Wind Energy in the Southern Regions of Russia: History, Current State and Development Prospects

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Abstract. The article relevance is to suggest possible principle of resort regions activities improving by modern technological innovation adaptation. There were applied methods of comparative, statistical analysis, synthesis, content analysis, economic modeling and data on resort and spa sector functioning and wind power plants construction and implementation. The development strategy of wind energy involves the creation of completely new industry; the task is not only to construct wind power plants (WPP), but also create system of technical regulation, training, organization of localization of wind turbine production, its certification and development. Solving this problem requires formation of new competencies for creation and management of wind farms, organization of wind turbines mass production, organization of after-sales services, competencies in marketing, development and sales of new products.

1. Introduction
Currently, the study of alternative energy sources for resort and spa sector is particularly relevant. Increasing of greening level is also up-to-date. One of the most promising energy sources is wind turbine stations creation. Development strategy of wind energy involves creation of completely new industry; the task is not only to construct wind power plants (WPP), but also create system of technical regulation, training, localization organization of wind turbine production, its certification and development.

2. Literature review
There are different literature sources and articles on the mentioned topic on resort and spa sector improvement listed in the references below ([1-11]) and also some others. But history, current state and development prospects on wind energy in the southern regions of Russia needs further development.
3. Methodology and data
There were applied methods of comparative, statistical analysis, synthesis, content analysis, economic modeling, and data on resort and spa sector functioning and wind power plants construction and implementation.

4. Results
Many people believe that development of alternative energy sources is purely modern phenomenon. Meanwhile, in the USSR, wind power was used to electrify the country during the first five-year plan. The experimental wind farm in Balaclava with capacity of 100 KW was developed under direction of inventor Yuri Kondratyuk and installed there in 1931. Before the war, it produced electricity for the Balaclava-Sevastopol tramline. During the war it was destroyed.

In the spring of 1932 Grigory Ordzhonikidze came for rest to one of sanatoriums near Yalta by insistence of his doctors. The People's Commissar of Heavy Industry and Energy was very puzzled by power supply problems of the South Coast of Crimea. More precisely, it was almost complete absence of electricity in the evenings, when all Yalta plunged into darkness. The Commissar found situation way out, when he was admiring the top of Ai-Petri mountain, where winds always blow. When he returned to Moscow, he ordered to announce competition for projects of powerful wind power stations, capable to provide electricity for Southern Crimea. This wind power plant (WPP) has to become the third one in the Soviet Union. The first WPP was built in 1930 near Kursk by the project of engineers Ufimtsev and Vetchinkin. The second one was built in 1931 in Balaclava. It was designed by self-taught inventor Yury Kondratyuk. Only a few of our compatriots know this name but in the Kennedy Space Center Museum it is listed on the golden list of earthlings who opened the way to space for humanity. Calculations and ideas of Yuri Kondratyuk, outlined in his works "On interplanetary travel" (1926) and "Conquest of interplanetary expanses" (1929), were used by American astronauts in creating the lunar program and landing on the Moon. At the same time Yury Kondratyuk did not create his works in the quiet of offices. He worked as lubricant and car trailer, then as mechanic and builder at elevator station and his everyday life always was managed by the absolute minimum. The writer Oles Gonchar called him the genius in the windings. Learning about the competition for the design of wind power stations at Ai-Petri, Yuri Kondratyuk decided to participate in it. The essence of the project suggested by Kondratyuk was the construction of reinforced concrete mast on the Bedene-Kir plateau, four kilometers north of the peak of Ai-Petri. This place is located at the altitude of 1324 m above sea level, and the average annual wind speed there reaches 89 m / s. The height of the tower was to be 165 m, it was supposed to place two three-bladed propeller-wind turbine with the diameter of 100 m on it. Igor Kondratyuk and his few colleagues sent their project to the competition under the code name (or, as they said, the motto) “Icarus”.

