# Methodological Approaches to Modelling the Assessment of Geo-Environmental Impact of Energy Given the Quality of Life (on the Example of the Baikal Region and Belarusian Regions)

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***Abstract* — The paper is concerned with the results of an international project carried out together with researchers from Belarus and Armenia with the support of the EASR (The Eurasian Association for the Support of Scientific Research, established in July 2016 on the initiative of the Russian Foundation for Basic Research in cooperation with the partner organizations of Belarus, Armenia, Kyrgyzstan, and Mongolia.) Fund. The project aims to develop methods and technologies for assessing the geo-environmental impact of the energy industry in the region. The focus of the study is the negative impact on the environment and, as a consequence, a decrease in the quality of life. The study does not consider the power supply. Its priority is the development of tools for intelligent support of decision-making in this field.**

***Index Terms* — intelligent support of decision-making, energy, ecology, quality of life.**

## I. Introduction

The studies on the assessment of the geoenvironmental impact of energy in the region [1, 2] are conducted within the framework of an international project implemented in cooperation with the teams of scientists from Belarus and Armenia, with the support from the EASR-RFFI funds. The focus of the paper is the main results of the project carried out by the Russian side.

The fundamental scientific problem addressed by the project is the development of methods and geo-information technologies for assessing the geo-environmental impact of energy in the region [3]. The object of research from the Russian side is the Baikal natural territory, comparable in size to Belarus and Armenia.

The paper places an emphasis on the development and integration of modern information technologies for intelligent decision-making support within the framework of the problem. To implement the project, a Web-based information system (WIS) was developed. This system integrates mathematical and semantic methods [4, 5] and tools for assessing the geo-environmental impact of energy in a region, a database, a knowledge base, and a geographic information system. Individual WIS components are implemented as agents-services [6]. The ontology of the environmental impact of energy, ontology of pollutants and WIS architecture are presented in the paper.

The project aims to develop methods and technologies for the assessment of the geoenvironmental impact of energy in the region. It fits well into the main task of geoecology.

Geoecology is understood as an interdisciplinary scientific field that unites research into the composition, structure, properties, processes, physical and geochemical fields of Earth's geospheres as a habitat for humans and other organisms. The main task of geoecology is to study changes in the life-supporting resources of the geosphere shells under the influence of natural and anthropogenic factors, their protection, rational use, and control to preserve the productive and natural environment for present and future generations [1, 2].

One of the important tasks of geoecology is to study changes in the life-supporting components of

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the environment under the influence of natural and anthropogenic factors, their protection, rational use, and control, to preserve them for the present and future generations.

The study of changes in life-supporting resources entails the management of these resources, i.e. the management of human interaction with the environment and the impact of human society on its components.

It is important to assess the impact of such an anthropogenic factor as energy on the components of the natural environment and the quality of life of the population.

The novelty of the project is determined both by its interdisciplinary nature and by the integration of modern information technologies for accomplishing the tasks set (geo-information technologies based on 3D geo-visualization; intellectual technologies of semantic modeling: ontological and cognitive modeling; BigData technology).

The developed methods and technologies can be applied to support decision-making on improving the quality of life, given the energy and environmental factors.

The relevance of the project is determined, on the one hand, by the importance of the issue of assessing the geo-environmental impact of energy in a region, and on the other hand, by its insufficient research and the need to attract modern geo-information and intelligent technologies for solving it.

In the course of the project, the main specific problems to be solved by the project were clarified and expanded. These are 1) to analyze the existing methods for estimating the air pollutant emissions from energy facilities and existing models for the spread of pollution caused by emissions from energy facilities (given the wind rose, transfer, etc.); 2) to select and justify the methods recommended for the use in the project, to modify and adapt them, and develop original methods, if necessary; 3) to identify critical facilities that affect the life-support and natural environment of the region (in the energy, water, and other sectors), to connect critical facilities with the quality of life of the population [7]; 4) to analyze the approaches to the construction of geo-information systems, design a geo-information system based on 3D geo-visualization, determine the types of interfaces for displaying and analyzing the information; 5) to determine the composition of data necessary for the use of recommended methods, identify sources of information, assess their availability and financial costs of acquiring the information; collect and structure the necessary information; design and implement a database; 6) to develop the architecture of a Web-based information system (WIS) that integrates mathematical and semantic methods and tools for assessing the geo-environmental impact of energy in the region, databases, knowledge bases and a geo-information system; to develop a knowledge base structure within WIS; 7) to develop a system of ontologies [8] for describing the domain, adapt and develop tools for semantic modeling, construct semantic models for assessing the impact of energy on geo-ecology of the region; 8) to test WIS and apply the developed methods and technologies to support making decisions on the justification and formulation of recommendations for the energy development given the requirements of geo-ecology.

## II. The environmental impact of energy

In recent years, the issue of the environmental impact of energy has been widely discussed in the scientific world. Scientists try to investigate the negative consequences of the energy facilities operation for the environment and identify areas of harmful influence. The findings of the Russian and foreign scientists are considered below.

