Use of energy potential of thermal power plants in engineering infrastructure of the city

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Abstract. In the current energy market thermal power plants (TPP) must compete with other sources of thermal and electrical energy and at most of the city's heat and power plants, there are significant reserves to improve efficiency associated with the use of the power potential of the TPP in the city's engineering infrastructure. The article summarizes the developed technologies aimed at increasing the efficiency of TPP due to their use in urban engineering infrastructure in the following areas.

Main part
In the current energy market thermal power plants (TPP) must compete with other sources of thermal and electrical energy. The current model of the wholesale market of electricity and power determines the principle of equality of generators regardless of the distance of electricity transmission between the power plant and consumers. Tariffs for electricity from TPP located in the center of loads include a transport component comparable to the cost of electricity generation. In such conditions, the TPP is becoming increasingly difficult to compete in the wholesale electricity market from nuclear power plants, HPPs and GRES. At the same time, there is a decrease in the thermal efficiency of the TPP due to a significant reduction in the generation of electricity by thermal consumption caused by a decrease in heat supply from the TPP to hot water and process steam [1]. However, at most of the city's heat and power plants, there are significant reserves to improve efficiency associated with the use of the power potential of the TPP in the city's engineering infrastructure.

Joint production of heat and electric energy, as well as products and services needed in the municipal utilities, allows to achieve a systemic effect in the energy sector, as well as to obtain more favorable operating conditions for TPP facilities [2].

The article summarizes the developed technologies aimed at increasing the efficiency of TPP due to their use in urban engineering infrastructure in the following areas [3]:

- use of TPP for utilization of snow and snow-ice mass exported from city streets in special installations due to the use of low-potential heat sources;
- joint use of the engineering infrastructure of centralized heat and water supply to consumers, namely the use of urban TPP in the drinking water preparation scheme of the centralized cold water supply system.

The analysis of snow reclamation technologies currently in use has shown that there are several ways to dispose of snow removed from city streets with the use of both stationary snow-melting units (SSMU) and mobile units, usually operating on liquid fuels. To date, the leader in the number of used snow melting units is Moscow. However, the SSMU implemented in the metropolitan area does not use low-
potential heat sources from the TPP, except for the heat of the purge water of the circulating water supply systems. The carried out research of realized, and also offered for realization of technical and technological decisions on disposal of snow taken out from city streets has shown that for today there are no energy-efficient solutions that allow using the power potential of the TPP to solve the problem of snow utilization.

In the field of drinking water preparation, there are also significant reserves for improving the energy efficiency of the TPP due to the joint use of the engineering infrastructure of centralized heat and water supply to consumers.

Consider the developed schemes for the use of TPP for the utilization of snow removed from city streets.

The main advantages of using TPP for snow utilization are: transport accessibility associated with the location of TPP in the city; availability of low-potential sources of heat, suitable for the utilization of snow; availability of water treatment systems.

It is suggested that snow should be disposed of in a snow melting chamber installed in the territory of the TPP. As a heat carrier it is proposed to use one of the following sources of heat: reverse network water and circulating cooling water after the turbine condenser.

The technologies presented in figures 1 and 2 are applicable for the utilization of a significant amount of snow-ice mass, within a few hundred tons per hour.

**Figure 1.** Scheme of using the heat of circulating water after a turbine condenser (RF patent No. 165883).

**Figure 2.** Scheme of using heat of reverse network water as a heating agent (RF patent No. 165483).

The advantage of the technology of using circulating cooling water after the turbine condenser (figure 1) is the maximum thermal efficiency, due to the use of the heat of the exhausted steam turbines. The disadvantages of the contact method of snow utilization at the TPP include the need to install wastewater treatment plants of sufficiently high capacity for water purification after the snow melting.
chamber, as well as a limited scope of use due to the operation of the TPP with a minimum condensation load in the winter.

The most reasonable from the point of view of applicability to the TPP is the scheme using the reverse network water (figure 2). The advantage of this scheme is the rather high thermal efficiency associated with the increase in the generation of electricity by thermal consumption due to the lowering of the return water temperature in front of the network heaters.

A cost-effective solution across the city is the joint use of the engineering infrastructure for centralized heat and water supply to consumers, namely the use of urban TPP in the drinking water preparation scheme of the centralized cold water supply system.

