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LEGAL AND TECHNICAL ASPECTS FOR PLANNING WIND POWER PROJECTS IN THE RUSSIAN FEDERATION

Examiners: Professor, D.Sc (Tech.) Olli Pyrhönen

D.Sc (Tech.) Katja Hynynen

ABSTRACT

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Master's thesis

2019

71 pages, 7 figures, 10 tables and 2 appendices

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Keywords: wind power industry, regulatory framework, grid requirements, the Russian Federation

This thesis addresses the key aspects of the regulatory framework and official technical requirements for wind energy market in the Russian Federation. The motivation for this analysis was to create a general understanding of actual condition and legislative environment of wind power industry which is useful for external investors intending to enter the Russian market of wind energy.
First, the project documentation review was done to define the core sections of a project plan that has to be mandatory presented for all wind energy projects. The main regulations are provided by Decree of the Government of the Russian Federation of 16.02.2008 N87. In addition, the analysis of the real project documentation was conducted for the case of wind power plant (WPP) Yarovoe and was shown the acceptable variations of the document structure from the template stated by law. Second, the requirements for wind power projects enabling governmental support were described. The key criteria, that have to be fulfilled by WPP in order to receive support under capacity mechanism for renewable power generation, are based on the rules of qualification procedure, competitive selection and evaluation of localization level of the project. Third, grid requirements for connecting a new WPP to the Unified Energy System of the Russian Federation are listed to be taken into account during a planning stage of project development. Fourth, the general description of the wholesale electricity and capacity markets in the Russian Federation is presented. It includes the structure and regulatory framework that define the operation and rights and obligations of market participants. The main focus was on the renewable power generation and corresponding specific features of these markets. Finally, the crucial challenges for wind industry development in the Russian Federation and possibilities to overcome them were defined, providing an insight on essential changes in regulations and technical requirements which may ensure more attractive economic environment for investment decision-makers.

ACKNOWLEDGEMENTS

I want to say “thank you” for the patience and understanding to Olli Pyrhönen and Katja Hynynen who were my supervisors during this work. And also, I want to say “thanks” to my parents, Sergey and Tatjana, for their support.

All this wonderful journey could not be possible without my beloved wife Anna Shigina. You are my heart and soul. Thank you for your belief in me and your kindest words.

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LIST OF ABBREVIATIONS

ATS	Administrator of the Trading System
CapEx	Capital Expenditures
CPT	Competitive Power Take-off
IEA	International Energy Agency
IEC	International Electrotechnical Comission
IRENA	International Renewable Energy Agency
IRR	Internal Rate of Return
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction
NPV	Net Present Value
PI	Profitability Index
PSC	Power Supply Contract
RAWI	Russian Association of Wind Industry
SCADA	System of Control and Data Acquisition
SO	System Operator
STGT	Siemens Gas Turbine Technology
VAT	Value-added tax
WPP	Wind power plant

1 INTRODUCTION

In 2016, the Russian Federation, together with 197 countries of the world, signed the Paris Agreement. These countries account for more than 75% of carbon dioxide emissions into the atmosphere [1]. In accordance with this agreement, it is planned to keep the growth of the global average temperature well below 2°C and make efforts to limit the temperature increase to 1.5°C by 2050. Clearly, the achievement of carbon neutral energy supply (without greenhouse gases emission) around the world in coming decades is possible only with a significant global increase in generation based on renewable energy sources [2].

However, the current status of renewable generation, in particular wind power plant (WPP), is still poor in the Russian Federation. As confirmation of this statement, the installed capacity of WPP will reach 140 MW by the end of 2019, representing slightly more then 0.1% of the installed capacity of Russian energy system [3]. Nevertheless, the assessed technical potential of wind resource is 17101 million MWh/year, i.e. the Russian Federation has an enormous unused potential of electricity production based on wind resources [4].

In turn, wind energy market is growing dramatically around the globe thanks to clear economical and environmental advantages of renewable energy utilization. Thus, International Energy Agency (IEA) foresees a growth of installed capacity for onshore wind equal to 309 GW from 2019 to 2024, if the main case scenario was assumed [5]. Consequently, there are some challenges interfered to wind industry development in the Russian Federation that refers not to the technology itself but to the existing environment in which wind power projects should be materialized.

Another reason for insufficient rates of wind industry development in the Russian Federation may relate to the specific features of the national economy. First, the wide availability of fossil-based energy carries does not promote the economic feasibility of renewable generation and, hence, the increase in its penetration. Second, the short history of open innovation approach in the engineering field led to the lack of national expertise and experience in wind energy technology and resulted in the extremely limited capabilities to develop renewable generation in appropriate manner. Consequently, the external support is required for the fast and efficient promotion of wind power industry in the Russian Federation.

Based on the facts presented above, it might be concluded that in order to reach international climate agreements on decarbonization of energy production the Russian Federation has to increase significantly the rates of the wind industry development progress. Moreover, to achieve visible results in the short period of time the support of international experts in the field are required. External investments are also an important step to accelerate wind power industry in the Russian Federation. However, the existing disparities between international and the Russian regulatory and technical frameworks may be a barrier for international players to enter the Russian renewable energy market.

The main objective of this thesis is to provide an insight on legislative and technical frameworks which define wind energy market development in the Russian Federation. The key regulations applicable for wind energy projects have a direct impact on the installed capacity growth of WPP and the flow of internal and external investments to wind power industry. Therefore, the clear understanding of the core national regulatory and technical aspects is crucial for successful wind energy market development in the Russian Federation and achievement of international climate agreements. Thus, this thesis covers the essential features of wind power project documentation and regulations and may be used as a first introduction of the Russian environment with respect of renewable energy market for foreigners.

The remainder of this thesis consists of six chapters. Chapter 2 presents a review of project documentation that must be prepared for every wind power project in the Russian Federation. The scopes of the compulsory sections of project plan is described based on the Decree of the Government of the Russian Federation of 16.02.2008 N 87. Moreover, the comparison with the real project plan for WPP Yarovoe in Altai region is implemented. The requirements for wind power projects that ensure an opportunity to receive a governmental support is given in Chapter 3. The main criteria and procedures of its approval are considered including the qualification of generator based on renewable energy sources, competitive selection of wind power projects and the confirmation of the sufficient localization level. Chapter 4 aims to summarize a basic information needed for the implementation of the technological connection of a new WPP to the Unified Energy System of the Russian Federation. The wholesale electricity and capacity markets are briefly discussed in Chapter 5 with a special focus on the regulatory features applicable for generators based on renewable energy. The understanding of the wholesale electricity and capacity markets operation is

vital for profitable activities of WPP and has to be gained on the early stages of wind power projects development. Chapter 6 represents an analysis of existing barriers for wind energy industry growth in the Russian Federation and possible ways to overcome them. Chapter 7 concludes the main investigations of this thesis.

2 PROJECT DOCUMENTATION REVIEW

Documentation requirements are an essential part of the process as it is crucial to follow rules in each specific country. In the Russian Federation there is a law that regulates all forms of the so-called capital construction. This law is called Decree of the Government of the Russian Federation of 16.02.2008 N 87 (as amended on 07/06/2019) “On the composition of sections of project documentation and requirements for their content”. It regulates standards for objects of manufacture purposes (factories, defense objects, energy purposes objects), non-manufacture (social buildings, houses), linear objects (pipelines, railways, electricity lines) [6]. Considering WPP, it is a manufacture object itself which is supplemented by linear objects – roads and power transmission lines.

2.1 Decree of the Government of the Russian Federation of 16.02.2008 N 87

According to the Decree of the Government of the Russian Federation of 16.02.2008 N 87, project documentation should consist of text and graphic parts. The text part contains information regarding the capital construction object, a description of the adopted technical and other decisions, explanations, links to regulatory and (or) technical documents used in the preparation of project documentation and calculation results justifying the decisions made. The graphic part displays the adopted technical and other decisions and is performed in the form of drawings, diagrams, plans and other documents in graphical form [6].

Preparation of project documentation should be carried out in accordance with the legislation of the Russian Federation on state secrets. In order to implement the architectural, technical and technological solutions contained in the project documentation for the capital construction object during the construction process, working documentation package is developed consisting of documents in text form, working drawings, specifications of equipment and products.

The need to develop requirements for the content of sections of project documentation, the presence of which is not mandatory according to the regulations, is determined by the agreement between the design organization and the customer of the documentation under consideration.

The need to develop design documentation for the capital construction object in relation to individual stages of construction is established by the customer and indicated in the design assignment.

The possibility of preparing design documentation for individual stages of construction should be justified by calculations confirming the technological feasibility of implementing the adopted design decisions during the construction stages.

Design documentation for a particular construction phase is being developed to the extent necessary for the implementation of this construction phase. The specified documentation must meet the requirements for the composition and content of sections of the design documentation established by the regulations for capital construction projects.

For the purposes of the Decree of the Government of the Russian Federation of 16.02.2008 N, the construction phase is understood to mean the construction of one of the capital construction objects, the construction of which is planned to be carried out on one land plot, if such an object can be commissioned and operated independently, that is, regardless of the construction of other capital construction objects on this land plot, as well as the construction of a part of the capital construction project, which can be commissioned and operated independently, i.e. depending on the construction of other parts of this capital construction facility [6].

Titles and scopes of the sections

Project documentation for capital construction of facilities for industrial and non-industrial purposes consists of 12 sections, the content requirements of each section is given below.

Section *ONE* is called “Explanatory note” and it starts with a name of the basis document for construction. It can be a federal target program, a development program for a constituent entity of the Russian Federation, a comprehensive program for the development of a municipal formation, a departmental target program and other programs; a decision of the President of the Russian Federation or the decision of property owner [6].

Then goes initial data and conditions for the preparation of design documentation for the capital construction facility. The explanatory note indicates the details of the following documents: design assignment task, the approved and registered plan of the land, reporting documentation on the results of the engineering process, permission for deviations from the limit parameters of the permitted construction of capital construction facilities; other initial permits established by legislative and other regulatory legal acts of the Russian Federation, including technical and town-planning regulations. The other mandatory facts that should be included are:

- information on the functional purpose of the capital construction object, the composition and characteristics of production and data on the design capacity of the capital construction facility
- information on the raw material base, production needs in water, fuel and energy resources. In case of WPP it will be information on the use of renewable energy sources and secondary energy resources
- information about the inventions used in the project, the results of patent research;
- technical and economic indicators of the designed capital construction projects
- information on the availability of developed and agreed upon special technical conditions (if it is necessary to develop such conditions)
- claim of the possibility of carrying out the construction of the capital construction facility at the construction stages with the allocation of these stages, that is extremely important for a WPP construction.

Section *TWO* is called "Planned scheme of the land-use" and consists of two parts – the text and the graphical part.

The aim of the text part is to give characteristic of the land given for construction. The next step is the zoning. The land should be divided into zones (primary, auxiliary, utility, warehouse and service) and each zone should have its own justification. Also, each building should be given a sanitary protection zone and if it is necessary to determine these zones in accordance with the legislation of the Russian Federation – for WPP noise protection calculations are needed which should be put on map later. The next is justification of land-use according to city building plan and city technical plan. The list of notifications is needed in addition to text part.

- Justification of decisions on the engineering preparation of the territory, including decisions on the engineering protection of the territory and capital construction objects from the consequences of dangerous geological processes, flood, surface and ground waters
- Description the vertical layout of local landscaping
- Justification of transport communications schemes providing external and internal (including inter-workshop) cargo transportation. In case of WPP, it is also very

important because of the size of wind turbine's blades and a tower. Also, that is necessary for maintenance purposes

The graphical part consists of schemes of the planned structures, organization of the land with the display of:

- locations of existing and planned capital construction projects indicating the existing and planned porches and approaches to them;
- buildings and structures of the capital construction to demolition (if any);
- decisions on planning, landscaping, and lighting of the territory;
- stages of construction of the capital construction facility;
- traffic patterns of vehicles at a construction site;
- a plan of underground earth masses;
- a consolidated plan of engineering and technical support networks with a designation of the points of connection between the designed capital construction object and existing engineering and technical support networks;
- a situational plan for the location of the capital construction in land borders with indication of closest settlements near the construction area, zones with special conditions for their use, provided for by the Town Planning Code of the Russian Federation as well as with the display of the protected natural sites.

Section *THREE* is called "Architectural decisions" is mostly related to non-manufacture objects (like houses) because it's about object appearance – color, size and how it correlates with near standing objects. The listed above characteristics are not crucial for WPP because of usual remote destination from housing sites.

Section *FOUR* is "Constructive and space-planning solutions". This section is also divided into the text and graphical parts. Text part consists of description, measurements, this section is dedicated to building and construction engineering decisions such as:

- natural data - topographic, engineering-geological, hydrogeological, meteorological and climatic conditions.
- underground surface data - strength and deformation ground characteristics, underground water level.

- description of the design and technical solutions of new objects on every level.
- substantiation of design decisions and measures providing: noise and vibration reduction, removal of excess heat, fire safety, compliance of buildings, structures and structures with energy efficiency requirements and the requirements of equipping them with meters for using energy resources – for energy objects [6].

