Georgia

# Security of Supply Statement in Electricity Sector

2021

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# 1. Legal Regulation on Security of Supply and Key players in Electricity Sector

## 1.1. Law on Energy and Water Supply

The main law regulating the energy sector of Georgia is the Georgian Law on Energy and Water Supply (hereafter The Energy Law). The Energy law, implementing related EU regulations into Georgian legal framework, was adopted by the Parliament of Georgia on December 20, 2019.

The Energy Law incorporates the following EU legislations: (1) Directive 2009/72/EC of the European Parliament and of the Council concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC; (2) Regulation (EC) No 714/2009 of the European Parliament and of the Council of 13 July 2009 on conditions for access to the network for cross-border exchanges in electricity and repealing Regulation (EC) No 1228/2003; (3) Directive 2005/89/EC of the European Parliament and of the Council of 18 January 2006 concerning measures to safeguard security of electricity supply and infrastructure investment; (4) Directive 2009/73/EC of the European Parliament and of the Council concerning common rules for the internal market in natural gas and repealing Directive 2003/55/EC; (5) Regulation (EC) No 715/2009 of the European Parliament and of the Council of 13 July 2009 on conditions for access to the natural gas transmission networks and repealing Regulation (EC) No 1775/2005; and (6) Council Directive 2004/67/EC concerning measures to safeguard security of natural gas supply.

The Energy Law in relation to the electricity sector establishes:

- a general legal framework for the generation, transmission, distribution, supply and trade;
- issues related to governing and organization, regulation, monitoring and supervision of the electricity sectors;
- open access to the electricity markets;
- cross-border trade of electricity;
- the criteria and procedures applicable to calls for tenders and permits for energy activities, the operation of electricity systems and access to them;
- public service obligations in electricity sectors;
- customer rights and their protection;
- measures to ensure an adequate level of security of supply
- the legal framework for defining of security of supply policies

- procedures to ensure the reliability of supply, determined in accordance with the requirements of competitive electricity and natural gas markets.

The Energy Law purpose is to ensure:

- establishment of a legal framework for uninterrupted supply of electricity at defined quality standards for the benefit of all categories of customers in Georgia;
- secure, reliable and efficient operation of electricity system;
- setting rights and obligations of the Georgian National Energy and Water Supply Commission (THE COMMISSION ) and regulated undertakings;
- encouraging full opening of electricity market based on the principles of competitiveness, transparency and non-discrimination;
- establishment of general rules for the organization and functioning of the electricity market, taking into account future relationships with the Parties of the Energy Community, its pan-European integration;
- setting terms and conditions for the provision of public service obligations and to ensure the protection of interests of final customers;
- regulation and monitoring of the unbundling of transmission system operators and distribution system operators;
- adequate conditions for investments, including, interconnections with neighboring systems and in other facilities enhancing the security of supply;
- regional and international cooperation of system and market operators, THE COMMISSION and other state authorities.

## 1.2. Law on Encouraging the production and use of energy from renewable sources

Georgia has an obligation under the Association Agreement between the EU and the European Atomic Energy Community and their Member States and Georgia (hereafter “Association Agreement”) and Protocol Concerning the Accession of Georgia to the Treaty establishing the Energy Community (hereafter “Protocol”) to harmonize the EU Directive 2009/28/EC on the Promotion of the use of Energy from Renewable Sources. Georgia has fulfilled this obligation and implemented the Law on Encouraging the Production and Use of Energy from Renewable Sources (hereafter “The Law on RES”) on December 20, 2019.

The Law on RES establishes:

- legal framework for promoting the production and use of energy from renewable energy sources;
- mandatory national targets for the total share of renewable energy in gross final energy consumption and for the share of renewable energy in transport;

- rules regarding support schemes, statistical transfers between Georgia and the Contracting Parties of the Energy Community, joint projects between Georgia and the Contracting Parties of the Energy Community, as well as between Georgia and third countries, guarantees of origin, administrative procedures, information and training, and access to the power grid for energy generated from renewable sources;
- sustainability criteria for biofuels and bio-liquids.

The Law on RES sets a national target for renewable energy at 35% to be achieved by 2030. It also provides the freedom to choose support schemes to achieve the aforementioned national target. The Law on RES obliges the Government to approve the National Renewable Energy Action Plan (NREAP) submitted by the Ministry of Economy and Sustainable Development (hereinafter "the Ministry") every 2 years. NREAP sets renewable energy targets and specific regulatory measures to promote the use of renewable energy in the heating and cooling sector. In 2019, the government established NREAP in line with EU Directive 2009/28 / EC to promote the use of renewable energy, even though EU Directive 2009/28 / EC was not being implemented at the time. The goals of NREAP are as follows:

1. Description of the current legislative and institutional framework for renewable energy in accordance with the requirements of the EU Renewable Energy Directive.
2. Offering a number of political and investment measures (indicating their estimated investment value).

The Ministry shall adopt Support Schemes in accordance with the Law on RES and submit them to the Government of Georgia for approval. The Government shall, upon the submission of the Ministry, approve the Support Schemes within 12 months after the entry into force of the Law of RES. Prior to approval, the Support Scheme must be agreed with the state authority on state aid in order to take into account the principles of competition. The Support Scheme also includes (but is not limited to) investment assistance, tax exemptions or reductions, tax refunds, green certificates and direct pricing schemes with special green tariffs and tariff premiums.

In July 2, 2020, the Government of Georgia has adopted the resolution N403 on Approval Support Scheme of Generation and Use the Energy from Renewable Energy Sources (Hydro Power Plant) and ordered that resolution shall into force upon publication. The Renewable Energy Support Scheme (Hydroelectric Power Plants) defines measures to facilitate the construction and operation of hydropower plant with installed capacity above 5 MW built in Georgia by private investor. The new Support Scheme is example of the Contract of Difference (CfD) and covers two components: support period (8 months per year during ten years) and premium tariff (changeable additional tariff on the top of wholesale price).The Law of Georgia on Public and Private Partnership ("PPP") was adopted on May 4, 2018. It establishes the legal bases for public and private cooperation, including rules and procedures related to the development and implementation of a public and private partnership projects, principles of public and private cooperation, and sets relevant institutional system, also regulates all other issues related to the public private partnership. According to PPP law, the objectives of public and private partnerships are to enhance the efficiency of projects; to meet public interests by creating new public infrastructure and/or providing public services and/or improving existing public infrastructure and public services; to attract private financing; to enhance the efficiency of public finances; to arrange the sharing of risks between the public and private sectors and to benefit from the know-how of a private partner.

Resolution N426 of the Government of Georgia on Approval of the Procedure for Developing and Implementing a Public-Private Partnership Project came into force on August 17, 2018. It was developed in accordance with the Law on Public and Private Partnership and aims at defining the procedure for developing and implementing a public-private partnership project.

### 1.3. Establishment of Security of Electricity Supply legislative framework

Under the Association Agreement and Protocol Georgia undertook an obligation to implement EU Directive 2005/89/EC concerning measures to safeguard security of electricity supply and infrastructure investment. However European Union has updated directive 2005/89/EC in the context of the Clean Energy for all Europeans package developed according to the Paris Agreements. Regulation (EU) 2019/941 on Risk-Preparedness in the Electricity Sector repealed Directive 2005/89/EC. Under article 418 of the Association Agreement between Georgia and EU, Georgia undertook an obligation of Dynamic approximation that stipulates the requirement of updating "*Annexes to this Agreement, including in order to reflect the evolution of EU law and applicable standards set out in international instruments deemed relevant by the Parties*". Also according to the Order of Georgian Government N183 (January 30, 2020) on Approval of Manual on Approximation of Georgian Legislation with EU Legislation the latest version of EU legal act is strongly encouraged to be transposed into national legislation. Accordingly, Georgia managed to harmonize EU regulation 2019/941 on risk-preparedness in the electricity. This so called, early implementation was positively accepted by Energy Community (during the adoption process of the draft document), despite the fact that Regulation 2019/941 has not yet been adopted as mandatory acquis in the Energy Community and the Directive 2005/89/EC is still part of the Energy Community acquis. Moreover, most of the requirements of 2005/89/EC Directive are already enshrined in the law on Energy and Water supply (Energy Law) of Georgia adopted in December 20, 2019.

The Energy Law requires to adopt the secondary legislation. Under Article 132.2.D the Ministry *"approves the rules of security of supply electricity and natural gas which regulate functions and responsibility of energy enterprises, market players, users of the system and beneficiaries in the process of achieving the minimum level and standard of security of supply electricity and natural gas."* Georgia met its obligation and the Ministry has approved on December 2, 2020 the Security of Electricity Supply Rules (hereafter "SoS Rules") with three attachments. The SoS Rules incorporate the main provisions of the Regulation (EU) 2019/941 on risk-preparedness in the electricity sector. The SoS Rules were prepared by JSC Georgian State Electrosystem (hereafter "GSE") in cooperation with the Ministry of

Economy and Sustainable Development of Georgia and the Georgian National Energy and Water Supply Regulatory Commission (hereafter the Commission).

The SoS Rules establish the following requirements:

- to mitigate the risks of electricity supply as well as to prevent and prepare for managing crisis in electricity sector;
- on risk management planning;
- on establishment of methodologies of Generation Adequacy Assessment and Identification of National Electricity Crisis Scenarios
- on exchanging the information relevant to security of supply;
- on contribution to the overall objective of safeguarding an adequate level of security of energy supply;
- on the roles and responsibilities of the electricity undertakings, electricity market participants, system users and customers in view of mitigating, preventing risks of electricity supply;
- to manage electricity crisis in a spirit of transparency and in full regard for the requirements of a competitive electricity market.

Under the SoS Rules the Ministry of Economy and Sustainable Development of Georgia has approved three methodologies:
1) Methodology of Identification of National Electricity Crisis Scenarios (Attachment #1)
2) Methodology of seasonal and short-term adequacy assessments (Attachment #2) and
3) Methodology of medium and long-term adequacy assessment (Attachment #3).

### 1.3.1 Methodology of Identification of National Electricity Crisis Scenarios

Pursuant to articles 4 of SoS rules TSO shall identify and assess the most relevant electricity security risks and crisis scenarios in accordance with the previously developed methodology. GSE prepared and submitted to the Ministry a methodology on Identification of National Electricity Crisis Scenarios, which was approved as Attachment #1 of SoS Rules on December 2, 2020. Based on the methodology GSE in cooperation with the Ministry has to identify the most relevant Electricity Crisis Scenarios and the Ministry as a competent authority for electricity security issues has to ensure that all risks relating to the security of electricity supply are assessed.

The methodology identifies the most relevant risks and emergency scenarios in relation to system adequacy, system security and fuel security:

- natural hazards;
- accidental hazards going beyond the N-1 security criterion and exceptional contingencies;
- consequential hazards including consequences of fuel shortages, malicious attacks, such as cyberattacks;
- hostile and criminal attacks

### 1.3.2. Methodologies of Generation Adequacy Assessment

GSE submitted to the Ministry for approval a methodology for assessing seasonal, long- to medium term as well as short-term adequacy. The methodologies were adopted together with the SoS Rules on December 2, 2020.

Under article 6 of the SoS rules, TSO shall carry out seasonal and short-term adequacy assessment in compliance with the methodology developed pursuant to Attachment #2 of the SoS Rules and long-term and medium-term adequacy assessment – in compliance with the methodology developed pursuant to the Attachment #3 of the SoS Rules.

The adopted methodologies cover at least the following issues:

a. unpredictable/unplanned circumstances, such as the probability of outage of the transmission capacity and unplanned outage of power plants, severe weather conditions, variability of demand and variability of energy production from renewable energy sources;
b. the probability of occurrence of electricity crisis;
c. the probability of occurrence of a simultaneous crisis;
d. consideration of the investment intentions (for at least next 5 (five) calendar years) of transmission system operator and other entities as regards the provision of cross-border interconnection capacity.

The use of medium to long-term adequacy assessment ensures that decisions of Georgia on possible investment needs are made on a transparent and commonly agreed basis (among stakeholders). Short-term and seasonal adequacy assessments are used to detect possible adequacy related problems in short timeframes, namely seasonal (six months ahead) and month, week-ahead to at least day-ahead adequacy assessments. These assessments shall first ensure risk awareness for all relevant stakeholders and support system operation by identifying what are the risks and when risks exist.

GSE shall carry out long - to medium term as well as short-term adequacy assessments in accordance with the developed methodology. The relevant system adequacy assessment reports shall be submitted to the Ministry.

Under Article 138 of the Energy Law requires the Ministry to prepares and publishes a common single security of electricity supply report for Georgia covering inter alia the overall adequacy of the electricity system of Georgia to supply current and projected demands.

### 1.3.3 Risk Management Plan

Pursuant to Articles 7- 8 of SoS Rules, the Ministry, in cooperation with IGES (Inter-institutional Group for Energy Security)[1], the Commission , TSO, distribution system operators, electricity generators and, if necessary, other energy enterprises and organizations representing household and non-domestic consumer interests shall establish a risk management plan.

Risk management plan shall:

- cover electricity security risks and electricity crisis scenarios
- involve planned or implemented national and regional measures to prevent, prepare for and mitigate electricity crisis
- establish the role and responsibilities of the Ministry, the Commission and other state bodies and authorities as well as of electricity undertakings, electricity market participants, system users and customers;
- identify the contribution of the market-based and non-market based measures in coping with electricity crisis
- describe the mechanisms used to inform the public about any electricity crisis.

The Risk Management Plan will be approved after 2 years from the date of entry into force of the SoS Rules. Plan shall be updated at least every four years.

### 1.3.4 Monitoring of Security of Supply

The Ministry is responsible for monitoring of Security of Supply. According to Article 138 of the Energy Law, the Ministry has to monitor the security of electricity supply in Georgia, in cooperation with the Commission and other competent national authorities as well as with transmission system operators for electricity.

The monitoring of Security of Supply covers:

- the supply and demand balance in the electricity market of Georgia
- the level of expected future demand and foreseen additional capacity being planned or under construction
- the quality and level of maintenance of networks
- measures to cover peak demand and to deal with shortfalls of one or more suppliers.

Under Article 138.2 the Ministry has the obligation to prepare and publish a common single report on the security of supply of electricity, integrating the information gathered and compiled by the Ministry

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[1] IGES shall be compiled with the representatives of the Ministry, the Commission, the transmission system operator and other relevant stakeholders in the field of security of electricity supply. IGES shall serve as the inter-institutional co-ordination platform for energy security issues and its meetings are convened by the Ministry as needed. The Ministry shall be entitled to adopt detailed rules on the set-up and organization of IGES

itself, the Commission and, where applicable, other competent national authorities and the transmission system operator.

The date of first report of security of supply monitoring is stipulated by Article 167 of the Energy Law and is determined as March 31, 2021. After this date, by July 31 of every second year the Ministry shall prepare the report, which in advance shall be submitted to the Energy Community Secretariat.

The report shall inter alia cover the overall adequacy of the electricity system of Georgia to supply current and projected electricity demands, including:

- operational security of electricity networks
- the projected balance of supply and demand for the period of next five (5) years;
- the prospects for security of supply for the period between five (5) and fifteen (15) years from the date of the report; and
- the investment intentions, for the next five (5) or more calendar years, of transmission system operators and those of any other party of which it is known, as regards the provision of cross-border interconnection capacity.

The section of the report dealing with the investment intentions of the interconnection should take into account:

- the principles of congestion management
- existing and planned electricity transmission lines
- expected patterns of generation, supply, trade, cross-border exchanges and consumption of electricity, allowing for energy efficiency/demand-side management measures
- regional, national and pan-European sustainable development objectives, including, the Energy Community priority electricity infrastructure projects.

While monitoring of the security of supply and preparing the report the Ministry has the right to gain all data and the information from the Commission collected in course of carrying its regulatory functions, as well as any other relevant information possessed by other competent national authorities of Georgia without any delay upon receipt of respective written request, considering the obligation to ensure non-disclosure of the commercially sensitive information.

GSE is obliged to provide the Ministry with information on its investment intentions and on investments related to the building of internal electricity transmission lines that materially affect the provision of cross-border interconnection capacity as well as with information on cross-border cooperation.

## 1.4. The main players in energy sector and their roles:

### 1.4.1. The Ministry of Economy and Sustainable Development of Georgia

According to the Energy Law he Ministry of Economy and Sustainable Development of Georgia has to:

- develop and periodically approve the state energy policy
- approve supply safety regulations and supervise compliance
- define support schemes and protection regimes

The Ministry is the competent authority for ensuring the security of electricity and natural gas supplies in Georgia. Responsibilities of the Ministry regarding the Security of Supply under the Energy Law are to

- develop a strategy for actions in the emergency in the electricity and natural gas sectors
- ensure the development and improvement of the legislative and normative basis
- specify energy potential of Georgia
- approve the security of supply rules regulating the functions and responsibilities of energy undertakings, market participants, system users and customers.

The Ministry, in cooperation with the Commission and other competent national authorities, implements the security of supply norms for electricity and ensures:

- continuity of secure and reliable supply of electricity to final customers in Georgia;
- transparent and stable regulatory framework for the electricity activity, roles and responsibilities of the electricity market participants;
- effective functioning, development and integration of a single electricity market in Georgia
- appropriate maintenance and, where necessary, renewal of electricity transmission and/or distribution networks;
- investments in electricity networks to meet a foreseeable demand from the electricity market;
- promotion of electricity produced from renewable energy sources;
- sufficient transmission and generation reserve capacities;
- a balance between the demand for electricity and the availability of generation capacities;
- reduction of long-term effect of the growth of electricity demand;
- promotion, of the energy efficiency and the adoption of new technologies, including demand management technologies, renewable energy technologies, smart metering technologies and distributed generation of electricity, in order to manage a real-time electricity demand;
- encouragement of the energy conservation measures;
- removal of administrative barriers hampering investments and minimized administrative burden to investments in the electricity infrastructure for the access of new electricity generation capacities;
- removal of barriers that prevent the use of interruptible contracts and conclusion of contracts of varying lengths for both producers and customers.

### 1.4.2. The role of Energy and Water Supply Regulatory Commission

The Georgian National Energy and Water Supply Regulatory Commission is the legal person established under the Law of Georgia on National Regulatory Authorities. The Commission regulates Electricity, Natural Gas and Water Supply Sectors. The Commission is independent from any other governmental authorities and acts under the Law of Georgia on National Regulatory Authorities and the Energy Law. The Commission approves its own budget and is financed through a fee imposed on licensees. The Commission issues licenses and sets tariffs for electricity generation, transmission (no separate license will be issued for dispatch services, it will be included within transmission license issued by the Commission) and distribution services.

Article 132.4 of the Energy Law refers to competence of the Commission in relation to security of supply, *"The Commission … shall contribute to the security of supply under the terms and conditions stipulated in this Law and other applicable legal acts, and within their specific scope of competences in the energy sector."*

The specific role of the Commission with regards to the security of supply is stipulated in Article 134 of the Energy Law and consists the cooperation with the Ministry to develop and implement the security of supply rules for electricity, as well as under Article 138 of the Energy Law the security supply monitoring function of the Ministry is executed in cooperation with the Commission.

## 1.5. Energy Policy

The Government of Georgia, represented by the Ministry, is in charge of policy formulation and strategic planning. Namely, under Article 7 (State Energy Policy) of the Energy Law the Ministry shall develop, in cooperation with the Government, the Commission and other relevant parties, the *State Energy Policy* for a period of at least ten years and following the adoption and promulgation by the Parliament in compliance with relevant rules, shall implement it. In addition, the State Energy Policy shall provide for the strategy and priorities, whether of short, medium and/or long term, in electricity and natural gas sectors, including strategic development of electricity generation, transmission (including cross-border) and/or distribution as well as natural gas production, transmission (including cross-border), distribution, storage and/or LNG activities;

The draft Energy Policy Concept, developed in 2020, describes the current situation, vision, priorities and challenges in the Georgian energy sector, as well as ways to solve them.

According to the mentioned document, renewable energy is one of the main issues in the development of the energy sector. In addition, the use and integration of various renewable energy sources, which mainly include solar and wind energy, will make a significant contribution to the country's energy security. One of the strategic goals of the new energy strategy is to integrate renewable energy sources and meet the increased demand.

Security of supply is a key component of the draft energy policy concept document. The Government's strategic role in this regard is to promote security of supply, endorse energy efficiency and encourage and support investment in energy infrastructure. Energy efficiency is another very important issue included in Energy Policy Concept draft document. It envisages the encouragement of various measures and initiatives of the state energy efficiency policy.

Moreover, the gradual approximation of Georgia's legislative and regulatory framework with the EU's Energy acquis is another strategic task planned to be fully achieved. With the aim of achieving deeper economic and political relations, gradual approximation of Georgian legislation with the EU legislation is important.

One of the most important measures to achieve the aforementioned goal is the development and subsequent adoption of the integrated National Energy and Climate Plan (NECP).

The NECP covers the period from 2021 to 2030, and is built upon 5 Key dimensions:

- Decarbonisation
- Energy Efficiency
- Energy Security
- Internal Energy Market
- Research, innovation and competitiveness.

The national plan shall define objectives for each dimension and, for each objective, a description of the policies and measures planned for meeting these objectives shall be provided. The national plan shall be adopted as an integral part of the State Energy Policy or as an annex thereto.

The plan builds on existing national strategies and plans and provides an overview on the current energy system, the energy and climate policies and national targets for aforementioned dimensions.

Drafting process of the NECP had begun in March 2020, with the working groups initial inputs collected at the end of summer. The first draft was completed, updated and submitted to the Energy Community in early autumn. Work on Scoping for Strategic Environmental Impact Assessment (SEA) has already begun.

One more strategic important task is strengthening of Georgia's role as a transit route in the region. Georgia is an important transit country: as a connecting corridor between Europe and Asia, has a potential to strengthen its role in implementation of East-West and North-South transit projects. Effective development of its geopolitical location, will contribute to the country's energy security and economic development.

The draft Energy Policy Concept also underlines the importance of energy security. The challenges and solutions to these issues (e.g. developing internal energy resources, Developing the regional energy exchange and cooperation, Developing country's capacity for international energy transit).

The above mentioned Energy policy draft document is planned to be approved by the end of 2021.

## 1.6. Energy Balances

Under Article 60 of the Energy Law the Electricity Transmission Network Code shall establish rules for the elaboration of electricity balances providing the forecasted data of the generation of electricity and supply and demand in the system and applied for dispatching and balancing operations. Electricity balances shall be prepared and updated on the periodical basis in cooperation with operators of interconnected systems and other relevant system users. The Balance shall be published on the website of the transmission system operator. A key role of the electricity balance is to allow pre-analysis of the expected condition that the system may encounter after a certain amount of time, allowing it to be prepared to meet the expected condition. The structure of the electricity balance consists of: generation, losses on generation facilities (station losses or self-consumption), consumption, transmission losses and import-export.

Qualified enterprises and generation facilities are obliged to introduce us their consumption / generation forecasts by November 1 of the current year with reference to the relevant monthly (hourly) data for the following year. For the sustainability and safety of the power system, the received from TSO information is processed by November 20 of the current year and the regime is calculated.

