Principles of sustainable development of new resources from waste for the oil and gas processing industry

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Abstract: The article considers the main principles of sustainable development of new resources from waste for oil and gas processing industries. The reserves of waste-free technologies and the principles of sustainable development in the field of waste management are disclosed that provide Foresight and modern trends in the oil and gas processing industry.

1. Introduction
Today, it is difficult to imagine the life of a modern person without functionally important chemicals and materials based on them, such as: fuel, polymer materials and plastics, rubber and synthetic fabrics, paints and varnishes, metals and alloys, solvents and extractants, freons and varnishes, materials for communications, radio, television, transport, technology, household chemicals, etc.

Without chemistry and chemical technology, it is impossible to imagine the life of a modern person [1]. However, using the received material substances as goods, few people think about the questions: what is the technology of obtaining this or that material? How much money is spent on obtaining a commodity product and how much waste is received at the same time? What is waste in general, what is its chemical basis and how can it be used?

Naturally, the modern world, the world community is a civilized system - open to understanding the global role of industrial and domestic waste. Therefore, the solution of the set of problems of rational utilization and processing of modern wastes of the chemical, oil and gas processing industry will allow solving not only the question of saving raw materials and energy but will also ensure an increase in the standard of living of modern people, which is especially urgent and in demand in the modern world.

The conduct of literary and patent search made it possible to analyse domestic and foreign waste-free technologies that are in demand in the oil and gas processing industry, which are developing in four main directions [2]. First of all, it is the creation of various types of drainless technological systems, based on existing, implemented and promising methods of purification. Secondly, it is the development and implementation of a system of modern methods for recycling production and consumption wastes, taking into account the fact that solid waste is a complex concentrated mixture of polluting chemicals. Thirdly, it is the organization of fundamentally new processes for obtaining traditional types of oil and gas processing products, which allow eliminating or reducing the technological stages at which the main amount of waste is formed. Fourthly, it is the creation of territorial industrial complexes (TIC) with a closed structure of material flows of raw materials and wastes inside the TIC, which have a minimum of emissions and waste.

It should be noted that the large-scale technological research and developments carried out in developed countries are associated
with a reorientation to a waste-free lifestyle or products that provide minimum waste, development of methods for collecting and sorting waste, ensuring the economic efficiency of their re-use. The problem of rational disposal is also significant for our region. As part of the development of the oil and gas processing cluster of the Tyumen Oblast (region), which will reach full capacity by 2020, the issues of effective ways of waste disposal have been resolved. "Oil and gas processing cluster - cluster without waste". This statement is not a simple slogan, but the current principle of the development of the region, which was reflected in normative documents, in the annual message of the governor to the deputies of the regional Duma [1]. The economy of the region is diversified taking into account the development priorities for the extraction and deep processing of hydrocarbon raw materials without waste: first of all, RN-Uvatneftegaz, Antipinsky oil refinery, creation of a special waste-free zone at SIBURTobolsk enterprises. A system cluster of global oil and gas chemical industries is formed from deep processing to the processes of creating commodity polymer materials [2].

Thus, sustainable development of the oil and gas processing industry is ensured by the fact that new principles are being developed as special promising targets for waste disposal, which emphasizes the relevance of our study. As part of the implementation of the key task, the goal of the study was also set: formation and development of methodological approaches for analysing the efficiency and sustainability of the development of the oil and gas processing industry without waste, as the leading sector of the economy, including the economy of the Tyumen region.

2. Research

Research objectives: identification of key trends in the long-term development of the oil and gas processing industry without waste, taking into account the features of its modern structure; systematization and analysis of the most popular trends in waste management, forecasting of the Foresight of the oil and gas processing industry, taking into account the issues of rational waste management, identification of key directions and priorities; a comparative analysis of key trends in the long-term perspective of various companies; based on the results obtained, defining global trends in the development of the oil and gas processing industry without waste, their analysis, the construction of a road map up to 2050 [2].

