Estimation of the efficiency of involvement of renewable energy sources in the energy balance of the south region of Russia

D V Nikiforova and D Krivaya
National Research University "Moscow Power Engineering Institute", Russia, 111250 Moscow, Krasnokazarmennaya, 14
Dvnikiforova@yandex.ru

Abstract. The article contains a study on the feasibility of using renewable energy sources, in particular wind energy, for energy supply to consumers in the southern region of Russia. The paper presents the results of an economic assessment of the efficiency of construction of a wind farm with an installed capacity of 300 MW, as well as a comparison of two options for financing the project. Conclusions and recommendations are formulated to stimulate and support renewable energy sources in the southern region of Russia.

1. Introduction

As living standards raise, the demand for energy increases, people need more energy and are exploring many options for obtaining it. Renewable energy sources are the only way to overcome energy demand, and they include solar, wind, biomass, tide, ocean and geothermal energy [1].

The active development of alternative energy on a global scale began after the 1973 oil crisis, when humanity realized an unacceptably high degree of dependence on fossil fuel sources and their prices. Despite the active opposition of the oil and gas lobby, in the modern world the use of alternative energy sources is promising in terms of both economic and energy efficiency.

An additional stimulus for the development of alternative energy has also been provided by the political, economic and environmental crises that have occurred in recent years, which potentially affect the energy security of states and regions. On May 29, 2020, in Norilsk, at the TPP-3, an accident occurred, a leak from a tank in which there were about 21 thousand tons of diesel fuel. As a result, the Daldykan and the Ambarnaya rivers were polluted, the concentration of harmful substances in the water is greater than the rate of tens of thousands of times. Elimination of the consequences of the accident will take several months, and the ecosystem will be able to recover only in a few years.

Currently, Russia has remarkable experience in the creation and implementation of power plants based on renewable energy technologies. The main dilemma for the development of this industry remains the lack of real government support, despite the basic regulations adopted in 2000, as well as the growing need to protect the environment. Why Wind Power Plants? WPP do not consume fossil fuels and, thus, do not emit fuel combustion products into the atmosphere and do not have solid waste. Each kWh of electricity from a wind farm, replacing electricity from a coal-fired TPP, prevents harmful emissions of sulfur oxides, nitrogen oxides, fly ash and greenhouse gases into the atmosphere, as well as storage of ash and slag waste. Installation of 500 MW of WPP with an annual output of 1.5
billion kWh of electricity will save more than 500 thousand tons of fuel equivalent per year and prevent the annual emission of the atmosphere in order:
- 1.5 million tons of carbon dioxide;
- 12,000 tons of sulfur oxides;
- 7800 tons of nitrogen oxides;
- 12,600 tons of fly ash,
as well as storage of ash and slag waste in the amount of 200,000 tons.
Wind generators do not consume fossil fuels during operation. The operation of a 1 MW wind turbine in 20 years saves about 29 thousand tons of coal or 92 thousand barrels of oil.

2. Regulations and legislative support
Gradually, with the development of renewable energy sources, the legislative framework was also improved, which is aimed at stimulating the use of renewable energy sources. Having studied and analyzed a large number of materials and sources, the Laws on RES adopted in the territory of the Russian Federation from 1992 to 2019 are structured by year (Table 1).

One of the main results of legislative support is the establishment of the production of domestic equipment for renewable energy plants on an industrial scale, including for export. This leads to a gradual decrease in the cost of 1 kW of installed capacity, which significantly affects the reduction in the cost of generated electricity.

| Year   | Law                                                                 |
|--------|----------------------------------------------------------------------|
| 1992   | The principle of adequately meeting the development and environmental needs of present and future generations |
| 1995   | A legislative act at the level of the President and the Government of the Russian Federation, which provided for energy saving in Russia. |
| 1996   | "About energy saving"                                               |
| 1998   | Federal Law “On State Policy in the Sphere of Use of Non-Traditional Renewable Energy Sources”. |
| 2003   | The Government of the Russian Federation approved the Energy Strategy for the period up to 2020. |
| 2009   | About the main directions of state policy in the field of increasing the energy efficiency of electricity based on the use of renewable energy sources. |
| 2012   | About the approval of a set of measures to stimulate the production of electricity based on the use of renewable energy sources. |
| 2013   | About amendments to the Main directions of state policy in the field of increasing the energy efficiency of electricity based on the use of renewable energy sources for the period until 2020. |
| 2014   | About measures to streamline and stimulate the production and use of electricity based on renewable energy sources. |
| 2015   | About stimulating the use of renewable energy sources in the retail electricity markets. About equipping filling stations with charging stations for vehicles with electric motors. About measures to stimulate the use of renewable energy sources in the wholesale electricity and capacity market [2]. |
| 2016   | About introduction to the State Duma a bill aimed at stimulating the use of peat in energy. About granting of subsidies from the federal budget for technological connection of generation facilities that are based on the use of RES. About measures to stimulate the development in Russia of the production of equipment for solar energy based on photoelectric conversion. |
### 3. Rationale for choice of region

Krasnodar region is perfect for implementing the project for construction of WPP: Krasnodar region has a good natural and climatic conditions, namely huge wind resources. According to its geographical location Krasnodar region is in the wind zone of the southern hemisphere and in large parts of observed relatively strong air current [3]. On almost 50% of the territory, the average annual wind speed reaches 4-5 m/s, which, given the size of the country, i.e. more than 75.5 sq. km, predetermines the presence of a huge wind energy potential. In some areas of Krasnodar region average wind speed is 6 m/s and above, making them promising areas for the use of wind energy.

