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Wind parks' operation in the context of system adequacy

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Summary: **From the experience of TSOs in whose systems are installed significant wind power, it appears that wind parks (WP) have technical and operational characteristics which significantly differs them from other types of power plants. WP's available power can vary between zero and installed power, depending entirely on meteorological factors and, in particular, on the wind speed. WP production can be predicted only within certain limits, which makes it necessary for TSO to balance in real time the differences between prognosis and actual production, which can be significant. Since the volume of installed power in WP for which are expressed intentions of connection, is much higher than the RTR in the National Energy System (NES), the RTR value is the power limiting criterion. Thus, according to the rules of ANRE, Transelectrica annually establishes the maximum installed power in WP, acceptable in terms of RTR availability existing in NES.**

Index Terms: **Adequacy, dispatchable unit, load degree, power characteristic, loading/unloading, rapid tertiary reserve (RTR), technical permission, wind potential, wind speed**

I. SETTING THE PREDICTED LOAD DEGREE OF WP

Hourly wind electricity prognosis continues to record large errors, which can reach several thousand of MW (maximum positive error was of 3999 MW, in 2004, in Germany, wind generation leader in Europe) [1].

In determining the predicted load degree of the installed WP in a electrical energy system, should consider the following aspects:

- ⇒ Most wind generators have at terminals a voltage of 690 V. Each wind generator is equipped with a step-up transformer, and the links inside the WP are performed, usually, at medium voltage (20 kV). From experience, it resulted that losses in a wind park are approximately of 2.5%.
- ⇒ Backwater effect leads to the decreasing of power of a wind park with approx. 15%.
- ⇒ Wind speed is a size that significantly differs even within the same emplacement.

From the above considerations, it has resulted that the power produced by a WP is always lower than the installed power.

Setting the predicted load degree of the installed WP in NES can be determined through statistical or empirically methods. Statistics experience on the operation of WP in Romania is insignificant. Therefore, estimating the load degree of the installed WP in NES is empirically done. The load degree of the installed WP in NES will be determined by statistical methods when the installed power in wind parks in Romania will allow this.

From the maps showing the wind potential in Romania shows that the wind speed in Romania is of 7-8 m / s.

Based on the power characteristics of the generators in operation in other systems, it is known that wind generators operate when wind speed reaches a certain minimum value of 3 - 5 m / s and does not exceeds the maximum value of 25 - 28 m / s.

Figure 1 shows typical power characteristic considered for a wind generator:

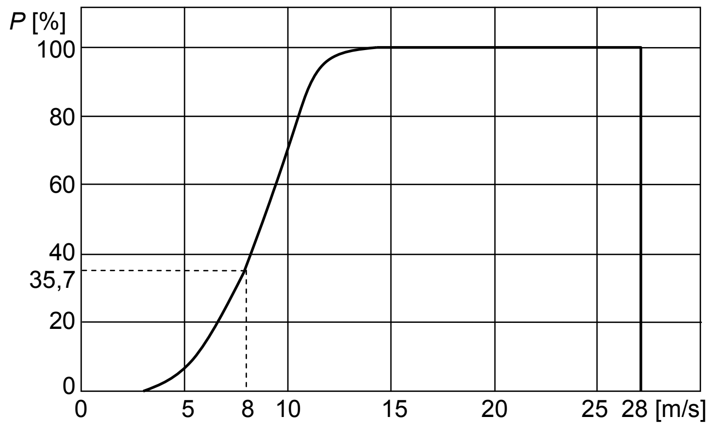

Fig. 1. Power characteristic of a wind generator

Maximum power that can be taken from the energy of air masses is [2]:

$$P_{WA,\max} = \frac{8}{27} \cdot A \cdot \rho \cdot v^3 \qquad (1)$$

where: A – scanned area by the wind generator group paddles;
ρ – air density (ρ_{air} = 1,2 kg/m^3);
v – wind speed.

It results that the available power of a WP is proportional to the air density, wind speed to third power and with scanned area by the generator paddles.

If we consider P_n of a wind generator of 1,000 kW and wind speed at which P_n is reached is of 12 m / s, then the produced power by the wind generator, according to the formula above, when the wind speed is of 8 m / s is of 296 kW, which means 30% of P_n. It results that WPs in Romania will work, on average, with 30% of installed power, as in (2).

$$k_{use} = 0{,}3 \qquad (2)$$

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II. RTR DETERMINATION

For RTR determination at loading, are considered: hydro groups with barrier lakes and moulded reserve of the thermal groups.