The problem of ensuring comprehensiveness and ecological safety during waste disposal with additional extraction of mineral and organic raw materials is considered in the aspect of development priorities and the creation of technologies of the XXI century - the technologies of "Green Chemistry". At the same time, in our understanding, three main tasks are solved ensuring:

- creation of waste-free production processes with a closed or reverse technological cycle;
- transfer of waste to environmentally safe or inert substances;
- expansion of the mineral and raw materials base due to the transformation of industrial waste into a useful commercial product.

Waste management is possible with the following principles:

- compliance with the hierarchy of waste management (priority): prevention, minimization, reuse;
- precautionary principle based on the implementation of cost-effective measures;
- principle of proximity (waste is processed, where it is formed);
- principle of producer responsibility is based on the principle "polluter pays" and establishes the physical and financial responsibility of the producer for the entire life cycle of the product.

Disposal of products is shifted to the manufacturers, which motivates them to develop products that are less hazardous to the environment and can be disassembled, reused and recycled. We are considering the principles of sustainable development of new resources from waste for the oil and gas processing industry in dynamics, from the middle of the last century. Having carried out content analysis of scientific articles and monographs in the field of waste management, we note that integrated practices have developed largely. The format of integrated practices reflects not only the development forecasts of a particular area, but also includes the content of strategic aspects of achieving the desired prospects for waste disposal in the medium and long term. This way of
organizing the interaction of key principles and the plan for their implementation in the production of the oil and gas processing industry was called "Foresight" [3].

A significant point should be noted: it is necessary to carefully develop the methods of Foresight focused on waste disposal. They can be considered at the interface of methods for forecasting and waste management. At the same time, it is mandatory to include representatives of all groups of key stakeholders in the process, which makes it possible to achieve high effectiveness of programs through their general coordination and discussion at all stages of development of waste management issues. Foresight programs and waste management projects are implemented at the supranational, national, regional and corporate level, with a wide range of research areas within the framework of such basic areas as oil refining, oil and gas production.

3. Results and discussion

When solving the problem of developing new resources from waste for the oil and gas processing industry, we consider it necessary to take into account certain groups of technologies: process, basic and breakthrough. We used such a system in the proposed methodology for assessing the efficiency of waste disposal of the fuel and energy complex. We consider process technologies of waste disposal as part of industrial production; these are those that are already born with production. Basic technologies of waste recycling are those that are most in demand "now" and "here", at this point in time. Breakthrough technologies are technologies for waste recycling previously not implemented, or implemented at an insufficient level, which can qualitatively improve production conditions, thereby providing the most beneficial competitive advantages. A methodology for estimating the efficiency of waste disposal through a defined system of RES indices (Resource capacity, Ecological, Security), revealing waste from the position of resources, ecological compatibility and safety, which is necessary for a comprehensive presentation and application prospects. The methodology included monitoring of oil and gas processing companies taking into account the following criteria: availability, sufficiency (frequency of mention in open waste reports), objectivity, specificity of indicators. Considering the monitoring of the open reporting of more than 20 oil and gas processing companies, a list was drawn up. Among the set of criteria, those that most often occur in open reporting mattered.

The Foresight programs of waste management is a reference point for the future. At the current level, this priority is based on a system of real trends that have evolved in the oil and gas processing industry [4]. We will reveal the main trends of the oil and gas processing cluster in more detail.

The first trend is the rational use of APG from the production and collection of associated gas, transportation and processing of associated gas. The high level of APG utilization in the first half of 2016 was found to be 86.1% (on the example of the Tyumen region). The increase in production of natural gas and APG - at the level of 800-1000 billion m$^3$/year. The production of the C2+ fraction - at the level of 60-80 million tons/year. The growth rate of production in 2050 - 2.5%. The growth rate of consumption in 2050 - 3.6%. The increase in the output of primary products of NGP is projected to be 18% by 2030. From the point of view of chemical technology, natural gas and APG are the most valuable hydrocarbon raw materials along with oil, chemists and technologists know about it. Paraphrasing the words of the outstanding scientist D.I. Mendeleev, we note that burning gas is not only a significant amount of harmful emissions released into the atmosphere, but also billions of rubles lost. With the growth of oil production, associated petroleum gas production is increasing. The volume of associated gas production in 2012 amounted to 175 million m$^3$. Utilization of petroleum gas reached 35.4% and amounted to about 62 million m$^3$ [4]. Processing of natural gas with the receipt of commodity products is determined by the need to increase the level of socio-cultural, economic efficiency and sustainability of the economic complex of the Tyumen Oblast.

