Improving the reliability of the energy supply to the district boiler house

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Abstract. Currently, measures are being worked out at generation facilities, in particular at district boiler houses, the implementation of which will increase the reliability of both individual elements of the system and the entire energy supply system as a whole, improve its technical and economic indicators, and achieve the target financial indices of the enterprise. As one of such measures, the article considers the ways of organizing a mini-TPP (thermal power plant) on the example of a large district boiler house for the purpose of energy supply for their own needs. This solution will increase the energy independence of the boiler house from the external network, reduce the cost of electricity consumption. The paper presents the results of a technical and economic analysis of options for organizing own generation, taking into account the actual operating conditions of the boiler house, linking the mini-TPP to the existing communications of boiler house, the impact of the joint operation of the mini-TPP and the boiler house on the sanitary zone. Based on the analysis of the loading graphs of the electric equipment of the boiler house, the required capacity of the gas engine generator plant and the place of its installation on the production site are determined. The operation of the gas engine generator plant involves the production of electric energy only for its own needs without issuing it to an external electrical network, in connection with which an automation system is provided that does not allow electricity to be issued to an external network. This restriction is related to the requirements of the technical specifications of the electric grid company.

1. Introduction

The traditional year-round mode of operation of the district boiler house will allow the maximum use of the installed capacity of the gas engine generator plant, and relatively low electricity consumption is the most attractive from the point of view of using the production site of the boiler house for the introduction of new equipment with relatively low capital costs [1-5].

The analysis of the consumption of the electricity of the boiler house for the periods of previous years [6-9], the average hourly consumption indicator of which is 754.3 kWh, and the maximum peak during cold spells reaches 1032.9 kW, determined the choice of a power plant with an installed electric capacity
of up to 1000 kW. In order to reduce the cost of repair and operation costs, the number of installations should be minimal.

Figure 1. Average hourly electricity consumption for the boiler house's own needs.

2. Materials
In order to select a promising Mini-TPP, the technical and economic indicators of SIEMENS equipment are presented, which is based on the installation of the model 954 SFGM 560 with a capacity of 954KW and the proposed KG-1000SL electric unit №1 from the Supplier on the basis of the LIEBHERR G9512 installation with a capacity of 976KW. Power plants equipped with a recycling unit are supplied in a modular design [10-16].

Figure 2. Power units KG-1000SL (left) and 954 SFGM 560 (right).

A comparative analysis of power plants is presented in table 1.

Table 1. Comparative analysis of power plants.

| № | Name                              | KG-1000SL | 954 SFGM 560 |
|---|----------------------------------|-----------|--------------|
| 1 | Rated electric power, kW         | 976       | 954          |
| 2 | Rated thermal power, MW/h        | 0.86      | 1.14         |
| 3 | Number of motors/generators in the module, pcs. | 2/2        | 1/1          |
| 4 | Specific fuel consumption for the release of thermal energy, kg/MW | 166.81   | 148.93       |
| 5 | Specific fuel consumption for electric energy, g/kWh | 166.8    | 148.9        |
| 6 | Load factor                      | 0.77      | 0.79         |
| 7 | The cost of fuel consumption for the year of operation, million rubles | 45.346   | 36.246       |
| 8 | The cost of the equipment, million rubles | 41.643   | 36.816       |
Based on the combination of technical and economic indicators of two Mini-TPP plants, the choice of implementation of a generation source based on the 954 SFGM 560 gas engine generator plant that is manufactured by SIEMENS was determined.

3. Results
The possibility of implementation of a project of own generation in a district boiler house is represented by three options [17-24]:

- Construction of the facility by own resources of boiler house;
- Energy service contract, version 1 (ESC-1). The construction of engineering networks is carried out by resources of a boiler house, the supply of equipment is carried out at the expense of the energy service company (ESC);
- Energy service contract, version 2 (ESC-2). The construction of engineering networks and the supply of equipment is carried out by own resources of ESC.

