Potential of renewable and alternative energy sources

V Konovalov[1,3], O Pogharnitskaya[1,4], A Rostovshchikova[1] and I Matveenko [2,5]

[1] Natural Resource Economics Department, National Research Tomsk Polytechnic University, 30 Lenin Ave., Tomsk, 634050, Russia
[2] Foreign Language Department, National Research Tomsk Polytechnic University, 30 Lenin Ave., Tomsk, 634050, Russia

E-mail: [3] sltan@ngs.ru, [4] pov@tpu.ru, [5] mia2046@yandex.ru

Abstract. The article deals with application potential of clean alternative renewable energy sources. By means of system analysis the forecast for consumption of electrical energy in Tomsk Oblast as well as main energy sources of existing energy system have been studied up to 2018. Engineering potential of renewable and alternative energy sources is evaluated. Besides, ranking in the order of their efficiency descending is performed. It is concluded that Tomsk Oblast has high potential of alternative and renewable energy sources, among which the most promising development perspective is implementation of gasification stations to save fuel consumed by diesel power stations as well as building wind-power plants.

1. Introduction

In recent years increasingly greater attention is paid to the problems of utilizing clean alternative renewable energy sources to meet energy supply demands in different agricultural and industrial spheres. The relevance and perspectiveness of the given trend are conditioned by the two key factors: catastrophic situation in the environment and necessity of searching for new kinds of energy [1].

Due to slow and sure resource depletion of basic energy sources, first of all, oil and gas, as well as limits in development of hydro- and atomic power, many countries carry out the research in extension of alternative energy sources use – peat, oil shale, bitumen, unconventional gases, energy of Earth heat, sun, wind, ocean, biosynthesis etc [2]. The research in alternative energy sources utilization is in progress in Russia as well. The Government Executive Order of the Russian Federation by 28 August 2003 № 1234 approved the energy strategy in Russia for the period up to 2020. The order is focused on necessity of using renewable sources of energy and local types of fuel.

2. Research object and methods

Studying the forecast for energy consumption and capacity within the period 2013-2018 developed by JSC «SO EES» based on facts and forecasts on production and commercial operation of electrical power engineering entities, approved programs of regional social-economic development as well as information on concluded utility connection contracts (table 1), there seems no doubt in the conclusion that in the nearest future the demands for renewable and alternative energy sources will be increasing, therefore, the research problem becomes even more urgent.

Table 1. Forecast of energy consumption in Tomsk Oblast energy system, mln. kWh.

Indicator	2014 (forecast)	2015 (forecast)	2016 (forecast)	2017 (forecast)	2018 (forecast)
Electrical energy consumption, mln. kWh	9344	9421	9531	9609	9688

The energy system was developed in the 1960's, mostly in Tomsk city and neighboring regions. The intensive process of energy system development took place in the 1970-80's. Within this period the railway road "Asino – Beluy Yar" was built, the consumers of the adjacent to railway road areas were supplied with electricity, agricultural consumers of south-eastern regions were provided with electrical energy, and intensive development of the northern oil fields started. In the field area the new towns (Strezhevoy, Kedrovuy) were built, Lyginetskoye, Igol'skoye, Gerasimovskoye, and other oil fields were developed, for their energy supply substations and transmission lines were built.

The primary power sources of Tomsk Oblast energy system are power stations Tomsk state district power plant (SDPP)-2 (Ru–331 MW) and Tomsk thermal power plant (TPP)-3 (Ru–140 MW), Tomsk auxiliary boiler (Ru–14.7 MW) incorporated in Tomsk branch of JSC «TGK–11» and SCC TPP (549 MW) belonging to JSC «Siberian Chemical Combine». The other generating capacities include, as a rule, units of small generation at some industrial enterprises such as gas-turbine and gas-engine power plants (stations of industrial plants) of installed capacity 61.2 MW. The energy supply of Tomsk Oblast is scarce. In 2012 the power exchange with neighboring regions united in energy system of Siberia and Ural amounted 3.635 bln. kWh or 40 % of annual energy consumption.

The scarcity of Tomsk Oblast in electrical energy causes the search for the ways of decreasing its dependence on outside power providers and, hence, increasing its power safety.

Availability of natural gas deposits and its production at the level of 4–4.2 bln.m^3 allows the potential possibility of building new gas power generating units in Tomsk TPP–3, mini–TPP on the basis of gas-turbine and gas-diesel power generating units of low capacity. Besides, the forecasted tendency of outstripping growth of natural gas cost in comparison with coal cost conditions the necessity of using gas at efficient power equipment only.