Section *FIVE* "Information on engineering equipment, networks of engineering and technical support, a list of engineering and technical measures, the content of technological solutions" should consist of the following subsections. All the subsections have their text and graphical parts, which reveal the plot of section. In WPP design the most accurate subsections should be A, E, G.

a) subsection "Power supply system";

b) subsection "Water supply system";

c) subsection "Water disposal system";

d) subsection "Heating, ventilation and air conditioning, heating networks";

e) subsection "Communication Networks";

f) subsection "Gas supply system";

g) subsection "Technological solutions".

Section *SIX* "Project of construction organization" is a description of the features of construction in the selected area and a description of logical stages of the construction.

- Assessment of the development of transport infrastructure and information on the possibility of using local labor in the implementation of construction;
- A list of measures to attract qualified specialists for construction, as well as student construction teams, including on a rotational basis;
- Justification of the adopted organizational and technological scheme that determines the sequence of construction of buildings and structures, engineering and transport communications, ensuring compliance with the deadlines for the completion of construction (its stages) established in the construction schedule;

- Substantiation of the need for construction in personnel, basic construction machines, mechanisms, vehicles. Also, in fuel and lubricants, as well as in electric energy, steam, water, temporary buildings and structures;
- Proposals for ensuring quality control of construction and installation works, as well as equipment, structures and materials supplied to the site and mounted;
- Justification of the accepted duration of the construction of the capital construction facility and its individual stages;
- A list of measures to organize the monitoring of the condition of buildings and structures located in the immediate vicinity of the facility under construction, earthworks, construction, installation and other works on which may affect the technical condition and reliability of such buildings and structures (if any).

Section *SEVEN* "The project of the organization of work on the demolition or dismantling of capital construction projects" is carried out if necessary, the demolition (dismantling) of the object or part of the capital construction project. It is not usually necessary because practices say that new WPP are constructed in almost unexplored areas.

Section *EIGHT* "List of measures for environmental protection" in the scope of WPPs should contain:

- environmental impact assessment results of the capital construction project;
- a list of measures to prevent and (or) reduce the possible negative impact of the planned economic activity on the environment and the rational use of natural resources during the construction and operation of the capital construction facility.
- list and calculation of costs for the implementation of environmental protection measures and compensation payments.

Section *NINE* "Fire safety measures" is mostly about safety rules and it should involve:

- description of the fire safety system of the capital construction facility;
- the rationale for fire distances between buildings, structures and outdoor installations, ensuring fire safety of capital construction facilities;

- description and justification of design decisions to ensure the safety of people in case of fire;
- description and justification of fire protection (automatic fire extinguishing installations, fire alarms, warning and the evacuation of people in case of fire, internal fire water supply, smoke protection);
- information on the category of buildings, structures, premises, equipment and outdoor installations on the basis of explosion and fire hazard.

Section *TEN* "Measures to ensure access for persons with disabilities". This section is almost written for non-manufacture object while WPP is a manufacture object. For energy object these rules are not relevant. But at the same time in the Russian Federation there are different programmed to support people with disabilities. One of the programs ensures that governmental supported companies should have certain percentage of personnel with disabilities.

Section *ELEVEN* "Economical estimates for the capital construction project" should contain the text part of the explanatory note to the economical estimate documentation - summary of costs, a consolidated estimate of the cost of construction, object and local estimates (estimates), estimates for certain types of costs. Estimated documentation for the construction of capital construction projects, financed with the involvement of budget funds of the budget system of the Russian Federation in the amount of more than 50 percent, is compiled using the approved estimated standards, information about which is included in the federal register of estimated standards. The development and application of individual estimated standards intended for the construction of a particular facility according to the technologies for the production of work provided for in the project documentation, working conditions and supply of resources that are absent or different from the technologies considered in the estimated standards contained in the federal register of estimated standards, is carried out by decision of the Government of the Russian Federation [6].

Section *TWELVE* "Other documentation in cases provided by federal laws" shall contain documentation, the need for the development of which during the design and construction

of the facility is provided specifically for each individual case by legislative acts of the Russian Federation.

2.2 The case of wind power plant Yarovoe

The first part is dedicated to the Decree, in turn this section is aimed to show and describe a case of the real wind power project in the Russian Federation. The Decree consists of 12 sections and content of each of those may vary depends on customer's needs. As an example of these variations the case of WPP Yarovoe in Altai region is presented below. Firstly, the executive summary is described to provide an insight on the project and then the main sections and its content are mentioned.

2.2.1 Executive summary

The project involves the construction of the first phase of the Yarovoe WPP with an installed capacity of 23 MW. The total installed capacity of the Yarovoe WPP is planned to be 92 MW. The construction site is located in the west of the Altai region in the Kulunda district near the town of Yarovoe. As a result of the implementation of the first project stage, an energy generating facility will be constructed with an annual electricity generation of 96.43 million kWh. The project is simultaneously an innovative and infrastructural object of the Altai region. The first phase of the project will consist of 10 wind turbines with a nominal capacity of 2.3 MW. As a result of the project, the new WPP will provide electricity to the regional electric grid [7].

Currently, a full range of pre-project approvals and surveys was carried out. In particular, 2-year wind-measuring surveys were completed and land for the construction of a WPP was allocated. Furthermore, the principal consent was obtained for connection of a WPP to electric grids from Altayenergo, a branch of energy distribution company of Siberia and Regional Dispatch Department of the Altai region and Altai Republic, a branch of the System Operator of the Unified Energy System. As an outcome, the Business Plan of the "First Stage of Construction of the WPP Yarovoe 23 MW" was prepared by VentRus company.

Efficiency characteristics. Performance indicators calculated on the basis of cash flow on invested capital (for the payback period) [7]:

- Net present value (NPV) - 0.06 billion rubles.
- Internal rate of return (IRR) - 12.7 (for a period of 13 years)

- Profitability index (PI) - 1.03
- Simple payback period - 8.08 years
- Discounted payback period - 12.44 years;
- Positive budget effect - 0.6 billion rubles.

Financial sources. The total cost of the project is 2.91 billion rubles. Sources of financing for the Project - own funds of VentRus company and borrowed funds.

Suggested financing conditions [7]:

- Maximum loan amount - 2.2 billion rubles.
- The use of the loan is carried out in separate tranches during 29 months.
- The interest rate on the loan is 8%;
- Repayment of the main debt is carried out in equal quarterly installments, the first of which comes after 28 months from the date of signing the loan agreement.
- Final repayment of debt no later than 149 months (12 years 5 months) from the date of signing the loan agreement. The borrower has the right to early repayment of the loan without paying penalties.
- The first interest period begins on the date following the date of first use and ends after 28 months from the date of conclusion of the loan agreement. The second and each subsequent interest period is 3 months.

Interest is paid on the last business day of the interest period. Equity includes previously invested funds and additional contributions from shareholders. The share of equity at the investment stage of the project is at least 20% of the total project cost.

Strategy – four main stages. Pre-investment stage (18 months):

- Beginning: formalization of the project idea.
- End: approval by Vnesheconombank of a business plan, obtaining approval from "VEB" Group of Companies for the provision of project credit.

Investment stage (29 months):

- Beginning: preparation of project documentation for negotiations with a wind turbine supplier.
- End: commissioning of the WPP.

Stage of the payback period (10 years):

- Beginning: the beginning of the operation on the wholesale electricity market and electricity sales.
- End: completion of the project payback period (loan repayment).

Stage of market pricing (from the end of payback period). Beginning: sales of electricity at market prices.

Market information. Up to 30% of energy consumption in the Altai region is imported from the Unified Energy System of Siberia. Depreciation of electric networks reaches 70%. Regional grid companies of the Altai region should compensate for losses in electric grids, first of all, by acquiring electric energy produced at qualified generating facilities connected to the networks of grid organizations and operating on the basis of using renewable energy sources in accordance with federal law No. 35-FZ “About the electric power industry” [8].

Investment attractiveness of the project for the Bank. Investment attractiveness of the project is characterized by the next parameters [7]:

- the total cost of the project is 2.91 billion rubles (criterion:> 2 billion rubles);
- the estimated size of the credit line is 2.2 billion rubles. (criterion:> 1 billion rubles.)
- NPV - 0.06 billion rubles. (criterion:> 0)
- simple payback period - 8.1 years
- discounted payback period - 12.44 years (criterion:> 5)
- positive budget effect - 0.6 billion rubles.

The investment project provides for the possibility of controlling the targeted use of the funds of “VEB” Group of Companies. As collateral for the loan, the rights to land plots and fixed assets acquired or created as part of the project are proposed. Own funds at the investment stage in the shared financing of the project will amount to at least 20%. The technologies used in the project comply with the highest environmental performance standards.

Possible risks related to the project [7]:

- Underfunding of the project at the investment stage;
- Low quality of construction and installation works;
- Delays in signing the project contracts;
- Violation of obligations by suppliers and contractors;

- Inconsistency of the tariff calculation methodology with design calculations;
- Unqualified staff;
- Deterioration of production rates due to process violations;
- Risk of breaking relations with the main buyer;
- Low quality of financial control, coordination and the organization of design work;
- Inflationary pace;
- Economic instability;
- Change in the conditions of the electricity market

Project strength. The project corresponds to the strategic directions of development of the energy sector of the Russian Federation, contributes to the social and economic development of the region. The project contributes to the innovative development of Russian energy sector and provide an opportunity to compensate the existing deficit in the energy balance of the Altai region.

2.2.2 Sections description

Section *ONE* – analysis of wind energy resource on the preliminary chosen site. The set of sites is usually selected on the base of availability of connection (not very remote region) and availability of wind resource. In this way the first stage is wind monitoring during no less than 1-3 years. For the construction site of a WPP in the zone specified by the customer, the area was monitored to determine the optimal locations of wind turbines taking into account the efficiency indicators and the impact of turbulence loads. First of all, the meteorological data obtained as a result of the annual wind monitoring were analyzed. The measurements should be held on different heights (30, 40, 50, 60 m) for windspeed layout development. Also, it is necessary to give the full specification of the equipment and fault structure and statistics. Based on the obtained meteorological data, a map of the wind energy potential for the region under consideration was compiled, including topographic model of the local area that contains object that effect WPP generation. Based on this map an optimized plan for the location of the WPPs was developed taking into account the existing preconditions and the possibility of connecting to the network. The most valuable wind characteristics are – average wind speeds on different heights and its repeatability, turbulence in the region, daily variations of wind speed. To optimize the layout of the WPP, annual electricity production was calculated.

Section *TWO* - Selection and justification of the types and parameters of wind energy equipment. When choosing a wind turbine model as the main technical requirements for the equipment, three parameters were taken into account: the unit rated power of the wind turbine, class of wind turbines in accordance with IEC 61400-1 and permissible temperature ranges of wind turbines. Each of these parameters is discussed in more detail below.

As part of the implementation of Russian projects, it is recommended that wind turbines with a rated power of 2.0 to 3.0 MW be considered due to the overall dimensions and economic parameters. An additional advantage is the multi-series production and the availability of a choice of spare parts for units as well as verification of structure, since such aggregates have been produced for quite a long time. According to IEC61400-1, a wind turbine class characterizes the wind conditions of its use and imposes certain requirements on the wind turbine installation sites. In the third edition of the standard the wind turbine class is determined by the extreme wind speed and turbulence intensity, in accordance with Table 2.1.

Table 2.1 Turbine classification [9]

Wind turbine class		1	2	3	S
V ref	m/s	50	42.5	37.5	parameters are assigned to designers
A	I ref	0.16			
B	I ref	0.14			
C	I ref	0.12			

In this table the parameter values are given for the axis of the wind wheel. V ref - calculated extreme wind speed at 10-minute averaging. 1,2,3 - normal wind turbine classes, S - special class. A - a subclass of wind turbines designed for increased turbulence; B - a subclass of wind turbines designed for moderate turbulence; C - a subclass of wind turbines designed for low turbulence. I ref– the expected value of the intensity of the air flow turbulence at an average wind speed of 15 m / s, determined over a 10-minute interval. The final step is temperature analysis. After that market analysis goes with the comparison of all possible versions of the equipment.

Section *THREE* - Development of the layout of the WPP. The position of the wind turbine installation sites was determined on the basis of the following principles:

- Losses for placement in the WPP should not exceed 8%; Wind turbines are installed in places with the highest wind potential;
- Wind turbines should be concentrated near the power lines (110 kV), to which you can connect to transmit electricity, and near existing roads;
- Wind turbines should be located on a minimum number of land plots;
- The noise impact of the WPP should be minimal: the distance from the wind turbine to objects with normalized noise figures should be at least 300 m;
- The distance from the wind turbine to the existing motorways and power lines should be at least 150 m (the sum of the height of the axis of the rotor of the wind wheel and the length of the blade).

In general, the construction site of the WPP should be located in the zone of high wind potential, due to which high utilization factors of installed capacity will be achieved.

