Renewable Energy Sources in Formation of South Urals Modern Urban Systems

A Ju Khudyakov, S G Shabiev
Department of Architecture, South Ural State University, 76, Lenin Avenue, Chelyabinsk 454080, The Russian Federation

E-mail: hoodojnik@mail.ru

Abstract. The article considers the vital problems of renewable energy sources using by the example of the South Urals as a part of a general energy system of the Russian Federation, makes a forecast and gives recommendations on the application of specific technologies: solar energy, wind energy, deep heat energy and geothermal energy. It also considers the influence of the climatology on selection of the development pattern for the alternative energy industry. The article contains an example of wind energy used as a driver of the Karabash company town development in the Chelyabinsk region. The development of the economic energy sector is extremely important for the Russian Federation, both from the point of view of strategic security and from the point of view of integration into a modern development on the principles of Sustainable Development. To provide a full understanding of the role of alternative energy in the energy sector of the country, the article presents the materials illustrating the regional potential in terms of alternative energy sources use. This article is a part of the global research on the settlement system evolution in the South Urals. The authors studied the historical, geographical, demographic, economic characteristics of the region. Finally, a forecast for development at the regional level was made. Some of the aforementioned results were obtained due to the testing research in the learning process of the students from the South Ural State University (national research university). Keywords: Alternative energy industry, renewable energy sources, stable development, settlement system of the South Urals.

1. Introduction
The energy policy of Russia is aimed at the maximum efficient use of the natural energy resources and the potential of the energy industry to ensure stable economic growth, improvement of the population quality of life and assistance to strengthening of the foreign economic positions.

The energy strategy of the Russian Federation forms new benchmarks of the energy industry development under the transfer of the Russian economy to the innovative development path provided for by the “Concept of Long-Term Socioeconomic Development of the Russian Federation until 2020” approved by resolution of the RF Government # 1662-r dated 17 November 2008 [1].

It is provided for by the law that programs of socioeconomic development of regions must be based on the energy strategy of the Russian Federation until 2030 adopted by the Government on November 13, 2009 (resolution # 1715-r).
Implementation of the energy strategy of the Russian Federation provides for development of the RF area planning scheme in the sphere of energy (approved by resolution of the RF Government # 2325-r dated 01.11.2016). The area planning scheme provides for local, regional and general power engineering facilities, including: linear-type facilities (pipelines, power transmission lines, etc.), atomic power plants (APP), thermal power plants (TPP), thermal condensing power plants (CPP), hydraulic power plants (HPP), pump-storage power plants (PSP), wind power plants (WPP), substations, etc. [2].

In this regard, it is the first time when the modern energy complex development strategy considers alternative renewable energy sources at the level of federal programs.

At a more detailed studying of the materials on justification of the draft area planning scheme of the Russian Federation in the sphere of energy industry it has turned out that prospects of alternative energy source development are not outlined within the framework of the Ural Federal District development. The system of the energy complex at the current development stage is presented in figure 1.

![Figure 1. Fragment of the area planning scheme of the Russian Federation in the sphere of energy industry. Layout of federal facilities in the sphere of energy industry (existing facilities and facilities under construction).](image)

Prospects of the RF energy complex development are presented in figure 2.

It follows from the above schemes that it is not assumed to allocate federal facilities using renewable sources on the territory of the Ural Federal District (UFD) in the part of the South Urals.

However, the question of using alternative sources to generate electrical and thermal energy is rather vital, in particular, for Chelyabinsk and Kurgan regions. In 2014 electric energy consumption in the UFD comprised 178,09 bln. kWh, generation of electrical energy (APP, HPP, TPP) - 177,7 bln. kWh. Thus, the UFD experienced power shortages in 2014. At the same time, Sverdlovsk and Tyumen regions had power surplus, while Kurgan and Chelyabinsk regions experienced power shortages [3].
In 2014 Chelyabinsk region experienced power shortage. Over 2014 electrical energy generation increased by 3.6% as compared to 2013 and comprised 23700.8 mln. kWh, while the consumption grew by 1.1% and reached 36141.1 mln. kWh. In 2014 the volume of electrical energy consumption in the region exceeded the volume of generation by over 1.5 times. The power shortage in the region was covered at the cost of the cross-flows from the neighboring regional energy systems. It is expected that by the end of 2020 electrical energy consumption in Chelyabinsk region will grow by 4.9% and reach the level of 37894 mln. kWh, while generation of electrical energy will grow by 26.9% and reach the level of 30085 mln. kWh. At the same time, the power shortage in the region covered at the cost of the cross-flows from the neighboring regional energy systems will be decreased by 37.2% as compared to 2014 and comprise 7809 mln. kWh.

The global share of conventional energy sources (gas, coal, oil) comprises about 85% of the total volume of the generated energy, while the alternative energy sources generate no more than 1.5% of energy. The remaining energy is generated by the atomic power industry (6.5%) and the hydraulic power industry (7%).

