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Increasing Capacity Impact of Power Source Sinergy on Power Flow Evaluation Based on Auxiliary Generator

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Abstract

Steam power plant PT Sinergy Power Source is one of the private steam power plants that have a capacity of 30 MW and supplies 3 main expenses namely PT Mekabox, PT Sopanusa, and PT Sunpaper. Currently, the total load that must be fulfilled by steam power plant PT SPS for the three factories is 25.33 MW and will continue to grow because of the increase in the production number of each plant. With the increasing amount of production, the amount of load will increase so that additional generator capacity is required. This research aims to determine the analysis of power flow planning and coordination setting system protection against the addition of 30 MW generator capacity. Analyze the power flow using software with the Adaptive Newton-Rapson method. The results of the study showed after the 30 MW generator was added, the work percentage of generators 1 and 2 was lighter and the value of the power flow is relatively the same if the load value is unchanged. According to the findings, there was a power loss of 0.408 MW before the addition of 30 MW generators and 0.449 MW following that addition. The utilization percentage of generators 1 and 2 which were initially used at 80.3 percent drastically fell to 50.2 percent owing to the inclusion of the 30 MW generator so that generators 1 and 2 work could become lighter. These are the clear changes after the addition of the 30 MW generator.

Keywords

Coordination, Generator, Power Flow, Voltage

INTRODUCTION

Coal is frequently used to fuel steam power plants, which are widely used to generate energy around the world. Even though there are enough coal reserves in the globe to last for roughly two centuries, the technology that is primarily employed today to produce power from coal has a substantial detrimental impact on the environment. Energy analysis is possibly the most significant of the analytical methods since it is a practical, convenient, and easy way to evaluate and enhance thermal producing station Energy and energy evaluations are used in this chapter to study and better understand the operation of steam power plants as well as to identify and assess potential process changes that could increase plant efficiencies [1], [2]. Then, a few other process configurations are suggested. Energy is beneficial for giving a thorough breakdown of the losses for the entire plant and its constituent parts in terms of waste energy emissions and irreversibilities. The significance of energy in improving the performance of steam power plants is illustrated by a few concrete instances. Efficiency-boosting actions should only be taken after carefully weighing them against other aspects. Energy analysis provides useful information about plant performance. Results of energy analyses can be used to improve the effectiveness of thermal generating stations as well as their potential economic and environmental performance.

Steam Power Plants are plants that rely on the kinetic energy of steam to produce electrical energy. The main form of this type of power plant is a Generator that is connected to a turbine that is driven by kinetic power from hot/dry steam. Steam Power Plants use a wide range of fuels, especially coal and fuel oil as well as MFO for early start-ups [3], [4]. The steam power plant is the most used in Indonesia because of various advantages such as can be operated with various types of fuel such as petroleum or coal, can be built with varying capacities, can be operated with various loading operations, and the continuity of operation and long life span. A steam power plant has five main components namely boiler, steam turbine, boiler feed water pump, condenser, and generator [1], [5], [6]. These components work in conjunction to produce electrical energy.

Many steam power plants have operated in Indonesia one of them is Steam Power Plant PT Sinergy Power Source which is located in Mojokerto, East Java, and has a total capacity of 30 MW. The steam power plant was established in 2015 and started operating in early 2017 with an initial target to supply 3 different companies, namely PT Mekabox, PT Sopanusa, and PT Sunpaper. The total time of load demand from all three companies above according to the last existing data of 25.33 MW will continue to increase due to the increased amount of production that is targeted specifically at PT Sunpaper which continuously adds Paper Machine projects to the production needs. Meanwhile, the total number of energy generation produced by steam power plant PT Sinergy Power Source

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remains at 30 MW with increasing load demand so that the needed addition of generator capacity to remain able to meet the load.

In the project plan to add a capacity generator that will be built by PT Sinergy Power Source in the future set capacity of the generator used at 30 MW. Of course, the plan to add capacity to this generator needs to be in-depth calculations such as the number of power streams and coordination of the protection system layout to be used [7], [8]. In the issue above this work aims to analyze the power flow and coordination and setting protection system that will be used in planning the addition of generator capacity in the PT Sinergy Power Source. By doing this, the research is expected to know the number of power flows and the coordination settings of existing protection systems as well as in planning the addition of 30 MW generator capacity in the PT Sinergy Power Source fore so that Provide clear and precise imagery, calculations, and settings to allow energy generation to be generated after the addition of generator capacity can meet the demands of load and work optimally.