The technical and methodological literature discusses liquid and gaseous oil and gas industrial waste, characterized by specificity of origin and composition. In a generalized form, this information is presented in Figure 1.
Increasing the energy efficiency of the fields is the next priority for the oil and gas chemical cluster. In accordance with this, the first stage of the gas turbine power plant (GTPP) with a capacity of 20 MW operates at Ust-Tegusskoye field, with utilization of up to 55 million m$^3$ of gas per year. In 2013, the second stage of the GTES is launched, bringing the total useful capacity to 60 MW, which will further rationally dispose of 150 million m$^3$ of gas per year. At the Tyamkinskoye and Kalchinskoye fields, two GTPPs were built, with a capacity of 18 MW each. In this connection, the percentage of utilization of associated petroleum gas by 2017 reaches a world average of 95% [5, 6].

The project to increase the capacity of the existing central gas fractionation unit (CGFU, Tobolsk) to process a wide fraction of hydrocarbons, with an increase in the volume of NGL processing from 3.5 to 8.0 million tons, which is a comprehensive project not only for the region but also for the world industry.

The second trend is advanced processing of crude oil. The total annual capacity was 273,0 million tons, including 28 operating refineries (254 million tons), 4 GPPs (7.8 million tons), 80 mini-refineries (10.8 million tons). The share of advanced processes for primary processing is low. Deepened processes account for only 16.7% across Russia. Cracking accounts for 63%, hydrocracking - 2.9%, visbreaking - 5.4%, coking - 2.1%. Let us point out the fact that these processes need to be developed. The volume of the main output of the Tyumen cluster: gasoline (52-62%), stable gasoline (11-13%), kerosene (18-22%), diesel fuel (20%), with oil and gas losses.

The development of the oil and gas chemical cluster is connected with the activities of the Antipinsky Refinery, where 2.6 million tons of oil are processed every year, with the equipment capacity of 4 million tons. It produces diesel and motor low-sulfur fuel - 840 thousand tons; furnace fuel - 226 thousand tons; stable gasoline - 503 thousand tons; mazut - 1004 thousand tons. Today, the enterprise operates with an increase in capacity to 8 million tons per year. A wide range of refined petroleum products with a modern technological configuration and processing depth up to 95% (including secondary processes: hydrocracking, dewaxing, coking production, sulfur production according to Klaus), meeting the environmental requirements of EURO-5 standards, as well as obtaining concomitant modern products and materials in demand on the market [5]. The third trend is
realization of the pyrolysis process. The current number of pyrolysis units does not allow processing existing raw materials and fully meeting the domestic demand. Construction of new pyrolysis facilities (ZapSibNeftekhim) with the launch in 2018 will increase the capacity for the production of monomers. "West Siberian complex of deep processing of hydrocarbon raw materials with a capacity of 2 million tons per year" includes a pyrolysis plant for 1.5 million tons of ethylene per year. ZapSibNeftekhim will change the face of all Russian petrochemicals. The fourth trend is production of polymers. Polymer production is a promising priority for the oil and gas chemical cluster of the Tyumen Oblast, which is being considered through the implementation of investment projects, which will make a powerful breakthrough and reach the international level in terms of volume and quality of products. Analysis of existing trends shows the possibility of additional waste production. When choosing criteria for waste selection, great attention was paid to the demand of the product on the market and the possibility of drawing the attention of ecologists, technologists, and chemists to this substance. Basic products included oil sludge, polymerization waste, atactic propylene, carbon monoxide (CO), carbon dioxide (CO2), acids, aluminum chromium catalysts of various brands, oil emulsions, spent heavy oil fractions and many others. Some of these compounds, such as oil sludge, atactic propylene, acids are already in demand, others are the subject of research as basic products, for example, in the development of waste gas processing processes - the use of carbon dioxide as a feedstock, which is a source of carbon. Hydrogen is used as a source of energy for synthesis. The highly demanded compound, isobutene, which is used in the production of rubbers, can also be obtained from ethanol. There are catalysts that make it possible to obtain tryptane from dimethyl ether and methanol, a high-energy compound that can be used as an effective fuel additive. A promising direction is the use of carbon monoxide, industrial gases to produce intermediates for the synthesis of ethanol, acetone, butanol, etc.

