Ten-Year Network Development Plan of Georgia 2021-2031

Transmission System Operator JSC “Georgian State Electrosystem”

Legal basis of Ten Year Network Development Plan

Ten Year Network Development Plan of Georgia is elaborated according of "Law Of Georgia On Electricity And Water Supply"

Author of Ten Year Network Development Plan

Ten Year Network Development Plan of Georgia is elaborated by the TSO of Georgia JSC Georgian State Electrosystem (GSE) by agreement with agreement of transmission licensees LTD Energotrans and JSC Sakrusenergo.

The consultations regarding use of information, materials and analysis given in in Ten Year Network Development Plan, also about the implementation of requirements of this plan may be provided by TSO. Tel.: +(99532) 2 510 202.

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The discussion and approval of Ten Year Network Development Plan

The plan discussed and agreed by the Government on February 11 of 2021 session.

The plan approved by the Minister of Economy and Sustainable Development of Georgia on February 17, 2021 by #1-1/42 order.

Ministry of Economy and Sustainable Development of Georgia, Georgian National Energy and Water Supply Regulatory Commission the transmission system operator, electricity transmission licensees, other agencies and interested took part in discussions of Ten Year Network Development Plan.

Action of Ten Year Network Development Plan

Ten Year Network Development Plan is obligatory implemented act.

The plan is designed for the period 2021 to 2031 (inclusive).

Licensees/subjects responsible for implementation of the plan are shown in Annex D-4.

The implementation of Ten Year Network Development Plan is controlled by the Ministry of Economy and Sustainable Development of Georgia.

Document content

The current document is a printable English version of the ten-year network development plan of Georgia for 2021-2031, which, unlike the Georgian full document, only includes the following sections:

Main document

1. Executive Resume;
2. List of existing and perspective power plants;
3. Identified projects and investment needs for Infrastructure strengthening.

Annexes

1. Cost estimates of planned projects;
2. Map of transmission network of Georgia.

Full version of the document is only available in Georgian language. To get its electronic version, please see the link below from GSE's official web site:

http://www.gse.com.ge/sw/static/file/TYNDP_GE-2021-2031_GEO.pdf

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Annexes:

1 Executive Resume

Electric power sector composes an important part of the national economy having enormous influence on the social status of Georgia's population, and therefore development of the energy infrastructure constitutes the countrywide strategic goal.

The emerged cross-border electricity trade opportunities, high electricity demand growth and need for evacuation of the energy generated by the planned power plants, call for investments in the transmission infrastructure for ensuring adequate development of the network. Such objective targets availability of the transmission network capable ensuring of the consistent response to generation and demand growth by reliable and safe transportation of electricity, without any interruptions caused by outage of any single network element.

This Ten-Year Plan presents the time-tagged program designed for reinforcing infrastructure of the national transmission system, addressing the existing problems, responding to the future challenges and implementing the opportunities. It assumes adequate evolution of Georgian power system considering realistic scenarios and projects relevant to 2021-2031 time span.

The Ten-Year Plan aims at presentation and analysis of the future environment and reduction of uncertainties to obtain plausible projections and establish unified and well-structured vision about transmission grid development.

In general, development of the transmission system is a long-term process targeting reinforcement, expansion and upgrading of the network in line with generation and demand growth.

This document covers all components relevant to the development of Georgian power system. However, other projects that are not included in this Ten-Year Plan may also be reviewed in current and/or subsequent years. In addition, some projects described herein may be modified, implemented in shorter timeframes or delayed. All such changes will be accounted for in 2022-2032 version of this plan.

The goal of GSE is development of stable, reliable, cost-effective and efficient transmission system ensuring at any development stage:

- Security of Supply, network reliability, Power quality;
- Sufficient transfer capacity for fulfilling increased consumption, integration of renewable energy sources into the network and power exchange with neighboring countries;
- Preparedness for integration into ENTSO-E's Ten-Year Network Development Plan.

The reason of long-term development planning is explained by the need for the future transmission network satisfying all applicable design requirements, main from which is **single contingency (N-1) criterion**.

In case additional reasonable projects will be identified, they will be considered in the next Ten-Year Network Development Plan of Georgia.

The planning process shall consist of the following major stages:

- Data collection;
- Data processing;

- Modelling;
- removing or mitigating any deficiencies;
- Preparation of the unified transmission grid development plan.

Fig. 1.1 Preparation stages of Unified Georgian Transmission Network Development Plan

1.1 Data Management

Inputs for Ten year Plan include: Information on installed capacities, outputs, geographical locations, categories and their commissioning years of the planned hydropower plants as well as decommissioning dates of aged power plants represent; forecasted characters of consumption growth in power system; agreements with neighboring countries about construction of cross-border infrastructure; Assignments from Ministry of Economy and Sustainable Development of Georgia and memorandums of Georgian government, based on which changes in projects are implemented; Minimal technical requirements on power plants and their units and specific requirements on back-to-back stations.

1.2 Planning Period

The planning period was divided into the following three time spans:

Short-Term Planning Period extended over 3 years after the base year (2020), i.e. the period of 2021-2023.

2. **Mid-Term Planning Period**, covering 4th and 5th years from the base year (2020), i.e. the period of 2024-2025.

3. **Long-Term Planning Period**, including 6th to 10th years from the base year (2020), i.e. the period from 2026 to 2031.

1.3 Operating strategy, security of supply and adequacy level of Power system

Operation strategy. For purposes of analyzing power system security and designing appropriate control systems, it is helpful to conceptually classify the system-operating conditions into five states: normal, alert, emergency, in extremis and restorative.

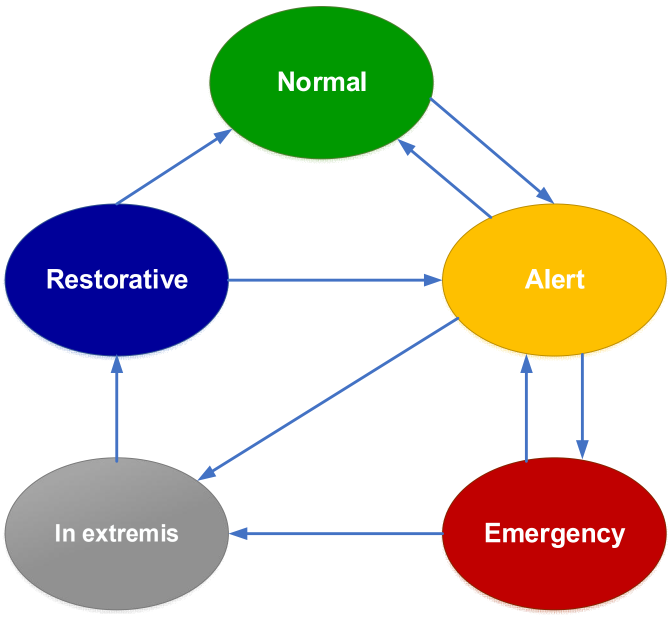

Fig. 1.2 Power system operating states

In the normal state, all system variables are within the normal range and no equipment is being overloaded. The system operates in a secure manner and is able to withstand a contingency without violating any of the constraints. This means there are enough reserves of generation in power system as well as enough reserves of transmission system capacity. System meets N-1, G-1 and N-G-1 conditions.

The system enters the alert state if the security level falls below a certain limit of adequacy, or if the possibility of a disturbance increases because of adverse weather conditions such as the approach of severe storms. In this state, all system variables are still within the acceptable range and all constraints are met. However, the system has been weakened to a level where a contingency may cause an overloading of equipment that places the system in an emergency state. If the disturbance is very severe, the in extremis (or extreme emergency) state may result directly from the alert state.

Preventive action, such as generation shifting (security dispatch) or increased reserve, can be taken to restore the system to the normal state. If the restorative steps do not succeed, the system remains in the alert state.

The system enters the emergency state if a sufficiently severe disturbance occurs when the system is in the alert state. In this state, voltages at many buses are low and/or equipment loadings exceed short-term emergency ratings. The system is still intact and may be restored to the alert state by the initiating of emergency control actions: fault clearing, excitation control, fast-valving, generation tripping, generation run-back, HVDC modulation, and load curtailment. If the above measures are not applied or are ineffective, the system is in extremis; the result is cascading outages of possibly a shut-down of a major portion of the system. Control actions, such as load shedding and controlled system separation, are aimed at saving as much of the system as possible from a widespread blackout.

The restorative state represents a condition in which control action is being taken to reconnect all the facilities and to restore system load. The system transits from this state to either the alert state or the normal state, depending on the system conditions.

Whenever all elements are in normal state as well as all parameters are within their normal range, operation of Georgian transmission network corresponds to the "alert state". Therefore, **the most critical problem of Georgian transmission network is security of supply and leitmotif of transmission network development within next ten years will be security of supply** and **its improvement as well as upgrade of system reliability.**

1.4 Bottlenecks and Development Drivers of Georgian Transmission Network

Main network bottlenecks. Georgian transmission network is predominantly oriented from west to east. The most of the energy is generated in the west part of the country (total installed capacity of the HPPs located at the west amounts to 2510 MW), with the main consumption in the east part (Tbilisi-Rustavi node). Such imbalance is especially explicit during spring and summer, when due to the high water flows available in Georgian rivers, the thermal power units located at the east (near Gardabani) are not operated, and the power flows in the west-to-east direction.

The problem is faced in the west part of the system (500/220 kV mains along Enguri-Zestaponi route) during tripping of 500 kV OHL Imereti, because 220 kV mains are unable to transfer full load flow. Cross border lines of Georgian transmission network are not basically backed-up and their outages create risk of emergency. Furthermore, there are several 220 kV dead-end lines trip of which is some threat for system stability.

In the recent years, following the power consumption, the peak loading of substations has increased sharply* , especially in Tbilisi and Batumi nodes. N-1 criteria is not fulfilled in some substations, which means the restriction of the consumers will be necessary in case of outage of one of the (auto)transformers.

Below are listed weaknesses experienced along this route:

- Non backed-up Interconnetion lines:
  - Kavkasioni, 500 kV;
  - Gardabani, 330 kV;
  - Alaverdi, 220 kV;
  - Meskheti, 400 kV;
  - Adjara, 220 kV;
- Radial/inadequately backed-up Network of West Georgia:
  - Imereti, 500 kV;
  - Zekari, 500 kV;
  - Autotransformer at Enguri, 500/220 kV;
  - Egrisi 1,2, 220 KV;

* - with an exclusion of COVID-19 pandemic period

  - Kolkhida 2a, 220 KV;
  - Kolkhida 2, 220 KV;
- Batumi supply grid:
  - Paliastomi 1,2, 220 KV;
- 220 kV grid of Shida Kartli, backed-up inadequately:
  - Surami;
  - Urbnisi;
  - Liakhvi;
  - Aragvi;
- Dead end transmission lines:
  - Kolkhida 3, 220 KV;
  - Derchi, 220 KV;
  - Lomisi, 220 KV;
  - Manavi, 220 KV;
  - Paravani, 220 KV;
  - Sno (Ksani – Dariali HPP), 500 KV;

Development Drivers. The Georgian Transmission Network were designed for parallel operation with the North Caucasus and Armenia/Azerbaijan power systems. Specifically, generation of the HPPs located in the West Georgia was transmitted to Russia, while the power plants located in the East Georgia were supplied with fuel from Azerbaijan.

After Georgia re-gained independence, prices for fuel supply for thermal units of Georgia grew significantly, and currently eastern part of Georgia is supplied with power from the HPPs located at the west. Meanwhile, Turkish energy markets becomes steadily attractive entailing construction of the HVDC back-to-back station in Akhaltsikhe, as well as encouring the majority of the greenfield projects that are under development in Georgia. Due to its geographical location, Georgian transmission network may be used for energy transit between 1) Russia and Armenia/Iran, 2) Azerbaijan and Turkey, 3) Russia and Turkey, and 4) Armenia/Iran and Turkey.

Georgian power system endures acute shortage of operating reserves resulting in law power quality in isolated regimes. In addition, when any large power unit fails, emergency control system initiates load shedding. For dealing with such situation, sufficient operating reserves shall be provided by both construction of regulated hydro power plants (with water storage) and high capacity combined-cycle gas turbines as well as rehabilitation of the existing thermal power plants.

- Prospective regulated HPPs
- Prospective seasonal HPPs
- Prospective demand growth
- Thermal power plants scheduled for decommissioning
- New combined cycle thermal power plants
- ⇔ Necessary upgrades of cross-border (inter-system) links
- ⇔ Necessary upgrades of internal network links
- O Existing bulk generation region
- O Existing bulk demand region

Fig. 1.3 Map illustrating development drivers of Georgian electric power network

Assuming above, the main development drivers of Georgian transmission network development drivers will be targeted to:

- Transmission of the existing generation;
- Fulfillment of single contingency (N-1) criterion (improvement of reliability)
- Reclamation of the new energy resources / integration of new HPPs into the network;
- Increasing network potential with respect to power transit;
- Establishment of reliable power supply centers for promoting development of potential production/tourist centers;
- Responding to the (naturally) increasing demand in the power system;
- Replacement of the aged thermal units with flexible and cost-effective combined-cycle thermal power plants;
- Provision of sufficient operating reserves;
- Improvement of the power quality.

1.5 Forecasted Energy and Capacity Balances

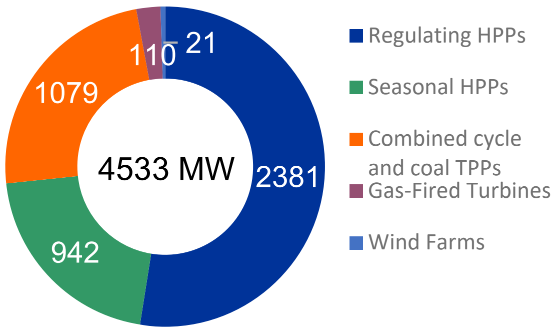

Fig. 1.4 Installed capacities of the existing power plants

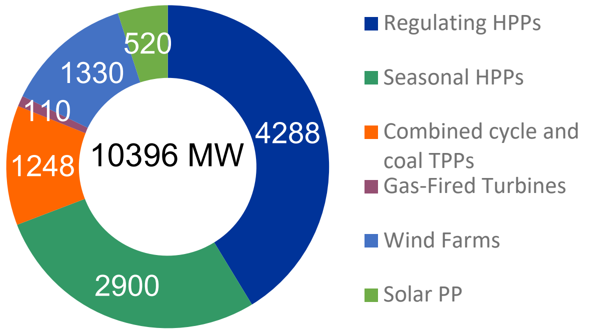

Fig. 1.5 Installed capacities of power plants as for 2031

At present, total installed capacity of electric power plants operated in Georgia amounts to 4533 MW. From this, 2381 MW is generated by the so called "regulated" HPPs (with water storage), 942 MW by "seasonal" (run-of-river) HPPs, 110 MW by Gas Turbines, 21 MW Wind farms and 1079 MW by thermal power plants and combined-cycle gas turbines (Fig. 1.4). Roughly 74% of the total in-country installed capacity is provided by HPPs, including 52% generated by regulated hydro power plants.

For 2031, the total installed capacity available in Georgian power system will grow to 10396 MW (Fig. 1.5). From this, 4288 MW will be attributed to regulated HPPs, 2900 MW to seasonal HPPs, 1330 MW to Wind Power Plants, 520 MW to Solar Power Plants, 110 MW to Gas turbines and 1248 MW to high efficiency combined cycle as well as coal thermal power plants, which will replace the older Gardabani TPP's Units Nos. 3, 4 and 9. For 2031, percentage share of hydropower in total national installed capacity will grow to 69%, including 41% share of regulated hydro power plants. This will ensure use of the water stored during flood season for low flow periods, thus reducing dependence on import of electricity and fossil fuels necessary for operation of thermal power plants. It is noteworthy that share of wind and solar power plants for 2030 will be approximately 18% and furtherly will go to increase during next years.

Base of load and generation growth, the annual energy balance of Georgia for all the scenarios has been drawn up. Below is given balance of energy for the scenario (fig 1.6) considering on time integration of all prospective power plants into the grid and annual consumption growth of 5%.

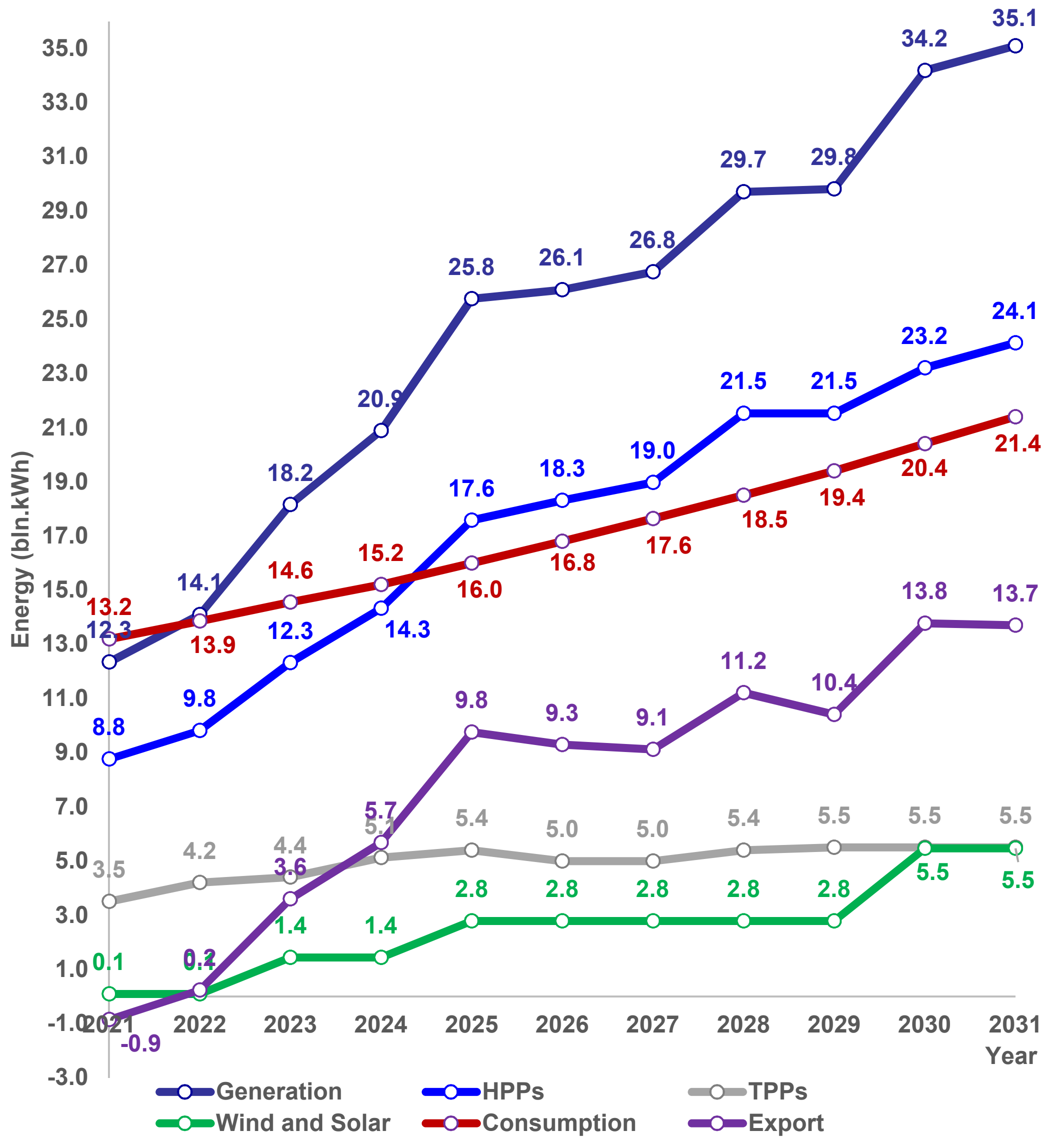

Fig. 1.6 Georgian generation, consumption and export graphs for L2G3

Summary. Based on forecasted balances presented above, it may be concluded that construction of the new cross-border lines with neighboring states is necessary. The most critical period in terms of intensity of the power export is flood season, including so called Summer Maximum and Summer Minimum regimes.