At present, on December 1 of the current year, the Ministry of Economy and Sustainable Development of Georgia approves the energy balance for next year. However, from 2021 the Ministry will be relieved from this duty. A change in the current year balance may be made when a new generation facility or a qualified enterprise is added.

Stakeholders include both generation and consumption facilities, as well as transmission and distribution licensees, the regulatory (the Commission) and the Ministry of Economy and Sustainable Development of Georgia.

Security of supply and balance of electricity are directly linked with each other, since the balance is used to analyze the forecast modes (regimes) that are determined by the balance (due to the fact that capacity may not be extracted from a particular generation facility or even consumption cannot be covered due to unprepared infrastructure).

The existing forecast balance is approved for 2021, due to the deadlines provided by law.

In accordance with the Order №1-1/601 the Minister of Economy and Sustainable Development of Georgia (December 23, 2019) on the approval of the electricity (capacity) balance for 2020, - electricity (capacity) balance is approved for 2020 from January 1, 2020 to December 31, 2020. In addition, in order to ensure the sustainability, stability and reliable operation of the power system, the electricity dispatch licensee is authorized to make an independent decision on the replacement of sources according to the total volume of electricity imports under the electricity (capacity) balance, according to the supplier country.

### 1.7. Network Development Plans

According to Article 53 of the Energy Law, each transmission system operator shall annually submit to the Commission a Ten-Year Transmission Network Development Plan (TYTNDP) based on existing and forecast supply and demand. TYTNDP shall contain efficient measures in order to guarantee the adequacy of the transmission network and security of supply.

TYTNDP shall:

- provide information on existing and forecasted demand for and supply of electricity or natural gas;
- provide forecasted domestic generation of electricity or production of natural gas and cross-border exchanges in electricity or natural gas;
- indicate the main transmission infrastructure that needs to be built or upgraded over the next 10 years;
- contain all the investments already decided and identify new investments which have to be executed in the next three years;
- provide time frame for all investment projects;
- provide information on integration of new production facilities into the network (including those using renewable energy sources);
- provide other information necessary for effective operation and management of energy systems in Georgia pursuant to the requirements laid down by this Law, the applicable Transmission Network Code, and regulations on the security of supply.

Following the elaboration of and consultation with stakeholders, the transmission system operator shall submit the draft TYTNDP to the Ministry and Commission no later than 1 October of the relevant year. The Commission shall consider the TYTNDP: shall examine whether it covers all investment needs and submit its comments and recommendations to the Ministry within the period of 1 month from the date of its receipt.

The Ministry, subject to the approval of the Government of Georgia, no later than the end of the relevant year, shall adopt TYTNDP. The implementation of the TYTNDP shall be monitored and evaluated by the Commission and the Ministry within their competences.

## 1.8. Incentives for Construction of RES Capacities

Under Article 5 of the Energy Law one of the general principles of organization, regulation and monitoring of energy activities are promotion of the generation of electricity from renewable energy sources and of the combined generation of electricity and heat.

Moreover, Article 7 of the Energy Law states that, The State Energy Policy shall provide measures aimed at the use of renewable energy sources for the generation of electricity and consumption of electricity produced from such sources, as well as any incentives and support mechanisms applied for the promotion of the use of renewable energy sources.

In line with Article 37 (Promoted generation of electricity), Generation of electricity from renewable energy sources and high-efficiency cogeneration may be incentivized by promotional and support mechanisms under the terms and conditions stipulated in applicable laws or established by the Government under its normative acts with the aim at achieving the goals of the generation of electricity from renewable energy sources and/or of the combined generation of electricity and heat as set for Georgia in applicable legal acts.

The new energy legislation promotes domestic and foreign investment in rehabilitation and improving industries such as coal, natural gas, water supply, and using local hydropower and other sustainable and alternative tools.  It also describes small power plants with an installed capacity of 15 MW, emphasizing the value of their production for the effective and environmentally friendly use of renewable energy resources.

In addition, Georgian Parliament approved the law on *Encouraging the Production and Use of Energy from Renewable Sources* at December 20, 2019. The purpose of this law is to establish the legal basis for the promotion, encouragement and use of energy from renewable sources.

Before adoption the Law on RES, The Government of Georgia has introduced a variety of initiatives aimed at encouraging investments in clean energy. Signing memorandum between the state and investors for the construction of hydropower plants is one of the encouraging mechanisms. The first support mechanism of encouraging construction was established in 2008. The Government adopted resolution N107, State Program Renewable Energy 2008 on the approval of the rules on ensuring the construction of new sources of renewable energy". In 2013, the Government adopted a new resolution N214 "on the Approval of the Rule of interest expression on the feasibility study of electric stations construction in Georgia and their operation".

In 2014, the Government amended resolution N214 with decree N40, "on the approval of the rules and conditions for submission on proposals to the Ministry of Energy of Georgia for technical and economic research, construction, ownership and operation of those power plants, which are not included in the List of Potential Power Plants in Georgia and will be identified by the investors".  Pursuant to the Decree N40, the obligatory requirement of the memorandum of understanding  is that "after starting exploitation of power plant, the full amount of generated electricity should be sold in the local market for 10 years, every year in January, February, March, March, April, September, October, November and December".

| **Georgian Legislation concerning the Renewable Energy Sources and Support Schemes** | | | |
|---|---|---|---|
| **Name** | **Scope** | **Status** | **Notes** |
| Resolution No. 107 State Program "Renewable Energy 2008" | National/ sectoral | Adopted in 10 April 2008 | establishes rules and procedures for development of renewable energy sources |
| Resolution No. 214 on the "Approval of Rules for Expressing Interest in Conducting Technical and Economic Feasibility Studies for the Construction, Ownership and Operation of Power Plants in Georgia | National/ sectoral | Adopted in 21 August 2013 | introduces rules for expressing interest in conducting technical and economic feasibility studies for new RE power plant projects |

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|---|---|---|---|
| Decree No. 40 of the Minister of Energy of Georgia | National/ sectoral | Adopted in 18 April 2014 | Regulates the rules for construction, ownership and operation of Hydro Power Plants and Wind Power Plants and other renewable energy resources, which are not included in the List of Potential Power Plants in Georgia and will be identified by the investors |
| The Law of Georgia on Public and Private Partnership ("PPP") | National | Adopted on 4 May, 2018. | Determines the legal basis for public-private partnerships (among other in energy), including the rules and procedures related to the development and implementation of public-private partnership projects, the principles of public-private partnership, and relevant institutional systems, as well as other matters related to public-private partnerships. |
| Resolution N426 of the Government of Georgia "On Approval of the Procedure for Developing and Implementing a Public-Private Partnership Project". | National | Came into force on 17 August 2018 | This regulation in the energy sector regulates projects that provide for guaranteed electricity purchase agreements and constitutes a concession pursuant to Article 2 (j) of the Law |
| National Renewable Energy Action Plan | National | Adopted in 13 August 2019 | This plan has developed a national policy framework for renewable energy sources, which is also compatible with Renewable Energy Directive 2009/28/EC |
| Law of Georgia on Energy and Water Supply | National | Adopted in 20 December 2019 | Stipulates that energy from renewable energy sources shall be supported with different transparent and non-discriminatory manner |
| "Law of Georgia on promoting the Generation and Consumption of Energy from Renewable Sources" | National | Adopted in 26 December 2019 | Georgia has fulfilled the international obligation and implemented EU Renewable Energy Directive 2009/28/EC |

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| Resolution No 403 of the Government of Georgia On the approval of Support Scheme (Hydroelectric Power Plants) of the Generation and Use energy from Renewable Energy Sources Energy Support and Use Scheme from Renewable Sources | National | Adopted in July 2, 2020 | Supports 5MG HHP with premium tariff |

# 2. Electricity Sector

Georgia has started to implement a reform that efforts to transform the power market.

The reform will evolve the market that will be guided by European Union (EU) internal market principles: competition, transparency, non-discrimination and sustainability.

The Energy Law provides the legal basis for the power related secondary legislation, the main pieces of which are the Electricity Market Model Concept and the Electricity Market Rules. On 16 April 2020, the Government of Georgia adopted the Electricity Market Model Concept. As for the Electricity Market Rules, it was adopted by the Commission on August 11, 2020 for all segments of the wholesale market.

## 2.1. Electricity Market

### 2.1.1 Current Market Structure

The current model of the Georgian energy market provides a clear distinction between the duties and responsibilities of the entities functioning in the energy sector.

Ministry of Economy and Sustainable Development of Georgia carries out the state policy in energy sector, participates in adoption of the state strategy and programs, studies their implementation and draws up the relevant recommendations.

One of the main objectives of the Ministry is to create the competitive environment in the energy market. The Ministry has the right to make decisions on deregulation or partial deregulation of a specific segment of the sector.

According to the state energy policy, Ministry's priorities include the preferential utilization of renewable and alternative resources and the attraction of foreign investments in the energy sector.

Georgian National Energy and Water Supply Regulatory Commission is the regulatory body for the energy sector. The main source of its finance is the regulatory payment paid by the licensees, importers, providers and Electricity System Commercial Operators.

The Commission issues the generation, transmission, dispatching and distribution licenses. It should be noted, that power plants less than 13 MW do not need generation license.

Georgian National Energy and Water Supply Regulatory Commission approves the tariff methodology. According to this methodology, commission identifies and regulates the generation, transmission, dispatching, distribution, transition, import, supply and consumption tariffs, as well as the tariffs of the system's commercial operator services, the guaranteed capacity fee and the guaranteed capacity source's power generation tariff. It should be also noted, that hydropower plants greater than 13 MW built after August 1, 2008, have been fully deregulated and are entitled to trade electric power at deregulated tariffs. There are 13 licensees and 25 low capacity power plants in Georgia. Among them, only Engurhesi and Vardnilhesi have been remained in state ownership.

Electricity transmission and transit are carried out by two transmission licensees:

1. Listed in the fixed assets of the JSC Georgian State Electrosystem (GSE) are 35–110–220 kV transmission lines and 500/220/110/35 kV substations. GSE is a joint stock company owned by LEPL National Agency of State Property, while its management rights are transferred to the Ministry of Economy and Sustainable Development of Georgia.

2. JSC Sakrusenergo manages the 220/330/500 kV transmission lines.

GSE is the only dispatch licensee. It is in charge of Georgian power system operative management, bearing also responsibility for 500-220-110-35 kv transmission facilities' proper operation as well as for power system stability. The central dispatchers provide the operation of the power system as an unified object. Two companies carry out distribution of electricity in Georgia: JSC Telasi, supplying the capital city and its surrounding area, and JSC Energo-Pro Georgia, providing electricity to the other territory of the country.

Electricity System Commercial Operator (ESCO) ensures purchase and sale of balance Electric Power (capacity) (including by means of conclusion of middle- and long-time import/export agreements), and sets up the unified data base on wholesale purchase and sale (including creation and management of unified registry of reporting) and submits relevant information.

In terms of the Memorandum of Understanding (MOU) on construction of a new power plant, signed between the Government of Georgia, ESCO and the relevant person, commercial operator is required to sign a direct agreement with the relevant person about the purchase of the electricity generated in newly built power plant, under the conditions, which were agreed by the Georgian government, ESCO and the relevant person.

According to the current electric power marker rules, electric power sector licensees conclude short term or long term direct contracts on sale and purchase. The contracts are made between the customer and producer, while the contract on the balance capacity purchase is made with the commercial operator.

The commercial operator balances the difference between the actual consumption and the amount of the electric power specified by the direct contract between customers and producers.

The electric power trading is carried out by the commercial operator in two ways.

1) First way is either the unplanned over consumption or when the direct contract is not made. In this case the customer automatically purchases electricity from ESCO.

2) According to the second version ESCO and the customer sign a contract, which doesn't specify either the amount or the price of the required electric power. After each concrete request the sides offer the prices acceptable for them. In this case the trading is carried out in the so-called electric power exchange format, which doesn't affect the consumer tariff. ESCO renders services according to the tariffs established by the Commission.

Direct customer receive electricity (capacity) from the networks owned by a generation, transmission, micro-generating power plant or any network owned by other consumer. They purchase electricity from the system's commercial operator or producer through the direct agreement

### 2.1.2 The Market Concept

As mentioned, on April 16, 2020, the Government of Georgia adopted the Electricity Market Model Concept. The Concept introduces general principles for organizing and functioning of the wholesale market of electricity. The Market Concept aims:

- to establish attractive environment for investors and to provide free options for consumers by developing competitive and transparent electricity markets;
- to form organized electricity markets, day-ahead and intraday markets, as well as balancing and ancillary services market and the market for bilateral agreements;
- to provide clear distinction between the duties and responsibilities of the entities functioning in the electricity sector;
- to form competitive and liquid market price. Furthermore, the Market Concept sets out the mechanism for fulfilling the obligations envisaged by the contracts that were concluded before the Law on Energy entered into force and special requirements of supplying occupied territories of Georgia with electricity.

The electricity wholesale market is divided into 4 segments:

- Day-ahead Market
- Intraday Market
- Bilateral Agreements' Market
- Balancing and Ancillary services market.

### 2.1.3. Key Electricity Market Participants

Wholesale market players are:

- electricity market operator
- transmission system operators

- distribution system operators
- electricity producers
- traders
- suppliers
- large customers
- Wholesale Public Service Organizations (WPSO).

The operator of day-ahead and intraday markets shall ensure the operation of the respective markets, administer the registry of the markets' participants, and establish transparent, accessible and reliable system of financial settlements.

The operator of balancing electricity and ancillary services shall ensure operation of the respective markets, determine balancing products, calculate imbalance prices, and determine the value of financial guarantees for securing the payment for products and imbalance costs.

The transmission system operator (TSO) will:

- determine the forecasted volume of balancing and ancillary service products;
- manage the energy system on self-dispatching principle and undertake other balancing measures;
- organize a cross-border balancing mechanism, including emergency support; and
- register the persons responsible for balancing, including balancing service providers and assigning codes to them;
- manage and develop electricity metering system for retail market operations, ensure accessibility of the hourly metering data.

Final consumer can freely choose the supplier on the wholesale electricity market and purchase electricity.

Wholesale public service organizations, universal service suppliers, suppliers of last resort and public service producers, including a source of guaranteed capacity, are obliged to provide public services. The obligation to provide public services is temporary arrangement which shall be reviewed at least once every two years.

The wholesale public service is established to support electricity generation from renewable energy sources and their integration into the market, to support the universal service providers by ensuring a stabilized purchase price and to secure the supply of electricity to occupied territories (Autonomic Republic of Abkhazia). For these purposes, the wholesale public service provider shall:

- purchase electricity under guaranteed power purchase agreements and sell it on organized market;
- ensure financial settlement with the producers participating in the renewable support schemes and other support schemes;
- ensure financial settlement with the public service generators for differences in price between the market price and the price established by the Commission;

- purchase electricity on the organized market to secure supply to the occupied territories and be responsible for relevant imbalance;
- ensure financial settlement with universal service providers for differences in price between the market price and the price established by the Commission.

The electricity purchased by the guaranteed power purchase agreement can be sold on the organized market by the public wholesale public service organization or by the producer itself. In order to compensate the price difference or to implement other facilitative arrangements the producer and the public wholesale service organization can execute the agreement that shall be agreed with the government of Georgia. Otherwise, the difference shall be paid by the wholesale public service organization. Producers that are beneficiaries of the facilitation scheme of the renewable energy shall ensure sale of the electricity themselves. Costs envisaged by the facilitation scheme shall be paid by the public wholesale public service organization.

Producers providing public services shall trade on the organized market. The obligation of the electricity producers to provide public services is reflected in the conclusion of the agreement on price difference with the wholesale public service organization. The difference between the price provided by the agreement and day-ahead market price shall be paid to the wholesale public service organization by the producer in case of positive difference; in case of negative difference the wholesale public service organization shall pay the difference to the producer.

WPSO mechanism is based on the allocating revenues from the price difference between the price of Power sold by Power plants under the Public service obligation at organized market and their tariff.

This revenue is allocated to cover cost of Power consumed in Abkhazia, PPAs price and universal service supplier price difference (all this power is traded at Georgian energy exchange).

WPSO functions and fulfilment of goals depend on an optimal (price and volumes) trade of PSO-PP and PPA-PP at organized markets. This is very important to provide the SoS without harming WPSO.

The electricity for the consumption on the occupied territory of Georgia shall be purchased on the day-ahead or intraday market.

The Market Concept further envisages electricity supply by universal service providers. They will supply electricity to households and small enterprises that have not selected a specific supplier on a regulated basis.

The supplier of last resort will supply electricity with tariff set by the regulator to those consumers who have lost the supply due to planned or unplanned suspension in the supplier's activities or due to material breach of supplier's obligations.

### 2.1.4. Bilateral Agreements' Market

Nowadays , the rules of bilateral market is under development and will be the part of Market Rules as well as day ahead and intraday market rules and balancing and ancillary services market rules. From

July 1, 2021 platform for Over-The-Counter (OTC) will be in place and market participant will have possibility to trade.

### 2.1.5. Day-ahead and Intraday electricity Market

First time in Georgia the Energy Exchange was founded. Its main activity is conclusion of bilateral contracts, Day-Ahead and later, preparation, organization and coordination of the activities needed to form the daily organized markets.

The Georgian Energy Exchange has been founded with the instruction and coordination of the Ministry with 50%-50% co-participation of GSE and ESCO.

The Energy Exchange is a neutral, unbiased and transparent organization. The Exchange will ensure introduction and operation of a Day-Ahead and daily markets through the software services of consulting company Nord Pool Consulting.

The introduction of free, competitive and hourly energy markets is part of reforms that Georgia implements in terms of accession to the Energy Community Treaty.

On May 28, 2020, the Commission issued the electricity market operator license to the JSC Georgian Energy Exchange to operate the Day-Ahead and Intraday markets. Day-ahead Market started "dry-run" operation in July 1, 2020. Go live of this Market Segment is 1 July of 2021. The starting date of operation of the intraday market is July 1, 2022. The purposes of Day-Ahead and Intraday markets are:

- Creating a legal framework for the development of a competitive electricity market in Georgia and the formation of a fair price;
- Promoting efficient generation and consumption of electricity by introducing hourly trading, which allows for demand management (an hourly differentiated price offered by the supplier to the end customer and using other measures);
- Introduction of principles and procedures based on the best European practices in the electricity trade;
- Establishment of a secure, transparent, accessible, and uniform system of a financial settlement.

### 2.1.6. Balancing and Ancillary (supporting) services' Market

On May 28, 2020, the Commission issued the electricity market operator license to the GSE to operate the Balancing and Ancillary services Market;

As mentioned before, on August 11, 2020, the Commission adopted the Electricity Market Rules for all segments of the wholesale market. This rules contain balancing and ancillary services market rules.

According to the Electricity Market Concept the starting date of operation of Day-Ahead and Balancing and Ancillary Services Markets is July 1, 2021 and the starting date of operation of the intraday market is July 1st, 2022; Until July 1st, 2021 the Day-Ahead and Balancing Markets are testing and running with potential participants in simulation regime.

The purposes of the Balancing and Ancillary Services market are:

- Maintaining the balance between consumption and supply, for which balancing reserves are used;
- Purchasing the balancing reserves in a transparent manner;
- Activating the balancing reserves – on the principle of minimum price;
- Determining the optimal value of balancing reserves and the list of balancing service providers by receiving price applications;
- Eliminating the imbalance by the fair and optimal price at any time;
- Establishing a secure, transparent, accessible, and uniform system of a financial settlement.

Electricity Balancing and Ancillary Services Market Rules shall govern the following:

- the operation of the balancing and ancillary services market, the obligations of the Transmission System Operator (TSO) and a Market Operator in terms of balancing the Electricity System;
- the obligations of Balance Responsible Party (BRP) and Balancing Service Provider (BSP);
- conditions for procurement of balancing capacity and balancing energy ;
- the conditions for the registration of BRPs and BSPs;

The core principles of market organization and regulation shall be as follows:

- safety and reliability of market operation and related services;
- provision of balancing and ancillary services in a competitive, transparent, non-discriminatory and legal manner;
- protection of the rights and legitimate interests of electricity market participants and end consumers;
- undertaking financial responsibility by the market participant for any imbalance caused by such market participant;
- using the lowest cost reserves available for TSO for the needs of the system;
- settlement by marginal pricing for balancing energy and pay as bid principle for balancing capacity on the Electricity Balancing Market;
- introduction of a self-dispatching model for planning and operation of the power system;
- supporting the market liquidity.

The Electricity Balancing Guideline provides that specific products may be used by TSOs to ensure system security, stability and reliability. Nowadays, Georgia does not really have a commitment to develop standard products that is provided in the EBGL. However the products will follow the logic of the ENTSO-E standard products because of future compliance requirements.

With the aim to follow the above mentioned goals the Georgian products for electricity balancing shall include:

- Frequency Containment Reserve (FCR)
- Automatic Frequency Restoration Reserve (aFRR)
- Manual Frequency Restoration Reserve (mFRR)

It is planned to add the following types of balancing services at the normative level in the near future:

- Fast Emergency Reserve (ERf)
- Slow  Emergency Reserve (ERs)

This products is used for electricity balancing in non-emergency and emergency situations. Emergency is operating state subject to the reasonable control of the TSO to eliminate the situation in the Electricity System that causes deterioration of electricity qualitative indicators and putting into operation of system automatic equipment required for maintaining sustainable operation of the Electricity System that may or will be followed by electricity curtailment and disconnection of customers, as well as to prevent the imbalance of electricity supply and consumption; Hence, Emergency Reserves are meant to be utilized during emergency modes to maintain generation adequacy and system stability

All Reserve Products shall be defined by the TSO. They are reflected in the market rules and the latter is approved by the Georgian National Energy and Water Regulatory Commission.

## 2.2 Electricity System

### 2.2.1. Electricity Generation

#### 2.2.1.1. Generation Capacities and Electricity Generation in recent years

##### 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 electricity produced in the country comes from the largest Enguri HPP having installed and operating capacities of 1,300 MW and 1,200 MW respectively. This plant in tandem with Vardnili Cascade HPPs (second largest hydropower facility in Georgia) and other relatively lower capacity HPPs compose the pool of regulated hydro power plants with total installed capacity of about 1,990 MW.

By the end of 2019, total installed capacity will equal to 4247 MW, which includes installed capacity of HPPs 3300 MW and installed capacity of thermal power plants of 925 MW. It is anticipated that in 2020¬2030, additional capacity of new HPPs wll be added, which will provide the increase of total installed capacity from the existing 4247 MW to 5014 MW by 2022, 5984 MW by 2024 and 7945 MW by 2030.

In line with the growth of hydropower generation, Georgia's dependence on imported and thermal power gradually decreased. In 2007, the total power output generated by HPPs amounted to 6.8 bln kWh, i.e. 82% of full national demand. In 2010, total hydropower generation grew to 9.4 bln kWh covering 93% of the demand. In 2014, domestic hydropower generation decreased to 8.3 bln kWh, as for 2017 – 9.2 bln kWh and for 2018 – 9.95 bln kWh. Such variations in hydropower generation is explained by varying hydrology conditions, as well as rehabilitation of the existing plants

Georgian power system is connected to Russia, Turkey, Azerbaijan and Armenia and biggest part of electricity trade comes from first two countries. Energy import from mentioned power systems is implemented in order to satisfy demand increased in winter period, as for energy export – due to the surplus of electricity generated during natural fluid period in summer. Energy exchange between Georgia and Armenia is carried out in smaller volumes, relatively.