According to Vorobyov V.I. (Russia), an analysis of existing principles for the design and development of large thermal power plants (TPPs), and optimization models described by different authors shows that they do not take into account the actual air pollution effects since the specific placement of populated settlements that appear in the zone of the polluted area (especially in built-up areas) is not taken into consideration. Based on a full-scale instrumental survey of the urban area, Vorobyov V.I. determined the concentrations of harmful impurities at various distances from the pollution source (the territory of the TPPs, the sanitary protection zone, the residential development). The findings indicate that the maximum permissible concentration is exceeded at a distance of up to 18 km from the pollution source. Arslanbekova F.F. (Russia), who investigated the environmental impact of thermal power plants (TPPs) and motor vehicles, believes that the zone of the most intense air pollution by harmful impurities under torches of TPPs reaches a radius of 3-5 km. Nikiyenko Yu.V. (Russia) investigated the main points of the influence of thermal pollution on the microclimate of the adjacent territories. According to her calculations, the presence of a cooling pond in the area where NPPs and TPPs are located inevitably leads to negative environmental consequences, including maximum temperature, precipitation, and other anomalies. Kozhanov A.A. (Russia) offers methods of geo-environmental assessment of the influence of the fuel and energy system, based on establishing the relationship between natural conditions and anthropogenic impact. The studies on the interconnection of Energy, Environment, and Climate Change are also conducted in other countries, for example, [9-12]. The use of GIS-technologies and 3D-geovisualization is considered in [13, 14].

Nevertheless, the studies on the assessment of the environmental impact of energy have not considered the quality of life so far.

## III. The quality of life

Scientists introduced the concept of quality of life in the 1960s when the attempts were made to model the trajectories of industrial development. There are many

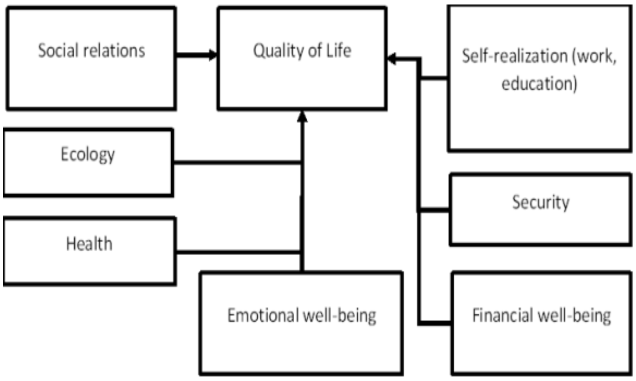


***Fig. 1. Quality of life as defined by the World Health Organization.***

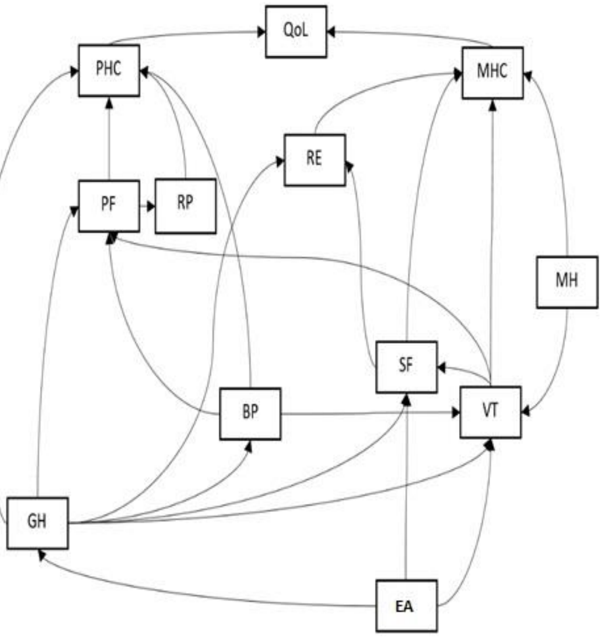


***Fig. 2. A cognitive map of life quality indicators using the procedure SF-36 (all links are positive)***
***Story:***
***PF (Physical Functioning) – physical functioning.***
***RP (Role-Physical Functioning) – role functioning conditioned by physical state.***
***BP (Bodily pain) – pain intensity.***
***GH (General Health) – general health.***
***VT (Vitality) – life activity.***
***SF (Social Functioning) – social functioning.***
***RE (Role-Emotional) – role functioning preconditioned by emotional state.***
***MH (Mental health) – mental health.***
***PHC (Physical health) – general component of physical health.***
***MHC (Mental health) – general component of mental health.***
***QoL (Quality of Life) – integral index of quality of life.***
***(EA) – energy access.***
***A correlation analysis was used to test the hypothesis. The dynamic data (2011-2017) on life expectancy in the Russian Federation and emissions from stationary sources were used to build a scatter diagram (Fig. 3). The correlation coefficient was -0.79, which indicates the presence of a strong negative relationship.***

different definitions of the quality of life but the most comprehensive is in the context of health care. Quality of life is understood as a set of objective and subjective parameters that characterize the maximum number of sides of an individual's life, their position in society and satisfaction with it. According to the definition of the World Health Organization [15], the factors determining the quality of life embrace not only financial well-being but the state of security, health, human position in society, ecology and, most importantly, the assessment of all these factors (Fig. 1). The integral index of the quality of life includes the indicators of health, social relations, emotional well-being, and financial well-being. In the framework of the considered project, the list of quality of life indicators includes the environmental factors.

