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Organization of Energy Efficient Generation Systems with RES - Components

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Abstract. The issues of organization of operation of heat generation systems as modernization objects considering modern requirements of their prospective development as an integrated combination of traditional heat generation system with RES components and technologies are shown in the article. The main directions of development of generation systems with RES components in assessment of ecological and economic approaches of modernization are formulated. Technological capabilities of RES-components for implementation of energy-efficient modernization and low-carbon emissions projects and creation of integrated electric power systems of thermal energy are shown.

INTRODUCTION

The priorities of energy technology development are aimed at increasing efficiency, environmental safety and sustainability in relation to the human environment. Energy generation facilities in operation in the Republic of Kazakhstan mostly use energy coals from local coal mines as fuel. In combination with outdated technologies for obtaining electric and thermal energy, this creates problems associated with the low efficiency of these energy facilities, as well as unacceptable heavy load on the environment due to high emissions into the atmosphere.

Therefore, the organization of operation of coal-fired heat and power generation (CHP) systems should be considered as the basis for a modern integrated and systematic approach to the formation of scientifically sound technical policy in the field of ensuring the required energy efficiency and environmental friendliness.

In this regard, at least two basic guidelines should become basic: maximizing energy efficiency at a given level of reliability and minimizing total or lifetime costs.

Here, the following characteristics of ESTG functioning should be highlighted as the main groups. These groups will be: design, operation and manageability. The group of properties "Development" includes technical and economic indicators of ESTG, characterizing the stability and dynamism, inertness and discreteness. The group of properties "Functioning" will be characterized by complex, interrelated properties of economy and reliability. And the group of properties "Manageability" will have to include such properties of ESTG, such as the incompleteness of information, adaptation and uncertainty of the optimal solutions, self-organization and multi-criteria.

Based on the above, we will set the task to analyze the existing technological state, identify new trends in high performance energy technologies that are in harmony with the environment and their applicability in existing energy technologies.

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EXPERIMENTAL METHOD AND TECHNIQUE

Energy-efficient development of ESTG in the criteria of requirements of ecological and economic approaches of modern modernization is aimed at formation of economically and environmentally acceptable fuel and energy balances.

They consist of the following: strengthening the energy-saving policy, as part of all extracted energy resources is lost, which leads not only to economic but also to environmental damage; reconstruction of the heating sources and electric power components with the use of highly efficient modern gas turbine (GTU) and combined cycle gas turbine (CCGT) units; expert evaluations on investment and energy-efficient projects; priorities for the investment of energy facilities; development and correcting of the energy balance [1-4].

To assess the economic efficiency of modernization of energy facilities it is advisable to use the following characteristics as the main indicators: internal rate of return, payback period and profitability.

The analysis of functioning ESTG power systems should be carried out based on system analysis methods with substantiation of power efficiency indicators and mathematical modeling and calculate on of power equipment characteristics. The priority direction in the analysis of functioning of energy systems is to meet the requirements of ISO 13602-1-2009 - Energy Technical Systems "Analysis Methods".

Perspective planning of ESTG development includes goals and cycles and planning horizons. Development planning should be carried out in the context of short-term – (1...3) years, medium-term – (5...7) years and long-term – (10...15) years. Development of generating capacities. It is recommended to substantiate feasibility of CHP construction, selection of type and unit capacity taking into account existing and prospective schemes of regional components and systems of heat supply, level and concentration of heat loads, dynamics of their growth, volumes and modes of power generation both in heat and condensation modes, as well as efficiency of power generation in condensation mode in comparison with power supply from the wholesale market [3-5].

Justification of solutions in planning the development of innovative energy efficiency solutions should be carried out by comparing development options by assessing their relative efficiency by the criterion of minimum total discounted costs.

It is preliminary to determine the comparison of operational technological indicators of the energy object. For this purpose, losses of electrical energy can be used. They could be calculated by one of the generally accepted methods in the electric power industry in particularly operational calculations or calculation days, or average loads, or number of hours of the largest power losses or estimation of losses based on data on existing configurations and schemes of power supply and actual values of operational loads.

