

Part 8

RENEWABLE ENERGY SOURCES

8.2. Wind power plants (WPPs)

8.2.4. Overview of WPPs development as of 2014

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ABSTRACT

Among renewables being intensively developed, wind power sector takes the leading position. According to [1] in 2013 total capacity of all of the renewables (except all hydro) achieved 560 GW_e, including wind power plants making 318 GW_e (or 57 % of all renewables without hydro). In 2012 capacity of wind power plants constituted 283 GW_e, i.e. during one year an increase by 12 % was achieved. In this article technological aspects and information on equipment for wind power plants are presented. It is done with sectioning the article into grid connected, autonomous and hybrid plants as of 2013. In this article the materials from the first version of section 8 “Renewables” of Information Electronic Constantly Updated Open System “The Best Available and Perspective Nature Protection Technologies in the Russian Power Industry” of the Moscow Power Engineering Institute (<http://osi.ecopower.ru>), prepared by JSC ENIN [2] and actual materials have been used.

1. GRID CONNECTED WIND POWER PLANTS OF MEGAWATT CAPACITIES

Brief description. Wind plants equipped with automation control system via system of conjugation with the power grid produce electricity to the power grid.

Types and capacities of energy generating equipment, where it is recommended or possible to implement the technology under consideration. At the time being a world’s market of equipment for wind power plants has been formed (and it is a full sector of machine manufacturing). Capacities of single units for grid wind power plants constitute from approx. ~ 1,0 to 7,5 MW_e (the largest unit has a diameter of its wheel of 127 m). A trend towards increase in single unit capacity can be noticed especially for off-shore plants. For on-shore plants optimal capacities of the units are still from 3 to 4 MW_e. Engineering decisions of wind power units configurations vary a lot (tower constructions, orientation mechanisms, gear boxes, control systems, electrical appliances, automation systems, etc.). Information on 3 types of wind units, produced by one of the leading manufacturing companies, is presented in Table 1. This company offers 13 types of wind units, 3 of them - in the capacity range from 0,8 to 0,9 MW_e, 9 - ranging from 2 to 3,05 MWe and one with capacity of 7,58 MW_e.

Таблица 1. Wind units manufactured by Enercon GmbH (Germany)

Description	E-44/900	E-115/3000	E-126/7580
Installed capacity, kW _e	900	3000	7850
Wheel diameter, m	44	115,7	127
Tower height, m	45/55	92/149	135
Turbine design	Without a gear box, with variable rotation speed, with separate blades		
Number of blades	3	3	3
Rotation speed, rpm	12...34	4...12,8	5...11,7
Brake system	3 independent control systems with power feed at emergencies, brakes and a lock on a rotor		
Critical wind speed for stoppage of the unit, m/sec	28...34 (with control of a storm situation)		

Complete information on parameters of wind units, produced by “Enercon GmbH”, is available at

www.enercon.de. For further information on wind units one can find below some other well-known foreign manufacturers of wind units of megawatt capacities and their web-addresses:

- Siemens (Germany) – www.energy.siemens.com,
- GE (USA) – www.ge-energy.com,
- Vestas (Denmark) - www.vestas.com,
- Clipper Windpower (USA) – www.clipperwind.com,
- Bard Engineering GmbH (Germany) – www.bard-offshor.de.

In the Russian market there are available 1 MW_e wind units “Raduga-1”, manufactured by JSC “GMKB Raduga” named after A. Berezniak. According to [4] parameters of this wind unit are the following:

- nominal generator capacity – 1000 kW_e;
- range of working wind speed – 5...25 m/sec;
- wheel’s diameter – 48 m;
- tower height – 38 m;
- number of blades – 3;
- wheel’s speed (variable) – 21...42 rpm;
- estimated speed of storm wind - 60 m/sec;
- designed lifetime of the unit parts - 25 years;
- average annual power production - 2600...4900 thous kWh.

Range of applicability. Grid connected wind power plants are reasonable in regions with high wind potential. They work in the range of wind speeds, established for each certain power unit. They are connected to a power system.

Main restrictions on application of wind power plants:

- location of outermost installations of on-shore power plants not closer than 300 m to the dwellings; for off-shore wind power plants there are no such restrictions;
- periods of calm or storm wind outside the range of applicability;
- the overall capacity of wind power plants and other generating facilities, connected to the grid, but not fully controlled by the energy system must not exceed 10...15% (according to some recommendations it’s up to 25 %) of the total power system capacity; this is to escape sustainability of the system.

Advantages and disadvantages.Advantages:

- general advantages, characteristic for all of the renewables (no emissions of pollutants and GHGs, organic fuel savings, diversification of energy sources, company’s image increase aspects, etc.). In addition to them:
- specific cost of 1 kW of installed capacity of a wind power plant is comparable with that of TPPs (some sources give this figure for wind power plants a bit lower than for TPPs);
- low operational cost (there is no necessity in operational personnel at the plant site, nevertheless prophylactic works, substitution of oil and other works are needed).

