Automation of processes at oil and gas enterprises as the main factor of resource saving

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Abstract. This article considers the practicality of applying automation processes for resource saving. For this purpose, the issue of energy intensity of the oil and gas complex was investigated. We also analyzed the life cycle of the oil and gas industry product, i.e. fuel. Then we studied how automation systems can be applied at its different stages and what changes in energy intensity of an enterprise the introduction of automated systems leads to.

1. Introduction
Energy efficiency and energy conservation are priority factors for the modern oil industry. This has become especially important as part of the new climate agenda [5] aimed at reducing air pollution by combustion products of carbon-containing fuels. Current global energy consumption is constantly growing and is predicted to continue growing as can be seen on the figure 1 [11].

![Figure 1. Forecast of global energy consumption [5].](image)

According to the International Energy Agency, global energy demand will increase by 30% by 2040, making energy conservation an increasingly important issue.

The main energy saving principles are the use of alternative renewable and secondary energy resources, the use of non-energy-intensive technologies and equipment, the adoption of measures for...
the rational use of available energy resources, etc. The energy saving principles also include assessing the economic feasibility of applying any energy-saving technologies and solutions and increasing the efficiency of power plants consuming different types of energy carriers [11].

Concepts of energy conservation and energy efficiency are closely related but have different definitions. Saving means consuming less of a resource or refusing to use it, while efficiency means getting the desired result using less energy.

Energy efficiency process can be considered at three levels - technology, equipment, and process organization.

At the technology level, energy efficiency is increased by improving the operating principle of a process unit. This can be an alternative change in the energy resources used or an increase in the product quality or work performed.

At the equipment level, energy efficiency can be improved by increasing equipment efficiency and reducing losses.

At the organizational level, in addition to changes in management and in product strategy, increasing or decreasing the length of the technological chain affect the growth of energy efficiency. Managers at the enterprises can increase integral activity indicators, combining applied technologies, and also changing the geography of sales and production (supply and logistics). Therefore, there are changes of specific energy consumption per unit of capitalization, profits, and other indicators [15].

For instance, such an indicator as the energy efficiency index is used to determine the improvement of energy efficiency at enterprises. It is most commonly used in industry, especially in the petrochemical and chemical industries, which makes it convenient for the oil and gas complex.

Considering the feasibility of implementing measures for resource saving at oil and gas enterprises, we must pay attention to the fact that improving energy efficiency can manifest itself in different forms. These forms include:

- Unchanging process output while reducing energy consumption.
- Increased process yield with unchanged energy consumption.
- Such an increase in process yield that, in relative units, exceeds the corresponding increase in energy consumption.

At present, the energy efficiency index is used to assess changes in energy efficiency over a certain period and is of interest in terms of tracking the effectiveness of measures of environmental and economic policy of the enterprise, the authorities in a particular territory in the field of energy efficiency [8].

Given the high percentage of energy consumption in the refining industry, it is worth noting that the most energy consumption systems are process units. Only the consumption of direct fuel reaches 6-8 % (wt.%) per refined oil. The level of useful use of energy resources consumed by refineries is 23 - 26 %, and 74 - 77 % is lost (14 - 16 % is flue gases, 48 - 52 % is cooling water and air, and 8 - 12 % is released into the environment) [13;19]. Therefore, many plants aim to reduce the cost of the product by reducing energy costs.

Analysis of losses that resulting from the equipment operation at a refinery shows that the greatest losses are characterized by the tube furnace. It is quite clear that the main potential for savings, not less than 90%, lies in the technological processes themselves, especially in the heat recovery system. Thus, it is worthwhile noting that modernization, aimed at improving energy efficiency and energy saving, should start from reactor system, separation system and heat exchange system. Proper design of heat recovery scheme allows to significantly reduce the load on furnaces, steam heaters, as well as water and air coolers. That way, the reduction of energy consumption can be 10-20% (and in some cases up to 40%-50%) of the initial energy consumption [13].

Having studied basic concepts related to optimization of energy consumption at oil and gas enterprises, we return to the topic of resource-saving measures. Here we should take into account that automation is one of the most significant directions of innovative industry development. Automation
as a scientific and practical activity direction includes meeting modern requirements to the production organization; reducing human role in the management of technological processes; use of mathematical apparatus; application of modern control means (sensors, controllers), computer and microprocessor technology, network technologies [11].

The main result of the process automation can be considered an increase in labor productivity. Reducing labor intensity of basic and auxiliary processes in the oil and gas industry allows the rational use of resources, at the same time maintaining a high social level of employees in the industry. Further in the article we will consider in detail the advantages of automation application at the oil and gas enterprises [1].

2. Materials and methods
Oil and gas companies always imply a branched structure. They especially require automation, i.e. the maximum use of modern equipment and software [4].

Considering this process, we should note that the production automation involves the use of a large amount of sophisticated equipment that provides drilling, production, field gathering, preparation and transfer of oil and gas from the field to the consumer without direct human involvement, only under its control.

The ultimate goal of production automation, of course, is to reduce all kinds of costs while ensuring high labor productivity and safety [4].

Based on this, we can consider what kind of benefits automation provides. As a rule, they include an increase in the speed of performing repetitive tasks, improving the work quality, increasing the management accuracy, parallel tasks execution, quick decision-making in typical situations [16].

The automation process is necessary at all stages of the technological cycle in the industry, starting with the exploration of oil and gas resources, evaluation of field reserves, continuing with well drilling, oil and gas field development and ending with the transportation and storage of extracted resources, as well as their processing and distribution to the end consumer [1].