Energy efficiency increasing of the power generating object, on the CHP example, can be achieved by increasing the specific supply of electrical energy due to sequential optimization of equipment of the system of technological functioning of the plant [5-8].

The main principles of integration of newly constructed and upgraded ESTG facilities into the existing power systems can be formulated as necessity to consider the impact of the newly connected component of the ESTG on the change of operating modes of the existing power system as a whole. Connection of the energy infrastructure of a newly constructed facility shall not have a negative impact on the operation of other parts of the energy system. Type and parameters of energy resources consumed by newly constructed ESTG facilities shall be selected, if possible, identical to the already used energy resources.

The figure 1 shows the example of solar high-temperature energy technologies for heating the feed water of the heat generation system what can be effectively used to reduce fuel consumption in modernized heat generation facilities, for example, in areas with high solar activity [6,7].

Moreover, for harmonious modernization and ensuring the recommended degree of energy efficiency the newly introduced components of ESTG energy connections to the existing energy facilities should be sufficiently considered. At the same time the specific features of the long-term development plan of the energy system, which should also provide the necessary conditions for the capacity of energy communications, as well as the limiting capacity of transformers in operation and other conditions, should be considered.

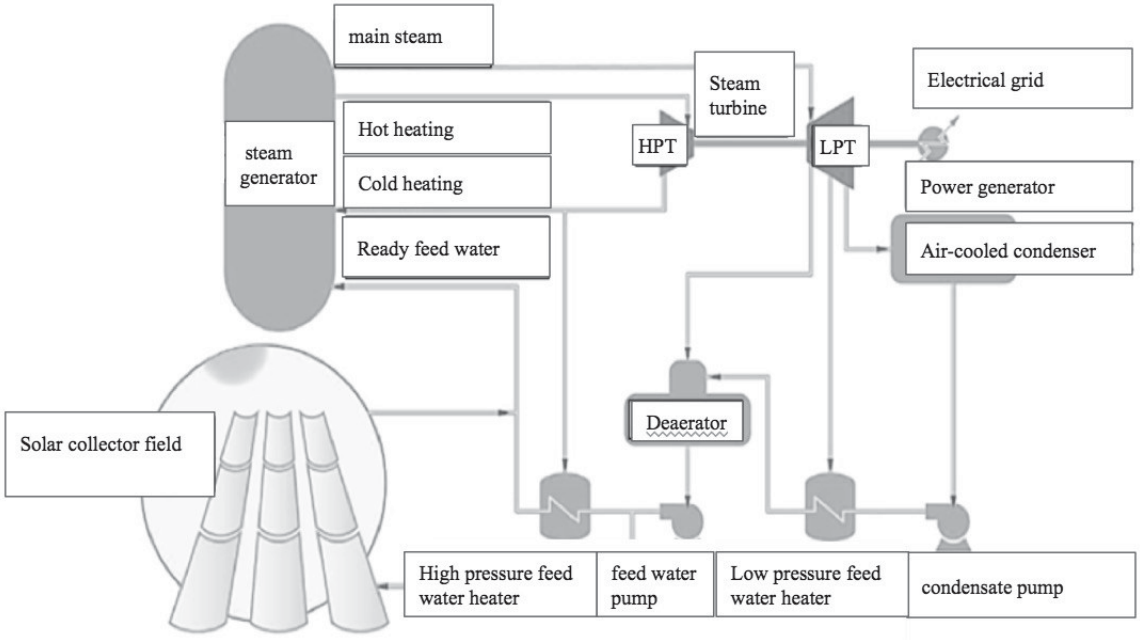

FIGURE 1. Scheme of RES heating of power plant feed water using solar thermal energy

To evaluate the effectiveness of ESTG commercial investment projects when developing business plans for feasibility studies and other documents that lead to economic benefits, namely, additional income to reduce costs or avoid a reduction in income, the organization is considered to be a profit center for evaluating the effectiveness of projects. In the process a comparison with the basic version is made.