PROCEDURE

This research uses descriptive research methods, where research begins with collecting data, analyzing data, and interpreting it. The descriptive methods of implementation are conducted through survey techniques, case studies, comparative studies, studies on time and motion, behavioral analysis, and documentary analysis. So researchers will take the data in the field of both measurements and calculations that will then be analyzed and simulated in the aid program [9], [10]. The Program will provide a report related to the power flow and protection system so that researchers can find out what the system is still capable of supplying good power and how to coordinate its protective system. The research took place in July 2019 at PT Sinergy Power Source Mojokerto. The process of completion of this research is done by several procedures so that the research is done following the case study discussed that is the selection and identification of data required see Single Line Diagram system in steam power plant PT SPS For power analysis and protection system coordination. The phases of this research procedure are presented in Figure 1 in the form of flowcharts as below.

From the data we already have, then simulate using software to facilitate the process of power flow analysis and coordination and setting of the protection system. The first thing to do in this software simulation is to draw a single-line electrical system diagram of PT Sinergy Power Source which is where each component in a diagram such as generators, buses, loads, and others are given the input data according to the data and characteristics of the components we already have. If there are any component data or inline diagram depictions that do not match the settings and configurations that are inserted then the software will not be able to properly run the Power Flow analysis (Error). Once the data entered is complete and correct, the power flow analysis process can be followed by the processing of the power flow method used in the simulation the Adaptive Newton-Raphson method. The result of a line chart simulation created in Software is a report consisting of numeric data and report results from the calculation of the power flow performed by the program. From the results of the simulation, then we analyze the power flow manually. Manual analysis of power flows includes several calculations such as voltage analysis, active reactive and apparent power analysis, power loss analysis, and energy loss analysis. Here is the calculation formula of the aforementioned analysis. For the analysis of the protection system, a single line diagram as detailed in Figure 2 that has been simulated previously is divided into several stages to classify protection system settings in which protection system equipment is used here using an overcurrent Relay. Below is a picture of the stage division for finding out the condition. These steps are concerned with data collection, simulating process, performance, and analysis.

