

# Monitoring of Innovative Technologies and Projects in the Field of Improved Industrial Energy Efficiency and the Industrial Implementation of New Energy Sources Aimed at Sustainable Development of the Northern (Arctic) Russian Regions

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## Abstract

**Objective:** The study is aimed at identifying and analyzing technologies and projects in the field of improved industrial energy efficiency and the implementation of new energy sources at enterprises focused on industrial introduction in the Northern (Arctic) Regions of Russia and promoting their sustainable development. **Methods:** An expert study is a key method of research. The concept and methodology of monitoring and two-level expert evaluation of advanced projects and technologies have been developed; the project selection criteria have been formed. In the formation of the research methodology the experience of Western countries during the two-level expert evaluations were taken into account. Nine experts in the field of the energy were invited. Mathematical processing of expert data was carried out by an averaged evaluation of the expert committee members' opinions and by determining the resulting expert opinion. For the analysis of the markets for application of the selected technologies the statistical and economic research method was used. **Findings:** The theoretical and methodological framework has been developed to select the most promising projects. An array of information about markets for applying the best technologies in Russia and in the world has been formed. The problems have been identified that hinder the development of this industry in Russia and in the world, an electronic catalog of existing and emerging projects and technologies has been created. With a view to the urgency and importance of the Arctic Russia the priority was given to the projects with a high stage of development. Recommendations have been developed to improve the effectiveness of cooperation between Russian educational and scientific organizations conducting research in the field of industrial energy efficiency improvement and the introduction of new energy sources at enterprises and the industrial enterprises operating in the Northern regions of Russia. To determine the key scientific leaders in the given subject area we assessed the degree of readiness of Russian scientific institutions to the introduction of advanced technologies in the target scientific direction. The results will serve as a basis in the implementation of an effective state policy for the development of the Russian Arctic regions, which since 2016 will complement the range of activities, developed in 2014 within the Russian government decree. **Applications/Improvements:** The complex of selected technologies allows organizing energy-efficient and environmentally friendly business activities for sustainable development of the Arctic regions of Russia and also can be used regardless of the weather conditions and can serve to energy efficiency improvement of any industrial enterprises in all climatic zones.

**Keywords:** Arctic, Energy Efficiency, Innovative Projects, Monitoring, New Energy Sources, New Industrial Technologies, Project Evaluation

## 1. Introduction

Currently, the Russian economy is one of the most energy intensive in the world. According to this indicator, Russia's GDP is almost 2 times behind the average values of the world and more than 3 times the average value of this indicator in Europe. The urgency of the problem of improved industrial energy efficiency, including the Arctic zone of Russia and the Far North regions is proved also by the fact that low energy efficiency leads to a high consumption of energy resources. According to the Russian Ministry of Energy estimation Russia consumed 6% of world consumption of energy resources per year in 2008, while energy efficiency was estimated at 0.42 tons of oil equivalent per USD 1,000 of GDP (0.19 t. o. e. of the world average)<sup>1</sup>.

In 2008, the Russian government set ambitious goals for improving energy efficiency of the Russian industry by 40% by 2020<sup>2</sup>. However, by 2015 the energy intensity of the Russian industry was reduced by only 5.61%<sup>3</sup>. Thus, in the next 5 years, energy consumption of the Russian industry must be reduced by almost 35%.

The experience of recent years shows that the achievement of introduced plans without a large-scale scientific research in the field of energy efficiency and new energy sources over the next 5 years is not possible. One of the key roles in this direction is given to renewable energy sources. By 2035, according to the Energy Strategy of Russia for the period until 2035 the electricity production based on renewable energy source is expected to increase 15 fold<sup>4</sup>. According to the BP Statistical Review 2015 report, nuclear energy and renewable energy sources in 2014 showed the largest increase – +4.8% (+2.3% in 2013) and +3.1% (+1.1 % in 2013) compared to previous years<sup>5</sup>.

Currently, more than 1,000 organizations are engaged in the development of new technologies of improved energy efficiency and new energy sources, however, today in Russia there are no scientific works aimed to systematize all the scientific experience in the specified scientific topics of the last years. Within the scientific and research work carried out with the support of the Ministry of Education and Science of the Russian Federation, the aim was to monitor the scientific activity in the field of improved energy efficiency and the introduction of new energy sources at enterprises and also to find out among emerging technologies the most advanced and those that are able to have the greatest impact on the industrial development of the Far North of Russia.

