Prospects for combined production of electric energy, heat and cold – a current direction in energetics in the conditions of the transition to a green economics

Rashid Jalilov[1*], and *Nigora* Sharipova[1]

[1]Bukhara Engineering Technological Institute, 15, street K.Murtazoyev, Bukhara, Bukhara region, 200100, Uzbekistan

Abstract. The article is devoted to the study of the implementation of combined systems designed for a wide range of energy services offered to the consumer, the use of resource-saving and environmentally friendly systems in order to increase their reliability in the context of the transition to a "green" economics. It analyzes various technologies for using generations (+ cold production), which are significantly superior in their performance to the world's best technologies for combined generation of electric energy, heat, etc.

1 Introduction

As noted [1-2, 17], currently in Uzbekistan, as in many developed countries, they pay great attention to the transition and creation of a "green" economics, ensuring an efficient, resource-saving and environmentally friendly economics of the state in the face of climate change. Resolution of the President of the Republic of Uzbekistan No. PP-4477 dated 10/04/2020. "On approval of the strategy for the transition of the Republic of Uzbekistan to a green economics for the period 2019–2030" is aimed at improving the regulatory framework and policies for the green economics, encouraging innovative green investments through partnerships between public and private sectors. The document approved the Strategy for the transition of the Republic of Uzbekistan to a "green" economics for the period 2019-2030 [1-2]. First of all, the "green" economics is aimed at the economical consumption of those resources that are currently subject to depletion (oil, gas, coal) and the rational use of inexhaustible resources [2-3, 17]. At the core the green economics is comprised of clean or "green" technologies.

Among the tasks aimed at increasing the energy efficiency of basic sectors of the economics, diversifying the production and consumption of energy resources and developing the use of renewable energy sources, the following were noted:

* Corresponding author: zhalilov.rashid@mail.ru

- Reconstruction and modernization of generating capacities of existing power stations with the introduction of highly efficient technologies based on steam-gas and gas turbine installations.
- Introduction of new technologies for generating thermal energy, including technical cogeneration technologies in central boiler houses, coal-fired steam turbine power installations at super over critical steam parameters.

Priority areas for the implementation of the Strategy in the field of heat power include: the introduction of new technologies for generating thermal energy, modernization and reconstruction of outdated equipment of boiler houses, turning them into cogeneration installations, equipping consumers with modern metering devices, the use of solar collectors for heating water in boiler houses, etc. In addition to the combined production of heat and electricity at thermal power stations, the use of generations (+ cold production) is becoming relevant, and the use of chemical fuel cells provides not only the generation of electrical energy, but also the production of fresh water, the shortage of which is beginning to become more and more apparent in many countries. Among new energy sources, generators of intermediate types of energy carriers, hydrogen and electrochemical, solid-state and methanol, gas hydrate and bio-energy, deserve special attention.

A review of scientific literature shows that by the transition to the creation of a “green” economics, hydrogen has been selected as the most common element on the surface of the earth and in space, the heat of combustion of hydrogen is the highest, and the product of combustion in oxygen is water (which is again introduced into the circulation of hydrogen energy). With the transition and creation of a “green” economics, hydrogen energy becomes an alternative energy [5-11, 13-15, 17].

Hydrogen has a number of advantages, since it is universal and can be used similarly to natural gas - in transport, industry, electric power, and also stored and transmitted similar arms. There is a selection and sources of hydrogen production, from coal and oil to atomic energy [3-5, 8-10, 13-17]. Gradually, projects using hydrogen in the area of large and distributed energy, energy accumulation and all types of transport, from cars to airplanes and sea vessels become serial. The new energy revolution may lead to a change in the power system and the gradual formation of the overall global energy market based on hydrogen [2-5, 8-10, 13-17].

In modern industrial enterprises, especially food and agricultural purposes, there is a huge need and in the cold when processing and storing agricultural products, in the production and processing of meat-dairy products and in the production of pet meat.

