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SIGNIFICANT PARAMETERS OF WIND POWER PLANTS AND THEIR INFLUENCE ON RECIVING DEVICES OPERATION

Key Words: wind power plants, wind power plants systems, law on power engineering, parameters of wind power plants, electrical energy quality

Abstract: In the article the Authors consider the state of legal regulations on power quality standards currently valid in Poland. The paper presents considerations on the effect of initial applied parameters of a modern wind power plant on the quality of a receiver performance.

INTRODUCTION

Nowadays, when the power consumption by power systems continuously increases the scientists more and more approvingly search for restorable energy sources considering also applications making use of wind energy. By the end of 1987 there were over 15,000 existing and operating wind power plants in California (USA) that generated the power of over 1300 MW.

The wind power plants, apart from considering various energy conversion methods applied therein, are divided into two main groups referring to the power they generate. The first group comprises power plants of power capacity over 100 kW, in publications often referred to as "WECS" (wind energy conversion system), while the other includes low capacity power plants (below 100 kW) - called "SWECS" (Small WECS).

Wind motors usually operate at significant revolution speed alterations that, depending on controlling system used, get reduced down to 30% of rated speeds. Beside the above it should be also kept in mind that considering a receiving device itself not the differences in wind power plant design are the most essential but the input parameters, e.g. voltage, amplitude and frequency, curve course and harmonic content, determining the quality of electrical energy.

2. LAW REGULATIONS CONCERNING THE QUALITY OF ELECTRICAL ENERGY

Polish law regulations issued so far concerning the quality of electrical energy are defined within documents [1,2,3,4,5,6]. A remarkably interesting fact is that according to statistics state on 1997, most of legal acts mentioned above has the status of instructions; the regulations being only the subject to recommendations and indications but not the standards.

The coming process of Poland's integration with European Union would require new approach (creation) to Power Engineering Law to ensure compliance with Euro-Standard EN50160. Some sort of preliminary lawsuit are two projects of Minister of Industry and Trade dated 1994 that refer to attaching the entities to power supply network, bearing the costs of the latter, turnover of electrical energy, rendering industrial services and quality standards of services in favour of customers. Even today however, each producer of electrical energy should take the above suggestions into account and focus on the parameters considered below (requirement of Electricity Distributing Company being the one that purchases the energy).

Key Input Parameters of a Power Plant

Deviations of voltage - representing the difference between the real and rated voltage values should not be greater than ± 5%; in case of the receivers having their power devices continuously connected to power network, using the voltage below 1 kV, and receivers having their devices connected temporarily to power network independently from the voltage level, within rural areas - should not exceed +5% and -10%.

Allowable voltage drop within receiving system being supplied from the source or main power distribution station for the purpose of lighting, heating or power system should not exceed 7% whereas for the power system as that - not greater than 9%.

Voltage oscillations - series of alterations of voltage efficient value occurring at speed not lower than 1% U_N per second within time intervals not longer than 10 min.

Number of voltage alterations per min	0,1	0,5	1	5	7,5	10	50	100	500	1000
Allowable change amplitudes for regular oscillations acc. to IEC [%]	3,0	3,0	2,7	1,7	1,5	1,4	0,87	0,74	0,7	0,3
as above but for irregular oscillations in networks 110 kV	2.0	2,0	2,0	1,7	1,5	1,4	0,87	0,74	0,7	0,3

Table 1. Allowable voltage oscillations

Allowable deviations of frequency equal to +0,2 and -0,5 Hz within the time period over 15 min

Allowable passive power consumption by the energy producer should not exceed tφ = 0,4.

Course of voltage curve is determined by a voltage distortion coefficient expressed with the following formula:

$$\nu = \sqrt{\sum_{n=2}^{k} U^2_{n\%}}$$

where $U_{n\%}$ - effective value of n-harmonic of voltage expressed in percentage of network rated voltage, k - limit of summing (assumed k = 25).

Level of voltage distortion ν_p in a given point of the network, the value of voltage distortion coefficient that is not exceeded within 90% of time of 24-hour day.

Temporary values of voltage distortion coefficient that may reach values greater than recommended and limit values of distortion level within 2,4 h period of 24-hour day. They should not however, exceed the allowable values.

	Recommended allowable values		Limit allowable values	
Network	level ν_{pd} [%]	temporary value $\nu_{d\,max}$ [%]	level ν_{pd} [%]	temporary value $\nu_{g\,max}$ [%]
110 kV	1,5	3,0	3,0	4,5
Medium Voltage	5,0	10,0	10,0	15,0
Low Voltage	7,0	14,0	10,0	15,0

Table 2. Allowable voltage distortions within industrial power network

Besides, in three-phase networks two other coefficients are important: the coefficients of voltage and current asymmetry of adverse order α_2 and zero order α_0 expressed in per cents as follows: $\alpha_{U2} = \frac{U_2}{U_1}100$, $\alpha_{U0} = \frac{U_0}{U_1}100$ (for I respectively), where U_1, U_2, U_0 (I_1, I_2, I_0) - effective values of symmetric components in coincidential, adverse and zero order, respectively.

The allowable levels of asymmetry for electrical rotating machines equal to: $\alpha_{U2} \leq 2\%$, $\alpha_{U0} \leq 2\%$, $\alpha_{I2} \leq 5\%$, $\alpha_{I0} \leq 5\%$, respectively.