The special status of the Arctic regions is defined by the Russian Federation Government Decree of 21.04.2014 No. 366 “On approval of the State Program of the Russian Federation “Socio-economic development of the Russian Arctic region for the period till 2020”<sup>6</sup> as well as targets and goals are set for the Far North of Russia.

In the Russian Arctic, the most powerful industrial complex is created and the scales of economic activity are considerably superior to other polar countries' results. Here about 20% of Russia's GDP is produced and there is up to 22% of total Russian exports<sup>7</sup>. In addition, there is 20% of Russian oil and 62% gas in the Russian Arctic. Thus, the Arctic regions play a significant role in the formation of Russia's GDP and have significant potential for increasing production capacities, especially in the oil and gas sector. Such a high value of the Arctic in the industrial sector of Russia, as well as a significant lag in energy efficiency behind the Western countries, determine the relevance of improved industrial energy efficiency and the development of the Far North and the introduction of new energy sources.

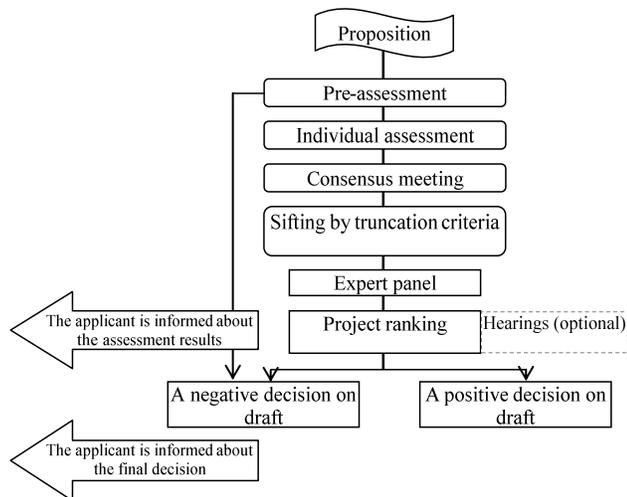
## 2. Research Methodology

At the first stage of the research work on monitoring projects and technologies to improve energy efficiency and promote new energy sources at the enterprises, no concepts in the world practice were found that would fully meet the objectives of the scientific work. In this regard, the authors have developed their own concept of monitoring and two-level expert evaluation, which includes the following key steps: Application on a specialized Internet resource, a preliminary assessment, the first stage of expert evaluation, the second stage of the expert evaluation, the ranking of projects and completion events. The stages of monitoring and the selection process are presented in detail in Figure 1<sup>8</sup>.

To form a general concept, the EU and Euratom practice for the two-level evaluation of promising projects<sup>9,10</sup> was used.

After the monitoring concept development using Science Citation databases the monitoring of Russian scientific organizations was undertaken, which was related to their scientific work (or their readiness for the introduction of innovative projects and technologies) in the field of energy efficiency and the introduction of new energy sources at enterprises.

To evaluate the research activity in these areas, to identify leading institutions that have made the greatest contribution to the development of this scientific field,



**Figure 1.** Stages of the process of monitoring and selection of technologies and projects in the field of energy efficiency and development of new energy sources.

to assess of changes in the amount of the annual scientific contribution from the 20th to the 21st century, the analysis of scientific works in more than 700 universally recognized scientific journals in Russia, publishing works in the field of energy efficiency and new energy sources was carried out. The analysis of the research activities was carried out over the past 5 years (2010–2014) using the Russian Science Citation Index (RSCI)<sup>11</sup>.

### 3. Research Results

#### 3.1 The Results of the Analysis of Russian Research Organizations’ Research Activities in the Field of Improved Industrial Energy Efficiency Development and Industrial Implementation of New Energy Sources

The conducted analysis allowed us to achieve the following key results:

- A list of organizations which in the period from 2010 to 2014 made the greatest contribution to the development of improved energy efficiency and new energy sources was made.
- Sectors of the economy with the highest scientific potential for the introduction of new energy sources and improving energy efficiency by using the existing ones were revealed.