During 2006-2010, energy export volumes were continuously increasing year-by-year. In 2011-2013, due to the increased internal consumption, volume of electricity export was decreased, during 2014 – implemented energy export was equal to 0.6 bln kWh, which was 25% increase compared to the same indicator for 2013. It is noteworthy that in 2014, due to the increased consumption, 0.85 bln kWh energy import was implemented – an increase of 75% from the same data of 2013. In 2015-2016, export / import volumes are slightly different. Energy export implemented during 2017 is equal to 0.686 bln kWh, as for import – it reached 1.5 bln kWh. Import increase in that year compared to the same indicator from 2016 was result derived from consumption growth and postponement of commissioning of prospective power plants. According to the data of 2018, energy import was equal to 1.5 bln kWh and export – 0.589 kWh.

*Table 1. Existing Power Plants in Georgian Power System for the end of 2019*

| № | Power Plant | Installed capacity (MW) | Number of units | Type | Commissioning year |
|---|---|---|---|---|---|
| 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 |

| № | Power Plant | Installed capacity (MW) | Number of units | Type | Commissioning year |
|---|---|---|---|---|---|
| 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 |

| № | Power Plant | Installed capacity (MW) | Number of units | Type | Commissioning year |
|---|---|---|---|---|---|
| 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 |

| № | Power Plant | Installed capacity (MW) | Number of units | Type | Commissioning year |
|---|---|---|---|---|---|
| 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 | Ghoresha HPP | 0.125 | 1x0.125 | Small HPP | 2017 |
| 75 | Kintrisha HPP | 6 | 2x3 | Run-of-River | 2017 |
| 76 | Nabeglavi HPP | 1.9 | 2x0.95 | 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 | Kheori HPP | 1.41 | 1 x1,41 | Run-of-River | 2018 |
| 80 | Bororna HPP | 2.5 | 1x2.5 | Run-of-River | 2018 |
| 81 | Kasleti 2 HPP | 8 | 46 | Run-of-River | 2018 |
| 82 | Jonouli 1 HPP | 1.8 | 1.8 | Run-of-River | 2018 |
| 83 | Kirnati HPP | 51 | 5x10.2 | 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 | 3.5 | 2x1.75 | Run-of-River | 2019 |
| 89 | Oro HPP (Zemo Orz. HPP) | 1.12 | 1x1.12 | Run-of-River | 2019 |
| 90 | Unit №9 | 300 | 1x300 | Thermal Power Plant | 1991 |
| 91 | Units №3, №4 | 272 | 130+142 | Thermal Power Plant | 1963 |
| 92 | Gas turbine | 110 | 2x55 | Thermal Power Plant | 2006 |

| № | Power Plant | Installed capacity (MW) | Number of units | Type | Commissioning year |
|---|---|---|---|---|---|
| **93** | Tkibuli Coal TPP | 13 | 2x6.5 | Thermal Power Plant | 2011 |
| **94** | Gardabani CCGT | 230 | 2x75+80 | Thermal Power Plant | 2015 |
| **95** | Wind Farm | 20.7 | 6x3.45 | Wind farm | 2016 |
| **I** | **Sum of Regulating HPPs** | **2381.12** | | | |
| **II** | **Sum of RoR HPPs** | **919.84** | | | |
| **III** | **HPPs in total** | **3300.96** | | | |
| **IV** | **TPPs in total** | **925** | | | |
| **V** | **Wind farm** | **20.7** | | | |
| **VI** | **System** | **4246.66** | | | |

*Table 2. Electricity Generation and consumption in past (2016-2019) years (bln kWh)*

| Year | Total Generation | HPPs | Thermal | Wind | Consumption | Net export |
|---|---|---|---|---|---|---|
| 2016 | 11.58 | 9.33 | 2.25 | 0 | 11.5 | 0.08 |
| 2017 | 11.53 | 9.21 | 2.23 | 0.09 | 12.34 | -0.81 |
| 2018 | 12.79 | 10.53 | 2.18 | 0.086 | 13 | -0.21 |
| 2019 | 14.14 | 11.2 | 2.85 | 0.093 | 13.65 | 0.49 |
| 2020 | 11.18 | 8.25 | 2.84 | 0.091 | 12.62 | -1.46 |

#### 2.2.1.2. Operation of Generation units

The major Georgian generation sources are concentrated in Western Georgia, particularly in Enguri River basin and include Enguri HPP and Vardnili HPP. During the summer flood period (May-June-first half of July) the total power generated by these plants amounts to 1250 MW. Part of the generated electricity (250 MW) is transmitted to Abkhazia by OHL Kolkhida-3 (Vardnili HPP – Ochamchire), other part (near 120 MW) is used for feeding Zugdidi, Menji and Khorga substations. The remaining part, about 860 MW by 500 kV OHL Imereti and 130 MW by 220 kV main parallel of OHL Imereti, is transported to the east and distributed between export to Turkey through SS Akhaltsikhe (600 MW) and power supply of Tbilisi-Rustavi load center.

Meantime, demand of the bulk load centers of Tskaltubo-Kutaisi (100 MW) and Zestaponi (250 MW) is mainly balanced by several local hydro power plants located in Kutaisi-Tskaltubo (320 MW) and Zestaponi (30 MW) regions. Thus, roughly 865 MW power is available for transfer through OHL

Imereti to the east. From this, about 407 MW is required for feeding Tbilisi-Rustavi and Khashuri-Gori load centers and remaining 590 MW may be transferred to Turkey. Since OHL Imereti is unable to transport more than 865[1] MW during summer months possibilities for power transit from Russia to Turkey are limited, even Georgian and Russian power systems operate in parallel regime and 100 MW capacity of the HVDC back-to-back station in SS Akhaltsikhe remains "vacant." This "free power" of back-to-back station may be dedicated to transfer power inflows from Azerbaijan and/or Armenia under the island layout.

Below is the average statistics of past years regarding outage of generation units in Electricity system of Georgia and resulted energy not supplied since G-1 criterion is not met by their outages.

*Table 3. Reliability indicators and averaged statistic for 2015-2018 of emergency outage of 100 MW or more powerful generation units*

| № | Name | Voltage | N | T | U | DE |
|---|---|---|---|---|---|---|
| | | kV | (Numb/year) | (Hour/year) | % | (kWh/year) |
| 1 | Enguri HPP g1 | 500 | 3.2 | 10.63 | 0.12 | 5'667 |
| 2 | Enguri HPP g2 | 500 | 2 | 1.78 | 0.02 | 0 |
| 3 | Enguri HPP g3 | 500 | 1.6 | 8.12 | 0.09 | 0 |
| 4 | Enguri HPP g4 | 500 | 3.8 | 42.53 | 0.49 | 0 |
| 5 | Enguri HPP g5 | 500 | 3 | 6.03 | 0.07 | 201'903 |
| 6 | Gardabani unit N3 | 220 | 0 | 0 | 0 | 0 |
| 7 | Gardabani unit N4 | 220 | 0 | 0 | 0 | 0 |
| 8 | Gardabani unit N9 | 500 | 0 | 0 | 0 | 0 |
| | | | | ჯამი | | **207'570** |

In the table above: N – number of outages of element per year; T – Recovery time after emergency outage. U – Number of emergency outages in % (T / 8760 * 100%). (T/8760). DE – Amount of Energy not supplied during year.

### 2.2.1.3. Renewable Energy Sources

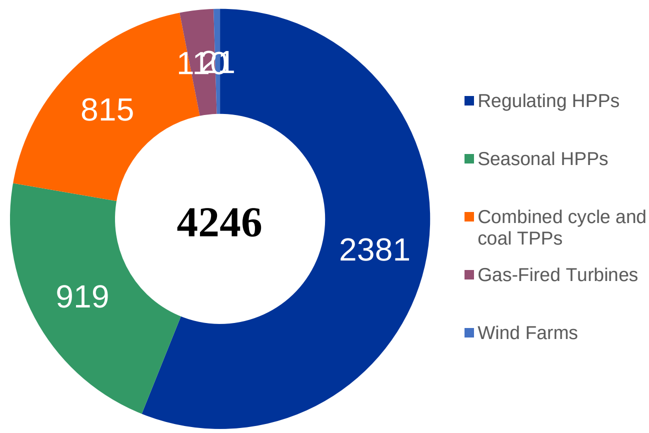


*Fig. 1 Existing Generation capacity mix (MW)*

At present total installed capacity of electric power plants operated in Georgia amounts to 4246 MW. From this 2381 MW is generated by the so-called "regulated" (storage) HPPs, 919 MW by "seasonal" (run-of-river) HPPs, 110 MW by Gas Turbines, 21 MW Wind farms and 815 MW by thermal power plants and combined-cycle gas turbines (Fig. 1). Roughly, 78% of the total in-country installed capacity is provided by HPPs, including 56% generated by regulated hydro power plants. So, Georgian electricity generation system mainly consists of Renewable energy sources.

As already mentioned, Georgia is very rich of hydro resources and hence, general part of planned generation projects is HPPs. Besides Georgia has big potential of other renewable energy sources – wind and solar. Planned development of generation capacities will be discussed in next chapter.

### 2.2.1.4. Activities related to the construction of new Generation capacities

1. Inputs for Network Development Planning

According to article 53 (Network Development Plan of Georgia) of the Energy Law:

*2) Georgian Ten Year Network Development Plan should contain:*

*a) Information on existing and predicted demand supply;*

*b) Reasonable forecast about generation, supply and cross-border flows with other countries;*

*…*

*f) Information on integration of new generation objects (including RES) into the grid.*

According to the Network Rules, article 39, paragraph 6:

*transmission network development plan, along with other information should include information about the operational characteristics of the transmission network, which includes:*

*...*

*g) transmission network development, which is based on forecast of consumption growth;*

*h) transmission network development, which is based on plans of construction of new power plants.*

*i) offers about construction of new interconnection lines and substations.*

*j) planned interflows with neighboring countries.*

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. 2. Approximate prices of new transmission elements. 3. Agreements about construction of transboundary infrastructure, between Georgia and neighboring countries and Development of surrounding grid. 4. Special requirements for generators and DC links. 5. Assignments about changes to be made in TYNDP, coming from Ministry of Economy and Sustainable Development of Georgia /Government.

Actual data on prospective generation objects and consumption growth forecast is sent by Ministry of Economy and Sustainable Development to GSE by official letter on annual basis. Such information included to last approved ten-year plan (TYNDP 2020-2030) is presented in tables below:

*Table 4. Forecasted installed capacities by generation type (MW)*

| Energy source | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *hydro* | 3301 | 3443 | 3693 | 3945 | 4540 | 4927 | 5357 | 6137 | 6137 | 6137 | 6536 | 6536 |
| *thermal* | 925 | 1175 | 1295 | 1295 | 1405 | 1405 | 1355 | 1355 | 1355 | 1355 | 1355 | 1355 |
| *wind* | 21 | 21 | 354 | 354 | 354 | 354 | 686 | 686 | 686 | 686 | 686 | 1330 |
| *solar* | | | 130 | 130 | 130 | 130 | 260 | 260 | 260 | 260 | 260 | 520 |
| *biomass* | | | | | | | | | | | | |
| *other* | | | | | | | | | | | | |
| *sum* | 4247 | 4639 | 5472 | 5724 | 6429 | 6816 | 7658 | 8438 | 8438 | 8438 | 8837 | 9741 |

*Table 5. Perspective HPPs with predicted data*

| № | Name | Installed capacity (MW) | Annual output (GWh) | Type | Exp. Commissioning date | Category[3] |
|---|---|---|---|---|---|---|
| 1 | Khelra | 3 | 17 | Run-of-River | 2020 | 2 |

| № | Name | Installed capacity (MW) | Annual output (GWh) | Type | Exp. Commissioning date | Category [3] |
|---|---|---|---|---|---|---|
| 2 | Ifari | 3 | 17 | Run-of-River | 2020 | 2 |
| 3 | Sashuala 2 | 5 | 23 | Run-of-River | 2020 | 1 |
| 4 | Rachkha | 3 | 11 | Run-of-River | 2020 | 1 |
| 5 | Chapala | 0.43 | 3 | Run-of-River | 2020 | 2 |
| 6 | Tbilisi sea | 1 | 3 | Run-of-River | 2020 | 2 |
| 7 | Chartali | 2 | 12 | Run-of-River | 20/01/2020 | 3 |
| 8 | Mashavera 1 | 2 | 9 | Run-of-River | 21/02/2020 | 3 |
| 9 | Mashavera 2 | 2 | 9 | Run-of-River | 22/02/2020 | 3 |
| 10 | Zemo karabulakhi | 1 | 7 | Run-of-River | 23/02/2020 | 3 |
| 11 | Stori 1 | 20 | 103 | Run-of-River | 14/04/2020 | 1 |
| 12 | Lakhami 1 | 6 | 37 | Run-of-River | 19/04/2020 | 2 |
| 13 | Lakhami 2 | 10 | 50 | Run-of-River | 19/04/2020 | 2 |
| 14 | Boko | 1 | 5 | Run-of-River | 01/06/2020 | 3 |
| 15 | Zekari | 2 | 11 | Run-of-River | 06/06/2020 | 2 |
| 16 | Khrami | 1 | 7 | Run-of-River | 06/06/2020 | 2 |
| 17 | Skhalta | 10 | 28 | Run-of-River | 09/07/2020 | 1 |
| 18 | Dvirula | 2 | 10 | Run-of-River | 13/11/2020 | 2 |
| 19 | Mtkvari | 53 | 230 | Run-of-River | 01/12/2020 | 1 |
| 20 | Jagon-Nashumi | 2 | 9 | Run-of-River | 01/12/2020 | 3 |
| 21 | Naceshari | 2 | 8 | Run-of-River | 01/12/2020 | 3 |
| 22 | Deka | 1 | 6 | Run-of-River | 01/12/2020 | 3 |
| 23 | Small Zekari | 2 | 12 | Run-of-River | 01/12/2020 | 3 |
| 24 | Sashuala 1 | 7 | 33 | Run-of-River | 29/12/2020 | 1 |
| 25 | Narovani | 1 | 4 | Run-of-River | 31/12/2020 | 2 |
| 26 | Kasleti 1 | 8 | 46 | Run-of-River | 31/03/2021 | 3 |
| 27 | Baisujbani | 5 | 33 | Run-of-River | 08/04/2021 | 3 |

| № | Name | Installed capacity (MW) | Annual output (GWh) | Type | Exp. Commissioning date | Category[3] |
|---|---|---|---|---|---|---|
| 28 | Akhalsofeli | 5 | 27 | Run-of-River | 08/04/2021 | 3 |
| 29 | Lopota 1 | 6 | 34 | Run-of-River | 24/04/2021 | 2 |
| 30 | Samkuristskali 1 | 5 | 26 | Run-of-River | 30/04/2021 | 1 |
| 31 | Samkuristskali 2 | 26 | 129 | Run-of-River | 30/04/2021 | 1 |
| 32 | Kvemo orozmani | 1 | 4 | Run-of-River | 01/06/2021 | 3 |
| 33 | Lahlachala | 12 | 53 | Run-of-River | 01/06/2021 | 3 |
| 34 | Torzila | 2 | 7 | Run-of-River | 14/06/2021 | 3 |
| 35 | Khobi 2 | 47 | 202 | Run-of-River | 10/08/2021 | 1 |
| 36 | Plato | 10 | 39 | Run-of-River | 29/08/2021 | 3 |
| 37 | Borjomi | 2 | 11 | Run-of-River | 29/08/2021 | 3 |
| 38 | Buja 1 | 2 | 10 | Run-of-River | 01/10/2021 | 2 |
| 39 | Buja 2 | 1 | 5 | Run-of-River | 01/10/2021 | 2 |
| 40 | Buja 3 | 2 | 11 | Run-of-River | 01/10/2021 | 2 |
| 41 | Sorgiti 1 | 13 | 60 | Run-of-River | 06/10/2021 | 3 |
| 42 | Sorgiti 2 | 10 | 48 | Run-of-River | 06/10/2021 | 3 |
| 43 | Laskadura | 7 | 33 | Run-of-River | 17/11/2021 | 2 |
| 44 | Baramidze | 8 | 39 | Run-of-River | 01/12/2021 | 2 |
| 45 | Udzilaurta | 8 | 41 | Run-of-River | 01/12/2021 | 2 |
| 46 | Darchi | 17 | 94 | Run-of-River | 01/12/2021 | 3 |
| 47 | Zoti | 44 | 169 | Run-of-River | 01/12/2021 | 2 |
| 48 | Khada 1 | 3 | 17 | Run-of-River | 01/12/2021 | 3 |
| 49 | Shavi aragvi 1 | 3 | 14 | Run-of-River | 01/12/2021 | 3 |
| 50 | Khevi | 3 | 22 | Run-of-River | 01/12/2021 | 3 |
| 51 | Nakra | 8 | 35 | Run-of-River | 01/01/2022 | 2 |
| 52 | Dzegvi | 16 | 82 | Run-of-River | 03/01/2022 | 3 |
| 53 | Chordula | 2 | 9 | Run-of-River | 12/01/2022 | 3 |

| № | Name | Installed capacity (MW) | Annual output (GWh) | Type | Exp. Commissioning date | Category[3] |
|---|---|---|---|---|---|---|
| 54 | Fona | 11 | 55 | Run-of-River | 20/01/2022 | 3 |
| 55 | Nakhidura | 9 | 57 | Run-of-River | 01/02/2022 | 3 |
| 56 | Goginauri | 5 | 19 | Run-of-River | 10/02/2022 | 2 |
| 57 | Barisakho | 14 | 64 | Daily Reg | 26/02/2022 | 3 |
| 58 | Akavreta | 20 | 84 | Run-of-River | 01/05/2022 | 3 |
| 59 | Sadmeli 2 | 4 | 23 | Run-of-River | 01/06/2022 | 3 |
| 60 | Meneso | 8 | 41 | Run-of-River | 01/06/2022 | 3 |
| 61 | Lukhra | 5 | 23 | Run-of-River | 21/06/2022 | 3 |
| 62 | Gubazeuli 6 | 3 | 20 | Run-of-River | 11/07/2022 | 3 |
| 63 | Akhalqalaqi | 10 | 54 | Run-of-River | 01/09/2022 | 3 |
| 64 | Khrami 3 | 16 | 112 | Run-of-River | 06/09/2022 | 3 |
| 65 | Tbilisi | 20 | 113 | Run-of-River | 21/10/2022 | 3 |
| 66 | Khadori 3 | 5 | 28 | Run-of-River | 21/10/2022 | 2 |
| 67 | Chiora | 14 | 68 | Run-of-River | 06/11/2022 | 2 |
| 68 | Bjuja 2 | 5 | 26 | Run-of-River | 16/11/2022 | 3 |
| 69 | Metekhi 1 | 37 | 145 | Daily Reg | 01/12/2022 | 2 |
| 70 | Metekhi 2 | 12 | 63 | Run-of-River | 01/12/2022 | 2 |
| 71 | Khada 2 | 1 | 8 | Run-of-River | 01/12/2022 | 3 |
| 72 | Shavi aragvi | 5 | 25 | Run-of-River | 01/12/2022 | 3 |
| 73 | Nakra 1 | 9 | 40 | Run-of-River | 31/12/2022 | 3 |
| 74 | Nakra 2 | 13 | 60 | Run-of-River | 31/12/2022 | 3 |
| 75 | Kizilajlo | 4 | 23 | Run-of-River | 25/02/2023 | 3 |
| 76 | Okropilauri | 4 | 22 | Run-of-River | 10/04/2023 | 3 |
| 77 | Digomi | 18 | 95 | Run-of-River | 05/06/2023 | 3 |
| 78 | Gebi | 14 | 71 | Run-of-River | 08/08/2023 | 2 |
| 79 | Gere | 9 | 41 | Run-of-River | 08/08/2023 | 2 |

| № | Name | Installed capacity (MW) | Annual output (GWh) | Type | Exp. Commissioning date | Category[3] |
|---|---|---|---|---|---|---|
| 80 | Sakaura | 12 | 59 | Run-of-River | 08/08/2023 | 2 |
| 81 | Majieti | 12 | 63 | Run-of-River | 08/08/2023 | 2 |
| 82 | Bakhvi 2 | 36 | 123 | Run-of-River | 13/08/2023 | 3 |
| 83 | Kamara | 14 | 65 | Run-of-River | 21/09/2023 | 3 |
| 84 | Namakhvani | 433 | 1,496 | Seasonal reg | 01/10/2023 | 2 |
| 85 | Tsablari 2 | 24 | 85 | Run-of-River | 30/11/2023 | 2 |
| 86 | Lajanuri 1 | 5 | 27 | Run-of-River | 31/12/2023 | 2 |
| 87 | Lajanuri 2 | 5 | 31 | Run-of-River | 31/12/2023 | 2 |
| 88 | Lajanuri 3 | 5 | 33 | Run-of-River | 31/12/2023 | 2 |
| 89 | Jonouli 2 | 32 | 129 | Run-of-River | 23/02/2024 | 3 |
| 90 | Vedi | 24 | 115 | Run-of-River | 26/02/2024 | 3 |
| 91 | Nenskra | 280 | 1,219 | Seasonal reg | 01/10/2024 | 1 |
| 92 | Kheledula 3 | 51 | 255 | Run-of-River | 15/12/2024 | 3 |
| 93 | Tsirmindi | 16 | 77 | Run-of-River | 26/02/2025 | 3 |
| 94 | Khobi 1 | 60 | 320 | Run-of-River | 01/10/2025 | 3 |
| 95 | Akhaldaba | 74 | 366 | Run-of-River | 01/10/2025 | 3 |
| 96 | Paldo | 7 | 48 | Run-of-River | 31/12/2025 | 3 |
| 97 | Mleta | 5 | 31 | Run-of-River | 31/12/2025 | 3 |
| 98 | Qvesheti | 10 | 70 | Run-of-River | 31/12/2025 | 3 |
| 99 | Bochorma | 5 | 32 | Run-of-River | 31/12/2025 | 3 |
| 100 | Qvedi | 2 | 10 | Run-of-River | 31/12/2025 | 3 |
| 101 | Andeziti | 1 | 4 | Run-of-River | 31/12/2025 | 3 |
| 102 | Dizi | 250 | 960 | Daily Reg | 2025 | 3 |
| 103 | Mtkvari casc. 4 | 78 | 615 | Run-of-River | 13/08/2026 | 3 |
| 104 | Khudoni | 702 | 1,528 | Seasonal reg | 01/10/2026 | 2 |

| № | Name | Installed capacity (MW) | Annual output (GWh) | Type | Exp. Commissioning date | Category [3] |
|---|---|---|---|---|---|---|
| 105 | Oni 1 | 122 | 441 | Run-of-River | 01/10/2029 | 3 |
| 106 | Oni 2 | 84 | 339 | Run-of-River | 01/10/2029 | 3 |
| 107 | Tskhenistskali casc. | 193 | 910 | Run-of-River | 01/10/2029 | 3 |
| 108 | Kvanchiani | 230 | 920 | Daily Reg | - | 3 |
| 109 | Ieli | 80 | 305 | Daily Reg | - | 3 |
| | Total | **3545** | **14020** | | | |

