# IN ORDER TO INCREASE THE STABILITY OF THE ELECTRIC POWER SYSTEM, INSTALLATION OF ENERGY STORAGE NEAR 500 KV SUBSTATIONS AND JUSTIFICATION OF ITS NEED

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**Annotation.** ***The results of the conducted investigations are obtained based on the day-to-day observations of the country's electric energy regimes, on the basis of which the need for Energy storage is substantiated, which is why the real regime images of the energy system are presented, measures necessary for continuous balancing of the country's consumption and supply and mode aspects of parallel operation with neighboring energy systems are also outlined.***

**Key words:** ***energy storage, Hydroelectric power station (Hpps), voltage, electric power system, installation of energy***

**Most of the hydro generation of Georgia's energy system is located in Western Georgia, while a relatively larger share of consumption comes from Eastern Georgia (especially the Tbilisi - Rustavi junction), today's energy security largely depends on it, meaning the only 500 kV power transmission line that connects the main source of hydro generation with the eastern part of Georgia. The 500 kV power transmission lines coming from Zestafoni to the east are insured, which is why electricity transportation from Zestafoni to the east is safer and more reliable.**

**During the period of water abundance, approximately from May to August, when thermal plants are stopped or some are under repair, the energy system works in parallel mode with the neighboring country and energy flows from west to east, or the energy system of Georgia works in autonomous mode and at this time exports are carried out with a HVDC (High-voltage direct current), then the country's maximum consumption is in the morning and evening During peak times, the 500 kV transmission line in West Georgia may become overloaded or the line load may approach operating limits.**

**For example, in the event of an emergency shutdown of the 500 kV power transmission line in the western part of the country, when there is a total load on the 500 kV power line and the autotransformers of the 500 kV substations, that the 500 kV power line is the condition for the operation of the emergency automation system, the operation of the emergency automation system will shut down the generation and the corresponding customer in the eastern part of the country, which will avoid a complete blackout, because the connection between western and eastern Georgia will remain with 220 kV power lines, and the said 220 kV voltage network will not be overloaded.**

**Also, if we work in autonomous mode in case of frequeny drop, which can be caused by emergency shutdown of generation or if we work parallel mode with a neighboring country, import is in progress (>50MW) and emergency shutdown of the interconnection transmission line , at this time due to malfunction of the emergency automation system, not enougt consumers to disconnect because automatic frequency unloading is possible to operate, automatic frequency unloading in**

**summer setting mode will start tripping users from 49.2 Hz and disconnect users when the frequency drops to 47 Hz, with a step of 0.1 Hz for each step of 40 MW, while in winter setting mode it will start tripping users at 49 Hz and disconnect if the frequency drops to 47 Hz, consumers will receive 40 MW in each step with a range of 0.1 Hz, and if the frequency drops below 47 Hz, the generators will be protected against falling frequeny and will turn off the generator. Also, due to the malfunctioning of the emergency automation system, due to the disconnection of unnecessary consumers, if the frequency in the system exceeds 51 Hz, then the protection against the increase in frequency will work on the generators and turn off the generators.**

**During the planned or emergency shutdown of the internal system 500 kV power transmission line, when there is so much load on the line that the emergency automation system operation condition is not met, a reactive power deficit is created in the system in proportion to the length of the power transmission line multiplied by 0.9, for example, if a 500 kV power transmission line The length is 128 km, if it is turned off, the deficit of reactive power is 128x0.9=115 Mvar, at this time the voltages in the system drop and the country's consumption also decreases, which during parallel operation during the current import with the neighboring country will reduce the flow of electricity (import) and increase the electricity during export. The flow (export) is proportional to the change in the reduction of the country's consumption, then it will be regulated and the export-import schedule with the neighboring country will be restored by the generator with automatic generation control (AGC). e.g. In the event of a planned shutdown of the 500 kV transmission line in the western part of the country, a regime is prepared in advance, which means the active power loading of the hydroelectric power stations in eastern Georgia and especially in the Zestafon junction, in order to reduce the load on the 500 kV power line in the eastern direction, and the reactive power of the generators is maximally loaded in the power stations in order to increase the voltage.**

**It is also important to note that the 500 kV power transmission line, the length of which is 165 km, should be turned off along with the 500 kV reactor in case of a planned shutdown of the line, because the reactive power deficit (165x0.9=149 mvar) caused by the line shutdown should be compensated by the shutdown of the 500 kV reactor. By turning off the 500 kV reactor, an excess of reactive energy of 180 mvar will be created in the system, which will compensate for the deficit of reactive energy obtained by turning off the line.**

