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Mini-Central heating and Power Plant (CHP): the choice of the optimal structure and modes of operation

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Abstract. The paper provides an overview of the different types of organizations of mini-CHP, the results of a comparative evaluation of their performance in terms of the variable load. The recommendations to improve power facilities of the mini-CHP on the basis of system analysis methods and the technical and economic optimization are defined.

1. Introduction

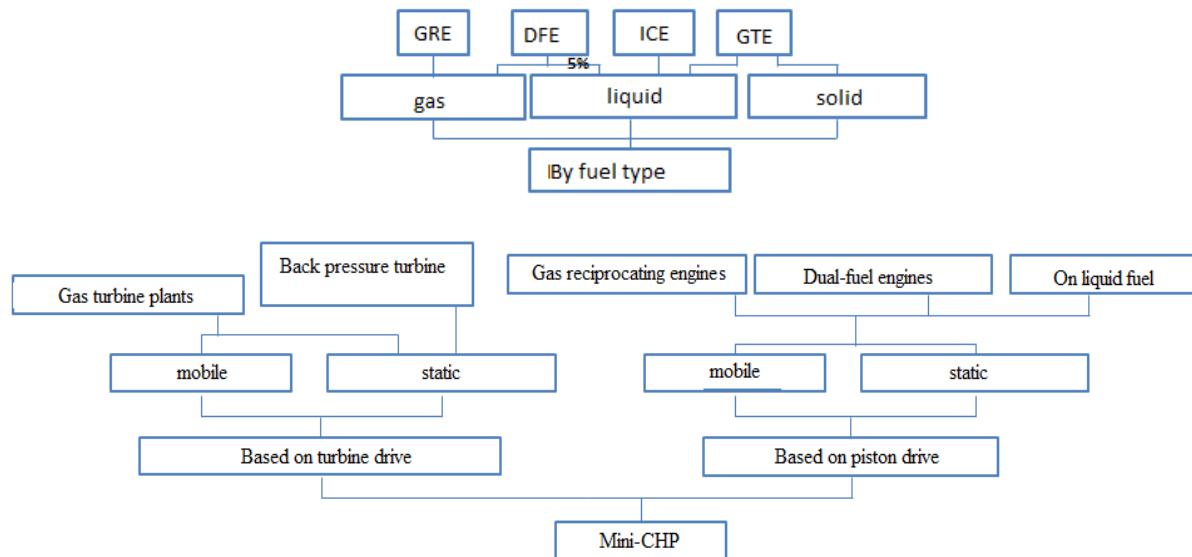
Boiler systems are the most common sources of thermal energy in Russia. Large district heating plants with an installed capacity of 100 MW supply with warmth hundreds of apartment buildings and an important thermal power facilities in the infrastructure of cities. In Kazan, for example, 122 district boiler houses operate.

2. Main part

Power supply (in this case electricity) of boilers themselves for their own use (pump drives, blast equipment, cooling fans) is realized from an external source, which is often the only way for the boiler house. Power failure in the boiler room in the winter period and the subsequent shutdown of equipment can lead to consequences connected with heavy losses. Consequently, the most promising solution to ensure the reliability and efficiency of boiler plants, including covering their own needs in electricity and additional sales of surplus power generated in the overall network is setup on existing boilers generators, drive, which can be a gas piston or gas-turbine engine (GTE) with hardware of flue exhaust gas utilization (mini-CHP). Organization of mini-CHP based on district boiler increases the reliability of power supply, thus energy loss during transportation and the cost of fuel for production of heat and electricity are reduced to a minimum. Building of structure of mini-CHP can be varied. Image 1 shows the possible options of CHP structure applied to the reconstructed and newly projected sources.



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Im. 1. Variants of organization of mini-CHP.

