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**COMPLEX MAPPING OF ENERGY RESOURCES
FOR ALLOCATION OF SOLAR AND WIND ENERGY OBJECTS**

Abstract. The paper presents developed methodology of solar and wind energy resources complex mapping at the regional level, taking into account the environmental and socio-economic factors affecting the placement of renewable energy facilities. Methodology provides a reasonable search and allocation of areas, the most promising for the placement of wind and solar power plants.
Key words: Solar energy, wind energy, mapping of the resource potential.

Introduction. The development of renewable energy in Russia nowadays needs to be solved not only the technological challenges and adoption of legislation providing state financial support for the projects, but also study the issues related to the resources assessment of the various types of renewable energy sources (RES) for the territory of Russia.

It is used to relate to renewable energy sources following types: solar origin (the energy of solar radiation, the hydraulic energy of rivers, wind, biomass, ocean energy), non-solar origin (geothermal, tidal), various waste products and sources of low-grade heat in combination with heat pumps.

Since the list of types of renewable energy is very wide and diverse in the present work we selected solar and wind energy resources for a detailed review.

Currently accumulated vast amounts of data, in varying degrees, provides a factual basis for renewable energy research. Thus in addition to the problem of data verification, analyze the adequacy of the methods for their preparation, there are difficulties of visual display in a convenient form for analysis. An important task is its accumulation in the form of databases, as well as mapping of renewable energy potential for different regions of the country.

In addition to the scientific and methodological value such research have great practical relevance, since the database and GIS should be an important tool for analyzing the efficiency of renewable energy practical use in various regions of Russia and to make reasonable technical and management solutions.

The relevance of the work is determined by the need to create a mapping techniques for renewable energy resource potential, taking into account the full range of assumptions and limitations

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of renewable energy at the regional level. On this basis, possibly to carry out zoning in order to select the most promising areas for the development of renewable energy.

Materials and methods. Existing world experience of mapping the renewable energy potential is not sufficiently mature and not quiet applicable to the territory of Russia, due to the great heterogeneity of the natural, environmental, economic and social processes. The task of developing methods of integrated geoinformation mapping of renewable energy resources, identify and rank the factors influencing the possibility of renewable energy resources use within the selected area in Russia has a great scientific and practical importance for the development of advanced clean energy technologies in a centralized and autonomous energy.

Renewable energy potential have to be assessed by the feasibility of drafting and analysis of multiscale map material on various subjects. Evaluating solar and wind energy resources through conventional techniques deals with a vast array of data (weather station measurements), which often refers to areas far from the point of the proposed construction of the wind farm, or detailed and reliable measurement data linked to point of interest (wind energy monitoring data) however, it is insufficient in terms of the time series length. Therefore, in the comparative analysis of different data sources, the space weather modeling justified and it made appropriate to use as a source of data on solar and wind energy characteristics in order to obtain more detailed data sets.

For a fair presentation of the resource base of wind and solar energy evident at the present time is lack of adequate baseline data and, therefore, the need to develop and analyze methods of interpolation and mapping of a wide range solar and wind energy characteristics, including derivatives (calculated) values.

We proposed a method of mapping, based not only on the currently existing regulations, but also on the experience of projecting companies operating on the territory of Russia, as well as classical and geographical mapping techniques.