The forecast effect of the implementation of the project for all options is calculated with the following conditions [25-31]:

- the average load factor of an electric unit, with an average annual electricity consumption of 754.3 kWh, is $754.3/954 = 0.79$;
- operating time of the equipment – 6000 hours;
- the period until the first major repair is 10 years (60 000h);
- the calculation of the effect was performed for the period of operation of the power plant for 10 years;
- the period of validity of the energy service contract is 6 years.

At the production site of the boiler unit, the construction of one installation with an electric capacity of 954 kW produced by SIEMENS is being considered. The design of the Mini – TPP is container, the location is in the area of the central material warehouse on the site of the demounted exhaust stack H=30 m in accordance with figure 3.

### Table

|   | Description                                                                 | Cost 1 | Cost 2 |
|---|----------------------------------------------------------------------------|--------|--------|
| 9 | The cost of major repairs, million rubles                                 | 4.4    | 14.3   |
| 10| The cost of maintenance and average repairs for the period before major repairs, million rubles | 20.6   | 21.6   |
| 11| The cost of oil consumption for carbon monoxide for 1 year of operation, million rubles | 1.155  | 0.328  |
| 12| Cost of electricity, rub/kWh                                              | 2.40   | 2.32   |
| 13| Profit for 10 years of operation, taking into account price indexation, million rubles | 47.4   | 54.4   |
| 14| The cost payback period is discounted                                     | about 4 years | about 3 years |
The installed capacity of the gas engine generator plant: electric - 954 kW, thermal - 1.14 MW / h. The generator voltage is 0.4 kV.

The connection of the generator to the power supply scheme of the boiler house is shown in figure 4.

Figure 3. The plan of placement of a gas engine generator plant on the territory of the boiler house.

Figure 4. The connection of the generator of the gas engine generator installation to the scheme of the electrical equipment of the boiler house.
It is planned to connect the thermal unit of the Mini-TPP to the scheme of its own heating and hot water supply needs of the boiler house [32-36].

The calculated values of emissions of harmful substances during the operation of the boiler house equipment with a gas engine generator installation will not exceed 75% of the maximum permissible concentration at the border of the sanitary protection zone and in residential buildings.

In calculating the efficiency of a Mini-TPP plant, the number of operating hours per year is underestimated to a minimum level of 6000 hours, in order to intentionally worsen the financial result indicator from the time of unplanned downtime. The estimated period of operation before major repairs with an inter-regulatory period of 60,000 hours will be 10 years.

The declared park resource of the installation is up to 240,000 hours.

The values of the cost of the power plant equipment in the calculation are taken from the technical and commercial proposal of the supplier company.

In the conversion to the domestic currency, the cost of purchase of all equipment with VAT will be 35.143 million rubles:

- gas engine generator installation Siemens SGE-56SL, 0.4 kV. The basic set is 21.945 million rubles;
- recycling unit – 6.065 million rubles.;
- auxiliary equipment – 6.625 million rubles.;
- container – 0.51 million rubles.

The cost of design and survey works, installation and construction work and works on technological connection will amount to 7.738 million rubles.

The total cost of implementation for the boiler house will be:

- \(35.143 + 7.738 = 42.881\) million rubles with VAT, \(36.816\) million rubles without VAT.

The cost of operating a mini-TPP plant without taking into account the price indexation for a period of 10 years will amount to 74.860 million rubles, including:

- repair work;
- technical maintenance;
- fuel.

The cost of repair work and maintenance received from the supplier company is 38.6 million rubles for the period before major repairs (10 years).

Fuel costs, that are equal 3.246 million rubles per year, calculated according to the method of distribution of fuel costs for the supply of heat and electric energy.

4. Conclusion

According to the results of the study, it was determined that the construction of a mini-TPP according to the first option at its own expense is characterized by a high financial burden for the boiler house, due to large capital and operating costs.

The implementation of the project under the terms of ESC-2 is the most appropriate from the point of view of the distribution of costs for the implementation of the project and operation between the Company and the Energy Service Company. This option is the most optimal from the point of view of the financial burden for the boiler house.

Option 3 has a long payback period and the lowest profitability, and therefore is the least promising.
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