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ПОВЫШЕНИЕ ЭФФЕКТИВНОСТИ ИСПОЛЬЗОВАНИЯ ПРОТИВОАВАРИЙНОЙ АВТОМАТИКИ БЕЛОВСКОЙ ГРЭС

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IMPROVING THE EFFICIENCY OF USING EMERGENCY AUTOMATION AT BELOVSKAYA GRES

The energy system of the Kemerovo region - Kuzbass is one of the largest energy systems in the country, the third largest in terms of electricity consumption out of 10 energy systems in the unified energy system of Siberia.

The absolute projected increase in the maximum load on the Kemerovo Region power system by 2029 compared to 2023 will be 451 MW, the projected increase in electricity consumption for the same period will be 3059 million kWh. Thus, a steady increase in the maximum load and electricity consumption on the power system is projected for the period up to 2029.

In accordance with the draft Scheme and program for the development of the Unified Energy System of Russia for 2024-2029, in 2027, Belovskaya GRES is scheduled to modernize equipment (unit No. 2 K-215-130-1) with an increase in capacity by 15 MW. Due to this, the projected installed capacity in the Kemerovo Region from 2027 will be 5480.84 MW.

Any disconnection of overloaded connections in distribution networks directly affects the amount of electricity generated at stations. The PA devices automatically introduce restrictions on electricity generation, which leads to a decrease in the economic efficiency of the station due to undersupply of electricity. As a result, an important task of modern PA systems is to automatically ensure restrictions on the overload of primary equipment with an increase in its throughput.

The main component of PA efficiency is the technical level, which includes:

- technical perfection (speed, selectivity, sensitivity);
- reliability of operation;
- software level;
- integration capability.

In accordance with [1], automatic equipment overload limiting devices (AOPO) are designed to prevent the current load of the protected elements from being unacceptable in magnitude and duration.

The AOPO device must provide:

- triggering when detecting that in any of the three phases the current through the protected element exceeds a specified value at a given ambient temperature;
- issuance of a control action after a specified time delay.

The speed of the AOPO is achieved by choosing the right response time, selectivity is achieved by using the OV, and sensitivity is calculated by determining the setpoint settings from temperature. The overwhelming majority of failures in the operation of devices are false and/or excessive responses. Microprocessor devices of the PA allow almost instantaneous "assessment" of an emergency situation and generate OV to prevent or resolve emergency situations.

Thus, the efficiency of the AOPO is increased by correctly determining the OV, improved tuning from external influences (temperature). As well as the use of additional measures.

To increase the efficiency of the AOPO, the following set of measures is considered in the work:

- Determination of the type and volume of control actions;
- Calculation of the setting parameters and operating algorithms.

Determination of the type and volume of control actions

The types and volumes of protection functions implemented by the AOPO device must ensure the absence of an inadmissible current load on the protected element in terms of magnitude and duration.

AOPO devices for the 110 kV overhead power line of the Belovskaya GRES [2] must monitor the current on each monitored 110 kV overhead power line, taking into account the direction of power from the station busbars and depending on the magnitude and duration of the recorded current overload, ensure the effects of the signal stage and working stages.

The signal stage is aimed at sending a signal to the control panel to attract the attention of the operating personnel.

The working stage with several time delays and the following order of implementation of control actions:

1) (OG-1) to disconnect one of the generators TG-1, TG-2 from among the generators to be disconnected at Belovskaya GRES;

2) (OG-2) to disconnect the second generator TG-1, TG-2 from among the generators to be disconnected at Belovskaya GRES;

3) to disconnect the 110 kV switch of the controlled overhead line with the prohibition of automatic reclosing.

In addition, another stage with several time delays is provided in reserve.

The AOPO has the ability to control the power of generators started for shutdown, rank them by the value of the output power and, first of all, shut down the most loaded unit. Analyzing the OV, it can be said that a large number of stages when setting up the AOPO does not give a positive result, since the parameters of the lines that do not go beyond the permissible values in some circuits can only be obtained by completely shutting down TG-1 and TG-2. Additional OV stages increase the response time. Therefore, it is necessary to include the ability to control the previous mode (KPR) in the AOPO functioning algorithm. This is implemented by creating and transmitting a signal with the SMZU software package, implemented in the controlled section.