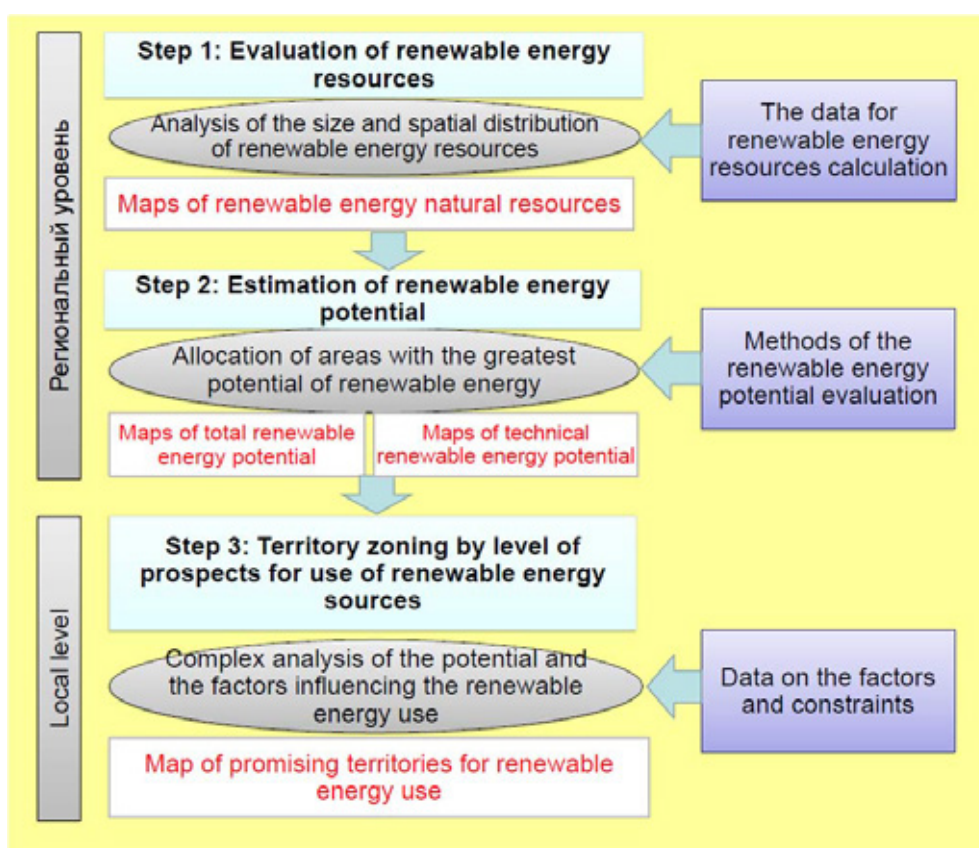The sequence of assessment and mapping of solar and wind energy resources is shown in Figure 1.

Fig. 1. The sequence of assessment and mapping of solar and wind energy resources

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It is recommended to carry out resource assessment of the territories in several stages. In the first phase the creation of a detailed cartographic material is preceded by an analysis of data on the particular renewable energy sources characteristics and their verification in a given area. The first step is to conduct a detailed analysis of the spatial distribution of natural resource properties.

In the second stage, it is needed to study the spatial distribution of gross and technical potential in the region, calculated on the basis of the existing evaluation methods and technical characteristics of modern power plants.

In the 3rd phase, the analysis of the factors and zoning on the prospects of development of renewable energy in the region and placing of RES power on it's territory. Accordingly, the theme of maps needed for such assessments, divided into 3 blocks:

• maps of natural renewable energy resources;
• maps of gross and technical renewable energy potentials;
• maps of factors and constraints that affect the placement of RES objects.

The result of the assessment should be an integrated maps of suitability and promising regions for allocation of solar and wind energy objects of various size.

Only the preparation and comprehensive analysis of the various cartographic materials allows to make regional assessments of renewable energy resources closer to the reality and to ensure the most reasonable decisions on placement of renewable energy objects.

Results and discussion. The results of developed methodology testing for the Southern and North Caucasian Federal District showed that this region is promising for the development of renewable energy both by the presence of natural and technical potential of solar and wind energy, as well as by the presence of experience in the implementation of renewable energy projects.

The list of maps compiled during the solar and wind energy potentials analysis for the territory of South of Russia includes:

• 4 maps of wind energy natural potential (the average wind speed at a height of 10 m and 50 m according to the land-based and satellite measurements, the repeatability of wind speeds);

• 2 maps of wind energy gross and technical potential (the energy of air flow per unit area, the estimated wind power capacity of a given type);

• 3 maps of solar energy natural potential (total daily solar radiation – the total value for the year, between April and October and June-August);

• 6 maps of solar energy gross potential (direct solar radiation on the surface of the differently oriented values (annual, April-October and June-August);

• 27 maps of solar energy technical potential (the efficiency of water heaters of 3 different types, designed for standard hot water temperature and different periods of averaging – year, April-October and June-August).