Section *FOUR* - Estimation of annual electricity generation. The time period for measuring meteorological data is 1-3 years. Therefore, it is not representative for predicting a long-term wind regime. The average wind speed can vary significantly from year to year. That's why theoretical model is built using National Centers for Environmental Prediction (NCEP) and the National Center for Atmospheric Research (NCAR) databases. A very important aspect is losses calculation – total losses percent should not be very high. The highest shares are electricity grid losses and losses on icing (in some regions). The total losses scheme looks like this with typical dimensions: losses on technical readiness (5.0%), loss of electricity in the connection cables in WPP 2.5%), losses associated with a change in the surface roughness of the blades (0.3%), Hysteresis loss (0.1%), icing loss (2.0-8.0%), losses when disconnecting the network (1.0%) [7]. In addition to this some errors associated with calculations may occur as calculations go many years ahead, the structure of them is shown in table 2.2.

Table 2.2 Root-mean-square losses [7]

Root-mean-square losses for energy calculation	%
Relative wind speed	6.1
Flow model	6
Loss of turbine placement in the WPP	3.6
Power curve	3
Interannual variability (10years)	2
Total root-mean-square error of production determination (10 years)	10

Section *FIVE* – The electrical scheme of a WPP. This section gives a review of grid connection, taking into account the developed plans for placing wind turbines on the ground, and the most optimal options for laying cable lines of the internal network of the main WPP scheme are considered. The individual connection of each wind turbine with a separate cable line is also calculated and compared for various parameters. And the choice of switchgear and transformer set at the substation is being calculated.

Section *SIX* - The main facilities of the WPP. Here the key word is “facilities” – that means that the section contains wind turbine fundament specification with underground surface characteristics. The next step is road map for elements delivery and construction of WPP and choice of road configuration on the WPP site.

Section *SEVEN* - Project Implementation Schedule contains dates of each stage of the WPP construction – chart and project plan with timetables of all deliveries, construction processes and launches.

Section *EIGHT* – Financial assessment. Based on the results of the pre-design study, the total investment costs including value-added tax (VAT) for the construction of a WPP were determined. The cost of wind turbines is determined taking into account delivery to the nearest port and further along the roads. The installation cost is also calculated on the basis of the technical and commercial offer of the company. It is also necessary to remember the cost of the preparation of the site and the construction of the necessary infrastructure. Based on all the data, the economic indicators of the project are calculated (listed at the beginning of this Chapter) including maintenance costs and risks of the project. The main risks of the projects are underfunding of the project at the investment stage, a low quality of construction and installation works, delays in signing project contracts, the violation of obligations by

suppliers and contractors, inconsistency of the tariff calculation methodology with design calculations, unqualified staff, a deterioration of production rates due to process violations, a risk of breaking relations with the main buyer, a low quality of financial control, the coordination and organization of design work, an inflationary pace, an economic instability and a change in the conditions of the electricity market.

3 WIND PROJECT REQUIREMENTS ENABLING GOVERNMENTAL SUPPORT

3.1 The qualification procedure for renewable generation

The qualification of the generating facility means that the power plant is acknowledged as a facility utilizing renewable energy sources, for which there is a special form of governmental support - power supply contracts (PSC). Without a qualification procedure, a WPP will profit as a facility of traditional energy generation [10]. In addition, there are four parties which have to make a preliminary approval: the Russian Association of Wind Industry (RAWI), Ministry of Industry and Trade, Ministry of Energy and the market Council.

In the wholesale capacity market PSC was introduced as a capacity mechanism until 2024. It is a contract for 15 years, according to which the investor is guaranteed to receive profit from the power plant operating on the basis of renewable energy. According to PSC for the operating WPP, the minimum capacity factor is set at 27%. If this indicator is in the range of 50-75% (the capacity factor is 14–20%), the generator has to pay a penalty, and if the capacity factor is below 50%, PSC becomes not valid. The performance of PSC guarantees the return of capital with a fixed rate of return of 12% [11]. In addition, the investor makes a profit from the sale of electricity in the wholesale electricity market without additional governmental support.

In order to recognize the generator as qualified, the market Council checks the design documentation (according to Decree of the Government of the Russian Federation of February 16, 2008 No. 87) and the WPP itself according to the criteria (commissioning of the facility, belonging to renewable energy facilities, inclusion of the facility in the regional development scheme, the ability to generate electricity, network connection, etc.) in accordance with approved protocols [6]. In addition, the Market Council checks the mandatory list of documents and the actual site inspection. The confirmation procedures are carried out by a commission consisting of representatives of the Ministry of Industry and Trade, the Market Council and the Ministry of Energy in accordance with Decree of the Government of the Russian Federation of May 28, 2013 No. 449 [12]. After verification, the object is added to the registry. The qualification procedure must be repeated every three years.

The list of qualified WPP with capacity more than 1 MW operating in the price zones of the wholesale market is presented in Table 3.1. The installed capacity of the qualified WPP constitute 94,6% of total wind generation capacity in the Russian Federation which is

roughly 191 MW. In turn, small-scale WPP operating in non-price and isolated zones of the wholesale market represents the rest share of generation and do not receive the governmental support in the form of PSC and is listed in Table 3.2.

Table 3.1 List of qualified generating facilities (WPPs with installed capacity >1 MW) operating on the wholesale electricity and capacity markets in Russia [13]

№	Name, Location	Coefficient of localization, %	Number of wind turbines	Installed capacity, MW
1	*Mirniy WPP*, Krasnodar region	n.a.	2	4.8
2	*Elistinskaya WPP*, Kalmyk Republic	n.a.	2	2.4
3	*Ulyanovskaya WPP-1*, Ulyanovsk region	28	14	35
4	*Ulyanovskaya WPP-2*, Ulyanovsk region, Cherdaklinsky district,	60	14	50.4
5	*Tupkildy WPP*, Republic of Bashkortostan	n.a.	3	1.65
6	*Tamar-Utkul WPP*, Orenburg region	n.a.	7	2.725
7	*Sydakskaya WPP*, Republic of Crimea	n.a.	35	3.76
8	*Presnovodnenskaya WPP*, Republic of Crimea	n.a.	55	7.39
9	*Tarkhankutskaya WPP*, Republic of Crimea	n.a.	133	17.253
10	*Sakskaya WPP*, Republic of Crimea	n.a.	180	20.83
11	*East-Crimea WPP*, Republic of Crimea	n.a.	17	2.81
12	*Donuzlavskaya WPP*, Republic of Crimea	n.a.	63	6.77
13	*Ostanenskaya WPP*, Republic of Crimea	n.a.	10	25
			Total installed capacity	180.788

Table 3.2 List of WPPs with installed capacity >0.1 MW operating in non-price and isolated zones of the wholesale electricity and capacity markets in Russia [14]

№	Name, Location	Number of wind turbines	Installed capacity, MW
1	*Ushakovskaya WPP*, Kaliningrad region	3	5.1
2	*WPP in Tiksi*, Republic of Sakha (Yakutia)	3	0.9
3	*WPP on Beringa island*, Kamchatka region	2	0.55
4	*WPP in Ust-Kamchatsk*, Kamchatka region	1	0.275
5	*WPP in Novikovo*, Sakhalin region	2	0.45
6	*WPP in Amderma*, Nenets Autonomous region	4	0.2
7	*Anadyrskaya WPP*, Chukotka Autonomous region	10	2.5
8	*WPP in Labytnangi*, Yamalo-Nenets Autonomous region	1	0.275
		Total installed capacity	10.25

3.2 Competitive selection of wind power projects

The target installed capacity of wind generation was legislatively fixed as 3.35 GW in the Russian Federation by 2024 [15]. Annually, to achieve this goal, the market Council conducts selections of renewable generation projects for implementation. In accordance with the requirements of the legislation on support for renewable energy sources, the selection of renewable energy projects for the conclusion of PSC is carried out on a competitive basis. The competitive selection is carried out once a year for the right to build WPP for 5 years in advance. The main competitive criterion is the specific capital expenditures (CapEx) for the construction of WPP [16].

When entering the competition for power selection, the project developer must have either a guarantor, which is a generating company with a capacity of at least 2.5 GW, or a financial guarantee from the bank in the form of an additional 5% of the project estimate. The bank imitates a letter of credit as a financial guarantee, which is provided by the guarantor. After passing the competitive selections, the winning projects go into the construction and operation phase, during which a number of procedures go through [17].

After connecting to the network and starting work, it is required to transfer monthly data on generation - the “green” certificate - to Administrator of the Trading System (ATS), this

procedure is also called certification. In accordance with the energy sold per month, the developer receives a premium from the market regulator as a facility operating on the basis of renewable energy [17].

The map of existing WPP and selected for implementation until 2023 WPP projects in the Russian Federation is shown on Figure 3.1. The total installed capacity of WPP that will be constructed in the next 3 years is 3149,36 MW.

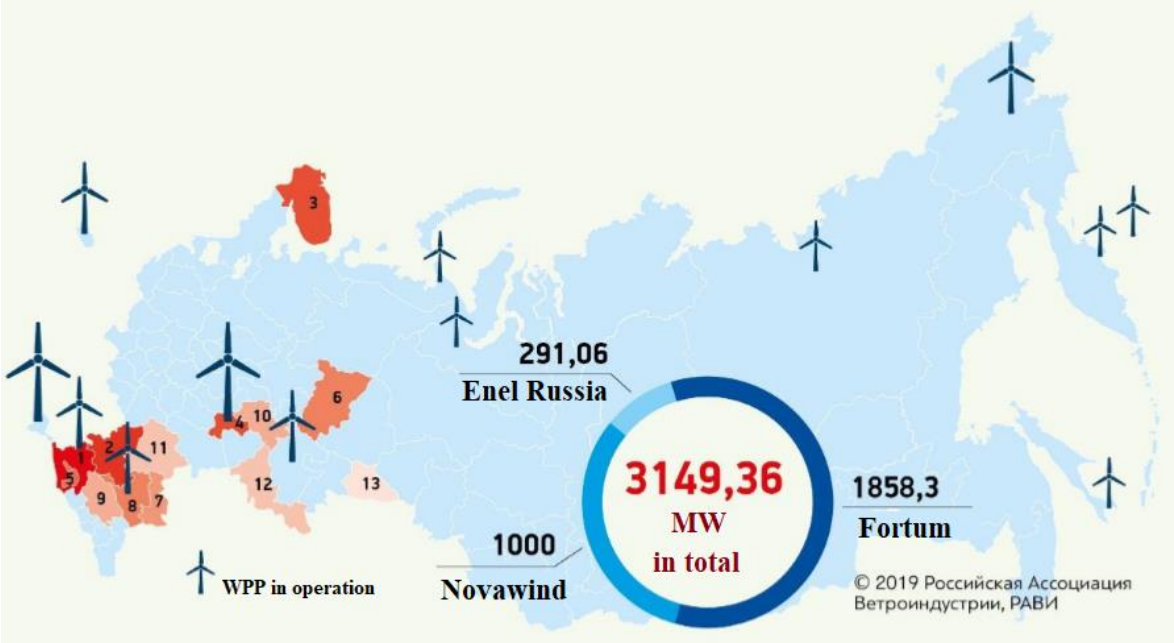

Figure 3.1 The map of selected for implementation until 2023 wind energy projects in the Russian Federation [adopted from 4]

The regional structure of selected wind power projects is presented on Figure 3.2. The majority of selected WPP sites are on the South of European part of Russia. For example, the largest capacity equal to 860 MW is announced to be materialized in Krasnodar region. In total, there are 13 regions of the 1st price zone of the wholesale electricity and capacity market in which the projects of WPP construction was supported by government and selected for implementation until 2023.

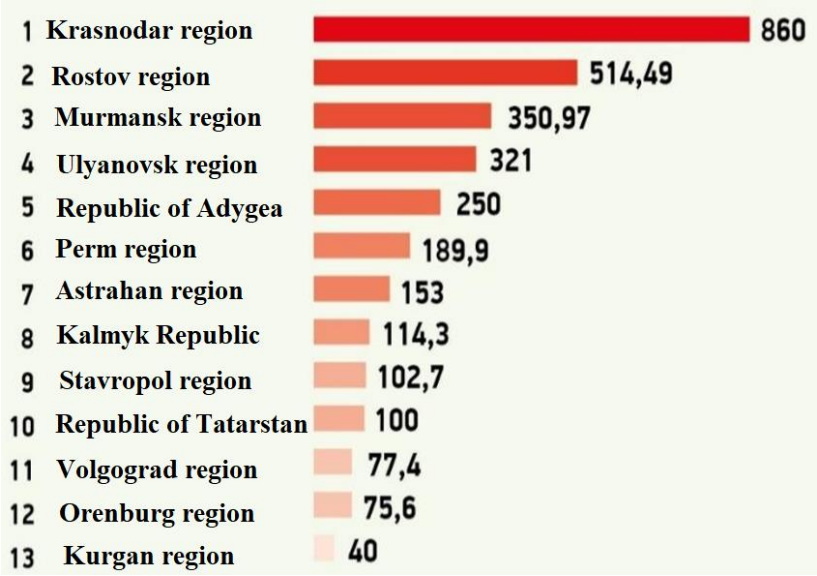

Figure 3.2 The regional structure of selected for implementation until 2023 wind energy projects in the Russian Federation, MW [adopted from 4]

Currently, there are three main companies represented on the wind industry market in the Russian Federation. The target capacity of WPP that have to be built until 2023 is shared among them. According to Figure 3.1, the major share of required wind capacity is supplied by Fortum and is approximately 1858 MW. The second part by volume is roughly double less and represents wind power projects proposed by Novawind. In turn, Enel Russia owns the smallest share of wind power capacity of 291.06 MW that will be materialized in coming years.