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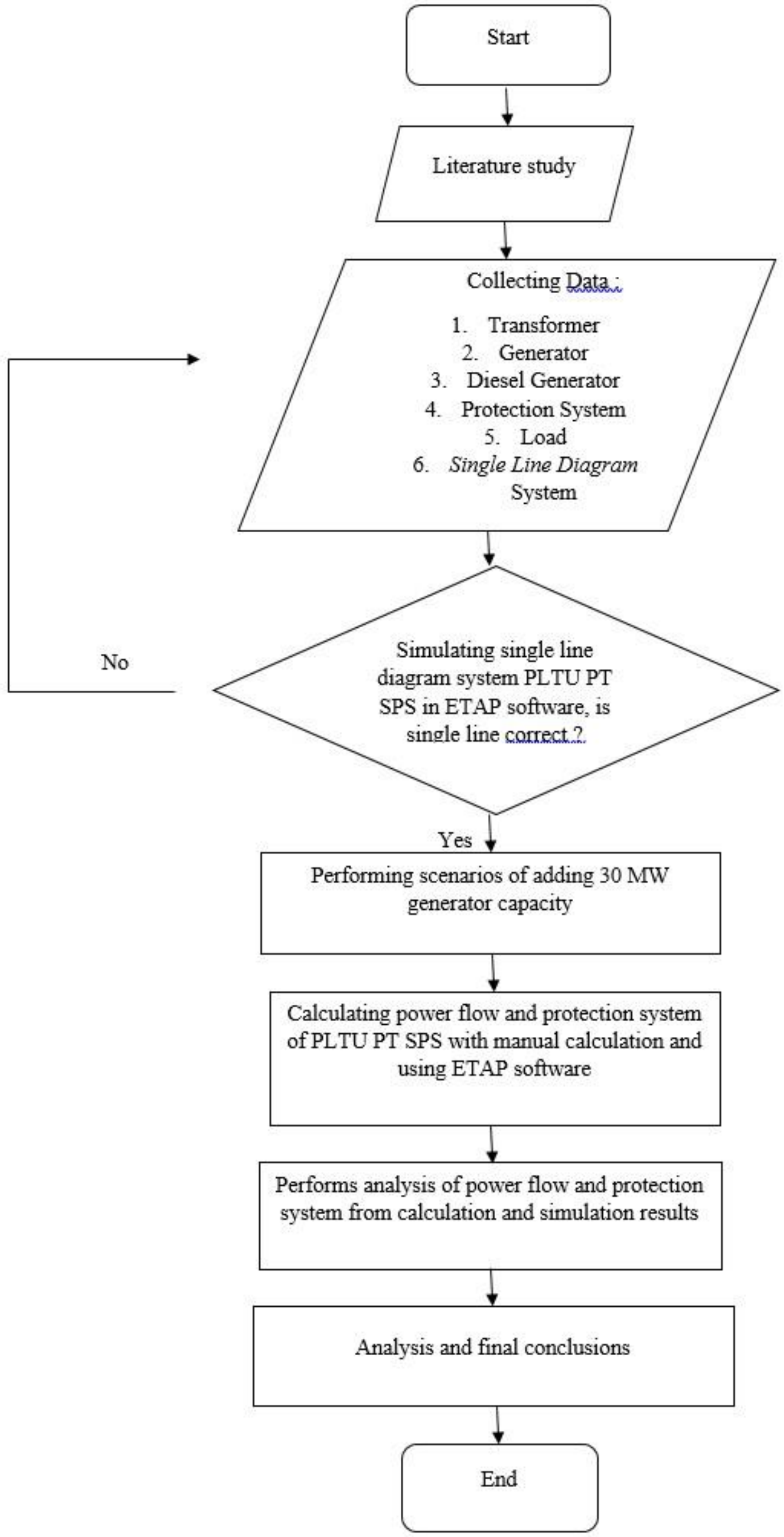

Figure 1. Flowchart of research method

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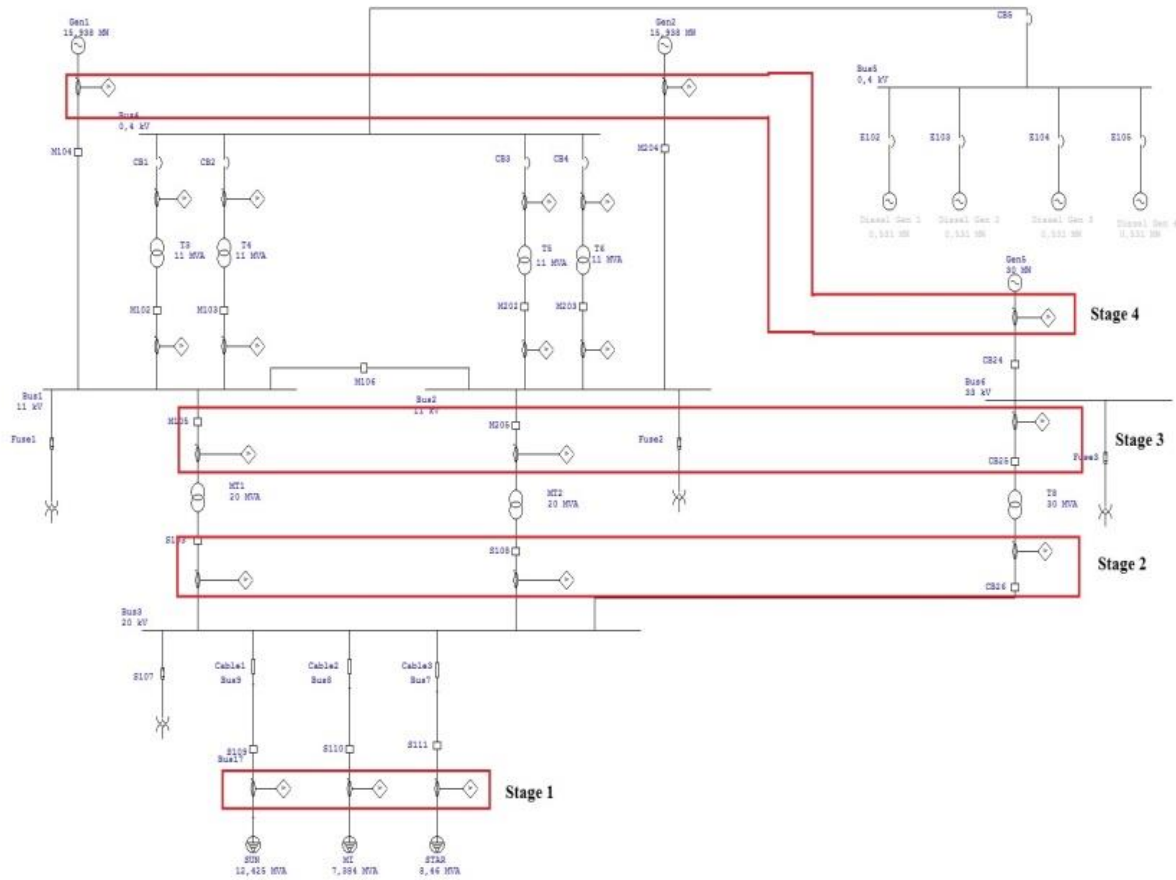