At the same time, teams of such serious scientific institutions as the Ukrainian Institute of Industrial Energy (UIIE) and the Central Wind Energy Institute (CWEI) worked on the project of the Crimean WPP. But "Icarus" bypassed its competitors-academics – when in November of 1932, Igor Kondratyuk arrived to Moscow to defend the project of Crimea WPP, it turned out that the institutes had not yet presented their developments. Only one month later, UIIE handed over the project of a wind power plant with a capacity of 3 MW, and CWEI – 5 MW. Igor Kondratyuk’s project provided 24 MW. For comparison, in the USA, where wind power is now very widespread, the first wind farm appeared in 1941, its capacity was 1,250 kW.

"Icarus" was recognized as the winner of the all-Soviet Union competition. Crimean WPP designed by Igor Kondratyuk had to become the most powerful and the highest in the world, Ordzhonikidze took its construction under personal control. It would seem that success was guaranteed. However, the great plan collapsed overnight: after the death of Ordzhonikidze in 1937, began investigations of objects that was sponsored by him. Ordzhonikidze died in February, and already in May, the project of Ay-Petri Wind Farm was declared as "obviously defective." It was decided to abandon the construction of two-tier installation of wind farm and was built single-tiered one with one wind turbine. A year later, this
decision was recognized as reckless – in 1938 the construction of the Crimean WPP was stopped forever.

All that remains "Icarus" is reinforced concrete "glass" on Ai-Petri, which has to become the foundation for the 165-meter structure. Moreover, the invaluable experience of designing a huge reinforced concrete tower held from within by strained steel cables. Based on this experience, the already mentioned associate of Kondratyuk and Nikitin, created the Ostankino television tower three decades later.

Today on the peninsula there are 4 state-owned wind power plants that operate seven wind farms with 544 wind turbines: Donuzlav Wind Power Plant (total capacity 18.7 MW), VodEnergoRemnaladka (26 MW), Tarkhankut Wind Power Plant (15.9 MW), and East-Crimean Wind Power Plant. Since the beginning of operation, they have developed more than 300 million kW/h. In addition, there are 16 projects for the construction of WPPs using wind installations of 2–3 MW each.

If these projects were implemented, that will bring more than 5 thousand MW to the peninsula. Theoretically, the declared capacity is able to provide almost the entire Crimea with electricity. In Crimea investors of solar and wind power stations hope for return on investment. The mechanism for the return of funds invested in the energy project is not working yet. But the Crimean WPP are already considering the possibility of expanding the production of components for wind power plants in Russia, which had not been produced before.

The main obstacle for development of green energy in the Crimea is the high cost of equipment and long payback. For example, mini-station with capacity of 5 Kw, capable for needs of average household, will cost for its owner almost 500 thousand rubles and pay off will be at about 10 years.

Nevertheless, small solar and wind power plants, which are actively conquering the market all over the world, will gradually reduce the load on the grid in the Crimea and significantly reduce electricity consumption. We are sure that green energy can become more attractive area for investment, also there should be green tariff for generating companies and preference for domestic equipment manufacturers.

Kerch WPP LLC is the largest and so far the only privately owned wind energy company in Russia. There are plans to build four more stations with a total capacity of 420 MW. The Stepnaya WPP with installed capacity of 282.5 MW should be in Pervomaisky.

In addition to it is planned to build “Eastern” wind farm with a capacity of 100 Mw in the Leninsky district, “Prisivashskaya” wind farm with a capacity of 25 Mw in Sovetsky district and “Zolno” wind power plant with a capacity of 12.5 megawatts in Saksy district. Preparations for their construction has already begun.

Wind measurements were made at construction sites with the involvement of European certified companies, land was allocated, design and survey work was completed, and the working documentation was ready for Vostochnaya and Prisivashskaya stations. However, the implementation of projects is delayed indefinitely. The problem is that the mechanism for returning investments in renewable energy facilities is not yet available to investors in Crimea. And without it, alternative energy cannot compete with traditional thermal and atomic. In Ukraine the role of the return mechanism was played by the so-called green tariff – raising factor with which the state bought electricity generated by solar and wind stations.

