# INTEGRATED RESOURCE-SAVING TECHNOLOGY OF HYDROCARBON RAW MATERIAL PROCESSING

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The stability of the state and society is mainly characterized by the level and quality of interaction of three main types of resources – energy, material, labor. At the present stage, a significant role is given to energy resources, which can be classified as follows: 1) eternal energy of the first and second kind; 2) renewable energy; 3) non-renewable energy. Non-renewable energy, which includes hydrocarbon energy, namely, natural gas, oil, coal, is characterized by the lowest multiplicity of reserves. At the same time, the largest contribution to the balance of world energy – 90% comes from non-renewable energy, the reserves of which are depleted and, according to forecasts from various experts, these reserves will last for 50–100 years. The remaining 10% comes from eternal and renewable energy. The question remains unresolved: what to do next, what energy will replace non-renewable energy to ensure the functioning of man-made systems and objects that ensure human life? In addition to these problems, when using non-renewable energy, the problem of climate change on the Planet acutely arises. After the man-made disaster at the nuclear power plant (Fukushima, Japan), Germany refused to use coal and nuclear power plants to generate heat and electricity. To compensate for the lost energy, a transition to "Green" energy was made – solar and wind energy. It was established that "Green" energy is not able to compensate for the lost energy due to the rejection of coal and the "peaceful" atom. The reason for this lies in the shortcomings of "Green" energy and unresolved problems of these technologies.

To extend the service life of man-made systems on non-renewable energy, the following recommendations are proposed:

1) transfer of industry to resource-saving technologies that ensure a productivity coefficient of 75–100%;

2) transfer of man-made systems to alternative energy sources, non-hydrocarbon energy.

For a longer term, as non-renewable energy reserves are depleted, a raw material triad is proposed in [1], including nitrogen, water, carbon dioxide. The choice of this triad is due to the following factors:

1) high multiplicity of reserves of the triad components and their renewability;

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2) cheapness of raw materials;

3) environmental neutrality of the original raw materials and their processed products in combination with resource-saving technologies.

Based on this triad, we propose to obtain environmentally friendly fuel – hydrogen, and to organize complex production of petrochemical synthesis products based on carbon-containing and nitrogen-containing compounds.

As a basic example, we will consider the integrated processing of natural gas (NG), for simplicity, we will take methane as NG.

The goal of integrated methane processing is to increase the efficiency of methane processing from 15% to 75% due to cooperation of production facilities, increasing the selectivity of the process, reducing the formation of by-products and secondary waste, as well as the useful processing of the latter.

Below is the cooperation of the following production facilities:

1. Methanol production [2, p. 157] – synthesis-gas processing for methanol production is obtained by catalytic steam-carbon dioxide conversion of methane, synthesis of raw methanol at a pressure of 50–300 kgf/cm$^2$, rectification of raw methanol.

The following products are formed as by-products: 1.1 spent catalysts for methane conversion and methanol synthesis, which, according to the technology we propose, are utilized with their transformation into active catalysts for methane conversion into synthesis gas and methanol synthesis; 1.2 purge gases from the methanol synthesis cycle are sent to ammonia production to obtain hydrogen; 1.3 methanol water after the stage of rectification of raw methanol is purified using microbiological purification in methanol production.

2. Production of methanol for the needs of the gas production industry by the method of partial catalytic oxidation of methanol.

The use of methanol in industry is widely and fully described in the work [2, p. 225].

3. Production of acetylene by thermal-oxidative pyrolysis of methane at a temperature of 1800–2000 °C, oxygen obtained from air is used as an oxidizer.

By-products – 3.1 waste synthesis gas obtained in the process of thermal-oxidative pyrolysis of methane in the amount of 10,000 m$^3$/t of acetylene, is used to obtain methanol according to the "short" scheme, according to paragraph 1.; 3.2 waste solution of N-methylpyrrolidone – acetylene absorbent – is transferred for disposal for the purpose of its repeated use in the process of acetylene absorption; 3.3 soot is used for the production of automobile tires; 3.4 nitrogen is formed during the separation of air (79% by volume of the original air), which is sent to the production of ammonia.

The ways of using acetylene are widely and fully described in the work [3, p. 248].

4. Production of acetic acid by the method of catalytic carbonylation of methanol. Carbon monoxide required for the process is obtained by absorption with copper-ammonia solution at elevated pressure from synthesis gas (p. 1, 2, 3.1).

5. Synthesis of methanol and higher aliphatic alcohols C2 - C5+ by catalytic hydrogenation of carbon monoxide on promoted catalysts.

6. Obtaining ethylene, propylene, butylene, synthetic gasoline, diesel fuel by converting methanol on high-silica zeolite catalysts.

7. Obtaining dimethyl ether by catalytic dehydration of methanol in the presence of special catalysts. In comparison with known refrigerants, dimethyl ether has a wide range of available raw materials for its production, low cost, environmental safety, high performance characteristics.

Thus, the goal set in the work to increase the degree of useful use of non-renewable raw materials and, accordingly, to reduce the share of by-products is achieved through the following innovative developments:

– creation of a complex of industries in which rational processing of raw materials, waste, secondary material resources into target products is organized;
– development of new processes and industries based on them, capable of processing material and energy waste, secondary material resources into target products;
– increasing the selectivity of chemical-technological processes;
– abandonment of low-yield and non-selective chemical-technological processes and industries;
– introduction of artificial intelligence elements into the control system of chemical-technological processes under unconditional control by a person (operator) [4, p. 243;5, p. 21;6, p. 77; 7, p. 189].

**Conclusion:**

1. The efficiency coefficient of man-made systems has been increased from 15% to 75%, i.e. five times.
2. The specific consumption of raw materials in the target products has been reduced five times.
3. The emission of waste from man-made systems has been reduced five times.
4. In order to make a balanced decision in each specific case, it is necessary to develop a feasibility study accompanied by the section “Environmental Impact Assessment” of the decisions taken.
5. To close obsolete unprofitable production facilities while simultaneously replacing them with new highly productive, competitive production facilities.
6. To prepare a scientific and technological base for the practical use of alternative energy sources.

7. To develop new technological processes using alternative energy sources, ensuring economic efficiency and environmental safety of production facilities and target products obtained on their basis.

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