It is obvious that the classical approach (for example, burning, biodegradation, burial) assumes the physical destruction of a useful product contained in the waste products of enterprises in the form of organic and inorganic constituents. At the same time, there are irrecoverable losses of minerals already extracted, and the processes of ecological waste neutralization are not complete, they only partially reduce the environmental load on the technological process or the territory of the enterprise (for example, storage of spent catalysts in closed, expensive bunkers and burning of high-boiling point waste in furnaces or flares, etc.). Such an approach does not allow developing "mechanisms of stability and competitiveness of oil and gas enterprises" [5]. Let us note the fact that the problem of disposal of waste with additional extraction of mineral raw materials should be considered in the aspect of "the priorities of sustainable development of Russia, civilization and the creation of new technologies of the XXI century". Among the main factors and priorities of sustainable development in Russia are the following areas that ensure: creation of waste-free production processes with a closed or reverse technological cycle; environmental safety, which involves the transfer of all toxic waste into environmentally safe or inert substances; additional extraction of mineral resources, which implies expansion of the mineral resource base and creation of a useful commodity product. In modern conditions, the "green" economy is developing, the main purpose of which is sustainable development of civilization, and analysis of trends from the standpoint of the methodology for the efficiency of waste disposal allows us to formulate a number of key positions: to plan possible wastes; to plan synthesis methods; to transfer toxic waste to non-toxic; to take into account environmental consequences; to reduce the number of stages of the process; to neutralize catalytic systems to safe; to monitor waste in real time; to ensure minimum accidents.

4. Conclusion
Thus, the priority trends in the oil and gas refining industry provide a set of new volumes of industrial waste that can become new sources of raw materials and a combination of resources in terms of chemical composition, physical and chemical parameters. A qualitative analysis of the prospects for the development of the oil and gas processing cluster, an analytical review of existing world practices in the field of waste management within the framework of forecasting and foresight of the fuel and
energy sector development, data on existing forecasts and prospective technological directions of waste utilization are systematized. The following aspects are analyzed: modern waste structure, key trends in the development of recycling technologies; the role of local types of waste in the structure of the regional block. The role of waste as a result of globalization and the need for resource regionalization are uncovered. The need to reduce the volume of oil production is shown and the peculiarities of the growth of the gas industry are revealed. The need for reasonable integration and diversification of waste management is presented. The features of the vector of development of green chemistry are revealed with the strengthening of the influence of the ecological factor for the transition to sustainable development of the fuel and energy sector. The need for using a methodological apparatus in the field of waste management is shown, which includes the practice of forecasting, strategies and methods of foresight used in the practice of various countries. The possibilities of companies in solving the issue of waste management are considered.

References

[1] Degtyarev P A 2012 Plan for the development of gas and petrochemical industry in Russia for the period up to 2030 Mater. of the Intern. Conf. "Gas and Oil Chemistry"- 2030 (Moscow: Alliance-Analytics) 23 p.

[2] Egorov A N 2016 Oil and Gas Processing Industries. Technology. Security. Ecological compatibility (Tyumen: IUT) 150 p

[3] Egorova G I 2012 Disposal of wastes as a social problem of improving the quality of human life Coll. Mater. of the Intern. Sc. and Pr. Conf. (St. Petersburg: Express) pp 46-50

[4] Egorov A N 2014 Wastes from Petrochemical Industries (Tyumen: Tyumen State Oil and Gas University) 126 p

[5] The concept of long-term social and economic development of the Tyumen Oblast until 2020 and for the future until 2030 Annex to the order of the Government of the Tyumen Oblast of 05.25.2009 № 652-rp (as amended of 10.02.2016 No. 94-rp).