*Table 6. Perspective TPPs*

| № | NAME | Instaled capacity (MW) | Efficiency (%) | Type | Commissioning date | Category[3] |
|---|---|---|---|---|---|---|
| 1 | 1-Thermal | 250 | 55 | CCGT | 01.01.2020 | 1 |
| 2 | 2-Thermal | 250 | 55 | CCGT | 01.01.2021 | 3 |
| 3 | 3-Thermal | 250 | 55 | CCGT | 01.01.2023 | 3 |
| 3 | 4-Thermal | 250 | 55 | CCGT | 01.01.2025 | 3 |

*Table 7. Prospective solar, wind, geothermal or other renewables*

| № | Project | Region | Installed capacity (MW) | Annual output (GWh) | Type |
|---|---|---|---|---|---|
| 1 | Imereti-1 | Imereti | 420 | 1100 | Wind |
| 2 | Rikoti | Imereti | 65 | 219 | Wind |
| 3 | Central | Imereti | 120 | 560 | Wind |
| 4 | Tkibuli | Imereti | 50 | 321 | Wind |
| 5 | Zestaponi | Imereti | 50 | 165 | Wind |
| 6 | Kutaisi | Imereti | 50 | 171 | Wind |
| 7 | Pona | Inner Kartli | 25 | 87 | Wind |
| 8 | Nigoza | Inner Kartli | 50 | 232 | Wind |
| 9 | Kartli-2 | Inner Kartli | 100 | 317 | Wind |

| № | Project | Region | Installed capacity (MW) | Annual output (GWh) | Type |
|---|---|---|---|---|---|
| 10 | Pirveli | Inner Kartli | 110 | 388 | Wind |
| 11 | Zemo | Inner Kartli | 11 | 39 | Wind |
| 12 | Kaspi | Inner Kartli | 50 | 205 | Wind |
| 13 | Plevi | Inner Kartli | 35 | 140 | Wind |
| 14 | Martkopi | Tbilisi | 50 | 172 | Wind |
| 15 | Tbilisi | Tbilisi | 50 | 200 | Wind |
| 16 | Didgori | Lower Kartli | 50 | 193 | Wind |
| 17 | Pirveli-1 | Lower Kartli | 30 | 114 | Wind |
| 18 | Saakadze | Lower Kartli | 15 | 56 | Wind |
| 19 | Udabno | Kakheti | 5 | 8 | Solar |
| 20 | Algeta | Lower Kartli | 50 | 67 | Solar |
| 21 | Akhaltsikhe-1 | Samtskhe-Javakheti | 50 | 65 | Solar |
| 22 | Akhaltsikhe-2 | Samtskhe-Javakheti | 50 | 65 | Solar |
| 23 | Gardabani-1 | Samtskhe-Javakheti | 50 | 68 | Solar |
| 24 | Gardabani-2 | Samtskhe-Javakheti | 50 | 68 | Solar |
| 25 | Gldani | Tbilisi | 50 | 67 | Solar |
| 26 | Kaspi | Inner Kartli | 50 | 66 | Solar |
| 27 | Marneuli | Lower Kartli | 50 | 67 | Solar |
| 28 | Saakadze | Lower Kartli | 50 | 67 | Solar |
| 29 | Ksani | Inner Kartli | 50 | 66 | Solar |
| 30 | Gareji | Kakheti | 15 | 20 | Solar |
| 31 | Gardabani | | 3 | 25.9 | Biogas |
| | **Total** | | **1854** | **5399** | |

*Category 1 - projects at construction stage; Category 2 - projects at license stage; Category 3 – future projects*

2. Generation mix by 2030

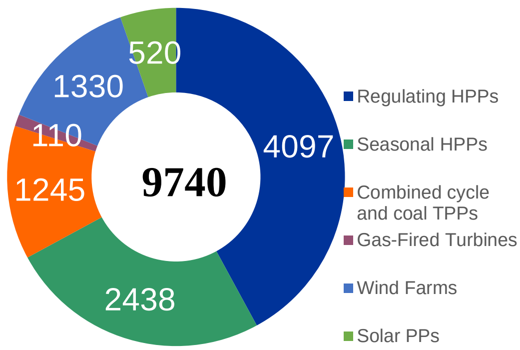


*Fig. 2 Generation capacity mix by 2030 (MW)*

For 2030, the total installed capacity available in Georgian power system will grow to 9740 MW. From this, 4097 MW will be attributed to regulated HPPs, 2438 MW - to seasonal HPPs, 1330 MW - to Wind Power Plants, 520 MW - to Solar Power Plants, 110 MW to Gas turbines and 1245 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 2030, percentage share of hydropower in total national installed capacity will grow to 67%, including 42% 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.

# 3. Scenarios of Georgian Transmission Network Development

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:

*Table 8. Scenarios of transmission grid development of Georgia*

| 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 |

Annual consumption growth for base scenario is 5% which is based on internal GSE's study as well as on 5-years plans of distribution licensees (5-7 %). Analysis of development scenarios also includes 3% pessimistic and 7% optimistic growth rates.

Table 8 includes different options of annual consumption growth and generation commissioning:

- G1 scenario means timely commissioning of 10% of total installed capacity of prospective power plants and postponement of rest capacity (90%) by 10 years;
- G2 scenario – on time commissioning of 25% of total installed capacity of prospective power plants and postponement of rest capacity (75%) by 5 years;
- G3 scenario – timely commissioning of all 100% of prospective power plants.

Power system may be developed according to one of the options (combination of generation expansion and consumption growth).

Based on the statistic of past years, Georgian power system is being developed between the G1 and G2 scenarios. That is a result of continuous postponement in the commissioning of large power plants. In parallel of this, consumption growth is about 5% per annum which leads to the situation where generation development is outcome by consumption growth and therefore dependence on energy import is increasing. These also leads to the necessity of construction of new thermal power plants – several high efficiency (combined-cycle gas turbine, CCGT) thermal power plants are planned to be commissioned till 2025 with total installed capacity of 750 MW or more. Such situation is the reason of restriction of development of RES (wind and solar) energy in Georgia, because there is a lack of reserve capacities in Georgian power system necessary to balance variable RES generation, so GSE is active in analysis of RES integration possibilities into the system in order to achieve enough level of the stability of Georgian power system.

## 3.1. Generation Adequacy

The analysis has been conducted with hourly granularity for each year from 2020 to 2030 in the different scenarios: G1L1, G1L2, G1L3, G2L1, G2L2, G2L3, G3L1, G3L2, G3L3. Where L1 - 3%, L2 - 5%, L3- 7% of annual consumption growth, G1 – on time commissioning of 10% of total capacity of prospective power plants and postponement of integration of rest power by 10 years. G2 – timely commissioning of 25% of prospective generation and deferment of commissioning of rest of power by 5 years. G3 - commissioning of full 100 %) prospective capacity (all power plants).

Generation adequacy indexes have been calculated for all years.

LOLP (LOSS OF LOAD PROBABILITY) index represents the correlation between the number of iterations in year, when generation is less than consumption, and the total number of iterations.

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

where:

$N_{DNS}$ is number of iterations for which $DNS > 0$

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

N is the total number of iteration (8760).

The average value of the unserved energy ("EXPECTED DEMAND NOT SUPPLIED" EDNS) represents the ratio between unserved energy and total number of iteration.

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

LOLE ("THE LOSS OF LOAD EXPECTATION") - the expected number of days in a year where load will not be met at least once in that day.

Results of calculation for most optimistic, moderate and most pessimistic development scenarios of generation and consumption – respectively G3L1, G2L2, G1L3 - are given in figures below:

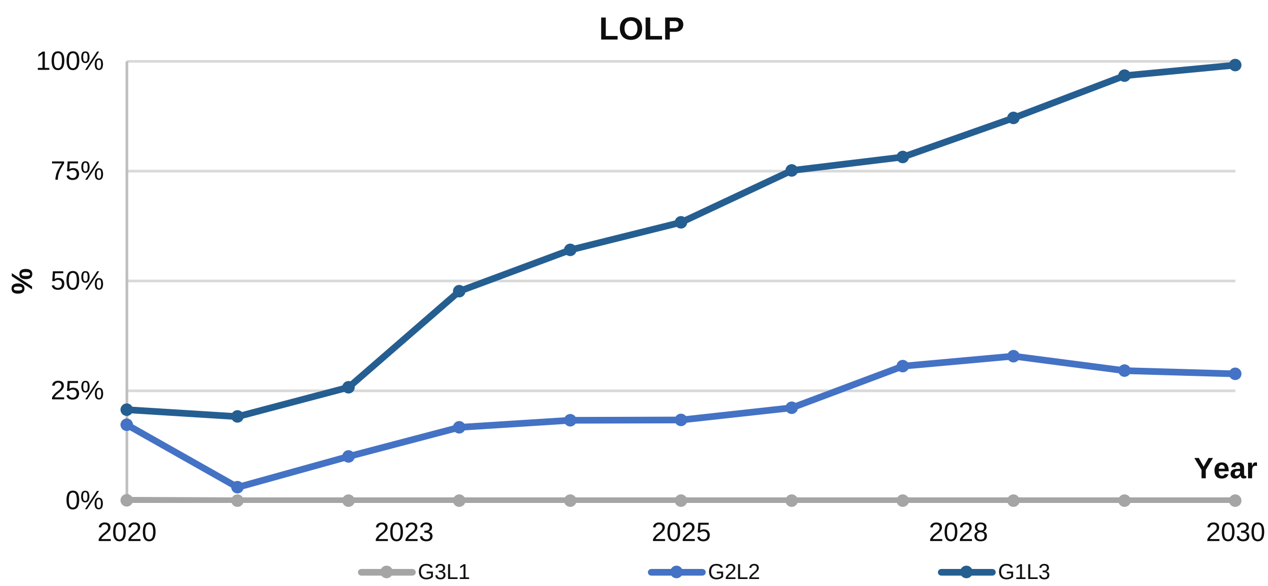


*Fig. 3 Loss of load probability (LOLP)*

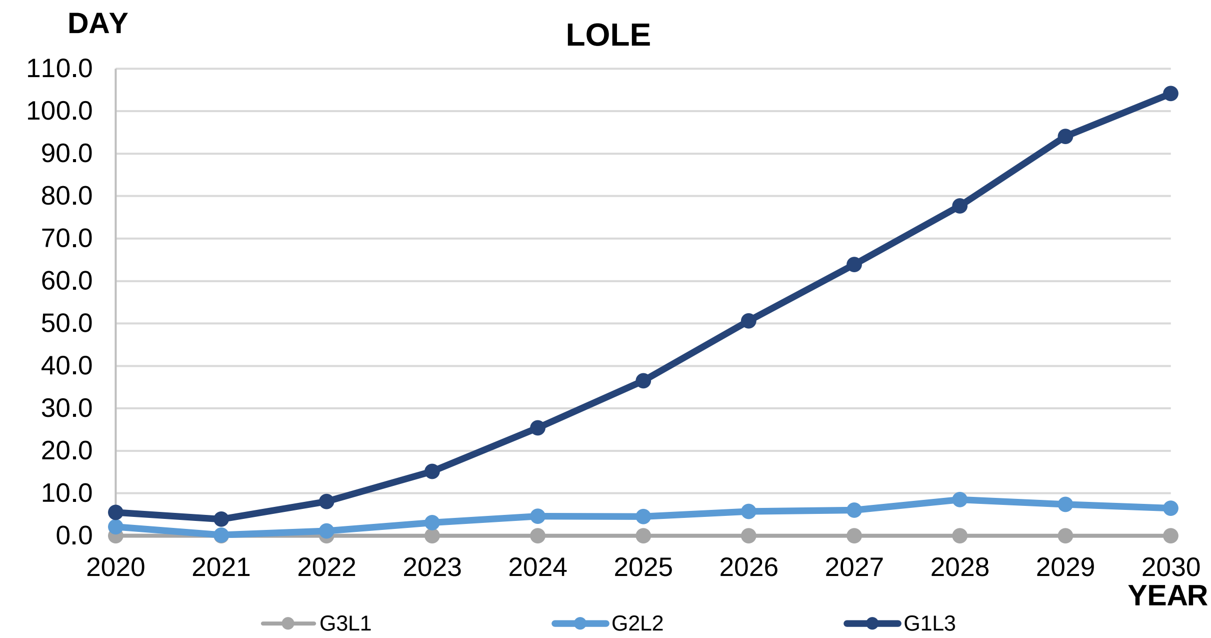


*Fig. 4 Loss of load expectation (LOLE)*

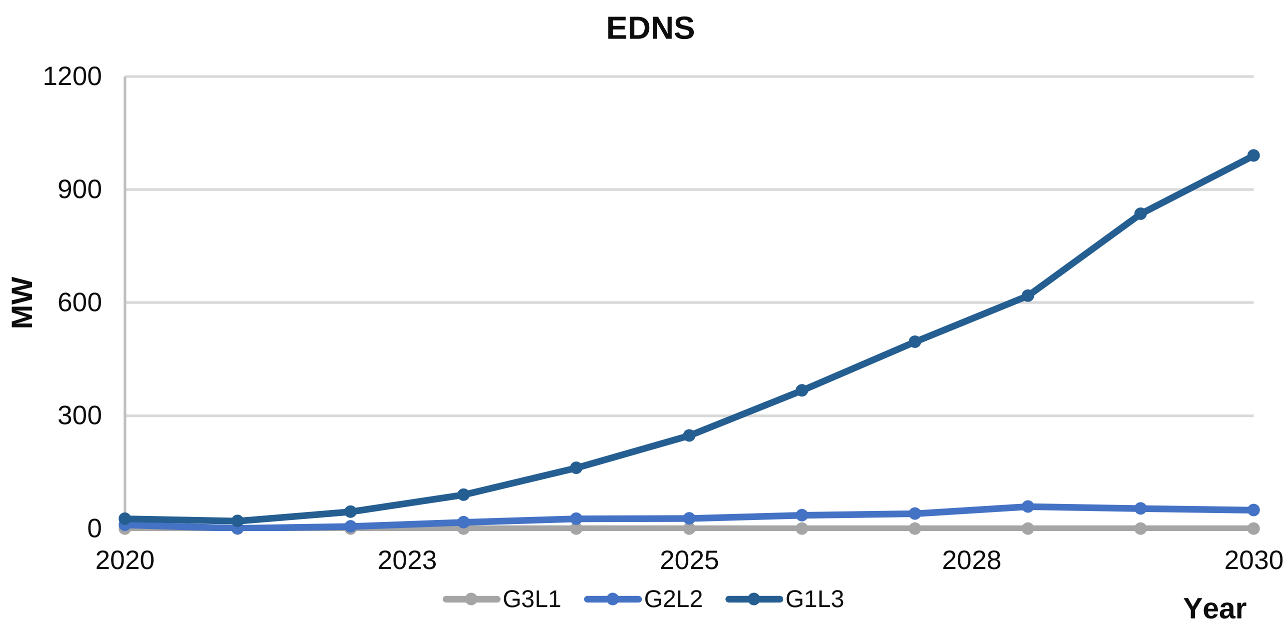


*Fig. 5 Expected demand not supplied*

In order to avoid the reduction of security of supply the following measures have to be taken:

1. Construction of 500 kV parallel line of 500 kV OHL "Imereti" in order to increase reliability of power evacuation from Enguri node;
2. Timely construction of cross border transmission infrastructure;

3. Future Generation objects have to be in operation at least according the schedule;
4. Existing generation objects must (!) improve their technical situation, according the "Network Rules", regulation approved by Georgian National Energy and Water Supply Regulatory Commission and "Technical Operation Rules for Power Plants and Networks", regulation approved by Government of Georgia;
5. HPPs with Reservoirs (Khudoni and Nenskra HPPs, Tskhenistskali, Mtkvari and Namakhvani cascasdes) have to be commissioned on time in order to "save energy" for winder period;
6. It is recommended to construct pymped-storage HPPs which will lead to improve generation adequacy, power system stability and flexibility and to make opportunity to integrate additional capacities coming from sources of variable generation (solar and wind) to the network.
7. Conduct measures to ensure increased power efficiency and mitigation of consumption growth.

## 3.2. Necessity of Thermal Power Plants

As far we know, Georgian power system is mainly powered by integration of the hydro power plants, operation of which is characterized by seasons of the year. The following is noteworthy: annual consumption growth exceeds 5% during last years, which seems to be maintained in future. It is noteworthy approximately 20-25% of installed capacity of HPP take part in covering base load. In addition, due to deferment of commissioning of prospective hydro power plants, their generation cannot respond respectively to the demand growth. Such imbalance causes increasing deficit of base capacity, which is especially explicit during winter (January, February, March, November, December). Therefore, increase of import and decrease of security of supply and flexibility of system takes the place.

According to above mentioned, to eliminate the shortage of base power and to ensure security of supply in Georgian power system, it is reasonable to construct thermal power plants, namely, 500-600 MW combined- cycle gas turbine and to hence ensure 1600-1700 MW total installed capacity of TPPs till 2025. Considering topology of high voltage network, it is recommended to integrate this capacity into the east part of transmission network.

## 3.3. Opportunities of integration renewable energy sources into the Georgian power system

### Foreword

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 CAPEX of wind turbines and PV panels more and more decreases, hence the utilization of Wind and Solar Energy becomes increasingly attractive. The time needed for their construction is much less compared to the HPPs (due to the lack of penstock system and the dam). Also the OPEX (expenses in operation period) is minimal. On the backgrounds of deferment of construction of HPPs and intensive growth of electricity demand of the country, the utilization of domestic resources become especially important in order to ensure security of supply. WPPs and SPPs can play an important role in this regard. However, their integration should not happen by sacrificing system reliability.

Wind and solar power plants have number of characteristics, which have negative effect to system stability, in particular generation variation. This problem is less presented in solar power plants because their generation is more depended on calendar than on weather. Another positive issue for solar energy is that their generation can be correlated to the consumption, which is usually increasing during day hours. As for wind energy, its generation is sharply depended on weather and on wind in particular. It is especially noteworthy stopping of wind turbines in case of appearing strong wind resulting power deficit and generation of harmonic distortion in transmission network. At the same time, there is no practical possibility of correlation of their generation to the consumption. Hence, in order to ensure reliable operation of power system, fulfill of special requirements will be necessary in case of integration of wind and solar energy, which will be even bigger challenge for Georgian system due to the difficulty of voltage and frequency control. Except “Network Rules” requirements, Wind farms should satisfy limitations related to the present Georgian power system in order to connect them to the transmission network.

### Contributing factors of assimilation of Wind and Solar energy

Based on the best European experience, countries implementing large capacity integration of wind and solar power stations into their System should have the following characteristics:

- Enough inertia constant (total installed capacity of operating generation units in power system): Total installed capacity of Georgian electricity power system is near 4.5 GW. Most of the time in a year, it usually has parallel synchronous connection to IPS/UPS system (Russia), which has significantly bigger inertia constant than Georgian system as a whole, and hence, it provides frequency regulation in Georgian system. In case of isolate operation, frequency deviation in our system takes place. The right measure to resolve this issue is to construct large-scale storage HPPs with important amount of inertia as well as energy storages which will act respectively in case of frequency deviation, including the cases where it is caused by variation in RES (wind and solar) generation. Mentioned projects are part of TYNDP of Georgia and their commissioning are planned for next ten years.
- Large and mutually reserved internal and cross-border transmission network: TYNDP of Georgia includes interconnection projects in direction of all neighboring systems – with Russia – 500 kV OHL Stepantsminda (GE) – Mozdok (RU); Armenia – 500 kV OHL Marneuli (GE) – Airum (AM); Azerbaijan – 2-circuit of 330 kV OHL Gardabani (GE) – Agstafa (AZ) (dismantling of existing single circuit line and construction of new 2-circuit one); and Turkey – 400 kV OHL Akhaltsikhe (GE) –

Tortum (TR); after realization, mentioned projects with Russia, Azerbaijan and Turkey will improve reliability of energy exchange between Georgia and mentioned systems. Commissioning of these projects are planned in next ten years.

- Power system Flexibility, enough capacity to Primary, Secondary and Tertiary reserves, pumped-storage power plants and fast-acting reactive power compensator sources: Currently, Georgian power system is lack of enough amount of capacity reserves – there is necessity of refurbishment of regulation systems at most of the existing power plants, implementation of which is planned in next years. As for new power plants, requirements on reserves are already included in "Network Rules". Besides this, there is also project of pumped-storage power plant with installed capacity of 570 MW in west part of Georgia (near Enguri HPP) and also the project of installation of reactive power compensation equipment with total installed capacity of 600 MVAR at substations of Tbilisi region – first stage includes 100 MVAR reactive power compensators, procurement procedures for consultation and purchasing/installation are already ongoing and its estimated completion date is end of 2021. Next stages will be implemented in next 5-6 years.
- Accurate Wind forecast; Modern methods for planning of Power System operation and programs integrated to SCADA: The project of wind forecast system is ongoing with support of USAID. The main aim of having wind forecasting system in TSO is to increase security of supply based on wind generation predictions from power plant owners as well as alternative independent parties. Mentioned project, after completion, will reduce required reserves, that is caused by VRE forecast error, also, dispatcher of National control center will have information about power flows on lines in near future.
- Integration of power system into the united energy market: the process of establishment of the balancing market is already started in Georgia, which, after completion (forecasted date is 2021), will give motivation to Power Plants to upgrade their voltage and speed regulatorsand by this way to provide more benefit to the grid stability.

## Inputs and Assumptions

With the support of consultation consortium DIGSILENT, DMCC and R2B, GSE has performed "VRE Integration Study in Georgian Grid" in 2018, one of the main objective of which was to identify the maximum possible VRE integration levels for 2020, 2025, 2030 without reducing Grid stability. The main project assumptions were as follows:

- Potential of 1850 MW RES integration:
  - 520 MW of Solar Power Plants;
  - 1330 MW of Wind Power Plants;
  - Annual consumption growth 5-6%.
- from 2020:
  - Existence of balancing market is taken into account;

   - existence of forecasting system for consumption, RES and ROR HPPs is taken into account.
- 2025 year:
   - All planned HPPs are commissioned except Khudoni HPP and Tskhenistskali HPPs cascade.
- 2030 year:
   - All planned HPPs are commissioned.