**Table 1.** The 60 institutions with the greatest scientific contribution to the field of energy efficiency technologies development and the introduction of new energy sources

No.	Scientific and Research Institution
1	Moscow Power Engineering Institute
2	National Research Tomsk Polytechnic University
3	Lomonosov Moscow State University
4	Peter the Great St. Petersburg Polytechnic University
5	South Ural State University (National Research University)
6	All-Russian Institute of Farm Electrification
7	Kuban State Agrarian University
8	N. P. Ogarev Mordovian State University
9	The Bauman Moscow State Technical University
10	Kazan National Research Technological University
11	Kazan State Power Engineering University
12	Novosibirsk State Technical University
13	B. N. Yeltsin Ural Federal University
14	State National Research Polytechnical University of Perm
15	Peoples’ Friendship University of Russia
16	Kurchatov Institute
17	National Research Nuclear University MEPhI
18	Melentyev Energy Systems Institute Siberian Branch of the Russian Academy of Sciences
19	National Mineral Resources University
20	Volga State University of Technology
21	R. Ye. Alekseyev Nizhny Novgorod State Technical University
22	National Research Tomsk State University
23	Gubkin Russian State University of Oil and Gas
24	National University of Science and Technology MISiS
25	Joint Institute for High Temperatures RAS
26	Yu.A. Gagarin Saratov State Technical University
27	Ufa State Petroleum Technological University
28	M.T. Kalashnikov Izhevsk State Technical University
29	Omsk State Technical University
30	Southern Federal University
31	Orenburg State University
32	D. Mendeleev University of Chemical Technology of Russia
33	Tambov State Technical University
34	Far Eastern Federal University

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35	Moscow State Technological University "Stankin"
36	Tomsk State University of Control Systems and Radioelectronics
37	Voronezh State Technical University
38	Tver State University
39	V. I. Lenin Ivanovo State Power University
40	Tomsk State University of Architecture and Building
41	South Russian State Polytechnic University
42	M.V. Lomonosov Northern (Arctic) Federal University
43	National Research University of Electronic Technology
44	Ioffe Physical-Technical Institute of the Russian Academy of Sciences
45	Belgorod State University
46	Irkutsk State University
47	Institute of Service and Business
48	South-West State University
49	Samara State Technical University
50	Siberian Federal University
51	Lipetsk State Technical University
52	Far Eastern State Transport University
53	Institute of Solid State Physics
54	Saint Petersburg Electrotechnical University
55	Penza State University
56	Komsomolsk-na-Amure State Technical University
57	N.N. Semenov Institute of Chemical Physics RAS
58	Technological Institute for Superhard and Novel Carbon Materials
59	Saint Petersburg Academic University of the Russian Academy of Sciences
60	Saint Petersburg National Research University of Information Technologies, Mechanics and Optics

A list of 60 scientific organizations in Russia was compiled using the Science Citation Database, which made the greatest contribution to the development of improved energy efficiency and new energy sources in the period from 2010 to 2014.

The conducted detailed analysis of scientific works of these organizations has shown that most of them have an economic profile and therefore, are engaged in scientific activity exclusively from the point of view of largely theoretically based research. In this regard, these organizations were excluded from further analysis. Instead, the organizations which have technical projects in the field of

improved energy efficiency and the development of new energy sources, developed during the specified period or having them under development since 2014, have been included additionally in the list of the organizations under analysis.

The research has revealed that various sectors of the economy have different potential for the introduction of new technologies in the field of improved industrial energy efficiency and the implementation of new energy sources at enterprises. The study found that the following sectors have the greatest potential in the research areas in this regard: Power industry (19% of the total number of published works), engineering (9%), construction industry (7%), electrical engineering and automation (6%), agriculture and forestry (4%), mining and geology (3%), ecology, biology and water management (3%). The share of all other industries accounted for 49% of the total number of published scientific papers in the period from 2010 to 2015.

It should also be noted that most of the projects submitted by the presented organizations are focused on the development and use of alternative energy, in particular renewable energy sources. Research in this area is particularly relevant in view of the fact that the development of renewable energy sources has been identified among the main tasks of the State Program on Energy Efficiency and Energy Development. The Program provides the input of 6.2 GW of generation based on renewable energy sources up to 2020, which will increase the share of this generation in the current power balance from 0.8 to 2.5%<sup>12</sup>.

### 3.2 Determination of Target Regions within the Framework in Research

It should be noted that monitoring efforts are focused on the selection of improved energy efficiency technologies that can be effectively implemented in the industry of Russia Northern regions (Figure 2). These regions have been statutorily prescribed in the USSR with minor amendments in 2012<sup>13</sup>.

