Energy-Saving Environmental Projects: approaches to evaluation and results of environmental impact

Nina Plyaskina
Doctor of Economics, Leading Researcher, Institute of Economics and Industrial Engineering, SB RAS, 17 Acad. Lavrent’ev Ave., 630090 Novosibirsk, Russia
Professor, Novosibirsk State University, 2 Pirogov St., 630090 Novosibirsk, Russia
E-mail: pliaskina@hotmail.com

Abstract. Recently, much attention has been paid to reducing environmental damage to the environment throughout the country. Over the past twenty years, Public Joint-Stock Company "Gazprom” has been working on the implementation of environmental projects for the transfer of motor vehicles to alternative motor fuels. The report suggests a toolkit for assessing the impact of energy saving projects on the environment, based on the adaptation of the input-output model for the fuel and energy complex. The model is based on the assumption that the main amount of greenhouse gas emissions is produced by burning fossil fuels. As an indicator for estimation of environmental efficiency of the projects has proposed the coefficient of carbon intensity - the amount of carbon dioxide released per unit of the final product of the industry. This ratio reflects the impact of industries on the environment. The advantage of the input-output model is the opportunity to conduct a comparative analysis of the environmental load of industries on the environment and to determine the multiplicative effect of implementing energy-saving projects.

1. Introduction
Russia has the considerable potential of energy saving which involvement in economic circulation will allow to reduce significantly consumption of energy resources, to increase energy security of the country and to considerably reduce load of a surrounding medium. According to the experts the potential of energy saving of Russia is 40–47 per cent of the modern energy consumption, at the same time capital intensity of energy saving is twice lower in comparison with an increase of the production of fuel and energy resources. Feature of the present stage of development is increase in a role of pollution-free energy resources. In 2003 under the auspices of UNECE the international project "Blue Corridor” [1] which main objective – expansion of a range of use of natural gas as the alternate engine fuel is prepared.

Alternatively to engine fuel compressed natural gas was widely adopted, however, according to experts and ecologically safe liquefied natural gas is economically more favorable. In the long term it is worth expecting it widespread introduction, both for private use, and in the industrial production.

The leader of the gas engine market in Russia is PJSC ”Gazprom” which is actively realizing energy-saving projects. The researches conducted in Public Joint-Stock Company (PJSC) ”Gazprom” show that use of liquefied natural gas and compressed natural gas in motor, railway, river and air transport, in construction and agricultural automotive equipment, will allow to
reduce significantly load of a surrounding medium, to reduce risk of a covering of needs for engine fuels, will increase receipts in budgets of various levels.

The use of compressed natural gas as a fuel in the river transport will lead to a reduction in the level of toxicity of the exhaust gases in 3-5 times (in comparison with modern marine diesel engines). When translating into unit cost of heat, the use of natural gas is approximately 1.5-2 times more profitable than diesel fuel.

From the point of view of economic efficiency use of natural gas alternatively to gasoline will lead to essential decrease in ecological damage to a surrounding medium in country scales as the coefficient of emissions of carbon dioxide at combustion of compressed natural gas is significantly lower. It is possible to carry to other advantages: decrease of noise influence at engine run; decrease of negative impact on climate; reduce operational costs for the upkeep of vehicles.

PJSC "Gazprom" is the leader of the national gas engine market which is characterized by dynamic body height recently. In 2007 the Board of directors approved "The Target Comprehensive Program for the Development of Gas-Filling Network and the Natural Gas-Powered Equipment Park for 2007-2015" in PJSC "Gazprom", during which the following is planned:

• construction at the expense of PJSC "Gazprom" in Russia 200 more Automobile Gas-Filling Compressor Stations;
• increase in vehicle fleet on natural gas on 50 thousand units;
• liquidation of non-gasified sections of federal and regional highways.

In the report assessment of influence on a surrounding medium of the ecological project of PJSC "Gazprom" - transition to the alternate engine fuel - natural gas is carried out. The tools based on adaptation of the input-output model (IOM) are used.

2. Methodological approaches to the assessment of environmental pollution

Approaches for assessing the impact of economic activity on the environment can be divided into two classes: measuring pollution volumes and using economic and mathematical models. Use of measurements increases accuracy of results, however a large number of specific ecological parameters at calculation of volumes of pollution in country scales is required. The most effective methodology for assessing the environmental impact of individual industries and their complexes is the application of economic-mathematical models.

Models for estimating greenhouse gas emissions MARKAL and ENPEP were widely used [2-3]. MARKAL (MARKet and ALlocation) is a power supply simulation tool using the linear programming method. The database of the model contains characteristics of various technologies, as well as general parameters of the energy economy, the time horizon is divided into periods. The optimal solution is determined to meet the demand in each period, the output data are presented in the context of economic sectors: resource consumption, production capacity, costs, emissions, etc. Calculation of greenhouse gas emissions on a national scale is unlikely, since a large number of specific input information is required. MARKAL is a universal software package and is used by environmentalists in more than 40 countries mainly to assess the investment attractiveness of projects at the micro level. The ENPEP (Energy and Power Evaluation Program) model is a tool for the development, comprehensive analysis and optimization of the development of the fuel and energy complex in the region or the country as a whole. This model is used in 60 developing countries of the world to estimate the amount of pollution from the fuel and energy complex using a scenario approach. However, ENPEP does not allow estimating the multiplicative effect of reducing pollutant emissions and its impact on the economy of the country.
3. Adaptation of the Input-Output Model for estimation of carbon dioxide emissions

On the basis of the input-output model (IOM), various modified balance models are being constructed. We proposed a modification of the IOM for the use of energy in the same way as the approach of A.G. Granberg [4-5] to the model of the intersectoral balance of labor inputs. Consumption of energy resources is presented both directly in the process of economic activity, and indirectly, in the form of consumption of goods and services produced for use in other industries. The energy contribution to the full output of the industry consists of the amount of energy expended for the release of goods and services that are used in the production process, as well as the energy that is expended directly in the production process. The model is based on the assumption that the main amount of greenhouse gas emissions is due to burning of fossil fuels. As a result, a model is obtained that is a "projection" of the model of the inter industry balance on the fuel and energy complex. The concept of a string vector of direct carbon dioxide emission factors per unit of fuel burned, which characterizes the degree of efficiency of industries from the point of view of the impact on the environment, has been introduced. The indicator is expressed in $t\text{CO}_2/\text{TOE}$ (TOE - Tonnes of Oil Equivalent).