2 Materials and methods

Electrolysis allows you to split water molecules to hydrogen and acid-burden, and if the electricity is received for this process from renewable sources, then the "green" hydrogen will be obtained. This technology will become an excellent opportunity to reduce emissions and increase the value of net energy [8, 13]. The cost price of process (6-7) dollars / kg, when using electricity from an industrial network, (7-11) dollars / kg using electrical energy, selected from the wind generator, (10-30) dollars / kg using solar energy. Biomass hydrogen is obtained by thermochemical or biochemical disposal. With a thermochemical method, biomass is heated without access of oxygen to a temperature (500-800) °C (for wood waste), which is much lower than the temperature of the coal gasification process. As a result of the process, hydrogen (NG), methane (CH_4), carbon monoxide (CO) is released. Cost price of process (5-7) dollars/kg.

It is known [8-11, 13, 15, 17] that fuel cells are electrochemical devices that convert the chemical energy of the fuel directly into electrical energy. They generate electrical energy as a result of an electrochemical reaction. Their efficiency varies from 46 to 61%, so fuel

cells can become the basis for a highly efficient hybrid energy cycle. The efficiency of a fuel cell does not depend on its size and load (Figure 1), and the heat generated during the reaction can be effectively used in cogeneration. The fuel cells themselves have exceptionally low emissions levels.

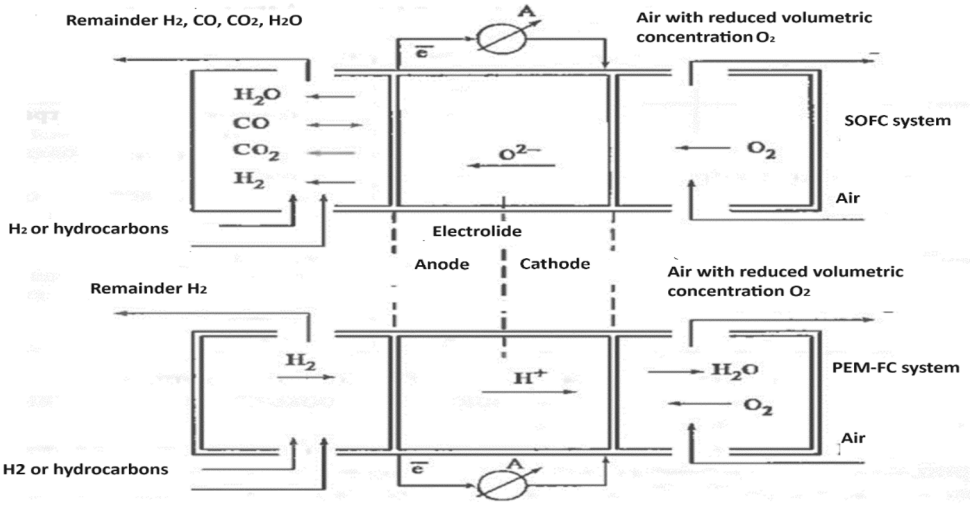

Fig. 1. Fuel cell operation diagram (Siemens).

Remainder After merging with the Westinghouse division, Siemens is focusing on the creation of power stations with solid oxide fuel cells of tubular design. Particularly suitable for hybrid cycles are solid oxide and liquid carbonate fuel cells with a high-temperature gas flow at the outlet, the energy of which can be used by a gas turbine installations (Figure 2).