*Table 9. Prospective Solar Power Plants*

| № | Project | Location | Installed capacity (MW) | Annual Generation (mln kWh) |
|---|---|---|---|---|
| 1 | Udabno | Kakheti | 5 | 8 |
| 2 | Algeta | Kvemo kartli | 50 | 67 |
| 3 | Akhaltsikhe-1 | Samtskhe-Javakheti | 50 | 65 |
| 4 | Akhaltsikhe-2 | Samtskhe-Javakheti | 50 | 65 |
| 5 | Gardabani-1 | Kvemo Kartli | 50 | 68 |
| 6 | Gardabani-2 | Kvemo Kartli | 50 | 68 |
| 7 | Gldani | Tbilisi | 50 | 67 |
| 8 | Kaspi | Shida kartli | 50 | 66 |
| 9 | Marneuli | Kvemo kartli | 50 | 67 |
| 10 | Saakadze | Kvemo kartli | 50 | 67 |
| 11 | Ksani | Shida kartli | 50 | 66 |
| 12 | Gareji | Kakheti | 15 | 20 |
| | | ***Sum*** | ***520*** | ***695*** |

*Table 10. Prospective Wind Power Plants*

| № | Project | Location | Installed capacity (MW) | Annual Generation (mln kWh) |
|---|---|---|---|---|
| 1 | Imereti-1 | Imereti | 420 | 1100 |
| 2 | Rikoti | Imereti | 65 | 219 |
| 3 | Central | Imereti | 120 | 560 |

| № | Project | Location | Installed capacity (MW) | Annual Generation (mln kWh) |
|---|---|---|---|---|
| **4** | Tkibuli | Imereti | 50 | 321 |
| **5** | Zestafoni | Imereti | 50 | 165 |
| **6** | Kutaisi | Imereti | 50 | 171 |
| **7** | Fona | Shida kartli | 25 | 87 |
| **8** | Nigoza | Shida kartli | 50 | 232 |
| **9** | Kartli-2 | Shida kartli | 100 | 317 |
| **10** | Pirveli | Shida kartli | 110 | 388 |
| **11** | Zemo | Shida kartli | 11 | 39 |
| **12** | Kaspi | Shida kartli | 50 | 205 |
| **13** | Flevi | Shida kartli | 35 | 140 |
| **14** | Martyofi | Tbilisi | 50 | 172 |
| **15** | Tbilisi | Tbilisi | 50 | 200 |
| **16** | Didgori | Kvemo kartli | 50 | 193 |
| **17** | Pirveli-1 | Kvemo kartli | 30 | 114 |
| **18** | Saakadze | Kvemo kartli | 15 | 56 |
| | | ***Sum*** | ***1330*** | ***4680*** |

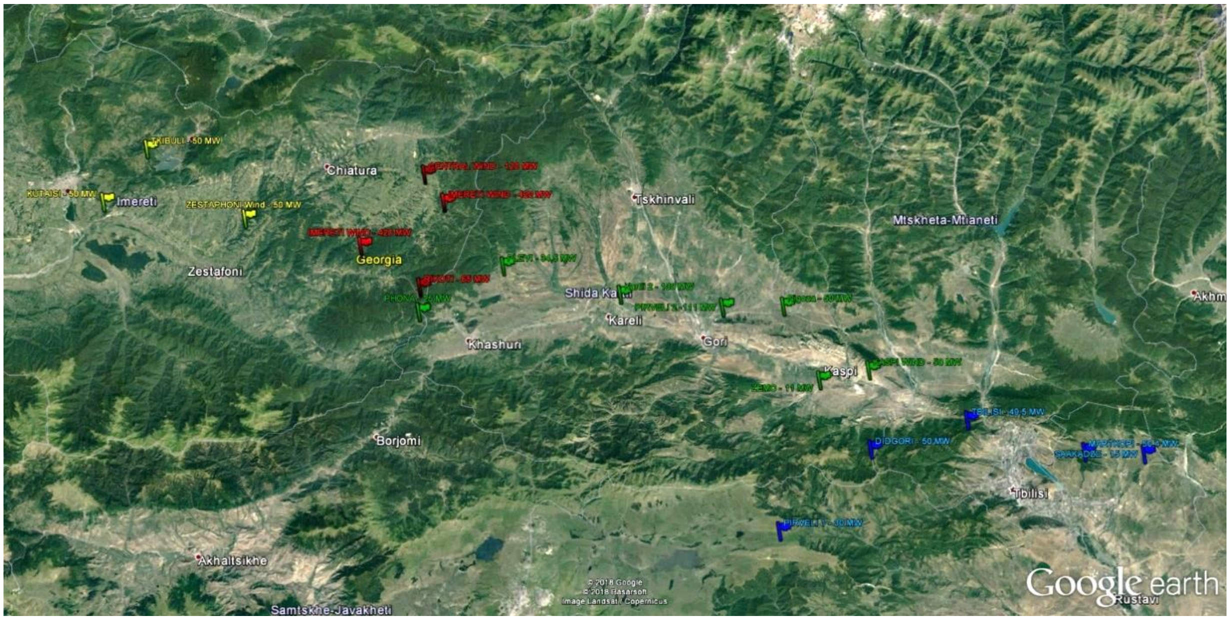


*Fig. 6 Geographical location of perspective Wind Power Plants*

Due to their geographical location, Wind Power Plants have been divided by following zones:

- West – 150 MW;
- Central West – 605 MW;
- Central East – 380 MW;
- East – 195 MW.

## Results of the study

According to the results of technical study, in 2020, 2025 and 2030 scenarios it is possible to integrate variable renewable energy sources in Georgian power system with the amounts of capacity shown in Table 11.

*Table 11. Maximum total permissible integration of RES*

| Maximum total permissible integration of RES | RES Integration | | | |
|---|---|---|---|---|
| | 25%<br>Wind: 333 MW<br>Solar: 130 MW | **50%**<br>Wind: 665 MW<br>Solar: 260 MW | **75%**<br>Wind: 1000 MW<br>Solar: 390 MW | **100%**<br>Wind: 1330 MW<br>Solar: 520 MW |
| 2020 Year | | #2a #2c #3 | | |
| 2025 Year | *Re-calculation of permissible levels are ongoing (see comment at the end of chapter)* | | | |
| 2030 Year | #2a #2c | | | #2b #4 |

*In the table, green color means that it is permissible undoubtedly or by taking into account of insignificant activities, yellow corresponds admissibility with the consideration of implementation of specific measures, Red inadmissible.*

With considering of the following events and factors:

1. #1 - „The effect of saturation"- variable RES cannot meet the main goal of their integration in an effective manner, cannot replace thermal generation and/or import. Additional energy generated by them directly increases export, or, otherwise, portion of generation to be restricted/limited.
2. #2 - Operation of variable RES requires existence of additional high amount of regulating reserves (upward and downward) in the system. Regulating reserves existing in the system are limited and in some cases it is required to additionally mobilize such balancing capacities in order to increase level of RES integration. In particular:
   a. #2a - The necessity to find an additional 260 MW upward reserve, which may be additionally implemented in case of using one of the unit in Enguri HPP to be used just for providing reserves.
   b. #2b - It is necessary to ensure an additional 380 MW upward reserve.
   c. #2c - Necessity of finding an additional downward reserve. It is obligatory for all RES to ensure existence of downward reserve equal to 30% of their installed capacity.
3. #3 - Necessity of measures for frequency stability (e.g. Batteries).
4. **#4 - Strengthening of the transmission network to avoid overload of OHLs and transformers in case of integration of RES.**
5. Excess energy generated by renewable energy sources should be exported, otherwise, should be limited to some extent:
   - ✓ Technically, capabilities of cross-border exchange with other countries are enough, but, market of neighboring states should be attractive for export at a particular moment.
6. Importance of geographic scattering effect in integration of RES:
   - ✓ Maximum geographical scattering of Power Plants operating on variable renewable energy sources (RES) reduces reserves needed for their balancing.
   - ✓ This approach maximizes opportunity to integrate of RES.
   - ✓ Respectively, high concentration of renewables installed capacities in particular area will restrict the possibility of total integration.

Therefore, with the consideration of: network development plan, rehabilitation plan of speed governors and excitation systems, existence of system services, existence of forecasting system of RES, ensuring downward reserves by RES in some cases, maximum geographical scattering or RES and exporting and/or restricting their excess energy:

- ✓ Until 2020-2021 (after activation balancing mechanisms), it is possible to integrate 333 MW Wind and 130 MW Solar Power in Georgian power system (25% of potential);
- ✓ For 2025 – New calculation under the Generation expansion plan is ongoing, results will be available in near future.
- ✓ For 2030 – integration of 1000 MW Wind and 390 MW Solar Power Plants (75% of potential).

*Table 12. Recommended maximum installed capacity of solar power plants*

| recommended maximum total installed capacity of solar power plants (MW) | | | |
|---|---|---|---|
| Year | 2020 | 2025 | 2030 |
| Installed capacity | 130 | * | 520 |

These amounts can be periodically changed to some extent, therefore, recalculation and respective clarification of RES integration possibilities for 2025, 2030 will be made during next years.

* - Currently, under the supervision of Ministry of economy and sustainable development preparation of Generation Expansion Plan is in progress, under the scope of which recommended amounts of Wind and Solar capacity to be integrated into Georgian power system is being recalculated, results will be available in near future.

The main challenge in integration of wind and solar energy into the Georgian power system is that analysis of the possibility of integration this kind of RES capacity needs to be updated annually. The reason of this is that they have variable generation through not only year or month, but even day. This leads to the necessity to have enough capacity reserves in the system. However, nowadays Georgian power system does not have reserve capacities and as mentioned above, construction of large power plants (including reservoir HPPs) are generally delayed. So, in order to maintain stability of Georgian power system, the careful and accurate assessment of the possibility of integration of Wind and Solar energy is highly important and therefore, such kind of analysis is held by GSE frequently, every year.

## 3.4. Transmission System

### Present Situation

According to "Network Rules", transmission network development plan, besides other information must include information about operational characteristics:

a. General characteristics of transmission network including cross-border connections with neighboring countries;
b. Current situation of transmission network and analysis about locations not satisfying planning criteria;

c. … capacity of high voltage overhead lines;
d. Power flow analysis of transmission network in case of maximum loads;

## Transmission System Operator

Joint Stock Company "Georgian State Electrosystem" (GSE) – Dispatch Licensee became Transmission System Operator according to amendments (12 December 2014) to the "Georgian Law on Electricity and Natural Gas". The parent company of GSE holding 100% of its shares is the state-owned JSC Georgian Partnership Fund. GSE was founded in 2002 in result of merger of former state-owned electricity transmission and dispatch companies (JSC Electrogadatsema and Electrodispatch Ltd.). Based on the Licenses and tariffs charged for transmission and dispatch services approved by the Commission, GSE implements technical control of the power system for ensuring stable supply/consumption regimes, and transmission of locally generated and imported power to distribution companies, eligible customers and neighboring states' power systems. GSE holds power transmission and dispatch licenses approved by THE COMMISSION on 20 December 2002.

## System Dispatch

The National Dispatch Centre (NDC) located in GSE's headquarters undertakes operating control of Georgian power system, and is responsible for sound operation of 500/400/330/220/110/35 kV transmission facilities and overall stability of the system as in the steady state, so under contingencies. This facility is equipped with state-of-the-art technologies allowing collection of the system information in on-line regime, remote control of the system and effective response to disturbances. For this, NDC receives comprehensive data from dispatched substations and power plants, maintains continuously updated database and promptly reacts to emergencies.

## Power Transmission

The balance sheet assets owned by GSE and its daughter company Energotrans consist of 500/400/330/220/110/35 kV overhead lines with total length of 4,380 km and 94 substations with aggregated installed capacity of 12,114 MVA, including strategically important seven 500 kV and twenty-four 220 kV substations.

## Mission

Gaining leading position in the regional energy sector, increasing the transit potential of the country and provision of domestic and foreign customers with high quality, reliable power transmission services.

## Current Opportunities for Power Exchange with neighboring countries

In result of its geographical location, Georgia can gain an important function in course of the planned regional integration of the power systems of the Caucasian (and Black Sea) countries assuming promotion of energy trading between these states and development and use of Georgian hydropower resources.

At present, power exchange between Georgian power system and its neighboring systems is carried out by 500, 400, 330, 220 kV overhead lines.

Energy exchange is implemented: From Georgia to Russia, Turkey, Azerbaijan, Armenia and vise-versa as well as From Russia to Turkey, from Azerbaijan to Turkey. Cross-border overhead lines serve for realization this task, however, such "international" power flows are restricted due to both limitations stemmed from the acceptable operating modes of national power system and transmission capacities of above mentioned cross-border OHLs.

*Table 13. Present 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 |
| | „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" AC-480 | 330 | Export | 210 | 240 | S |
| | | | Import | 210 | 240 | S |
| **Armenia** | „Alaverdi" AC-300 | 220 | Export | 150 / 100 | 150 / 100 | S / I |
| | | | Import | 150 / 100 | 150 / 100 | S / I |
| **Turkey** | „Meskheti" AC-3x500 | 400 | Export | 700 | 700 | B |
| | | | Import | 700 | 700 | 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

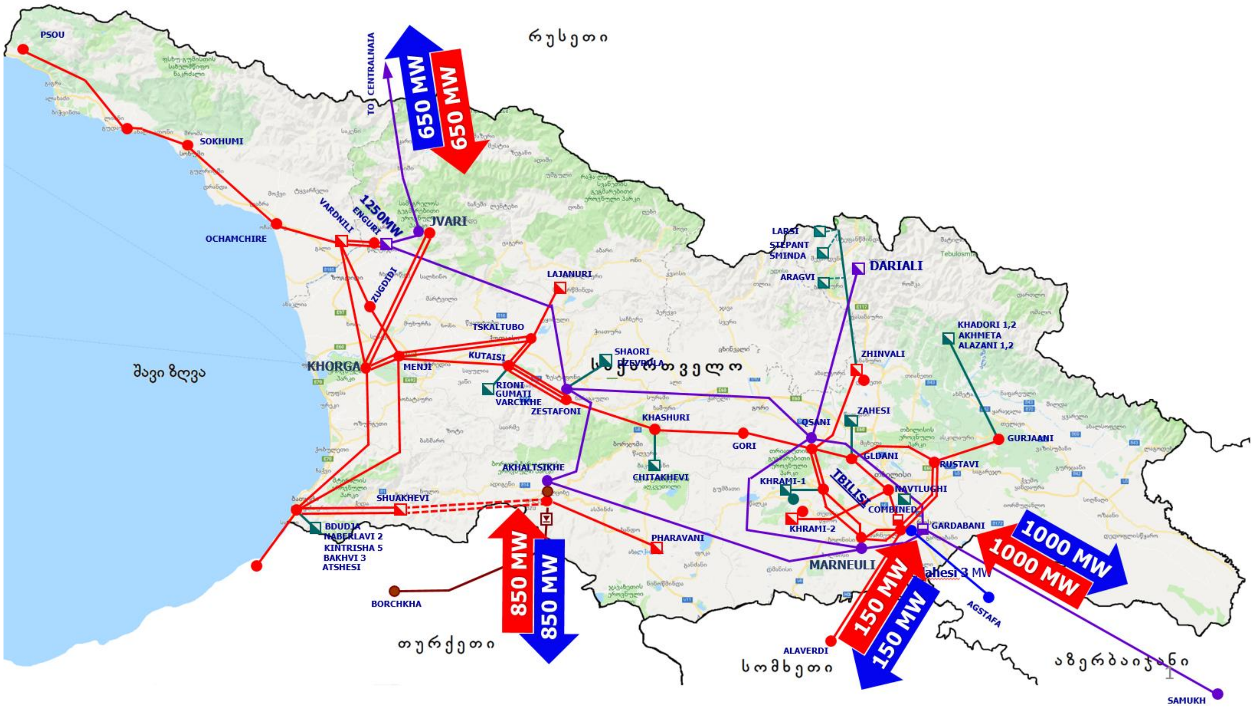


*Fig. 7 Cross-border transfer capacities between power systems of Georgia and its neighboring countries*

## Main Present Power Exchange Flows

As noted above, the major Georgian generation sources are concentrated in Enguri River basin, and include Enguri HPP and Vardnili HPP. During summer flood period (May-June-first half of July), the total power generated by these plants amounts to 1250 MW. From this, one part (250 MW) is transmitted to Abkhazia by OHL Kolkhida-3 (Vardnili HPP – Ochamchire), other part (122 MW) is used for feeding Zugdidi, Menji and Khorga substations. Remaining almost 865 MW by 500 kV OHL Imereti and 132 MW by 220 kV main parallel of OHL Imereti is transported to the east, and distributed between export to Turkey through SS Akhaltsikhe (600 MW) and power supply of Tbilisi-Rustavi load center. Meantime, demand of the bulk load centres of Tskaltubo-Kutaisi (100 MW) and Zestaponi (250 MW) is mainly balanced by several local hydro power plants located in Kutaisi-Tskaltubo (320 MW) and Zestaponi (30 MW) regions. Thus, roughly 865 MW power is available for transfer through OHL Imereti to the east. From this, about 407 MW is required for feeding Tbilisi-Rustavi and Khashuri-Gori load centers, and remaining 590 MW may be transferred to Turkey. Since OHL Imereti is unable to transport more than 865[1] MW, during summer months, possibilities for power transit from Russia to Turkey are limited, even Georgian and Russian power systems operate in parallel regime and 100 MW capacity of the HVDC back-to-back station in SS Akhaltsikhe remains “vacant.” This “free power” of back-to-back station may be dedicated to transferring power inflows from Azerbaijan and/or Armenia under the island layout.

It should be noted that, assuming such loading of OHL Imereti, its loss should lead to overloading and tripping of 220 kV transmission mains connecting Enguri HPP and SS Zestaponi that is avoided by operation of Emergency Control System (ECS), which initiates generation reduction in Enguri basin and load/export shedding in Tbilisi-Rustavi/Akhaltsikhe, such as to keep the power flow within acceptable limits.

Therefore, the eastward transmission capacity must be increased by means of constructing parallel branch to 500 kV Imereti that will allow avoidance of generation/load shedding by ECS, i.e. development of the transmission network should ensure fulfilment of single contingency (N-1) criterion under any operating mode.

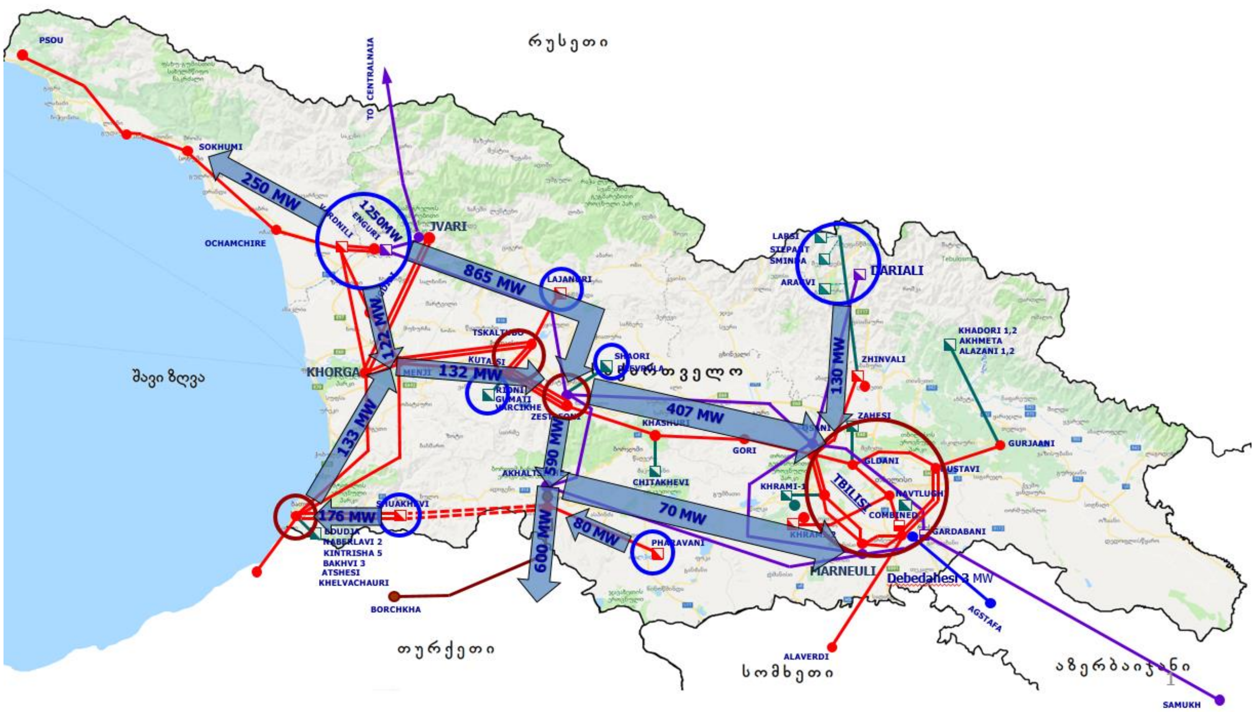


*Fig. 8 Bulk power flows during flood period*

## Present transmission grid of Georgia

Georgian Power system had been designed for parallel operation with big united power system and as well as for case of simultaneous operation of all interconnection line with Russia, Armenia and Azerbaijan. Hence 500 kV grid which had radial topology in territory of Georgia, was backed up by three neighbor countries simultaneously. Moreover, 500 kV grid was acting as one of the branch of big power system. Hence, emergency outage of any network element (500 kV OHL or big generation unit) in Georgian system didn't lead to limit consumers. Starting from 90's, due to the independent reasons, there was no possibility of parallel synchronous operation with more than one neighbor country, which caused leaving internal radial network of Georgia as well as any operating interconnection line without backup. Specific emergency situation was in case of island operation of Georgian power system. In such case, outage of any 500 kV OHL as well as any dead end 220 kV OHL (see below) and 100 MW or bigger generation unit (#3, #4, #9 unit in Gardabani and units in Enguri HPP) causes severe condition in emergency point of view. One of the reason of this situation is that there are no speed governors and excitation system in some part of generation units or, at least they are aged enough and decommissioned because they do not meet requirements of "Technical Operation Rules" and "Network Rules", which leads to more difficult condition of voltage control as well as more difficult situation for frequency control in isolated mode.

At the end of 2016 the following projects in terms of transmission network reinforcement have been commissioned: 220/110 kV SS Khorga, double circuit 220 kV OHL Khorga-Menji (Khorga 1,2), construction of 500/220 kV SS Jvari was completed. In 2019, double circuit 220 kV OHL Jvari-Khorga (Odishi 1,2) will be commissioned as well as SS Jvari will be tied to 500 kV OHL Kavkasioni resulting in backup of existing Network bottlenecks such as 500/220 kV AT Enguri, Double circuit 220 kV OHL Egrisi 1,2, 220 kV OHL Kolkhida-2a, 220 kV OHL Kolkhida-2. At the end of 2016, 220 kV OHL Sataplia 2 has been commissioned as well, as for 220 kV OHL Ajameti 3, it was completed and commissioned in 2017. These two 220 kV OHLs increase safe evacuation of the generation from Kutaisi-Tskaltubo node, also together with new infrastructure of JvarI-Khorga increase reliability of 220 kV grid in West part of Georgia. Construction of double-circuit 220 kV OHL Batumi-Shuakhevi was completed in 2017 as well, which, at first stage will ensure integration of Shuakhevi HPP into the grid.