The cost of electricity from the end consumer from a WPP located in such places can be 0,15 – 0,18 $ per kW*h, taking into account the investment component, according to economic forecasts, by the Vygon Consulting organization.

In this regard, the Krasnodar region, namely the city of Yeysk, is considered one of the most suitable territories of the Russian Federation for the use of wind energy. In addition, the Krasnodar region is volatile, it receives about 36% of electricity from its own sources, while in other regions - about 60%.

In recent years, there has been a significant increase in investment for the implementation of RES projects, it is worth noting a large contribution to the development of road and transport networks through which easy and not so expensive, you can ensure the transportation of the equipment from place to place [4]. As part of the promotion of the plan "Development of RES for the period up to 2024" and the federal project "Modernization of the electric power industry in Russia until 2024" together with the organizations "VETROEN-YUG" and "VES-YUG", the Ministry of Industry and Energy are ready to implement an investment project on installation and use of wind power plants with a total capacity of 300 MW, in the city of Yeisk, Krasnodar Krai.

### 4. Investment project WPP

Investments in design, equipment and construction and installation work amount to 438,4 million $, which in terms of 1 kW of installed capacity is 1461 $/kW.

Annual expenses for depreciation, maintenance and repairs, salaries and deductions to social funds and others amount to 27,27 million $.

Annual output is 919.8 million kWh, taking into account ICUF for this project. Electricity consumption for the station's own needs is 10%.
The company will not be able to 100% finance the construction of a WPP, there are 2 variants for implementing the project:

1. The company invests 25% of its own funds and takes 75% on credit at 10% per annum;
2. The company receives state support in the amount of 33.3%, own investments 33.3% and a loan in the amount of 33.3% at 10% per annum.

The discount rate is considered as the risk-free rate and risk premium, hence the rate is 12.15% (9.916% and 2.23%).

The risk-free rate of return is the theoretical rate of return on a zero-risk investment. The risk-free rate represents the interest that an investor would expect to receive from a completely risk-free investment over a period of time. For 2019, it is 9.916% [5].

The risk premium is the return in excess of the risk-free rate of return that the investment is expected to generate. For 2019 - 2.23% [6]. Table 2 shows the results of calculations of the economic assessment of investment investments for two financing options. The net present value in both options is greater than 0, the internal rate of return is higher than the discount rate, the discounted payback period of the project is less than the estimated period of the project.

| Table 2. Criteria for evaluating the effectiveness of an investment project |
|---------------------------------------------|-------------------------------|
| Index                             | 1st variant | 2nd variant |
| NPV, million $                   | 187,8           | 381,53       |
| IRR, %                           | 17             | 22           |
| PP, years                        | 12,5           | 7            |

Figures 1 and 2 show the dependence of the tariff on NPV, from which it can be seen that there is a potential for reducing the selling rates.

**Figure 1.** Project with financing variant 1st  
**Figure 2.** Project with financing variant 2nd

Comparing the results of the two financing variants, we can say that both cases of project implementation are possible and expedient.

**5. Conclusion**

In order to take a leading position in the renewable energy market, it is necessary to adhere to a number of measures:

- To support the development of renewable energy, it is necessary to create rules and organize laws;
- Maintain active international relations to maintain and exchange information;
- Invest in equipment development and research;
- Adopt a number of measures that will take continuous government support as subsidies;
In order for the regions to purchase equipment for the further development of renewable energy sources in their area, it is necessary to introduce a system of preferential crediting;

- To reduce CO2 emissions into the atmosphere, it is necessary to introduce a tax, as well as introduce a tax system for consumers and producers;
- Mandatory, for all organizations, it is necessary to introduce a training program to improve the qualifications of employees;
- The main factors in the development of renewable energy sources are the climate and geographic features; it is necessary to create scientific centers that will study territories favorable for the implementation of renewable energy sources.

6. List of symbols

RES - renewable energy sources;
WPP - wind power plant;
TPP - thermal power plant;
ICUF - installed capacity utilization factor;
NPV - net present value;
IRR - internal rate of return;
PP - discounted payback period.

References

[1] Renewable energy and environment - a future perspective [Electronic resource] / Cyberleninka. - Access mode: https://cyberleninka.ru/article/n/renewable-energy-and-environment-a-future-perspective
[2] Documents and events [Electronic resource] / Government of the Russian Federation - Access mode: http://government.ru/rugovclassifier/565/events/
[3] Lyatkerh VM Optimal use of the energy of tides // Reports of the Academy of Sciences. - Federal State Budgetary Institution "Russian Academy of Sciences", 2006. - T. 411. - No. 4. - S. 476-479.
[4] Grigorash O.V. The current state of electricity production by renewable sources in the world and in Russia / OV Grigorash, Yu. P. Stepura, AS Ponomarenko, Yu. V. Kondratenko // Proceedings of KuyuGAU. - Krasnodar. 2012. No. 6. P. 159 - 163.
[5] Key rate of the Bank of Russia [Electronic resource] / Bank of Russia - Access mode: https://www.cbr.ru/hd_base/KeyRate/
[6] Calculation of the size of ERP (Equityriskpremium) for the Russian market [Electronic resource] /SwissAppraisal-Access mode: https://swissapp.ru/upload/iblock/a0f/Swiss_Appraisal_Analitics_ERP_Russia_4Q2018.pdf