The study conducted under the guidance of an author indicates that it is difficult to obtain an integral index using rigorous mathematical methods. The artificial intelligence methods are proposed for this purpose, namely, cognitive modeling, which is one of the directions of semantic modeling [5, 16]. Moreover, until recently, the research into the integral index of quality of life has not taken into account the impact of energy supply, whereas a shortage of energy resources can have a significant impact on both the level and quality of life. The studies also propose including the external factors in the quality of life indicators, in particular, the extent to which people are provided with energy resources (access to energy) (Fig. 2) [17].

The preliminary testing of the hypothesis about the impact of energy on the quality of life of the population shows that there is a relationship between life expectancy and the volume of air pollutant emissions from stationary sources (including energy facilities).

There were additional studies of the dynamic data (2011-2017) on life expectancy in the Republic of Belarus and emissions from stationary sources in a regional context (Fig. 4). During the study period, the values of the correlation coefficient varied from -0.33 (2016) to -0.78 (2015). The average value of the coefficient in the study period was -0.63.

The findings of the study indicate that the operation of energy facilities (in terms of emissions) has an impact on life expectancy and, consequently, on the quality of life of the population.

## IV. Proposed problem-solving methods and approaches

The development of tools for intelligent support of energy and environmental decision-making in the discussed project involves the methods of geo-information technologies based on 3D geo-visualization [18], critical infrastructure research methods [7], decision-support methods, knowledge engineering methods, object approach methods (analysis, design, programming), system and application programming methods, design methods of database, methods of information and expert

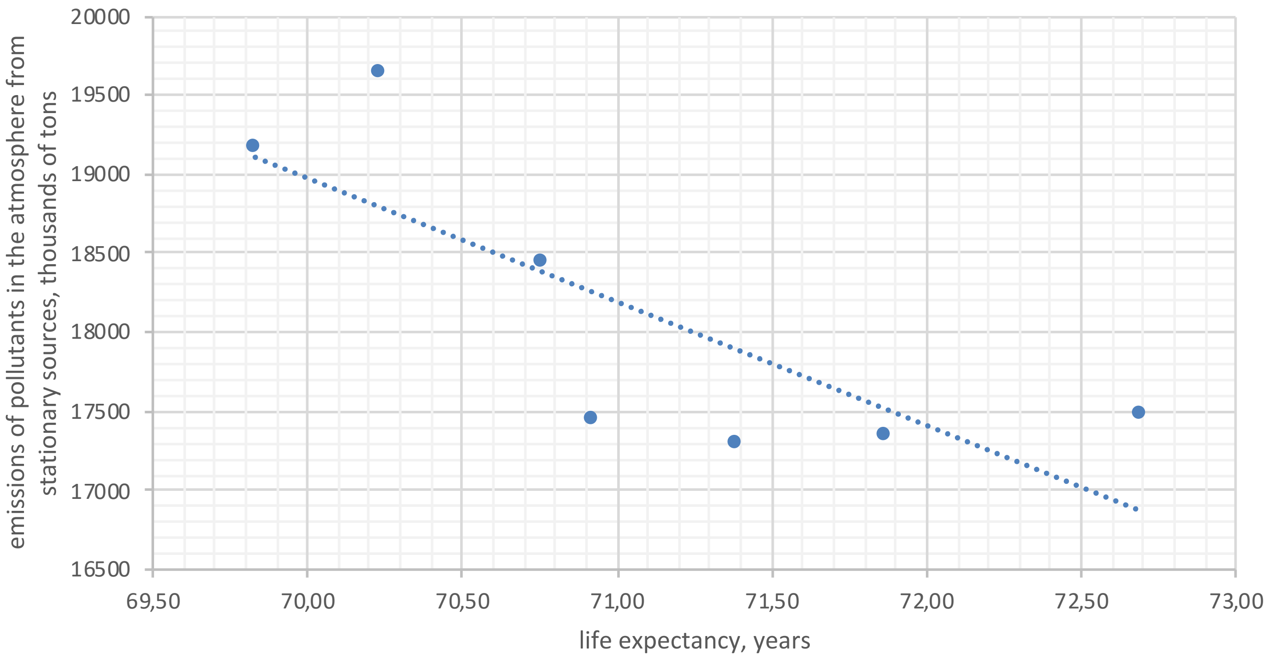


***Fig. 3. Scatter diagram of data on life expectancy and emissions from stationary sources in the Russian Federation in 2011-2017.***

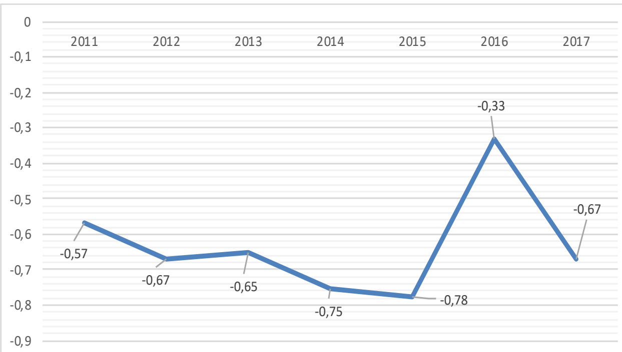


***Fig. 4. Dynamics of change in the correlation coefficient of life expectancy in the Republic of Belarus and emissions from stationary sources in a regional context.***

systems, as well as the methods devised by the authors, including the method of situational management, semantic modeling (primarily ontological and cognitive), and intelligent technologies for decision-making support [5]. The authors' methods of constructing an ontological space of knowledge in the field of energy; as well as the methods of semantic (ontological and cognitive) modeling in power engineering, methods of 3D-geovisualization and methods of visual analytics with elements of cognitive graphics, and the methods of intelligent systems development, which are designed to support making strategic decisions in the energy sector [19], are proposed to be developed and adapted to the project theme.

