Implementing new technologies and program products in the ecologic sphere of oil and gas chemical complexes

A A Lubnina¹, F F Galimulina¹, G R Garipova¹, V V Bronskaya² and O S Kharitonova³,⁴

¹Department of Logistics and Management, Kazan National Research Technological University, 68 Karl Marx Street, Kazan 420015, Russian Federation
²Department of Chemical Process Engineering, Kazan National Research Technological University, 68 Karl Marx Street, Kazan 420015, Russian Federation
³Department of Chemical Technology of Petroleum and Gas Processing, Kazan National Research Technological University, 68 Karl Marx Street, Kazan 420015, Russian Federation

E-mail: olga.220499@mail.ru

Abstract. An innovative form of cluster policy of petrochemical companies that is the cluster intensification of environmental competitiveness (CIEC), which will be contributed to improve the competitiveness of petrochemical companies by accelerating the implementation of production processes that are more cost-effective and better for the environment is proposed in the article.

The main objective of the cluster policy realization is to ensure high rates of economic growth and to diversify the economy by increasing the competitiveness of factories, suppliers of equipment, components, specialized production and service services of research and educational organizations forming territorial-production clusters.

There is more actively introducing new technologies and innovative design solutions, almost automatically eliminating unnecessary and far-fetched barriers, liquidating duplicative units in the cluster of factories in comparison with other methods of organization of production.

Petrochemical industry is important for the economy of the Republic of Tatarstan. At the same time it is one of the main consumers of energy and a serious source of environmental pollution. An innovative form of cluster policy of petrochemical factories — the cluster intensification of environmental competitiveness (CIEC), which will greatly improve petrochemical factory competitiveness by accelerating the implementation of production processes that are more cost-effective and better for the environment is proposed in the article.

Potential benefits from the CIEC:

- increase in general energy efficiency — 5% (10-20 years), 20% (30-40 years);
- overall reduction of production costs due to increasing productivity — 20% (5-10 years), 50% (10-15 years);
- reduction of pollution and effluent water emissions — 25% (5-10 years), 75% (10-15 years);
cost reduction due to intensification of processes along the entire value creation chain - 30% (10 years), 60% (30-40 years).

The action plan will accelerate the implementation of the CIEC in the petrochemical industry. It is aimed at the technology realization in plants through three interrelated activities:

- development of research programs;
- piloting and demonstration of innovative technologies;
- transfer of knowledge and technologies.

The research program is fully integrated along the value creation chain from basic and applied research to piloting, testing and demonstration of innovative technologies on a semi-industrial scale to scaling new technology at the factory (figure 1).

**Figure 1.** Stages of the cluster intensification of environmental competitiveness (CIEC).

The lack of available piloting and demonstration capabilities is a major obstacle to the implementing innovative technologies in the petrochemistry sphere. The demonstration object will be built into the system to allow piloting and demonstration of perspective technologies on a semi-industrial scale to overcome this barrier. The aim is to confirm the technical and economic characteristics, to develop a comprehensive design/model before scaling follow-up processes.

Another major obstacle for the realization of innovative petrochemical technologies is the lack of awareness of availability and development of technologies and their application fields. Knowledge and technology transfer seeks to remove this barrier by collecting knowledge on new - how, research and development and implementing them worldwide, spreading information through seminars, training and instruction. The action plan will be managed through organizations and structures that monitor progress and quality of work. The CIEC Action Plan is to debug the development and implementation of innovative technologies in conjunction with interested organizations. All activities will be built into existing structures of participating partners.

The main directions of development of innovative technologies within the CIEC:

- reduction of energy and resource intensity of production;
- reduction of emissions of harmful substances and minimization of production waste;
- introduction of safe technologies;
- reduction of time of the implementation of innovative technologies on the market;
- reduce costs along the value creation chain.