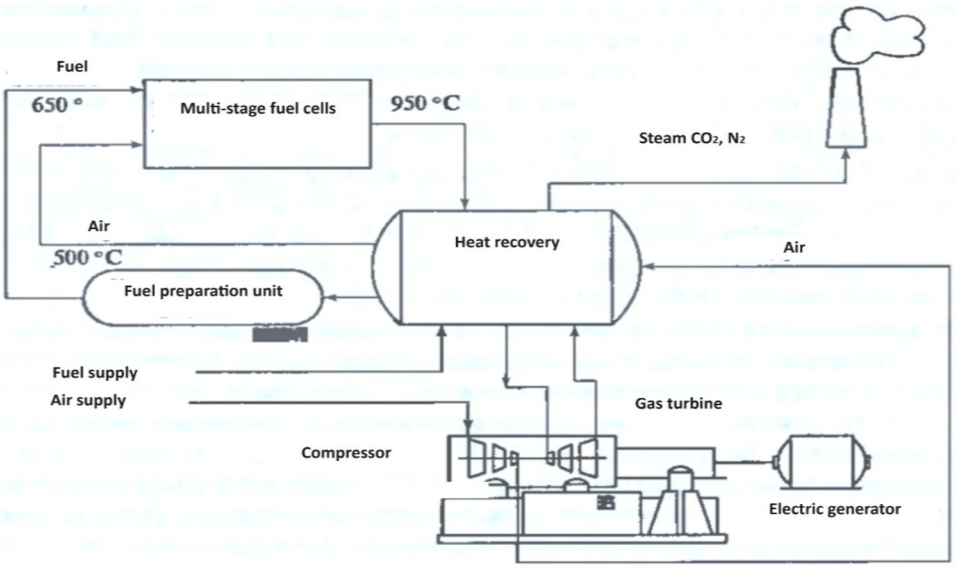

Fig. 2. Concept of combining a gas turbine installations with fuel cells.

Significant progress in the development of fuel cells has been achieved by the company Siemens (Germany). Demonstration and operating installations have been created, confirming the prospects of the ongoing research (Table 1).

Fuel cells are arranged in separate blocks and consist of round and flattened tubular elements 50-150 mm long. Power of one element reaches 200 Watt a voltage of 0.65V.

Table 1. Technical data of fuel cells from (Siemens).

Fuel cell type	Ambient temperature, ^{0}C	Efficiency factor of electricity generation, % no more	Fuel used	Note
PEM – FC (polymer-electrolyte, membrane FC)	60-80	40	Natural gas, hydrogen	Demonstration installation
PAFC (phosphoric acid FC)	160-220	40	Same	Commercial production of more than 200 copies
MCFC (fusible carbonate in fuel cell)	620-660	65	Natural or synthetic gas, hydrogen	Demonstration installation
SOFC (solid ceramic FC)	800-1000	70	Same	Same

Specific indicators of fuel cells do not exceed 200 W/kg and 200 W/m^3, and unit costs were $12,000 per.1 kW of installed capacity with the trend of this value decreasing by 2020 to $500.

A device consisting of fuel cells, fuel and oxidizer supply systems, removal of reaction products and automation is called electrochemical generators (EChG). A power station based on fuel cells, in addition to ECG, includes the following systems: preparation and processing of fuel and oxidizer, conversion of direct current into alternating current (inverter), processing of reaction products and utilization of their heat.

The company Ballard Power Systems (Canada) has developed a stationary power station with solid polymer fuel cells with a power of up to 250 kW, operating on natural gas. International Cells Corporation (USA) has created a model of a power station with phosphoric acid fuel cells with a capacity of 200 kW and combined production of electrical energy and heat [11-16].

As studies have shown [11-16], gas turbine installations can be used with high efficiency in thermal circuits of air-storage gas turbine thermal power stations (ASGT TPS) (Figure 3).