Figure 2. Stage division setting relay against current and time

After dividing the protection system settings as above, then the process covers:

a. Calculates short three-phase and two-phase dashes for use as a pick-up current calculation on the current relay adjustment.
b. Calculating the value of the relay pickup current
c. Determining the setting of a more precise current relay.

Once we calculate and know the settings of the OCR relay used then we conduct simulated protection coordination in the simulation by disruptions at each stage to see if the coordination and setting of the protection system are correct and able to handle the problem appropriately.

RESULT AND DISCUSSION

Analysis of the power flow performed before and after the addition of the 30 MW generators includes voltage analysis, active power analysis, reactive power, phantom power, power loss analysis, and energy loss analysis. Many works have been reported for the additional power plants covered in performance improvement [8], [10], [11]. For analysis of the protection system is done after the addition of a 30 MW generator capacity. The voltage analysis here focuses on the number of drop voltages present in the system before and after the addition of 30 MW generators. Here are the tables and charts of drop voltage in the three factories both before and after the addition of the 30 MW generator as given in Table I and Table II.

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TABLE I
VOLTAGE DROP VALUE BEFORE GENERATOR 30 MW ADDED

Load Name	Bus Position	Load Type	Voltage in Bus (kV)	Voltage in Load (kV)	Voltage Drop (kV)	Voltage Drop Percentage (%)
MI	Bus 3	Lumped	20	19,783	0,217	1,08
Star	Bus 3	Lumped	20	19,718	0,282	1,4
Sun	Bus 3	Lumped	20	19,595	0,405	2,02

TABLE III
VOLTAGE DROP VALUE AFTER GENERATOR 30 MW ADDED

Load Name	Bus Position	Load Type	Voltage in Bus (kV)	Voltage in Load (kV)	Voltage Drop (kV)	Voltage Drop Percentage (%)
MI	Bus 3	Lumped	20	19,732	0,268	1,3
Star	Bus 3	Lumped	20	19,667	0,333	1,6
Sun	Bus 3	Lumped	20	19,543	0,457	2,2

