.042	18.685	17.238	19.420	19.295	18.753
Podgorica 4	110	22.850	22.359	20.376	22.628	22.466	21.757
Podgorica 5	110	18.258	17.932	16.601	18.283	18.173	17.694
Podgorica 6 (I)	110						
Podgorica 6 (II)	110						
Podgorica 7	110	17.493	17.209	16.026	16.423	16.339	15.966
Podgorica 8	110						
SE Briska gora	110	8.640	8.585	8.322	7.010	6.998	6.939
SE Slano	110	15.241	14.651	12.820	16.243	16.014	15.223
SE Velje brdo	110	28.990	28.305	26.825	32.780	32.483	31.762
SE Dragalj	110						
SE Čevo	110						
Tivat	110	13.486	13.388	12.931	13.503	13.470	13.312
Trebješica	110	5.275	5.252	5.147	3.683	3.680	3.662
Tuzi	110						
Ulcinj	110	3.508	3.500	3.464	3.837	3.834	3.819
VE Brajići	110	12.130	12.023	11.543	10.870	10.841	10.707
VE Gvozd	110	8.180	8.037	7.544	8.246	8.197	8.019
VE Krnovo	110	7.911	7.783	7.337	8.061	8.016	7.852
Vilusi	110	6.608	6.559	6.370	3.641	3.636	3.616
Virpazar	110	9.047	8.988	8.714	7.947	7.932	7.859
Žabljak	110	7.474	7.400	7.206	6.593	6.573	6.521

Table 11-4: Short-circuit current values 2032

Čvor		2032					
		Tropolni			*Jednopolni*		
Naziv	Vn [kV]	I''_{3p} [kA]	I'_{3p} [kA]	I_{3p} [kA]	I''_{3p} [kA]	I'_{3p} [kA]	I_{3p} [kA]
Brezna	400	11.018	10.707	9.762	11.270	11.159	10.796
Lastva	400	11.289	11.064	10.224	11.159	11.085	10.789
Pljevlja 2	400	16.241	15.801	14.112	15.048	14.920	14.378
Podgorica 2	400	14.005	13.491	11.452	14.182	14.002	13.190
Ribarevine	400	14.927	14.521	12.667	13.153	13.046	12.499
HE Perućica	220	10.269	10.096	9.451	7.695	7.662	7.532
HE Piva	220	12.357	11.443	10.039	12.210	11.897	11.347
Mojkovac	220	7.405	7.318	6.978	6.071	6.051	5.971
Pljevlja 2	220	20.605	19.754	17.180	22.650	22.298	21.108
Podgorica 1	220	13.504	13.172	11.910	12.265	12.172	11.787
Andrijevica	110	5.652	5.557	5.339	4.662	4.640	4.588
Bar	110	7.256	7.214	7.042	7.603	7.587	7.522
Bar 2	110	15.262	15.082	14.311	17.741	17.659	17.296
Bečići	110	8.797	8.741	8.515	7.827	7.812	7.750
Berane	110	24.197	23.069	20.785	27.504	27.004	25.894
Bijela	110	8.871	8.827	8.636	8.346	8.333	8.275
Bijelo Polje	110	10.397	10.299	9.936	11.342	11.303	11.153
Brezna	110	24.197	23.069	20.785	27.504	27.004	25.894
Budva	110	16.473	16.277	15.518	15.926	15.864	15.616
Buljarica	110	8.378	8.325	8.109	7.454	7.440	7.381
Cetinje	110	10.238	10.152	9.820	9.031	9.009	8.919
Danilovgrad	110	12.015	11.772	10.972	9.047	9.001	8.837
Herceg Novi	110	7.552	7.518	7.370	7.462	7.451	7.401
Igalo	110	7.417	7.384	7.238	6.844	6.834	6.791
KAP	110	20.191	19.745	18.185	17.062	16.954	16.548
Kličevo	110	19.431	18.710	16.723	18.147	17.932	17.276
Kolašin	110	8.852	8.787	8.534	9.613	9.587	9.485
Kotor	110	14.357	14.235	13.746	14.097	14.057	13.895
Lastva	110	20.801	20.541	19.526	23.890	23.775	23.308
Luštica	110	13.208	13.105	12.689	12.528	12.497	12.369
Mateševo	110	7.166	6.946	6.545	5.555	5.511	5.423
Mojkovac	110	8.942	8.876	8.620	9.710	9.684	9.580
Možura	110	3.818	3.806	3.758	4.350	4.345	4.324
Mrke	110	13.069	12.406	11.236	11.554	11.376	11.029
Nikšić	110	21.308	20.422	17.974	21.217	20.916	19.987
Nikšić - Željezara	110	21.308	20.422	17.974	21.217	20.916	19.987
Pljevlja 1	110	9.194	9.141	8.936	9.168	9.151	9.081
Pljevlja 2	110	9.311	9.254	9.036	9.445	9.425	9.349
Podgorica 1	110	31.331	30.086	26.276	35.914	35.355	33.455
Podgorica 2	110	32.244	31.118	27.411	36.045	35.566	33.823
Podgorica 3	110	20.653	20.124	18.383	20.955	20.771	20.115
Podgorica 4	110	25.097	24.357	21.919	24.610	24.368	23.498
Podgorica 5	110	19.723	19.244	17.653	19.584	19.424	18.852
Podgorica 6 (I)	110	20.399	23.123	22.494	21.701	21.513	20.832
Podgorica 6 (II)	110	26.720	25.810	22.955	27.166	26.846	25.736
Podgorica 7	110	18.757	18.349	16.950	17.297	17.179	16.748
Podgorica 8	110	24.585	23.826	21.395	25.510	25.232	24.260
SE Briska gora	110	8.998	8.930	8.638	7.181	7.166	7.102
SE Slano	110	21.308	20.422	17.974	21.217	20.916	19.987
SE Velje brdo	110	31.787	30.602	26.844	35.979	35.460	33.639
SE Dragalj	110	6.755	6.713	6.562	3.631	3.627	3.612
SE Čevo	110	11.153	10.885	9.993	11.215	11.122	10.793
Tivat	110	13.205	13.103	12.689	13.370	13.335	13.189
Trebješica	110	6.269	6.087	5.721	4.608	4.575	4.503
Tuzi	110	8.309	8.221	7.910	6.824	6.804	6.731
Ulcinj	110	3.378	3.369	3.332	3.798	3.794	3.778
VE Brajići	110	12.849	12.744	12.403	11.267	11.240	11.151
VE Gvozd	110	12.917	12.657	12.050	11.768	11.695	11.517
VE Krnovo	110	13.847	13.496	12.649	12.486	12.390	12.141
Vilusi	110	6.893	6.850	6.696	3.705	3.701	3.686
Virpazar	110	9.250	9.176	8.879	8.092	8.073	7.994
Žabljak	110	7.588	7.512	7.316	6.693	6.674	6.621