Similar projects exist in Russia, but these preferences are not yet available for Crimean companies. An investor can count return on investment for 15 years when signing relevant contract and observing several conditions. First of all the level of localization of the project in the Russian Federation already in 2016 should be no less than 25 percent with gradual increase in the domestic component to 65 percent by 2019.

In addition renewable energy facilities should be participants in the wholesale electricity market of the unified energy system of the Russian Federation, the amount of capital expenditures for the construction of one such facility should not exceed 110 thousand rubles per Mw of installed capacity. Alas, it is not necessary to count on return on investment in the already operating project of Ostaninskaya WPP: its equipment is almost completely imported.
But for the new projects investors expect to use Russian components, the production of which still needs to be adjusted. At “Ostaninskaya” WPP in Leninsky district of Crimea, 10 WTU-2.5 wind turbines manufactured by the Ukrainian company Furlendvindtekhnolod are operating. Some of the components are Ukrainian, some are imported. The towers are completely Ukrainian, the frames of the gondolas too. Much has already been done for the production of wind turbines in Russia and from 2019 it is planned to ensure the localization of projects at the level of 30 percent. And further in the amount stipulated by the current legislation of Russia – 65 percent.

However, there remains one obstacle, while not allowing investors to count on a return on investment. For well-known reasons, the Crimea today is cut off from mainland Russia, and its energy is not physically included in the Unified National Energy System of Russia.

Wind power industry is experiencing rebirth in Russia. This time large Russian energy companies as Rosatom and Enel Russia take on creation of wind farms and organization of production facilities. Their projects are implemented in the South at Adygea, Krasnodar Territory and in Rostov Region, where many different WPP have already been announced. The main idea is in creating new industry, where the southern projects of energy giants and their new production facilities will play the role of pioneers. Projects for wind farms creation are announced together with projects for creation of component parts production. The total investment for wind energy of the Don and Kuban area will be about $ 1.7 billion, or 97 billion rubles by 2020.

Energy follows the latest innovations. In 2016 Rosatom won the tender for the construction of three wind power plants with total capacity of 610 MW – one in Adygea and two in Krasnodar Territory. Another wind power facility was declared by Enel Russia energy company (in the South it owns Nevinnomysskaya SDES). By 2020 it plans to build a wind power plant with total installed capacity of 90 MW in Azov district of Rostov region. Initially the developer of construction project was the German holding Sowitec which did great preparatory work.

Rosatom develops strategy for creation of completely new industry in Russia. The state corporation has set itself the tasks not only in WPP construction, but also creating system of technical regulation, training, organizing localization of wind turbine production, certification, and developing.

Novawind is new division of Rosatom whose main task is to consolidate efforts of state corporation in the advanced segments and technological platforms of electric power industry. The company was founded in September 2017 with a registered capital of 1.1 billion rubles. At the initial stage Novawind merged all the wind energy assets of Rosatom and is now responsible for the Wind Energy sector strategy implementation.

Solving this problem requires formation of new competencies for creation and management of WPP in Russia, organization of wind turbines mass production, organization of after-sales services, competencies in marketing, development and sales of new products. VetroOGK JSC which has been implementing projects for the creation of WPP has entered management circuit of Novawind JSC since 2016. In the new business structure, VetroOGK is responsible for the design and construction of wind farms and production of electricity based on wind energy. Until 2022 enterprises with control loop of Novawind JSC will create wind power plants with total capacity of 970 MW.

Novawind is also going to begin production of equipment for wind farms in Rostov region. The assembly production of components and assemblies is planned to be launched at site of Atommash plant (Volgodonsk district). The total investment is 15 billion rubles (about 263 million dollars).

Also in December 2017 the government of Rostov region and management company Vetroenergetika (manages Wind Energy Development Fund established by energy company Fortum and Rosnano) concluded agreement according to which in 2019-2022 years will be built WPP with aggregate capacity of up to 600 MW in Don region.

