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## ENERGY EFFICIENT TECHNOLOGIES AT OIL FIELD FACILITIES

**Abstract:** One of the most appropriate solutions to reduce diesel consumption is the use of associated petroleum gas, which inevitably accompanies the oil production process. In the analysis performed, the use of APG significantly reduces greenhouse gases emission into the atmosphere.

**Keywords:** diesel, associated petroleum gas.

It is known, oil is one of the most important minerals ensuring the well-being of many countries including Russia. More than 500 million tons of oil are produced annually in our country. However, a significant number of oil fields are located in the Arctic zone, the border of which runs along the Arctic Circle. The development of such fields is complicated by climatic conditions, difficulties in cargo delivery and oil transportation, as well as distance from powerful energy systems.

The oil production method is chosen depending on the features of the field and the particular well. There are formation characteristics; oil properties; the presence of mechanical impurities, water and associated gas. Currently, the pumping method is mainly used. To prepare oil for transportation, booster pumping stations and separation plants are provided. All equipment of the well facility, complex for preparation of commercial oil and external oil transportation is a powerful consumer of electric and thermal energy.

An analysis of energy consumption of one of the fields within the Nenets Autonomous District shows that up to 95% of electric energy is used to provide process and household consumers. In following pie chart shows share ratio of electricity consumption by areas of use per year is showed (Fig. 1).

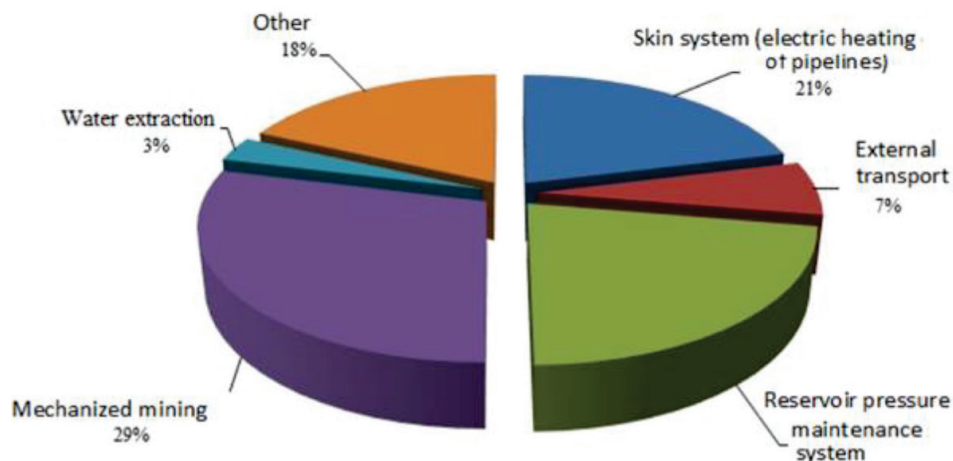


FIGURE 1. Ratio of electricity consumption by areas of use per year

Electricity generation is provided by diesel power plants. A significant amount of diesel fuel is also spent for thermal energy generation, taking into account the low temperature for heating calculation ( $-39^{\circ}\text{C}$ ) and, accordingly, the duration of a heating period of 289 days. Bar chart shows the data on specific energy consumption for the production of oil-containing liquid and oil in tons of oil equivalent per thousand tons of oil per year. According to the data, it can be seen that the increased specific energy consumption in the winter period is primarily associated with the cost of thermal energy generation (Fig. 2).

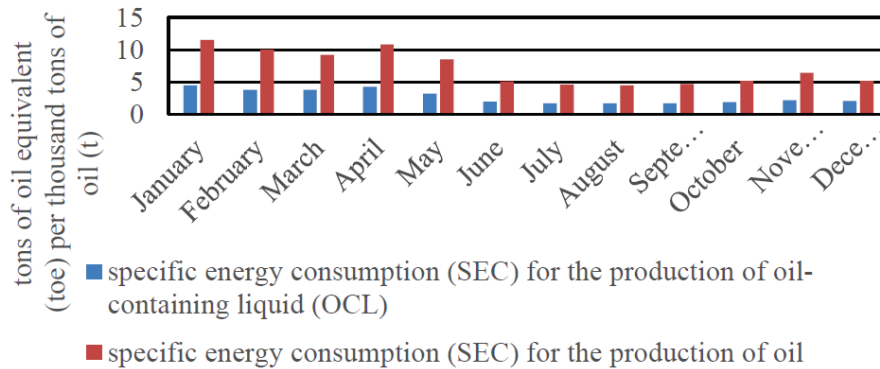


FIGURE 2. Specific energy consumption

Difficulties in diesel fuel delivery, the state policy in the field of improving the energy efficiency of production processes, the need to solve environmental problems in oil fields specify the search for alternative methods of heat and electricity generation.