By way of illustration of the approach to constructing a system of ontologies of an applied domain, Figures 5-6 show the ontology of the environmental impact of energy (Fig. 5) and the ontology of pollutants from energy facilities (Fig. 6).

As seen in Fig. 6, the energy companies (enterprises of the electric power industry, heat power industry, and fuel and energy resources extraction and transportation companies) can pollute water, air and soil (the focus of the project is air pollution, Fig. 5). Negative impact on the quality of life of a person can be either direct or indirect (through the plant-animal relationships, i.e. through the food chain).

Figure 6 demonstrates the first version of the ontology of pollutants from energy facilities. It is built based on [20] and illustrates the way of structuring the knowledge about the subject area. The ontology can be extended or used as a hybrid one, i.e. some of its concepts can be considered as meta-concepts, which will be described by detailed ontologies. For example, the concept of "Purification" can be represented by a detailed ontology of the methods and levels of purification; the concept of the "Combustion method" can be represented by extended ontologies describing different combustion methods for small and large boiler plants, thermal power plants, etc.

As mentioned in the introduction, a Web-oriented information system (WIS) has been developed to implement the project. It integrates mathematical and semantic methods, tools for the assessment of the geoenvironmental impact of energy in the region, a database, a knowledge base, and a geographic information system. The authors' results obtained earlier are supposed to be used to study energy security problems. The individual WIS components (Geocomponent, semantic modeling support tools, individual computational modules, database access components) are implemented as agents-services [6].

WIS architecture is shown in Fig. 7. There are four levels

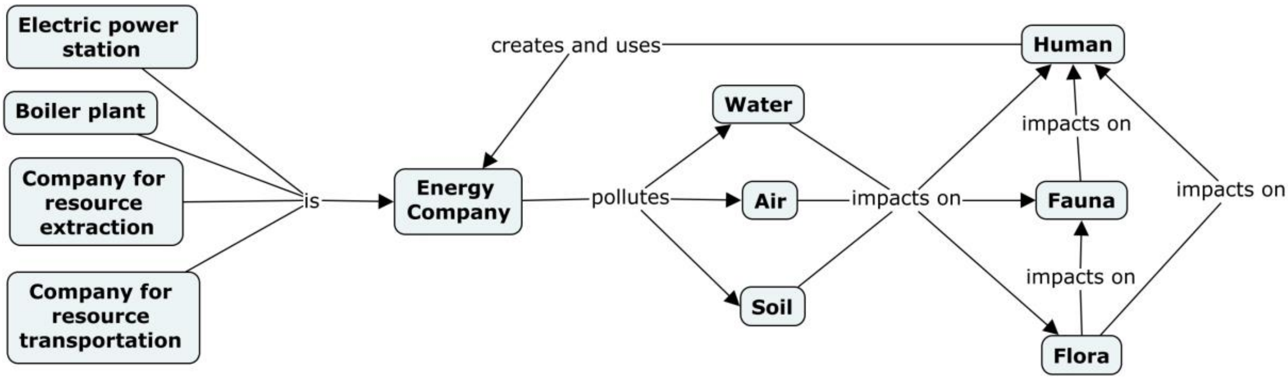


*Fig. 5. Ontology of the environmental impact of the energy sector.*

in the architecture: 1) the level of mathematical methods, models and software, which includes the software developed based on selected methods and models for calculating the volumes of pollutants and their impact on the quality of life of the population, and takes into account the capacity of energy facilities (energy supply) and population density in the considered territory; 2) the level of semantic modeling, which includes semantic (primarily cognitive) models for describing the interaction of factors that determine the quality of life, given the anthropotechnical factors, including availability of energy resources and the influence of pollutants from energy facilities on the environment; 3) the level of knowledge representation, which integrates the knowledge base storing descriptions of knowledge for constructing semantic models and an ontology system for describing knowledge of the subject domain; the latter can be used both for building a knowledge base and for designing a database; 4) the level of data representation, which integrates the geographic information system (GIS) and database, including geographic coordinates of energy facilities. GIS can be used both for the illustration of calculation results and for the visual interpretation of semantic models.

The meta descriptions of information presented at all four levels are stored in the Repository (its scientific prototype and tools for working with it were developed by Kopaygorodsky A.N., a member of the project team). The user interface is implemented using the components of the situational management language CML [21].

The methods listed above are used to assess the geo-environmental impact of energy in the regions (the Baikal region (Russia) and the regions of Belarus).