As an alternative for gas power engineering development one can consider the development of atomic energy and coal power stations.

It should be taken into account that the significant part of generating equipment at the Tomsk Oblast power stations are worn-out in service and require repair or replacement.

One more peculiarity of Tomsk Oblast energy system is the fact that primary energy sources are located in the south of Oblast, whereas significant part of power consumers, most oil production enterprises are situated in the north of the Oblast. Transportation of electrical energy from south to north is performed in long transmission lines of 110–220 kW in voltage, with very high current loads. It results in limitation of consumers' loads in transmission lines in post-emergency and repair conditions. In addition, at many substations of the energy system there is much tension around the issue of shortage in transformer capacity. These circumstances explain the fact that possible connections of new consumers to the power network are essentially used up in some nodes of power systems.

All mentioned above necessitates the improvements in the Tomsk Oblast energy system, among which much attention is paid to utilization of alternative energy sources and renewable energy resources.

Evaluation of technically feasible potential of renewable and alternative energy sources allows determining technical potential of principal kinds of renewable and alternative energy sources, among which wind energy seems to be the most profitable (table 2). In different parts of the world the application of wind energy has achieved the level which permits it to become the primary energy source. In developed countries, especially in Europe, the growth of wing energy generation was conditioned by the problem of global climate change for a long time.

Wind energy is the most preferable solution of international energy problems. It does not pollute environment and does not depend on fuel. Moreover, wind resources are available in any part of the world and they are sufficient to meet growing demands in energy [3].

Table 2. Annual technical potential of renewable and alternative sources of energy for Tomsk Oblast.

Kind of energy	Annual energy production, bln kWh	Annual heat production, mln Gcal
Wind energy	100 – 402	–
Solar energy	15 – 25	36
Small hydrostations	4.1	–
Biomass	4.7	26
Geothermal energy	–	76

The presented values describe total technical opportunities of energy production by means of renewable and alternative energy sources.

Comparison of the table data with the contemporary production level of electrical (5,5 bln KWH) and heat energy (12.3 mln Gcal) in Tomsk Oblast shows that technical potential of renewable and alternative energy sources exceeds significantly the energy demands.

To evaluate the real possibility of utilizing renewable and alternative energy sources, it is necessary, first of all, to determine their economic potential, i.e. that part of technical potential, the usage of which can be efficient at existing and forecasted indicators of power installations for existing and forecasted loads (energy demands).

To determine commercial potential of renewable and alternative energy sources, it is necessary to carry out a series of feasibility studies in definite points of their possible location (project technical and economic feasibility). Based on economic evaluations, technologies of renewable and alternative energy sources were ranked in their efficiency. The quantitative evaluations of potential generation of renewable and alternative energy sources competing with diesel power stations were given for the areas of decentralized power supply system where energy was generated by diesel power stations.

Such an analysis allows outlining the approaches to the development program of renewable and alternative energy sources in Tomsk Oblast including pilot projects for which design of technical and economic feasibility is reasonable.

Technologies of renewable and alternative energy sources can be ranked in descending order in terms of their efficiency in the following way:

1. Wood gasification power stations are efficient in the areas of decentralized power supply. In case of competition with diesel power stations they generate essentially (several times) cheaper electrical energy and are more preferable energy sources for isolated consumers.

Tomsk Oblast is rich in forest resources. Within the period of intensive development of forest industrial activity the industrial wastes amounted 260 000 tons. Even at the moment of maximum timber harvest, forest industry used only about quarter of forest resources subjected to cutting down that resulted in accumulation of mature and overmature planting.

Taking into account the fact that with the efficiency coefficient of gasification power stations 20%, the potential of electrical energy generation for Tomsk Oblast amounts in general approximately 160 - 640 mln kWh (i.e. 3 – 12 % of total energy generation).

2. Wind energy units are competitive in comparison with diesel power stations in the areas of decentralized power supply at average wind velocity more than 3,4 m/sec (such a velocity is typical for large number of residential areas). Their use allows reducing energy generation at diesel power stations and saving diesel fuel.

3. Small diversion hydrostations in some cases appear to be efficient for power supply of isolated consumers; however, conditions for building such hydro power stations are not favorable in Tomsk

Oblast due to plain relief. Potential scales of small hydropower industry development are not great – several plants with unit capacity in the order of hundreds of kilowatts.

