METHODOLOGY FOR PARAMETERS SELECTION AND EVALUATION
THE EFFECTIVENESS OF DECENTRALIZED ENERGY SUPPLY
SYSTEMS BASED ON RENEWABLE ENERGY SOURCES

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ABSTRACT
About 60% of Russia is located in isolated (autonomous) areas and mostly provided with electricity from diesel power plants running on imported fuel. According to the Russian Energy Agency (REA), the number of diesel power plants (DPP) operating in isolated areas is around 900, their power generation is about 2.54 billion kilowatt-hours per year. The cost of DPP producing energy is 0.25-2.0 Euro/kWh, which is significantly more expensive than in the areas with centralized power. Therefore, reducing the consumption of the imported DPP fuel is an important socio-economic problem. At the same time wind and solar energy potential have high rates in the areas with autonomous power supply, which can be effectively used by power complexes basing on renewable energy sources, ensuring a high proportion of replaced diesel fuel.

Keywords: wind energy sources, proportion of replaced diesel fuel, wind-diesel power plant, power economic estimation.

1. INTRODUCTION
Gross wind energy resources (WER) of Russia is about 80 x 10^15 kWh/year, technical WER - 6.2 x 10^15 kWh/year, economic WER - 31 x 10^12 kWh/year. About 38% of WER is concentrated in the European part, 30% - in the Far East, 16% - in Western Siberia and about 16% - in Eastern Siberia. Northern and Far Eastern territories of Russia have the high wind potential and the main power plants of are decentralized energy supply are located here [2].

Introduction of renewable energy sources and, in particular, wind-diesel power complexes can be an effective solution to reduce the costs of electricity generation and diesel fuel consumption. It provides increase power and environmental security for isolated consumers especially in areas with sufficiently high wind potential. Promising areas are northern and Far Eastern coastal regions of Russia; their wind potential has a high density (400 to 600 watts per m² at a height of 50 meters). According to the REA power supply systems introduction are planned in such areas, including renewable energy plant with capacity rated at 215 MW (Figure-1).

In the Science Education Center “Renewable energy sources” of Peter the Great Saint-Petersburg Polytechnic University within federal target program of Ministry of Education “Development of intelligent autonomous power supply methods and technologies from traditional and renewable energy sources for harsh climate conditions” are developed techniques and technologies of autonomous power supply through the establishment of module power complexes on the basis of renewable energy sources and primarily wind power.

Figure-1. Renewable energy potential by replacing power generating basing on diesel fuel for industrial customers in the Far East (according to CEA).

An analysis of existing international and domestic experience of DPP creation and operation in the United States (Alaska), Norway, Sweden, Canada and Finland [13] revealed that introduction of 55 operating power complexes and 50 in the design stage cannot fully be used to the Russia climatic conditions with lower winter temperatures, widespread permafrost zone, the most prolonged period of frost and icing of wind turbines blades, the lack of good roads conditions, transport and assembly equipment (Figure-2).
2. METHOD

Russia does not have the experience of determine parameters creation of such optimized systems for the required power consumption, power complexes on the basis of renewable energy sources, ensuring a high proportion of replaced diesel fuel. There it was developed a special method consisting of four interconnected functional blocks to solve the optimization problem (Figure-3).

Function blocks are combined into single multi-level optimization software, which provides a choice of composition, parameters and operating modes of the energy complex, using both traditional and renewable energy sources [7, 5].

The basis of the methodology for assessing wind energy resources (WER) in the first block is founded on the principle of a three-level sequential increase the accuracy of calculations:

- preliminary large-scale modeling and integrated assessment of wind energy resources;
- regional assessment of WER based on the mesoscale wind flow modeling and calculation of wind energy resources considering climatic characteristics of the region;
- multiscale modeling of wind flow and calculation of the resources according to the orography, relief, topography, etc. for a specific placement of the energy complex.

Selection and ranking of embodiments of the EC, based on multi-parameter comparison, is conducted in the second block [1].

Simulation modeling of the operating modes of EC with various composition and technical parameters of the equipment is conducted in the third block (Raghav Chakravarthy, et al., 2014). The main criteria of optimality the following items are [3]:

- minimum of the normalized cost of the electric power [8];
- minimum of the harmful emissions in CO₂ equivalent values [4];
- the maximum runtime (the battery life without maintenance);

Imitation calculation scheme includes the following mathematical models of the equipment:

- Wind turbine or wind power plant Models, counting the electricity generation based on wind potential prospective construction sites.
- Solar photovoltaic plant Model, defining the generation of electricity from the available options for the geopotential construction sites, the number and characteristics of the PhEM (photoelectric modules), shading effects and process control management system.
- DPP Model, defining the production of the diesel power, fuel consumption, emissions into the atmosphere, the service life before overhaul.
- Accumulating system Model (AS), defining the actual life of the accumulating battery (AB).
- Ballast loading Model (BL), defining the amount of the excess energy generated during regulation.
Model of intelligent control system, which provides regulation and redistribution of energy between the equipment according to the basic operating scenario of the EC and calculation of the power balance.

Financial and economic efficiency analysis of design solutions variants creating WDPP is conducted in the fourth block [6]. The financial and economic analysis is based on a comparison of the annual income and expenses on the project options for adopted life cycle.

### 3. RESULTS AND DISCUSSIONS

The proposed methodology implemented at designing and validation of the parameters of wind-diesel power complex in v. Anderma of Nenets Autonomous District, has improved the technical and economic parameters of the project by:

- reducing the amount of electricity production in the DES by using wind energy to 510 ths. kWh to 160 ths. kWh;
- reducing the consumption of diesel per 303 ths. liters per year, accounting for savings of 12.5 mln. rubles;
- reducing maintenance costs, replacement / repair of the DGS by 1.3 times;
- reducing CO₂ emissions by 600 tons;
- reducing the price of electricity at the final consumer by 38% to 45.2 rubles / kWh to 28.2 rubles / kWh;
- increasing the profitability of the project at the expense of the tariff in the amount of 45 million rubles in year.

### 4. CONCLUSIONS

1. The technique of substantiation parameters and operating modes of the power complexes based on the renewable energy sources is offered. Software is a unified multi-level optimization space, including an assessment of resource potential in the deficit of natural climate information, the selection and optimization of the structure and parameters of the equipment with a system of intellectual control that provides high replacement of the diesel.

2. The implementation of the principles of multi-purpose comprehensive approach to the creation and evaluation projects based on renewable energy complexes provides the increase of technical - scientific and technical - economic level and the investment attractiveness of projects for remote areas in difficult climatic conditions.

3. Using the suggested approach improves energy and environmental security and reliability of the areas of decentralized energy supply, reduce the amount of fuel brought from afar and electricity prices for end consumers.

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### REFERENCES