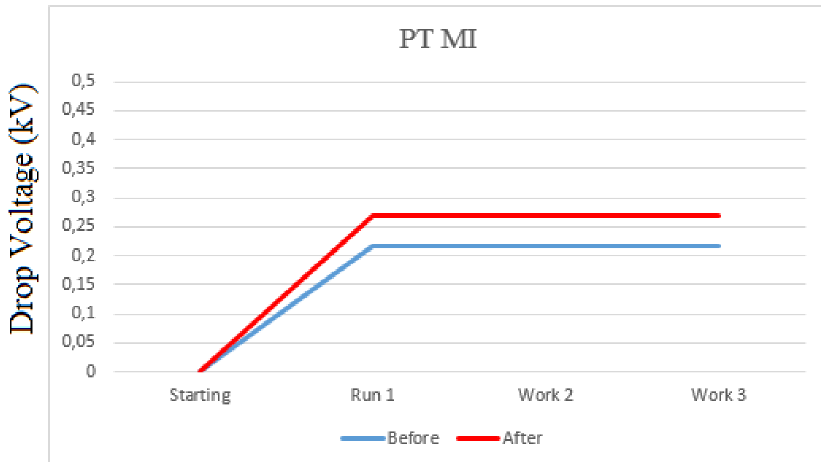

Figure 3. Voltage drop Chart at PT MI before and after the addition of 30 MW generator

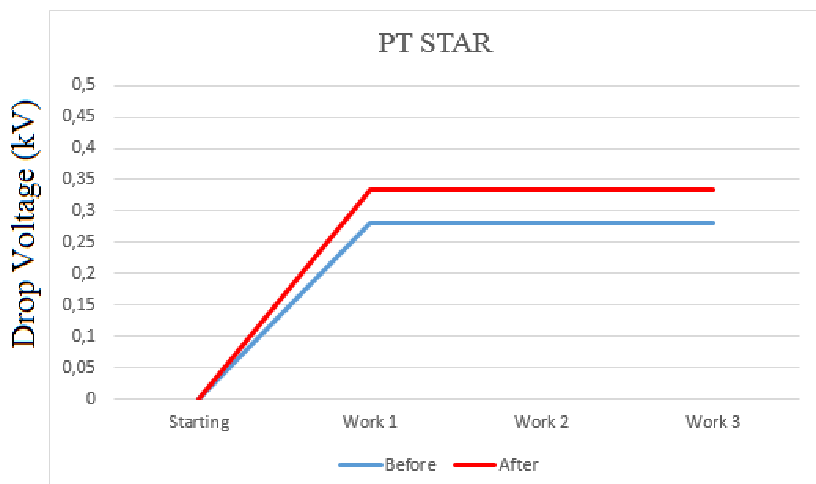

Figure 4. Voltage drop chart at PT Star before and after the addition of 30 MW generator

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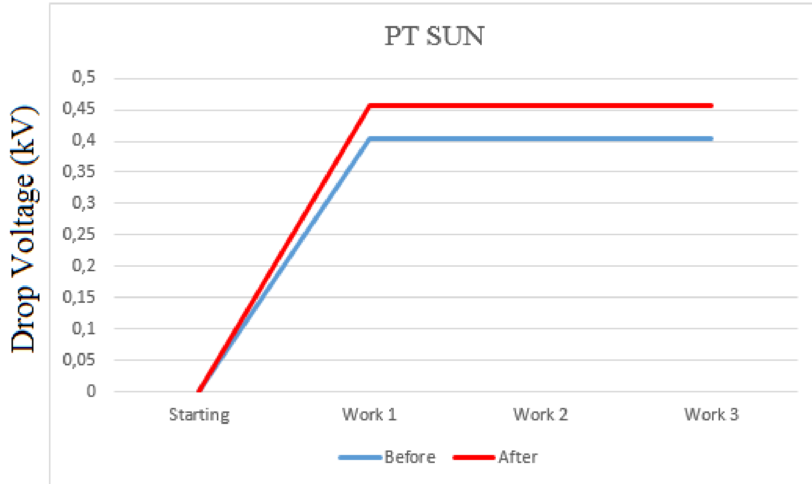

Figure 5. Voltage drop chart at PT SUN before and after the addition of 30 MW generator

As shown in Figure 3, Figure 4, and Figure 5 above the value of the voltage drop in the three factories above increased after the addition of the 30 MW generator. This is because the increase in the generator will certainly also increase the amount of transmission to send existing electrical power so that the total number of obstacles present in the system throughout will also increase. Regarding the voltage drop, the system should be maintained till it becomes a stable condition [12], [13]. Therefore the number of voltage drop in the three factories above increased after the addition of the 30 MW generator. The drop in voltage that exists at each load both before and after the addition of the 30 MW generator is relatively similar and is at a safe level. The maximum voltage drop limit according to NEC (National Electrical Code) is 5% so the drop voltage value is still in good value. Analysis of the third power above is calculated from sources, buses, and loads, but this paper focuses more on analysis in the source area because at this point changes in power flow are the active, reactive, and apparent more noticeable difference before and after addition 30 MW Generator Capacity as listed in Table III and Table IV.