Figure 3.3 illustrates the allocation of capacity among the main stakeholders throughout the timeline. Based on the diagram, the yearly installed capacity will be increasing until 2021 in which achieves the number of 737.77 MW. Fortum's WPP starts operation every year within the considered period. In turn, Novawind's facilities will be completed before 2023, while Enel Russia has projects only in 2020 and 2021. The brief companies' profiles are given below.

Figure 3.3 The competitive selection results of wind energy projects until 2023 in the Russian Federation with companies contribution, MW [adopted from 4]

Fortum is a Finnish energy company operating in Nordic and Baltic countries, Poland, India and Russia. It has more than 50 years experience of working in the Russian Federation. The key focus areas include power and heat sales on the wholesale market as well as district heating solutions for local communities. Fortum owns and operates 8 thermal power plants in total. Facilities are located in the Southern Urals, where the manufacturing is mainly represented by metals industry, and in the Western Siberia, where oil and gas industry has a significant power. Russian power generation capacity of Fortum is 4.794 GW, while the capacity of heat production is 10.094 GW in Russia. Significantly, Fortum operates the 1st wholesale market WPP in Ulyanovsk region and continues to play a leading role in wind industry development in the Russian Federation [18].

Novawind is a part of Rosatom Group founded in 2017. It consolidates all Rosatom's wind energy assets. The company is actively forming of new competences in the field of wind energy in the Russian Federation, as WPP's design, construction and management. The announced installed capacity of Novawind's WPP will reach 1 GW by 2022. In addition, Novawind develops production facilities to accomplish the national goals for the localization level of wind turbines' components [19].

Enel Russia is a power generating company and Enel's key asset in the Russian Federation. Its' total gross installed electrical capacity is 5.6287 GW, that is equal to 5.2554 GW net installed capacity. Enel Russia operates 4 coal power plants situated in the central Russia, in

the Ural region and in the north Caucasus. As Enel Russia is active in the field of renewable generation, the company was awarded 2 projects of 201 MW and 90 MW in a federal public wind power projects competitive selection in 2017 which will be completed by the end of 2021 [20].

3.3 The localization level

The localization of equipment is aimed at developing its own production capacities in the Russian Federation, opening research centers and innovative industry growth in the country. According to the position of the RAWI, the officially stated localization requirement of 65% for Russian industrial companies is not unattainable because the list of companies interested in the Russian wind energy market is continuously increasing [21].

The degree of localization must be confirmed by the Ministry of Industry and Trade of the Russian Federation. Both procedures take place in parallel (as well as obtaining permission to connect to the network), for qualification the established period is 45 days from the moment of connection to the network, for localization - 30 days [10].

For the commissioning of a wind power facility in the Russian Federation, the equipment manufacturer is required to conduct mandatory certification of non-localized equipment acquired abroad. After that, the equipment can be used in the construction of the WPP [16].

The overview of possible suppliers for key wind turbine components located in the Russian Federation is given on Figure 3.4. As it may be concluded, both large international corporations as ABB, Vestas and local large and medium local enterprises are taken into account. The total number of companies put under consideration by the RAWI is equal to 29 [4]. The majority of them are located in European part of the Russian Federation with the highest density around Moscow and Saint Petersburg. The map of manufacturing facilities for the localization of wind turbine components production in presented on Figure 3.5.

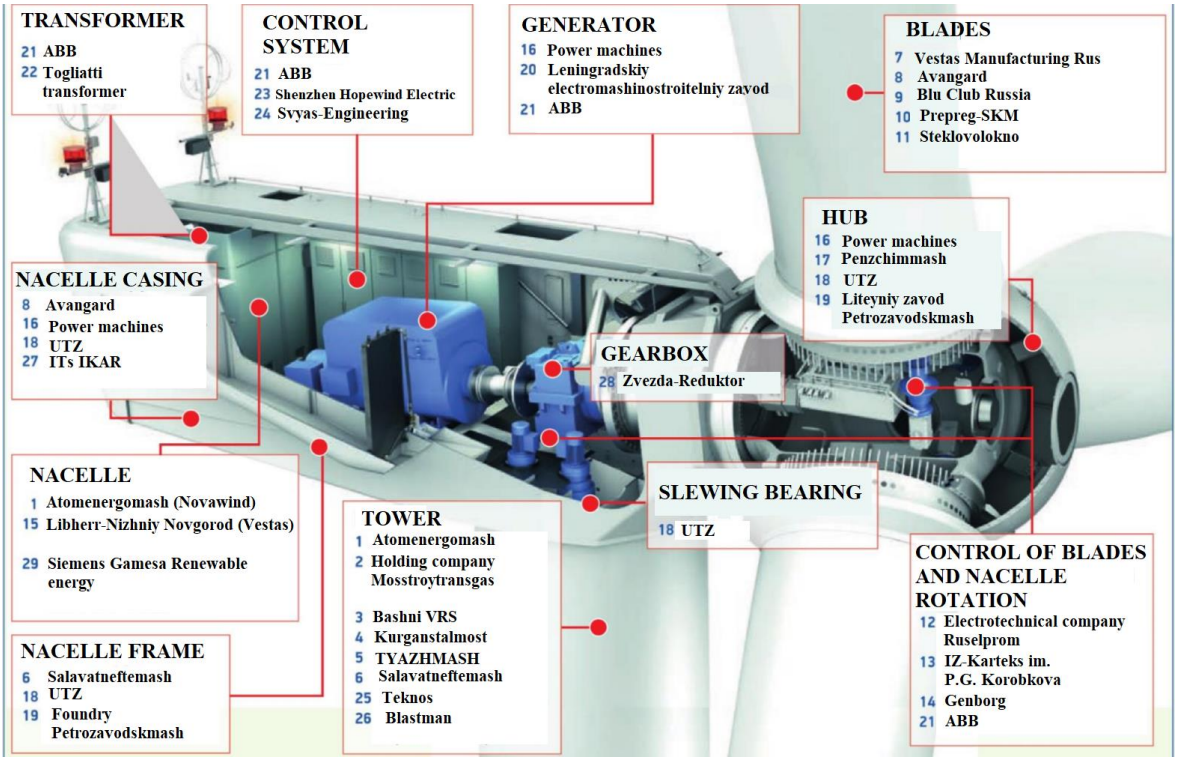

Figure 3.4 The localization of wind turbines' components production in the Russian Federation [4]

Figure 3.5 The map of manufacturing facilities for the localization of wind turbine components production in the Russian Federation [4]

As a part of foreign investments attraction for the development of wind industry in the Russian Federation, the Ministry of Industry and Trade, the Government of the Ulyanovsk Region and the Danish company Vestas signed the agreement named “Creation and development of the production of rotor blades for WPPs that have no analogues in Russia” in 2018 [22]. The expected volume production is up to 300 blades per year. The works started in the production building of the factory “Aerocomposite”. Moreover, the design of the wind turbine towers was implemented at the end of 2018 and afterwards the factory named “Towers VRS” was established in Taganrog (Rostov region). This facility became Russia’s first production of towers for WPPs. The development was continued with the launch of a nacelle factory for Vestas wind turbines V-126-3.45 MW with a capacity of 3.6 MW at Liebherr company in Dzerzhinsk (Nizhny Novgorod region) [22].

Another example of localization of the manufacturing was done under the agreement between Siemens Gamesa Renewable Energy and Siemens Gas Turbine Technology (STGT). According to that, the assembly of nacelles of wind turbines SG 3.4-132 with a capacity of 3.4 MW was founded at STGT site in the Leningrad region [23]. The first announced order was for Azov WPP with a projected capacity of 90 MW. In addition, there is a contract for the supply of wind turbines with a total capacity of 201 MW for company “Enel Russia” that will be utilized for the WPP in Murmansk region [20]. The generators for Siemens Gamesa wind turbines will be produced by Russian enterprise “Ruselprom”.

The estimated target indicators of the contribution of individual components to the localization of wind turbines production in the Russian Federation is shown on Figure 3.6. The largest share of 18% reflects the manufacturing of wind turbine blades and is mostly provided by Vestas plant in Ulyanovsk. The second large percentage of the total volume of locally produced wind turbine components, which is equal to 13%, represents towers that can be manufactured on sites of companies such as Vestas, Atomenergumash and Mosstroytransgas. The third share of 10% refers to gearboxes production, then 9% states for wind turbine hubs, 8% - for inverters. The portions of design and technical drawings, construction of control system and installation work are equal to 7% for each of listed, while the other wind turbines components are characterized by shares less than 5% of the total local production stream.

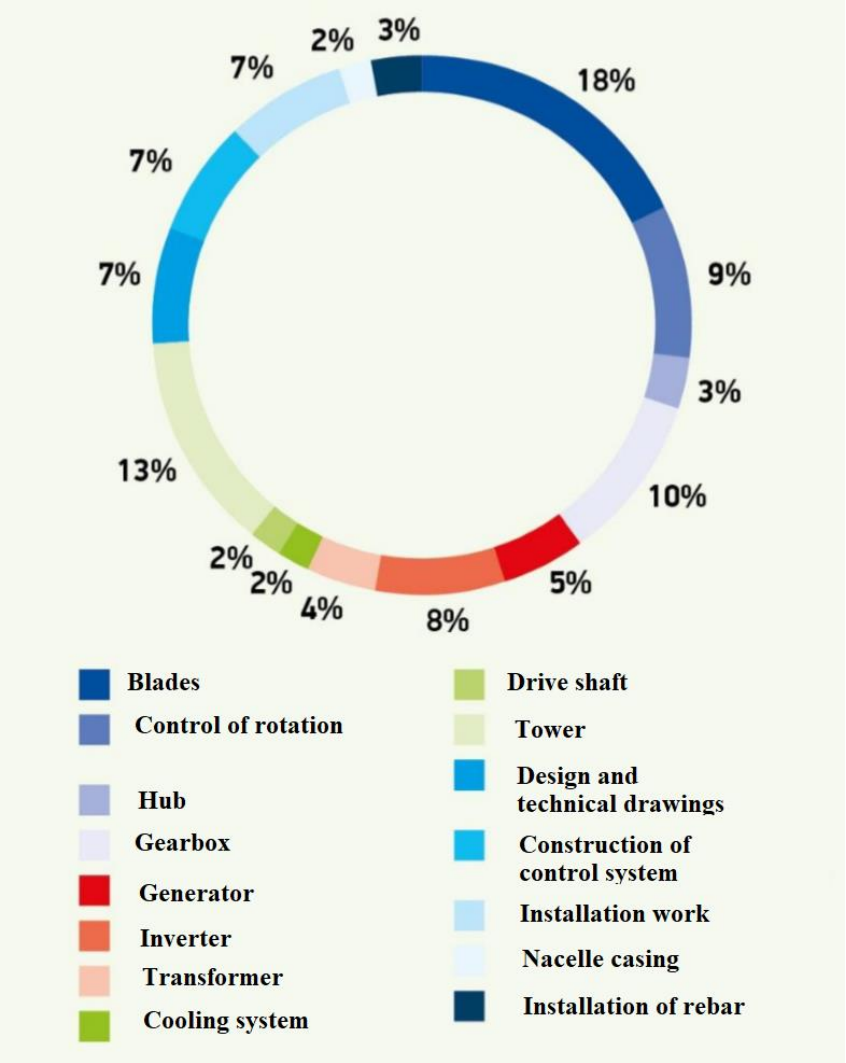

Figure 3.6 Target indicators of the contribution of individual components to the localization of wind turbines production in the Russian Federation [4]

4 GRID REQUIREMENTS

Rules for technological connection to the existing energy system infrastructure is an essential part of the process of a construction of a power plant. The process of connection is rather strict and structured and consists of several stages. The process begins with the filling an application, after which Contract Agreement Procedure has to be held which ends with the Conclusion of an agreement. When the first stages are over the owner of the generator can start the Implementation of Technological connection activities. After the completions of described preliminary stages actions must be legalized by Rostekhnadzor [24].

“Notification procedure” conducted by Rostekhnadzor on the commissioning of power plants sent by applicants whose power receiving devices range from 150 kW to 670 kW, connected to electric networks with a voltage class of up to 20 kV, as well as by grid organizations regarding power supply facilities up to 20 kV, built (reconstructed) in the interests of the applicant’s technological connection [25].