On the maps of natural and technical potential was highlighted by shading the territory of the Greater Caucasus, which is associated with a lack of precision of the models used by NASA to obtain long-term average values – of solar performance and in particular wind energy in areas with strongly dissected relief.

As a test area for further analysis of factors influencing the placement of renewable energy facilities, Volgograd region was selected as having sufficient natural potential of wind and solar energy. For the selected region evaluation criteria of natural and environmental factors, and conducted by zoning suitability have been selected to accommodate solar and wind energy, as well as the criteria for assessing the socio-economic conditions for the development of renewable energy. Zoning took into account the factors of the following types: natural (topography, hydrology, modern geological processes), environmental (protected areas, natural and cultural monuments, agricultural lands with special conditions of use (gardens, forests), technical (availability of implementation experience in the renewable energy projects), social (demographics), economic (energy change). For more flexibility, the analysis criteria shared by several levels to effect solution (Table 1), and size of the projected object.

In addition to the result map (the example given on Figure 2) maps of factors taken into account in the analysis were compiled, including:

- map of land resources;
- map of transport networks;
- map of specially protected areas;
- population map;
- map of power supply dynamics.

**Ranking criteria for the degree of influence on the decision on placement
of renewable energy facility in the selected area**

| Type	Rate	Influence on decision making
strict limitation	3	construction of the facility on renewable energy is completely forbidden
conditional limitation	2	construction prohibited, but can be realized if the positive effect of the object will be sufficiently high
low limitation	1	the construction can be carried out after a more detailed assessment of the facility's impact on the environment
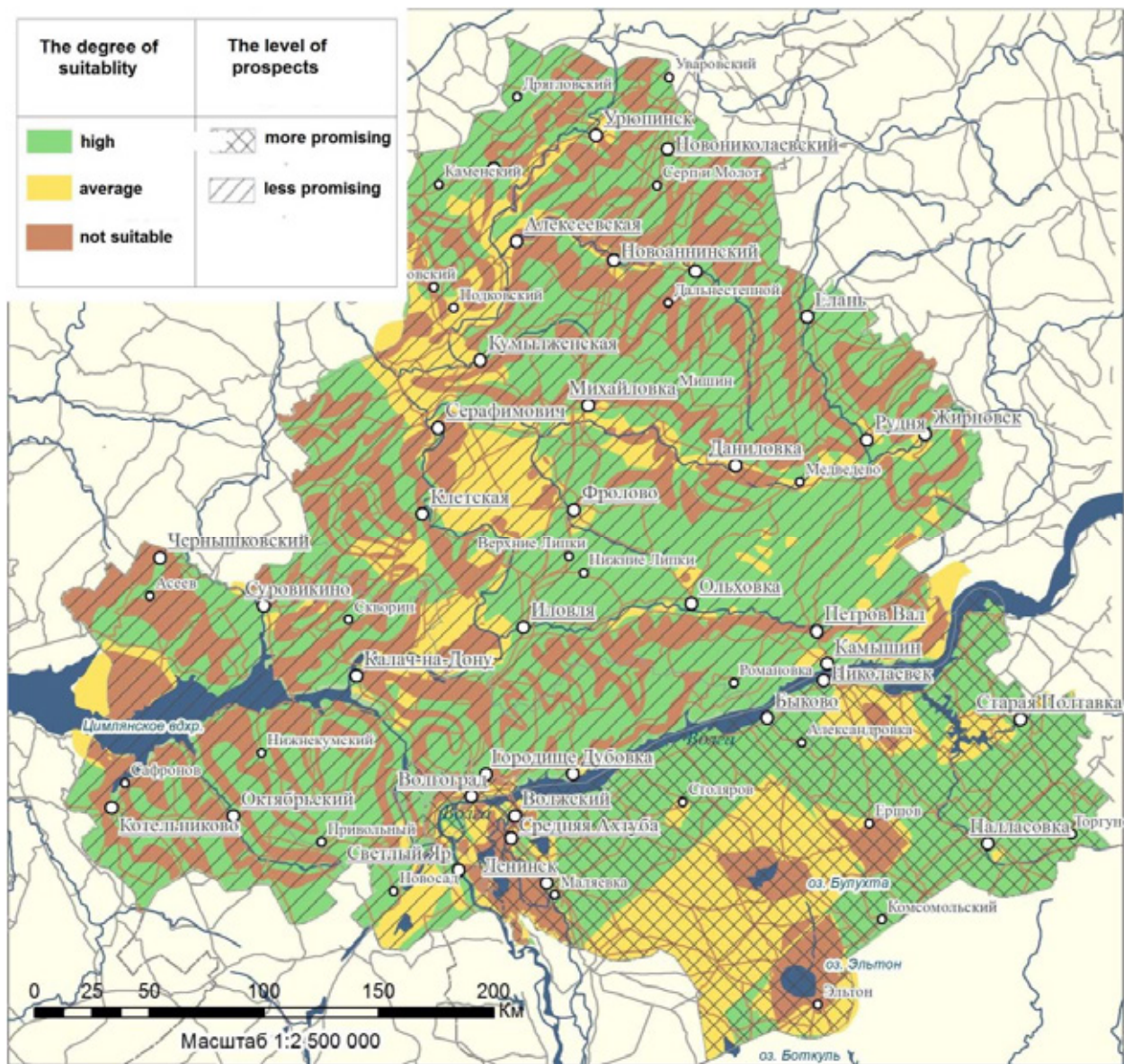
Fig. 2. Sample of suitability map for Volgograd region for solar and wind power objects placement