TABLE IIIII
ACTIVE, REACTIVE, AND APPARENT POWER ANALYSIS IN SOURCE BEFORE 30 MW GENERATOR ADDED

Generator	Position in Bus	Rated (kV)	Active Power (kW)	Reactive Power (kVar)	Apparent Power (kVA)	Generator Percentage Usage (%)
1	Bus 1	11	12.791	7.051	14.605	80,3
2	Bus 2	11	12.791	7.051	14.605	80,3

TABLE IV
ACTIVE, REACTIVE, AND APPARENT POWER ANALYSIS IN SOURCE AFTER 30 MW GENERATOR ADDED

Generator	Position in Bus	Rated kV	Active Power (kW)	Reactive Power (kVar)	Apparent Power (kVA)	Generator Percentage Usage (%)
1	Bus 1	11	8.000	6.366	10.224	50,2
2	Bus 2	11	8.000	6.366	10.224	50,2
3	Bus 6	33	9.511	651	9.533	31,7

From the results of analysis and calculations can be seen a significant difference between the three power above before and after the addition of the 30 MW generator. Before the addition of the 30 MW generator, the active, reactive, and apparent power values of the source (generators 1 and 2) were greater than after the addition of the 30 MW generator capacity. This is due to the addition of 30 MW generators in the system, the work of generators 1 and 2 can be reduced because the generator work is divided into three. Moreover, all three modes of operation of the generator above are in swing mode so that all three generators work in a way that meets both voltage and power deficiencies in the system where the terminal voltage angle value of the generator will be kept Specific operating values. Therefore the big power of the third value in generators 1 and 2 is reduced after the 30 MW generator is added because all three generators work together (synchronization) to get balanced results and keep up the good work to meet the Load request. The power loss is essentially the magnitude of the lost power on a network, with the same

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magnitude of power transmitted from the source minus the amount of power received. So the calculated power loss given in Table V and Table VI is in the load area before and after the addition of 30 MW generators.

TABLE V
POWER LOSS VALUE BEFORE 30 MW GENERATOR ADDED

No	Factory	Power In (MW)	Power Used (MW)	Power Loss (MW)	Total Power Loss (MW)	Power Loss Percentage (%)
1	PT MI	5,684	5,596	0,088		
2	PT Star	8,240	8,124	0,116	0,416	1,63
3	PT SUN	11,511	11,299	0,212		

TABLE VI
POWER LOSS VALUE AFTER 30 MW GENERATOR ADDED

No	Factory	Power In (MW)	Power Used (MW)	Power Loss (MW)	Total Power Loss (MW)	Power Loss Percentage (%)
1	PT MI	5,678	5,590	0,08		
2	PT Star	8,232	8,116	0,116	0,449	1,76
3	PT SUN	11,540	11,287	0,253		

The results of the simulation in the table above can be seen the existing power loss value in the system amounted to 0.408 MW before the addition of 30 MW and 0.449 MW generators after the addition of 30 MW generators. The power loss that exists in the system either before or after the addition of the 30 MW generator is not very different or relatively the same because the amount of load is worth a fixed. The loss of power here can occur due to losses on the conductive loss on the charger. It can be deduced from the simulation results and the calculation of the power loss manual contained in the system is still in good condition.

CONCLUSION

Analysis of the power flow after adding a 30 MW generator did not undergo significant changes due to the amount of load remaining the same. The obvious changes after the addition of the 30 MW generator can be look in the usage percentage of generators 1 and 2 which were initially used at 80.3% significantly decreased to 50.2% due to the added 30 MW generator so that generators 1 and 2 work could become lighter. Drop voltage and existing power loss in the system are still in good condition (under 5%) and the setting and coordination of the protection system after the addition of the 30 MW generator already works well as shown in the simulation.

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