One of the most appropriate solutions to reduce diesel consumption is the use of associated petroleum gas, which inevitably accompanies the oil production process. In the analysis performed, the use of APG significantly reduces greenhouse gases emission into the atmosphere. Moreover, in Russia, the volume of greenhouse gas emissions due to APG flaring is more than the total amount of the fields of Nigeria, Iraq and Iran. There are objective reasons for this related to oil production, distance of domestic fields from settlements – potential energy consumers.

In Russia, APG is used primarily for oil heating in special process furnaces at the stages of marketable product obtaining and during preparation for transportation. However, such furnaces do not provide heat recovery for a system for exhaust gases, the temperature of which reaches  $583^{\circ}\text{C}$ . The use of gas-water heat exchangers widely used at compressor stations would provide the rotational field camp and production facilities with thermal energy, thereby reducing diesel fuel costs. However, currently, for heating, its own hot-water boiler-house using diesel fuel is used, and electric heaters are used at distant sites (Fig. 3).

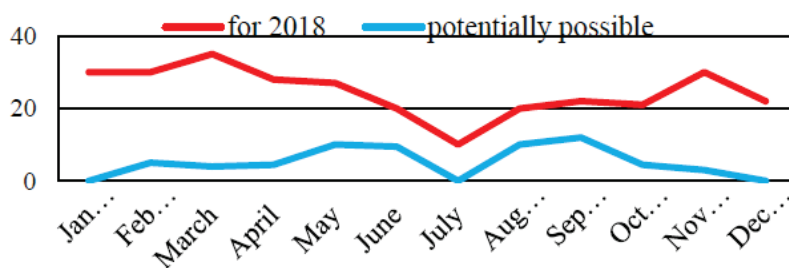


FIGURE 3. The use of gas-water heat exchangers widely used

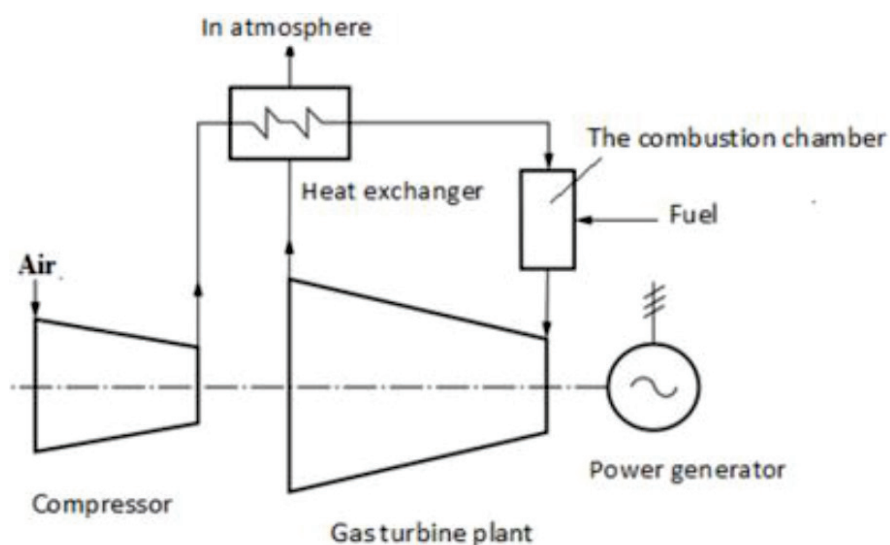
The boiler house also is not provided with the heat recovery system, while significant heat losses are associated with the above-ground laying of heating networks, poor insulation and non-compliance of burning characteristics of rotational field camps enclosing structures with the current energy saving requirements (Fig. 4).



**Figure 4.** Modern automated heat points with weather control

As a result, excessive consumption of thermal energy also leads to an excessive consumption of diesel fuel. In addition, to reduce thermal energy consumption, it is possible to use modern automated heat points with weather control.