1.6 Development Scenarios and Methodology

Planning scenarios are defined to represent the future environment. Scenario analysis is necessary to obtain realistic picture of a future. Scenarios are means to approach the uncertainties and acknowledge interaction between these uncertainties.

Each scenario encompasses several planning cases, i.e. particular situations that may occur within the framework of the specific planning scenario.

At least the following three time horizons shall be considered:

- Short-term horizon (typically 1-3 years);

- Mid-term horizon (typically 4-5 years);
- Long-term horizon (typically 6-10 years).

Investments encompassed for transmission network reinforcement which correspond transmission network development plan should include all the represented cases and should encompass commissioning dates of new network elements.

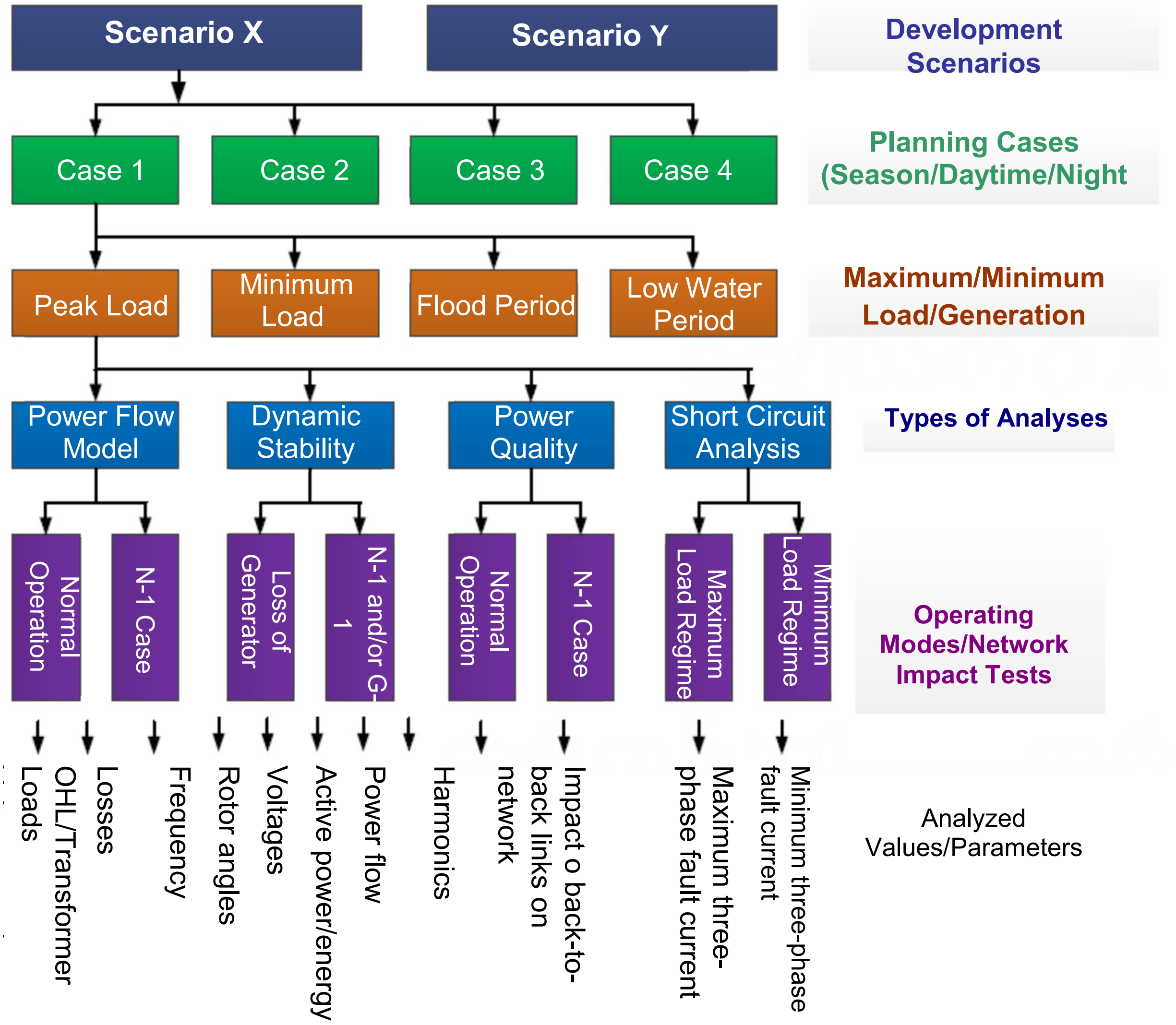

Fig. 1.7 Process of technical analysis of the scenarios

Analysis and network impact tests shall be performed for each design case to identify future problems and adequate technical requirements for network reinforcements. **The line of critical importance for the country is selected based on requirement of fulfilling N-1 criterion without the need of shedding the customer loads.**

The following studies have been performed for checking the planned network reliability status:

- Power flow analysis
- Short circuit analysis
- Voltage analysis
- Stability analysis
- Harmonic analysis

Several scenarios of Georgian transmission network development were reviewed. Information about prospective generation facilities to be integrated into the network was used as the input data for planning. Such facilities were divided into the following categories:

Category 1 Power plants under construction;

Category 2 Power plants Under Licensing stage;

Category 3 power plants Under feasibility-studies.

Table 1.1 Demand & Genaration growth scenarios

GROWTH OF LOAD | GENERATION	"G1" 10%[Y]+90%[Y+10]	"G2" 25%[Y]+75%[Y+5]	"G3" 100%[Y]
3 % growth "L1"	L1G1	L1G2	L1G3
5 % growth "L2"	L2G1	L2G2	L2G3
7 % growth "L3"	L3G1	L3G2	L3G3

Consumption forecast annual growth rate in base scenario is 5%, which was defined based on the analysis of forecast of economic parameters received from Ministry of economy and sustainable development.

The table gives various options of annual consumption growth and generation commissioning. G1 scenario envisages commissioning of 10% of the total installed capacity of prospective power plants in the planned timeframes, and integration of the rest capacity will be postponed by 10 years, G2 – timely commissioning of 25% of total installed capacity, and the rest 75% - after 5 years, while G3 - timely integration of full composition of prospective generation - 100% integration into the network.

Generally, development of transmission grid depends on scenario of integration of new generation and power demand growth rate. Anyway, in case of development by any scenario until 2035-2045 all three categories of new hydro power plants will be integrated into the grid. As for demand – it represents combination of internal demand and power export. In other words, if internal demand is being less increased, then power export will be increased more and vise-versa. Hence, **in case of development of generation and demand by any scenario, transmission grid shall be developed by the same option corresponding to timely integration of generation.**

1.7 Generation Adequacy

Adequacy - Ability of the power system to continuously satisfy electricity consumption in condition of both planned and forced outages of a network element.

Generation adequacy indexes are calculated for all years:

1. LOLP (LOSS OF LOAD PROBABILITY)

$$LOLP = \frac{N_{DNS}}{N}100\%$$

Where:

N_{DNS} represents the number of iteration,when $DNS > 0$

$$DNS = \sum demand - \sum generation$$

N Is total number of iteration (8760).

2. The average value of the unserved energy ("EXPECTED DEMAND NOT SUPPLIED" EDNS) which shows the ratio between unserved energy and total number of iteration during the year.

$$EDNS = \frac{\sum DNS}{N}$$

3. LOLE ("THE LOSS OF LOAD EXPECTATION") – number of days (in year) during which demand is not satisfied at least once.

The calculation results are given below.

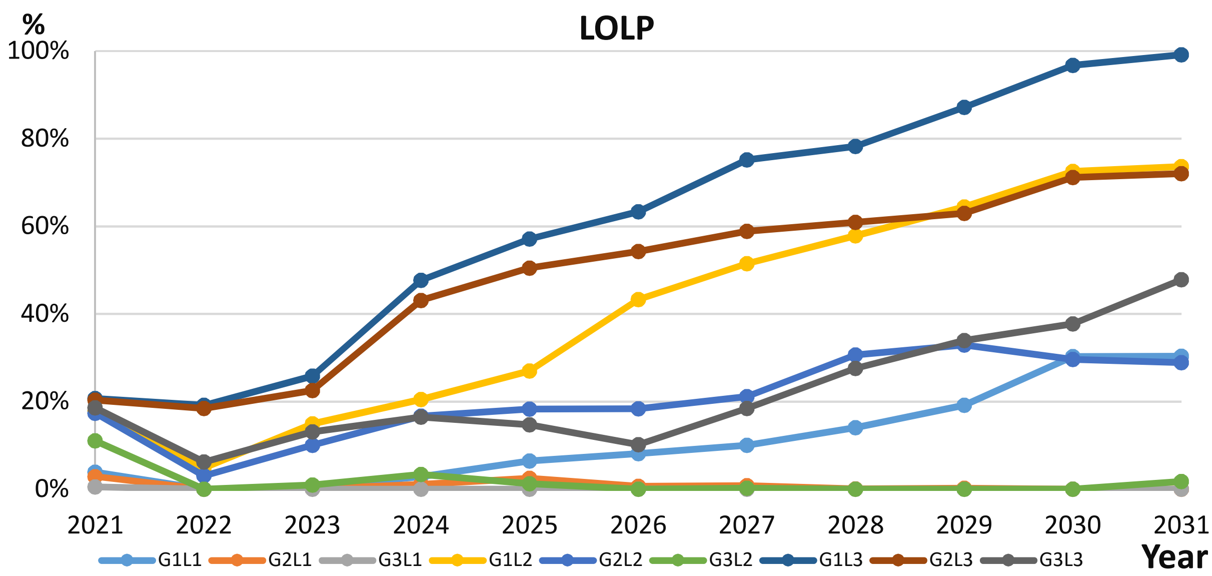

Fig. 1.8 Loss of load probability (LOLP)

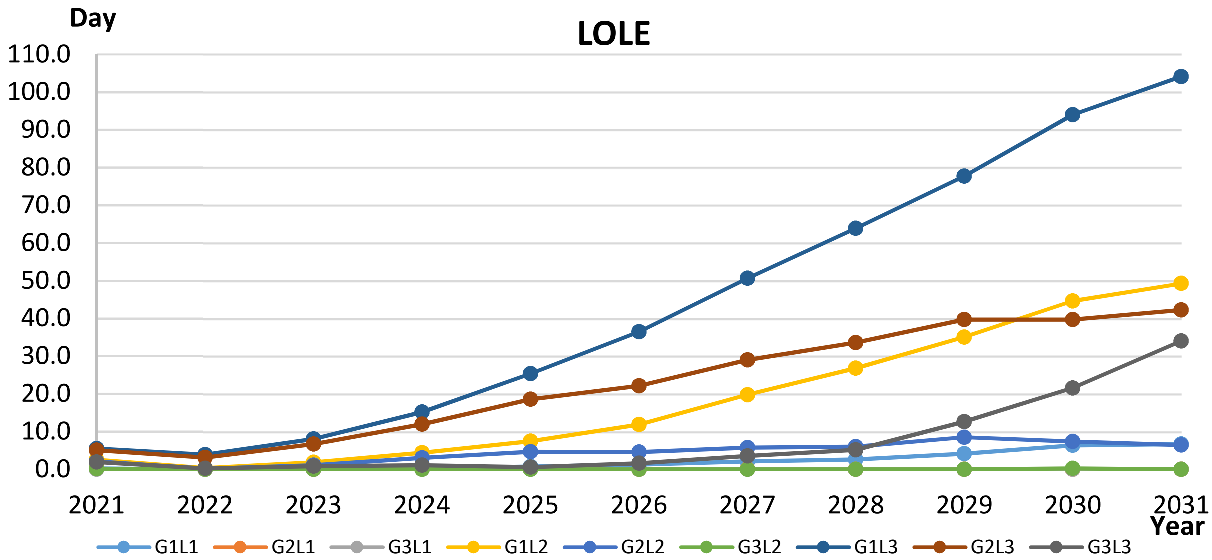

Fig. 1.9 Loss of load expectation (LOLE)

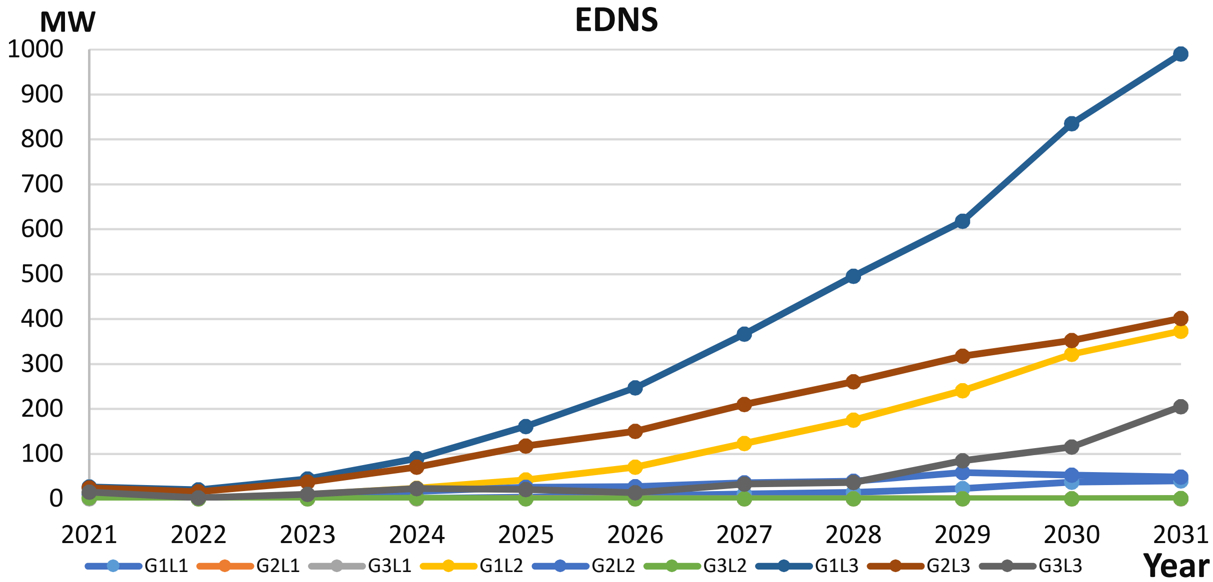

Fig. 1.10 Expected demand not supplied

1.8 Identified Projects and Required Investments

The projects planned for implementation have been divided into the following three groups:

1. ***Internal Projects**,* including the projects affecting power transit and reliability;
2. ***Cross-Border Projects***, i.e. the projects affecting capacity and reliability of the transit flows among the power systems of Georgia and its neighboring states;
3. ***Local Projects**,* comprising 220 kV and 110 kV dead-end feeder lines.

Transmission Licensee does not implement local projects. The direct impact on development of the transmission network is provided only by Cross-Border and Internal Projects. Therefore, 18 of such projects were selected for detailed review.

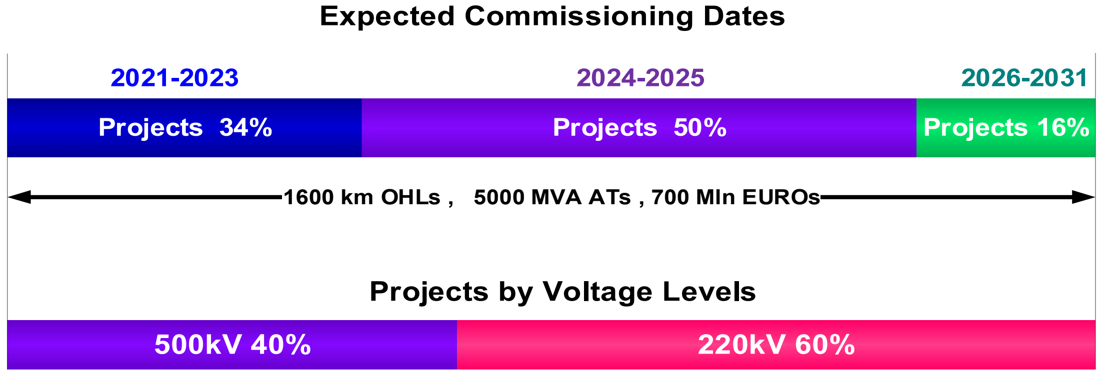

Fig. 1.11 Summarized Data of internal system and cross-border importance Projects

The Cost-Benefit Analysis (CBA) has been performed for the foregoing 18 projects planned for implementation in the transmission network during 2021-2031. Applying the CBA methodology, expected benefits where weighted against estimated investment costs and environmental impacts individually for each project.

Installed capacity of 500/400/330/220/110 kV autotransformers in Georgian transmission network will increase by about 5000 MVA, and the total length of 500/400/330/220/110 kV overhead transmission lines by 1600 km. This will ensure improved reliability of the network along with satisfying the single contingency (N-1) criterion at each development stage, allow Georgia to undertake transit hub function, provide for more than 1000 MW exchange in both east-west and north-south directions, and integration of additional 3500-4000 MW hydropower into the network. Total forecasted investment value of the foregoing projects amounts to about 700 million Euros.

1.9 Major Calculation Results

Power flow analysis. In the base case, nodal voltages and power flows in the transmission remain within acceptable limits for the total planning horizon of 10 years. Meantime, during 2021-2024 (i.e. prior to the planned construction of 500 kV OHL Jvari-Tskaltubo-Akhaltsikhe), 220 kV network in the West Georgia is overloaded under single contingency (N-1) case, namely if 500 kV OHL Imereti is lost. As a result, ECS initiates shedding of 200-300 MW load in the eastern part of Georgia along with generation reduction by the same amount in Enguri-Vardnili nodes in order to avoid mentioned.

Power losses. Power losses in Georgian transmission network at 500/400/330/220 kV voltage levels very in the range of 0.71%-3.35% percent.