3. INFLUENCE OF ENERGY QUALITY ON RECEIVER OPERATION

Electrical energy parameters, mentioned in the previous section, fundamentally affect the operation of the receivers, their durability, efficiency and power consumption. The charts presented below show few example characteristics demonstrating the influence of supply voltage on some parameters featuring the sources of light.

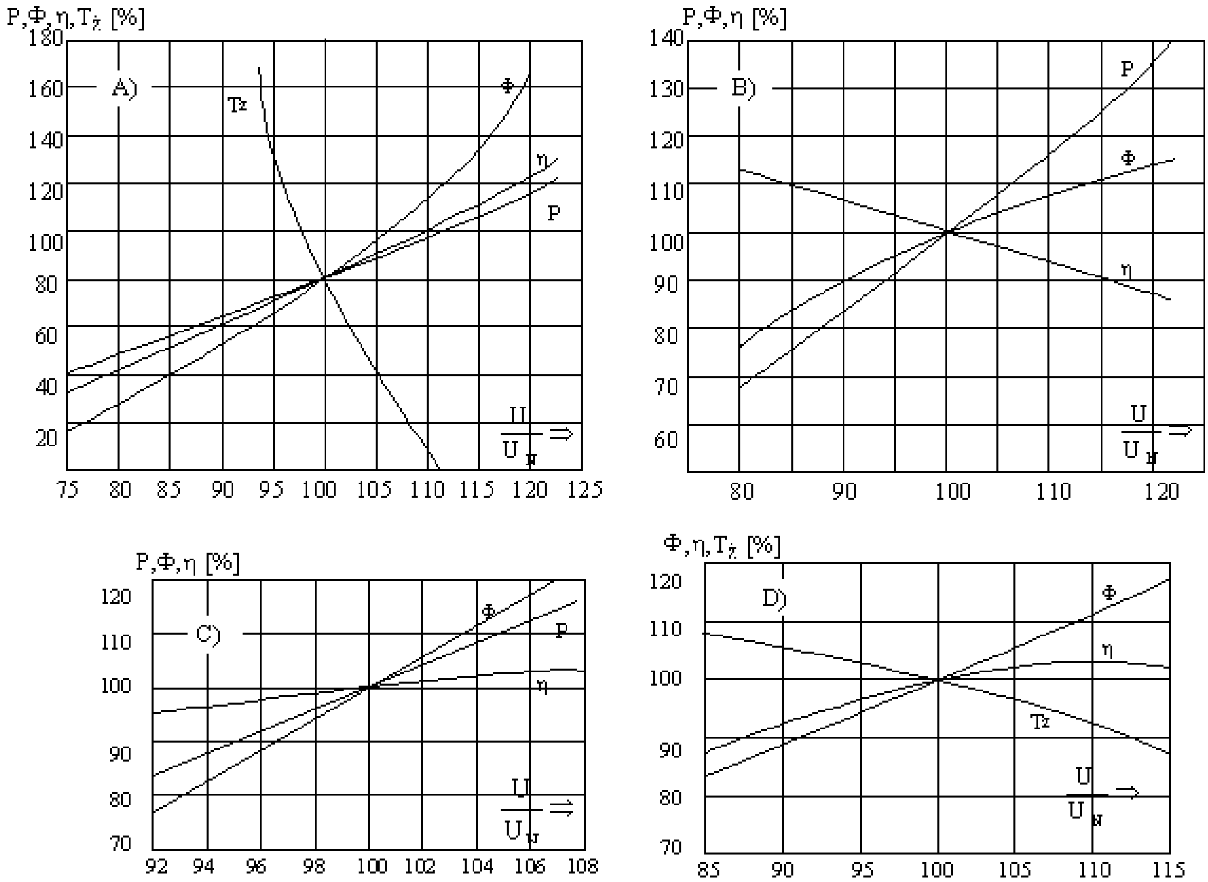

Fig.1 Influence of light source voltage on: a) gas-filled bulb, b) fluorescent lamp c) high-pressure mercury-discharge lamp d) high-pressure sodium-discharge lamp

P - power absorbed from network; Φ - light beam; η - lighting efficiency; $T_ż$ - durability.

As it can be seen from the above charts, the reliability and efficiency of lighting systems depends on the type and quality of light sources used and also on the quality of electrical energy delivered. The parameters of electrical energy affect not only the performance of the light sources presented above but they affect all electrical devices and as reason-effect consequence all the other elements involved (e.g. mechanical elements, hydraulic elements, etc. operating as actuators).

The table below is to present the influence of electrical energy quality on electrical machine performance, namely induction motors.

Characteristic parameter	Changes of parameter values at voltage equal to:	
	0,9 U_N	1,1 U_N
Starting and maximum torque	-19 %	+21 %
Turning torque	-19 %	+21 %
Synchronous rotation	const	const
Slip	+23 %	-17 %
Rotation at full load	-1,5 %	+1 %
Efficiency at 100% of load	+2 %	slight increase
cos φ at 100% of load	+1 %	-3 %
Current at 100% of load	+11 %	-7 %
Starting current	-10 ÷ -12 %	-
Temperature increase at 100% of load	+6 ÷ +7 %	-
Magnetizing current	+70 ÷ +170 %	-

Table 3. Influence of voltage deviations on induction motor parameters

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