CIEC is a radically new approach in the organization of technological process of creation of new competitive products. It is planned to organize a joint center for creation of innovative technologies (in the sphere of ecologization of production, energy reduction and resource intensity, waste minimization), including piloting and demonstration projects, risk assessment, feasibility study, scale of production...
using infrastructure of scientific and industrial complexes or universities, with the participation of interested ministries and departments on the initiative of cluster petrochemical factories.

However, the efficiency analysis of oil and gas chemical cluster factories did not allow to reveal objective regularities of their development since the start of the cluster program development. In connection with it the factor analysis was carried out to identify groups of factors that are of the greatest importance for oil and gas chemical cluster development. In order to compare the change in the significance of indicators, the factor analysis was carried out for two periods:

- 2009-2012 — the period of the beginning of cluster development of the economy of the Republic of Tatarstan;
- 2013-2016 — the period of realization and completion of the cluster development program.

We will carry out factor analysis using Statistica tool on the basis of the set of considered indicators that will allow to classify variables depending on their importance for oil and gas chemical cluster. The conducted analysis grouped all researched data for 2009-2012 into three groups of factors with own values of factors in table 1.

| Table 1. Dynamic factor analysis results. |
|-----------------------------------------|
| Factors (structure) | Specific weight of the factor in total dispersion | Factors (structure) | Specific weight in total dispersion |
|----------------------|-----------------------------------------------|----------------------|-----------------------------------|
| 2009-2012            |                                               | 2013-2016            |                                    |
| factor 1 — production activity effectiveness (cost of fixed assets, shipped goods of own production; performed works and services by own forces; salded financial result; production of innovations; expenses on marketing innovations; salary of employees; index of industrial production; share of workers employed in harmful and/or dangerous working conditions) | 56% | 1) factor 1 — the effectiveness of innovative and environmental activities (cost of fixed assets; salded financial result; production of innovations; expenses on marketing innovations; expenses of organizational innovation; expenses of environmental actions; emissions of polluted waste water; investments in fixed capital; salaries of employees; share of workers employed in harmful and/or dangerous working conditions) | ↓ 53,3% |
| factor 2 — the effectiveness of financial activity (investments in fixed capital, profitability of products, current liquidity ratio, autonomy ratio) | 19,1% | 2) factor 2 - the effectiveness of production activities (shipped goods of own production, performed works and services by own forces; Emissions of atmospheric pollutants (EAP); index of production) | 23,1% |
The dynamic factor analysis made it possible to identify the restructuring of the importance of factors. Let's give an interpretation of the revealed tendencies of the specific weight of each factor in the total dispersion.

- Decrease in production activity effectiveness (factor 1). The results of factor analysis in 2009-2012 determined the main group of production factors (56% of dispersion), which consisted of factors characterizing the volume of produced products, including innovative, average monthly salary of employees, etc. However, the key factors characterizing the oil and gas chemical cluster production activity effectiveness were transferred to the second group in 2013-2016 (23.1% of dispersion). Consequently, the industrial development of the economy has taken second place with the implementation of cluster development program.

- Decrease in the effectiveness of investment activity (factor 2). The results of factor analysis in 2009-2012 of the second most important group of factors determined the group characterizing investment efficiency of cluster factories, which included indicators that are profitability of products, current liquidity ratio, autonomy ratio, etc. However, these indicators entered the third group of factors in 2013-2016, thereby reducing its importance for oil and gas chemical cluster development. It indicates that the cluster development reorientation from the application of traditional, lagging technologies to innovative, environmental friendly, energy and resource-saving technologies, reduces the financial stability of factory.

- Increase in the effectiveness of innovative and environmental activity (factor 3). As a result of factor analysis in 2009-2012 the indicators characterizing the environmental activity of factory including the expenses of environmental actions and capacity commissioning, discharges of polluted effluent water, EAP and so on (24.7% of dispersion) were defined in a separate group. However, in 2013-2016 these indicators moved into the first group of factors together with indicators of the effectiveness of innovative activity which were previously scattered among different groups of factors (53.3% of dispersion).