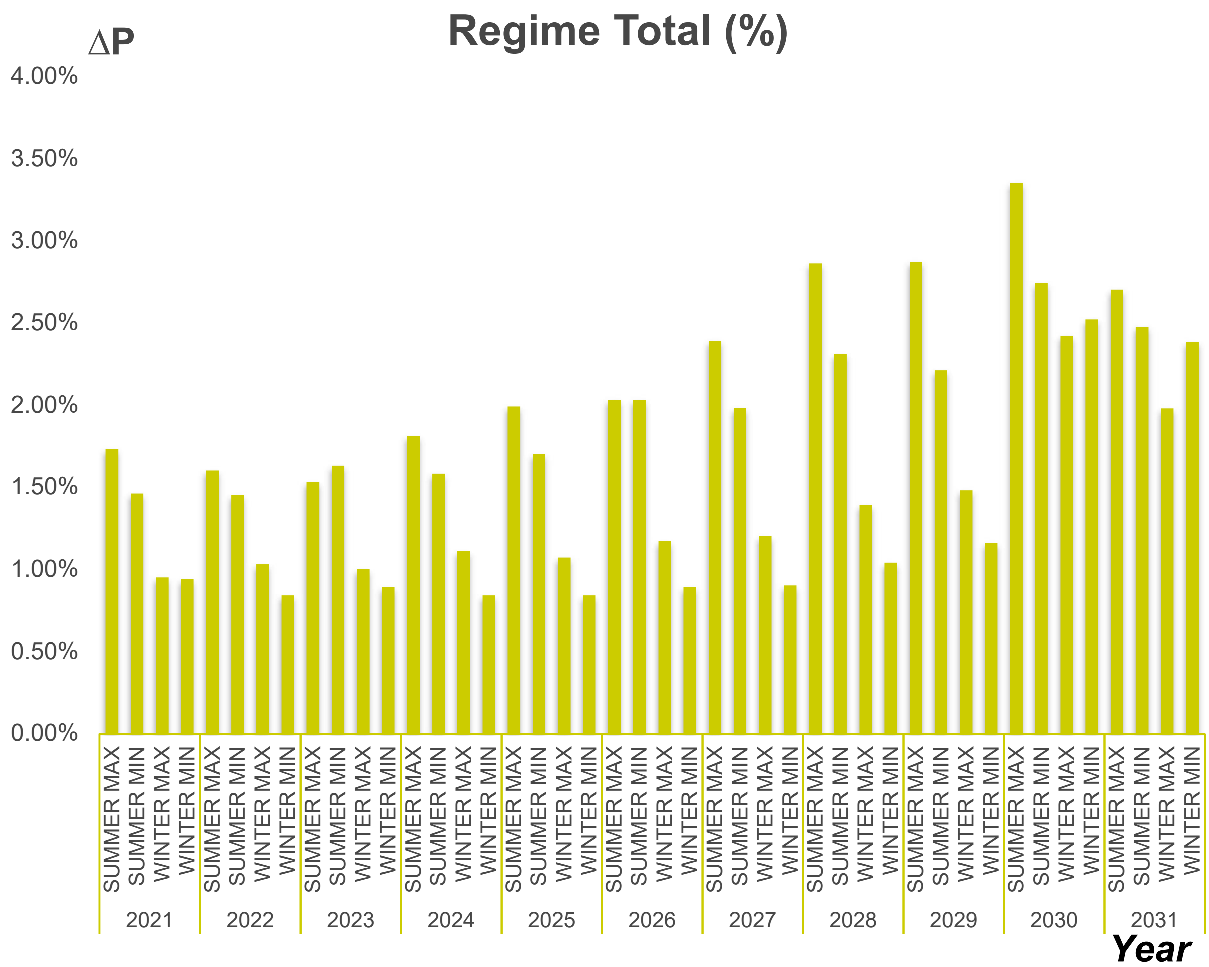

Fig. 1.12 Dynamics of transmission losses during 2021-2031 by seasons

Short circuit analysis. For the Ten-Year Network Development Plan of Georgia, the maximum and minimum short circuit currents have been calculated for the most critical and characteristic years (2021, 2026, 2031). The maximum short circuit currents were calculated assuming operation of all generators and cross-border lines of Georgian electric power system, while the case when the fewer number of generators appropriate to the summer minimum regime are operated, and all cross-border OHLs are switched off was considered when calculating the minimum short circuit current values. As calculations showed, in certain substations, the estimated short-circuit currents for 2031 are 70%-80% higher than for 2021 and may two times exceed the current values. Therefore, electrodynamical and thermal ratings of the equipment installed in power plants and substations should be verified to timely make relevant replacements.

Dynamic Stability Analysis studies power system behavior and ability of maintaining synchronous operation of the generators during limited contingencies. Such analysis was performed for maximum summer demand mode of Georgian power system for 2021, 2026 and 2031, considering the following disturbances: Emergency tripping of 500 kV OHLs; Outage of 500/220 kV autotransformers; Tripping of back-to-back link or 400 kV Georgia-Turkey line; Shutdown of the power units of Enguri HPP, 9th Thermal Unit and Khudoni HPP.

According to results of the analysis, Georgian transmission network (power system) maintains stability during any disturbances, subject to the following preconditions: During 2021-2023, in cases involving tripping/shutdown of 500 kV OHL Imereti, 500 kV OHL Kavkasioni, power unit of Enguri HPP or 9th

Thermal Unit, ECS should intervene for shedding of the appropriate customer loads and/or generation facilities. During 2024-2031, system stability is naturally maintained in case of any disturbances.

Harmonic analysis. The most powerful source of harmonics in Georgian electric power system is 700 MW Akhaltsikhe HVDC back-to-back station. In near future new HVDC links will be added to Georgian transmission network, such as 350 MW HVDC station at Batumi, and additional 350 MW link at SS Akhaltsikhe. In addition, construction of 700 MW HVDC back-to-back station in Armenia near to Georgian border is planned which will be connected to Georgian transmission grid. For the base case (N), analysis included calculation of individual and Total Harmonic Distortion rates, while for single contingency (N-1) cases (considering having one of 220 kV or 500 kV lines out of operation), only Total Harmonic Distortion (THD) was calculated. According to derived results, all THDs, for both N and N-1 modes are within the standard limits.

Summary: based on results of above analyses, the planned transmission network is reliable, provides stability of the power system and maintains system parameters within the limits set forth in the Grid Code.

1.10 Georgian Transmission System Development Indicators

Future constructions of 500/400/220/154/110 kV OHLs and substations planned during next ten year are mainly intended for integration of the new hydro power plants, necessity of improving reliability and security of supply as well as increment of transit potential.

Table 1.2 Summary data on High-voltage OHLs and substations

Overhead Lines		Substation autotransformers and Back-to-Back Links	
Rated Voltage (kV)	Length (Km)	Rating (kV)	Capacity (MVA)
500	907	500/400	875
400	32	500/330	0
330	21	500/220	3960
220	1797	330/220	400
110	3550	220/110	6509
Sum	**6307**	**Sum**	**11744**

The following diagram illustrates dynamics of total generation capacity (MW), installed apparent capacity of 500/400/330/220/110 kV transformers and autotransformers (MVA) and total length of transmission lines expressed in 500 kV OHL equivalent (km).

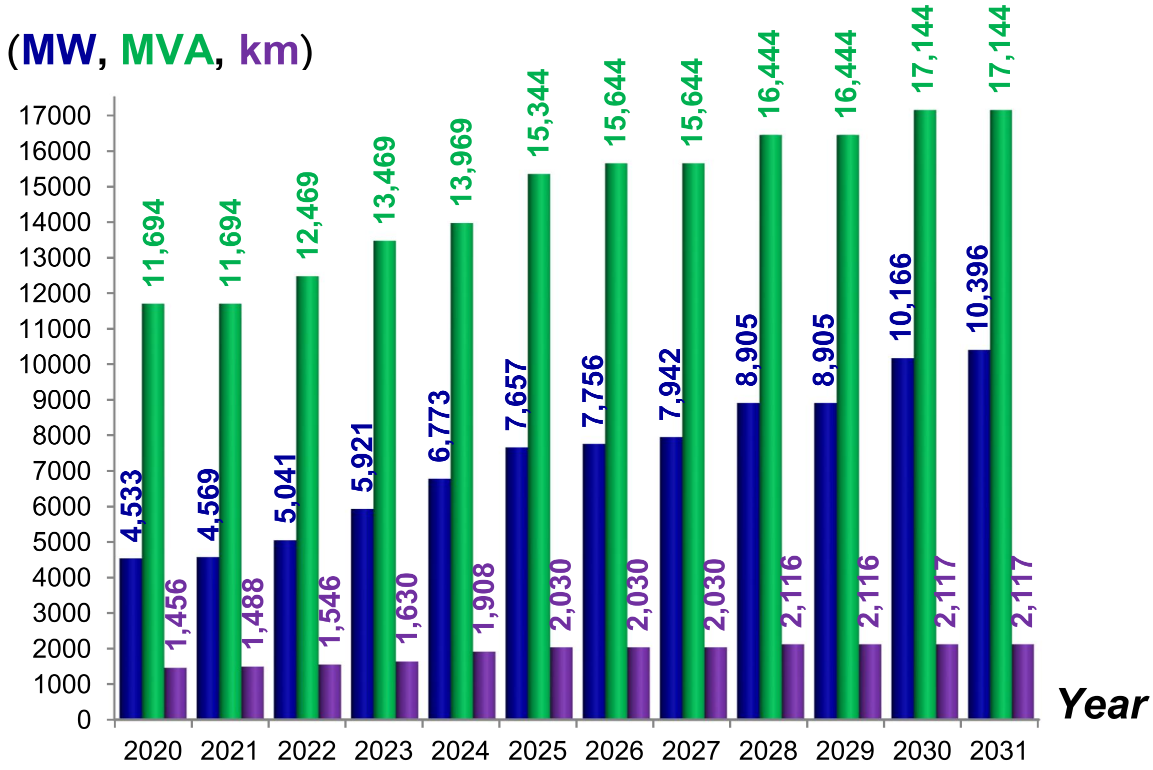

Fig. 1.13 Dynamics of Georgian generation and 500/400/330/220/154/110 kV transmission infrastructure development during 2020-2031

Several indicators describing development of Georgian transmission network were calculated from the diagram given on Fig. 1.13, such as length of overhead line needed for evacuation of 1 MW installed generation capacity (in 500 kV OHL equivalents) and total installed capacity of 500/400/330/220/110 kV (auto)transformers.

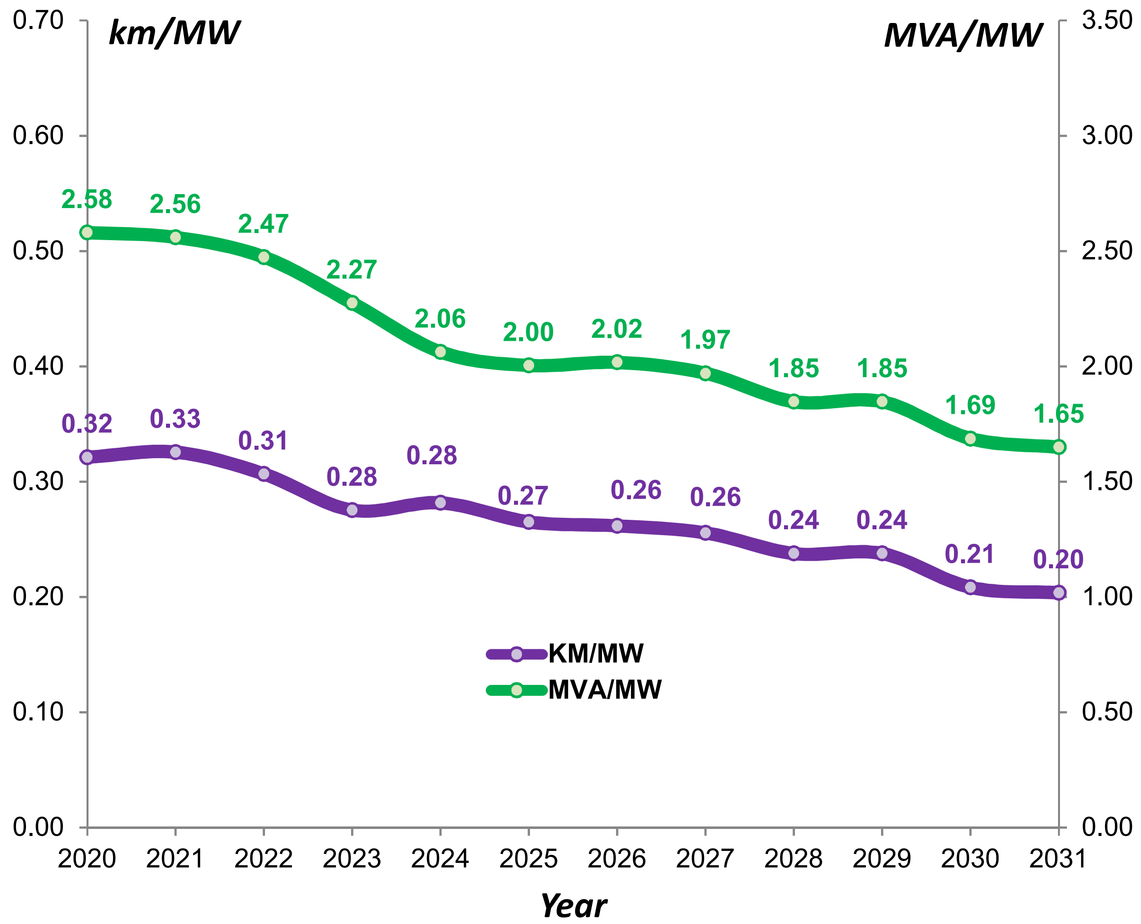

Fig. 1.14 Relationship between development of Georgian transmission network and generation infrastructure

Summary: Despite reduction of unit equivalent length of the transmission network and specific capacity of (auto)transformers per evacuated 1 MW generation, the calculations show that during 2024-2031, Georgian power system will be more stable comparing to 2021-2023 time span. Therefore, it is apparent that improvement of the reliability is accompanied by improvement of network effectiveness and cost-efficiency.

1.11 Capabilities of Power Exchange with Neighboring States in 2025-2031 Time Span

The existing cross-border links serve for power exchange between Georgia and Russia and transit from Russia and Azerbaijan to Turkey, as well as for bidirectional power exchange between Georgia and Turkey, Azerbaijan and Armenia. However, such power flows are restricted due to both limitations stemmed from the acceptable operating modes of national power system and physical capacities of above cross-border OHLs (fig. 1.15 and tab. 1.3).

For 2025-2031 horizon, Georgia, due to its geographical location, will gain an important role in the planned regional integration of the power systems of the Caucasian (and Black Sea) countries assuming promotion of energy trading between these countries and development and use of Georgian hydropower resources.

For 2025-2031, cross-border links between Georgian and its neighboring power systems will significantly advance, allowing 1400 MW power exchange with Turkey, 1600 MW with Russia and 700 MW with Armenia. There is already possibility of 700-1000 MW power exchange between powers systems of Georgia and Azerbaijan.

Table 1.3 Power exchange capabilities with neighboring power systems

Country	Cross-border line, conductor	Nom. Voltage (kV)	Exchange	TTC Summer (MW)	TTC Winter (MW)	Mode
Russia	,,Kavkasioni" AC-3x300	500	Export	570	650	S
			Import	570	650	S
	,,Stepantsminda" (Ksani-Stepantsminda-Mozdok) AC-3x300,2025	500	Export	1000	1000	S
			Import	1000	1000	S
	,,Salkhino" AC-400	220	Export	50	50	I
			Import	150	150	I
Azerbaijan	,,Mukhranis Veli" AC-3x300	500	Export	630	710	S
			Import	630	710	S
	,,Gardabani" 2022 AC-480	330	Export	630	710	S
			Import	630	710	S
Armenia	,,Alaverdi" AC-300	220	Export	150 / 100	150 / 100	S / I
			Import	150 / 100	150 / 100	S / I
	,,Marneuli" (Marneuli-Ayrum) AC-3x330,2025	400	Export	700	700	B
			Import	700	700	B
Turkey	,,Meskheti" AC-3x500	400	Export	1050	1050	B
	,,Tao" (Akhaltsikhe-Tortum) AC-3x500,2024		Import			
	Batumi-Muratli 2030	154	Export	350	350	B
			Import	350	350	B
	,,Adjara" AC-400	220	Export	150 / 150	150 / 150	I/ R
			Import	150 / 150	150 / 150	I / R

S synchronous mode
I isolated mode
B operation with Back-to-back station
R in the reserve

In particular, each of the 400 kV OHLs “Tao” and “Meskheti” can transfer up to 1500 MW but their total transfer capacity is limited by the ones of Akhaltsikhe HVDC back-to-back units, value of which will equal to 1050 MW after 2030.

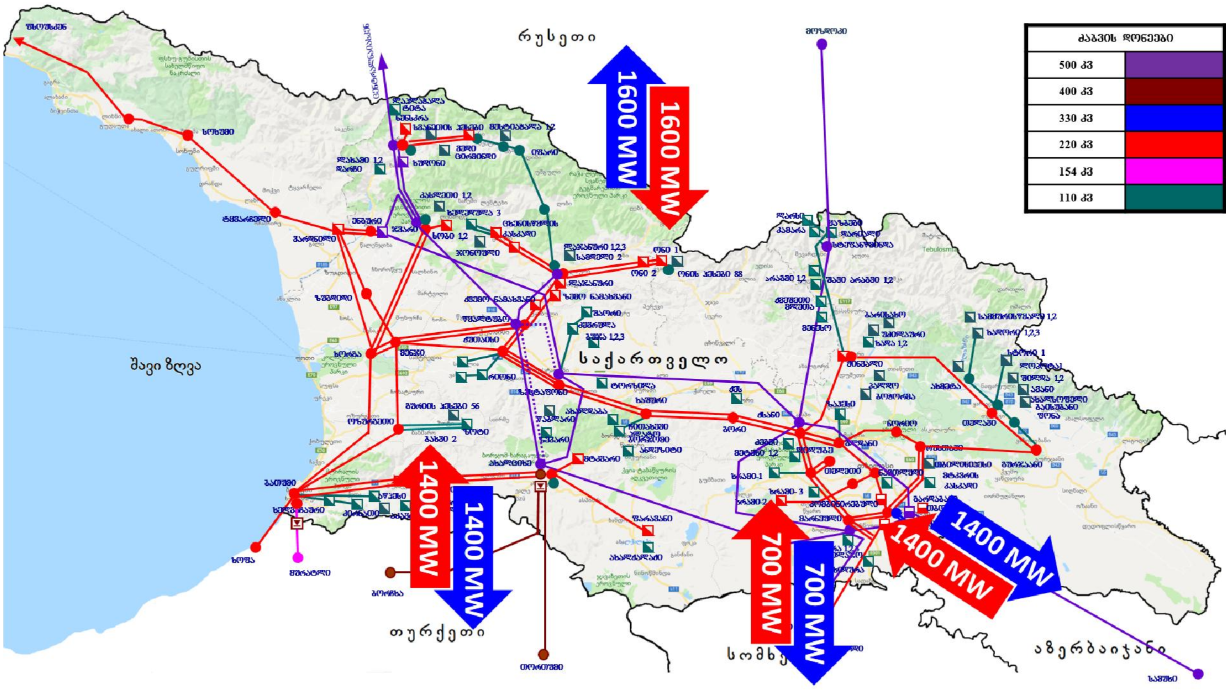

Fig. 1.15 Cross-border transfer capacities between power systems of Georgia and its neighboring countries as for 2031

1.12 Opportunities of integration of renewable energy sources into the transmission network of Georgia

In recent years, the interest in construction of wind and solar power plants in Georgia has been particularly increased. Therefore, Georgian Electricity Transmission System Operator JSC "Georgian State Electrosystem", with the support of European consultant’s consortium DIgSILENT-DMCC-R2B, has studied the possibilities of integration of variable renewable energy sources into the Georgian power system. The results of the research are as follows:

- ✓ Till 2020-2021 years (after implementation of balancing mechanisms) Georgian power system can integrate 333 MW wind and 130 MW solar power plant (25% of potential);
- ✓ By 2025 – **calculation of recommended summary amounts of capacities of wind and solar power plants for mentioned period is being performed in scope of “Generation Expansion Plan”, results of which will be available in near future**;
- ✓ By 2030, above-mentioned forecasted values for wind and solar energy are respectively 1332 MW and 520 MW (100% potential).

1.13 Ten-year development plan of SCADA and information technology (IT)

Georgian State Electrosystem (GSE) is the transmission system operator serving the function to maintain system stability and reliability for short-term and long-term periods. Especial challenge is to balance the system usage-supply and export-import in real time (online) so that to maintain power quality parameters within normal limits. Another challenge is to manage energy system, and to maintain stability and integrity in emergency modes. In order the company to be able to generate and exchange all required accurate data for energy management, it is necessary to integrate a variety of information technology platforms applied to GSE system, which should correspond to the Ten-Year Network Development Plan of Georgia. This is the basis for SCADA and Information Technology (IT) Development Plan, which, along with transmission network development, is part of mentioned ten-year plan.