In addition, starting from 2021, in case of outage of 500 kV OHL Imereti, disconnected capacity of consumers will decrease significantly, since OHL Imereti will be reserved by at least three 220 kV OHLs. 220 kV line Surami – Urbnisi – Liakhvi is not effectively reserved and in case of overload of 500 kV OHLS Kartli-2 and Vardzia, and in case of outage of either of them, there is a threat of overloading 220 kV route and splitting Georgia's power supply system. In case of outage of 220 kV lines connecting to SS Gldani, 220 kV OHL Aragvi might overload because of Gldani's increased consumption.

The following elements were commissioned in 2017: 500 kV 250 MVAr regulated reactor in Zestaponi, which contributed significantly to the flexibility of the system in terms of voltage / reactive power regulation.

In the years 2016-2017, the substation Marneuli 500/220 with 660 MVA installed capacity has been commissioned and 125 MVA Autotransformer was added to it in 2017, which made a significant positive impact on the power supply of the region Tbilisi.

Consequently, the number of network bottlenecks has been reduced.

In recent years, the peak loads of substations have been increased sharply in parallel of power system consumption, especially at Tbilisi and Batumi nodes. The N-1 criteria is still challenge for some substations, which means restriction of consumers will be necessary in case of outage of one of the autotransmitters in those substations.

Bottlenecks of transmission network of Georgia are:

- Non backed-up Interconnection 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
  - Kolkhida 2a, 220 KV
  - Kolkhida 2, 220 KV
- Batumi supply grid:
  - Paliastomi 1,2, 220 KV
- 220 kV lines 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
- Generation of which shutdown time not completed G-1 criterion:
  - Generators of Enguri HPP
    - Unit №9
    - Unit №4
    - Unit №3

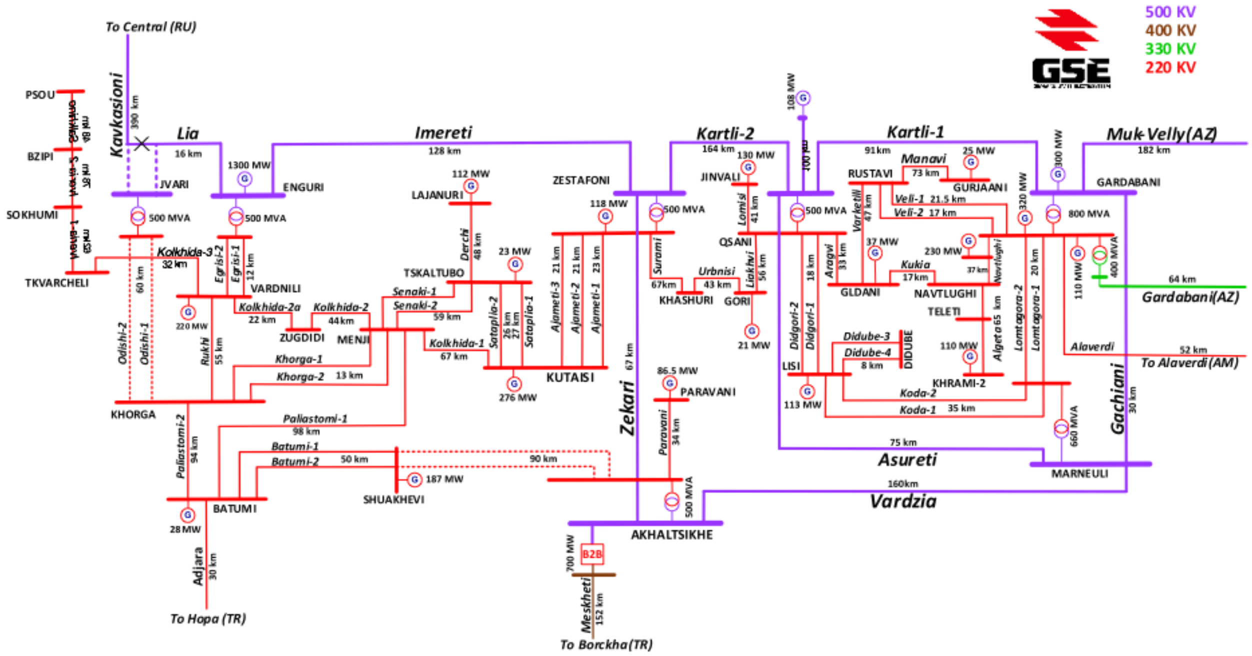


*Fig. 9 Single line diagram of Georgian electricity transmission network*

The biggest challenge for system stability is the outage of 500 kV OHL Imereti which supplies the most part of East Georgia from Enguri bus bar during summer period. Hence, despite of existence of very high reliable emergency automatic in Georgia system, average level of energy not supplied caused by outage of OHL Imereti is about 1 ml. kWh/year. After Imereti, the most problematic elements of network in terms of emergency outage are 220 kV OHL Paliastomi 2 (because simultaneous outage of these two 220 kV OHLs led to complete blackout of Adjara region), then 220 kV OHL Kolkhida 3 (Abkhazia region), 9th unit of Gardabani, 2nd and 3rd units of Enguri and 500 kV OHL Kavkasioni (cross-border line with Russia). In this point of view, 400 kV OHL “Meskheti” connecting Georgian system to Turkish is worth to be separately noted because its outage led to 7.27 mln kWh nonrealized energy export, which is not energy not supplied to Georgian consumers, but it is energy that had to be transferred as export to Turkey what would be significant revenue for Georgia and participants of its power system.

As a conclusion, operation mode of Georgian transmission network corresponds “alert mode” even if there are all the elements at normal operating condition and all the parameters are at their normal ranges. Therefore, security of supply is the most critical problem of Georgian transmission network and increase of security of supply/system reliability is the main scope of transmission network development during nearest ten years.

Hence, maintain of following security criteria:

- N-1, G-1
- Maintaining voltage level in permissible range
- Maintaining frequency in permissible range

will be goal of Georgian transmission network and whole power system, the achievement of which requires strengthening the transmission network and adding new element to the grid.

## Main Network Bottlenecks of the Georgian transmission network and projects to eliminate them

Transmission network of Georgia has predominantly axial arrangement i.e. it is oriented from west to east. The main 500 kV substations are “Enguri”, “Jvari”, “Zestaponi”, “Akhaltsikhe”, “Ksani”, “Gardabani” and “Marneuli”. Transmission grid of Georgia may be theoriticaly divided into East and West districts, dividing bus bar of which is SS „Zestaponi”.

Power capacity of 500 kV OHL is about 5 times more than power capacity of 220 kV OHL, hence main part of power flows is implemented by 500 kV OHLs of Georgian Transmission network. Enguri HPP is connected to Zestaponi bus bar by 500 kV OHL Imereti. There is no paralel branch of this line in east part of Georgia and therefore, emergency outage of Imereti causes overload of 220 kV energy corridor Vardnili-Zugdidi-Menji-Kutaisi-Zestaponi. Hence, non-existance of 500 kV parallel connection of Imereti is the main bottleneck of West part and entire Georgian transmission network. Therefore, in order to meet N-1 criteria, system automatic should trip part of consumers in East Georgia and part of Generation in Enguri HPP in such manner that after fault in steady-state power flow on 220 kV OHLs in West part of Georgia will not exceed pertimatable ranges. In addition, emergency outage of 500 kV OHL Zekari (Zestaponi-Akhaltsikhe) may be the result of impossibility of power transit from Russia to Turkey in summer flooding period.

Despite 67 km 500 KV OHL line “Zekari” is backed up by OHLs “Qartli 2”, “Vardzia”, the sum of length of these two lines is near 325 km what makes impossible to backup OHL “Zekari” in case of bulk power flow on this line.

Supply of substation Batumi is carried out by long overhead lines – Paliastomi-1 (Menji-Batumi) and Paliastomi-2 (K-Batumi) 97 km and 94 km respectively. This lines represents the parallel branch of 220 kV energy corridor Vardnili-Zugdidi-Menji. Due to their legths there are voltage problems in 220 kV ss Batumi. This issue is actual in case of power export from Batumi to Khopa (Turkey). In addition, outage of either Paliastomi-1 or Paliastomi-2 may result overload of 220 kV OHLs Kolkhida-2a and Kolkhida-2 (this problem will be eliminated after commissioning of “Batumi-Akhatsikhe” project).

One of the most problematic element of East part of Georgian transmission grid is 220 kV OHL Kolkhida-3 which serves power transit from Vardnili HPP to Abkhazia (250 MW). This is due to non-existance of parallel line of Kolkhida-3. Hence, outage of this line results abundance in system which is equal to power flow on Kolkhida-3 in pre-fault mode.

500 kV OHL Kavkasioni which is main connector of Georgian and Russian power systems is weak point of Georgian system as well due to its legth (405.5 km) and difficult relief of highway (main ridge of Kavkasioni). Outage of above mentioned line has negative effect on stability of Georgian system and Power Quality (frequency control is mainly implemented by Russian system).

400 kV OHL Meskheti – connecting Georgia to Turkey. However legth of this line is not critically huge (less than 150 km), it will serve in 700 MW transit and its emergency outage will cause huge abundance of power in Georgian power system.

220 kV OHL Alaverdi (Gardabani-Alaverdi) connects Georgia to Armenia and is weak point by which is possible to implement only 150 MW power exchange between this countries in synchronous mode and 100 MW in Island mode.

Disbalance of Active as well as reactive power may be the result of outage of 500 kV lines in Georgian system and action of system automatic. Hence, fast-acting, regulated reactive power compensator SVS or FACTS Device may be required in both East and West part of Georgian power system.

Thus, weak and problematic points of Georgian transmission networks are:

- 500 kV OHL Imereti;
- 500 kV OHL Zekari;
- 500 kV OHL Kavkasioni; 400 kV OHL Meskheti; 220 kV OHL Alaverdi;
- Security of Supply of Ajara-Abkhazia districts;
- Security of Supply of Kakheti district;
- Reliability of network of Shida Kartli;
- 220 kV OHL Kolkhida 3;
- Enguri units;
- 9$^{th}$ thermal unit of Gardabani.

Several projects are considered in 10-year network development plan of Georgia which will resolve above mentioned problems, integrate new HPPs into the grid and reinforce transit ability of Georgian system.

Jvari-Tskaltubo-Akhaltsikhe Project (in parallel of integration of Enguri HPP, Namakhvani HPP and other HPPs) will resolve the most problematic issue in Georgian transmission network – complete backup of 500 kV OHL Imereti and Zekari, after outage of which system automatic will not trip consumers in Georgia.

Ksani-Stepantsminda-Mozdok Project, which is parallel line of 500 kV OHL Kavkasioni, will reserve it and reinforce stability of Georgian system. Outage of 500 kV OHL Kavkasioni will not result power abundance or deficit and therefore trip of consumers or generation by system automatic. This project will partly backup 500 kV OHL Imereti by North Kavkasian network.

400 kV OHL Akhaltsikhe-Tortum will fully backup 400 kV OHL Meskheti (Akhaltsikhe-Borchkha) and power disbalance will not arise after outage of 400 kV OHL Akhaltsikhe-Borchkha.

Marneuli-Airum Project (500 kV OHL Marneuli-Airum) will fully replace 220 kV OHL Alaverdi and ensure reinforcement of power transit ability among Russia-Georgia-Armenia-Iran.

These projects, besides of above mentioned goals may have some other designations, for example, integration of HPPs and increase of cross-border capacity (see chapter “Identified Projects and Investment Needs“).

Project “Akhaltsikhe – Batumi” will increase reliability of supply of “Adjara” region (besides integration of “Shuakhevi” and other HPPs of Upper Adjara region) and will help to backup 500 kV OHL “Imereti” with projects “Jvari – Khorga” and “Tskaltubo – Zestaponi”.

Power plants “Khudoni HPP”, “Nenskra HPP” and “Namakhvani Cascade HPPs” are increase on one hand flexibility of the system and on the other hand inertia constant and with this respect they increase the sustainability of the Energysystem. Therefore after commissioning of these HPPs, outage of Enguri units and N9 block will not be problematic.

To ensure reliability of Kakheti region power supply, construction of 110 kV route Akhmeta-Telavi-Gurjaani is planned (within 220 kV range), as well as addition of 220 kV wing to SS Telavi, reinforcement of SS Telavi with 220 kV wing and 125 MW autotrasformer, addition of new 220/110 kV 125 MW autotransformer at SS Gurjaani“. In addition, construction of 220 kV OHL from Telavi to Jinvali is planned, which will significantly improve level of reliable evacuation of the power from both power plants of Kakheti and Zhinvali HPP.

Reliability plan of Inner Kartli network is under elaboration.

The project of construction of second circuit of 330 kV OHL Gardabani-Agstafa serves for provision of 700-1000 MW power exchange capability between Georgia and Azerbaijan in compliance with N-1 criteria.

Below, in fig. 10 all the planned projects from TYNDP of Georgia are shown with dash lines.

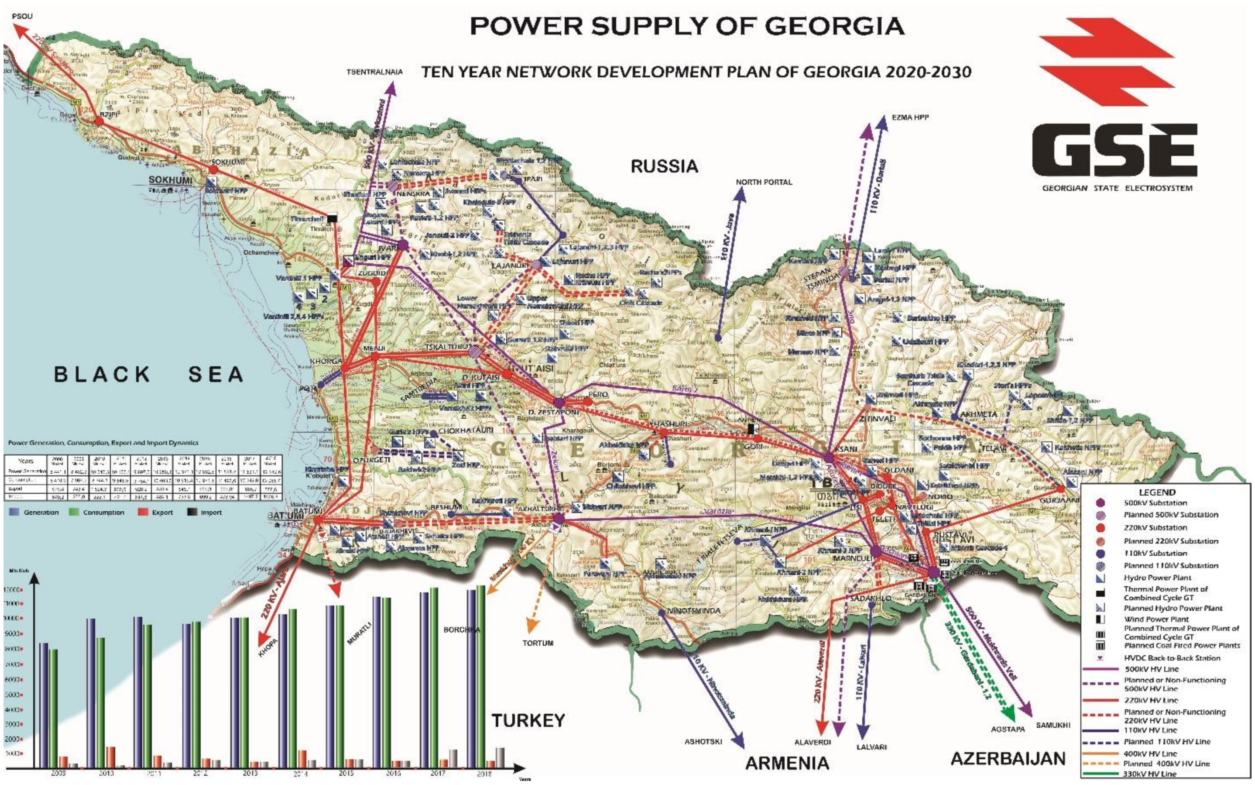


*Fig. 10 Development of Georgian electricity transmission network in 2020-2030 time span*

*Summarized data of existing HV overhead lines:*

Total length of 500 kV OHLs: 923 km

Total length of 400 kV OHLs: 32.6 km

Total length of 330 kV OHLs: 21.1 km

Total length of 220 kV OHLs: 1916 km

*Summarized data of existing HV substations:*

| | |
|---|---|
| 500/220 kV | 3 960 MVA |
| 220/110 kV | 5 984 MVA |
| 330/220 kV | 400 MVA |
| 500/400 kV | 875 MVA |
| **Total:** | **11 218 MVA** |

## Drivers of Georgian Transmission System Development

Development of the transmission network is influenced by various factors that are specific to individual electric power systems. For Georgia, these are: Network Security, connection of new power plants and consumers, usage of transit potential etc which are underpinned with Georgian legislation. Currently Georgian electric power system is in transition – transformation of transmission network developed for operation with big power system in order to create reliable transmission network ready for presence and future challenges; Replace of aged Soviet Union equipment with modern one of European standards.


- 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. 11 Illustrating map of development drivers of Georgian electric power system*

## Primary Development Drivers of Georgian Transmission Network

Georgian Legislation According to 1st clause of article 53 (Ten-Year Network Development Plan of Georgia) of Georgian Law on "Electricity and Water supply": Transmission system operator should, per annum, prepare/revise Ten-year Transmission Network of Georgia Development Plan based on the existing and forecasted indicators of supply and consumption. This ten-year plan should include effective measures for ensuring adequacy of transmission grid and security of supply.

*According to 1st clause of Article 33 of Georgian Network Rules:* The Dispatch Licensee is obliged to conduct necessary studies for transmission network planning periodically or upon necessity in order to provide economic, safe, reliable and stable operation of transmission grid.

So development drivers, given below, are implications of Georgian Legislation.

Improvment of security of supply/system reliability. According to Article 30, paragraph 2 of "Network Rules", *for estimation of network reliability two criteria : a)adequacy – ability of the system to uninteruptely meet the demand for electricity, in both plaaned outages and emergency cases. b) stability – ability of the system to withstand disturbances such as short circuit or unexpected outages of system elements.*

During power transfer from generation facilities to the loads, the loss of any single line may cause load shedding or even full blackout. From such lines the major one is 500 kV OHL Imereti connecting Enguri HPP to the load centres located east of Zestaponi, and at Akhaltsikhe substation providing power export to Turkey. The Emergency Control System (ECS) provides certain reliability level, however its activation causes short-term disconnection of the customers and, in addition, even ECS cannot provide 100% guarantee of network survival. Therefore, for ensuring required reliability level, it is necessary to design the system in conformity with single contingency (N-1) condition, such as when any single line is lost, other lines should be capable to undertake the load without disconnecting the customers, subject to maintaining power quality within prescribed limits.

Fulfillment of growing demand/creation of reliable supply centers to develop potential factories/ tourist centres. Goal of transmission network development is not only to ensure network stability at 500-400-330-220 kV level but also to supply consumers directly connected to transmission grid as well to distribution level in a reliable manner. Hence, construction of substations, reinforcement of existing ones and installation of additional transformers and autotransformers is planned in order to fulfill N-1 criteria. Besides this, consumption growth in Tbilisi region requires to increase of reactive power demand as well, which results in lower voltage levels. In order to avoid this issue, installation of reactive power compensation equipment is necessary.

Transmission of the existing generation. Under certain operating regimes, topology of the transmission system may limit transportation of the existing generation to the load centers. The major power supply source of Georgia is Enguri HPP, which during summer months covers more than a half of total country consumption, as well as participates in electricity export to Turkey. Despite construction of SS "Jvari", SS "Khorga" and double-circuit 220 kV OHL "Khorga-Menji", during summer excessive water period, the only 500 kV OHL "Imereti" from Enguri HPP into the Georgian network as well as 220 kV route "Enguri HPP – Vardnili HPP – Zugdidi – Menji" still restricts power transit from Russian Federation and from Enguri-Vardnili nod towards eastern Georgia, Turkey and Armenia.

Reclamation of the new energy resources. Georgia is rich in resources of renewable energy, utilization level of which is low, also, practically, there is no organic fuel resources in this country. Internal demand of Georgia as well as consumption of Turkey and its bordering European countries. HPPs provide increase of system stability (due to the regulation ability and provision of system inertia), but their construction is very time-consuming. Georgia also has potential of variable generation sources (wind and solar), which can be built in considerably shorter time compared to HPPs, but in case of their integration with high volumes, achieving of stability of power system becomes the challenge.

GSE, with help of European consultants, has defined the maximum levels of acceptable capacities of such sources according to regions.

Increasing network transit potential. Georgian transmission grid, due to its geographical location, can play role of transit hub among the its neighboring systems. Besides this, the more-developed cross-border infrastructure to all neighboring system results in the lower price for electricity import and the higher one for export. Therefore, for the purposes of realization of transit potential as well as of achieving of economic and energetic safety, construction of infrastructure with 1000±400 MW power exchange capability with all neighboring countries is planned.

Decommissioning of old thermal power plants and integration of new ones. There is replacement process of technically eldered and low efficient TPPs with new ones having high technical characteristics and/or working on cheap fuel, for integration of which there will obviously be necessary modernization of transmission infrastructure.

Improvement of power quality. Provision of sufficient operating reserves will allow to address the problem related with frequency that is one of the power quality parameters.

As regards to the second power quality parameter – voltage, it shall be regulated by automatic regulators installed on the generators and tap changers of transformers and autotransformers that are approximately in the similar state as the speed governors, i.e. their one part is inoperable and other damaged. Therefore, the following is necessary for dealing with voltage instability problems:

- Rehabilitation of the voltage regulators installed in the existing power plants;
- Obligation of all power plants to participate in voltage regulation;
- Periodic testing/checking of voltage regulators at each power plant;
- Installation/upgrading of automatic tap changers of power transformers and autotransformers installed in the substations.

Flexibility of the power system was significantly improved during recent years, mainly due to projects implemented in Georgian State Electrosystem, which are still ongoing, specifically:

- Installation of the generators' grouped regulation system in the national dispatch center and gradual (staged) integration of the regulated plants into the network;
- Improvement of Emergency Control System, which allows to maintain system stability during loss of any critical OHLs or autotransformers;
- Automation of the substations allowing their full remote control from dispatch center;
- Rehabilitation of OLTC (on-load tap changer) of transformers;
- Installation of regulating reactors;

Construction of energy storage batteries and pump storage hydro plants, which will solve problems regarding power reserves and/or exceed summer generation – on studying stage.

## 3.5. Distribution Network

Distribution network in Georgian power system includes 110 kV and lower voltage networks.

There are two distribution licensees:

1. JSC Telasi – owning distribution network supplying the biggest consumption center in Georgia - Tbilisi city, capital of Georgia;
2. JSC Energo-Pro Georgia – owning the rest part of distribution network in Georgia – cities, villages etc.

Like transmission system operator DSOs based on Georgian legislation and Network Rules are obligated to elaborate and revise basis development plans (five-year distribution network development plans) of their network on annual. Every year they submit the five-year plans to the transmission system operator. The TSO reviews and prepares/sends its remarks to the Commission, which, after taking into the consideration all the remarks and making necessary corrections by respective DSOs, approves five-year plans.