The alternative energy industry is subdivided depending on the energy generation source. Currently, the following types of renewable and alternative energy sources are outlined: solar energy, wind energy, deep heat energy, geothermal energy, tidal energy, biofuel, biogas, etc. We can exclude usage of geothermal energy and tidal energy on the territory of the South Ural.

The economic efficiency of using different energy sources defines their application spheres. The cost of generation with application of solar energy is on the average 5-6 times more expensive than generation of wind energy. Based on this assumption, we can conclude that usage of solar collectors and solar batteries currently becomes efficient in the regions with a high deficiency of electrical and thermal energy. Besides, the efficiency of using solar energy can greatly vary depending on the region.
In particular, on the territory of the South Urals usage of solar energy in southern areas of the region can be twice and more efficient than in the northern part of the region. The map of distribution of solar radiation on the territory of the Russian Federation is presented for illustration (figure 3).

![Map of distribution of solar radiation on the territory of the Russian Federation and the neighboring countries](image)

**Figure 3.** Map of distribution of solar radiation on the territory of the Russian Federation and the neighboring countries (A N Afonin, K L Lipiyainen, V Yu Tsepelev, 2005).

Thus, we can conclude that solar energy can be used on the territory of the South Urals to a limited extent to ensure local power supply of civil construction facilities; to provide backup and emergency energy source; for power supply of private accommodation units and cottages; for power supply of recreation and leisure facilities, especially those located in hard-to-reach places. In any case, the main criterion for selection of such power supply method is economic efficiency.

One of the modern methods of thermal energy generation is the so-called thermal pumps using the principle of the environmental and soil temperature difference, generally below the freezing depth. Due to application of the heat (or cold) generation system it is possible to obtain from 2,5 to 6 kW of heat per each consumed kW of electrical energy. At the same time, thermal pump assemblies do not require any other energy source apart from the temperature difference and electrical energy for pumping the heat-transfer agent. The application range of such assemblies includes small industrial and civil buildings, private and mass residential sector. A drawback of such assemblies lies in considerably high costs at the stages of acquisition and start-up of the equipment, which makes them relatively unattractive.

One of the most perspective energy generation methods is wind energy generation. Currently, the cost of energy production by means of the wind energy is more than twice effective than energy production at gas flaring and more than thrice effective than energy generation at coal burning. Besides, it is necessary to note doubtless environmental advantages of this method.

The federal program on energy industry development of the Ural Federal District does not provide for allocation of WPP facilities. However, the documents of regional and local area planning can
provide for the relevant facilities. Application of such assemblies can be ever more effective considering the climatic features of the region [4].

**Figure 4.** Area planning of the Russian Federation by the average wind speed (DMB LLC, base material of the Federal Geodesy and Cartography Agency).

The distribution of wind loads by the wind speed is reflected on the map (figure 4). The southern part of Chelyabinsk region is in the area of increased wind loads and can be used for allocation of wind generation assemblies.

Considering the power shortage of Chelyabinsk and Kurgan regions, we can conclude that allocation of WPP in the short run will be one of the development vectors of the South Urals. For example, for generation of 1 kW of energy a network fleet of 200 wind generators will be needed, which can provide a small village in the south of the region.

Thus, the alternative energy industry in the South Urals is currently lowly evaluated at the level of federal programs, there are no opportunities and practice of selling excessive energy to the regional energy system as it happens in Europe. Town development solutions with application of alternative energy sources in the short run can improve the regional environmental situation. However, it would be strategically incorrect and unsafe for the Russian Federation to refuse from the conventional energy sources.

As an example of applying modern renewable energy sources we mention the concept of the general layout of Karabash under the experimental project (figure 5) developed by the chair of architecture of the South Ural State University (head of the chair of architecture S G Shabiev, project manager A Ju Khudyakov, student D D Grigorieva). The project based on the environmental town development method uses the affected territories of the slopes of Karabash mountain of Soimanovskaya valley within Karabash municipal district for allocation of fields of solar energy generators and wind generators.

Creation of the energy generation facility based on the renewable energy sources – wind and solar energy – was used as one of the development drivers in the target concept. The target task of recovery and rehabilitation of the affected territories was achieved, at the same, there appeared a new town development line – a ground for testing environmentally friendly energy generation technologies.
Figure 5. Concept of the general layout of Karabash. Layout of alternative energy sources.

2. Conclusion.
Thus, in the short term the South Urals will develop the alternative energy industry to a limited extent. The main emphasis should be made on the methods of wind generation and solar energy generation. Basic attention should be paid to the issue of stimulation at the regional level by means of the economic tools of the small generation usage, which will allow in a way to solve the problem of power shortage in the South Urals.

Even now several scientific developments in the universities of the UFD can be used as hi-tech and highly efficient substitutes to foreign products in the sphere of the alternative energy industry. Special attention should be also paid to development of industrial methods of energy generation system production, which will create an additional stimulus of the regional economic development and ensure reduction of energy generation costs.

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