1.14 New challenges and relevant solutions

1. **Electro mobiles –** Possible drastic increase of peak load; "prosumers" – system decentralization and nonpredictability and customers with changing requirements. *Solution/mitigation*: construction of Hydro Power Plants (HPPs) with reservouis, enhancement of energy efficiency, introduction of power storage stations and batteries, construction of thermal plants and inter-system power transmission infrastructure, perfection of control and operation systems, introduction of "smart grids", introduction of dynamic transfer capacity of transmission lines, optimal integration of wind and solar power stations (possibly with storage batteries), introduce VSC PLUS and FACTS equipment, utilize up-to-date planning and designing methods and software solutions.
2. **Challenges associated with the construction of new transmission lines by the end of next decade:** *solution/mitigation*: visual-friendly constructions, installation of multiple current towers and, under some exceptions, construction of cable transmission lines.
3. **Challenges associated with market liberalization.** *Solution/mitigation*: renewal of system control program and readiness for the trade with the Europe's domestic power market before-day and within-day, as well as rehabilitation of existing power stations as per "systemic service concept".
4. **Possible cyber attack risks and informational safety challenges.** *Solution/mitigation*: GSE conducts personnel awareness and introduction of ISO 27001 safety standard. Besides, foreign cyber security experience is adopted and relevant GSE staff ensures cyber security at all times.
5. **Pandemic.** Coronavirus (COVID-19) represents the last active epidemic of an infectious disease occurring worldwide. *Solution/mitigation*: In order to its prevention, the whole civil world including Georgia takes into account the recommendations elaborated by "World Health Organization" generally considering to maintain hygienic norms and the minimal safe distance between people as well as to move to the remote working mode in case of important part of the work fields. As a result, the risk of further spreading of mentioned infection decreases significantly. In this regard, working of Georgian state electrosystem JSC as well as whole Georgia is effective and successful.

1.15 Strategic Environmental Assessment

GSE aims for the construction of transmission infrastructure, which will provide reliable consumption, as well as minimal adverse environmental effect. This 10-year plan envisages strategic environmental assessment of all main projects.

1.16 Conclusion

Transmission system operator, together with transmission licensee strives to provide reliable and high quality services to its customers and develop its own infrastructure that is necessary for supporting to economic development of Georgia. The projects presented and discussed in this Ten-Year Plan represent an adequate response to the changes in economical and energy environment. GSE believes that implementation of these projects will meet wishes of Georgian society as well as will allow the national economy to effectively address the challenges and ensure the better future.

2 Existing and perspective PPs

2.1 Generation Data

Georgian power system is characterized by asymmetric generation/consumption pattern due to law demand and high generation in summer and high demand and low generation in winter allowing Georgia to export the power during summer period. During winter, when less water is available for HPPs, thermal power's share in total generation increases to 28% from the less than 1% in summer.

The third of aggregated energy produced in the country comes from the largest Enguri HPP having installed capacity of 1,300 MW. Second largest power plant is Vardnili cascade HPPs. This tandem, together with other relatively lower capacity HPPs compose the pool of regulating hydro power plants with total installed capacity of about 2,380 MW (1,992 MW comes from reservoir HPPs, 389 MW from daily regulating HPPs).

By the end of 2020, total installed capacity was equal to 4533 MW, which includes installed capacity of HPPs 3323 MW, wind power plants 20.7 MW and thermal power plants 1190 MW.

Tab. 2.1 Existing Power Plants in Georgian Power System for the end of 2020

№	Power Plant	Installed capacity (MW)	Number of units	Type	Commissioning years
1	Enguri HPP	1300	5x260	Regulating	1978
2	Vardnili 1 HPP	220	3x73.33	Regulating	1971
3	Khrami 1 HPP	113.5	3x37.6 + 1x0.65	Regulating	1947
4	Khrami 2 HPP	110	2x55	Regulating	1963
5	Shaori HPP	38.4	4x9.6	Regulating	1955
6	Dzevrula HPP	80	4x20	Regulating	1956
7	Jinvali HPP	130	4x32.5	Regulating	1984
8	Rioni HPP	48	4x12	Run-of-River	1933
9	Gumati HPP cascade	66.7	4x11 + 3x7.6	Run-of-River	1958-1956
10	Vartsikhe HPP cascade	184	8x23	Run-of-River	1976-1977
11	Lajanuri HPP	111.8	3x37.28	Daily Reg	1960
12	Zahesi HPP	36.8	4x3.2 + 2x12	Run-of-River	1927
13	Ortachala HPP	18	3x6	Run-of-River	1954
14	Chitakhevi HPP	21	3x7	Run-of-River	1949
15	Atshesi HPP	16	2x8	Run-of-River	1937
16	Satskhene HPP	14	2x7	Run-of-River	1992
17	Khadori HPP	26	2x12+2x1	Run-of-River	2004
18	Larsi HPP	19.5	2x6.5	Run-of-River	2014
19	Paravani HPP	87	2x43.27	Run-of-River	2014
20	Bjuja HPP	12.2	3x4.08	Small HPP	1956
21	Tetrikhevi HPP	13.6	2x6.8	Small HPP	1952
22	Alazani HPP	4.8	2x2.4	Small HPP	1942
23	Abhesi HPP	2.01	1x0.888+2x0.56	Small HPP	1928
24	Sioni HPP	9.1	2x4.57	Small HPP	1964

25	Ritseula HPP	6.3	1x3.816+2x1.296	Small HPP	1967
26	Chala HPP	1.5	1x1.5	Small HPP	1941
27	Chkhori HPP	5.4	1x2.9+1x2.45	Small HPP	1967
28	Dashbashi HPP	1.3	3x0.42	Small HPP	1935
29	Mashavera HPP	0.8	1x0.8	Small HPP	1949
30	Kabala HPP	1.5	3x0.45	Small HPP	1953
31	Kakhareti HPP	2.1	2x1.04	Small HPP	1957
32	Martkopi HPP	3.9	1x3.87	Small HPP	1952
33	Intsoba HPP	1.8	1x0.6+2x0.6	Small HPP	1998
34	Kazbegi HPP 2	0.38	2x0.19	Small HPP	1951
35	Energetiki HPP	0.59	1x0.59	Small HPP	2006
36	Algeta HPP	1.3	1x1+1x0.25	Small HPP	2006
37	Matchakhela HPP	1.6	2x0.8	Small HPP	1957
38	Misaktsieli HPP	3	1x2+1x1	Small HPP	1964
39	Skuri HPP	1		Small HPP	1958
40	Tiriponi HPP	3.2	2x1.6	Small HPP	1951
41	Khertvisi HPP	0.3	2x0.152	Small HPP	1950
42	Kinkisha HPP	0.9	2x0.452	Small HPP	1954
43	Atchi HPP	1	1x0.74+1x0.288	Small HPP	1958
44	Rustavi HPP	0.5		Small HPP	2009
45	Sulori HPP	0.8		Small HPP	2009
46	Okami 2007 HPP	1.6		Small HPP	2009
47	Boldoda HPP	2.5		Small HPP	2009
48	Zvareti HPP	0.2		Small HPP	2010
49	Pshavela HPP	2.9	1x2.9	Small HPP	2010-2015
50	Igoeti HPP	2	1x0.525+1x1.25	Small HPP	1953
51	Sanalia HPP	5		Small HPP	2007
52	Mini khadori 1 HPP	0		Small HPP	2011
53	Khadori 2 HPP	6	2x3	Small HPP	2012
54	Khani HPP	0.3		Small HPP	2012
55	Racha HPP	11	2x5.5	Small HPP	2013
56	Dagva HPP	0.1		Small HPP	2013
57	Alazani 2 HPP	6	2x3	Small HPP	2013
58	Shilda HPP	5	2x2.5	Small HPP	2013
59	Kazbegi HPP	6	2x3	Small HPP	2014
60	Bakhvi-3 HPP	10	2x4+1x2	Small HPP	2013
61	Pantiani HPP	0.4		Small HPP	2012
62	Aragvi HPP	8.5	2x4.7	Small HPP	2014
63	Akhmeta HPP	9.1	2x4.57	Small HPP	2014
64	Pshavela HPP	1.95		Small HPP	2015
65	Kazreti HPP	2.5		Small HPP	2014
66	Debeda HPP	3.4	2x1.7	Small HPP	2015
67	Shakshaheti HPP	1.9		Small HPP	2014

68	Maksania HPP	0.5		Small HPP	2017
69	Dariali HPP	108	3x36	Run-of-River	2016
70	Saguramo HPP	4.2	2x2.25	Run-of-River	2016
71	Khelvachauri HPP	47.48	5x9,1+1 x 1,98	Daily Reg	2016
72	Marneuli HPP	0.25	1x0.25	Small HPP	2016
73	Shuakhevi HPP	178.72	2x89.36	Daily Reg	2017*
74	Goresha HPP	0.125	1x0.125	Small HPP	2017
75	Kintrisha HPP	5.50	2x2.75	Run-of-River	2017
76	Nabeglavi HPP	2	2x1	Run-of-River	2017
77	Skurididi HPP	1.33	1x1.33	Run-of-River	2018
78	Shilda 1 HPP	1.20	1x1.2	Run-of-River	2018
79	Kheor HPP	1.48	1x1.48	Run-of-River	2018
80	Bodorna HPP	2.5	1x2.5	Run-of-River	2018
81	Kasleti 2 HPP	9.1	2x4.55	Run-of-River	2018
82	Jonouli 1 HPP	1.85	1x1.85	Run-of-River	2018
83	Kirnati HPP	51.22	4x12.33+1x1.9	Daily Reg	2018
84	Old Energy HPP	21.39	3x7.13	Run-of-River	2018
85	Aragvi 2 HPP	1.95	1x1.95	Run-of-River	2019
86	Mestiachala 1 HPP	20	2x10	Run-of-River	2019
87	Mestiachala 2 HPP	30	3x10	Run-of-River	2019
88	Avani HPP	3.5	2x1.75	Run-of-River	2019
89	Oro HPP (Zemo orozman HPP)	1.12	1x1.12	Run-of-River	2019
90	Khelra HPP	3.38	2x1.69	Run-of-River	2020
91	Ifari HPP	2.98	2x1.49	Run-of-River	2020
92	Dzama HPP	0.811	2x0.405	Run-of-River	2020
93	Sashuala 2 HPP	5	1x5	Run-of-River	2020
94	Lakhami 2 HPP	9.5		Run-of-River	2020
95	Unit №9	300	1x300	Thermal Power Plant	1991
96	Units №3, №4	272	130+142	Thermal Power Plant	1963
97	Gas turbine	110	2x55	Thermal Power Plant	2006
98	Tkibuli Coal TPP	13	2x6.5	Thermal Power Plant	2011
99	Gardabani CCGT	230	2x75+80	Thermal Power Plant	2015*
100	TPP (Rustavi Azoti)	9.1	9.1	Thermal Power Plant	2020
101	Gardabani CCGT 2	255	2x84+87	Thermal Power Plant	2020
102	Wind Farm	20.7	6x3.45	Wind farm	2016
I	**Sum of Regulating HPPs**	**2381.12**			
II	**Sum of RoR HPPs**	**941.5**			
III	**HPPs in total**	**3323**			
IV	**TPPs in total**	**1189**			
V	**Wind farm**	**20.7**			
VI	**System**	**4533**			

2.2 Perspective PPs

The initial information for transmission grid development are following: 1. Load and Generation data, specifically, type of new object, installed capacity, annual output, commissioning date, category; Decommissioning dates of old power plants, load growth scenarios.

Data about generation (Table 2.2) was received from Ministry of Economy and Sustainable Development of Georgia

Table 2.2 Perspective HPPs with predicted data

№	Name	Installed Capacity (MW	Generation (Gwh)	Type
1	Sashuala 1	7.5	34.7	Run-of-River
2	Tbilisi sea	0.6	3.0	Run-of-River
3	Lakhami 1	6.4	37.0	Run-of-River
4	Dvirula	2.0	10.0	Run-of-River
5	Khrami	1.0	7.0	Run-of-River
6	Skhalta	9.0	27.0	Run-of-River
7	Akhatani	0.6	2.8	Run-of-River
8	Goginauri	5.0	19.0	Run-of-River
9	Khadori 3	5.4	27.5	Run-of-River
10	Lopota 1	6.0	34.0	Run-of-River
11	Borjomi	2.0	11.0	Run-of-River
12	Plato	10.0	39.0	Run-of-River
13	Lukhra	5.0	23.0	Run-of-River
14	Nakra 1	6.0	31.0	Run-of-River
15	Nakra 2	4.4	22.7	Run-of-River
16	Lukhuni	12.0	73.0	Run-of-River
17	Baramidze	8.0	36.0	Run-of-River
18	Chordula	2.0	9.0	Run-of-River
19	Gubazeuli 6	3.0	20.0	Run-of-River
20	Mtkvari	53.0	230.0	Run-of-River
21	Nakra	7.5	35.0	Run-of-River
22	Boko	0.5	2.8	Run-of-River
23	Zoti	46.0	172.0	Run-of-River
24	Naceshari	2.0	8.5	Run-of-River
25	Jagon-Nashumi	1.8	8.5	Run-of-River
26	Machakhela 1	30.0	127.0	Run-of-River
27	Machakhela 2	19.0	115.0	Run-of-River
28	Torzila	2.0	7.0	Run-of-River
29	Samkura 1	4.8	26.0	Run-of-River
30	Samkura 2	26.3	129.0	Run-of-River
31	Metekhi 1	37.0	145.0	Daily Reg
32	Akhalqalaqi	9.5	49.0	Run-of-River
33	Digomi	17.5	95.0	Run-of-River
34	Shushaneti	1.3	8.0	Run-of-River

35	Khuberi	1.8	8.0	Run-of-River
36	Duman mashavera	2.0	11.0	Run-of-River
37	Kizilajlo	4.0	25.0	Run-of-River
38	Khobi 2	47.0	202.0	Run-of-River
39	Jandara	0.3	1.2	Run-of-River
40	Chani	0.5	3.0	Run-of-River
41	Tashiskari	1.0	7.0	Run-of-River
42	Kasleti 1	7.6	43.5	Run-of-River
43	Narovani	0.6	2.6	Run-of-River
44	Buja 1	2.0	10.0	Run-of-River
45	Buja 2	1.0	5.0	Run-of-River
46	Buja 3	2.0	11.0	Run-of-River
47	Rachkha	3.0	11.0	Run-of-River
48	Stori 1	13.6	60.9	Run-of-River
49	MaJieti	12.0	63.0	Run-of-River
50	Gebi	14.3	71.0	Run-of-River
51	Gere	9.4	41.0	Run-of-River
52	Chiora	14.0	68.4	Run-of-River
53	Sakaura	12.0	59.0	Run-of-River
54	Laskadura	7.0	33.0	Run-of-River
55	Udzilaurta	8.0	41.0	Run-of-River
56	Sadmeli 2	4.5	22.5	Run-of-River
57	Darchi	17.0	94.0	Run-of-River
58	Tbilisi	20.0	113.0	Run-of-River
59	Kvirila	6.6	40.0	Run-of-River
60	Paldo	7.4	48.0	Run-of-River
61	Vedi	24.0	115.0	Run-of-River
62	Tsvirmindi	15.0	76.0	Run-of-River
63	Mleta	5.0	31.0	Run-of-River
64	Qvesheti	10.0	70.0	Run-of-River
65	Barisakho	14.0	64.0	Daily Reg
66	Bochorma	5.0	32.0	Run-of-River
67	Qvedi	1.7	10.0	Run-of-River
68	Andeziti	1.0	4.0	Run-of-River
69	Chartali	2.5	15.0	Run-of-River
70	Fona	11.0	55.0	Run-of-River
71	Meneso	8.0	41.0	Run-of-River
72	Qvemo orozmani	0.6	4.0	Run-of-River
73	Mashavera 3	4.0	26.0	Run-of-River
74	Mashavera 2	4.0	26.0	Run-of-River
75	Zemo karabulakhi	1.0	6.0	Run-of-River
76	Akavreta	20.0	84.0	Run-of-River
77	Tita	5.0	24.0	Run-of-River
78	Khada 1	2.6	17.0	Run-of-River
79	Khada 2	1.0	8.0	Run-of-River
80	Shavi aragvi 1	3.0	16.6	Run-of-River

81	Shavi aragvi	5.3	25.0	Run-of-River
82	Lahlachala	12.0	53.0	Run-of-River
83	Nakhidura	9.0	57.0	Run-of-River
84	Deka	1.2	6.0	Run-of-River
85	Khevi	3.0	22.0	Run-of-River
86	Sachale	0.7	4.0	Run-of-River
87	Berali	0.9	5.0	Run-of-River
88	Skurdidi 3	1.4	11.0	Run-of-River
89	Sashuala	2.6	13.0	Run-of-River
90	Shevakhuri	2.0	16.0	Run-of-River
91	Roshka	5.0	21.0	Run-of-River
92	Jonouli 2	32.0	129.0	Run-of-River
93	Gubazeuli	6.0	27.0	Run-of-River
94	Lajanuri 1	5.0	27.0	Run-of-River
95	Lajanuri 2	5.0	31.0	Run-of-River
96	Lajanuri 3	5.0	33.0	Run-of-River
97	Bakhvi 2	36.0	123.0	Run-of-River
98	Sorgiti 1	15.0	68.0	Run-of-River
99	Sorgiti 2	16.0	73.0	Run-of-River
100	Namakhvani casc.	433.0	1500.0	Seasonal reg
101	Oni 1	122.0	441.0	Run-of-River
102	Oni 2	84.0	339.0	Run-of-River
103	Natanebi 3	9.0	64.0	Run-of-River
104	Baisubani	5.0	31.0	Run-of-River
105	Akhalsopeli	5.0	27.0	Run-of-River
106	Dzegvi	16.0	82.0	Run-of-River
107	Kamara	13.0	64.0	Run-of-River
108	Nenskra	280.0	1200.0	Seasonal reg
109	Bakhvi 1	12.0	50.0	Run-of-River
110	Alpana	55.0	253.0	Run-of-River
111	Khani	6.0	29.0	Run-of-River
112	Khrami 7	3.0	19.0	Run-of-River
113	Tekhura casc.	112.0	650.0	Run-of-River
114	Natanebi 2	10.0	70.0	Run-of-River
115	Mtkvari casc. 4	78.0	615.0	Run-of-River
116	Stori 2	11.4	51.0	Run-of-River
117	Natanebi 1	6.0	40.0	Run-of-River
118	Ilto-Alazani	180.0	620.0	Run-of-River
119	Kheledula 3	51	255	Run-of-River
120	Khudoni	702.0	1500.0	Seasonal reg
121	Dizi	210.0	800.0	Seasonal reg
122	Tskhenistskali casc.	357	1683	Run-of-River
123	Kvanchianari	230	920	Seasonal reg
	Sum	**3865**	**15491**	

Table 2.3 Prospective TPPs

№	NAME	Installed capacity (MW)	Efficiency (%)	Type
1	3-Thermal	250	55	CCGT
2	4-Thermal	250	55	CCGT

3 Identified Projects and Investment Needs for Infrastructure strengthening

3.1 Identified Projects

As noted above (ref. to Sections 2 and 6), the projects to be implemented in the transmission network has been divided into the following three groups:

1. ***Internal Projects,*** including the projects affecting power transit and reliability;
2. ***Cross-Border Projects***, i.e. the projects affecting capacity and reliability of the transit flows among the power systems of Georgia and its neighboring states;
3. ***Local Projects,*** comprising 220 kV and 110 kV dead-end feeder lines.

The direct affect on development of the transmission network is provided only by Cross-Border and Internal Projects.

The estimated costs, as well as lengths and commissioning dates of these projects are of a forecasted nature, and GSE shall in no event be liable for their inaccuracy. These data shall be subject of review and specification during implementation of the projects by consultants and/or project developers.

Eighteen projects described below are of the system wide importance, and when implemented, will address current and future challenges. Each of these projects will provide individual infrastructural elements of the transmission network, although consisting of several sub-projects and/or power lines and substations operated at one or several rated voltages.