4. Large peat reserves permit (in case of buildup of its production and manufacture of fuel briquettes) significant reduction of Tomsk Oblast dependence on foreign coal consumed by boilers. No limitations for peat production were stated.

5. Geothermal heat supply is competitive with boilers over the whole territory of the Oblast. Areas where thermal deposits are discovered have demand for thermal energy, hence, it is reasonable to build thermal power systems in: Asino, Teguldet, Zyryanskoye, Pervomaiskoye, Beluy Yar, Bakchar, Podgornoye, Stepanovka, Nazino, Kolpashevo, Kataiga, Narym, Parabel', Kargasok and other settlements.

6. Thermal pumps using low-temperature heat in the areas of centralized power supply (where the energy is cheaper) are nearly equally-economic in comparison with boilers. Their implementation can be reasonable due uneconomic (ecological and social) reasons.

7. Geothermal power stations could theoretically be built in Tomsk Oblast. However, low temperature of thermal waters requires special equipment, which is not available at the moment.

8. Solar energy reaching our planet is known to exceed human energy demand 20000 times. Of its total amount approximately one-fourth is spent for water evaporation and, in fact, continuously more or less evenly accumulates in the atmosphere over any point of the world [4]. However, utilizing solar energy for electrical- or thermal supply is economically inefficient and application of its technologies is not reasonable on a large scale.

An integral part of attracting investments for development of alternative and renewable energy sources is arrangement of high energy efficiency demonstration zones.

Demonstration zone of high energy efficiency is a system of complex energy supply, where there are conditions for efficient use of fuel-power resources, solution of management, engineering, economic, and legal problems in the priority power supply fields, concentration of production and engineering-research foreign and domestic experience for further development in economy and social services.

Such zones may be arranged in Kolpashevo, Asino, and other settlements of Tomsk Oblast [5].

In the structure of such high energy efficiency zones there should be energy service companies engaged in production, transport, and distribution of fuel-power resources, ongoing engineering centers should be arranged to train and retrain specialists in the sphere of energy saving, to perform advisory service, hold seminars and other activities for information support in rational use of fuel-power resources [6].

When arranging demonstration zones of high energy efficiency, it is necessary to use the following primary principles:

- application of new promising technologies and facilities to produce, transport, and distribute heat energy;
- development of energy saving activity;
- development of commercial appeal and cost-efficiency of the demonstration projects.

3. Conclusions

In conclusion it should be noted that Tomsk Oblast possesses great potential of alternative and renewable energy sources, among which the most efficient is implementation of gas-generating power stations in order to save fuel consumed by diesel power stations as well as build wind power plants.

Alternative and renewable energy sources are most efficient in the areas of decentralized power supply where they are competitive with diesel power stations.

To develop the utilization of clean alternative renewable energy sources one needs to take actions at the national level.

1. To assume obligations in development of renewable sources at the legislation level.
2. To design market techniques for renewable energy development at the legislation level.
3. To provide consistent return on investments placed in the projects of "renewable energy".

4. To reform electrical energy markets forming the guaranties:
   • Elimination of barriers on the way to renewable energy source development;
   • Elimination of unfavorable conditions in the market;
   • Consideration of social and ecological costs resulted from environmental pollution as a part of energy cost.

References

[1] Magomedov A M 1996 *Alternative renewable energy sources* (Makhachkala: Yupiter) p 245
[2] Golitsyn M V, Golitsyn A M and Pronina N V 2004 *Alternative energy source* (Moscow: Nauka) p 159
[3] Veselovskiy O N and Shteiberg Ya A 1993 *Essays on the history of power engineering* (Moscow: Izdatel'stvo MEI) p 252
[4] Styrikovich M A and Shpil'rain E E 1981 *Power engineering. Problems and perspectives* (Moscow: Energiya) p 192
[5] The Order of State Duma of Tomsk Oblast № 1008 "On Energetic strategy of Tomsk Oblast for the period up to 2020" 2008 *Ofitsial'nuye vedomosti Gosudarstvennoy Dumy Tomskoy Oblasti* 13(135) **I** 28
[6] Rozhkova D S, Khadkevich I A, Glyzina T S and Matyugina E G 2014 Industrial management of peat sorbent production in Tomsk region *IOP Conf. Ser.: Earth Environ. Sci.* **21(1)** 1–4