The next stage is “Actual connection of the applicant's facilities to the electric networks” which is followed by actual reception (supply) of voltage and power. The final step is creation of the Act on the implementation of the technological connection, the Act on the delimitation of balance sheet ownership, the Act on the delimitation of the operational responsibility of the parties and the Act on the coordination of technological (emergency) reservation.

Another important part is technical aspects as the reliability of power distribution schemes of power plants, because it has a direct impact on the reliability of the energy system as a whole. Preliminary determination of the main technical solutions for power distribution schemes in accordance with the Standard of organization “Electric Power Systems. Definition of preliminary technical solutions for power output of power plants. Conditions for the creation of an object” allows energy entities (network and generation companies, a system operator) to determine the main provisions of the technical conditions for technological connection of new generating capacities to the Russian energy systems on the basis of minimal initial information and at low cost when entering new facilities and reconstructing existing power plants [26]. The main preliminary technical solutions for power distribution schemes for power plants are determined by the following bandwidth requirements:

- Sufficiency of transmission capacity of power transmission lines included in the power plant power distribution scheme - the sum of the rated capacities of all power plant generators should not exceed the preliminary capacity of the power plant power distribution scheme.
- Sufficiency of the preliminary capacity of the power plant switchgear - the sum of the nominal capacities of the generating equipment of the power plant connected to this power plant should not exceed the preliminary capacity of the power plant switchgear.
- Sufficiency of switchgear transformers - rated power of the largest generator of a power plant connected to this switchgear should not exceed the preliminary capacity of the transformers of this switchgear.
- The conditions for the sufficiency of the transmission capacity of power transmission lines, switchgears and switchgear transformers should be met during new construction and expansion of the power plant, for each stage of construction.

4.1 Application for technological connection

An application for technological connection is submitted in one of the cases listed below [26]:

1. Joining power units for the first time put into operation.
2. The maximum power of previously connected reconstructed units increases.
3. The external power supply scheme changes. In relation to previously connected power receiving devices, the reliability category, type of production activity, which do not entail a revision of the maximum power value, but change.

The application form for a technological connection has to go through the network organization under responsibility of the applicant. The applicant sends the application to the grid organization, whose electric grid facilities are located at the smallest distance from the boundaries of its section. In case that at a distance of less than 300 meters from the boundaries of the applicant's site there are several network organizations, the applicant has the right to send an application to any of them. With technological connection on an individual project, the applicant has the right to contact any network organization.

A network organization that guarantees a supplier and an applicant - a legal entity or an individual entrepreneur, for the implementation of the process of technological connection and conclusion of an agreement ensuring the sale of electric energy (power) in the market, sign documents in electronic form using an enhanced qualified electronic signature. An applicant - an individual, for the implementation of the procedure of technological connection and conclusion of an agreement ensuring the sale of electric energy (power) in the market, signs documents in electronic form with a simple electronic signature [27].

It is not allowed to submit simultaneously two or more applications for technological connection of the same power plant to different network organizations. However, there is an exception for cases, when it is necessary to use several power sources, the applicant notifies each of the network organizations. When technological connection of electrical installations of one distribution power supply organization to the electric networks of another distribution power supply organization, the application for technological connection is submitted in the prescribed manner to the power supply organization, the electrical networks of which have a higher voltage level. During technological connection of electric networks of a distribution power supply organization to electric networks of an adjacent distribution power supply organization having the same voltage level, an application for technological connection is submitted in the established manner by an electric supply organization that requires an increase in the flow of electric energy (power). The distributing power supply organization is obliged to regularly submit information to the System Operator [28]:

- on the total capacity of the issued technical specifications in the context of substations;
- on the volumes of actually connected capacity according to the issued specifications to their network facilities, indicating the dispatcher name of the connection for which the technical conditions are issued, and the names of substations;
- on the total capacity issued over the past quarter, indicated in applications for technological connections to its electrical installations received from applicants, and concluded contracts for technological connection with the dispatcher name of the connection for which technical conditions are issued, and the name of substations.

The System Operator summarizes the information on the issued specifications provided by the distributing power supply, and quarterly in the prescribed manner provides information:

- on capacity volumes according to the issued specifications;

- on the volumes of connected capacity according to the issued technical specifications.

When the technical capabilities for connecting new or additional capacities have been exhausted, the System Operator notifies the distributing power supply organization about this fact.

4.2 Essential terms of the technological connection agreement

This part represents key aspects of the agreement and structure it should follow.

1. A list of measures for technological connection (determined in the technical conditions, which are an integral part of the contract) and the obligations of the parties to implement them;
2. The term for the implementation of technological connection measures:

a) For preferable applicants specified in clauses 12.1, 14 and 34 of the Rules for technological connection - 6 months, in case of technological connection to electric networks, the voltage level of which is up to 20 kV inclusive, and if the distance from existing electric networks of the required voltage class to the boundaries of the section the applicant, on which the connected power receiving devices are located, is not more than 300 meters in cities and urban-type settlements and not more than 500 meters in rural areas [29];

b) For applicants whose maximum power is less than 670 kW - 1 year (if shorter periods are not provided for by the investment program of the corresponding network organization or by agreement of the parties);

c) For applicants whose maximum power of electronic control units is at least 670 kW - 2 years (unless other periods (but not more than 4 years) are provided for in the investment program by the respective network organization or by agreement of the parties);

3. Responsibility of the parties:
    a. the applicant's right to unilaterally terminate the contract in case of violation by the network organization of the terms of technological connection specified in the contract;
    b. for violation by the parties of the deadlines for the implementation of technological connection activities.

4. The procedure for distinguishing between the balance sheet of electrical networks and the operational responsibility of the parties.
5. The size of the payment for technological connection.
6. The procedure and deadlines for the payment by the applicant for technological connection.

4.3 The distribution of responsibilities for the implementation of technical specifications

In accordance with the clauses of the rules, the distribution of responsibilities between the parties for the implementation of technical specifications for all categories of applicants [29].

The applicant fulfills the specified obligations within the boundaries of the site on which the applicant’s connected power receiving devices are located. After that the network organization fulfills the specified obligations (including those related to the settlement of relations with other persons) to the borders of the site on which the applicant’s connected power receivers are located. The distribution of obligations between the parties during a technological connection is implemented. The important note is that attachment points cannot be located further than 25 meters from the boundary of the site on which the applicant's connected objects are located. Measures for technological connection within the boundaries of the site on which the applicant's power receiving devices are located are carried out by the applicant. In turn, measures for technological connection to the border of the site on which the applicant’s power receiving devices are located, including the settlement of relations with other persons, are carried out by the network organization.

4.4 Preliminary power distribution scheme and rated voltage of switchgears

The capacity of the entire complex of electrical equipment through which the generator is connected to the power plant switchgear must provide the full rated power of the generator to the tires of the specified switchgear.

Block enlargement associated with the connection of two or more generators to one block transformer is allowed provided that the power of the enlarged block is limited to a value of not more than 660 MW.

The voltage class of the switchgear and power lines of the power distribution scheme should be selected in accordance with the scale of rated voltages adopted in the energy systems of the Russian Federation: 6-10-20-35-110 (157)-220-330-500-750 kV.

The applicant for the technological connection addresses the licensee, whose electric networks are located at the nearest distance. The choice of the type of electric grid is carried out depending on the connected power. With the expansion, reconstruction of the existing and construction of a new power plant, the connection of new generators to the power plant switchgear must be carried out as follows [26]:

- with a new generator (power unit) capacity of up to 30 MW - to switchgear of 110 kV and below;
- power line with a voltage of 6-10 kV is connected to generators with power of 50 kW to 2 MW;
- at a capacity of a new generator (power unit) from 30 to 160 MW - to a switchgear of at least 110 kV;
- when the capacity of the new generator (power unit) is from 160 to 330 MW - to the switchgear not lower than 220 kV, if there is no voltage class of the specified voltage class in the region where the power station is located — not lower than 330 kV;
- if the capacity of the new generator (power unit) is from 330 MW or more, to the switchgear is not lower than 500 kV, if there is no voltage class of the specified voltage class in the region where the power station is located, not lower than 330 kV.
- substation with a voltage of 35-110 kV at a voltage of 6-10 kV with a connected generator power of 500 to 10,000 kW;
- substation 35-110 kV at a voltage of 35 kV with connected power up to 20 MW;

In the absence of the required voltage class at the existing power plant for connecting new generators, the construction of a new reactor class should be provided.

The communication of the switchgear at the power plant should be carried out using two or more transformers (autotransformers) with a rated power of at least the rated power of the largest generator (power unit) of the station connected to a switchgear of lower voltage from the two switchgears under consideration.

In the absence of the required voltage class at the existing power plant for connecting power lines connecting the power plant to the junction substation, the construction of new power plants of the appropriate voltage classes should be provided.

For newly constructed switchgears of power plants with voltage of 220 kV and higher, as a rule, typical switchgear schemes should be applied, providing more than one switch for connection (two switches for connection, scheme 3/2 and 4/3).

4.5 Power Lines and Power Distribution Schemes

The power transmission lines proposed for construction should be connected to the junction substations, while the construction of power lines connecting the power plants with one junction substation with more than four power transmission lines of the same voltage class is not allowed. In the absence of switchgear at the power plant, the closest junction substation having the voltage class at which the new generator is connected is accepted as the switchgear power plant. If the distance to the nearest nodal substation exceeds the maximum permissible length of the overhead lines or power lines of the power distribution scheme, a separate set of standards has to be applied. If the power plant (selected construction site) is located in a zone of dense urban or industrial development where it is not possible to lay the overhead line, cable lines or cable lines can be used to connect power lines to the power station, while the length of cable sections should not exceed the maximum permissible length presented in Table 4.1.

It is not allowed to carry out power lines through which power is supplied to new or expandable power plants using three-chain or more supports. For a 35 kV grid and below - the sufficiency of the transmission line capacity based on the permissible power transmission line. In this case, it is not allowed to use different cross-section of the wires of the power transmission lines in the scheme of issuing one station. The maximum power for power lines of 35 kV and below, determined on the basis of their allowable power at normalized current density, is given in Table 4.1.

Table 4.1. Capacity of a grid 35kV and below [26]

Voltage, kV	Maximum capacity, MW	Maximum length, km
10(6)	4	5
20	7,5/12,5	8
35	9/19	20

For a 110 kV grid and above - the sufficiency of the transmission line capacity, based on the real power of the lines, the values of the coefficient K is equal to 1.4 for 110 (157) kV overhead lines, K = 1.2 for 220 kV overhead lines and K = 1 for 330 kV overhead lines and above, the limitations of the largest permissible length of power lines, presented in Table 4.2.

Table 4.2 Capacity of a transmission grid [26]

Voltage, kV	Maximum capacity, MW	Maximum length, km
110(157)	30	80
220	135	250
330	360	400
500	900	500
750	2100	1000

For power lines constructed in the dimensions of the next voltage class, a corresponding increase in the maximum permissible length is allowed.

In the case of application in the power distribution circuit of cable line, for a voltage class of 110-330 kV, the data on natural power presented in Table. 2, are multiplied by a correction factor of 2, and for a voltage class of 500 kV by a correction factor of 1.25. In this case, the permissible cable length for a voltage class of 110-500 kV should not exceed 10 km. For a voltage class of 750 kV cable lines are not applicable. The recommended sequence for determining the preliminary power distribution scheme for a new built power plant is given in Appendix I.

4.6 Initial data required for the preliminary determination of the power distribution scheme

The following data is included in the initial data necessary to determine the preliminary scheme for power distribution of a power plant. The first two paragraphs are prepared by the investor, the next paragraphs are fulfilled provided to the investor by the electricity industry [26].

- The area of the proposed construction of the power plant (geo-referenced).
- Rated power, number of generators planned for installation. The sum of the rated capacities of all generators of the power plant, including those planned for installation. The voltage class of the switchgear of the power plant, to which (to) the power distribution schemes proposed for the construction of the power line will be connected.
- Map or scheme of electric networks in the area of the proposed construction of a power plant with topographic reference of power facilities. The investment program approved by the Board of Directors of the grid organization regarding the construction of new power lines and substations containing the dates of commissioning of electric grid facilities.
- Normal connection diagram of the electric grid of the power system in the area of the proposed construction of the power plant.

4.7 Presentation form for determining the preliminary power distribution scheme

The preliminary power distribution scheme is presented in the form of two graphic schemes (the main scheme of the power plant and the power distribution scheme with reference to nodal substations of the main electric network) and a table indicating the number and parameters of the elements included in it [26]. Table 4.3 may be considered as an example of the acceptable table form.

Table 4.3. The parameters of the power distribution scheme

№	Parameter	Dimension
1	Amount and nominal power of generators for connection	MW
2	Amount and voltage of existing switchgear	kV
3	Amount and voltage of new switchgear	kV
4	Amount of built new generator cells for each switchgear	Amount
5	Amount and voltage of new built transformers	MVA
6	Amount and voltage of existing transmission grid	kV
7	Amount and voltage of built new transmission grid	kV

5 THE WHOLESALE ELECTRICITY AND CAPACITY MARKETS IN THE RUSSIAN FEDERATION

5.1 The structure of the wholesale electricity and capacity markets

The wholesale electricity market

The electricity market model in the Russian Federation consists of three sectors of electricity trade: the market of long-term bilateral agreements, day-ahead market, balancing market [30].