**The shutdown of the 500 kV shunt reactor occurs during the peak of countrys consumption (during the maximum consumption of electricity in the country), because during the peak of the countrys demand increases as much as a possible and the user consumes reactive energy along with active energy, a deficit of reactive energy is created in the system and the voltages drop, because of this it is also possible to add reactive energy to the generators, then the shunt reactor is turned off or the shunt reactors that have Tap changer, it is possible to move the Tap changer to increase the voltage. 500 kV shunt reactors have 35 positions of Tap changer. The minimum reactive power consumption of a 500 kV shunt reactor is 115 mvar and the maximum reactive power consumption is 180 mvar, therefore it can be adjusted up and down within the range of 65 mvar. In this case, we will move the Tap changer in such a way that the 500KV shunt reactor consumes the minimum reactive energy. With the shutdown of the 500 kV shunt reactor, the voltages increase and the countrys consumption also increases. If the energy system of Georgia works in parallel with the neighboring country and the import is in progress, by turning off the 500 kV shunt reactor, the current import**

**will increase by about 50 MW, which will be adjusted by the generator on which automatic generation control (AGC) is entered and will adjust the import according to the schedule.**

**In the autonomous mode, during shutdown of the 500 kV shunt reactor, the mode is prepared in advance, the frequency must be artificially increased to 50.5 Hz, for this, the active power on the most powerful generator increases the frequency in the system quickly, and when the frequency reaches 50.5, we turn off the 500 kV shunt reactor, at this time the reactive energy released by turning off the shunt reactor is 180 Mvar will increase the voltage, increasing the voltage will increase the consumption of the country by about 50 MW and the frequency will momentarily decrease to 49.5 Hz, then the frequency will be adjusted by the frequency regulator, which is fed to one of the generators.**

**The 500 kV shunt reactor is turned on at the time of the country's minimum consumption, because at this time the consumption is reduced as much as possible, along with the reduction of the active energy consumption, the reactive energy consumption also decreases and an excess of reactive energy is created in the system and the voltages increase, because of this it is also possible to reduce the reactive energy on the generators, then the 500 kV shunt reactor is turned on or moving the Tap changer on the shunt reactor in order to reduce the voltage, in this case we will move the Tap changer to the position so that the 500 kV shunt reactor consumes the maximum reactive energy. By turning on the 500 kV shunt reactor, voltages decrease and the country's consumption also decreases, If the energy system of Georgia works in parallel with the neighboring country and imports are in progress, by turning on the 500 kV shunt reactor, the current import will decrease by about 50 MW, which will be regulated by the generator on which automatic generation control (AGC) is entered and will be corrected Imports according to schedule.**

**In the autonomous mode, during turned on the 500 kV shunt reactor, the mode is prepared in advance, the frequency must be artificially lowered to 49.5 Hz, for this, by quickly reducing the active power on the most powerful generator, the frequency in the system will decrease, and when the frequency reaches 49.5 Hz, we will turn on the 500 kV shunt reactor, at this time, by turning on the 500kV shunt reactor by the reactor The absorbed energy (180 mvar) will reduce the voltage, the reduction of the voltage will reduce the country's consumption by about 50 MW and the frequency will increase momentarily to 50.5 Hz, then the frequency will be adjusted by the frequency regulator, which is fed to one of the generators.**

**According to the regime, large-capacity hydro-generators and thermal power units have the ability to automatically partially regulate the deficit or excess of reactive power in the power system, this is immediately effective when the 500 kV shunting reactor and the internal system 500 kV power transmission line are turned on or off, as well as during parallel operation with other countries, the change in the flow of reactive power is automatically reflected on the inter-system line .**

**During the parallel operation of the Georgian energy system with the neighboring country, one of the generators is equipped with AGC (automatic generation control), which regulates export-import on the inter-system line according to the pre-approved schedule entered in the SCADA (supervisory control and data acquisition), and also one of the generators is equipped with a frequency regulator, which will adjust the frequency in the system in the event of an emergency shutdown of the inter-system line. For this, the load on the generator, on which the frequency regulator is inserted, should be approximately half of the nominal one, so that the generator has a range of regulation both for increasing and decreasing power.**

**During the operation of the Georgian energy system in autonomous mode, a frequency regulator is installed on one of the most powerful generators, which continuously adjusts the frequency in the system.**

**The most reliable mode is to operate the Georgian energy system in parallel mode with the neighboring energy system, from which the internal 500 kV power transmission network in Western Georgia will not be overloaded during the import, in the case of, at this time exports are carried out with a HVDC (High-voltage direct current), and the Georgian energy system will be connected to the neighboring energy system from which the import is carried out by at least two inter-system lines. . It is desirable that the neighboring power system works in parallel mode with another neighboring power system in order to improve the frequency quality.**