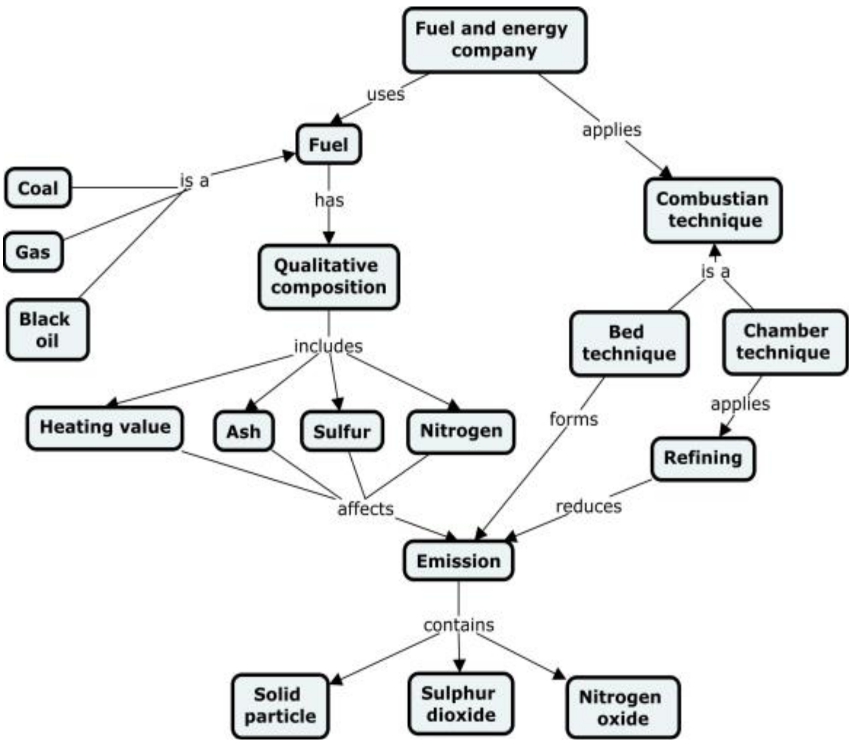


*Fig. 6. Ontology of pollutants from energy facilities*

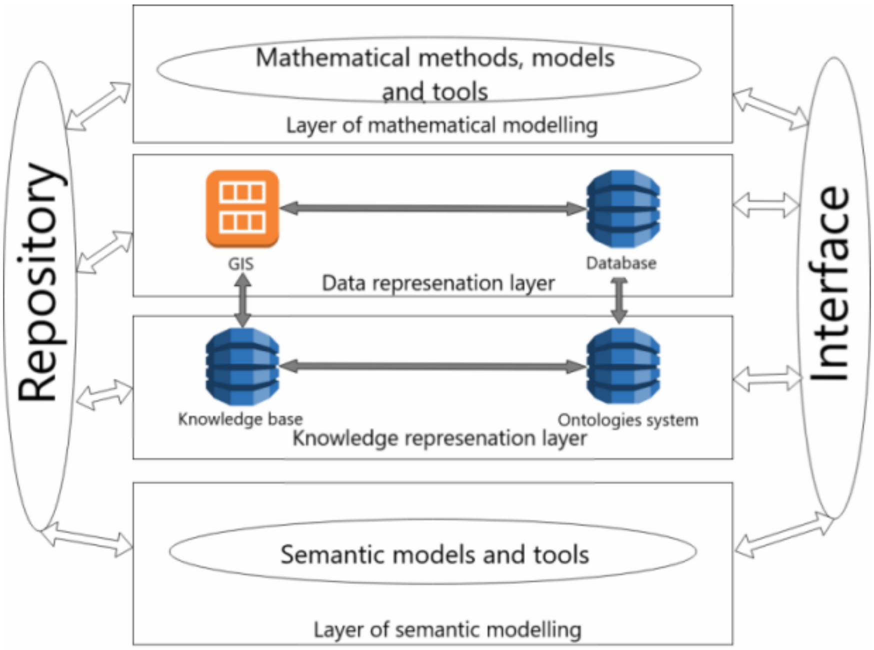


*Fig. 7. The architecture of the Web-based information system (WIS) to assess the geo-environmental impact of energy in the region.*

## V. Characteristic of objects of the research

The main air pollutants in the Russian Federation are carbon monoxide (CO), sulfur dioxide (SO2) and nitrogen oxides ($NO_x$). In 2011-2017, sulfur dioxide emissions decreased by 15% and accounted for 11.83% of the total emissions in 2017, nitrogen oxide emissions decreased by 3.13% and made up 11.02% of the total emissions, carbon monoxide emissions increased by 2.08% and reached 50.42% of the total emissions (Table 1).

The main sources of pollution in the territory of the Russian Federation in 2017 were mobile sources, i.e. mobile vehicles (45.5%), as well as manufacturing and energy enterprises. An analysis of the structure of emissions from stationary sources indicates that the greatest damage to the atmospheric air of the Russian Federation is caused by the mining industry (28.14%), the processing industry (33.21%) and the energy industry (20.27%) (Table 2). The data presented in Table 2 include both the statistical data and the data provided by Russian colleagues, project team members [20]. These data were subsequently included in the database, which was designed using the proposed ontological approach and the ontology system developed during the project.

However, some regions of the Russian Federation differ in the structure of emissions from stationary sources by type of economic activity. In particular, in the territory of the Baikal region, 52.02% of air pollutant emissions are produced by stationary sources supplying electricity, gas, and steam; and by air conditioning. This indicates a significant geo-environmental impact of energy facilities in the Baikal region.