Calculation of setup parameters and operating algorithms

After selecting the UV volume, it is necessary to consider the parameters of the AOPO operation.

Each AOPO device is implemented according to the step principle and contains a signal (first) stage and several working stages [3].

The current setting of the signal stage of the AOPO power transmission line device must correspond to:

$$I_{signal} = \min\begin{cases}\text{DDTN of the power transmission line protected by the AOPO device;}\\ 0,9\times\text{ADTN of the power transmission line protected by the AOPO device.}\end{cases} \quad (1)$$

$$I_{signal} = \max\begin{cases}\text{ADTN of the power transmission line protected by the AOPO device} - 100;\\ 0,9\times\text{ADTN of the power transmission line protected by the AOPO device.}\end{cases} \quad (2)$$

The response time of the AOPO signal stage is calculated using the formula:

$$t_{signal} = \max\begin{cases}t_{APV} + t_{\text{APV spread}} + t_{\text{switch-off time}} + t_{\text{switch-on time}}\\ t_{RZ} + t_{UROV} + t_{\text{own switch-off time}}\end{cases} \quad (3)$$

where t_{APV} – automatic reclosing time delay, s; $t_{\text{APV spread}}$ – APV spread time, s; $t_{\text{switch-off time}}$ – line switch trip time, s; $t_{\text{switch-on time}}$ – line switch on time, s; t_{RZ} – the longest protection response time, s; t_{UROV} – response time of breaker failure protection, s; $t_{\text{own switch-off time}}$ – proper tripping time of the line switch, s.

The response time of the tripping stages of the AOPO is calculated using the formulas:

$$\begin{aligned}
t_{5st.}^{\text{discon.}} &= t_{\text{overload}} - t_{UV};\\
t_{4st.}^{\text{discon.}} &= t_{5st.}^{\text{discon.}} - \Delta t - t_{UV};\\
t_{3st.}^{\text{discon.}} &= t_{4st.}^{\text{discon.}} - \Delta t - t_{UV};\\
t_{2st.}^{\text{discon.}} &= t_{3st.}^{\text{discon.}} - \Delta t - t_{UV};\\
t_{1st.}^{\text{discon.}} &= t_{2st.}^{\text{discon.}} - \Delta t - t_{UV}.
\end{aligned} \quad (4)$$

where $t_{1st.}^{\text{discon.}}, t_{2st.}^{\text{discon.}}$ – time delay for disconnecting one TG (OG-1 BGRES), s; $t_{3st.}^{\text{discon.}}, t_{4st.}^{\text{discon.}}$ – time delay for disconnecting the second TG (OG-2 BGRES), s; $t_{5st.}^{\text{discon.}}$ – time delay for disconnection of controlled 110 kV overhead power line with automatic reclosing inhibition, s; t_{overload} – time of maximum possible line overload, s; Δt – selectivity level (taken in the range of 0.5-5 s), s; t_{UV} – time of implementation of the UV, s.

The selected control action and operating algorithm are presented in the table.

Table

Parameters of operation of devices of AOPO Belovskaya GRES. Control actions

№	Protected element	General direction of power	Setting up automation			
			Step	I_{cp}., A	T_{cp}., A	Control actions
1	Overhead line 110 kV Bl – BGRES I(II) circuit	from tires station	1	-	5,037	Signal «Overload of the power line»
			2		5,95	Disconnection of one TG-1 case
			3		8,16	Disabling TG-1
			4		10,37	Disconnection of one TG-2 case
			5		12,58	Disabling TG-2
			6		14,79	Disconnection of 110 kV switch of controlled overhead line with prohibition of automatic reclosing
			-	-	-	Reserve

Thus, the increase in the efficiency of the AOPO in this work was achieved by determining the control actions (limiting the generators), calculating the setting parameters and operating algorithms (correction of the current setting based on the outside air temperature).

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