Thus, the indicators of development of innovative and ecological activities were more important than production and investment indicators as a result of the implementation of oil and gas chemical cluster development program. Therefore, there is a reorientation of cluster development from the use of traditional, lagging technologies to innovative, environmental friendly, energy- and resource-saving technologies, which allows to increase productivity of factories, minimize waste and reduce energy consumption of production activity.

It was built Cobb-Douglas production function to assess the effect of the cluster development program of oil and gas chemical complex of the Republic of Tatarstan, which includes 2 factors: labour and capital. The Cobb-Douglas function allows to adequately describe the dependence of the development of oil and gas chemical complex factories in a stable economic time. Preliminary evaluation of indicators allowed to identify that the production function in the considered two-factor model will take the form:

| Factors (structure) | Specific weight of the factor in total dispersion | Factors (structure) | Specific weight in total dispersion |
|--------------------|-----------------------------------------------|--------------------|-----------------------------------|
| 3) factor 3 - the effectiveness of environmental activities (total expenses of organizational innovations; expenses of environmental actions and commissioning of capacities; discharges of polluted effluent water; EAP) | 24.7% | 3) factor 3 — the effectiveness of financial activities (total expenses of technological innovations; profitability of products; current liquidity ratio; autonomy ratio) | 21.5% |
\[ Y = a_0 \cdot K^{a_1} \cdot L^{a_2} \quad (1) \]

where \( Y \) — EAP, thousand tons;
\( K \) — expenses of environmental actions and commissioning of capacities (mln. RUB);
\( L \) — the proportion of employees employed in harmful and/or dangerous working conditions (%);
\( a_0 \) — neutral technical progress coefficient;
\( a_1 \) — capital elasticity coefficient;
\( a_2 \) — labour elasticity coefficient.

Figure 2. Dependence of EAP volumes on the volume of expenses of environmental protection measures and commissioning of capacities and the number of workers employed in harmful and/or dangerous working conditions (made by the author using Wolfram Mathematica).

The study defines the elasticity as logarithmic derivatives to determine the coefficients of elasticity of capital \((a_1)\) and labour \((a_2)\), i.e. \( a_1 \) — the elasticity of EAP from expenses of environmental protection measures and commissioning of capacities, \( a_2 \) — the elasticity of EAP from the proportion of employees employed in harmful and (or) dangerous working conditions. Therefore we convert the production function (2) to linear form. As a result of logarithm of the right and left sides of the equality:

\[ \ln(Y) = \ln(a_0) + a_1 \ln(K) + a_2 \ln(L) \quad (2) \]

In order to obtain a linear function, we replace variables as follows:

\[ \ln(Y) = \ln(a_0) = a'_0 \]
\[ \ln(K) = K' \]
\[ \ln(L) = L' \]

The linear equation will be as follows:

\[ Y = a'_0 + a_1 \cdot K' + a_2 \cdot L' \quad (4) \]

To calculate unknown parameters of the production function, we use the least square method:

\[ Y = 56.3 \cdot K^{-0.13} \cdot L^{0.957} \quad (5) \]

We use the Fisher criterion to check the constructed Cobb-Douglas function for the adequacy of the original data:

\[ F_{\text{calc}} = 221.2509 \]
\[ F_{\text{tabl}} = 0.051927 \]

Adequacy of the resulting production function is confirmed by the Fisher table criterion, which exceeds the calculated indicator with 95% of accuracy, the numerator of freedom degree - 2, the denominator of freedom degree — 4.
Thus, when the offered actions (development of CIEC within the oil and gas chemical cluster), within the proposed cluster intensification of environmental competitiveness are carried out, it will be achieved 10% of increase in the expenses of environmental protection measures and commissioning of capacities (K) and 55% of decrease in the proportion of workers employed in harmful and/or dangerous working conditions (L), which will reduce the volume of EAP (Y) by 6.8% (775.6 thousand tons in 2017).

The article describes the organizational and economic model of increasing the contribution of the factor of environmental friendliness of production to the increase of competitiveness — the cluster intensification of environmental competitiveness (CIEC), which is a radically new approach in the organization of technological process of creation of new competitive products.

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