Table 1. Emissions from stationary and mobile sources of the Russian Federation, thousand tons [22].

| Years | Pollutants | | | | | Total |
|---|---|---|---|---|---|---|
| | $SO_2$ | nitrogen oxides | CO | volatile organic compounds | $NH_3$ | |
| 2011 | 4462 | 3649 | 15840 | 2977 | 70 | 32628 |
| 2012 | 4431 | 3452 | 16119 | 2563 | 81 | 32469 |
| 2013 | 4306 | 3423 | 15782 | 2834 | 82 | 32063 |
| 2014 | 4131 | 3379 | 15517 | 2741 | 87 | 31228 |
| 2015 | 4197 | 3381 | 15530 | 2716 | 94 | 31269 |
| 2016 | 4110 | 3460 | 15862 | 2756 | 96 | 31617 |
| 2017 | 3794 | 3535 | 16169 | 2742 | 101 | 32068 |

*Fig. 8. The Baikal Region of the Russian Federation.*

Table 2. Air pollutant emissions from stationary sources in the russian federation by type of economic activity for 2017 [22]

| Indicators | Russian Federation, total | | Republic of Buryatia | | Irkutsk region | | Transbaikal Territory | | Total for Baikal region* | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Thousand tons | % | Thousand tons | % | Thousand tons | % | Thousand tons | % | Thousand tons | % |
| Agriculture, forestry, hunting, fishing, and fish farming | 248.09 | 1.42 | 0.75 | 0.66 | 4.50 | 0.68 | 0.11 | 0.08 | 6.70 | 0.61 |
| Mining | 4918.90 | 28.14 | 5.49 | 4.84 | 111.63 | 16.92 | 15.67 | 11.68 | 154.55 | 13.96 |
| Manufacturing industries | 5803.48 | 33.21 | 12.60 | 11.12 | 178.91 | 27.11 | 21.01 | 15.66 | 250.75 | 22.64 |
| Electricity, gas, and steam; air conditioning | **3542.64** | **20.27** | **82.40** | **72.71** | **304.77** | **46.18** | **70.06** | **52.22** | **576.13** | **52.02** |
| Water supply; water disposal, organization of collection and disposal of waste, pollution control activities | 492.88 | 2.82 | 2.24 | 1.98 | 4.72 | 0.72 | 0.96 | 0.72 | 10.61 | 0.96 |
| Total by the studied types of economic activity | 17477.47 | 100.00 | 113.32 | 100.00 | 659.93 | 100.00 | 134.16 | 100.00 | 1107.41 | 100.00 |

*Including air pollutant emissions from Mongolia, which are not shown in the Table

Table 3. Emissions of pollutants from stationary sources in the republic of belarus by type of economic activity for 2017, thousand tons [25].

| Indicators | Pollutants | | | | | Total |
|---|---|---|---|---|---|---|
| | Solid | $SO_2$ | CO | $NO_2$ | Hydrocarbons | |
| Industry | 21.0 | 46.5 | 60.3 | 45.9 | 18.4 | 250.4 |
| Manufacturing industry | 13.3 | 42.8 | 40.9 | 24.5 | 4.5 | 175.2 |
| Chemical and petrochemical production | 5.6 | 39.5 | 15.4 | 18.9 | 1.2 | 120.5 |
| Production of coke and refined petroleum products | 1.4 | 37.5 | 7.4 | 5.7 | 0.5 | 83.9 |
| Chemical production | 1.8 | 1.1 | 1.9 | 2.1 | 0.5 | 13.1 |
| Production of rubber and plastic products, other non-metallic mineral products | 2.4 | 0.9 | 6.1 | 11.1 | 0.2 | 23.5 |
| Electricity, gas, steam, hot water and air conditioning | 5.9 | 3.7 | 18.5 | 20.7 | 6.4 | 61.8 |

At the same time, the Baikal region has many unique characteristics, which is why it has been chosen as an object of the study.

The Baikal region covers the territory of the Baikal catchment area and includes three constituent entities of the Russian Federation (Irkutsk Region, Transbaikal Region and the Republic of Buryatia) and Mongolia (Fig. 8). The economic activity of these territories is carried out within the catchment area of the lake, and one way or another it affects the environmental state of Lake Baikal.

The project pays special attention to the development of the industry in the Baikal region because the bulk of it is situated in the catchment area of Lake Baikal, which is included in the list of UNESCO World Natural Heritage sites. The lake is a unique natural object of world importance. It is the deepest (1637 m) and oldest (25–30 million years old) lake of the planet.

The Law "About Protection of Lake Baikal" of April 2, 1999, provided the legal framework for the protection of Lake Baikal and outlined the Baikal Natural Territory (BNT), where the operation and development of industrial production are prohibited or limited. Within this territory are the Irkutsk-Cheremkhovo industrial area of the Irkutsk region and the main industrial zone of the Republic of Buryatia. This law imposes serious restrictions on the development of industry in the region. There is a conflict between the need to protect the environment in the zone of the World Natural Heritage site and the need to ensure a decent standard of living (especially in the case of closure of city-forming enterprises).

The territories that make up the Baikal region differ sharply in terms of the level of industrial development. The share of products from the Irkutsk region in the industry of Russia is about 1.8%, while the products from the Republic of Buryatia account for less than 0.3%, and those from the Transbaikal Territory - 0.2%. The basis for the development of industry in the Irkutsk region is the energy industry, which ensures electricity generation; coal, oil and gas production. The energy industry provides for the operation of the aluminum, pulp-and-paper, chemical, and oil refining facilities. Timber harvesting, gold mining, engineering, production of construction materials, and ferrous metallurgy are developed.