The incentive was financial support for green energy including construction of WPP which started in 2013. Business that is having built solar plants or WPP receives a return on investment through so-called power supply agreements. According to them wholesale consumers are obliged to purchase electricity from renewable sources. Investors are guaranteed return on investment. At the same time for selected projects certain level of localization of equipment production in the Russian Federation should
be provided. Recall that measures of state support for construction of generating facilities that based on renewable energy sources involving return on investment with guaranteed returns works until 2024. In business circles and number of specialized departments consider it necessary to extend this program until 2035.

Our development of wind generator was carried out on using manufacturing technology and mass production of permanent magnet synchronous machines for high-torque and high-speed applications.

In construction of synchronous electric machines of radial flow (with or without permanent magnets), two main types of winding are used: concentrated winding and distributed winding.

Numerous studies show that distributed winding has several advantages in terms of electromagnetic quantities.

Solving the problem of simplifying for distributed windings reeling procedure will increase competitive advantages of synchronous electric machines with this type of winding.

Within framework of the project manufacturing technology of distributed winding consisting of individual coils, each of which is produced in frameless way is proposed.

| Table 1. Wind generator characteristics |
|-----------------------------------------|
| Characteristics                        | Description                       |
| Rated power (W)                        | 100.000 Watts                     |
| Maximum output power (W)               | 110.000 Watts                     |
| Charging voltage (V)                   | DC 380V                           |
| Output voltage (V)                     | AC 380V                           |
| Blades / number                        | 3                                 |
| Blade material                         | Glass Fiber Reinforced Plastic    |
| Main rotor blades diameter             | 20.8 m                            |
| Initial wind speed                     | 2 m/s                             |
| Nominal wind speed                     | 11 m/s                            |
| Rated rotation speed                   | 85 rpm                            |
| Speed adjustment (protection)          | Automatic + Manual                |
| Wind Power Utilization (CP)            | 42%                               |
| Output voltage (B)                     | 0-600                             |
| Rated current (A)                      | 125                               |
| Maximum current (short duration) (A)   | 160                               |
| Noise level (at a wind speed of 8m / s)| <60dBA                            |
| Generator conversion efficiency       | 92%                               |
| Generator weight                      | 2000kg                            |
| Turbine weight                         | —                                 |
| Free-standing match-diameter (mm)     | upon request                      |
| Mast height (m)                        | 30                                |
| OFF-GRID / ON-GRID network             | upon request                      |
| Recommended batteries                  | 800/1500Ah                        |

Thus, the following conclusions may be drawn.
The technology allows to increase specific power of electric machines with distributed winding. Electrical machines manufactured using this technology can be used as generators, starter-generators, linear, torque and high-speed engines. In accordance to suggested technology, prototype of wind generator will be manufactured.

The wind generator package includes: low-speed generator, 3 blades, 50 m of power cables, nose fairing, ultrasonic anemorumbometer, logic controller with remote monitoring, rectifier and ballast load controller, ballast load, three-phase network inverter (50 Hz, 400 V), free-standing tower 30 m high, anchor bolts for fastening, power unit of nacelle mechanisms (UPS). Its characteristics are at Table 1.

The wind generator is equipped with hydraulic braking system and independent system for controlling angle of installation of each blade.

5. Conclusions
Renewable energy in Russia took place as industry and is gaining momentum. Before the end of 2018 year, on the basis of renewable energy, it is planned to commission up to 200 MW of power plants in addition to 400 MW of existing ones. Thus potential of alternative energy sources will increase by 1.5 times.

As practice has shown, renewable energy in the regions takes place much faster than traditional generation and networks, becoming an effective tool for the development of territories, since all the design, construction and operation of solar power plants are carried out with the involvement of local contractors.

The development of renewable energy market is viewed as strategic priority not only from the point of view of increasing the share of green generation in the country's overall energy system, but also from the point of view of creating unique industrial competencies capable of creating a product that is competitive on world markets.

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