The issues of improvement of technological indicators of ESTG, namely, reduction of coal (or gas) fuel consumption, as well as improvement of ecological safety.

Particularly, using additional solar generation devices in the form of high-temperature solar thermal collectors, which are designed to form an integrated power generation with improved energy, economic and environmental performance. For example, the technological schemes of solar thermal plants for their own needs of thermal power plants, used in technologically developed countries, can be reduced to a scheme with the main technological units: the path of coal fuel supply, boiler and turbine generator, pulverized coal and air systems, as well as the use of additional renewable energy components.

The technological scheme of the solar plant described in Technology Roadmap Solar Thermal Electricity (Figure 2) is a combination of solar RES components which are high-temperature thermal unit and solar photoconverters. This scheme allows generating energy 24 hours a day, 7 days per week. PV-system produces a low cost daytime generation. The high-temperature solar thermal unit supplies energy to the steam turbines, generating energy. A natural fossil fuel power machine can be used as an additional backup device. Such arrangement of RES components can also be used in the process of modernization of existing coal or gas plants to improve their efficiency and environmental safety [6,7].

Improved environmental safety of the thermal power plant is achieved by integrating innovative and renewable energy components. One of the possible technological solutions when using RES components in solar power generation systems to improve environmental safety and thermal efficiency of solar high-temperature thermal unit is the design of solar collectors in a closed optically transparent shell. This will increase the service life of mirror surfaces of solar thermal collectors, protecting them from adverse and aggressive effects of natural and climatic conditions and human factor.

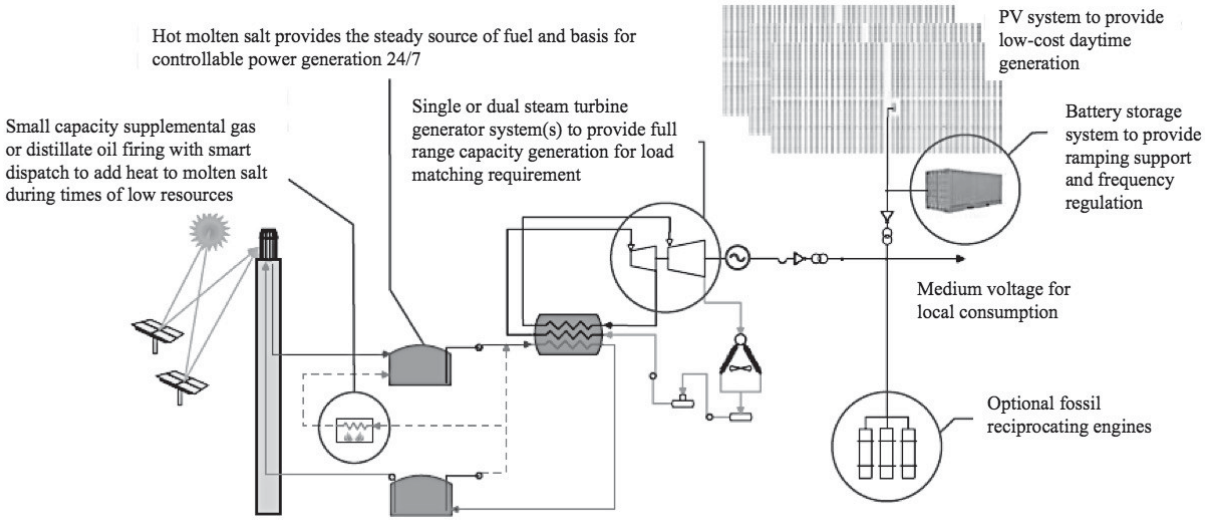

FIGURE 2. Prospective combined solar RES components as an option for modernization of thermal power plants in operation

Technological scheme of coal energy cycle with a subsystem of combined cycle of gas turbine and a system of carbon dioxide capture and storage will improve environmental safety. In this case, through the introduction of innovative technologies in the thermal power industry, it is planned to achieve dioxide emissions up to 669 gSO2/kWh by 2020 [6-9]. The data presented in Figure 3 demonstrate the development of coal power generation technologies in terms of energy efficiency improvement, primary fuel consumption efficiency, as well as environmental safety expressed in reduction of emissions of combustion products into the atmosphere.