To determine RTR at discharging are considered: hydro groups with barrier lakes and thermal groups that do not work with cogeneration, to minimum technical power. At hydro power plants, the minimum technical power is considered 0.

It is determined the scheduled RTR (RTR_{prog}) as being equal to the RTR amount resulted as available in the scheduling process of the previous calendar year. According to the Commercial Code in force, the market participants have the obligation to transmit to the TSO for each common diagram system (h) active available power (P_{disp}), minimum technical power (P_{min}) and physical notification (P_{NF}) for each dispatchable unit. Based on these values the RTR scheduled to increase (RTR_{prog+h}) and RTR scheduled to decrease (RTR_{prog-h}) are determined, by summation of these values, on each time interval, for each i dispatchable unit (n is the number of dispatchable units), as in (3) and (4):

$$RTR_{prog+h} = \sum_{i=1}^{n}\left(\mathrm{P}_{\mathrm{disp}_\mathrm{i}} - \mathrm{P}_{\mathrm{NF}_\mathrm{i}}\right) \quad (3)$$

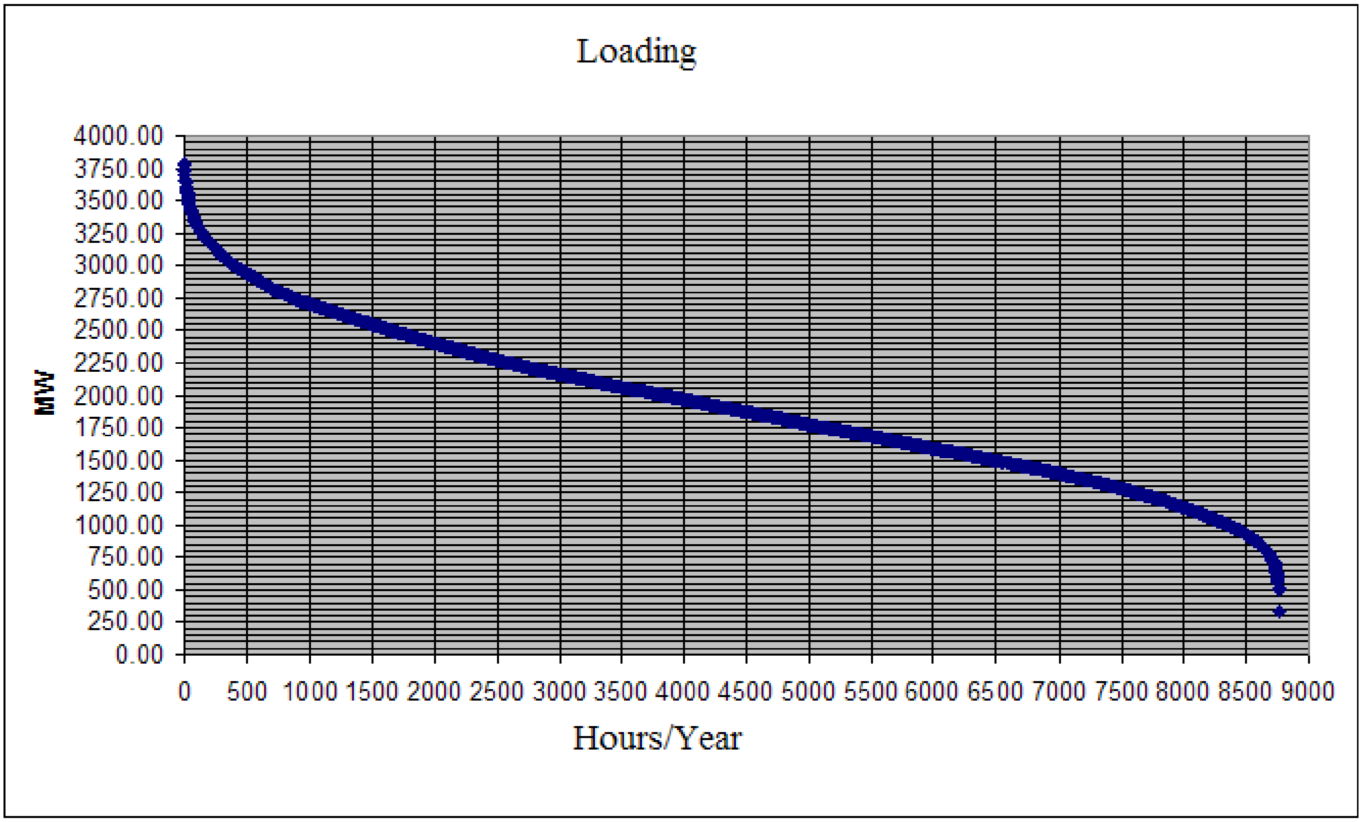
$$RTR_{prog-h} = \sum_{i=1}^{n}\left(\mathrm{P}_{\mathrm{NF}_\mathrm{i}} - P_{\mathrm{min}_i}\right) \quad (4)$$

The ranked curves of the hourly RTR scheduled at loading / unloading for previous year (2007) are shown in figure 2 and figure 3.