For this purpose, it is proposed to carry out an adjustable (up to 20 °C) heating of the drinking water of a centralized cold water supply system in an integrated bundle of a condenser of a dedicated steam turbine (figure 3).

Figure 3. Use of the steam turbine condenser of the existing TPP for water heating of the centralized cold water supply system.

The main result of the regulated heating of drinking water directed to consumers is the reduction of the heat consumption for heating the hot water supply system (HWS) of both open and closed heat supply systems, and the systemic energy effect is achieved by replacing part of the heat load of the HWS covered by the heating runs of the district heating turbines, used steam.

To estimate the energy efficiency of structural and regime changes in the thermal schemes of the TPP, a methodology based on the use of such an index of thermal efficiency as the specific generation of electricity for thermal consumption was applied. When calculating the energy efficiency indicators, this method takes into account the value of the specific power generation due to the steam turbine selections and the regenerative heating of the steam condensate used to heat the coolants [4].

The most reasonable from the point of view of investment efficiency is the technology using back-up network water for the utilization of snow at the TPP. Calculations show that for the conditions of Ulyanovsk TPP-1 at a capacity of 650 t/h and 500 hours per year, the savings in equivalent fuel (in 2017 prices) will be 13.21 million rubles and the discounted payback period will not exceed 4 years.

When the proposed technology for heating drinking water in a centralized cold water supply system is implemented at the TPP, the main effect is achieved by increasing the power generated by the turbine unit on thermal consumption because of the additional vapor passage into the built-in capacitor bank of the dedicated turbine.

Table 1 presents the results of the feasibility study for real conditions, providing for the implementation of regulated heating of drinking water at Ulyanovsk TPP-1. The calculation took into account that the proposed scheme is operated for 8 months (except for summer months and September), and the average hourly flow of drinking water is 1800 t/h, the actual data on drinking water temperatures
for different months of the year are taken into account, as well as the reduction of thermal efficiency to the decrease in the capacity of heating selections due to the use of warmer drinking water for hot water.

**Table 1. Results of the feasibility study for the technology of controlled drinking water heating.**

| Value                                              | Technology of heating with an open heat supply system |
|----------------------------------------------------|------------------------------------------------------|
| Total output of electricity by thermal consumption, kW·h | 3336.2                                               |
| Cold water consumption through condenser, t/h        | 1800                                                 |
| The value of the specific output of electricity by thermal consumption, kW·h/t | 1.9                                                  |
| Annual savings of conventional fuel, t               | 5184.0                                               |
| Saving conventional fuel, million rubles at 2017 prices | 20.19                                               |
| Capital expenditures, million rubles at 2017 prices  | 26.03                                                |
| Payback period, years                               | < 1                                                  |

Thus, the results of the feasibility study presented in Table 1 confirm the effectiveness of the proposed technology of controlled heating of drinking water at UITPP-1. Taking into account the capital costs in the amount of 26.03 million rubles, including the cost of installing additional pipelines, as well as the installation of ultraviolet disinfection, the payback period of the project does not exceed one year.

**Conclusions**

1. It is established that there are significant reserves for city heating and power plants to improve efficiency associated with the use of the power potential of the TPP in the city's engineering infrastructure.
2. A complex of new technological solutions providing for increasing the efficiency of the TPP due to the use of their energy potential in the urban engineering infrastructure is proposed and justified:
   - technologies for the use of TPP for the utilization of snow removed from city streets in snow melting plants due to the use of low-potential heat sources: return water and circulating water after the condenser;
   - technology for the use of urban TPP in the drinking water preparation scheme of the centralized cold water supply system;
3. The assessment of technical and economic indicators of TPP in the implementation of new technologies for the disposal of snow removed from city streets was performed. It has been established that the most effective technology is the use of heat of reverse network water.
4. As a result of the calculation of the energy efficiency of the technology for the use of urban heat and power plants in the drinking water treatment scheme of the centralized cold water supply system, the example of the city of Ulyanovsk revealed that the increase in the capacity developed by the turbogenerator for thermal consumption exceeds 3.3 MW in terms of a power unit with a turbine of type T-100-130.

**References**

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