Sixteen from described projects assume construction of overhead line or substation, and the remaining two – construction of HVDC link along with AC transmission line.

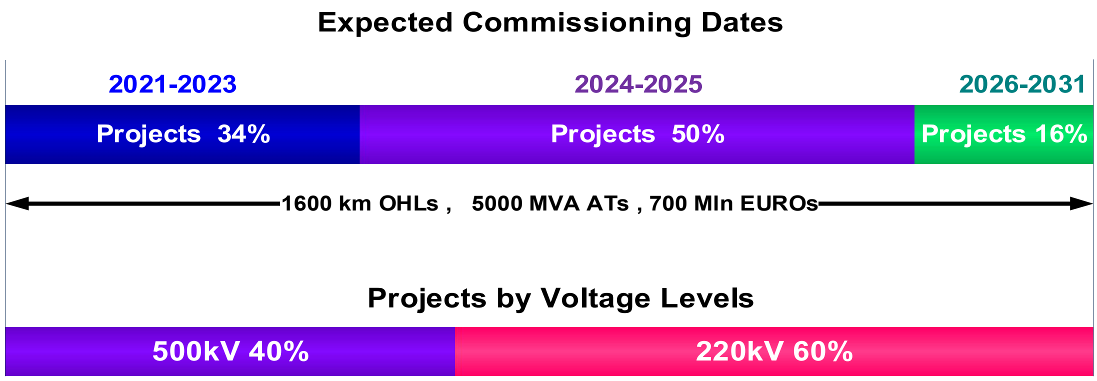

Fig. 3.1 Summarized Data of System-Importance Projects

As shown on the diagram given on Fig. 3.1, 34% of the projects will be commissioned during 2021-2023. This time span denoted as “short-term planning period”.

In 2024-2025, another 50% of the identified projects will be commissioned. This time span belongs to “mid-term planning period” covering the planned projects, which general characteristics and estimated technical and economical parameters are already determined.

In 2026-2031, rest 16% of the identified projects will be commissioned. This time span belongs to "long-term planning period".

The total length of transmission lines scheduled for 2021-2031 (accounting for each individual circuit) amounts to approximately 1600 km, and the total apparent capacity of the substations planned for the same period to 5000 MVA. It should be noted that 5 projects will serve for reinforcement of cross-border interconnections, including two projects envisaging construction of HVDC back-to-back link and interconnection line to Turkey, and other three interconnection projects with Russia, Azerbaijan and Armenia. Seven Project will increase internal transfer capacity and reliability.

Description of Each below presented project is composed of the following items:

- **Project Name**;
- **Project Importance**;
- **Commissioning Year**;
- **Forecasted Investment**, specifies the estimated project implementation costs in million Euros;
- **Current Status**, describes ongoing progress status of specific project.
- **Capacity of Integrated HPPs**, specifies installed capacities (in MW) of the HPPs to be integrated into the network by relevant project.
- **Reduction of Losses**, specifies incremental network losses to be incurred without specific project or any of its critical elements.
- **Increase of Network Transfer Capacity (Normal/Emergency Modes)**, specifies incremental network transfer capacity of the network (in MW) under steady state and contingencies (loss of parallel line) after implementation of specific project.
- **Project Flexibility Level**, specifies dependence of the project implementation on forecasted commissioning/network interconnection dates of HPPs, bulk increase of the load at specific node, etc.
- **Project Components**, lists appropriate OHLs, autotransformers, reactors and other elements of the transmission system included into the specific project scope.
- **Purpose of Project**, specifies project objectives.
- **Brief Description**, provides short narrative about project purpose, terrain conditions, etc.

Project Name: **Jvari-Khorga**

Project Importance: System

Project Commissioning Year: 2021-2022

Forecasted Investment: **20.6 million Euros (For the elements to be completed)**

Current Status: On construction stage

Capacity of Integrated HPPs: 159 MW

Reduction of Losses: 2 MW

Increase of Network Transfer Capacity (Normal/Emergency Modes): 200/400 MW

Project Flexibility and Influence on Reliability: High

Project Components:

To be Completed ➢

- P.1.1 Loop in/loop out of 500 kV OHL "Kavkasioni" to/from SS ''Jvari", 16 km (2x8 km);
- P.1.2 Double circuit 220 kV OHL ''Odishi-1,2" (Jvari- Khorga), length 60 km.

Completed ✓

- 500/220 kV SS Jvari, with installed capacity of 500 MVA;
- 180 (3x60) Mvar reactor to be installed in SS Jvari-500;
- 220/110 kV SS Khorga, with installed capacity of 400 MVA;
- Construction of second circuit 220 kV OHL "Menji-Khorga", conductor: 2xAC-400; Capacity: 400 MW;
- Installation of 2 bays in SS Menji for "Khorga-1,2" (Menji-Khorga);
- Loop in/loop out of 220 kV OHL Paliastomi-2 to/from 220/110 kV SS Khorga.

Purpose of Project:

- Improving reliability of power supply of Abkhazia, Samegrelo, Adjara and Guria (back up of OHLs Egrisi-1,2);
- Contributing to elimination of voltage instability problems in Batumi region (Adjara), improving reliability of the regional power supply and evacuation of the power generated by local HPPs;
- Integration of Khobi cascade HPPs into the network;
- High reliability and power evacuation of Khobi cascade and support to power export to Turkey;
- Upgrading flexibility of OHL Kavkasioni;
- Ensuring power supply of Poti Industrial Zone;
- Reinforcement of 220 kV grid in West part of Georgia;
- Reduction of consumers to be tripped by system automatic.

Project Description:

Jvari-Khorga is a multipurpose project designed for addressing several important objectives. The most important desired project outcome is improved reliability of West Georgia's 220 kV network. Specifically, after 220 kV OHL Paliastomi-2 is tied to SS Khorga, Jvari-Enguri and Khorga nodes will be interconnected by four parallel 220 kV OHLs thus increasing reliability of the power supply of 220 kV substations Enguri, Vardnili, Zugdidi, Khorga and Menji as well as backing up 500/220 kV autotransformer installed in SS Enguri, and 220 kV OHLs Egrisi-1,2, Kolkhida-2a, Kolkhida 2 and Paliastomi-2(1). Along with "Tskaltubo-Zestaponi", this project will increase transfer capacity of 220 kV main of entire east part of Georgian transmission network and in some extent will back up 500 kV OHL

Imereti, resulting decrease of amount of consumers to be tripped by ECS (Emergency Control System) in case of emergency outage of above mentioned 500 kV OHL.

In addition, tie-line connecting SS Khorga with OHL Paliastomi will improve power supply of 220 kV SS Batumi and entire Adjara and Guria Regions (due to significant shortening of this line's Batumi-Khorga section). Also, voltage instability problem in SS Batumi will be eliminated, and evacuation of the power generated by Shuakhevi HPP will be provided (at the first stage, only Batumi - Shuakhevi HPP section of 220 kV OHL Batumi-Akhaltsikhe will be constructed). One of the major purposes of SS Khorga is ensuring power supply of Poti Free Industrial Zone and prospective port. For this, installation of 400 MVA 220/110 kV autotransformer is envisaged. This substation may be connected with prospective power plants to be constructed in Samegrelo and west part of Lower Imereti, as well as with the ones planned in Jvari area (e.g. Khobi HPP). As about project geography, 16 km long 500 kV tie-line connecting OHL Kavkasioni and SS Jvari-500 runs on a quite complex and mountainous terrain, crossing the gorges and Enguri River. Although 220 kV OHL's route lays on a much flat lowland, it has to cross such a large river as Rioni is, as well as its numerous smaller tributaries.

Fig. 3.2 Single-line diagram of "Jvari-Khorga" Project

Table 3.1 Power plants integrated by the project "Jvari – Khorga"

№	Name	Installed capacity (MW)	Generation (million kWh)
1	Khobi HPP 2	47	202
2	Tekhura cascade HPPs	112	650
	Total	**159**	**852**

Project Name: **Batumi-Akhaltsikhe**

Project Importance: System

Project Commissioning Year: 2022-2024

Forecasted Investment: **35 mln Euros (For the elements to be completed)**

Current Status: On construction stage

Capacity of Integrated HPPs: 188 MW

Reduction of Losses: 10 MW

Increase of Network Transfer Capacity (Normal/Emergency Modes): 800/800 MW

Project Flexibility and Influence on Reliability: High

Project Components:

To be Completed ➢

- P.2.1 Double-circuit 220 kV OHL Shuakhevi-Akhaltsikhe, line length: 90 km, capacity: 2x400 MW;
- P.2.2 220/110/35 kV autotransformer in SS Shuakhevi.

Completed ✓

- Installation of 2 bays for 220 kV double-circuit OHL "Batumi-Akhaltsikhe" in 500 kV SS Akhaltsikhe;
- *Double-circuit 220 kV OHL Batumi-Shuakhevi, Line length 50 km, transfer capacity 2x400 MW; arrangement of two 220 kV bays in Batumi substation for 220 kV OHL Batumi – Akhaltsikhe.*

Purpose of Project:

- Improving reliability of the power supply to Adjara and Guria (backing up OHLs Paliastomi-1,2);
- Increasing export potential to Turkey;
- Providing high quality and reliable integration of Shuakhevi HPP, other prospective HPPs to be constructed in Adjara into the transmission network;
- Increment of reliability of west part of transmission network.

Project Description:

This is multipurpose project. First, this line will integrate Shuakhevi HPP (178 MW) into network and ensure reliable evacuation of their power output. HPP will be connected to both 220 kV substations of Batumi and Akhaltsikhe, and thus, along the sections Batumi-Shuakhevi-Akhaltsikhe the single contingency (N-1) criterion will be met under any operating regime. From SS Batumi-220, generation of Shuakhevi HPP may be further evacuated as for in-country supply (towards 220 kV substations Menji and Khorga), so for exporting to Turkey (154 kV SS Muratli) via the planned Batumi HVDC B2B station. Connection to SS Akhaltsikhe allows evacuation of the power generated by Shuakhevi and upper Adjara HPPs as for internal consumption by transmitting it to 500 kV Zestaponi and Gardabani (Marneuli) substations, so for exporting through Akhaltsikhe back-to-back links and 400 kV OHL Meskheti to Borchka (Turkey). Implementation of this project will improve reliability of the power supply to 220 kV SS Batumi (as well as entire Adjara and Guria Regions) due to connections with Shuakhevi HPP, and also will allow power transmission from Akhaltsikhe (East Georgia) to Batumi. All above, besides improving power supply of SS Batumi and fully fixing any voltage related problems therein, will allow evacuation of 350 MW power from this substation to Turkey.

This project will play role in reliability increment of west part of transmission network – resulting in decrease of load to be shedded by 100 MW in case of outage of 500 kV OHL "Imereti".

220 kV OHL Shuakhevi – Batumi was commissioned in 2017, which provides evacuation of Shuakhevi HPP capacity; "Shuakhevi-Akhaltsikhe" section will be commissioned in 2022.
According to the project, installation of 125 MW 220/110/35 kV auto-transformer at Shuakhevi HPP is planned for 2024, in order to integrate of adjacent HPPs into the network as well as to improve reliability of supply of adjacent 110/35 kV distribution network.

Fig. 3.3 Single-line diagram of "Batumi-Akhaltsikhe" Project

Table 3.2 Power plants integrated by the project "Batumi – Akhaltsikhe"

№	Name	Installed capacity (MW)	Generation (million kWh)
1	Shuakhevi HPP	178	437
2	Skhalta HPP	10	28
	Total	**188**	**465**

Project Name: **Ksani-Stepantsminda-Mozdok**

Project Importance: System/Transit

Project Commissioning Year: 2025

Forecasted Investment: 20.6 mln Euros (For the elements to be completed)

Current Status: Pre-construction works are ongoing

Capacity of Integrated HPPs: 189 MW

Reduction of Losses: 37 MW

Increase of Network Transfer Capacity (Normal/Emergency Modes): 700/1000 MW*

Project Flexibility and Influence on Reliability: Very high

Project Components:

To be Completed ➢

- P.3.1 500/110 kV SS "Stepantsminda", with installed capacity of 250 MW;
- P.3.2 500 kV OHL Stepantsminda-Border to Russia, length 13 km.

Completed ✓

- 500 kV OHL SS "Ksani" – SS "Stepantsminda", length 100 km;
- 12.6 km section of Ksani –Stepantsminda, 133/166 section;
- Installation of 110 kV bay for 500 kV OHL "Ksani-Stepantsminda" in 500 kV SS Ksani;
- Temporary 110 kV OHL connection between SS Ksani-500 and 500 kV OHL Ksani-Stepantsminda, length: 0.7 km.

Purpose of Project:

- Reliable realization of the power transit potential along the route Russia-Georgia-Armenia-Iran;
- Backing up the existing 500 kV OHL Kavkasioni (Georgia-Russia);
- Network integratin of hydro power plants located in Tergi River basin.

Project Description:

Implementation of this project will represent significant step towards improvement of reliability and stability of the entire Georgian transmission network. At present, Georgian electric power system mainly is synchronized with Russian system that is very advantageous with respect of reliability and frequency regulation (Russian system is 50 and more times larger comparing to the Georgian one). However, 408 km long 500 kV cross-border OHL Kavkasioni that is the only available link between Georgian and Russian systems can not ensure very high reliability of such parallel operation; due to significant length of this line, as well as extreme complexity of its route crossing the Great Caucasus Range, probability of emergencies on this line are quite high, and each emergency causes immediate full suspension of the power exchange with Russia. The project envisaging construction of 500 kV OHL Ksani-Stepantsminda-Mozdok, will back up OHL Kavkasioni and thus minimize interruption risks by ensuring transit of 700-1000 MW under single contingencies (N-1). In addition, operation of this line will allow increasing of the power exchange with Russia by about 1000 MW that will be definitely required during perspective, when bulk power trading is envisaged between Russia, Armenia and Iran (along with additional imported volumes required during winter season to cover Georgian power shortage). Also, the same line will be used for integration of the HPPs to be constructed in Tergi River basin (Larsi HPP, Dariali HPP, etc) into the network through 500/110 kV SS Stepantsminda. Moreover, this project will result in improved reliability of the power flows to 500 kV SS Ksani. It shall be noted that

500 kV section "Ksani – Stepantsminda" is finished, which will operate on 110 kV and provide not only import of Larsi HPP and Dariali HPP power into the transit network, but also provide alternative power supply of the existing 110 kV substations, which are connected in 110 kV OHL "Jinvali HPP – Kazbegi substation". After the project section between Mozdok and Stepantsminda will be constructed by Russian party, the entire OHL Ksani-Stepantsminda-Mozdok will be shifted to 500 kV. For interconnection of Larsi HPP, Dariali HPP and other HPPs from this region, 500/110 kV Autotransformer will be installed in SS Stepantsminda. The project alignment will consist of complex sections running through narrow gorges of Aragvi and Tergi Rviers, especially when crossing Caucasus Range followed by relatively flat terrain at the north.

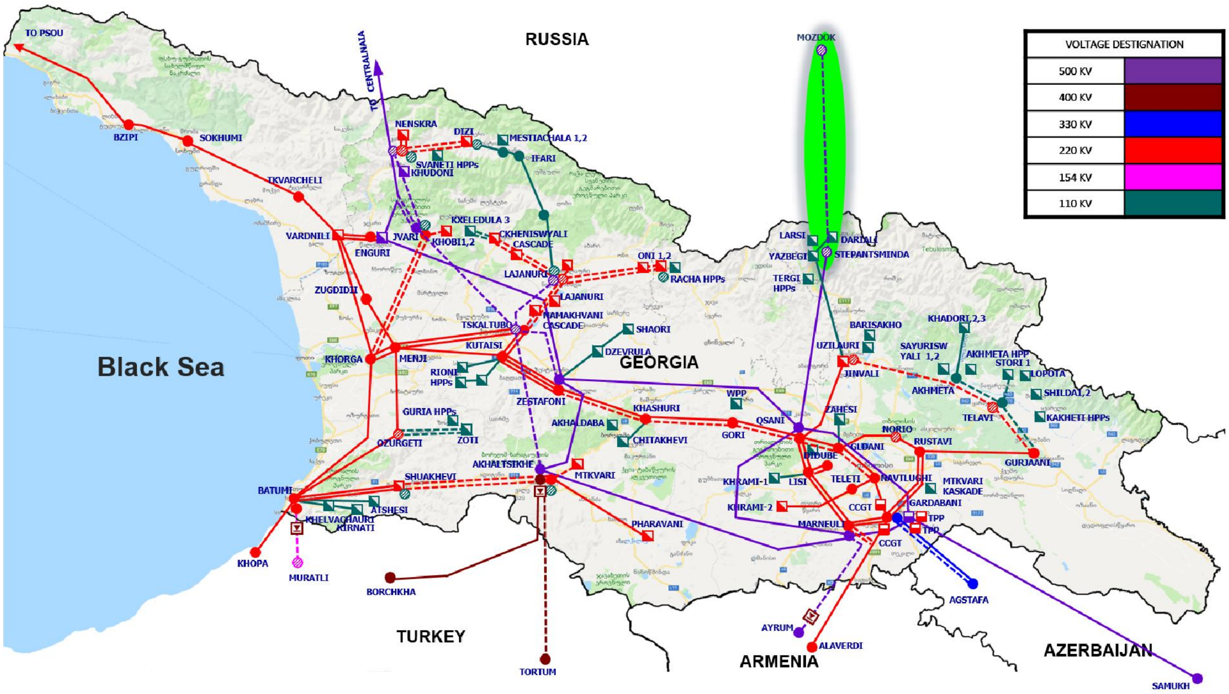

Fig. 3.4 Single-line diagam of "Ksani-Stepantsminda-Mozdok" Project

Table 3.3 Power plants integrated by the project "Ksani – Stepantsminda – Mozdok"

№	Name	Installed capacity (MW)	Generation (million kWh)
1	Larsi HPP	20	100
2	Dariali HPP	108	521
3	Aragvi HPP	8	50
4	Kazbegi HPP	6	35
5	Aragvi 2 HPP	2	13
6	Shavi aragvi 1 HPP	3	14
7	Meneso HPP	8	41
8	Shavi aragvi HPP	5	25
9	Kamara HPP	14	65
10	Mleta HPP	5	31
11	Qvesheti HPP	10	70
	Total	**189**	**964**

Project Name: **Marneuli-Ayrum**[1]
Project Importance: System/Transit
Project Commissioning Year: 2025
Forecasted Investment: **8.3 mln Euros (For the elements to be completed)**
Current Status: Construction works are ongoing
Capacity of Integrated HPPs: 0 MW
Reduction of Losses: <1 MW
Increase of Network Transfer Capacity (Normal/Emergency Modes): 700/700 MW
Project Flexibility and Influence on Reliability: High

Project Components:

To be Completed ➢

- P.4.1 500 kV OHL “Marneuli – Ayrum” (to Armenian power system) length - 35.56 km (construction of new OHL of 18.56 km – from SS “Marneuli 500” to Georgia-Armenia border).

Purpose of Project:

- Increasing power transit capabilities from Russia to Armenia/Iran.