Scheduled RTR in NES is established for each h time interval (RTR_{progh}) as being equal to the minimum amount of RTR, at increasing or decreasing, observed in the respectively time interval in the previous calendar year, as in (5).

$$RTR_{progh} = \min\left(RTR_{prog+h}, RTR_{prog-h}\right) \quad (5)$$

The available RTR in NES is established as the maximum amount of RTR, which was available in the NES in the previous year 8322 hours (representing 95% of 8760 hours). It results that the generation park of NES ensures RTR necessary for the operation of WP (which works on average with 30%) in 95% during the year, for 5% of the time being possible the production limitation in WP on the not ensuring the reserve criterion [3].



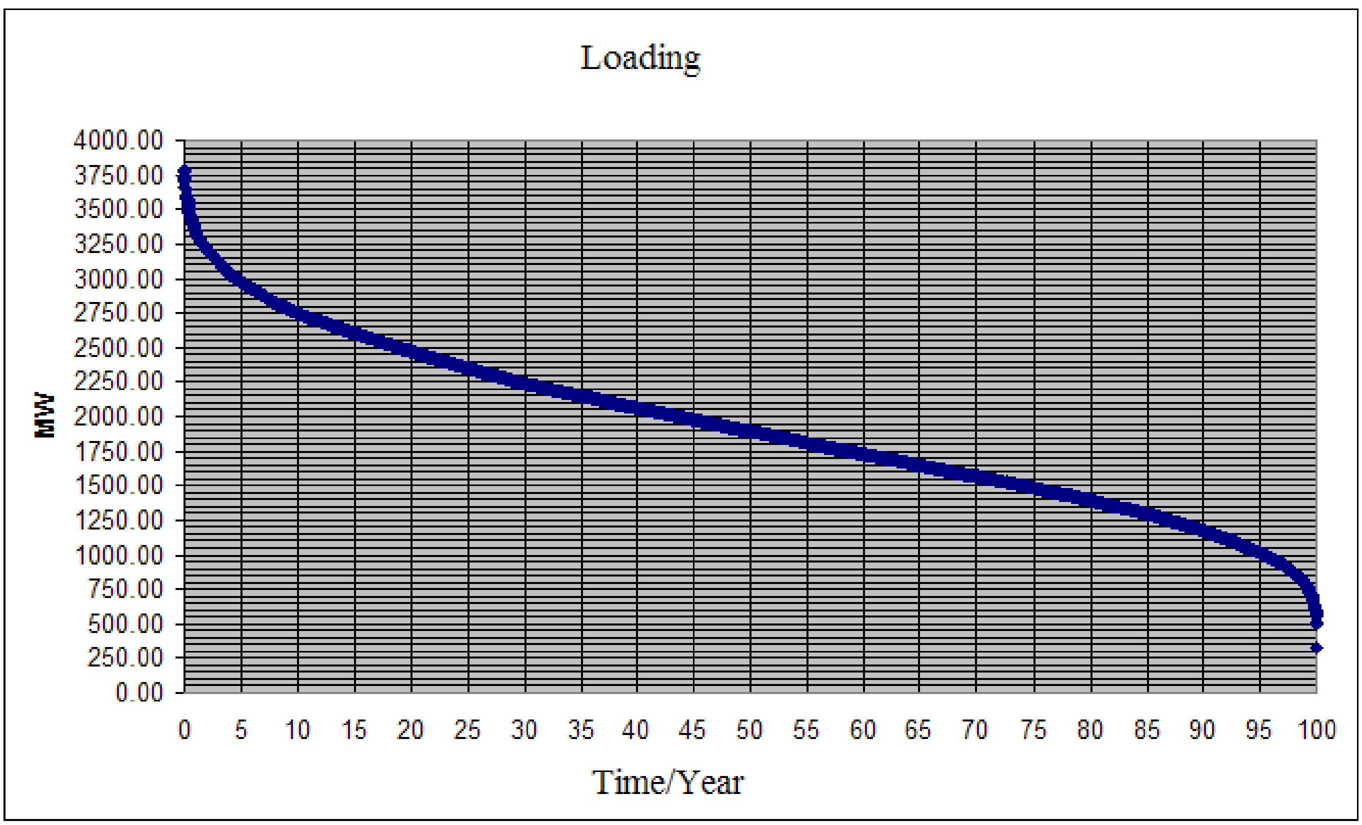


Fig. 2. Ranked curves of hourly RTR values scheduled at loading for previous year (2007)