**The emergency shutdown of 500 kV autotransformers in substations is also a big threat to the energy system of Georgia:**

1. **In 500 kV substations, when there is a consumer of more than 50 MW, i.e. a load of more than 50 MW from the 500kv voltage network to the 220 kv voltage network arrives at the autotransformer;**
2. **In 500 kV substations where the generation of more than 50 MW is included, that is, the load from the 220 kv voltage network to the 500kv voltage network is more than 50 MW on the autotransformer.**

**For example, emergency shutdown of 500 kV autotransformer in a 500 kV substation causes additional load on autotransformers in adjacent 500 kV substations (which are directly connected to 500 kV transmission lines). Whatever load was falling on the 500 kV autotransformer in the 500 kV to 220 kV network before the emergency shutdown, a little less load will be distributed and added to the autotransformers of the adjacent substations. This is especially undesirable during times of low water inflow into HPPs, when HPPs have small loads in the region of an autotransformer that has been turned off by accident. It should also be noted that if we are talking about the 500 kV autotransformers of Eastern Georgia, the same picture is when the thermal stations are not working, because at that time the load coming from the 500 kV to 220 kV network will be as large as possible. Also, during the shutdown of the 500 kV autotransformer, the voltages in the 500kV substation drop a lot in the 220 kV network, for example, before the emergency shutdown of the 500 kV autotransformer in the 220 kV network, if the voltage was 220 kV, then after the shutdown the voltage drops to 190 kV, while the voltages in the 500 kV network increase a lot. For example, if the voltage was 500 kV before turning off the 500 kV autotransformer, after turning off it even increases to 530 kV.**

**During the planned shutdown of the 500 kV autotransformer, the following mode is prepared: the generation sources in the node must be connected to the system and after connecting to the system, they must take the maximum active and reactive power, also the user must be transferred to the autotransformers of the neighboring region as much as possible, and all measures must be taken to reduce the load on the 500 kV autotransformer as much as possible before turning it off., the aforementioned can be implemented only at night, when the country's consumption is minimal, precisely during the shutdown of the 500 kV autotransformer, it is important to have an energy storage in the 500 kV substation, so that the 220 kV voltage network in the node is not overloaded during the shutdown period of the 500 kV autotransformer, and also at this time in the said node**

**Stabilization of the voltages in the 220 kV and 110 kV voltage networks and planned shutdown of the 500 kV autotransformer should be possible at any time during the day and night.**
**In order to lower the voltage in the system, it is possible to turn off the 500 kV back-to-back shunt capacitor, the said shunt capacitor generates about 70 mvar of reactive power.**
**It is also important to note that the 220 kV voltage network connecting the 500 kV substations to the 220KV substations and the 220 kV voltage network connecting the 220 kV substations to each other must not be paralleled with the 110 kV voltage network connecting the same substations, in the case of paralleling with the 220KV network, if the 220 kV power line is switched off in an emergency, then the 110 kV power line will be paralleled with the 500 kV power line, which may cause emergency shutdowns of the 110KV lines as a result of overloading the 110KV network.**
**The most noteworthy from the point of view of the regime is the moment when there is an undesirable fact of a complete blackout or partial blackout of the system, when it is not possible to supply electricity to a part of the countrys consumers due to damage to the power transmission lines. It will be very important to have an Energy Storage and its role in restoring the power system from zero in the event of a complete blackout of the power system, because in the case of starting a hydroelectric power plant from zero, when the hydroelectric power plant does not have voltage even for its own consumption, the chances of fully restoring the power system and maintaining the stability of the energy system are fragile, in which the system will be greatly assisted by an Energy Storage.**
**The hourly modes of the energy system of Georgia are different from each other and the energy modes are also different according to seasonality. For example, if the evening peak is fixed at 22:00 in summer, the evening peak is fixed at 18:00 in winter, the energy regime in every hour is different both in terms of active energy consumption and in terms of reactive energy consumption, and also the daytime energy regime is different on holidays and working days.**
**Consider the variation of the countrys consumption during the day, the evening peak lasts for about 2 hours, afters that the consumption starts to decrease and the minimum consumption is fixed at about 5 am, then the countrys consumption slowly starts to increase again until dawn, when the outdoor lights of country are turned off, the consumption decreases again for a while and then the consumption starts the increase to the morning peak, the morning peak lasts from about 12:00 to 14:00, then between the morning peak and the evening peak there is again a process of decreasing consumption and then increasing it.**
**During the day, the snow melts in the mountains, and by the evening, the water inflow to some hydroelectric power stations increases.**
**Based on the above, the need for energy storage is important, especially during times of water abudance.**

## R E F E R E N C E


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