Nevertheless, the majority of the selected technologies do not bind to a particular climate, therefore, may be implemented anywhere in Russia.

Firstly, it is due to the fact that most of the reviewed technologies are intended for sale within industrial enterprises and secondly, any of the considered technologies can allocate the required equipment in built-for-purpose modular structures.



**Figure 2.** Statutorily prescribed the Far North region and localities equated to them (regionalism according to Institute of Economic Affairs Kola Scientific Centre Russian Academy of Sciences)<sup>14</sup>.

As part of the research project all selected improved energy efficiency technologies and developed new energy sources can be used in Arctic climate (conditions of the

Far North, i. e. in the presence of melting or solid ice from 60% to 100% during the year and at a temperature below 40°C more than 10% of the time per year<sup>15,16</sup>.

### 3.3 The Projects Selected for the Two-Level Expert Evaluation

Projects developed by scientific organizations mentioned previously which made the greatest scientific contribution to the development of improved energy efficiency technologies and the development and introduction of new energy sources in the period from 2010 to 2014 were selected for the two-level expert evaluation. These projects are presented in Table 2.

The largest number of projects involved in the two-level expert evaluation is dedicated to the development and study of renewable energy sources, and several projects are related to creating energy-efficient buildings.

**Table 2.** List of projects participating in the two-level expert evaluation

#	University	Issue-related developed technologies
1	National Research Tomsk Polytechnic University	Design and creation of hybrid systems of electric energy storage buffer for autonomous energy units of renewable energy
2	Moscow Power Engineering Institute	Development of a new type of fuel pellets on the basis of renewable bioenergy sources
3	Lomonosov Moscow State University	Development of self-generated power supply systems based on renewable energy sources
4	Saint Petersburg State Polytechnic University	Development of high efficiency compact self-generated power supply systems
5	South Ural State University (National Research University)	Development of energy-efficient types of electric drives
6	All-Russian Institute of Farm Electrification	Development of self-generated power supply installation on the basis of solar concentrators
7	Kuban State Agrarian University	Development of theoretical bases, new technical scheme solutions with approbation in actual use of high efficiency environmentally friendly combined geothermal-solar heating system for the modernization of existing and for the construction of new hyper-thermal thermal water intake
8	N. P. Ogarev Mordovian State University	Development of energy-efficient light-emitting-diode lamps
9	The Bauman Moscow State Technical University	Development of an electrochemical generator based on fuel cells and nanocomposites
10	Kazan National Research Technological University	Improving of biofuels production technologies on the basis of processing and recycling of organic waste products of agriculture, forestry and woodworking industries
11	Kazan State Power Engineering University	Development and creation of efficient energy delivery systems at power engineering facilities
12	Novosibirsk State Technical University	Development of scientific and technological bases for the creation of microchannel catalytic multifuel processors (for PEMFC)