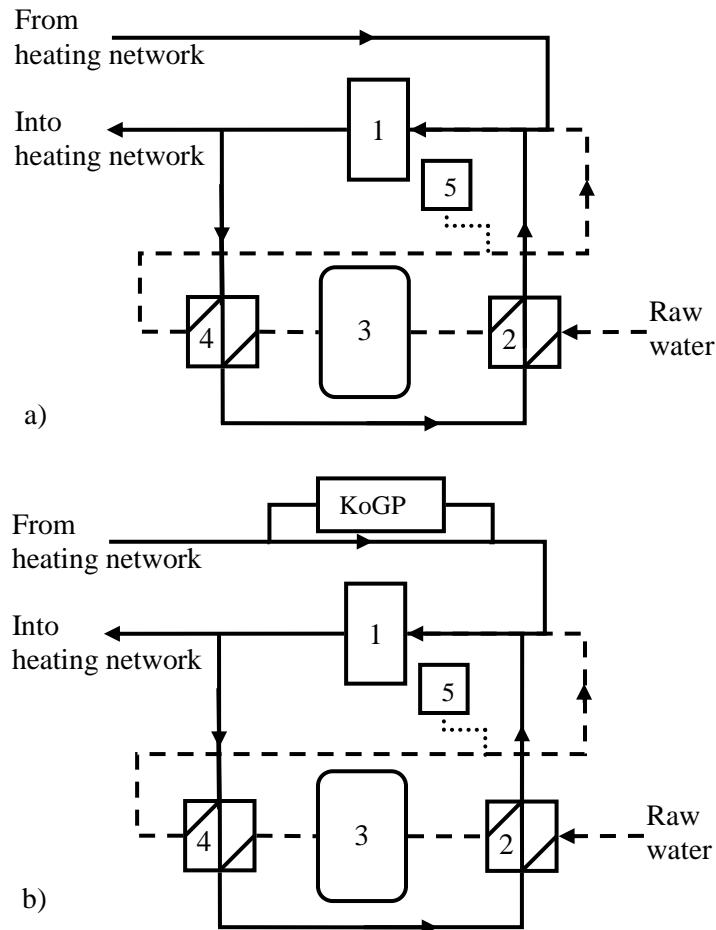
GRE- gas reciprocating engine; DFE- dual-fuel engine;
ICE- internal-combustion engine; GTE- gas turbine engine.

As seen in Image 1, for fixed installations, gas-fueled, competing options are mini-CHP based on GTE and GRE.

Heat boiler schedule is characterized with big unbalance. This leads to difficulties in selecting the operation mode of the cogeneration superstructure. It is known that the greater the number of hours electricity is generated on the basis of caloric intake per year, the higher the efficiency of the cogeneration settings (KoGS). Year-round thermal load in the boiler houses is only hot water (DHW). In this connection, the thermal power cogeneration unit of mini-CHP is advisable to be chosen based on the conditions covering the DHW load in the summer period, which provides its year-round operation and, therefore, the most effective use. On the other hand, the relative capital costs of establishment of power generation set decrease with the increasing of their unit power. Therefore, for the reconstruction of boilers in mini-CHP firstly it's necessary to choose the largest of them [2,3].

Similar object is a thermal boiler of Kazan city, located at Kashtanovaja Street, 18 (2a). Boiler room is equipped with boilers brand KVGM-10 at the number of 1 unit and HRG-8 at 3, with the pump: ZN-400-105 – 3 units, D-315-71- 3 units. Connected heat load of heating is 21.96 Gcal / h, of ventilation is 0.34 Gcal / h, DHW 3.58is Gcal / h.

This boiler was selected as the base object in research. Due to the fact that the boiler operates on natural gas, as options of its restructuring reorganization was considered superstructure based on GTE on the type GTES- 25P and based on gas engines brand of YMZ -8503 (Image 2b).



Im. 2. The scheme of the original water boiler and synthesized on the basis of its mini-CHP
 a- the original scheme; b- synthesized mini-CHP with cogeneration units:

1- water-heating copper; 2- the raw water heater; 3- chemical clearing; 4- heater of the chemical cleared water 5- reagent tank

Optimization of regime parameters of mini-CHP and its structural organization was conducted based on the methodology of System Studies of industrial CHP, which has been applied to the new object - water boiler house, translatable in mini-CHP mode [4, 5]. The method includes the analysis of the efficiency of heat and power facility, structural modeling of the synthesized object with improved performance and optimization of mode parameters on the selected criterion of efficiency.

In this case a power-economic optimization was held. The extremum (maximum) function was the object of search

where – reached fuel saves compared to the base case (heating from the boiler house, power supplying of boiler house from condensing power plant CPP) - the coefficient of the synthesized cogeneration of mini-CHP.

Optimization calculations were carried out by approved methods described in [5].

3. Conclusion

Comparative analysis of the results showed that the best performance is the structure of mini-CHP with GRE. Compared with the alternative base variant optimized mode provides 46% fuel savings. Option with GTE was less effective, but compared to the base case it also gave 41% fuel savings.

When working optimally mini-CHP based water boiler house allows you to fully meet its own needs for electricity in summer period and 50% of the needs of the boiler during the heating period.

4. References

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