Project Description:

The existing SS Marneuli will be expanded by construction of 500 kV switchyard that will be tied into the existing 500 kV OHL Vardzia (Akhaltsikhe-Gardabani). Also, 220 kV switchyard of this substation will be connected with the existing 500 kV OHL Mukhrani through 660 MVA autotransformer. All these will improve reliability of the power supply in the East Georgia, in particular 500/220 kV autotransformer in SS Gardabani will be fully reserved resulting no need to limit consumers in Tbilisi in case of outage of this autotransformer. In addition, the planned 180 Mvar thyristor-controlled reactor to be installed in SS Marneuli-500 will ensure keeping the voltage in Tbilis-Rustavi node close to the nominal value. In addition, SS Marneuli-500 will be connected to 500 kV side of SS Ayrum in Armenia where 700 MW (2x350 MW) 500/400 kV HVDC converter station will be constructed and interconnected by 400 kV single- (or double-)ciruict OHL to Hrazdan and further via 400 kV double-circuit OHL to Iranian transmission system. Therefore, Marneuli Project will allow exchange of 700 MW power between Georgia (or Russia) and Armenia (or Iran) and vise-versa. Practically, 500 kV OHL Marneuli-Ayrum will continue the transit route Mozdok-Stepantsminda-Ksani. From SS Ksani, power will be transferred to SS Marneuli through three 500 kV “routes”, such as Ksani-Marneuli, Ksani-Zestaponi-Akhaltsikhe-Marneuli and Ksani-Gardabani-Marneuli ensuring high reliability of the power exchange between Georgia-Russia and Armenia/Iran.

In addition, installation of 220/110 kV AT in 220 kV SS Marneuli and cut of 220 kV OHL Koda-2 into this SS increase reliability of above mentioned substation as well as opportunity of connection of consumption to it.

Fig. 3.5 Single-line diagram of “Marneuli-Ayrum” Project

*1 - **Project will be implemented by JSC** UES **“Sakrusenergo”***

Project name: **Rehabilitation of 220 KV OHL „Kolkhida-1“**
Project importance: System
Project Commissioning Year: 2022
Forecasted Investment: **3.8 million Euros**
Current Status: Preliminary system regime analysis for the project has been completed (GSE)
Capacity of Integrated HPPs: <1 MW
Reduction of Losses: <1 MW
Increase of Network Transfer Capacity (Normal/Emergency Modes): 150 MW
Project Flexibility and Influence on Reliability: High

Project Components:

- P.5.1 Reabilitation of 220 KV OHL „Kolkhida-1“.

Purpose of Project:

- Improving of Power system reliability and security of supply – Backing up 500 KV OHL „Imereti“;
- Decreament of emergency risks, quantity of emergency outages and energy not supplied.

Project Description:

Reinforsment of 220 KV network is considered, that will increase system stability and decrease load shedding capacity due to Emergency Control System activation caused by switching off 500 KV line “Imereti”.

Calculation results show that after finishing project “Jvari – Khorga” and “Tskaltubo – Zestaponi”, switching off 500 KV OHL “Imereti” (if the load was about 425 MW) will load 220 KV OHL “Kolkhida” between 180-225 MW. That is 30% more than the load on parallel lines “Senaki 1” and “Senaki 2”.

Considering technical conditions of OHL “Kolkhida 1” the transfer capacity of the line is less than 139 MW. Reinforcement of the line and increasing transfer capacity till 300 MW is required.

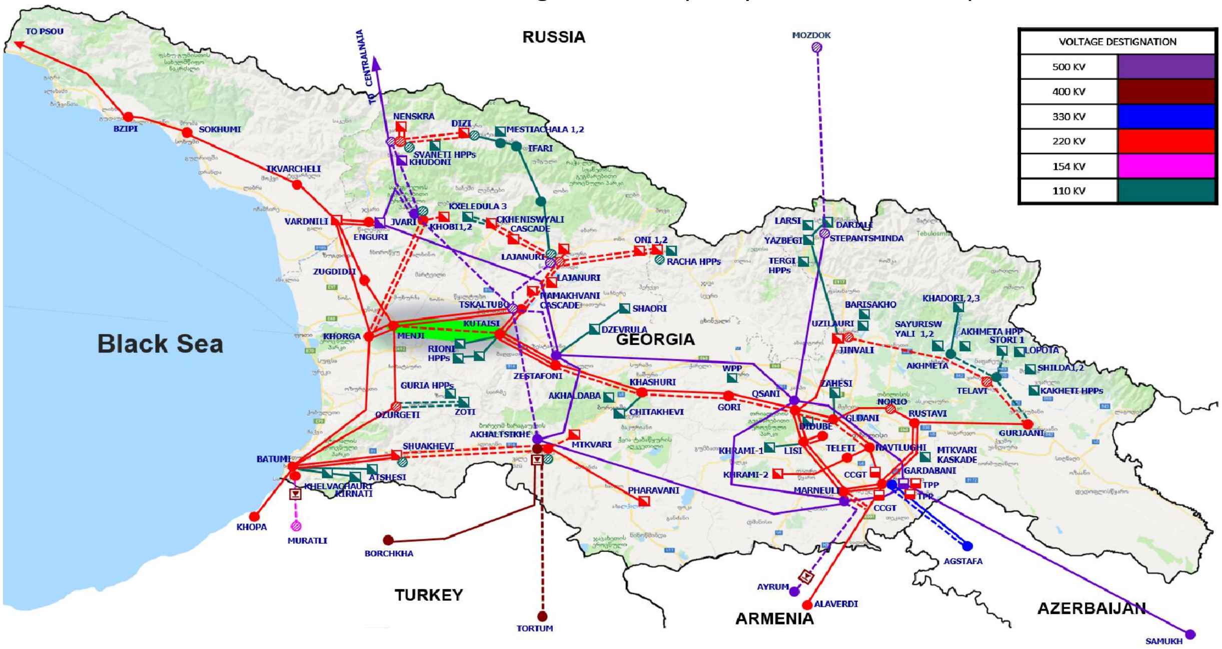

Fig. 3.6 Single-line diagram of project “Rehabilitation of Kolkhida-1”

Project Name: **Jvari-Tskaltubo-Akhaltsikhe**

Project Importance: System

Project Commissioning Year: 2023-2024

Forecasted Investment: **76.3 mln Euros**

Current Status: The feasibility study has been completed. **Special necessity of the project for Georgian transmission system has been identified**

Capacity of Integrated HPPs: 3074 MW

Reduction of Losses: 28 MW

Increase of Grid Transfer Capacity (Normal/Emergency Modes): 1200/2100 MW and 2400/4200 MW

Project Flexibility and Influence on Reliability: Very high

Project Components:

- P.6.1 500 kV SS “Tskaltubo” (501 MW, 250 MW regulating reactor);
- P.6.2 Extension of 500 kV SS "Akhaltsikhe" for connection to 500 kV OHL“Tskaltubo – Akhaltsikhe”; arrangement of bays;
- P.6.3 500 kV OHL “Jvari – Tskaltubo”, length - 80 km;
- P.6.4 Double circuit design of 500 kV OHL Tskaltubo-Akhaltsikhe with the construction of single circuit, length 104 km.

Purpose of Project:

- Increment of Power system reliability and security of supply – back up of 500 kV backbone Enguri-Zestaponi-Akhaltsikhe (OHL “Imereti” and OHL “Zekari”);
- Decreament of emergency risks, quantity of emergency outages and energy not supplied;
- Safe evacuation of the power from Khudoni-Enguri node to Turkey and eastern Georgian regions (Armenia);
- Increasing capability and reliability of the power transfer from Russia and Enguri Node to Turkey/Armenia;
- Safe Evacuation of generation power to the main grid: Khudoni HPP, Nenskra HPP, HPPs of Enguri and its tributaries, Tskenistskali Cascade, Namakhvani Cascade and Kheledula HPP; transit this power to the consumers (Tbilisi-Rustavi nodes) and as an export (to Armenia and Turkey).

Project Description:

This is the most necessary strategic importance project for Georgian electric power system, which when completed will upgrade the Western Georgian 500 kV system from the existing low reliability radial scheme (Enguri-Zestaponi) to the ring layout (Enguri-Zestaponi-Akhaltsikhe-Tskaltubo-Jvari-Enguri). Such upgrade will simultaneously address several major issues, including: **1.** Improved reliability of the existing network. The reason is that even prior to construction of Khudoni HPP and Nenskra HPP, additional 500 kV OHL is necessary in the western part of the transmission network to ensure both full back up of 500 kV OHL Imereti and Zekari and reliable evacuation of the power generated by Enguri HPP towards the East Georgia and Akhaltsikhe-Borchka cross-border line. At present, during emergency shutdowns of OHL Imereti, EMS devices initiate shedding of the 70%-80% of the load fed from this line in the Eastern Georgia (east from Kutaisi) and matching generation in the West Georgia (mainly Enguri HPP) that often exceeds 500 MW. No such event will occur after this project is implemented. **2.** Besides generation of Enguri HPP, Enguri Node receives power flow imported via 500 kV OHL Kavkasioni further evacuation of which towards Akhaltsikhe-Tbilisi is restricted by transmission capacity and reliability of OHL Imereti.

Commissioning of 500 kV OHL Jvari-Tskaltubo-Akhaltsikhe will address this problem by increasing transfer capacity of internal Georgian network from Jvari-Tskaltubo and Tskaltubo-Akhaltsikhe by 1200MW and 4200 MW respectively. **3.** Transmission of capacities of Khudoni HPP, Nenskra HPP, Mestiacha HP, Tskhenistskali HPP cascade, Kheledula HPP, Namakhvani HPP cascade etc. totally 3074 MW through substations Jvari, Tskaltubo and Zestaponi to bulk load center and to export to Turkey will be implemented.

Some modifications have been made in project "Jvari-Tskaltubo-Akhaltsikhe", based on which, 500 kV OHL Tskaltubo-Akhaltsikhe will be constructed on double-circuit towers at initial stage, but in order to minimize investments at this stage, only one circuit of this line will be arranged. In next years, respectively to the commissioning of HPPs, the growth of both the consumption and the cross-border exchange capabilities with Turkey and Armenia, construction of second circuit will be implemented.

Implementation of the project would be necessary even if integration of above mentioned HPPs was not realized.

Fig. 3.7 Single-line diagam of "Jvari-Tskaltubo-Akhaltsikhe" Project

Table 3.4 **Power plants integrated by the project "Jvari – Tskaltubo – Akhaltsikhe"**

№	Name	Installed capacity (MW)	Generation (million kWh)
1	Rachkha HPP	3	11
2	Mestiachala 2 HPP	30	107
3	Lakhami 1 HPP	6	37
4	Lakhami 2 HPP	10	50
5	Boko HPP	1	5
6	Mestiachala 1 HPP	20	69
7	Kasleti 1 HPP	8	46
8	Lahlachala HPP	12	53
9	Khobi 2 HPP	47	202

10	Sorgiti 1 HPP	13	60
11	Sorgiti 2 HPP	10	48
12	Laskadura HPP	7	33
13	Darchi HPP	17	94
14	Nakra HPP	8	35
15	Khelra HPP	3	17
16	Ifari HPP	3	17
17	Chordula HPP	2	9
18	Sadmeli 2 HPP	4	23
19	Lukhra HPP	5	23
20	Chiora HPP	14	68
21	Gebi HPP	14	71
22	Gere HPP	9	41
23	Sakaura HPP	12	59
24	Majieti HPP	12	63
25	Nakra 1 HPP	9	40
26	Nakra 2 HPP	13	60
27	Oni 1 HPP	122	441
28	Namakhvani HPPs casc.	433	1496
29	Lajanuri 1 HPP	5	27
30	Lajanuri 2 HPP	5	31
31	Lajanuri 3 HPP	5	33
32	Jonouli 2 HPP	32	129
33	Vedi HPP	24	115
34	Nenskra HPP	280	1219
35	Tsirmindi HPP	16	77
36	Oni 2 HPP	84	339
37	Qvedi HPP	2	10
38	Khudoni HPP	702	1528
39	Dizi HPP	250	960
40	Tekhura HPPs casc.	112	650
41	Alpana HPP	55	253
42	Lukhuni HPP	12	73
43	Tita HPP	5	24
44	Kheledula 3 HPP	51	255
45	Tskhenistskali HPPs casc.	357	1683
46	Kvanchianari HPP	230	920
	Total	**3074**	**11604**

Project Name: **North Ring - Tskaltubo**

Project Importance: System

Project Commissioning Year: 2023-2028

Forecasted Investment 144.5 mln Euros

Current Status: The feasibility study is ongoing

Capacity of Integrated HPPs: 2909 MW

Reduction of Losses: 13.5 MW

Increase of Network Transfer Capacity (Normal/Emergency Modes): 700 MW

Project Flexibility and Influence on Reliability: Moderate

Project Components:

- P.7.1 New 220/110 kV 250 MVA substation "Lajanuri";
- P.7.2 500 kV OHL Lajanuri-Tskaltubo, length 49 km;
- P.7.3 220 kV OHL SS Lajanuri-Lajanuri HPP, length 4 km;
- P.7.4 2-circuit 220 kV OHL Oni-Lajanuri, length 55 km;
- P.7.5 500/220 kV SS "Nenskra", 2x501 MVA;
- P.7.6 Loop in/Loop out of 500 kV OHL "Kavkasioni" in/from SS ''Nenskra", length 2 km;
- P.7.7 2-circuit 220 kV OHL Nenskra HPP-SS Nenskra, length 1 km;
- P.7.8 2-circuit 220 kV OHL Kheledula-Lajanuri, lengh 45 km;
- P.7.9 Extension of 220/110 kV SS Lajanuri with 500 kV switchyard, 801 MVA;
- P.7.10 500 kV OHL Nenskra-Jvari, length 47 km;
- P.7.11 Extension of 500 kV SS "Jvari" for connection of 500 kV OHL Jvari-Nenskra and arrangement of bays;
- P.7.12 Double-circuit 220 kV OHL Nenskra-Mestia, length 57 km;
- P.7.13 Loop in/Loop out of 500 kV OHL Jvari-Nenskra in/from Khudoni HPP.

Purpose of Project:

- Integration of HPPs located in Mestia Region into the grid;
- Integration of HPPs located on Nenskra River tributaries into the grid;
- Integration of Nenskra HPP into the grid;
- Integration of Khudoni HPP into the grid;
- Integration of Tskhenistskali Cascade HPPs and Kheledula HPP into the grid;
- Integration of Oni Cascade HPPs and the ones from Racha region into the grid.

Project Description:

The North Ring-Tskaltubo Project is one of the largest and is intended for integration of HPPs with roughly 2400 MW total capacity into the network. This project can be divided into 2 sections conventionally: **1** – double-circui 500 kV route “Jvari – Nenskra”, 500/220/110 kV substation “Nenskra”, double-circuit 110 kV route “Nenskra – Mestia”, 220 kV route “Lentekhi – Tsageri – Lajanuri”; **2** – 500/220/110 kV substation “Lajanuri New“ and 500 kV OHL “Lajanuri – Tskaltubo”. Safe and reliable integration of HPPs into the network is ensured by 500/220 kV 500 MVA substations Nenskra and Jvari (the latter is sited at the east end of entire project route), as well as by their interconnection with 500 kV transmission network; 500/220 kV Lajanuri New (located in the central part of the project) and 500 kV OHL Lajanuri-Tskaltubo connected to SS Akhaltsikhe (the bulk load centre - providing export of 1050 MW to Turkey). For the planned layout, the single contingency (N-1) criterion is satisfied even in case of loss of 500 kV OHL Lajanuri-Namakhvani-Tskaltubo.

This project shall entirely be devoted to evacuation of the HPPs' power. Therefore, construction of its specific sections will depend on interconnection of generation facilities with relevant nodes.

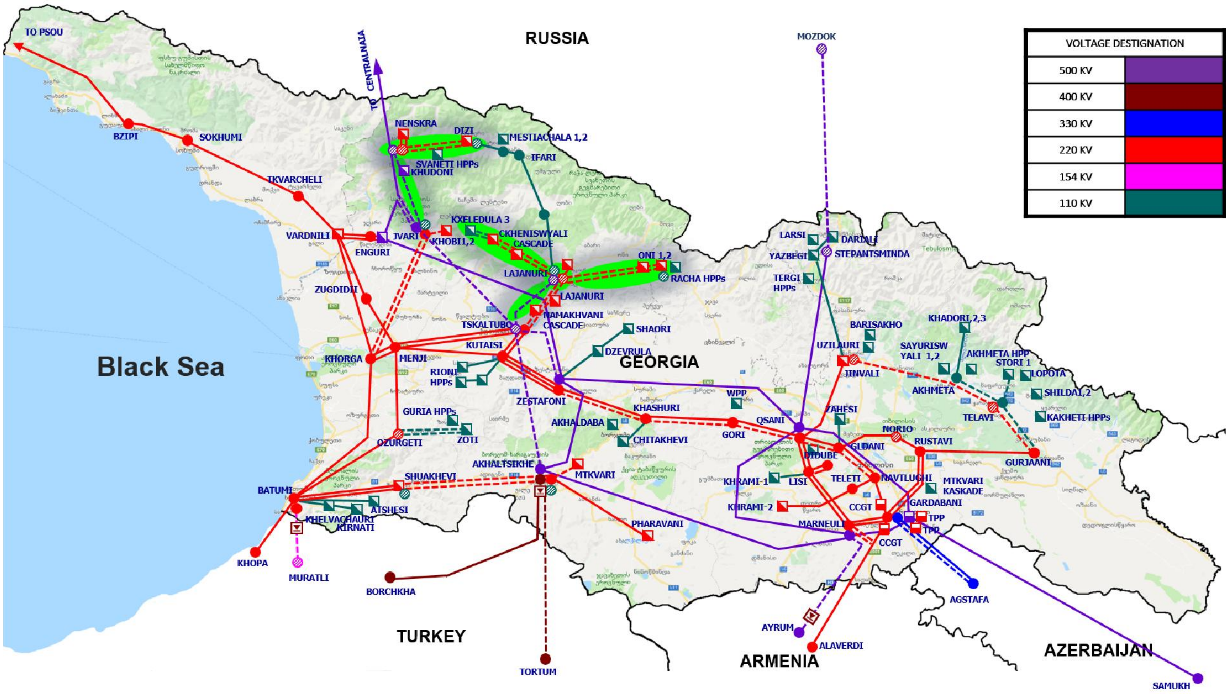

Fig. 3.8 Single-line diagram of "North Ring – Akhaltsikhe" Project

Table 3.5 Power plants integrated by the project "North Ring – Tskaltubo"

№	Name	Installed capacity (MW)	Generation (million kWh)
1	Rachkha HPP	3	11
2	Mestiachala 2 HPP	30	107
3	Lakhami 1 HPP	6	37
4	Lakhami 2 HPP	10	50
5	Mestiachala 1 HPP	20	69
6	Kasleti 1 HPP	8	46
7	Lahlachala HPP	12	53
8	Sorgiti 1 HPP	13	60
9	Sorgiti 2 HPP	10	48
10	Laskadura HPP	7	33
11	Darchi HPP	17	94
12	Nakra HPP	8	35
13	Khelra HPP	3	17
14	Ifari HPP	3	17
15	Chordula HPP	2	9
16	Sadmeli 2 HPP	4	23
17	Lukhra HPP	5	23
18	Chiora HPP	14	68
19	Gebi HPP	14	71
20	Gere HPP	9	41
21	Sakaura HPP	12	59
22	Majieti HPP	12	63
23	Nakra 1 HPP	9	40

24	Nakra 2 HPP	13	60
25	Oni 1 HPP	122	441
26	Namakhvani HPPs casc.	433	1496
27	Lajanuri 1 HPP	5	27
28	Lajanuri 2 HPP	5	31
29	Lajanuri 3 HPP	5	33
30	Jonouli 2 HPP	32	129
31	Vedi HPP	24	115
32	Nenskra HPP	280	1219
33	Tsirmindi HPP	16	77
34	Oni 2 HPP	84	339
35	Qvedi HPP	2	10
36	Khudoni HPP	702	1528
37	Dizi HPP	250	960
38	Alpana HPP	55	253
39	Lukhuni HPP	12	73
40	Kheledula 3 HPP	51	255
41	Tskhenistskali HPPs casc.	357	1683
42	Kvanchianari HPP	230	920
	Total	**2909**	**10723**

Project Name: **Guria**
Project Importance: System
Project Commissioning Year: 2022-2023
Forecasted Investment: **22.6 mln Euros**
Current Status: The feasibility study is ongoing
Capacity of Integrated HPPs: 160 MW
Reduction of Losses: 1.6 MW
Increase of Network Transfer Capacity (Normal/Emergency Modes): <5 MW
Project Flexibility and Influence on Reliability: Medium

Project Components:

- P.8.1 220/110 kV 250 MVA SS Ozurgeti with the perspective of increase;
- P.8.2 Loop in/loop out of 220 kV OHL “Paliastomi-1” to/from 220/110 kV SS Ozurgeti;
- P.8.3 Double-circuit 110 kV OHL “Ozurgeti – Zoti HPP”, 49 km, 2x110 MW capacity.