11.4 Power flows and voltage conditions

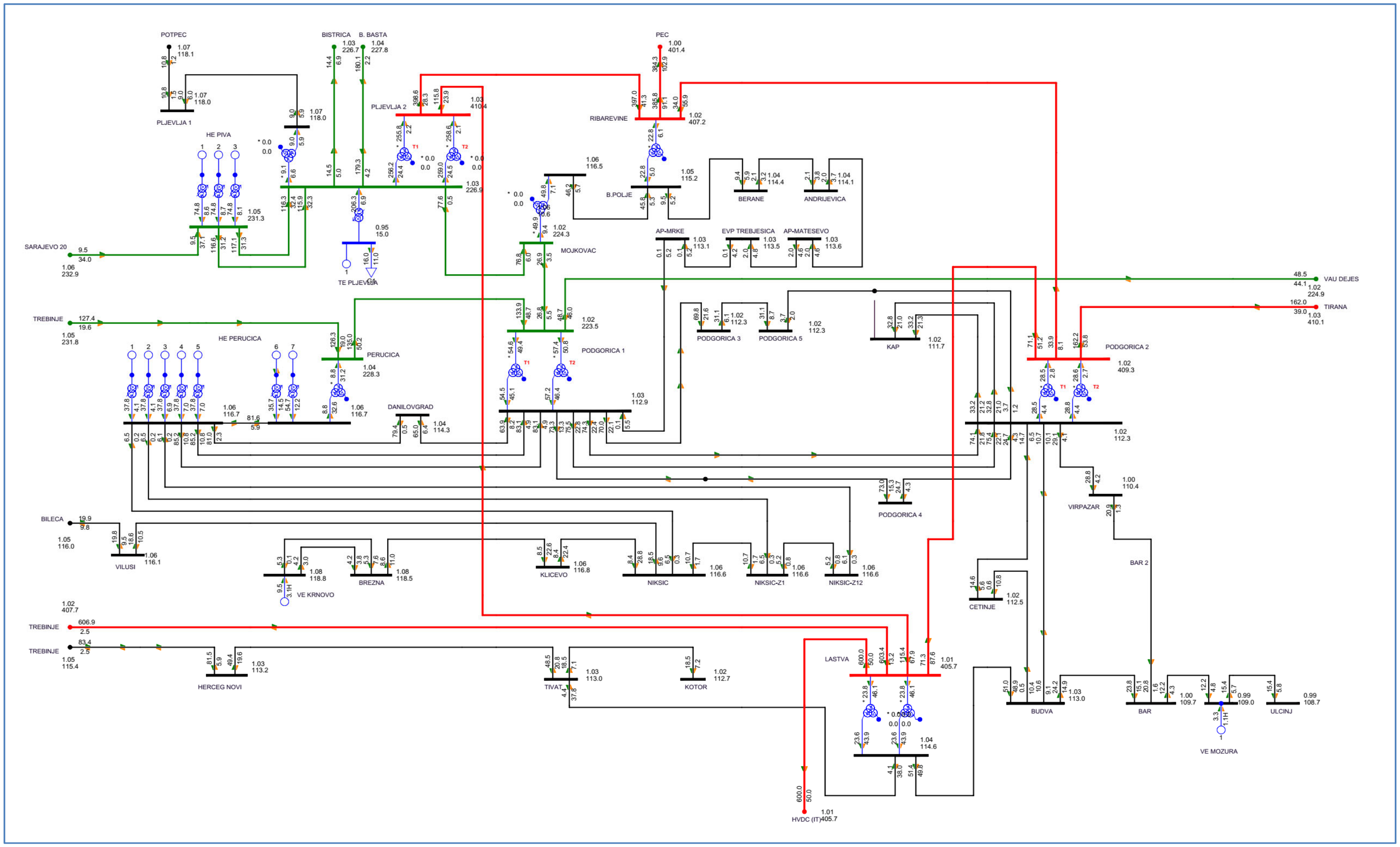

Figure 11-11: Power flows and voltage conditions in the transmission network of Montenegro for the high transit regime 2021