In the market of long-term bilateral contracts, the trade of electricity is carried out under regulated contracts and free bilateral contracts. In the regulated contracts sector, the Federal tariff service sets tariffs for electricity supplied to the wholesale market and purchased from the market. Volumes of electricity, which are not covered by regulated contracts, are sold at free prices within the framework of free bilateral contracts and the day-ahead market. Within the framework of free bilateral agreements, market participants themselves determine contractors, prices and volumes of supply. The basis of the day-ahead market is a competitive selection of price bids of suppliers and buyers a day before the actual delivery of electricity with the definition of prices and supply volumes for each hour of the day conducted by ATS. If there are deviations from the planned volumes of delivery for the day ahead, participants buy or sell them in the balancing market. Thus, this market is aimed to maintaining a balance between generation and consumption utilizing the most economical feasible sources at every moment.

In the market model regulated contracts have effectively replaced the previously regulated sector of the electricity market. One-stage liberalization of the wholesale electricity market could lead to significant changes in the level of electricity prices, affecting the competitiveness of both consumers and producers of electricity. Therefore, market liberalization was carried out gradually until 2011 by reducing the volume of bilateral regulated contracts twice a year. From 1 January 2011 within the price zones of the wholesale market regulated contracts are concluded only in relation to the volume of electricity intended for supply to the population, equivalent to the population categories of consumers, as well as to guaranteeing suppliers operating on the territory of the republics of the North Caucasus, the Tyva Republic and the Republic of Buryatia [30].

The general structure of the wholesale market in the Russian Federation is shown on Figure 5.1. It includes two price zones: the European part of Russia and the Urals (the 1st price zone); Siberia (the 2nd price zone). The allocation of two price zones is based on the limited transition capacity of the network between them. Also, an artificial restriction is imposed on the flow between price zones because of the different structure of generating capacities [28]. In the European part of Russia more than 70% of power production is thermal power plants, while hydropower plants represent more than 50% of the generation mix in Siberia. For this reason, the weighted average prices for electric energy in the 2nd zone are lower than in the 1st zone. Removing restrictions on the flow between price zones will cause an inevitable increase in energy prices in Siberia and lower prices in the European part due to the flow of cheaper energy from Siberian hydro power stations. The allocation of price zones is a generally accepted world practice, the purpose of which is to prevent an imbalance in the cost of electricity for territories with different composition of generating capacities.

The territories of the Russian Federation, where for one reason or another the functioning of the competitive market is impossible, are classified as non — price zones (Arkhangelsk region, Kaliningrad region, Komi Republic were assigned to the first non-price zone, the power system of the East in the far Eastern Federal district-to the second non-price zone) [30]. Electricity trade in non-price zones is carried out on the basis of regulated prices and has a number of specific features, for example, the presence of a single buyer model.

There is a list of territories of the Russian Federation in which the wholesale market is absent, so-called isolated areas. These areas include Kamchatka, Sakhalin, the Republic of Sakha or Yakutia (except for the South Yakut energy district), Magadan region [30]. In these territories, energy companies are not divided by type of business and are organized into joint-stock companies.

Figure 5.1 The structure of the wholesale electricity and capacity markets in Russia [30]

The wholesale capacity market

A capacity is a special commodity, the sale of which for a generating facility means the readiness for the production of electricity and the purchase of which for the consumer guarantees him the opportunity to purchase the necessary amount of electricity.

The capacity market is a trading system within which the following operations are carried out: selection of generating facilities according to economic and technical criteria; determination of the price of power and the conditions for its supply (terms and volumes, schedule, responsibility of the supplier); conclusion of contracts for the sale of capacity; ensuring physical deliveries and settlements for the delivered capacity [31].

Generating facilities undergo a competitive power take-off (CPT) to participate in the trade. A CPT is carried out by the System Operator (SO) four years in advance. Preliminary, the SO determines the volume of demand for generating capacity for the year of supply (taking into account the planned reserve), as well as the amount of capacity that needs to be taken for this year based on energy consumption forecasts. The SO sets the technical requirements and parameters of the generating equipment necessary to ensure the functioning of the power system. Suppliers submit price bids to a CPT and formulate a capacity offer. Moreover, the participants of a CPT represent both power plants in operation and facilities whose commissioning is planned after the completion of a CPT. The price request must contain the amount of available capacity of the generators, the values of their technical characteristics and the price of power for the period of delivery. Only applications in which the values of

the technical characteristics of generating facilities meet the minimum requirements defined by the SO are considered [28].

During a CPT, the price bids of participants are compared according to the values of technical parameters and prices for the capacity offered for sale in the wholesale market. The priority in the selection has a more efficient technical specifications and modern equipment. Auction of suppliers' bids is carried out on the basis of an optimization model that minimizes the cost of capacity. Some of the capacities for which a high cost or low technical specifications were declared do not pass the selection and do not receive payment for the capacity, meaning they do not participate in trade. In general, a CPT mechanism itself was created in order to provide the necessary volume of generating capacities taking into account reserves in the future development of the unified energy system and to stimulate the owners of power plants to modernize these capacities [32].

Directly at the time of delivery, capacity consumers pay the volumes declared by them at the prices established during the CPT. In turn, the SO monitors the readiness of generators for bearing the load through a special system for exchanging technological information with the automated system of the SO. Unreadiness to supply power is punishable by a reduction in the payment of capacity by a fine, which depends on how far ahead the supplier informed the SO that it is not ready to deliver capacity. The highest fines (up to full non-payment) are punished by sudden disconnection of generating capacities from the grid [28].

5.2 The regulatory framework of the wholesale markets organization and operation

According to the Federal law No. 35-FZ from 23.03.2003 "About electric power industry", the wholesale electricity and capacity market represents the market of the circulation of special commodities — electricity and capacity within the Unified power system of Russia in borders of common economic space of the Russian Federation involving large producers and large buyers of electric energy and capacity, as well as other persons who received the status of subject of the wholesale market and acting on the basis of the rules of the wholesale market, approved in accordance with the Federal law "About electric power industry" the government of the Russian Federation [8]. The criteria of reference of generators and purchasers to category of large actors are established by the Government of the Russian Federation.

With respect of official regulations, electricity has been regarded as a commodity that has next features related to its physical properties: the simultaneity of the processes of production and consumption of electricity; the need to perform balance generation and consumption at any point in time; the inability to determine precisely the volume of electricity production in connection with the probabilistic nature of consumption; physical inability to determine who made the electricity used by a particular consumer [8].

The capacity sale is considered as an obligation and ability to maintain the availability of generating equipment for power production characterized by stated quality to the extent necessary to meet the needs of the consumer of electricity. In turn, the electricity sale represents the physical supply of electricity to the consumer.

The legal basis for the functioning of the wholesale market are established by the Federal law “About electric power industry”, wholesale market rules established by the Government of the Russian Federation and normative legal acts of the Federal Executive bodies provided for by rules of the wholesale market.

The trade in the wholesale market of electricity and capacity is carried out in accordance with the agreement on accession to the trading system and regulations of the wholesale market, developed by the market Council – a self-regulatory organization of wholesale market participants.

The rules of the wholesale market regulate the relations connected with the turnover of electric energy and capacity in the wholesale market. The regime of export and import of electric energy is established in accordance with the legislation on state regulation of foreign trade activities. In non-price zones, where for technological reasons the organization of market relations in the electric power industry is not possible yet, the sale of electricity and capacity is carried out according to special rules.

According to article 35 of the Federal law “About electric power industry” the fundamental principles of the wholesale market organization are [8]:

- free access to participation in the wholesale market of all producers and buyers of electric energy complying with the rules of the wholesale market and meeting the requirements for the subjects of the wholesale market;

- free interaction of the subjects of the wholesale market acting under the rules of the wholesale market approved by the Government of the Russian Federation;
- freedom of choice of subjects of the wholesale market of an order of purchase and sale of electric energy through the formation of market prices and selection of price demands of buyers and price demands of sellers under the factor of minimum prices for electric energy, developing in separate price zones of the wholesale market, in accordance with the rules of the wholesale market or through bilateral contracts of purchase and sale of electric energy;
- taking into account the features of participation in the wholesale market of individual entities providing services to ensure system reliability and (or) producing electric energy at thermal, nuclear or hydro power plants;
- interaction of wholesale market entities on the basis of unconditional compliance with contractual obligations and financial discipline;
- obligation to purchase power by wholesale market entities in the manner and in cases established by the Government of the Russian Federation;
- the absence of discrimination in rules of the wholesale market concerning the subjects of the wholesale market owning existing or new objects of electric power industry.

In the regulation of the wholesale electricity and capacity market the Government of the Russian Federation conducts the next main functions [33]:

- approves the rules of the wholesale market, establishes rules of rendering services to ensure system reliability, services to ensure output of the Unified energy system of Russia from emergencies, services in formation of a technological reserve of capacity;
- approves the rules of conclusion and execution of public contracts in the wholesale market, the rules of state regulation (revision, application) of prices (tariffs) in the electric power industry, including the terms of consideration of their establishment, the list of submitted documentation, the procedure for mandatory examination of proposals and collegial decision-making;
- defines the fundamentals of pricing in sphere of controlled prices in the electricity sector, determining the principles and methods of calculation of prices in the electric power industry, and also establishes the procedure for submitting price bids by

wholesale market entities, the procedure for their selection and determining an equilibrium wholesale market price taking into account features of its price zones and defines and changes borders of price zones of the wholesale market taking into account technological and system restrictions of the Uniform power system of Russia.

In addition, the Government of the Russian Federation or the Federal Executive authorities authorized by it in the wholesale electricity and capacity market [33]

- carries out state regulation of the prices (tariffs), including establishes their limiting (minimum and (or) maximum) levels, except for the prices which state regulation according to Federal laws is carried out by Executive authorities of subjects of the Russian Federation;
- controls the application of state regulated prices in the electric power industry and checks the economic activities of organizations operating in the field of regulated pricing, in terms of the validity of the size and correctness of the application of these prices;
- monitors compliance with the requirements of the wholesale market entities of the legislation of the Russian Federation;
- monitors the activities of commercial infrastructure organizations, including through participation in the Supervisory Board - the market Council;
- establishes the allowances added to the equilibrium price of the wholesale market for determination of the price of the electric energy produced on the qualified generating facilities functioning on the basis of use of renewable energy sources.

The government of the Russian Federation also establishes the volume of purchase of the electric energy produced at the qualified generating facilities functioning on the basis of use of renewable energy sources obligatory for buyers of electric energy in the wholesale market and creates a public disclosure system in the wholesale market.

The functioning of the commercial infrastructure of the wholesale market is provided by the following organizations: self-regulatory organization - market Council (nonprofit partnership “Market Council”); the Commercial operator of the wholesale market - ATS; other organizations, in accordance with the contract of joining the trade system of the

wholesale market, the market Council is responsible for providing commercial infrastructure.

The market Council has the following functions [34]:

- determines the order of reference and maintains the register of wholesale market entities, the decision on awarding or depriving of the status of subject of the wholesale market;
- developing the form of the contract on joining to trading system of wholesale market, wholesale market regulations, standard forms of contracts, ensuring the implementation of trade on the wholesale market of electric energy, capacity, other goods, treatment which is carried out on the wholesale market and rendering of services related to the circulation of these goods in the wholesale market;
- organizes the system of pre-trial settlement of disputes between subjects of the wholesale market and electric power entities in the cases stipulated by the contract on joining to trading system of the wholesale market;
- installs the system and the order of application of property sanctions for infringement of rules of the wholesale market;
- involved in the drafting of the rules of the wholesale and retail markets and proposals for changes;
- exercises control over the actions of the system operator in accordance with the rules of the wholesale market;
- monitors compliance with the rules and regulations of the wholesale market subjects of the wholesale market and the organizations of commercial and technological infrastructures;
- performs recognition generating facilities functioning on the basis of renewable energy qualified generating facilities;
- carries out maintaining the register of issue and repayment of the certificates confirming production volume of electrical energy based on renewable energy;
- conduct control over observance by buyers of electric energy in the wholesale market of obligations on acquisition of a certain volume of the electric energy made on the qualified generating objects functioning on the basis of use of renewable energy sources, at the price determined in the order established by the Government of the Russian Federation.

Currently, an extensive regulatory framework has been formed to handle relations in the electricity and capacity markets. It includes 8 Federal laws, 46 resolutions of the Russian Government, orders of Federal Executive authorities (the Ministry of energy, the Federal tariff service, etc.). The main regulations forming the regulatory framework for WPPs operating in the wholesale electricity and capacity markets of the Russian Federation are summarized in Appendix II.