When using gas power plants, currently the gas turbine exhaust gases with a temperature of about 500°C are removed without recovery, increasing thermal pollution in the atmosphere. In addition, the non-regenerative cycle has a rather low efficiency (28-32%). In order to save energy, it is proposed to use a regenerative cycle to heat cyclic air, which is also widely used in gas turbine units for gas blower driving at compressor stations of gas mains (Fig. 5). The use of the regenerative cycle according to the analysis will decrease the specific consumption of fuel gas corresponds to an increase in efficiency up to 37%.



**FIGURE 5.** Regenerative cycle

Another possible vector of energy saving in the development of energy resources in the oil field is the use of the combined cycle providing for reduction of exhaust gases temperature and increase in plant efficiency up to 60%.

There are also potential opportunities for energy conservation in the power supply system of the main production sites of the enterprise. Technical losses in electric networks are load losses (37%) and idle losses (62%) due to uneven energy consumption.

A modern energy-efficient automated induction-resistive system, which allows maintaining the necessary temperature conditions for transportation of oil (40°C,..., 45°C) and water (+10°C) is implemented at the enterprise for electric heating of the main pipelines. However, in order to avoid inefficient energy consumption, the system requires modernization, which consists of installation of additional temperature sensors on each parallel pipeline upstream of a common collector.

In terms of using alternative energy sources at the fields under question, wind generators can be used to generate electric energy, since the facilities are located in the way of the Bolshezemelskaya Tundra with a flat relief. The average wind speed is 4-8 m/s, which determines the feasibility of wind generators application. The calculation for one production site presents that the energy saving potential will be 2102.4 t-hous-kWh/year when installing wind generators with a total capacity of 396 kW.

One of the latest trends in energy saving, in particular in the European Union, is the use of energy cogeneration. Thus, as of 2020, the contribution of cogeneration had planned in the field of energy saving of about 15% and as for reduction of greenhouse gases – 24%. In this case, the share of cogeneration using equivalent energy sources is growing. The feasibility of distributed energy application is based on the conventional selection of equipment for peak conditions, while the structure of energy consumption is uneven. The use of distributed energy based on gas engine generator plants (GEGP) with gas-diesel engines and waste modules is a particularly rational solution for experiencing power shortages of oil fields development. Starting from the production drilling stage, this solution will allow stopping usage of boiler houses. The modular technology will provide for the possibility of a gradual increase in generators and energy consumers, and will make it possible to replace the electrical heating of pipelines with heat using antifreeze.

However, distributed power generation does not currently exclude the need for the delivery of diesel fuel, preparation for the respective generators of fuel gas energy (APG), “crude” oil or its highly viscous derivative products. To solve this problem, it is proposed to use the well-known Stirling heat engine, which does not require special fuel preparation and uses any source of heat, such as solar energy, associated petroleum gas.

The Stirling thermodynamic cycle is based on the periodic heating and cooling of the working fluid, with energy extraction from the resulting pressure change.

External heat supply is carried out through a heat-conducting wall. The working fluid is in an enclosed space during operation.

Among the advantages of Stirling engines, the simple design, economical operation, environmental friendliness can be noted. However, bulkiness and material consumption, inertia when changing the heat flux, the need to create high pressures introduce limitations in the use of Stirling engines.

The energy-saving technologies associated with the need for temperature stabilization of rocks in permafrost conditions to avoid deformation of production wells and potential emergencies have the special place in the development of oil fields.

Permafrost rocks in the Bolshezemelskaya Tundra of the Nenets Autonomous Area occupy almost the entire central and northeastern parts of the district –95%. The thickness of permafrost rocks reaches 500 meters, the temperature ranges from  $-5^{\circ}\text{C}$  to  $-2^{\circ}\text{C}$ .

Currently, the following technical solutions are used to prevent permafrost thawing: strapping and suspension of casing strings, thermal insulation of casing strings and construction of seasonal cooling devices (heat pipes). A more reliable method to prevent soil from thawing is to use geothermal heat pumps, while heat can be used for heating and hot water supply facilities.

## Conclusion

The use of the proposed energy-saving technologies in the operation of oil fields will allow reducing costs for fuel, amount of hazardous emissions and heat pollution of the atmosphere.

**Conflicts of Interest:** The author declares no conflict of interest.