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13	B. N. Yeltsin Ural Federal University	Development of new proton-conducting electrolyte membranes for advanced electrochemical hydrogen energy devices
14	B. N. Yeltsin Ural Federal University	New proton electrolytes for practical use in medium temperature electrochemical devices for hydrogen energy and environmental security
15	State National Research Polytechnical University of Perm	Development of reducing energy consumption technologies in the field gathering of oil wells production
16	Peoples' Friendship University of Russia	New and renewable energy sources on the basis of the processing of organic waste in the lithospheric reactors in oil-like products
17	Kurchatov Institute	Solid polymer fuel cell with stabilized water balance
18	National Research Nuclear University MEPhI	Development of thin-film solar cells based on materials with a perovskite structure
19	Melentyev Energy Systems Institute Siberian Branch of the Russian Academy of Sciences	Development of thermal scheme of gas CHP of increased fuel efficiency
20	National Mineral Resources University	Development of technologies for the production of organic fuels from substandard carbonaceous materials of natural and technogenic origin on the basis of the creation of new composite structures
21	Volga State University of Technology	Development and study of catalytic systems for the production and conversion of energy in the anaerobic treatment of organic waste
22	R. Ye. Alekseyev Nizhny Novgorod State Technical University	Development of a modular processing technology of solid organic feedstock to motor fuel for electric energy generation in the municipal and regional distribution networks
23	National Research Tomsk State University	Physical basis for the creation of the photovoltaic solar and thermal energy on the basis of nanoheterostructures with integrated multi-layered optical elements and enhanced IR spectral sensitivity characteristics
24	Gubkin Russian State University of Oil and Gas	Development of heat generator operating by compressed gas energy in the fluid collection system production at the hydrocarbon deposits
25	National University of Science and Technology MISiS	Development of technology and technical solutions of polyfuel gas producer unit based on local and renewable fuel resources
26	Joint Institute for High Temperatures RAS	Development of the electrochemical cell with a specific energy of more than 350 Wh/kg
27	Yu.A. Gagarin Saratov State Technical University	Recovery methods of passport characteristics of burners (development of adaptive ultrasound technologies)
28	Ufa State Petroleum Technological University	Development of energy efficient cement production technology using alternative fuel sources
29	M.T. Kalashnikov Izhevsk State Technical University	Development of energy efficient and sun-protective window systems of new generation
30	Southern Federal University	Aerodynamic and aero acoustic design of the turbine rotor of wind-driven electric plant with a maximum coefficient of wind energy
31	Orenburg State University	Development of autonomous energy-efficient and multi-functional complex for processing organic waste
32	D. Mendeleev University of Chemical Technology of Russia	Development of technical solutions for creating high efficiency environmentally friendly power plants on the average power on the new energy sources
33	Tambov State Technical University	Development of technical solutions for creating polyfuel heat-generating systems on local and renewable fuel resources
34	Far Eastern Federal University	Development of Solar and heat pump units with heat accumulators for energy efficiency of heat supply systems
35	Moscow State Technological University "Stankin"	Development and creation of innovative energy-saving equipment and systems for industrial equipment
36	Tomsk State University of Control Systems and Radioelectronics	Development of energy-efficient combined autonomous power systems based on renewable energy sources

(Continued)

37	Voronezh State Technical University	Creating energy-efficient compact heat and mass transfer systems with the directionally moving fluidized bed
38	Tver State University	Development of solid oxide fuel cell with direct oxidation of hydrogen sulfide for use in miniaturized autonomous android robotic industrial systems
39	V. I. Lenin Ivanovo State Power University	Technology of energy-efficient production and conversion of energy based on thermal processing of organic feed
40	Tomsk State University of Architecture and Building	Development of energy-efficient low-rise buildings for the use in Siberia
41	South Russian State Polytechnic University	Development of resource-saving technology for building energy-efficient buildings
42	M.V. Lomonosov Northern (Arctic) Federal University	Development of high efficient low-power boiler systems (up to 4 MW) on biomass for the Arctic zone of the Russian Federation
43	National Research University of Electronic Technology	Development of energy-saving technologies of heat energy receipt from the waste of wood conversion and agricultural raw materials
44	Ioffe Physical-Technical Institute of the Russian Academy of Sciences	Powerful photoelectric converters of laser radiation with an efficiency of over 60% for the radiation energy systems
45	Belgorod State University	Receipt, structure and properties of advanced composite materials (nanomaterials) for renewable energy sources
46	Irkutsk State University	Development of new designs of microbial fuel cells
47	Institute of Service and Business	Development and research of autonomous renewable energy source based on the effects of wind and snow mass on the polymer generator
48	Samara State Technical University	Development of energy-efficient technology for the processing of heavy sulfurous oils
49	Siberian Federal University	Research of extrusion process for producing fuel pellets from peat and wood conversion waste and creating an energy-efficient device for its realization
50	Lipetsk State Technical University	Conducting scientific research in the field of creating new and renewable sources of energy for businesses, remote from the grid network
51	Far Eastern State Transport University	Development and creation of energy-saving technology of water transportation through the pipes in the northern regions of Russia
52	Institute of Solid State Physics	Development of hardware components and fabrication of laboratory samples of solid oxide fuel cell of planar construction ranging from 100 to 200 watts
53	Saint Petersburg Electro-technical University	New and renewable energy sources on the basis of thin-film cascading solar modules and hydrogen-air fuel cells
54	Penza State University	Creation of spark, explosion, fire-safe environmentally friendly effective hydrogen energy systems based on methane-hydrogen technologies and fibre-optic measurement
55	Komsomolsk-na-Amure State Technical University	Energy-efficient products, and electrical and thermal energy conversion and transmission systems for the North, Siberia and the Russian Far East
56	N.N. Semenov Institute of Chemical Physics RAS	Universal energy plants of average capacity on renewable forms of energy products
57	Technological Institute for Superhard and Novel Carbon Materials	Development of single crystals for creating quick-response quick-operating high voltage Schottky diodes
58	Omsk State Technical University	Energy fuel technology of production based on modular pyrolysis plants
59	Saint Petersburg Academic University of the Russian Academy of Sciences	Creation and research of the properties of new solar cells with an active area of array-based semiconductor filamentous nanowires
60	Saint Petersburg National Research University of Information Technologies, Mechanics and Optics	Dielectric, plasmonic and hybrid photonic nanostructures