Overview of activities of DSOs and information on their planned projects are presented in the next two sub-chapters.

### 3.5.1 JSC Energo-Pro Georgia

The main mission of joint stock company Energo-Pro Georgia is the procurement and distribution of the electricity in order to ensure supply of the consumers in safe, reliable and quality manner. In Georgia, 15 Hydro Power Plants and 1 Gas Turbine are under the ownership of Energo-Pro Georgia. Energo-Pro Georgia is a largest distribution company in Georgia with service area of 58 846 km$^2$ (around 85% of the Georgian territory) and serving more than 1 200 000 customers. Meantime, having up to 5680 employees, company is one of the largest employer in Georgia.

Distribution network and infrastructure

1. High voltage grid, 35/110 kV– improvement of infrastructure of electricity supply

   - Company distributes electricity at high voltage using 370-unit of 110/35 kV lines, including 4260 km overhead lines and 35 km cables. 190 units out of the above mentioned 370 (51%) was constructed during 1970s' so their nameplate parameters are significantly decreased. Company is implementing the process of their rehabilitation according to their importance and priority.

   - Up to 70 high voltage overhead lines have been given under the ownership to the company. These are theft lines with total length of 1000 km. Major part of them were ensuring backup supply for respective regions, hence, performance of particular emergency and current rehabilitation in respective areas results in outage of that regions. Therefore, company plans to restore part of such lines in operation during next five years.

- Energo-Pro Georgia performs the transformation of electricity received from transmission network to 0.4/6/10 kV voltage level by use of 352-unit of 110/35 kV substations, main part of which, at time of procurement, were having single transformer. In direction of their reinforcement, important projects have been realized in previous period which will be continued in next five years.

2. Medium and low voltage grid, 0.4/3.3/6/10 kV - improvement of infrastructure of electricity supply

   Besides 110/35 kV grid, company owns also 10/6 kV (with total length of 14 803 km) and 0.4 kV (with total length of 37 090 km) network, through which approximately 85% of total electricity consumed by the company is distributed. Hence, normal operation of existing grid plays a key role in reliable supply of the consumers. Usually, this infrastructure has radial topology and hence, except of 6/10 kV cable grid of some big cities, is not backed up. As a result, reliability of such network is lower compared to high voltage grid. Additionally, due to their length and location, restoration after emergency outages is long-term process, which leads to interruption of supply for particular consumers. Working on further development of medium and low voltage network is not possible without resolving of mentioned problem.

**General approach to improvement of service reliability**

Improvement of quality of network service and supply reliability indicators is traditionally planned by decrement of outage numbers and duration.

- The following works associated to security are planned at the first stage: replacement and reinforcement of insulation, replacement of aged towers by the new ones, deforestation in security zones of overhead lines, measures of protection of dimensions of the lines, modification of routes on emergency sections, installation of insulating spacers etc.
- Second phase will include activation of auto-recloser automatic on 6/10 kV overhead lines having vacuum circuit breakers.

**Investments for network reinforcement by years and structure**

In order to increase the reliability of security of supply and quality of supplied electricity, the following investments (table 14) are taken into account for next five years, considering rehabilitation-reconstruction of existing grid as well as construction of new infrastructure.

Table 14. Investments for network development projects

| | Total investments by years, mln GEL | | | | | |
|---|---|---|---|---|---|---|
| | 2021 | 2022 | 2023 | 2024 | 2024 | Sum |
| 110/35 kV | 20.4 | 35.3 | 40.4 | 43.2 | 44.6 | 183. 9 |
| 10/6/0.4 kV | 29.7 | 35.2 | 35. 3 | 36.4 | 37.4 | 174.0 |
| SCADA | 0. 8 | 1. 1 | 1. 3 | 1. 1 | 1 | 5. 3 |

| | Total investments by years, mln GEL | | | | | |
|---|---|---|---|---|---|---|
| | 2021 | 2022 | 2023 | 2024 | 2024 | Sum |
| Deforestation | 1. 6 | 1. 6 | 1. 6 | 1. 6 | 1. 6 | 8 |
| Ecology | 1. 3 | 1. 3 | 2. 3 | 5. 6 | 7. 6 | 18. 1 |
| Preparation of digital maps | 1. 2 | 0. 5 | 0. 5 | 0. 5 | 0. 3 | 3 |
| Arrangement of metering points on 1 kV and higher voltage | 1 | - | - | - | - | 1 |
| Totals | **56.0** | **75.0** | **81.4** | **88.4** | **92.5** | **393.3** |

Completion of projects of 10/6/0.4 kV voltage has vital importance for the reliability/stability and effective operation of respective network. Uninterrupted and gradual process of rehabilitation of medium and low voltage grid will give the possibility to increase satisfaction index of costumers and to maintain decrement trend of SAIDI/SAIFI indicators in upcoming years (figures 12 and 13).

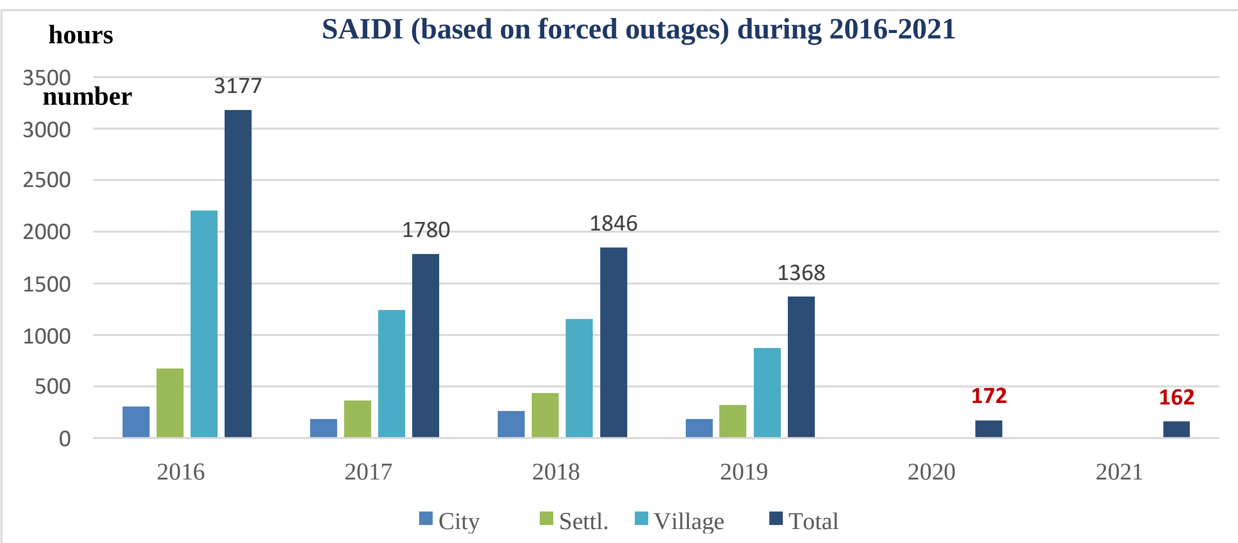


*Figure 12. SAIDI indicator in 2016-2021 years*

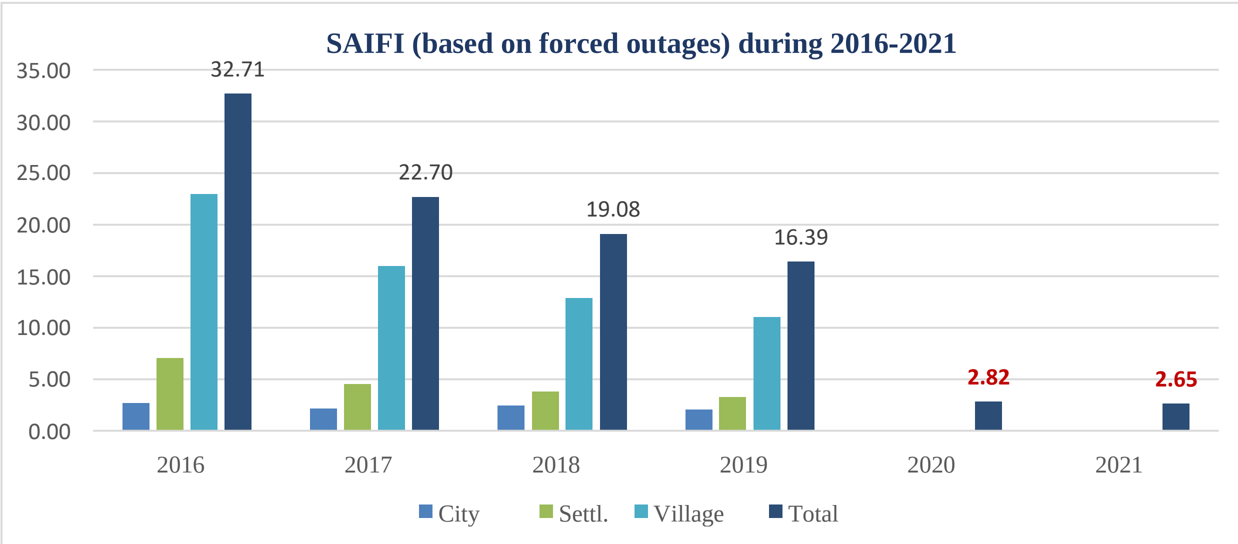


*Figure 13. SAIFI indicator in 2016-2021 years*

Note: SAIDI/SAIFI projections for 2020-2021 include 110/35 kV network of the company

### 3.5.2 JSC Telasi

JSC Telasi is the organization with the largest electricity network and electricity sale. The company procures electricity (capacity) from commercial operator of electricity power system and different producers (HPPs, TPPs etc.) of electricity on wholesale market in order to serve the consumers of Tbilisi city and its adjacent villages. The main types of activities include:

- Procurement and distribution (sell) of electricity;
- Service and maintenance of electricity distribution network;
- Service of electricity transit;
- Technical service of both domestic and non-domestic customers;
- Administration of unified integrated and coordinated system of electricity supply, water supply and cleaning service of Tbilisi city.

Number of customers of JSC Telasi by May 1, 2020 was 620 513, including 571 642 households and 48 871 non-households.

Indicator of electricity purchase and realization for 2019 was as follows: purchase – 2 902 984 535 kWh, transmission to network – 2 746 892 395 kWh.

Mission of the company – reliable, uninterrupted and quality electricity supply of the customers of Tbilisi city. Activity of JSC Telasi is directed to increase of investment attractiveness, to refine control systems, to introduce high-efficiency modern technologies, to develop service of the customers and to improve quality of the service.

**Research-planning of the transmission network**

Research with aim of planning transmission network includes the following tasks:

- Study of power flow in the network;
- Investigation of defined scenarios;
- Study of bus bar voltages;
- Studies regarding reliable operation of the network;
- Investigation of possible options of connections of new capacities to the network, according to the project of city development plan.

**Planned projects**

The Five-years plan of the company includes projects of the following direction, ensuring mitigation of existing problems, decrease in electricity losses, increase in power quality and further development in distribution network of Tbilisi city:

1. **Analysis of technical condition of equipment in 110/35 kV substations**. After analysis of defective acts, measurement and test results, assessment of the condition of equipment of each substation and their influence on reliability of electricity supply of respective consumers have been carried out, based on which the projects of reconstruction and modernization of distribution equipment in 110/35 kV substations have been planned. Total investments of 25 mln GEL (approximately 6.25 mln euros) are considered for their realization in 2021-2025 time span.
2. **Feathing of neutral through resistor**. In order to increase selectivity of overvoltage protection and relay protection of electrical equipment in case of phase-to-ground faults (after having positive results of such project in several substation), the long-term plan of earthing of neutral through resistor is being implemented, which ensures to trip only respective circuit breaker of faulted location in case of fault of cable network or other equipment, as a result of which short circuit current does not have impact on other equipment. Mentioned approach decreases overvoltage level, improves selectivity of protections and reliability of security of supply in case of single-phase short circuits in the network.
3. **Assessment of condition of the 10/6 kV equipment in central distribution points, distribution points and transformer substations.** Based on the acts of defect detection, tests and measurement, analysis of mentioned equipment in central distribution points, distribution points and transformer substations with a goal of detection of existing constraints has been performed. In order to mitigate such flaws, implementation of the projects of reconstruction and modernization central distribution points at transformer substations and modernization of distribution points are planned for 2021-2025 period.
4. **Analysis of electricity consumption and losses.** Consumption in distribution network of JSC Telasi goes to increase and actual losses goes to decrease annually, which is presented also in table below.

*Table 15. Statistic of electricity consumption and losses in network of Telasi*

| Parameter | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|
| Electricity injection into the network (mln kWh) | 2 022,80 | 2 062,87 | 2 251,58 | 2 419,35 | 2 788,71 | 2 934,76 | 2 970,29 | 3 107,9 |
| Useful electricity injection (mln kWh) | 1 819,28 | 1 907,42 | 2 114,50 | 2 273,48 | 2 629,30 | 2 773,43 | 2 818,94 | 2 952,2 |
| Calculated electricity losses (mln kWh) | 203,52 | 155,46 | 137,08 | 145,88 | 159,41 | 161,327 | 151,355 | 155,7 |
| Calculated electricity losses (%) | 10,06 | 7,54 | 6,09 | 6,03 | 5,72 | 5,50 | 5,10 | 5,01 |

Electricity losses presented above does not include electricity transit.

Forecasted electricity consumption and losses in network of Telasi for 2021-2025 are given in epy table below:

*Table 16. Forecast of electricity consumption and losses in network of Telasi for 2021-2025*

| Year | Forecasted total electricity consumption (without transit), kWh | Forecasted total electricity losses (without transit), kWh |
|---|---|---|
| 2021 | 2,813,000,000 | 180,032,000 |
| 2022 | 2,869,000,000 | 183,616,000 |
| 2023 | 2,927,000,000 | 187,328,000 |
| 2024 | 2,985,500,000 | 191,072,000 |
| 2025 | 3,045,500,000 | 194,912,000 |

5. **Modernization and renovation of the 10/6/0.4 kV transformer park.** This project foresees modernization and renovation of 10/6/0.4 kV transformer park, in particular:

- Replacement of old, resource-depleted power transformers by the new ones;
- Renovation of Transformer Park.

Mentioned project will ensure uninterrupted supply of consumers, increase reliability of operation of electrical equipment, improve ecological, fire and labor safety, and decrease technical losses.

6. **Introduction of energy-efficient transformers in the network of Telasi.** Measures taken by the company consider the usage of modern electrical equipment with the characteristics meeting the requirements of European standards and giving the possibility for further decrement of the losses.

In framework of mentioned project of modernization and renovation of 10/6/0.4 kV transformer park, gradual transition to the usage of energy-efficient transformers in 2021-2025 time span is planned. 77 unit of such equipment at 10/6 kV voltage level has been purchased with 2020 budget, which, according to the action pan, will replace dismantled power transformers or will be used for provision of the supply of customers associated with the new connections.

In addition, comparative analysis between energy-efficient and standard transformers have been done in case of full replacement with energy-efficient ones. As a result, the expected economic benefit is as follows:

- Annual economy expressed in energy – 20 520 000 kWh;
- Annual economy expressed in GEL – 2 379 294 (near 594 823 euros).

7. **Assessment of technical conditions and loading of 110/35 kV overhead lines.** Based on the acts of surveys and inspections and the defects detected on the first stage, total investment needs for the projects of reconstruction of the lines for 2021-2023 in equal to 3 mln GEL (0.75 mln euros) as estimate.

## 8. Analysis of incidents and emergency outages and measures

### 8.1 Analysis of reliable supply of the customers

Activities of JSC "Telasi" related to improvement of reliability of consumers supply is based on the following general indicators of security of supply:

- SAIDI – indicator of average duration of internal planned and forced outages expressed in time (minutes, hours) and assessed per one consumer;
- SAIFI – frequency of internal planned and forced outages expressed in numbers and assessed per one consumer.

Statistic of mentioned indicators based on planned internal and forced outages in 2017-2019 and their forecast for 2020-2025 are presented below in table 17:

*Table 17. Forecast and projection of SAIDI and SAIFI*

| | Actual | | | Forecast | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
| **SAIDI (hours)** | 11.7 | 9.9 | 9.85 | 9.84 | 9.8 | 9.5 | 8.6 | 7.1 | 5.5 |
| **SAIFI (numbers)** | 7.36 | 5.11 | 5.9 | 5.4 | 5.2 | 4.9 | 4.6 | 4.2 | 3.9 |

The goal of the company is to improve mentioned statistic, in particular, results for each following year, or at least to maintain last years' values which can be assumed as a target indicators of the company.

9. **Analysis of emergency outages (incidents) and planned projects for their minimization.** Detailed analysis of outages caused by faults of electrical equipment in the network of company during 2018-

2019 has been carried out, based on the results of which fault of cables is reason of almost 93% of outages in 2018 and 91% of outages in 2019. In order to mitigate mentioned problem, project of reconstruction and construction of 10/6 kV cables and overhead lines envisage total investment up to 10 mln GEL (2.5 mln euros) for 2021-2023.

10. **Analysis of increase of the capacity connected to the distribution network and definition of new capacities**

- **Analysis of project of development plan for Tbilisi city in order to assess new consumption centers and expected capacities**

Based on the basic analysis of project of development plan for Tbilisi prepared by Tbilisi city hall it was defined that there is not clear consideration of new capacities and perspective of their gradual coming in operation, what, in point of view of network development, does not give the possibility to consider or clearly define the activities to be performed in order to provide energy supply to new consumption centers. However, there are particular zones where possible increase of capacity can be estimated, for example, parks, adjacent territory of Gldani and Lisi lakes and for provision of their electricity supply company plans respective development projects.

- **Analysis of connection of new capacities to the distribution network of JSC "Telasi"**

Number of applications of both existing and new consumers, and therefore, required capacity to be connected to the network goes to increase annually. Readiness of distribution network is necessary in order to ensure their connection to the distribution network. For provision of above-mentioned task, analysis of expected new capacities to be connected to the network of company has been carried out, based on which annual expected average new capacity at 0.4 kV level is equal to 190 MW, at 6 kV and above – near 70 MW.

**11. Assessment of technical conditions and loading of 110/35 kV substations.** In process of forecasting of expected loadings of the substations, information on projected demand has been taken into consideration, expected loading of substations have been analyzed based on received letters and applications. Requirement on clause 8 of article 87 from "Network code" has been taken into account as well, stating that fault of one power network element (transformer, circuit breaker etc.) at 35/110 kV distribution substation with two transformer should not result in restriction of more than 30% of its load.

In frame of the project of optimization/major maintenance and procurement of power transformers in 110/35 kV substations, 6 mln GEL (1.5 mln euros) investment is considered in 2021-2024 time span.

**12. Total panned investment needs for network development in 2021-2025.** Planned investment projects for network rehabilitation and reconstruction for 2021-2025 is presented in table below.

*Table 18. Total investments for the projects planned for 2021-2025*

| Project | Investments, thousand GEL | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | Sum |
| Reconstruction and modernization of distribution equipment at 110/35 kV substations | 6 213 | 11 012 | 11 462 | 7 884 | 6 232 | 42 763 |
| Reconstruction and modernization of distribution equipment at 10/6 kV substations | 2 822 | 1 785 | 2 049 | 2 100 | 2 100 | 10 856 |
| Reconstruction and modernization of 110/35 kV overhead lines/cables | 100 | 0 | 3 057 | 1 500 | 2 500 | 7 157 |
| Reconstruction of 10/0.4 kV cables | 3 103 | 3 498 | 2 854 | 3 200 | 3 200 | 15 855 |
| **Total** | **12 238** | **16 295** | **19 422** | **14 684** | **14 032** | **76 671** |

13. **Analyzers of power quality.** Meeting requirements of “Network Code” approved by the Commission (resolution №10, 17.04.2014), in particular, provision of quality and reliable electricity supply for customers of distribution network presents one of the general and reliable supply of electricity to the customers of distribution network is one of the general obligations of the distribution company. For this purpose, JSC Telasi implements monitoring of its network using different devices installed both 110/35 kV and 10/6/0.4 kV grid. At present, the above mentioned process is going based on the information received from metering systems installed at 110/35/10/6 kV level. That gives the possibility to receive information on reactive power, voltage characteristics, load symmetry, harmonic distortion of the voltage (in limited capabilities) and other parameters at connection points for any time section.

    As for 0.4 kV network, at present, automated microprocessor system of substation monitoring (ASDM-2.0.10) is installed at 450 object and connected to mini-SCADA network, from which reception of the information on voltage and current characteristics is done. Almost all object of the company is integrated into network of automatic electricity metering control system, making possible to get information on voltage and current characteristics and actual time of electricity interruptions.

    In addition, in first quarter of 2020, JSC Telasi is going to purchase modern electricity quality analyzer device – G4500 class, which is designed to meter, register and assess electricity according to the requirements of 13109-97 state standard and IEC 61000-4-30, IEC 61000-4-15 and EN 50160 European standard and its usage gives opportunity to conduct comprehensive metering of defined electricity parameters in distribution network in both steady-state and transient processes. This process with support accurate detection of existing flaws in the network and adequate planning of respective measures.

## 3.6. Electricity Demand and maximum load

Total energy balance of Georgian electricity system for 2019 is shown in table below:

*Table 19. Summary parameters of Georgian power system for 2019*

| | |
|---|---|
| Peak Load (MW) | 2 051 |
| Hydro Generation - Seasonal HPPs (mln kWh) | 3 970 |
| Hydro Generation - Regulated HPPs (mln kWh) | 4 969 |
| Thermal Generation (mln kWh) | 2 840 |
| Wind Generation (mln kWh) | 84 |
| Export (mln kWh) | 243 |
| Import (mln kWh) | 1 627 |
| Total Consumption (mln kWh) | 13 248 |
| Total Generation (mln kWh) | 11 865 |

The total annual power output of seasonal power plants amounted to 3970 mln kWh, i.e. 11 mln kWh in average daily. The peak demand was experienced on 31 December 2019. During the whole year, the frequency was maximally closed to the standard value (50 Hz) fluctuating in the range of 50.00-50.01 Hz.

Level of technical losses was near 1.5% as well as outage statistic was the same as in previous years.

Below table 20 includes ten years statistic of consumption and summer and winter peak loads of Georgian power system.

*Table 20 Statistics of Electricity Power system consumption, summer and winter peak loads*

| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Y-11 | Y-10 | Y-9 | Y-8 | Y-7 | Y-6 | Y-5 | Y-4 | Y-3 | Y-2 | Y-1 | Y |
| $L_{SUM}$ | 1075 | 1167 | 1106 | 1200 | 1347 | 1374 | 1422 | 1540 | 1574 | 1633 | 1819 | 1935 |
| $L_{WIN}$ | 1712 | 1651 | 1538 | 1620 | 1682 | 1681 | 1811 | 1851 | 1869 | 2058 | 2043 | 2123 |
| $E$ | 8146 | 8411 | 7908 | 8746 | 9647 | 10194 | 10093 | 10619 | 10872 | 11494 | 12379 | 13069 |

Based on this statistic, dependence between the growths of peak load and consumption has been defined and used for forecast for next ten years.