Disadvantages

- necessity to stop the units when the wind speed is out of the

range of applicability (storm or calm); this negatively affects the work of related power system;

- low-frequency noise (3...15 Hz) coming from rotating wheels which depresses both human-beings and fauna at the plant site;
- death of birds (some evaluation gives the figure of 1% of birds flying across the site);
- increased specific areas, occupied by a wind power plant per 1 kW_e of installed capacity as compared to TPPs (in case wind installations are located one behind another, the minimal distance between them should be around 10 diameters of the wheel); there is a necessity to have a sanitary-protection zone some of 300 m wide from the outermost installations (with that agricultural works and some other works of such kind are possible inside the plant territory);
- architectural-and-visual negative acceptance of a wind power plant (this a subjective aspect: not for everyone "forest" of wind mills is a nice decoration of nature);
- low-frequency vibration at a distance of 60 m from a wind installation (they are absorbed in a sanitary-protection zone 300 m wide);
- ice on blades (because of scattering of ice particles during start-up of the engine warning measures of precaution are needed);
- radio interference (additional re-translators may be needed).

WPP references in RF (including Crimean objects, which earlier were not considered in statistics of RF): Vorkutinskaya – 1.5 MW_e; Anadyrskaya – 2.5 MW_e (Chukotka peninsula, in the zone of decentralized power supply); Kulikovskaya (Zelenogradskfya) – 5.1 MW_e (Kaliningrad province); wind power plant on Bering Island – 2 MW_e; Tupkeldy – 2 MW_e (Bashkir Rep.); Saratovskaya – 0.3 MW_e; Kalmytskaya – 1 MW_e; Marposadskaya (Chuvash Rep.) – 0.2 MW_e and a number of Crimean plants: Ostaninskaya – 25 MW_e, Saksakaya – 19 MW_e, Tarkhankutskaya – 15 MW_e, Sudakskaya – 6,3 MW_e, Presnovodnenskaya – 6,0 MW_e and Donzslavskaya – 2,9 MW_e.

A number of wind power plants are under design at various stages.

Information on existence/absence author's rights on the implemented technology, developers and/or legal owners of the technology

In the process of creation and improvement of equipment some components and technologies were defended by author's rights.

2. AUTONOMOUS WIND POWER PLANTS

Brief description. Wind units with automated control system via collector of energy (accumulator) produce power to the consumer. They are targeted at autonomous power supply of remote settlements and objects in regions with no centralized supply.

Types and capacities of energy equipment, where it is recommended or possible to implement the technology under consideration

Usually autonomous plants have capacities up to 1 MW_e, but often they are of tens kW_e. Two of the largest units available at the markets of Russia and Ukraine (which can be referred to autonomous), are presented in Table 2 [2].

Table 2. **Serial installations in RF and Ukraine**

Description	USW-56-100	AVE-250SM
Manufacturer	JSC "Vetro-energetika", Ukraine	GUP NPP "Vetroen", RF
Nominal capacity, kW _e	107,5	250
Generator type	asynchronous	synchronous
Current	3-phase, 380 V	3-phase, 380 V
Calculated working wind speed, m/sec	13	13
Range of working speed, m/sec	5...22	5...30
Wheel diameter, m	20	18...30
Tower construction	Metal grid	Conical tower
Regulator	Mechanic	Mechanic
Orientation mechanism	search	windrose
Production status	serial	serial

Range of applicability. Reasonable in regions with high wind potential. They work in the range of wind speeds, set for each certain power unit.

Main restrictions on application of wind power plants:

- location of outermost large-scale autonomous installations not closer than 200 m to the dwellings.
- periods of calm or storm wind outside the range of applicability, when wind power plant is inevitably out of operation and accumulators are discharging; this will demand a reserve source of power supply.

Advantages and disadvantages.

Advantages: general advantages, characteristic for all of the renewables (no emissions of pollutants and GHGs, organic fuel savings, diversification of energy sources, company image, etc.). Besides, low operational cost (there is no necessity in operational personnel at the plant site, nevertheless prophylactic works, substitution of oil and other works are needed.).

Disadvantages:

- necessity to stop the units, when the wind speed is out of the range of applicability (storm or calm) and exhaust of accumulators potential;
- ice on blades (because of scattering of ice particles during start-up of the unit warning measures of precaution are needed);
- radio interference (additional re-translators may be needed).

References in RF. There are a lot of small-scale autonomous plants across the country.

3. HYBRID POWER PLANTS

Hybrid power plant is a combination of an autonomous wind power plant with a diesel-generator or some other traditional source of power production. Such a combination makes it possible to get rid of chronic disadvantage of an autonomous wind plant – stoppage during periods of calm and storm winds. Besides, in such a manner it is possible to provide higher capacities of such a complex with high level of liability of power supply. Perspectives of such complexes are vast. But from the point of view of ecological effect this system can be referred as a renewable source to such an extent as how big is the share of the wind mill; coefficient of installed capacity use of the wind power plant is not high. In most cases it doesn't exceed 37 %. Indicators of a hybrid system, its advantages and disadvantages and all other

parameters should be proportionally distributed between diesel generator and wind power plant, correspondingly. It is clear that variety of options for combining of hybrid systems is large and to a very high extent depends on local conditions. Under such reasons hybrid systems are not considered further on in the Informational System.

REFERENCES

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