The share of the region in the production of aluminum

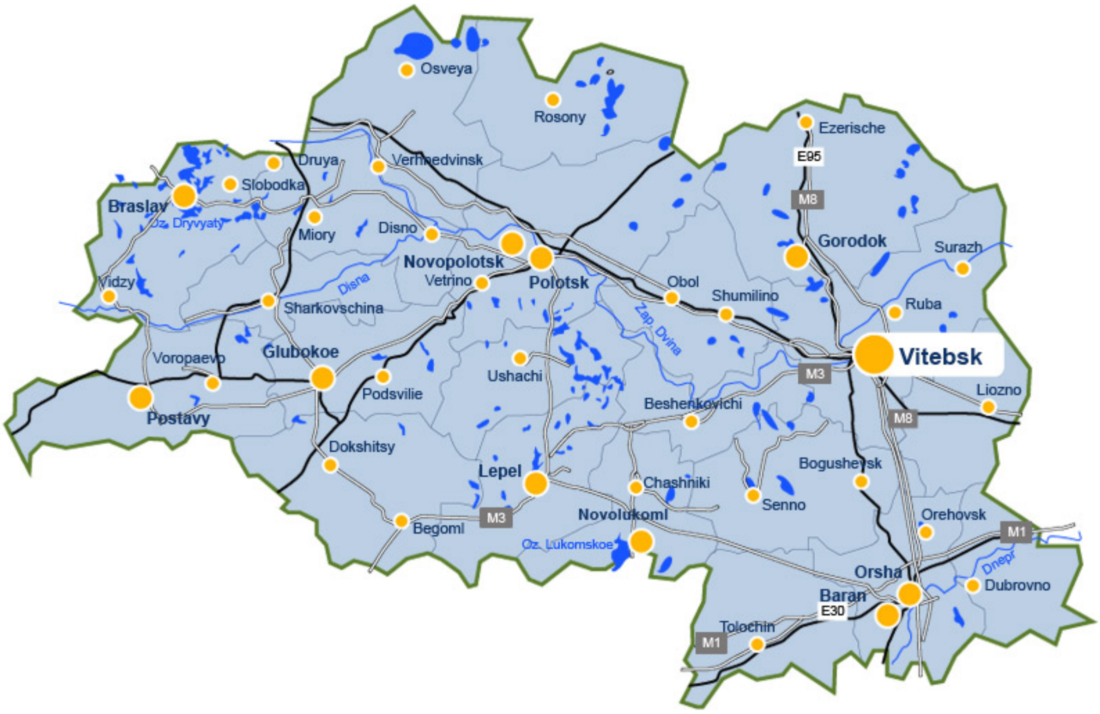


***Fig. 9. The Vitebsk Region of the Republic of Belarus.***

(35%), cellulose, (28%), caustic soda and chlorine (23%), plastic (12%), timber (11%), electric power (6%), radioactive materials, planes, industrial equipment, wood (15%), gold (10%) is considerable. The republic of Buryatia and Transbaikal Territory together generate electric power (using mostly coal) which is by a factor of 5 less than power generation by the Irkutsk region.

Sustainable development of the industry is impossible without the advancing growth of capacities in the energy industry. The issues of environmental protection are particularly acute here. The thermal power plants using solid fuel pollute the atmosphere and alienate significant areas under slag fields. Hydroelectric power plants damage an ecosystem by flooding considerable territories. According to short-term projections, the Irkutsk region will face a power shortage due to the development of the industry and transport, which will require new capacities to be commissioned [23].

Table 4. Air pollutant emissions in the regions of the republic of belarus for 2017, thousand tons [25]

| Indicators | Air pollutant emissions | | |
|---|---|---|---|
| | From stationary sources | From mobile sources | Total |
| Republic of Belarus | 453.4 | 787.2 | 1240.6 |
| Minsk and regions | | | |
| Brest region | 50.6 | 116.1 | 166.7 |
| Vitebsk region | 102.3 | 88.3 | 190.6 |
| Gomel region | 105.6 | 97.8 | 203.4 |
| Grodno region | 60.3 | 94.2 | 154.5 |
| Minsk | 18.3 | 136.8 | 155.1 |
| Minsk region | 68.6 | 178.6 | 247.2 |
| Mogilev region | 47.7 | 75.4 | 123.1 |

The main air pollutants in the Republic of Belarus are mobile sources, that is, mobile vehicles, as well as industrial enterprises and thermal power plants [24].

The sectors of the economy with the largest share of air pollutant emissions are the oil refining industry - 20.5%, electricity generation, households, and utilities - 12.9% each, engineering and metalworking, agriculture, chemical and petrochemical industries, transport and communications - 6.8-8.2% (Table 3).

As seen in Table 3, 48.12% of all industrial emissions come from chemical and petrochemical production, and more than 24% are from the energy industry enterprises. As evidenced by an analysis of the spatial structure of air pollutant emissions (Table 2), the largest shares of emissions are observed in Minsk (19.93%), Gomel (16.40%) and the Vitebsk region (15.36%).