6 CHALLENGES FOR WIND INDUSTRY DEVELOPMENT IN THE RUSSIAN FEDERATION

6.1 Barriers for wind industry development

For a better understanding of existing situation on wind energy market and specific factors determining its growth an electronic survey was conducted among the main Russian energy market participants by the RAWI [21]. Four categories of barriers were defined to classify the factors which has an impact on Russian wind energy sector: financial, legislative, infrastructural and other. The list of existing challenges for wind industry development in the Russian Federation is presented in Table 6.1. The sequence of factors within one category is from the highest power to the lowest based on the survey results, assuming 5 - as the strongest challenge and 1 - as not relevant influencing factor [21].

Table 6.1 The list of existing challenges for wind industry growth in Russia [adopted from 21]

No	Challenge	The level of relevance
	Financial barriers	
1	Weak governmental support	4.5
2	Lack of investments	4.3
3	Marcoeconomic environment in the country	4.2
4	Prosedure of tariffs definition for electricity purchasing	3.7
5	Instability of exchange rate	3.3
6	Cross subsidization	2.9
7	Complex tax system in the regions	2.6
	Legislative barriers	
8	Lack of ongoing support from other market participants (universities, banks, manufacturing companies)	3.4
9	Difficulties in interacting with local authorities	3.4
10	Lack of government standards in the industry	3.3
11	Lack of coordination between the state and design agencies	3.2
12	Difficulty in obtaining land for projects or during competitive selections	3.2
13	High level of required localization	3.0
14	Avaliability of wind resources data	2.5
	Infrastructural barriers	
15	Infrastructure (including transport accessibility)	3.8
16	Lack of equipment adapted for use in these regions	3.7
17	Availability of qualified personal	3.6
18	Network connectivity	3.3
19	Impact on the stability of the power system	2.8

Table 6.1 (continued)

	Other barriers	
20	Lack of methods for evaluating the effectiveness of renewable energy projects	2.8
21	Social factors (culture, organization of life in the villages)	2.5
22	The abundance of natural fossil energy resources in the region (oil, gas, coal)	2.1

Financial barriers

Based on the results of conducted survey financial barriers are the most important for wind energy market participants. The main challenge for many respondents, including foreign companies, is to understand how the invested capital will be returned to the investor under certain conditions.

Financial barriers are mainly the result of the attractiveness of potential investments, which is associated with the expected return. Since there are a few implemented wind energy projects and the financial results of the competitive selection are not available to a wide audience, it is difficult for new players to understand the market features and estimate a potential. Thus, the cost of electricity and capacity are crucial factors in determining the return on investment. It is foreseen that in the future, with the development of the industry, the economic system, including competitive selection, will improve towards accessibility and openness to all potential investors.

Another problem is related to the lack of requirements of system operators in terms of equipment redundancy of uninterrupted power supply. However, excessive duplication of renewable energy sources with traditional generation is considered as economically and technically impractical.

Moreover, some financial barriers are caused by the tough economic development in the Russian Federation in recent years. The current macroeconomic situation in the country complicates the process of finding a foreign partner or investor, so it is challengeable for some companies to enter the Russian market, which also creates difficulties for the development of the industry. This barrier is strengthened by the fact that wind power industry in the Russian Federation is still strongly based on know-how and technologies imported from abroad. Currency volatility should also be considered as a serious financial barrier, particularly for foreign investors.

It is crucial for investors to understand how long they can forecast a return on investment in the future. However, there is no clear clarity on what could be on the wind energy market in the Russian Federation in the long term, after 2024, due to the validity period of current governmental support mechanism. This makes it difficult to invest, for example, in the manufacturing industry around wind energy market, as this requires stable demand over the coming years.

Legislative barriers

Technical issues on connection to the power network and regulation of the WPP operation in energy grid, including power flows, have not yet been resolved. The detailed description of grid requirements was given in Section 4. As an example, the main requirement of energy system companies when operating a power plant in the grid is full synchronization with the system at a frequency of 50 Hz, in case of changes – disconnection. Thus, the fundamental update of energy system regulations is required for effective use of renewable resources and significant growth of wind industry.

Infrastructure barriers

The most of the shortcomings in the regulatory framework for the design of power plants based on renewable energy are due to the lack of practical experience in the construction of MW class WPPs, since the relevant rules and regulations have not yet been created or adjusted. For example, according to some respondents, there are problems in the WPP design standards for wind turbine manufacturers. There is a delay in homologation of international standards into national standards, for example, GOST R 54418-2014, which is equivalent to IEC 61400 for 2010.

Additionally, the land issue even in the Russian Federation (with an area of more than 17 million km^2) has an extremely high priority because of the high cadastral value of land in some regions. Some regions of the Russian Federation with sufficient wind potential have excess installed capacity mostly represented by thermal fossil-based generation. Comprehensively, the additional construction of WPPs will mean excess generation and is considered as impractical. MW-class WPPs occupy large areas, while there are challenges in the transfer of agricultural land in areas of unpromising and risky agriculture potential into the land for industrial and energy use that will ensure a permission for the materialization of WPP. In addition to the high price, the developer of wind energy project

may face an administrative barrier (for example, in regions with excess electricity, especially in the European part of Russia).

Moreover, the required level of wind turbine equipment localization described in Section 3.3 is also considered as a barrier for wind industry growth. Currently, achieving the necessary indicators is a time-consuming process. However, assuming current rate of market development, finally the implementation of legally enshrined indicators tends to be ensured.

Barriers for isolated regions

According to the survey, the most significant barrier in isolated areas is “Weak governmental support”. It may be the result of a weak understanding of the mechanisms of operation of WPP without a network and financial problems associated with shortcomings in the methods of tariff formation (prices for consumers in remote areas are much lower than the real cost of production). Another reason might be the small number of pilot wind energy projects in the regions. In turn, the consequence of this is the problem of interaction with local governments.

Another barrier that characterizes isolated energy supply zones is the infrastructure of these areas. Some regions of the country (for example, the Far North) are characterized by high territorial dispersion of settlements and low quality of transport links. The transportation period for many Northern regions is only 2-3 months and is carried out on temporary, unequipped routes. In these conditions delivery and unloading of the dimensional equipment is extremely difficult task. As an example, for installation of wind turbines in the village Ust-Kamchatsky used a 200-ton crane, which was necessary to deliver from Petropavlovsk-Kamchatsky (450 km).

Furthermore, there is a barrier associated with the qualification of the staff which belongs to universities. Currently, there are practically no specialized departments on renewable energy resources. Hence, the work on professional education of specialists is carried out in the structure of the Russian Academy of Sciences and a few universities. The improvement of competences and expertise is essential for the successful and rapid growth of wind energy industry in the Russian Federation.

6.2 Possibilities to overcome barriers for wind industry development

Suggestions to overcome financial barriers

Some interviewed experts believe that it is necessary to solve financial barriers, for example, through increasing the investment attractiveness of wind energy projects or additional government funding. The first option is possible, for example, by increasing investment in projects including foreign investments, for which the availability and understanding of governmental support schemes in the Russian Federation is crucial. Additionally, the reduction of interest rates when obtaining a letter of credit will also potentially improve the situation. In turn, it is necessary to take into account the main macroeconomic risks, including exchange rates. The second option, additional public funding, should be transparently implemented in an effective and efficient manner.

Clearly, any kind of governmental support additionally requires that project developers and investors prepare their projects in accordance with the highest international standards. Therefore, domestic and international wind energy associations can play a crucial role in supporting construction of new capacities of WPP through training seminars, conferences, etc.

In the current macroeconomic situation, a high degree of localization of production in the case of the development of domestic competitive equipment acts as an alternative to expensive equipment and spare parts that need to be imported from abroad.

Suggestions to overcome legislative barriers

First, barriers related to standards should mainly be addressed by the Russian Government, in particular by updating existing national standards in line with the latest standards of International Electrotechnical Commission (IEC). Stakeholders consultations will simplify this process and ensure covering of important aspects.

It is significant to understand that, for example, the land legislation is difficult to change for the needs of wind energy. However, the vast territory of the country creates opportunities for the investor to leave to the neighboring region, where there may be more free territory, a shortage of electricity and its cadastral price is lower. This strategy can create a competition between regions, which will increase the investment attractiveness of wind energy projects in the Russian Federation. In turn, an effective measure may be the revision of the state territorial planning, in which WPP will be located in those regions with the highest need.

The existing scheme of territorial planning contains only projects of WPP above 100 MW, however, it is important to add to it the scheme of development of medium and small-scale WPP. The planning is required in case of strong administrative barriers in one region, in order to be able to move the WPP to another, where these barriers will be less, and at the same time the investor and developer are guaranteed to receive their profits.

Secondly, some of the rules that caused delays in the procedures for qualification and localization of equipment have already been improved, for example, the conclusion of the qualification is not necessary to obtain a letter of credit from accredited banks.

Another suggestion is the postponement of the implementation of standards on the degree of localization. Some companies request such a postponement for the next year, while maintaining the degree of localization at the level of the current year. The state meets the requirements and prepares a draft document, which will prescribe delays with the commissioning of capacities for a year after and six months before, while maintaining the degree of localization prescribed in the last orders.

Thus, a transparent, realistic and more integrated approach to overcoming financial barriers is required. Today, the requirements for localization and qualification are no longer barriers, but in order to create a strong domestic Russian market, it is necessary to pay special attention to the issues related to these procedures. Some more specific bills are currently being further developed by the Government but only practical experience will show how feasible the new requirements are. In any case, the Russian Government needs to remain flexible and adjust these amendments if they prove ineffective.

Suggestions to overcome infrastructural barriers

Based on the experience of countries with developed wind energy markets, many aspects of future development can be understood as these countries also faced similar problems and found ways to solve them. Already today, some national networks can cope with the average share of wind energy (up to 40% of total energy consumption), for instance, Denmark. Harmonization of Russian network standards with global regulations is a long and time-consuming process. Therefore, in order to correct the existing shortcomings, the Unified Energy System operator needs to cooperate with private companies that propose specific changes to the rules of electrical installations and industry standards.

Suggestions to overcome barriers existing in isolated zones

Although the isolated power supply sector in the Russian Federation is huge, there are only a few WPP and, as described above, this is due to a lack of knowledge about the mechanisms of WPP operation and the peculiarities of tariff formation in these regions. One of the main ways to gain knowledge about the benefits of isolated power supply systems is to create a program of state-funded pilot projects. While there are no well-known cost-effective examples of projects, the wind energy industry in isolated regions will face a difficulties despite the fact that WPP could supply electricity at a lower cost than existing diesel-based power plants.

The part of the development program should be the implementation of various financing models, for instance, state subsidies, public-private partnerships, etc. Obviously, in the long term, this sector will develop, since tariffs in isolated zones are formed taking into account the cost of expensive long-haul fuel, the cost of which is borne by the state. In this case, WPP become the most attractive source of power.

Moreover, a pilot program of wind industry promotion should be accompanied by the development of promising research and development with leading universities and research institutes, which will invariably lead to increased innovation and competitiveness of products and services.

As discussed earlier, regulatory improvements for self-consumption projects could be an significant driver of the isolated power supply market.

Infrastructural challenges are now more acute, but can be addressed through flexible planning and improved logistics, such as the delivery of equipment to remote areas via the Northern sea route, and sometimes even by helicopter.

The summarized list of suggestions to overcome barriers for wind industry growth in the Russian Federation is given in Table 6.2. The sequence is from the most relevant and potentially effective proposal based on the survey to the less strong option.

Table 6.2 The list of suggestions to overcome challenges for wind industry growth in Russia [21]

No	Suggestion	The level of relevance
1	Overcoming of financial barriers (e.g. through governmental support or state funding)	4.4
2	The improvement of the legislation on issues of network connectivity	4.3
3	The improvement of the financial mechanism for the implementation of projects	4.2
4	Ensure availability and network integration	4.1
5	Improved coordination between market participants	3.9
6	Development of new local standards	3.0
7	Improvement of requirements for WPP qualification procedure	3.0
8	The decrease in the degree of localization	2.5
For isolated regions		
9	Public-private partnership	4.2
10	More flexible funding system for these regions	4.2
11	Increase of financing for R&D projects concerning the development of Arctic regions	3.9
12	Increase in tax benefits	3.9
13	Attraction of foreign partners (including foreign investors)	3.6
14	The improvement of the infrastructure in remote regions	3.5

Based on implemented research, there is an enormous need to create a completely new single coordinated approach of all market participants. The plan could be prepared starting with thorough analysis and a consultation process between relevant government authorities and stakeholder groups, including actual and potential investors. As a high-value possibility national and international associations should be involved in work on a program. The first step towards unification of wind industry market regulations in the Russian Federation was conducted by the International Renewable Energy Agency (IRENA) together with the Ministry of Energy in as part of the REmap project. Finally, the program should take into account regional development plans, include lobbying for renewable energy projects, reflect the general energy strategy of the Russian Federation and define a clear, long-term plan for the development of emerging wind power industry.

The results of analysis concerning wind industry growth potential in the Russian Federation is presented in Table 6.3. The existing barriers and the main high-ranked suggestions how to overcome them is listed to create a base for further work on wind industry development program for Russian market.