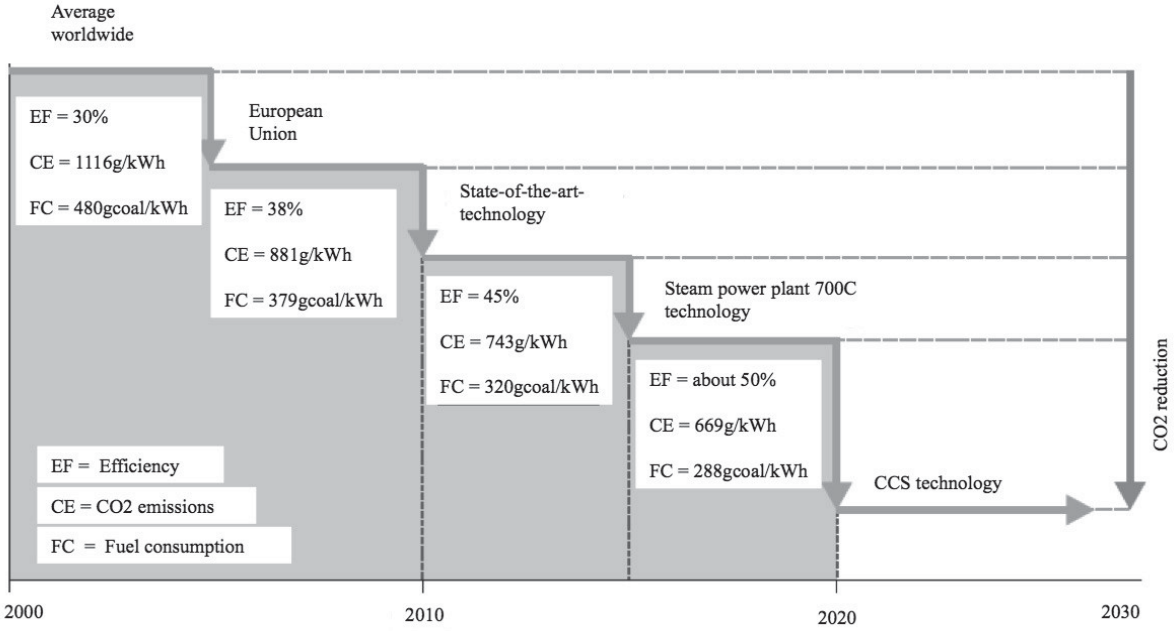

FIGURE 3. Demonstration of technological development of coal technologies in the energy sector

Existing technologies of coal power plants, which are currently in operation in the Republic of Kazakhstan, as well as in other countries of the former USSR, do not meet modern requirements. Especially it concerns emissions into the atmosphere, which for power plants using power coals of Ekibastuz coal deposit are much larger than it is

shown on figure 3 for level 2000. The same applies to energy efficiency and economy indicators. Therefore, using the studies of the state and priorities of new energy technologies presented in this paper, it is necessary to put into operation, as a matter of urgency, replacement and/or complementary technical solutions aimed at solving the above tasks of energy and ecological problems.

CONCLUSION

To summarize, at calculating project efficiency the following should be taken into account: all investment costs associated with project implementation, including loss of profit and additional effects of project implementation by comparing the proposed energy efficiency option with the best possible alternative. Moreover, generating capacities traditionally using coal or gas create opportunities to improve their energy efficiency and environmental safety through the creation of combined power and heat generating capacities of new generation with the use of innovative technologies and renewable energy components.

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