The Vitebsk region of the Republic of Belarus was selected as the object of the study (Fig. 9). This choice is due to the following factors:

- The Vitebsk region covers an area of 40.051 km², which is 19.29% of the entire territory of the country;
- The population of the Vitebsk region is 1.2 million people, that is 12.43% of the total population;
- 32.7% of all electricity (10001.9 million kWh) and 16.2% of heat (5626.6 thousand Gcal) are produced on the territory of the Vitebsk region;
- The Vitebsk region accounts for more than 45% of petroleum products produced in the Republic of Belarus. In the structure of the manufacturing industry of the region, the production of coke and petroleum products takes 51.9%;

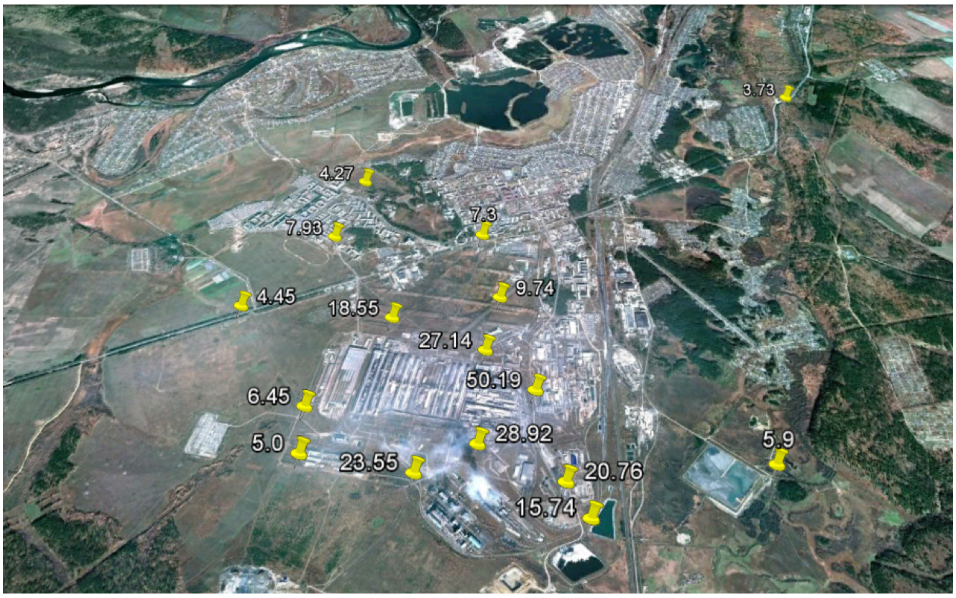


***Fig 10. 3D-visualization of pollution measurement results near energy facilities (SO4 content in mg / l near the Shelekhovskaya CHP).***

- Protected areas (Berezinsky Biosphere Reserve; National Park "Braslav Lakes"; Republican reserves "Yelnya", "Osveysky", "Krasny Bor", "Kozyansky", etc.) of the Vitebsk region occupy 9.5% of its area;
- The Vitebsk region ranks first in Belarus in terms of the density of the river network, the number and area of lakes. The rivers of the Vitebsk region belong mainly to the Western Dvina basin, which occupies 80% of its area. There are more than 2.8 thousand lakes in the region (Osveiskoye, Lukomlskoe, Drisvyaty, Drivyaty, Nesherdo, Snudy, Jezerishche, Strusto, Obsterno);
- The Vitebsk region ranks third in the Republic of Belarus in terms of air pollutant emissions (102.3 thousand tons from stationary sources, 88.3 thousand tons from mobile sources).

Thus, the main sources of air pollutant emissions in the Vitebsk region are the energy enterprises, the chemical industry, and vehicles.

## VI. Results and discussion

The paper is devoted to an important issue of the assessment of the geoenvironmental impact of energy in the region. The environmental studies normally do not consider separately the emissions from energy facilities, because it is difficult to separate them from general environmental pollution. This makes it difficult to plan and implement measures to reduce pollution by individual energy facilities. The paper proposes an approach to solving the problem of monitoring the geo-environmental impact of the energy industry in the region, based on the integration of mathematical models, GIS technologies and modern intelligent technologies in the framework of Web-oriented information system (Fig. 10). The novelty of the project is also determined by the fact that this is the first time the assessment of the geoenvironmental impact of the energy industry has taken into account the quality of life of the population. Cognitive modeling is seen as a tool for implementing this idea. The ontology system is proposed as a basis for designing databases and knowledge bases to provide information support. The proposed Web-based system, including an improved analytical tool for estimating the emissions from energy facilities and the spread of pollution, is considered as a prototype of the intelligent decision-making support system for improving the quality of life, given the geo-environmental requirements.

## VII. Conclusion

The focus of the paper is an international project, carried out under the guidance of an author with the support of the EASR - RFBR funds. The statement of the problem is formulated (the fundamental scientific task and the project objective), the relevance and expected results of the project are determined, and the methods for and approaches to its implementation are proposed. The main attention in the paper is paid to the information technology part of the project carried out by the Russian side. The illustrations of the proposed approaches are presented, including a cognitive map of indicators for assessing the quality of life, given the availability of energy resources; an ontology of the environmental impact of the energy sector; an ontology of pollutants from energy facilities; as well as the developed architecture of the web-based information system (WIS), which, together with the technology of its use, will be the final result of the project.

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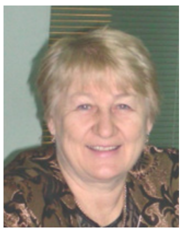

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