Table 6.3 The results of analyzed barriers for wind industry growth in Russia and suggestions to overcome them [1]

No	Barrier	Suggestion
1	**Financial**	Improving the project financing mechanism, including using public-private partnership
2		Capacity building: improving the professional level of project documentation, developing ready-made solutions.
3		Work with localized equipment (increasing the number of localized equipment in Russia).
4		Dissemination of market opportunities, for example, through national and international associations.
5		Openness, a clear policy in the long term for 2024: fixing the intention to develop renewable energy after 2024 and designating ambitious goals for the period until 2030-2035.
6		Conducting training seminars on financing wind energy projects and participating in conferences to exchange experiences with other wind energy markets.
7		Consideration of financial risks in the development of regulatory documents
8		Development of financial models that take into account the economic specifics of renewable energy facilities.
9	**Infrastructural**	Development of a state territorial planning program for renewable energy projects, according to which the systematic development of wind energy in those regions that really need it and in which there is a high potential for wind energy
10		The development of new territories
11		Development of techniques for the inclusion of installations in the network and work in it.
12		Updating the atlas of winds using additional source data (data from wind monitoring masts, satellite data, Merra databases, etc.).
13	**Legislative**	Harmonization of Russian standards with global ones (unification of GOST and IEC standards).
14		Collaboration with private companies regarding the specifics of renewable energy facilities in the standards.
15		New solutions to problematic issues (designing foundations and access roads to wind turbines, reserving WPP power, etc.)
16		Reducing delays in qualification and localization
17		Development of additions to existing regulatory legal acts (on the localization of wind turbine components, deferrals while maintaining the degree of localization, etc.).
18	**For isolated zones**	Development by the Federal Antimonopoly Service of new methods for isolated territories.
19		Construction of pilot projects with different types of support
20		Industry development for jobs.
21		Innovations in the wind energy for North regions (grants, projects, target programs) and the development of the Arctic.
22		The use of installation methods without cranes, the use of helicopter delivery
23		Development of equipment adapted to harsh climatic conditions.

7 CONCLUSIONS

The key aspects forming the regulatory and technical framework for wind energy industry development in the Russian Federation are the structure and content of project documentation, the requirements for wind power project parameters providing an opportunity to apply for and receive a governmental support, the grid requirements referring mainly to the rules of the technological connection of the new WPP to the existing energy system, the structure and operating concerns of the wholesale electricity and capacity markets. According to the analysis of these aspects and expert opinions of the main players of Russian energy market the crucial challenges for national wind industry development and possibilities how they can be overcome were defined.

The construction of WPP legislatively refers to a capital construction and consequently has to match corresponding regulations. The key law is the Decree of the Government of the Russian Federation of 16.02.2008 N 8 which is discussed in details in Chapter 2. The comparison of the officially stated structure and content and the case of WPP Yarovoe has revealed that there might be less sections in the real wind power projects, in particular, eight out of twelve mentioned in the Decree, characterized by less strong differences between their contents.

There are two main requirements for WPP that have to be fulfilled in order to receive a governmental support in a form of PSC: the completion of qualification procedure, the successful results of competitive selection which is possible only if the localization level is sufficient. The qualified generator is acknowledged as a power plant utilizing renewable energy sources by various governmental organizations. After the completion of qualification procedure the generating facilitates are allowed to participate in the competitive selection for PSC. The total installed capacity of WPP that can be selected is limited by the legislatively fixed target of 3.35 GW by 2024. The main criterion for the selection is the specific CapEx for the construction of WPP. Currently, the selected for implementation wind power projects were developed by three companies Fortum, Novawind and Enel Russia. In turn, the officially stated localization requirement for WPP is 65%. As it was estimated, the largest share of 18% contribution to the total local production will reflect the manufacturing of wind turbine blades. According to the RAWI, the Russian Federation has a capability to provide sufficient local production rate for individual components of wind turbines to fulfill

this requirement with support of international companies such as ABB, Vestas and Siemens Gamesa Renewable Energy.

The official requirements for the technological connection of new constructed WPP to the existing energy grid were discussed in Chapter 4. The stages of the application procedure, essential terms of the agreement, the allocation of the responsibilities for the implementation of technical specifications and the updated power distribution scheme are regulated strictly and have to be prepared very precisely.

The electricity market model in the Russian Federation consists of three sectors of electricity trade: the market of long-term bilateral agreements, day-ahead market, balancing market. The separate wholesale capacity market is a trading platform on which only generators withstood CPT are allowed to take part in. The general structure of the wholesale market in the Russian Federation includes two price zones, non-price zones and isolated zones for each of which the legislative base differs. Therefore, the relation of the WPP site to the certain zone of the wholesale market should be considered during the primary stage of the wind energy project development. The main official regulations including Federal laws and Decrees as well as the authorities and their functions are discussed in Chapter 5.

Based on the conducted analysis, the main existing barriers for the successful development of the wind energy industry in the Russian Federation are identified. First of all, there is a general lack of investment and investors, which is associated, inter alia, with the macroeconomic situation in the country. Simultaneously, a significant number of deficiencies in the regulatory framework are defined, that are caused by the fact that current standards do not take into account the specifics of renewable sources energy. Furthermore, there are challenges regarding the technical connection of the WPP to the energy grid, largely due to lack of experience. In addition, some problems with transferring agricultural land to industrial and energy lands suitable for the construction of WPP remain as a strong barrier for wind power installed capacity increase. These are currently the most fundamental challenges for a WPP penetration increase on the wholesale electricity and capacity market in the Russian Federation.

In turn, the situation in the regions of the Russian Federation with isolated energy supply, was analyzed separately. Despite the fact that wind energy can reduce the cost of electricity in these regions, today there are few wind energy projects planned or implemented on that territories. The key factor forming the current state of wind industry development in these

regions is the fact that the energy market in isolated areas is characterized by deficiencies in regulatory documents, underdeveloped general infrastructure in these regions and administrative barriers.

This thesis presents the possible options on how existing barriers can be overcome. The main objective of the Russian economic environment improvement is to create attractive conditions for investors by introducing an effective, open and affordable economic development model that will create a market similar to the leading wind energy markets of other countries. In addition, there are high-valued tasks to improve existing standards, especially for non-price zones of the wholesale electricity and capacity markets, develop territorial planning programs for wind energy projects and government participation in pilot projects in isolated regions. Therefore, one of the most important goals is to create an understandable and open market of wind power generation for all potential participants. As a result, the Russian Federation will gain an opportunity to decarbonize effectively the energy sector by utilizing a huge national potential of the wind resource.

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APPENDIX I

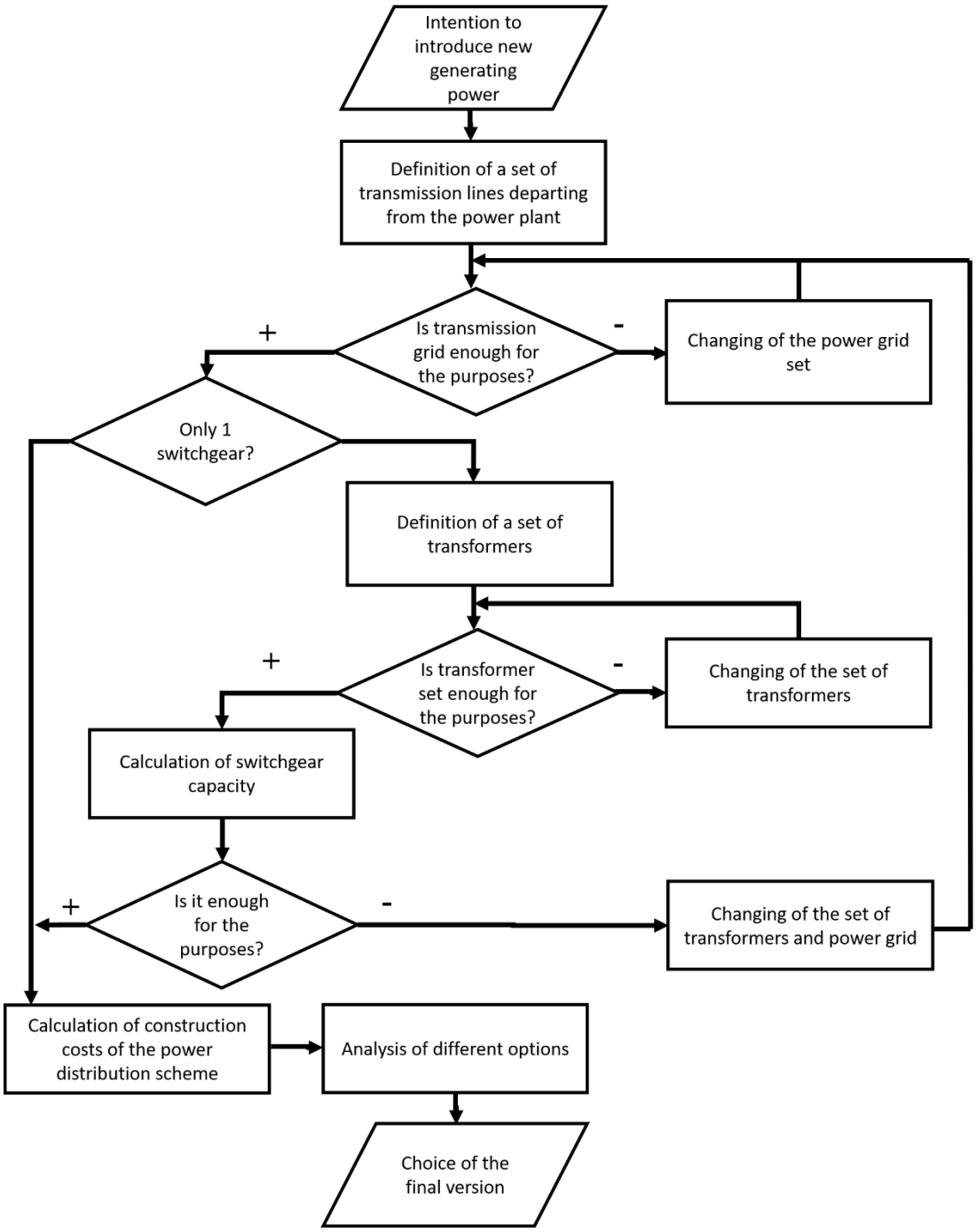

Figure 1. The recommended sequence for determining the preliminary power distribution scheme for a new built power plant [26].

APPENDIX II

Table 1. The core regulatory base for wind power plants operating in the wholesale electricity and capacity markets in Russia [21]

Document	Scope
Federal Law from March 26, 2003 No. 35-FZ "About the Electric Power Industry" (as amended on November 4, 2007)	Identification of measures to accelerate the development and role of the state in implementing the support of generators based on renewable energy
Decree of the Government of the Russian Federation of October 27, 2010 No. 1172	Rules for the functioning of the wholesale electricity and capacity markets
Order of the Government of the Russian Federation of 08.01.2009, No. 1-P	Approval of the state policy in the field of improving the energy efficiency of the electric power industry based on the use of renewable energy sources, which has set goals to achieve 4.5% of renewable energy sources (20% from hydro power stations) by 2020 (in the future, it was adjusted to 2.5%).
Decree of the Government of the Russian Federation of May 28, 2013 No. 449	A mechanism for stimulating the use of renewable energy sources in the wholesale market, according to which requirements for mechanisms for working with renewable energy sources in the wholesale market and norms by 2020 for the development of renewable energy sources were introduced
Order of the Government of the Russian Federation of July 28, 2015 No. 1472-r	The adjustment of the main target indicators prescribed in the 449th Resolution until 2020
Government Order from 08.01.2016, No. 1634-g	The territorial planning scheme of the Russian Federation in the field of energy, according to which 15 WPPs with a unit capacity of more than 100 MW and with a total capacity of 4.5 GW will be installed in Russia by 2030
Decree of the Government of the Russian Federation of 03.06.2008 No. 426 (as amended on September 19, 2016)	The qualification of a generating facility operating on the basis of the use of renewable energy sources
Order of the Ministry of Industry and Trade of the Russian Federation (Ministry of Industry and Trade of Russia) dated August 11, 2014 No. 1556	Approval of the procedure for determining the degree of localization in relation to a renewable energy facility to create its own competitively capable production of multi-megawatt wind turbines
Decree of the Government of the Russian Federation of July 17, 2015 No. 719	Criteria for correlation of domestic and foreign products in the absence of analogues in the Russian Federation
Decree of the Government of the Russian Federation of February 17, 2014 No. 117	Rules for maintaining the registry and issuing certificates
State standard GOST R 54418-2014	Information communication requirements between WPP components, such as objects of the system of control and data acquisition (SCADA)
Order of the Government of the Russian Federation of February 28, 2017 No. 375-r	The most recent changes in Degree No. 449

Table 1 (continued)

Document	Scope
Decree of the Government of the Russian Federation No. 610 of 23.05.2017	Making changes to the qualifications of a generating facility based on renewable energy sources and clarifying the localization of individual elements of wind turbines