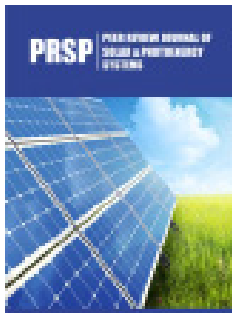


# Influence of Wind and Solar Power Plants on the Reliability of the Functioning of Power Systems

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## Opinion

Until recently, it was considered one of the most effective directions in the development of the electric power industry to increase the share of renewable energy sources (RES) in the balance of power and electricity of power systems in the form of wind and solar power plants (wind turbines and solar power plants), the main advantages of which are considered to be the economy of fossil fuel (coal, gas, fuel oil) and reducing environmentally harmful emissions into the atmosphere. However, at the same time, the influence of renewable energy sources on the controllability of the modes of operation of electric power systems and on the reliability of the functioning of the RES remains completely unexplored. This brief analysis is devoted to the last question.

**Keywords:** Power system; Wind and solar power plants; Rotating reserve; Power supply reliability; Accident; Damage

## Introduction

Currently, the world energy uses 318 million kW of wind turbines and about 142.4 million kW of solar power plants, of which the main countries of Western Europe account for about 227 million kW, or 49.3% (for the location of these power plants by country, see Table 1).

**Table 1:** Use of wind and solar power plants in Western Europe in 2018.

Name	Installed Capacity of Power System (Million kW)	Including MW I %%		
		Wind Turbines	Solar Power Plant	Total
England	108.28	21.37	13.12	34.49
		19.74	12.12	31.85
Germany	229.2	55.48	42.52	98
		24.2	18.55	42.76
France	133.46	14.95	9.61	24.56
		11.2	7.2	18.4
Denmark	15.07	7.08	0.99	8.08
		47	6.6	53.6
Austria	68.35	5.24	1.1	6.33
		7.66	1.6	9.26
Italy	115.22	9.28	19.28	28.57
		8.06	16.74	24.79
Spain	103.74	23.44	7.05	30.5
		22.6	6.8	29.4
Total	773.32	136.84	93.68	230.52
		17.7	12.11	29.81

From the presented data, it can be seen that on average in Western Europe, wind and solar power plants account for almost 30% of the total generating capacity, with the largest share

of wind turbines in Denmark (47%), and the highest share of solar power plants (18.6%) belongs to Germany.

A modern wind turbine contains a direct generator, an energy storage device (battery) and an inverter. If the offshore wind turbine is provided, then the power plant includes a HV cable for connecting the generator with the high-voltage electrical network

of the power system. When assessing the reliability of wind power plants and solar power plants, it was taken into account that wind turbines, as a rule, must operate without maintenance continuously for at least 15 years. The same rule was conditionally extended to the RES. Reliability indices of wind turbines and solar power plants obtained by the analogous calculation method are shown in Table 2.

**Table 2:** Estimated indicators of reliability of wind and solar power plants.

Name	Reliability Parameters					
	$\lambda^{ab}, 1/\text{ГОД} / 1/\text{year}$	$\bar{\tau}^{ab}, \text{час} / \text{отказ}$ hour / failure	$q, \text{отн.ед.}$ r.u	$\lambda^{int}, 1/\text{ГОД}$ hour/repair	$\bar{\tau}^{int}, \text{час} / \text{рем}$ hour / repair	$\bar{v}^{int}, \text{отн.ед}$ hour / r.u
Groun-based wind turbine	0.6667	6	0.000467	0.0667	4	0.00003
a. Generator	0.5	6	0.000342	0.0667	4	0.00003
b. Inverter	0.1667	6	0.000114	0.0667	1.5	0.000011
Water-based wind turbine offshore	0.6739	6.53	0.000503	1	1.5	0.001826
a. Generator	0.5	6	0.000342	0.0667	4	0.00003
b. Inverter	0.1667	6	0.000114	0.0667	1.5	0.000011
B. Cable HV. L=2 KM	0.0072	56	0.000046	1	16	0.001826
Solar Plant	0.1667	6	0.000114	0.0667	1.5	0.000011
a. Solar Panels	-	-	-	-	-	-
b. I nverter	0.1667	6	0.000114	0.0667	1.5	0.000011
Note:	The reliability indicators of wind turbines an solar power plants were obtained dy analogous calculation and require calculation when statistical information is available					

To study the influence of wind and solar power plants on the reliability of the functioning of power systems, the author's model of the reliability of power systems "SATURN" in version 3.3 was used.

The studies conducted allow us to draw the following conclusions:

A. An increase in the share of wind and solar power plants in energy systems determines the economy of fossil fuel and reduces harmful emissions into the atmosphere.

B. The same factor causes a decrease in the reliability of the power system, increases the likelihood of systemic accidents

with disconnecting consumers and causing them serious economic damage, reaching 1% of the produced GDP

C. This damage can be prevented by increasing the rotating reserve within the available EPS reserve, which will require an increase in funds for its maintenance due to additional fuel consumption.

The ratio of reducing the probable damage to consumers and the cost of additional fuel consumption to maintain the necessary rotating reserve in the power system makes it possible to economically substantiate the strategy and scale of introducing renewable energy sources into the electric power industry.

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