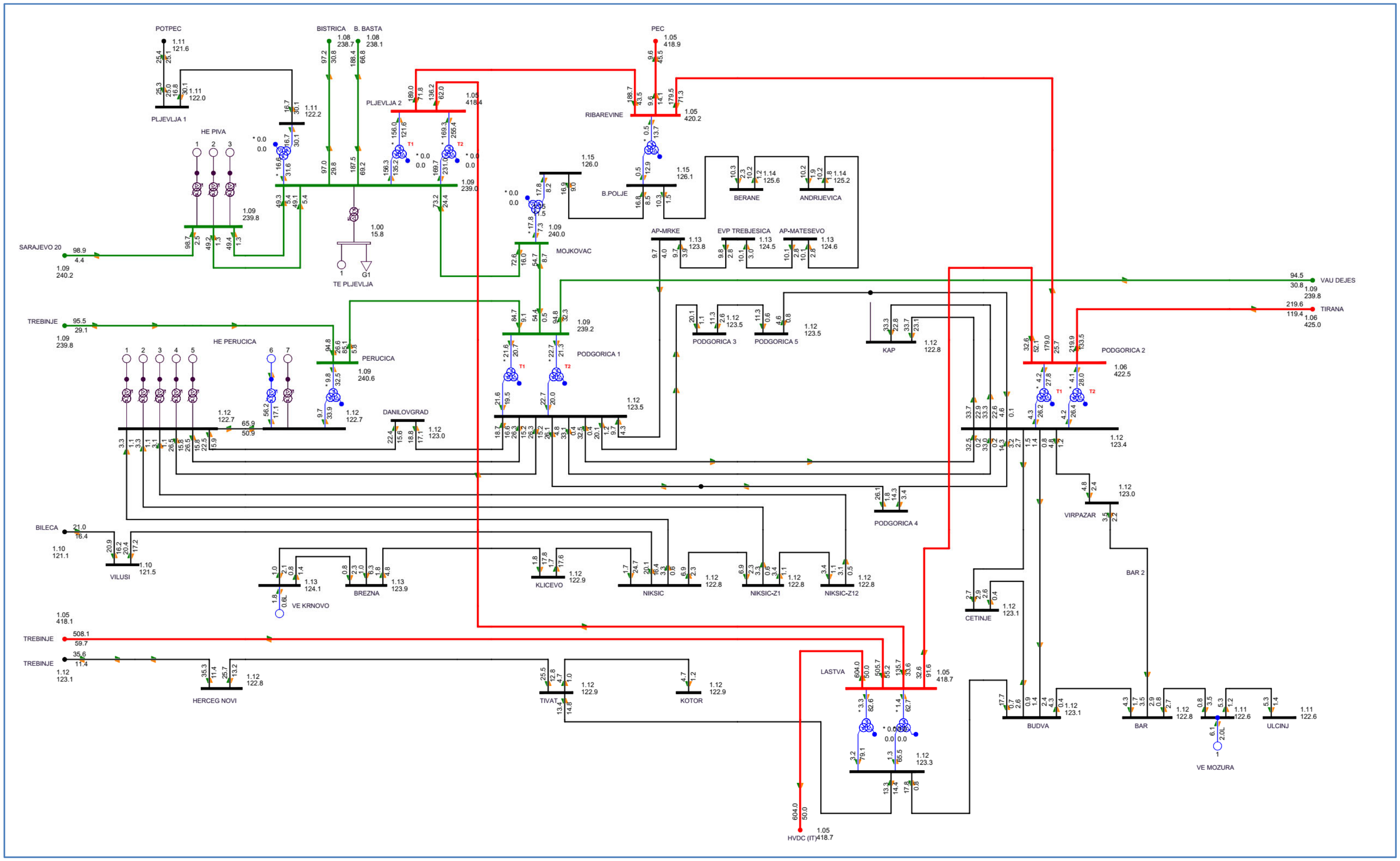

Figure 11-12: Power flows and voltage conditions in the transmission network of Montenegro for low load regime 2021