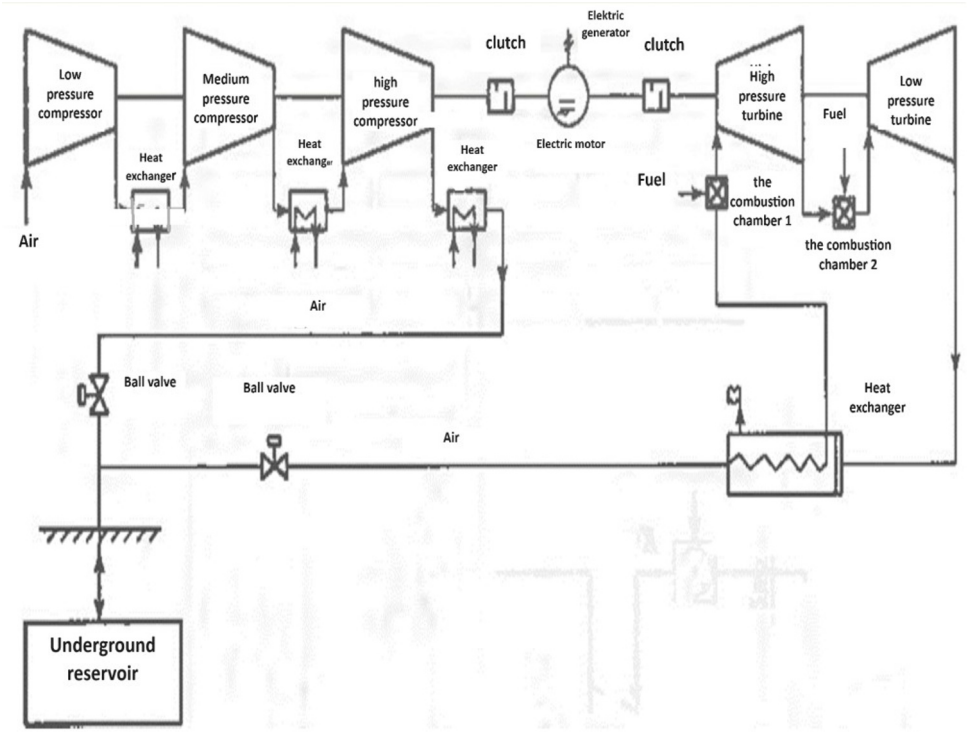

Fig. 3. Schematic diagram of an air-storage gas turbine thermal power station.

3 Results and Discussion

In Figure 4 shows the dependence of the relative change in fuel consumption flow to the SGD unit from the power of the SGD unit at different temperatures of high steam pressure.

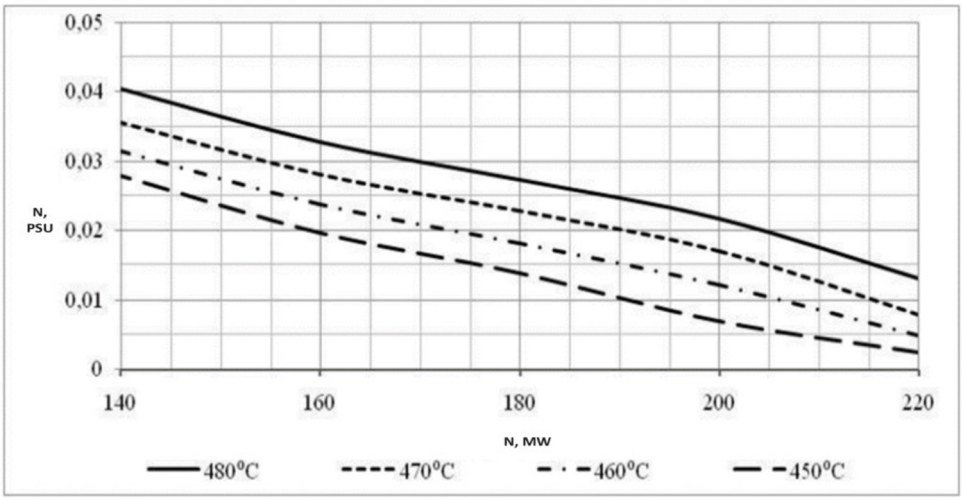

Fig. 4. Data on relative changes in fuel consumption.

Analysis of the data obtained shows:

- The SGD mode with base power has maximum efficiency 220 MW with high pressure steam heating from 445 to 470 °C.
- For each base load the optimal steam heating temperature high pressure is on the limit of either the dryness of the steam behind the last stage of the low-pressure cylinder, or the permissible temperature at the inlet to the high-pressure cylinder of the steam turbine (in the table, the optimal temperatures are highlighted in bold and are shown in Figure 3 of thermal power station equipment in accordance with modern requirements.