The coefficient of carbon intensity - the amount of carbon dioxide released per unit of the final product of the industry is considered by us as an indicator of the effectiveness of the implementation of environmental projects. Similarly, the total $\text{CO}_2$ emission factors are generated, since the total and direct emission factors are linked together by a matrix of total material costs. The advantage of models of interbranch balance is the opportunity to conduct a comparative analysis of the impact of industries on the environment and determine the multiplicative effect of implementation of energy-saving projects and reducing the environmental impact of the aggregated industries both for the country in general, and in a regional section.

4. Results

Model calculations are carried out on actual economic information – the input-output tables of a matrix of interindustry balance of the Russian Federation for 2003 in a section of 22 aggregated industries [6]. 3 types of primary energy are allocated: products of the Oil and Gas Industry, Coal, Combustible slates and Peat. As a result of calculations direct, indirect and complete emissions of carbon dioxide are determined by the aggregated branches. Due to the wide range of use of energy in the modern economy the common indirect emission considerably surpasses cooperative direct emissions. Accordingly, in industries with a relatively higher coefficient of carbon intensity, it is preferable to introduce environmental projects.

Based on the proposed approach, the aggregated industries of the input-output model are ranked in descending order of the coefficient of carbon intensity (Fig. 1). As a result of the calculations, the sectors with the highest value of this coefficient were identified: "Coal", "Ferrous metals", "Products of the Chemical and Petrochemical Industry", "Electric and Heat Energy", "Oil and Gas Industry products", "Building materials (including products of glass and porcelain and faience industry)". Industries where production is most effective from the environmental point of view: "Trade-intermediary services (including catering services)" and "Products of other types of activities".

At present, most of the projects aimed at reducing the negative impact on the environment are being implemented mainly in the country’s fuel and energy sector. Using the proposed approach, a comparative assessment of the multiplicative environmental effect was carried out for two stages of the implementation of the "Energy Conservation Program" of PJSC "Gazprom": 2001-2004 and 2005-2008 years.

As a result of the implemented energy saving measures, the total saving of fuel and energy resources (FER) by 2004 was 4.23 million tons of oil equivalent (toe), the largest reduction in $\text{CO}_2$ emissions occurs in Construction (319 thousand tons); Other industrial products (314
As a result of the implementation of energy-saving projects of the second stage, the energy savings by 2008 amounted to 2.8 million tonnes.

Despite the increase in costs for the implementation of energy-saving measures in 4 times (up to 3,124 million rubles), there was a decrease in environmental efficiency in 2 times: the cost of reducing one ton of carbon dioxide averaged 2,227 rubles, in 2004 - 377.5 rubles, which is due to the implementation at the first stage of the least capital-intensive activities.

The analysis showed that, on a countrywide scale, the implementation of the Energy Conservation Program in PJSC "Gazprom" does not produce a high overall CO$_2$ reduction effect, the change in the indicators under consideration is less than 1 per cent, since the gas industry 'is the least polluting industry among the fuel and energy sectors.

According to our estimates, the greatest effect on reducing CO$_2$ emissions should come from the realization of a huge potential for energy saving across the Russian Federation. The energy intensity of the Russian economy is 2.3 times higher than the world average, and the average European indicator is 3.2 times higher. The potential of energy saving in our country is about 40-47 per cent of the current value of energy consumption and is more than 350 million toe. Energy saving programs are the most effective in the production, transmission and distribution of energy, as well as in energy-intensive industries, which will provide a significant environmental effect in the form of reducing carbon dioxide emissions.

5. Conclusion
It should be noted that in the implementation of the environmental project of PJSC "Gazprom", the coefficients of carbon intensity have decreased in all aggregated sectors in the range of 0.49 - 2.86 per cent. The greatest load of a surrounding medium is rendered "Coal", "Electric and Heat Energy", by "Products of the Oil and Gas Industry". On a countrywide scale, the amount of carbon dioxide released has decreased by 1 million tonnes, evenly in all sectors due to the relatively equal rate of replacement of traditional fuels with natural gas. A significant reduction in emissions is observed in the sector "Products of the Oil and Gas Industry", which is due to

![Figure 1. Carbon intensity of aggregated industries, tCO2 / 1000rub](image-url)
the rapid pace of the transition of the equipment of PJSC "Gazprom" to natural gas. The use of natural gas in transport can significantly reduce the burden on the environment: the level of toxicity of exhaust gases is reduced by 3-5 times while reducing the cost of an alternative compared to diesel fuel by a factor of 1.5-2 times. Since the transition to gasoline fuel in the Russian Federation is slower than in most developed countries and the reduction in carbon dioxide emissions at the country scale is not so small, there is already a significant effect from the implementation of the program. It should be noted that the essential effect of introduction of the program of energy saving, despite lower rates of transition of the Russian Federation to gas motor fuel in comparison with the majority of the developed countries and slight reduction of volumes of emissions of carbon dioxide in country scales is observed.

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