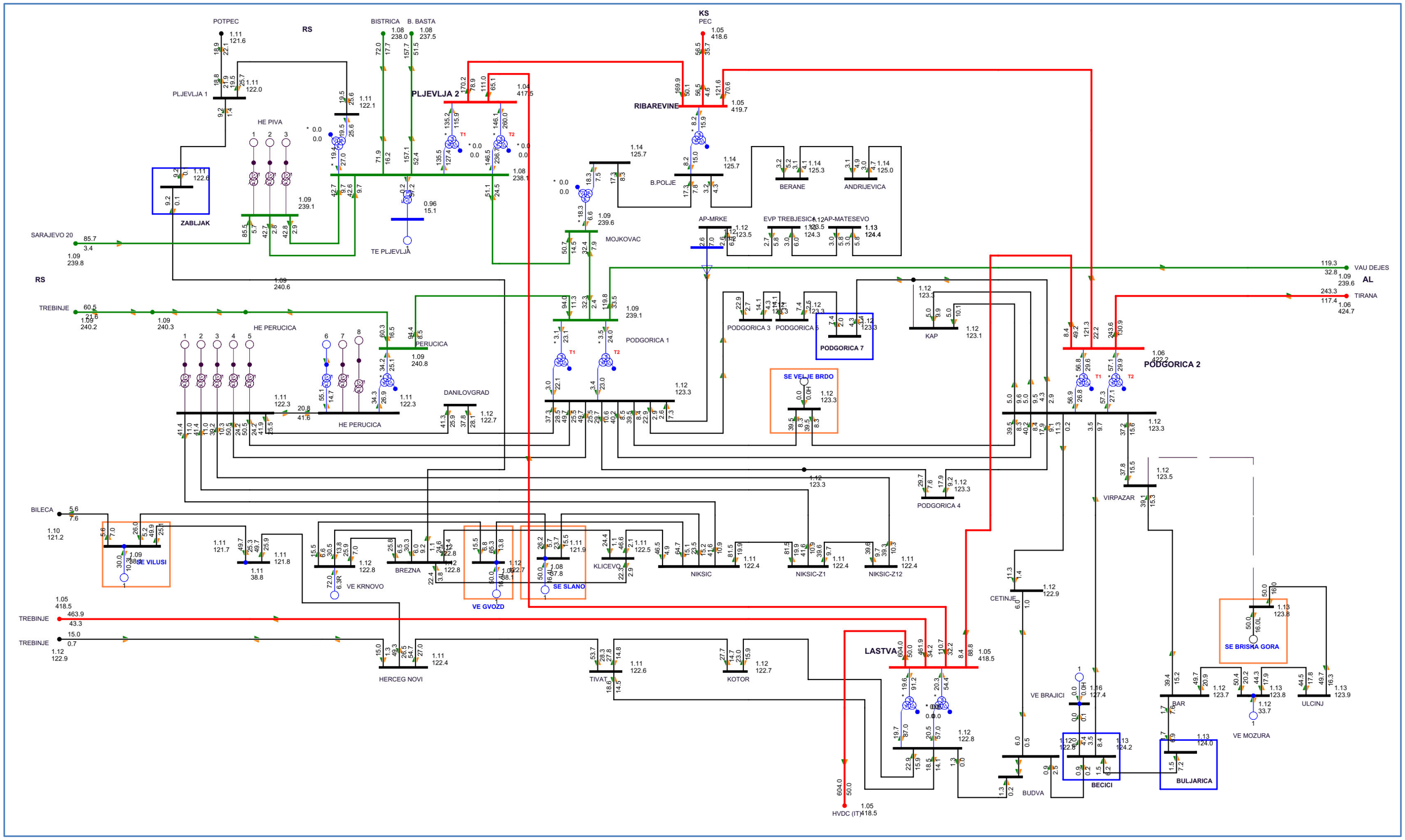

Figure 11-13: Transmission network topology for 2025

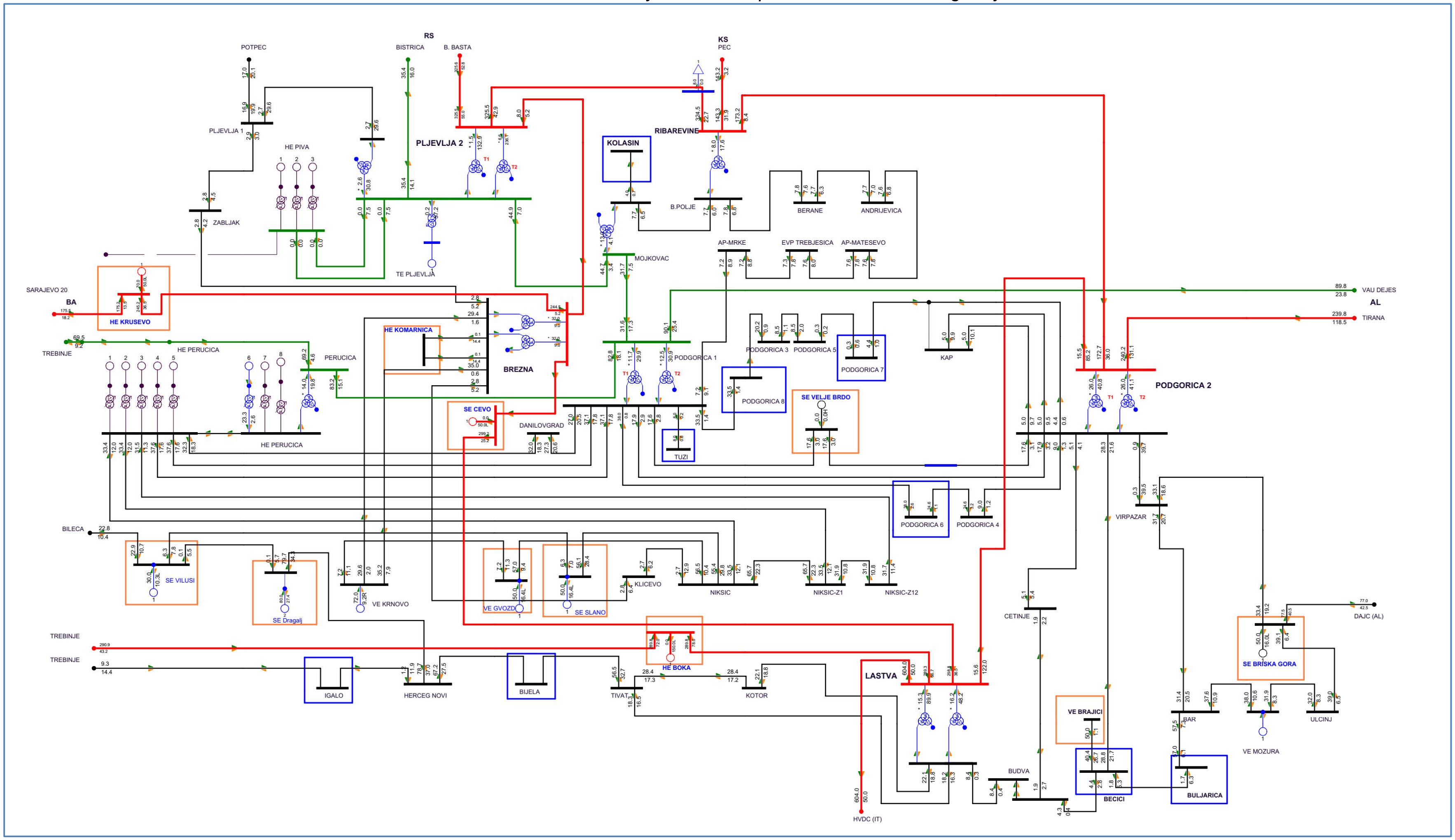

Figure 11-14: Transmission network topology for 2032

11.4.1 Connection of SS Bečići - Technical and economic analysis CEDIS (separate Addendum)