### 3.4 Description of the Selection Criteria and the Results of the Two-Level Expert Evaluation

In the course of the two-level expert evaluation the selection of projects was based on three groups of criteria, developed within the research:

- Scientific and technical superiority of the technology/project, consisting in the scientific validity of submitted proposal, potential application, the presence of the work plan, the level of maturity of the technology being developed.
- The quality and efficiency of the project implementation and management. This group of criteria is to assess the presence of the project team's necessary competence and experience, the availability of the necessary science and technology infrastructure, the required financing for the project.
- The effect of the project implementation (technology introduction). This group of criteria is devoted to the potential impact on the Russian industry through

the development, dissemination and use of project results.

These groups of criteria present the combined experience of the European<sup>10</sup> and domestic experience in the field of conducting expert evaluations for the selection of promising projects.

As a result of the two-level expert evaluation involving 9 independent experts in the field of energy and energy efficiency, based on the above criteria, 22 of the 60 reviewed projects were deemed the most promising to be implemented and able to provide the most important economic benefits for the development of Russian society and industry (Table 3).

### 3.5 Description of the Project, Recognized as the Best in the Result of the Selection

Thus, the Development of the Electrochemical Generators with the Energy Density of more than 350 Wh/kg project by the Federal State-financed Institution, United Institute of High Temperatures RAS has been recognized as the

**Table 3.** A list of advanced projects in the field of the improved energy efficiency technology and new energy sources development

Project rank	Institution	Technology	Amount
1	Joint Institute for High Temperatures RAS	Development of the electrochemical cell with a specific energy consumption of more than 350 Wh / kg	14.2
2	Gubkin Russian State University of Oil and Gas	Development of heat generator operating by compressed gas energy in the fluid collection system production at hydrocarbon fields	13.5
3	Saint Petersburg National Research University of Information Technologies, Mechanics and Optics	Dielectric, plasmonic and hybrid photonic nanostructures	13.5
4	Tambov State Technical University	Development of technical solutions for creating polyfuel heat-generating systems on local and renewable fuel resources	13.2
5	Ioffe Physical-Technical Institute of the Russian Academy of Sciences	Powerful photoelectric converters of laser radiation with an efficiency of over 60% for the radiation energy systems	13.0
6	National Research Tomsk State University	Physical basis for the creation of the photovoltaic solar and thermal energy on the basis of nanoheterostructures with integrated multi-layered optical elements and enhanced IR spectral sensitivity characteristics	12.8
7	The Bauman Moscow State Technical University	Development of an electrochemical generator based on fuel cells and nanocomposites	12.7

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8	South Russian State Polytechnic University	Development of resource-saving technology for building energy-efficient buildings	12.7
9	Far Eastern State Transport University	Development and creation of energy-saving technology of water transportation through the pipes in the northern regions of Russia	12.7
10	N.N. Semenov Institute of Chemical Physics RAS	Universal energy plants of average capacity on renewable forms of energy products	12.5
11	Moscow Power Engineering Institute	Development of a new type of fuel pellets on the basis of renewable bioenergy sources	12.3
12	Volga State University of Technology	Development and study of catalytic systems for the production and conversion of energy in the anaerobic treatment of organic waste	12.3
13	Tomsk State University of Architecture and Building	Development of energy-efficient low-rise buildings for the use in Siberia	12.2
14	Peoples' Friendship University of Russia	New and renewable energy sources on the basis of the processing of organic waste in the lithospheric reactors in oil-like products	12.0
15	Samara State Technical University	Development of energy-efficient technology for the processing of heavy sulfurous oils	12.0
16	National Research Tomsk Polytechnic University	Hybrid systems of electric energy storage buffer for autonomous energy units of renewable energy	12.0
17	South Ural State University (National Research University)	Development of energy-efficient types of electric drives	12.0
18	Belgorod State University	Receipt, structure and properties of advanced composite materials (nanomaterials) for renewable energy sources	11.8
19	Saint Petersburg Academic University of the Russian Academy of Sciences	Creation and research of the properties of new solar cells with an active area of array-based semiconductor filamentous nanowires	11.8
20	Tomsk State University of Control Systems and Radioelectronics	Development of energy-efficient combined autonomous power systems based on renewable energy sources	11.7
21	Kazan National Research Technological University	Enhancement technologies for producing biofuels	11.7
22	National Research University of Electronic Technology	Development of energy-saving technologies of heat energy receipt from the waste of wood conversion and agricultural raw materials	11.7