Therefore, if we consider the life cycle of the product in oil and gas complex, we note that its main stages are production, transportation of raw materials, storage, refining to obtain motor fuel, sales at gas stations, gasoline and diesel fuel use in motor vehicles. Schematically, lifecycle stages of motor fuels production and use are shown in figure 2 [2].

![Figure 2. The life cycle of motor fuel](image-url)

Thus, different automation tools are used at different stages.

For example, at the production stage, an automated supervisory control system is used for automation and dispatching of oil and gas well clusters, as well as other shop floor facilities. It is
designed for remote parameter monitoring and operational dispatching of equipment and includes telemetering, monitoring and registration of well parameters [6].

Automation is also being used in optimizing drilling operations and weather monitoring. Some energy companies have begun using automatic weather sensors to detect changes in seismic activity and in ocean and atmospheric levels. This can help predict when favorable conditions for major natural weather events, such as earthquakes and hurricanes, will occur, allowing oil and gas companies to take appropriate precautions in real time [3].

Pipelines can be monitored during the transportation phase through automation. Autonomous underwater vehicles and drones can be used to detect attacks and material vulnerabilities in the pipes.

In the phase of raw material processing and fuel production it is most often necessary to measure values of the following process parameters: pressure, temperature, level, flow rate. Measuring oil pressure and flow rate is a task that can easily be improved with automation. Installation of smart sensors, which are connected to centralized monitoring software, allows remote reporting of pressure, flow rate and oil level from the field without the need for the crew to be present on site [3].

At the production stage, flow measurement is essential to the process operation at facilities that produces from raw materials or adds value to a product. For example, measuring equipment are used in the oil and gas industry generally include volumetric and coriolis flow meters [10].

3. Results and Discussion

There are many ways to increase energy efficiency through automated processes, from modernization of technological equipment to the introduction of incentive programs for saving energy resources. Significant reduction in energy intensity of equipment and energy consumption in general can also be achieved through the use of special software products. This possibility is used at the Omsk Refinery.

Since 2011 the company started to use computer modeling in Aspen HYSYS environment as well as applying pinch analysis methods with the Super Target program, which allows finding effective solutions for optimization of unit heat flows. The simulation helped to reduce steam consumption for monoethanolamine regeneration at diesel hydrotreaters - by using the off-gas heat flow of diesel fuel. Therefore, using the results of modeling allowed saving up to 50% of steam. And the use of dynamic models for pumps allowed both to perform hydraulic calculations and select the required drive power for product pumping, and to determine the cavitation-free limits of equipment operation, which is extremely important when pumping liquids with high temperature.

The main and, most importantly, objective assessment of the energy efficiency improvement work that is being carried out at the Omsk Refinery is the dynamics of the energy intensity index. Since 2008, this index has decreased from 141 to 117 at the Omsk Refinery of Gazprom Neft. The introduction of automated optimization tools is also a part of this result (figure 3) [7].

According to the Ministry of Economic Development, in 2015-2018 the energy efficiency indicators of Gazprom, Surgutneftegaz, Tatneft and Transneft showed multidirectional dynamics, after the use of technologies and methods that ensure the automated system operation.

In accordance with Rosneft's data, energy efficiency indicators have improved by 14% over the past two years. According to the 2019 report, investments in energy efficiency are planned at the level of 16 billion rubles in 2021-2023 [17].

The key energy efficiency improvement measure in the production segment, according to LUKOIL, is replacement of asynchronous motors with valve motors, which are used as drives for submersible electric centrifugal pumps for the mechanized well stock. Modernization of pumps of the reservoir pressure maintenance system is also carried out [14].

Moreover, the data of Transneft show that based on the results of the corporate energy saving program in 2017-2019, the reduction of the company's demand for energy resources due to the accumulated effect (in tons of oil equivalent) averaged 1 % per year, or 2 billion rubles, and Gazprom Neft managed to save 5.3 million GJ as a result of energy efficiency programs in 2019 [9;18].
At the same time, Gazprom company managed to achieve an overall reduction of fuel and energy resources consumed by 2.9% in 2019 and a 3.2% reduction of their specific consumption in the most energy-intensive activity - gas transportation. These results were achieved primarily by optimizing the operation of electrical equipment at process facilities and reducing the gas amount being vented at decommissioned sections of gas pipelines. According to the report, the decrease in specific consumption of natural gas for own process needs in transportation was 22% in 2011-2019, compared to the target of at least 11.4% in 2011-2020 [12].

In Russia, with its longest gas transmission system in the world, fuel consumption for own process needs of the GTS accounts for 5-7% of the total gas inflow into the system. In general, in recent years there has been a downward trend in the share of gas used for own process needs (figure 4).

**Figure 4.** Gas consumption for technological needs of the gas transmission system [12].

4. **Conclusion**

Process automation has its own advantages. These include increasing the speed of repetitive tasks, improving the quality of work, increasing control accuracy, and others.

Drilling operations, diagnostics and inspections, pipeline monitoring, weather monitoring systems, and pressure and flow - all these areas constitute different stages of the oil and gas industry product lifecycle and can be adapted to automated systems, increasing the percentage of production efficiency.
By the example of major Russian companies such as Gazprom, Lukoil, Tatneft, and Transneft, we have seen how process automation has led to increased energy efficiency of production and reduced energy intensity.

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