Conclusions. The testing of methodology showed that the proposed composition of a series of maps provides a fairly complete solar and wind energy resource assessment at the regional level. Joint analysis of natural and technical potential maps helps to evaluate the prospects using different types of power plants on renewable energy, to make a comparative analysis of winds at different altitudes and solar radiation values, coming to the surface from different angles of inclination and orientation, to define the predicted production of heat and electricity. It is specially important to use all available data sources and make their comparison.

Maps of factors and constraints that affect the placement of objects on renewable energy allow to define territories, the most promising for allocation of solar and wind energy. At the same time production of individual maps showing the group of factors make it possible to clarify what type of restriction is present on a particular site, that can facilitate the search for information materials and analysis on a larger scale during the development process. Factors and constraints maps unit may vary depending on the nature, features and climate of the region. But the overall logic of their thematic content set forth in the procedure does not change.

Maps of promising areas are the main result of the evaluation. They marked the sites that are completely unsuitable for placing objects on renewable energy and sites with a low degree of suitability. About 50% of the Volgograd region territory marked with a high degree of suitability by the natural and environmental factors, as well as socio-economic background to the development of renewable energy.

The whole series of maps in general allows to evaluate the resource potential of solar and wind energy at the regional level with a sufficient resolution for this scale and reliability. Map series is an information basis for solving a variety of tasks on a regional scale.

T.S. Nokelaynen[1]

MAPPING OF THE ENVIRONMENTAL IMPACTS
OF RAILWAY TRANSPORT IN RUSSIA

Abstract. Nowadays more and more attention is paid to climate change policy and sustainable development, for which transport still presents a major challenge. Railway transport plays an important role in the pollution of the natural environment. Therefore, it is highly important to monitor and analyse the environmental impacts of railway transport at the county scale. For this purpose, the thematic ecological database was developed for the territory of Russia and the digital map of the environmental impacts of railway transport was created at a scale of 1:20 000 000. The map is representing linear pollution connected with railway transportation systems, which is accessed according to the traffic intensity and types of freight transported on the routes. The major criteria of evaluation are freight volumes, the presence of polluting cargos and passenger train frequency. Conducted research aims to support decision makers with comprehensive data on the environmental impact of railway transport and helps to define the priority regions of Russia requiring measures of improvement of transport and ecological conditions.

Key words: Railway Transport, Environment, Pollution, Ecological Mapping.

Introduction. Railway transport is historically the main form of arterial transport in Russia. The railway network distribution on the territory of Russia has developed very unevenly. This is due not only to the vast territory of the country, but also to a large territorial differentiation in its population, as

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