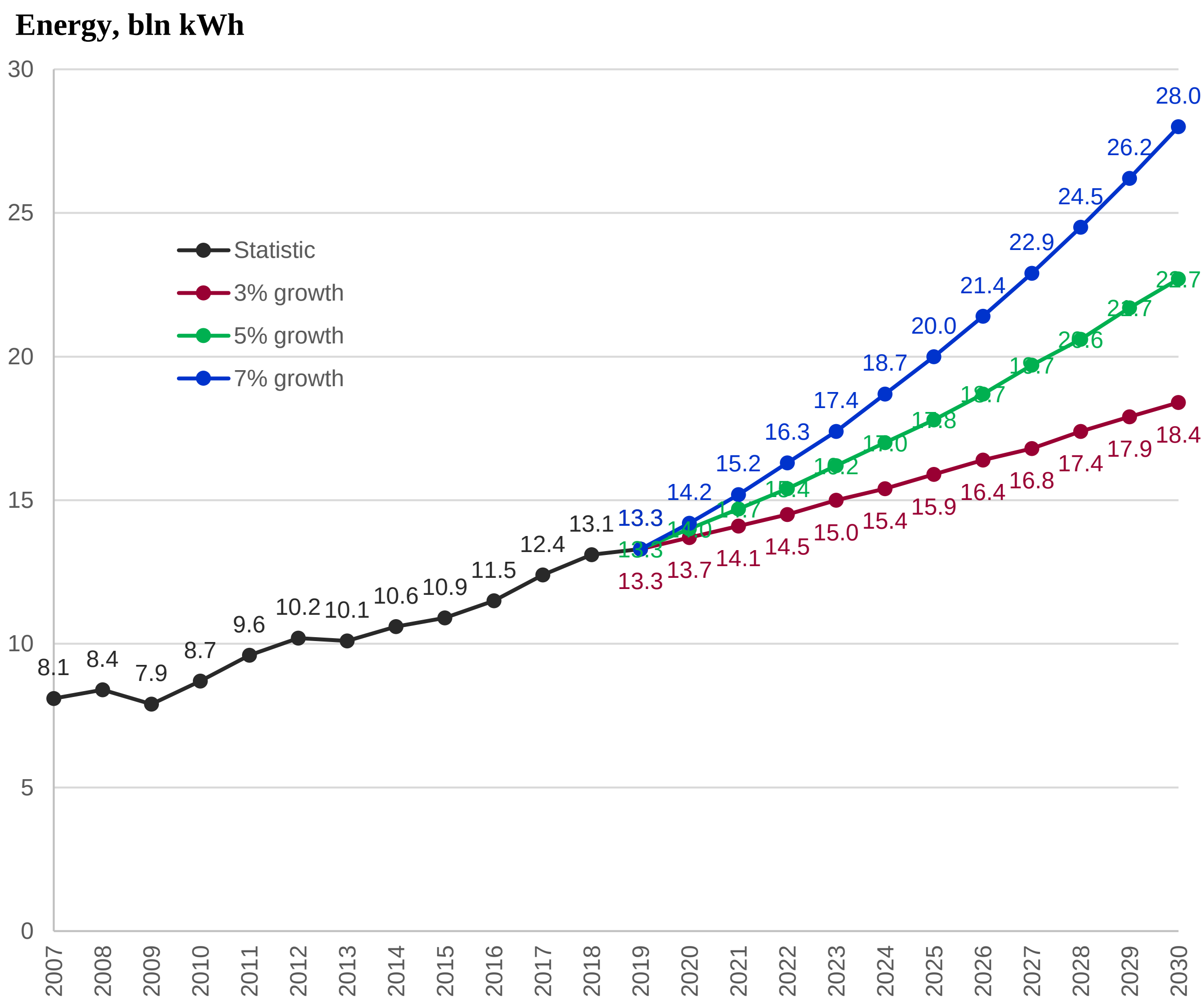


*Fig. 14 Statistic and forecast of consumption*

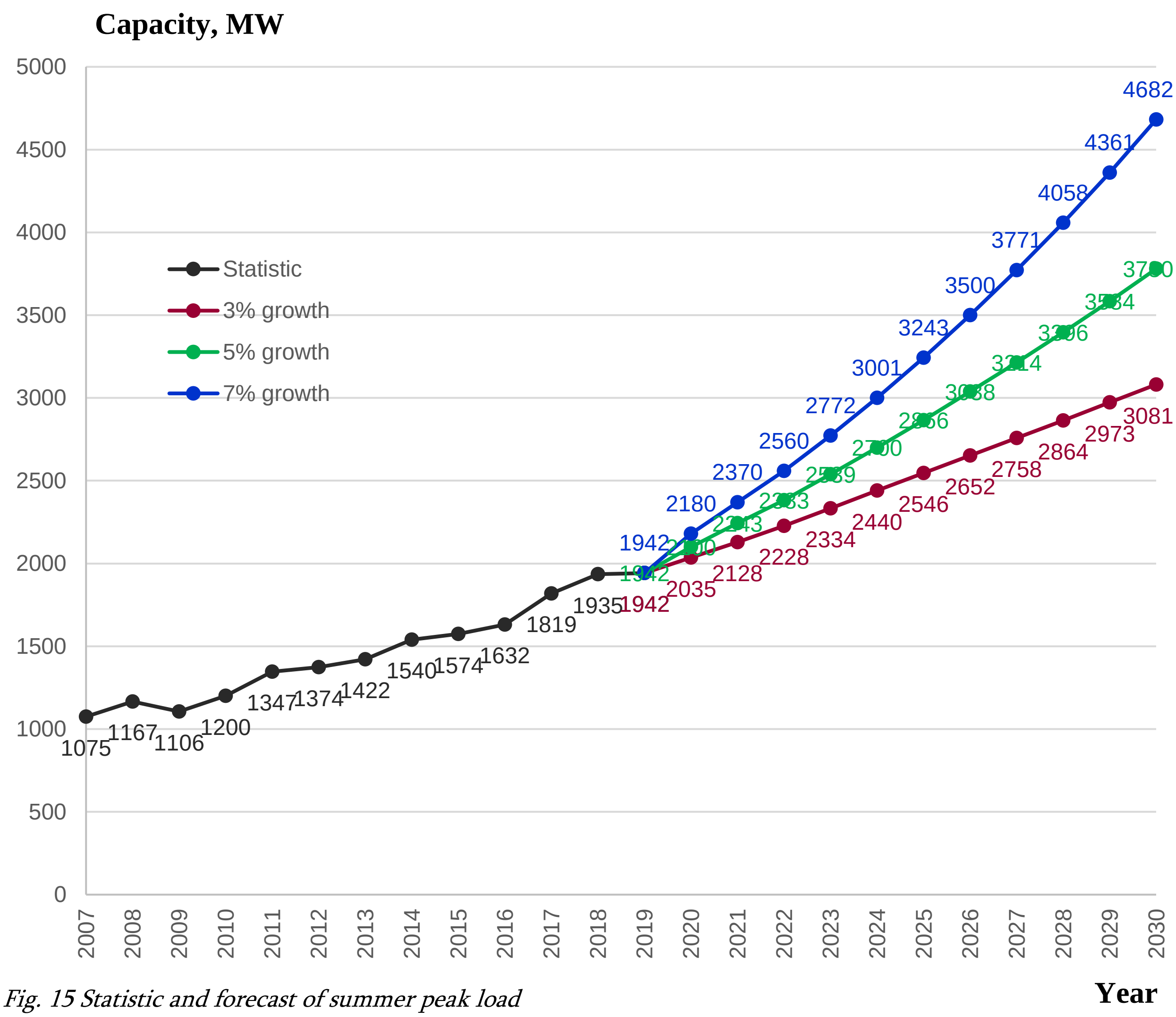


*Fig. 15 Statistic and forecast of summer peak load*

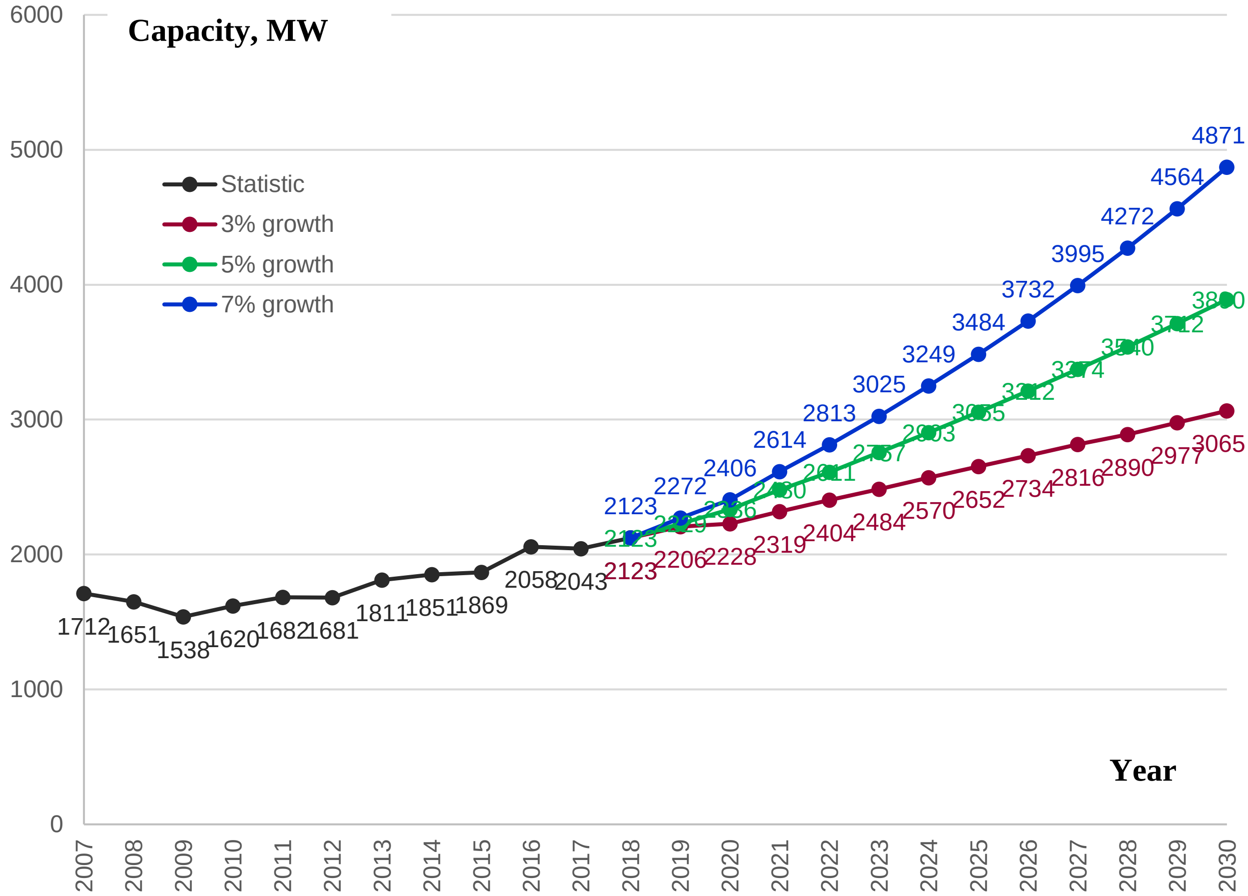


*Fig. 16 Statistic and forecast of winter peak load*

Sharp increment of electricity consumption and peak demand. Both total system consumption and summer peak load has been sharply increased during last two years. The most severe situation regarding decrement of voltage levels takes place in East part of Georgian power system, where energy is transported from West part of the system. Installation of reactive power compensation equipment and increment of (auto) transformer capacities are planned in order to resolve mentioned problem.

Electro mobiles – Possible drastic increase of peak load; "prosumers" – system decentralization and nonpredictability and customers with variable demand. *Solution/mitigation*: construction of Hydro Power Plants (HPPs) with reservoir, enhance energy efficiency, introduce power storage stations and batteries, construct thermal plants and inter-system power transmission infrastructure. Complete control and operation system, introduce "smart networks", introduce dynamic patency 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 modelling devices.

## 3.7. Balancing of Production and Demand in past years

Power exchange among power system regions are realized by excess generation in one of the district in order to supply excess consumption in other district. This exchange and power transmission is implemented by Georgian transmission network in such manner which ensures possible optimal proportion between economy and system stability which is better when higher number of generators are in service (especially in energy-deficit region); This means that if generation and consumption are balanced in one of the region then there is no need to export/import power to/from another region and as a result interregional OHLs are less loaded (stressed). On the other hand, high number of generators in operation results decrease of economy, use of generation of Thermal Power Plants is especially economically unjustified if there is a possibility to use energy of HPPs.

West part of Georgia is characterized with excess generation, in east part of Georgia the main consumption centers are located. The same picture will be maintained in next years, high number of Hydro Power Plants are considered in west part of Georgia, demand in east Georgia will continuously grow, especially if we consider that cross-border lines of Georgia and Turkey, Russia as well as Armenia will also practically increase consumption of east Georgia. Significant reinforcement of west part of Georgian transmission infrastructure will be partly difficult in 2020-2030 due to the difficult relief and harsh environmental conditions in north-west Georgia (Upper and lower Svaneti, upper and lower Racha). Hence, additional power evacuation from these districts besides of Power plants considered Ten year development plan will not be justified by system stability and economy point of view. Commissioning of new generation without transmission network reinforcement is justified in 500 kV nodes which are located in ss Zestaponi and its right side, in powerful consumption centers of both east and west part of Georgia (Khorga, Vardnili, Kutaisi, Tskaltubo, Zestaponi, Batumi, Gldani, Navtlugi, Lisi, Didube, Rustavi, Gardabani). Reserve of power integration after commissioning of power plants represented in table is almost exhausted in substations of upper and lower Svaneti, Racha-Lechkhumi and Shida Qartli. The results are logical: Mobilization of human and technical resources near the consumption center is simple task, transport, energy, water and communication infrastructure are available. In addition, if new generation capacity is connected to east part of Georgian transmission network, this will more or less result balance between generation and consumption and therefore less loading of transmission grid during power flow between east and west regions. On the other hand, if we look at opportunities of consumption growth, this value is the highest for "North Ring-Tskaltubo" project region where there is the fewest possibility of generation growth.

Opposite situation is for increase of consumption, growth of consumers is reasonable in regions rich with generation (especially, Enguri-Jvari-Khudoni-Upper Svaneti and Racha-Lechkhumi-Lower Svaneti) and there is less reserve in power consumption centers (Tbilisi substations).

Based on the fact that currently as well as in future share of Hydro generation is about 76% of total installed capacity of Georgian electricity system, there is a capacity excess during flood period, when consumption is not at its peak level and hence, Georgia implements energy export into neighboring countries. Opposite situation takes place from second part of July-August, when there is not enough water to operate Hydro power plants at their maximum output, in parallel of this, consumption is vastly increased and this leads to the reality when Georgian system starts importing energy from neighboring power systems. Furtherly, during autumn-winter thermal power plants (share is about 21% in total installed capacity of system generation) also come in operation, however, further decrement in hydro generation is the reason of energy import from neighboring states.

Statistic of Electricity production and demand in past years is shown in *table 2 - Electricity Generation and consumption in past*.

### 3.8. Forecast of Demand and Generation for the period of 2020-2030

According to clause 2 of article 53 (Network Development Plan of Georgia) of the Energy Law:
*2) Georgian Ten Year Network Development Plan should contain:*
*a) Information about existing and future (predicted) supply and demand;*
*b) Information on forecasted internal electricity generation and cross-border flows*
*...*
*f) Information on integration of new generation objects (including RES) into the network.*

According to the Network Rules, article 39, paragraph 6:

*transmission network development plan, along with other information should include information about the operational characteristics of the transmission network, which includes:*

*...*

*g) transmission network development, which is based on forecast of consumption growth;*

*h) transmission network development, which is based on plans of construction of new power plants.*

*i) offers about construction of new interconnection lines and substatntions.*

*j) planned interflows with neighbouring countries.*

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.
2. Approximate prices of new transmission elements.
3. Agreements about construction of trans-boundary infrastructure, between Georgia and neighboring countries and Development of surrounding grid.
4. Special requirements for generators and dc links.
5. Assignments about changes to be made in TYNDP, coming from Ministry of Economy and Sustainable Development of Georgia /Government.

Actual data on prospective generation objects and consumption growth forecast is sent by Ministry of Economy and Sustainable Development to GSE by official letter on annual basis.

Information on consumption forecast has been defined based on the development plans of distribution licenses.

*Table 21. Growth of consumption of country*

| Scenario | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Pessimistic* | 3% | 3% | 3% | 3% | 3% | 3% | 3% | 3% | 3% | 3% | 3% | 3% |
| *Normal* | 5% | 5% | 5% | 5% | 5% | 5% | 5% | 5% | 5% | 5% | 5% | 5% |
| *Optimistic* | 7% | 7% | 7% | 7% | 7% | 7% | 7% | 7% | 7% | 7% | 7% | 7% |

*Table 22. Energy consumption, bln. kwh (gross domestic consumption)*

| Scenario | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Pessimistic* | 13.11 | 13.5 | 13.91 | 14.33 | 14.76 | 15.2 | 15.66 | 16.13 | 16.61 | 17.1 | 17.61 | 18.14 |
| *Normal* | 13.65 | 14.33 | 15.05 | 15.8 | 16.6 | 17.43 | 18.3 | 19.22 | 20.18 | 21.2 | 22.26 | 23.37 |
| *Optimistic* | 14.12 | 15.11 | 16.17 | 17.3 | 18.51 | 19.81 | 21.2 | 22.68 | 24.27 | 26 | 27.82 | 29.77 |

Forecast of generation development by types is presented in *table 4. Forecasted installed capacities by generation type (MW).*

Data on prospective power plants (Hydro, Thermal, Wind and Solar) are shown in tables 5, 6 and 7.

In framework of TYNDP, 9 scenarios of development of generation and consumption growth are being analyzed by GSE, which are presented in *table 8. Scenarios of transmission grid development of Georgia.*

Based on the data on generation and demand growth, annual energy balance of Georgian electricity power system for base development scenario – G3L2 has been prepared (fig. 17).

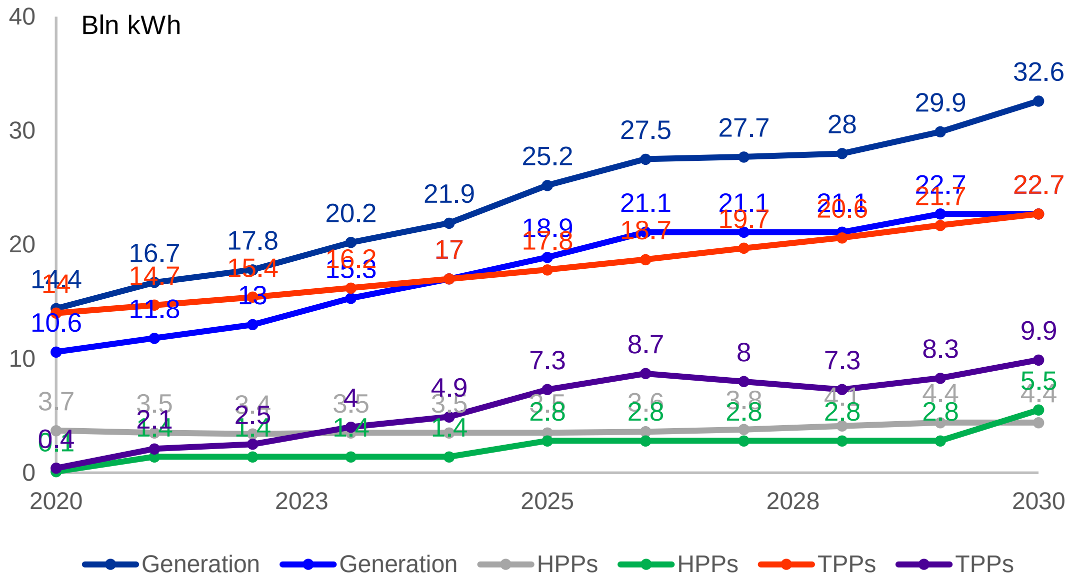


*Fig. 17 Generation, consumption and energy export of Georgian electricity system for G3L2 scenario*

The relation between hydro power generation and consumption growth shows that:

1. In case of timely commissioning of HPPs (optimistic scenario), for any scenario of consumption growth, Georgia's power supply system will not be depended on imported power or fuel required for its generation, after 2020-2022. Moreover, in cease of slow or moderate consumption growth scenario, electricity export might amount to 6-11 billion kWh per annum.
2. In case of moderate and pessimistic scenarios of generation expansion, while having moderate or high rate of consumption growth, dependence on electricity and/or fuel import will be significantly increase in Georgia – deficit can achieve 6-14 bln kWh/year.

## 4. Conclusions

The approximation of Georgian legislature to existing EU framework has opened up many opportunities for the expansion of the sector. Given that there is a steady increase in electricity consumption every year, it is clear that renewable energy, mainly wind and solar, will play an important role in changing the situation.

According to the current optimistic forecasts, in case of timely commissioning of all planned projects included in the ten-year plan, the generation of the country's electricity system should experience a significant increase, namely 2 times or more - from 4246 MW in 2019 to 9740 MW for 2030. This can be achieved based on the following:

- The Generation from HPPs (both regulating and seasonal) should be increased by 3235 MW (3301 to 6536 MW);
- The Generation from thermal PPs is expected to rise till 2024 but slightly decrease and largely remain stagnant from 2025 to 2030 (1355 MW);
- The Generation form Wind PPs will increase from 21 MW (Kartli-1 PP) to 1330 MW in 2030;
- The Generation from Solar PPs is non-existent at the present but is projected to increase to 520 MW in 2030.

Based on the statistics of the past years development of generation projects, it can be said that there are significant risks in terms of delays in the above-mentioned renewable energy generation projects. If all power plants are put into operation in time, Georgia can avoid dependence on imported electricity and fuel needed for its generation. However, if this condition is not met, dependence on both of the above types of imports may increase significantly.

As of today, security of supply remains one of the main problems of the Georgian transmission network. Therefore, increasing network reliability will still be one of the top priorities for the next 10 years. The following elements are the weak and problematic points of the Georgian transmission network:

- 500 kV OHL Imereti;
- 500 kV OHL Zekari;
- 500 kV OHL Kavkasioni; 400 kV OHL Meskheti; 220 kV OHL Alaverdi;
- Security of Supply of Adjara-Abkhazia districts;
- Security of Supply of Kakheti district;
- Reliability of network of Shida Kartli;
- 220 kV OHL Kolkhida 3;
- Enguri units;
- $9^{th}$ thermal unit of Gardabani.

From the list above the 500 kV OHL Imereti remains as one of the most problematic, mainly due to the absence of a parallel branch in eastern Georgia. 220 kV OHL Kolkhida-3 which serves power transit from Vardnili HPP to Abkhazia (250 MW), is one of the most problematic for eastern parts of the transmission grid. A number of projects are in consideration that in turn will allow to remedy problems in the transmission network, as well as integrate new PPs into the system and strengthen Georgia's transit capability.