most promising and able to have the most positive effect on the Russian industry project as a result of the two-level expert evaluation.

The aim of the project is the development and creation of the electrochemical generator with a specific energy content of more than 350 Wh/kg and a power density of 160 W/kg, based on cylindrical air-aluminum elements<sup>17</sup>.

High specific parameters of an experimental battery sample on the basis of air-aluminum elements will be

achieved by increasing the specific characteristics of the gas diffusion cathodes and aluminum anodes, which are the main components of air-aluminum elements, as well as battery design features. The scientific and technical results obtained in the course of the project are the basis for a new generation of environmentally-friendly electric power units, having an unique combination of power and functional performance, two to three times superior to the world level.

The units obtained in the course of the project may find use as backup power sources for emergency and auxiliary power units in aviation at Ministry of Defense and Ministry of Emergency Situations facilities, for autonomous battery charging systems, as well as to increase fuel endurance of battery electric vehicles in the electric transport.

The project budget is 8.55 million rubles, of which 6.8 million are the federal budget funds, 1.75 million are extra-budgetary funds.

The development of the selected project is particularly relevant in view of the fact that to date, the air-aluminum elements are one of the most promising developments in the field of energy sources in the world (Figure 3)<sup>18</sup>.

## 4. Conclusion

Thus, the following research results were achieved as part of our research work:

- The concept of monitoring and expert evaluation of projects and technologies in the field of improved energy efficiency and the introduction of the enterprises new energy has been worked out.
- The criteria and mechanism for evaluation and selection of projects have been developed.
- A sample of 60 scientific organizations of Russia has been implemented, which had the greatest influence on the development of improved energy efficiency technologies in the last 5 years.
- The two-level expert work on the assessment of innovative projects and technologies on the improved energy efficiency and the implementation of new energy sources has been carried out.
- A cataloged record of projects in the scientific field under consideration has been developed.

The research results will be used by the Ministry of Education and Science of the Russian Federation to

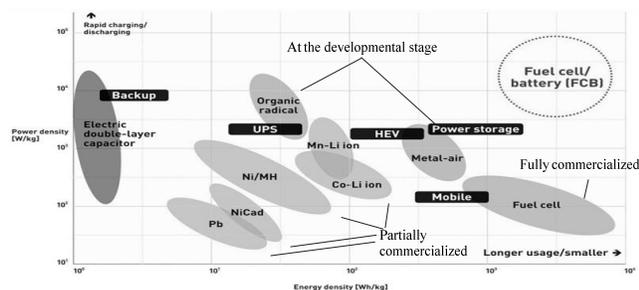


Figure 3. Battery types comparison.

address the challenges posed by the introduction of improved industrial energy efficiency and new energy sources technologies in industries in Northern (Arctic) regions in Russia, which are being developed in Russian scientific centers and institutions of higher education.

In the long term, the development of these technologies in Russia should ensure the sustainable development of enterprises located in the Northern (Arctic) regions of Russia, which in turn will enhance financial stability and investment attractiveness of organizations owning them.

Nevertheless, the results of the second phase of research show that pilot projects selected for further development and implementation cannot cover the entire set of problems related to improved energy efficiency in the Russian Far North.

In this regard, in the next phase of research it is essential to develop a coherent and connected system based on the selected projects, due to the fact that large gaps or even the impossibility of alignment and combination of some projects can be found in the future.

## 5. Acknowledgement

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