Purpose of Project:

- Integration of prospective HPPs of Guria region into the grid;
- Improvement of Security of Supply of Guria region;
- Increment of reliability of supply of Batumi region.

Project Description:

Main scope of this project is integration of prospective HPPs of Guria into the grid. For this purpose, tie-line from 220 kV OHL “Paliastomi-1” (Menji-Batumi) to the 220 kV part of new SS Ozurgeti will be constructed. This will improve security of supply of Batumi and Adjara regions as well as will additionally soften voltage problem in SS Batumi due to the supplying this substation by OHLs Ozurgeti-Batumi and Khorga-Batumi instead of two long ones (Vardnili-Batumi and Menji-Batumi). Hence, opportunity of power evacuation from this SS will be increased. In addition, it will be possible to import of part of Vartsikhe HPP power through its 110 kV wing (40-50 MW), thus increase reliability of this HPP (currently connected only to Kutaisi node) and relief of Kutaisi node. Construction of new 110 kV OHL “Ozurgeti – Zoti HPP – Chokhatauri” (to which the prospective HPPs of Guria region will be connected) will ensure reliable evacation of their generation into the grid.

Fig. 3.9 Single-line diagram of “Guria” Project

In order to improve security of supply of consumers of Adjara and Guria regions: **Distribution company has to be obligated to construct tie-lines from existing 110 kV OHLs "Chakvi" (existing "Ozurgeti-110" – "Batumi 110") and "Anaseuli" (existing "Ozurgeti-110" – "Kobuleti-110") to the new 220/110 kV SS Ozurgeti.**

Table 3.6 Power plants integrated by the project "Guria"

№	Name	Installed capacity (MW)	Generation (million kWh)
1	Sashuala 1 HPP	7	33
2	Sashuala 2 HPP	5	23
3	Baramidze HPP	8	39
4	Zoti HPP	46	172
5	Bakhvi 2 HPP	36	123
6	Gubazeuli 6 HPP	3	20
7	Bakhvi 1 HPP	12	50
8	Natanebi 1,2,3 HPP	25	174
9	Gubazeuli HPP	6	27
10	Sashuala HPP	2.6	13
11	Khevi HPP	3	22
12	Kvirila HPP	6.6	40
	Total	**160**	**736**

Project Name: **Akhaltsikhe-Tortum**

Project Importance: Transit

Project Commissioning Year: 2024-2030

Forecasted Investment: **100 mln Euros**

Current Status: The feasibility study is ongoing

Capacity of Integrated HPPs: < 5 MW

Reduction of Losses: 25 MW

Increase of Network Transfer Capacity (Normal/Emergency Modes): 350 MW

Project Flexibility and Influence on Reliability: High

Project Components:

- P.9.1 400 kV OHL Akhaltsikhe-Tortum; Length: 150 km (33 km to Georgia-Turkey border); Capacity 1850 MW;
- P.9.2 Extension of 500 kV SS Akhaltsihke for connecting 400 kV OHL “Akhaltsihke-Tortum”;
- P.9.3 Third 350 MW, 500/400 kV back-to-back link at SS Akhaltsikhe.

Purpose of Project:

- Improved reliability and power exchange capabilities between Georgia and Turkey;
- Baking up OHL Akhaltsikhe-Borchka.

Project Description:

Interconnection of bulk power HPPs to Georgian power system is planned aggregated capacity of which exceeds in-country consumption considering relevant grown rates, and hence the excess power shall be exported. With this respect, the most attractive option is export to Turkey, where demand on electric power consistently grows up. Therefore, it has been planned to increase capacity of Akhaltsikhe back-to-back station up to 1050 MW by adding the third 350 MW HVDC link. At the same time, transfer capacity of AC interconnection network between Georgia and Turkey will be increased by constructing 400 kV OHL Akhalstikhe-Tortum. Comparing to the existing 400 kV OHL Akhaltsikhe-Borchka (from Akhaltsikhe towards its southeast), the new line will be capable to export the energy to Turkey with higher reliability. Under the present scheme, power flows supplied via OHL Akhaltsikhe-Borchka towards the West Turkey is supplemented by capacities generated by Borchka HPP, Deriner HPP and other hydro power plants located in the eastern Black Sea Region of Turkey, which flood flow period coincides with the same of the West Georgi’s HPPs. Hence, power transit from Georgia is often limited in April-May-June months. Meantime, Tortum located in south of Akhaltiskhe, is close to the bulk loads of this region. Therefore, it is expected that power export in such new direction to the South Turkey will practically occur without any interruptions. In addition, these two 400 OHLs (Akhaltsikhe-Borchka and Akhaltsikhe-Tortum) will back up each other, such as in case of forced outage of one of them another will undertake transit function.

Fig. 3.10 Single-line diagram of "Akhaltsikhe-Tortum" Project

Project Name: **Batumi-Muratli**[1]

Project Importance: Transit

Project Commissioning Year: 2030

Forecasted Investment: **65.5 mln Euros**

Current Status: Preliminary system regime analysis for Project has been completed (GSE)

Capacity of Integrated HPPs: < 5 MW

Reduction of Losses: 2 MW

Increase of Network Transfer Capacity (Normal/Emergency Modes): 350 MW

Project Flexibility and Influence on Reliability: High

Project Components:

- P.10.1 One 350 MW, 220/154 kV DC back-to-back link at 220 kV SS Batumi;
- P.10.2 154 kV OHL Batumi-Muratli; Length: 15 km.

Purpose of Project:

- Improved power exchange capabilities between Georgia and Turkey;
- Improved reliability of power exchange capabilities between Georgia and Turkey.

Project Description:

Interconnection of bulk power HPPs to Georgian power system is on agenda, aggregated capacity of which exceeds in-country consumption considering relevant grown rates, and hence the excess power shall be exported. With this respect, the most attractive option is export to Turkey, where demand on electric power consistently grows up. Muratli (like Borchka and Tortum) is characterized by high level of consumption as well. Hence, installation of one 350 MW unit of Back-to-back station in SS Batumi as well as construction of 154 kV OHL Batumi-Muratli connecting Georgia to Turkey is planned. Above mentioned project will increase the ability of power exchange between Georgia and Turkey as well as opportunities of power transit for Georgia.

1-This project will be implemented by JSC "Energo-Pro Georgia"

Fig. 3.11 Single-line diagram of “Batumi-Muratli” Project

Project Name: **Namakhvani-Tskaltubo**

Project Importance: System

Project Commissioning Year: 2024

Forecasted Investment: **16.4 mln Euros**

Current Status: Preliminary system regime analysis for the project has been completed (GSE)

Capacity of Integrated HPPs: 433 MW

Reduction of Losses: 1.27 MW

Increase of Network Transfer Capacity (Normal/Emergency Modes): 1000 MW

Project Flexibility and Influence on Reliability: Moderate

Project Components:

- P.11.1 Double-circuit (splitted conductor into two parts in each phase) 220 kV OHL Namakhvani-Tskaltubo (construction of 2-nd circuit of OHL "Derchi"), length 24 km;
- P.11.2 Double-circuit (splitted conductor into two parts in each phase) 220 kV OHL Namakhvani-Tvishi-Lajanuri, length 34 km;
- P.11.3 Extension of 220 kV SS "Tskaltubo".

Purpose of Project:

- Evacuation of the power generated by Namakhvani Cascade HPPs (Upper and lower Namakhvani HPPs);
- Backing up of 500 kV OHL Lajanuri-TImproved reliability of evacuation of the power generated by Lajanuri HPP, Tskhenistskali cascade, Oni cascade, Kheledula HPP and other HPPs of region.

Project Description:

The purpose of this project is evacuation of the power from such important generation facilities as Namakhvani Cascade HPPs (Upper and lower Namakhvani HPPs, 433 MW in total). With double-circuit line (splitted conductor into two parts in each phase), OHL “Lajanuri – Tskaltubo” (one line will tie-line to Upper Namakhvani HPP and the other line will tie-line to Lower Namakhvani HPP) will provide evacuation of Namakhvani cascade’s power towards SS “Tskaltubo”. Through such integration into Namakhvani cascade grid, N-1 criteria will be met in case of outage of any OHL on this section, together with 500 kV OHL “Tskaltubo – Lajanuri”.

Fig. 3.12 Single-line diagram of “Namakhvani-Tskaltubo” Project

Table 3.7 Power plants integrated by the project "Namakhvani – Tskaltubo"

№	Name	Installed capacity (MW)	Generation (million kWh)
1	Namakhvani Cascade HPPs	433	1500
	Total	**433**	**1500**

Project name: **Rehabilitation of 500 kV OHL "Imereti"**[1]

Project importance: System

Project Commissioning Year: 2025

Forecasted Investment: **33.6 million Euros**

Current Status: Preliminary system regime analysis for the project has been completed (GSE)

Capacity of Integrated HPPs: >1000 MW

Reduction of Losses: >1 MW

Increase of Network Transfer Capacity (Normal/Emergency Modes): >1200/2100 MW

Project Flexibility and Influence on Reliability: High

Project Components:

- P.12.1 Rehabilitation of 500 KV OHL "Imereti", length 128 km (construction second circuit from Zestafoni SS to be connected to Tskaltubo SS, length 52 km);
- P.12.2 Extension of 500 kV substations Zestafoni and Tskaltubo.

Purpose of Project:

- Improvement of network stability and reliability of supply, reservation of 500 KV "Jvari – Tskaltubo – Akhaltsikhe";
- Decreasing the number of emergency situations, emergency switches and quantity of non-delivered power;
- Improved reliability of the power transfer from Khudoni - Enguri basin towards the east (towards Armenia);
- Improved ability and reliability of the power transfer from Russia and Enguri towards to Turkey/Armenia;
- Improved reliability of power evacuation from Khudoni HPP, Nenskra HPP and their tributaries HPPs towards consumption (Tbilisi, Rustavi) and export (Turkey, Armenia).

Project Description:

500 kV OHL "Imereti" is connectiong Enguri HPP generation node (<1500 MW) to consumption located in eastern part of Georgia. It should be mentioned that 500 kV OHL "Kavkasioni" is connected to Enguri node and in the eastern part of Georgia is located HVDC (700 MW) with the 400 KV OHL "Meskheti", connecting Georgia and Turkish systems.

The peak summer demand of Georgia is rising with 5% each year. During this period TPPs located in eastern part of Georgia are not under the operation. During dry period of summer the generation from seasonal HPPs are reduced and the significant part of consumption and export in turkey are fed from Enguri HPP. It should be mentioned that exporting Enguri HPP power in turkey is limited due to the 500 KV OHL "Imereti", the current capacity of the line is 750-870 MW. In case of demand growth, transferring enough power from Enguri to east will become unavailable, in spite of enough water in Enguri Reservoir. In this case reduction of export and starting TPPs will be needed. Increasing capacity of 500 kV OHL "Imereti" till its nominal value (≈2000 MW) will be actual even after building parallel OHLs "Jvari – Tskaltubo – Akhaltsikhe". This parallel OHLs will reserve 500 kV "Imereti" outage, but OHL "Imereti" will not be able to reserve outage any of its parallel 500 kV lines. The rehabilitation of 500 kV OHL "Imereti" is one of the most important project.

Project "Rehabilitation of 500 kV OHL Imereti" has been modified, in particular, the following elements have been added: construction of double-circuit from 500 kV SS Zestaponi side and its connection to 500 kV SS Tskaltubo, extension of 500 kV substations Zestaponi and Tskaltubo, their implementation is planned for 2025.

1 - Element of Project P.12.1 will be implemented by JSC** UES **"Sakrusenergo"

Fig. 3.13 Single-line diagram of project "Rehabilitation of Imereti"

Project name: **Renovation of substations**

Project importance: System

Project Commissioning Year: 2021-2025

Forecasted Investment: **16.3 million Euros**

Current Status: Preliminary system regime analysis for the project has been completed (GSE)

Capacity of Integrated HPPs: 0 MW

Reduction of Losses: >1 MW

Increase of Network Transfer Capacity (Normal/Emergency Modes): >100 MW

Project Flexibility and Influence on Reliability: Moderate

Project Components:

To be Completed ➢

- P.13.1 Replacement of A and B phases of 500/220 kV at in SS Zestafoni; Replacement of C phase of 500/220 kV at in SS Gardabani;
- P.13.2 Arrangement of two 110 kV bays at SS Zestafoni;
- P.13.3 110 kV switchyard and 2x63 MVA 220/110 kV autotransfermers in SS "Akhaltsikhe-500";
- P.13.4 110 kV switchyard and 2x63 MVA 220/110 kV autotransfermers in SS "Jvari-500";
- P.13.5 Renovation of 15 substations;
- P.13.6 110/35 kV switchyard 220/110/35 kV autotransfermers in SS “Oni-220".

Purpose of Project:

- Improving of stability of Georgian power system as well as security of consumers' supply.

Project Description:

Because of need of coverage annual growth of consumption, enlargement of existing or connection of new applicants (including consumption), increasing the capacity of listed substations, technical renewal and making infrastructural changes is required. Those substations are: 220 KV SS “Tskaltubo”, 220 KV SS “Gori”, 220 KV SS “Menji”, 220 KV SS “Didube”, 220 KV SS “Zugdidi”, 220 KV SS “Batumi”, 220 KV SS “Kutaisi”, 500 KV SS “Zestaponi”, 220 KV SS “Khashuri”, 220 KV SS “Gldani”, 220 KV SS “Navtlugi”, 220 KV SS “Lisi”, 220 KV SS “Rustavi”, 220 KV SS “Gurjaani”, 220 KV SS “Marneuli”, 500/220 KV SS “Gardabani”.

For reliable operation and increasing power the required procedure include changing of power equipments (autotransformers, transformers for their age and not enough power), renewal of primary and secondary equipment, renewal of cable system, infrastructural renewal, installation of IT technologies and progressing to the new technologies. This will increase reliability, stability of grid and safety of feeding the load.

Purpose of arrangement of two 110 kV bays at 500 kV SS Zestaponi is the integration of 100 MW Imereti Wind power plant and reliable evacuation of its power to the transmission network.

Project name: **Reinforcement of Kakheti infrastructure**

Project importance: System

Project Commissioning Year: 2023-2024

Forecasted Investment: **66.9 million Euros**

Current Status: The feasibility study is ongoing

Capacity of Integrated HPPs: 271 MW

Reduction of Losses: <1 MW

Increase of Network Transfer Capacity (Normal/Emergency Modes): 300 MW

Project Flexibility and Influence on Reliability: Moderate

Project Components:

- P.14.1 220/110/10 kV new substation in Telavi;
- P.14.2 110 kV OHL Stori HPP-NewTelavi, length 41.5 km;
- P.14.3 2-circuit 220/110 kV OHL Gurjaani-New Telavi, in 220 kV dimensions, length 44.2 km;
- P.14.4 110 kV OHL New Telavi-Akmeta in 220 kV dimensions, length 30.5 km;
- P.14.5 Rehabilitation of 220/110 kV SS Gurjaani;
- P.14.6 Reconstruction of 110 kV substations "Akhmeta";
- P.14.7 Reconstruction and rehabilitation of 35 kV Tusheti infrastructure, length 55 km;
- P.14.8 220 kV OHL NewTelavi-Zhinvali, length 62.6 km;
- P.14.9 220/110 kV new substation in Zhinvali.

Purpose of Project:

- Integration of new HPPs from Kakheti district;
- Improving security of supply of Kakheti region.

Project Description:

The main goal of the project "Reinforcement of Kakheti Infrastructure" is to integrate prospective hydro power stations in Kakheti region into the network and to increase reliability of supply of Kakheti and Dusheti regions. This envisages arrangement of 220 kV network from Gurjaani to Jinvali. Project has been modified, as a result of which the following projects are planned to be implemented: 1) Construction of new 220/110/10 kV SS Telavi; 2) construction of 2-circuit OHL between Gurjaani and New Telavi in 220 kV dimension, one of them operating at 220 kV, another one at 110 kV; 3) construction of new 110 kV OHL from SS New Telavi to SS Akhmeta also in 220 kV dimension; 4) construction of new 220 kV OHL connecting SS New Telavi to SS Zhinvali; 5) construction of new 220/110 kV substation at Zhinvali which will ensure to increase both security of supply and reliability of generation evacuation in Kakheti and Dusheti regions up to N-1 criteria. Besides this, rehabilitation of 220 kV SS Gurjaani and construction of 110 kV infrastructure in direction to Stori (summary potential of Stori cascade HPPs and HPPs near Napareuli region is up to 70 MW) is planned as well. In order to develop the turistic potential of Tusheti region, project of construction/rehabilitation of 35 kV network from SS Napareuli through Stori HPP in direction to Tusheti with total length of 55 km has been added to the project of “Reinforcement of Kakheti Infrastructure”.

Fig. 3.14 Single-line diagram of project "Reinforcement of Kakheti infrastructure"

Table 3.8 Power plants integrated by the project "Reinforcement of Kakheti infrastructure"

№	Name	Installed capacity (MW)	Generation (million kWh)
1	Khadori 3 HPP	5	28
2	Chapala HPP	0.43	3
3	Chartali HPP	2	12
4	Stori 1 HPP	13.6	61
5	Deka HPP	1	6
6	Baisubani HPP	5	33
7	Akhalsofeli HPP	5	27
8	Lopota 1 HPP	6	34
9	Samkuristskali 1 HPP	5	26
10	Samyuristskali 2 HPP	26	129
11	Fona HPP	11	55
12	Stori 2 HPP	11.4	54
13	Ilto-Alazani HPPs	180	620
	Total	**271**	**1085**

Project name: **Reactive power source (capacitor banks)**
Project Importance: System
Project Commissioning Year(s): 2021-2026
Forecasted Investment: **12 mln euros**
Current Status: Preliminary system regime analysis for Project has been completed (GSE)
Capacity of Integrated HPPs: 0 MW
Reduction in Losses: 6-8 MW
Increase of Network Transfer Capacity (Normal/Emergency Modes): 0 MW
Project Flexibility and Influence on Reliability: High

Project components:

- P.15.1 600 MVAR reactive power compensation equipment in 220 kV substations of Tbilisi region.

Purpose of Project:

- Maintaining of voltage levels in Georgian power system at permissible ranges during normal and N-1 state.

Project description:

While annual increase of electricity consumption in Georgia, there are low voltage problems expected at bus bars of substations located in east part of the country in case of maximum scenarios for 2025. This issue is particularly noticeable in N-1 mode, in case of outage of 500 kV OHLs “Kartli-2” and “Vardzia” resulting significant decrease of voltage levels in east part of Georgian power system.

In order to avoid above-mentioned problem, it is necessary to install reactive power-generating equipment (in particular capacitor banks) at 220 kV substations located in East part of power system (Navtlugi, Gldani, Lisi, Didube, Ksani, Gardabani, Marneuli). It’s noteworthy that some substations may be replaced by other ones, which will be defined at the study phase.