4 Conclusion

In our opinion, the tasks posed in [1] must be solved taking into account the "fuel" feature, ensuring the transition to "green" energetics. It is predicted that by 2050, 18% of the world's energy demand could be met by hydrogen, which is about 78 EJ. The corresponding emission reduction potential is 6 gigatons of CO_2 per year. To achieve this goal, the share of renewable energy sources in global final energy consumption must increase from 18% today to 65% in 2050.

References

1. Resolution of the President of the Republic of Uzbekistan No. PP-4477 dated October 4, 2020 "On approval of the strategy for the transition of the Republic of Uzbekistan to a green economy for the period 2019 – 2030." Lexx.Uz. (2019)
2. K.R. Allaev, Modern energy and prospects for its development. Under the general editorship of Academician A.U. Salimov, T.: "Fan va texnologiyalar nashriyot-matbaa uyi", 952 (2021)
3. Does Uzbekistan need a low-carbon development path for the country? https://nuz.uz/nauka-i-tehnika/49038-nuzhen-li-uzbekistan uputnizkouglerodnogo-razvitiya strany. html
4. Combined micro-sources of thermal and electrical energy, https://global.kawasaki.com/ru/energy/solutions/distributed power/index.htm
5. Trigeneration, http://www.energosovet.ru/entech.php?idd=98
6. District cooling supply with cogeneration, http://www. Energo-sovet.ru/ entech.phpidd=99
7. R.B. Zhalilov, U.U. Kamalov, Prospects for the combined production of electricity, heat and cold are a current trend in the energy sector in the context of digital transformation. Journal "Development of Science and Technology", Bukhara, Bukh ITI, **6**, 138-146 (2021)
8. Global energy of the future - hydrogen, smart networks and energy-efficient buildings, https://eenergy.media/2020/02/06/mirovaya-energetika-budushhego-vodorodniye-seti i enegoeffektivniye-zdaniya/
9. Hydrogen energy is a trend of the 21st century, http://atomicexpert
10. Hydrogen energy in the world 2020: status and prospects, https://yandex.uz/images/search textHydrogen energy
11. R.B. Jalilov, N.O. Sharipova, Study of the prospects for combining combined cycle gas plants with hydrogen fuel cells, Proceedings of the International Scientific and Technical Conference on the topic "Efficient Energy of the Future - Problems and Solutions." Fergana, Fer PI, 451-456 (2023)

12. R.B. Jalilov, A.D. Samigullin, O.G. Puzyreva, Current trends in the development of trigeneration systems, Materials of the XI International Scientific and Technical Conference “Innovative mechanical engineering technologies, equipment and materials - 2022” (MNTK “IMTOM - 2022”), Kazan, **2**, 239-247 (2022)
13. R.B. Jalilov, O.G. Puzyreva, Hydrogen energy is an alternative energy source for the future, Proceedings of the International Scientific and Technical Conference “Current problems of energy in the context of digitalization of the economy,” Bukhara, Bukh ITI, 112-116 (2022)
14. Rashid Jalilov, Umar Kamalov, Anvar Akhmedov, Prospects for the combined production of electric power, heat and cold - the current direction in the energy under the conditions of digital transform. Scopus, Conference Paper, CEUR Work-shop Proceedings, ITIDMS 2023, 2843 (2023) https://aip.scitation.org/toc/apc/2552/1
15. N. Grib, Hydrogen energy: myths and reality, http://www.ngv.-ru/maga-zines/article/vodorodnaya-energetika-mify-i-realnost/
16. V.M. Maslennikov, Combined production of electricity, heat and cold is a current trend in modern energy, http://www.Energy-strategy.ru/projects/energy 21.htm
17. R.B. Zhalilov, Prospects for the combined production of electricity, heat and cold are a current direction in the energy sector in the context of the transition to a “green” economy. Proceedings of the International Scientific and Technical Conference on the topic: “Efficiency of using innovative technologies in agriculture and water management.” MTU “TIQXMMI” Bukhara Institute of Natural Resources Management, Bukhara, 188-196 (2024)