Project name: **Security of supply of Tbilisi region**

Project Importance: System

Project Commissioning Year(s): 2021-2026

Forecasted Investment: **25.7 mln euros**

Current Status: Preliminary system regime analysis for Project has been completed (GSE)

Capacity of Integrated HPPs: 0 MW

Reduction in Losses: <1 MW

Increase of Network Transfer Capacity (Normal/Emergency Modes): 400 MW

Project Flexibility and Influence on Reliability: High

Project components:

- P.16.1 Loop in/loop out of 220 kV OHL "Alaverdi" in/from SS "Marneuli-500", length 2x16.7 km and arrangement of two 220 kV bays;
- P.16.2 Rehabilitation of part of 220 kV OHL Alaverdi, 7.5 km
- P.16.3 Construction of second circuit of 220 kV OHL "Aragvi" and arrangement of bays;
- P.16.4 220/110 kV SS "Norio", with 2x125 MVA installed capacity;
- P.16.5 Loop in/loop out of 220 kV OHL "Varketili" in/from SS "Norio-220", length 2x4 km;
- P.16.6 Reinforcement of 220 KV OHL "Kukia";
- P.16.7 Replacement of 500/220 kV 501 MVA autotransformer with 500/220 kV 801 MVA one in SS "Ksani-500".

Purpose of Project:

- Ensuring of reliability of supply of Tbilisi;
- Connection of “Gardabani CCGT-2” to transmission network and reliable evacuation of its power;
- Reinforcement of Marneuli-Gardabani nodes.

Project description:

Consumption of Georgian power system is increasing annually what is particularly noticeable in Tbilisi region. Secure supply of this region is impossible by existing infrastructure. hence, the project of “Security of supply of Tbilisi region” is planned. As a results of system regime analysis, N-1 criteria will be fulfilled after realization of this project ensuring uninterrupted supply of the consumers of Tbilisi.

In scope of connection of “Gardabani TPP-2” to the transmission grid, 220 kV OHL “Alaverdi” will be cut and become double-circuit from Gardabani SS side, as for another side it will be looped in / looped out in/from Marneuli SS as a result of which reliability of connection of above-mentioned Thermal power plant to the network as well as existing network around Tbilisi (Marneuli-Gardabani nodes) will be increased.

Fig. 3.15 Single line diagram of the project “Security of supply of Tbilisi region”

Project name: **Rehabilitation of 220 kV OHL Navtlugi-CCGT-Gardabani (Navtlugi 1,2) and construction second circuit of 220 kV backbone Zestafoni-Ksani**

Project Importance: System

Project Commissioning Year(s): 2024

Forecasted Investment: **42 mln euros**

Current Status: Preliminary system regime analysis for Project has been completed (GSE)

Capacity of Integrated HPPs: 230 MW

Reduction in Losses: <1 MW

Increase of Network Transfer Capacity (Normal/Emergency Modes): 400 MW

Project Flexibility and Influence on Reliability: Moderate

Project components:

- P.17.1 Rehabilitation of 220 kV OHL Navtlugi 1,2, length 38 km;
- P.17.2 Rehabilitation of 220 kV OHL "Surami", length 67 km;
- P.17.3 Rehabilitation of 220 kV OHL "Urbnisi", length 45 km;
- P.17.4 Rehabilitation of 220 kV OHL "Liakhvi", length 56 km.

Purpose of Project:

- Reliable fulfillment of increasing consumption of east Georgia and reliable evacuation of power of CCGT-1;
- Reliable satisfaction of increased consumption in Eastern Georgia;
- Possibility of integration of prospective HPPs and renewable energy sources into the grid;
- Back up of 500 kV OHLs “Kartli-2” and “Vardzia”.

Project description:

About 50 years ago the east and west parts of Georgian transmission system were connected by single 220 kV OHL from 220 kV SS Zestafoni to 220 kV SS Gardabani (through 220 kv SS Navtlugi). The sections Zestafoni-Khashuri-Gori-Ksani and Navtlighi-CCGT1-Gardabani are still old and outdated.

Nowadays the operational limits of 220 kV OHL Navtlighi-CCGT1-Gardabani (Navtlugi 1, 2) are at a very low levels and it’s impossible to evacuate the full generation of Gardabani 1 CCGT in a safe and reliable manner.

The operational limits of 220 kV backbone Zestafoni-Khashuri-Gori-Ksani is very low as well. In the future, the increased consumption in the eastern Georgia will cause the overloading of above-mentioned backbone in N-1 mode, in particular in case of outage of “Kartli-2” or “Vardzia”. In order to avoid these constraints, rehabilitation of 220 kV OHL "Navtlugi 1, 2" and reconstruction of 220 kV backbone of Kartli (Zestaponi-Ksani) with double circuit construction is necessary. Also there is a RES integration projects in Zestafoni, Khashuri and Gori substations, which will be supported by this project.

Fig. 3.16 Single line diagram of the project "Rehabilitation of 220 kV OHL Navtlugi-CCGT-Gardabani and construction second circuit of 220 kV backbone Zestafoni-Ksani"

Table 3.9 Power plants integrated by the project

№	Name	Installed capacity (MW)	Generation (million kWh)
1	Wind PPs	230	908

Project name: **Construction of second circuit of 330 kV OHL "Gardabani-Agstafa"**

Project Importance: System

Project Commissioning Year(s): 2021-2022

Forecasted Investment: 17 mln euros

Current Status: Preliminary system regime analysis for Project has been completed (GSE)

Capacity of Integrated HPPs: >0 MW

Reduction in Losses: <1 MW

Increase of Network Transfer Capacity (Normal/Emergency Modes): 400 MW

Project Flexibility and Influence on Reliability: Moderate

Project components:

- P.18.1 Construction of second circuit of 330 kV OHL "Gardabani-Agstafa", length 21 km (till Georgia-Azerbaijan border)*;
- P.18.2 330/220 kV, 400 MVA AT in SS Gardabani and arrangement of relevant bays.

Purpose of Project:

- Providing 700–1000 MW of capacity exchange between Georgia and Azerbaijan with fulfillment of N-1 criteria;
- Increase of both power exchange ability and reliability in direction of Azerbaijan-Georgia-Turkey;
- Improvement of reliability of the synchronous ring of Georgia-Russia-Azerbaijan systems.

Project description:

Connection to the Azerbaijan Energy System cannot provide sufficient level of reliability, the its transfer capability in the N-1 mode does not exceed 240 MW (transfer capacity of 330 kV OHL Gardabani). In case of construction of its second circuit, which has already started on Azerbaijan side, its capacity will be equal to transfer capacity of 500 kV OHL Mukhranis veli providing the possibility of 700-1000 MW power exchange between Georgia and Azerbaijan consequently allowing uninterrupted 700 MW power exchange between power systems of Turkey and Azerbaijan via the Georgian one. In addition, the reliability of the operation of Georgia-Russia-Azerbaijan synchronous ring will be increased.

Fig. 3.17 Single line diagram of the project "Construction of second circuit of 330 kV OHL Gardabani-Agstafa"

** - Project P.18.1 will be implemented by JSC UES "Sakrusenergo"*

Project Name: **Georgia-Russia-Azerbaijan power system connection project (feasibility study)**

Project Importance: Transit

Project End Time: 2021-2022 **Year**

Forecasted Investment:

Current Status: Pre-works to start feasibility study

Capacity of Integrated HPPs: 0 MW

Reduction of Losses: <1 MW

Increase of Grid Transfer Capacity (Normal/Emergency Modes): 350 MW

Project Flexibility and Influence on Reliability: High

Project Components:

- *Will be defined after completion of the study.*

Purpose of Project:

- Determination of optimal Projects for strengthening Transmission infrastructure, for joint operation of Georgia-Azerbaijan-Russian systems;
- Increasing reliability of these systems, and Increasing potential of electricity exchange;
- Regulation of the flow (including circulation flow).

Project Description:

Nowadays, Georgia-Russia-Azerbaijan power systems unable to operate in one ring. One of the cross border tie(s) of this ring is always turned off, which reduces the reliability of all three systems and increase the risk for Georgia and/or Azerbaijan systems IPS/UPS to lose synchronization with other powers systems (CIS, Baltic, Ukraine, Georgia). This reduces Georgia and/or Azerbaijan system(s) inertia constants and capability of frequency containment reserves, therefore it worsens the safety level of supply and power quality. Besides this, potential of power trade is decreasing between systems, for example, one power system cannot implement power exchange in two other power systems if does not happen scheme weakening (operation with island mode). One of the reason is "circulating" flow, which will move in the direction of "clockwise" in case of Georgia-Russia-Azerbaijan ring. This project (Feasibility Study) has to identify the technology, technical characteristics, installation point(s) and operation philosophy of equipment(s) for cross border flow control, in order to make possible joint operation of Georgia-Azerbaijan-Russian systems.

Project Name: **Georgia-Romania Black Sea (submarine) interconnection cable project (feasibility study)**

Project Importance: Transit

Project End Time: 2020-2022 **Year**

Current Status: feasibility study is ongoing

Project data such as: forecasted investment, capacity of integrated power plants, reduction of losses, increase of grid transfer capacity, project flexibility and influence on reliability and project components will be clarified after completion of feasibility study.

Purpose of Project:

- Connection of Georgian electricity power system to Synchronous grid of Continental Europe;
- Creation of the opportunity for electricity trading with European countries;
- Increasing of transit potential;
- Improvement of energy security level of Caucasus region;
- Support in construction of power plants operating on renewable energy sources.

Project Description:

Georgia-Romania Black Sea submarine interconnection project will connect Georgian power system (and South Caucasus region) to Synchronous grid of Continental Europe, therefore, give opportunity to Georgia to implement electricity trade with European countries. Mentioned project will assist energy security of European Union and Caucasus region, support development of renewable energy sector, increase transit opportunities and trade options between European Union and South Caucasus region which will have positive impact on electricity producers and transmission system operators.

Based on preliminary data, construction of double-circuit 500 kV between existing 500 kV SS Jvari and new 500 kV SS Anaklia will be constructed. The next part will be two-pole 500 kV DC submarine cable Anaklia-Constanta. In order to implement such connection, construction of 500/500 kV DC converter station with installed capacity of 2x500 MW at Anaklia substation is considered. Implementation of this project may require additional reinforcement of high voltage network of mentioned interconnected power systems, which will be revealed after completion of feasibility study.

ANNEX-1 COST ESTIMATES OF PLANNED PROJECTS

Estimated Costs and Commisionning Years

Project name	Project element			
	Esitmate commissioning year	№	Name	Estimate costs, EUROs
Jvari-Khorga	2021	P.1.1	Looping of 500 kV OHL "Kavkasioni" in SS "Jvari", 16 km (2x8 km)	
	2022	P.1.2	Double circuit 220 kV OHL "Odishi-1,2" (Jvari- Khorga), length 60 km	
			Total Project Cost	**€ 20,637,564**
Batumi-Akhaltsikhe	2022	P.2.1	Double circuit 220-kV transmission line Shuakhevihesi-Akhaltsikhe, length 90 km	
	2024	P.2.2	220/110/35 kV autotransformer in SS "Skuakhevi"	
			Total Project Cost	**€ 35,095,000**
Ksani-Stepantsminda-Mozdok	2025	P.3.1	500/110 kV SS "Stepantsminda", installed capacity 250 MVA	
	2025	P.3.2	500 kV OHL Stepantsminda-Border to Russia, length 13 km	
			Total Project Cost	**€ 20,630,000**
Marneuli-Airum	2025	P.4.1	500 kV OHL “Marneuli – Ayrumi” (to Armenian power supply system) length - 35.56 km (construction of new OHL of 18.56 km – from SS “Marneuli 500” to Georgian-Armenian border).	
			Total Project Cost	**€ 8,298,000**
Rehabilitaion of Kolkhida-1	2022	P.5.1	Rehabilitaion of 220 kV OHL "Kolkhida-1", length 66 km	
			Total Project Cost	**€ 3,765,000**
Jvari-Tskaltubo-Akhaltsikhe	2023	P.6.1	500 kV substation "Tskaltubo", 501 MVA, 250 MVAR	
	2024	P.6.2	Extension of 500 kV SS "Akhaltsikhe"	
	2024	P.6.3	500 kV OHL Jvari-Tskaltubo, length 80 km	
	2024	P.6.4	Double circuit design of 500 kV OHL Tskaltubo-Akhaltsikhe with the construction of single circuit, length 104 km	
			Total Project Cost	**€ 76,277,400**
North-Ring-Tskaltubo	2023	P.7.1	New 220/110 kV 250 MVA substation "Lajanuri"	
	2023	P.7.2	500 kV OHL Lajanuri-Tskaltubo, length 49 km	
	2023	P.7.3	220 kV OHL SS Lajanuri-Lajanuri HPP, length 4 km	
	2025	P.7.4	2-circuit 220 kV OHL Oni-Lajanuri, length 55 km	
	2025	P.7.5	500/220 kV SS "Nenskra", 2x501 MVA	
	2025	P.7.6	Loop in/Loop out of 500 kV OHL "Kavkasioni" in/from SS "Nenskra", length 2 km	
	2025	P.7.7	2-circuit 220 kV OHL Nenskra HPP-SS Nenskra, length 1 km	
	2028	P.7.8	2-circuit 220 kV OHL Kheledula-Lajanuri, lengh 45 km	
	2028	P.7.9	Extension of 220/110 kV SS Lajanuri with 500 kV switchyard, 801 MVA	
	2028	P.7.10	500 kV OHL Nenskra-Jvari, length 47 km	
	2028	P.7.11	Extension of 500 kV SS "Jvari" for connection of 500 kV OHL Jvari-Nenskra and arrangement of bays	
	2028	P.7.12	Double-circuit 220 kV OHL Nenskra-Mestia, length 57 km	
	2028	P.7.13	Loop in/Loop out of 500 kV OHL Jvari-Nenskra in/from Khudoni HPP	
			Total Project Cost	**€ 144,529,539**

Guria	2022	P.8.1	220/110 kV SS "Ozurgeti", 250 MVA	
	2022	P.8.2	Loop in/Loop out of 220 kV OHL "Paliastomi-1" in/from 220/110 kV SS "Ozurgeti"	
	2023	P.8.3	Double-circuit 110 kV OHL Ozurgeti-Zoti HPP, length 47 km	
			Total Project Cost	**€ 22,569,200**
Akhaltsikhe-Tortum	2024	P.9.1	400 kV OHL Akhaltsikhe-Tortum (till Georgia-Turkey border), length 33 km	
	2024	P.9.2	Extension of 500 kV SS "Akhaltsihke" for connecting 400 kV OHL Akhaltsihke-Tortum and arrangement of bay	
	2030	P.9.3	Third 500/400 kV back-to-back DC link at SS "Akhaltsikhe", 350 MW	
			Total Project Cost	**€ 100,157,400**
Batumi-Muratli	2030	P.10.1	220/154 kV back-to-back DC link at SS "Batumi", 350 MW	
	2030	P.10.2	154 kV OHL Batumi-Muratli, length 15 km	
			Total Project Cost	**€ 65,450,000**
Namakhvani-Tskaltubo	2024	P.11.1	Double-circuit (splitted conductor into two parts in each phase) 220 kV OHL Namakhvani-Tskaltubo (construction of 2-nd circuit of OHL "Derchi"), length 24 km	
	2024	P.11.2	Double-circuit (splitted conductor into two parts in each phase) 220 kV OHL Namakhvani-Tvishi-Lajanuri, length 34 km	
	2024	P.11.3	Extension of 220 kV SS "Tskaltubo"	
			Total Project Cost	**€ 16,401,000**
Rehabilitaion of Imereti	2025	P.12.1	Rehabilitation of 500 KV OHL "Imereti", length 128 km (Construction of second circuit from SS zestafoni to SS Tskaltubo, length 52 km)	
	2025	P.12.2	Extension of 500 kv SSs Zestafoni and Tskaltubo	
			Total Project Cost	**€ 33,600,000**
Renovation of substations	2021	P.13.1	Replacement of A and B phase of 500/220 kV at in SS Zestafoni; Replacement of C phase of 500/220 kV at in SS Gardabani.	
	2021	P.13.2	Arrangement of 110 kV 2 bays in SS Zestafoni	
	2022	P.13.3	110 kV switchyard and 2x63 MVA 220/110 kV autotransfermers in SS "Akhaltsikhe-500"	
	2023	P.13.4	110 kV switchyard and 2x63 MVA 220/110 kV autotransfermers in SS "Jvari-500"	
	2024	P.13.5	Renovation of 15 substations	
	2025	P.13.6	110/35 kV switchyard 220/110/35 kV autotransfermers in SS "Oni-220"	
			Total Project Cost	**€ 16,264,333**
Reinforcement of Kakheti Infrastructure	2023	P.14.1	220/110/10 kV new substation in Telavi	
	2023	P.14.2	110 kV OHL Stori HPP-NewTelavi, length 41.5 km	
	2023	P.14.3	Double-circuit 220/110 kV OHL Gurjaani-New Telavi, in 220 kV dimensions, length 44.2 km	
	2024	P.14.4	110 kV OHL NewTelavi-Akmeta in 220 kV dimensions, length 30.5 km	
	2024	P.14.5	Rehabilitation of 220/110 kV SS Gurjaani	
	2024	P.14.6	Reconstruction of 110 kV substations "Akhmeta"	
	2024	P.14.7	Reconstruction and rehabilitation of 35 kV Tusheti infrastructure, length 55 km	
	2024	P.14.8	220 kV OHL NewTelavi-Zhinvali, length 62.6 km	
	2024	P.14.9	220/110 kV new substation in Zhinvali	
			Total Project Cost	**€ 66,896,630**
Reactive power source (capacitors)	2021-2026	P.15.1	600 MVAR reactive power compensation equipment in 220 kV substations of Tbilisi	
			Total Project Cost	**€ 12,000,000**

Security of supply of Tbilisi region	2021	P.16.1	Loop in/loop out of 220 kV OHL "Alaverdi" in/from SS "Marneuli-500", length 2x16.7 km and arrangement of two 220 kV bays	
	2021	P.16.2	Rehabilitation of part of 220 kV OHL Alaverdi, 7.5 km	
	2022	P.16.3	Construction of second circuit of 220 kV OHL "Aragvi", length 34 km and arrangement bays	
	2024	P.16.4	220/110 kV SS "Norio", with 2x125 MVA installed capacity	
	2024	P.16.5	Loop in/loop out of 220 kV OHL "Varketili" in/from SS "Norio-220", length 2x4 km	
	2024	P.16.6	Reinforcement of 220 KV OHL "Kukia"	
	2026	P.16.7	Replacement of 500/220 kV 501 MVA autotransformer with 500/220 kV 801 MVA one in SS "Ksani-500"	
			Total Project Cost	**€ 25,726,000**
Rehabilitation of 220 kV OHL Navtlugi-CCGT-Gardabani (Navtlugi 1,2) and construction second circuit of 220 kV backbone Zestafoni-Ksani	2024	P.17.1	Rehabilitation of 220 kV OHL Navtlugi 1,2, length 38 km	
	2024	P.17.2	Construction of second circuit of 220 kV OHL "Surami", length 67 km	
	2024	P.17.3	Construction of second circuit of 220 kV OHL "Urbnisi", length 45 km	
	2024	P.17.4	Construction of second circuit of 220 kV OHL "Liakhvi", length 56 km	
			Total Project Cost	**€ 42,000,000**
Construction of second circuit of 330 kV OHL "Gardabani-Agstafa"	2021	P.18.1	Construction of second circuit of 330 kV OHL "Gardabani-Agstafa", length 21 km (till Georgia-Azerbaijan border)	
	2022	P.18.2	330/220 kV, 400 MVA AT in SS Gardabani and arrangement of relevant bays	
			Total Project Cost	**€ 17,144,402**
			TOTAL COSTS	**€ 727,441,468**

ANNEX 2 - MAP OF TRANSMISSION NETWORK OF GEORGIA