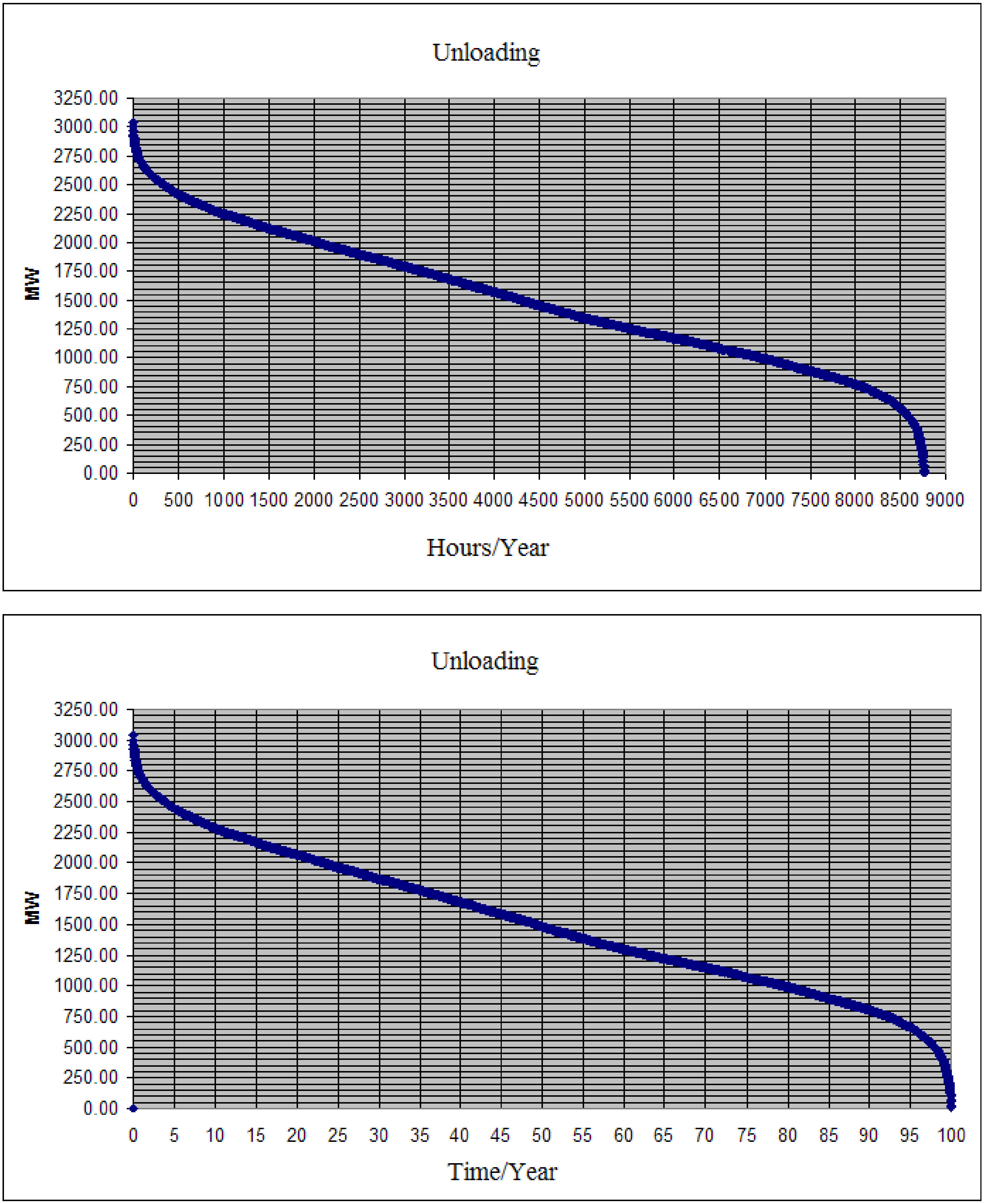


Fig. 3. Ranked curves of hourly RTR values scheduled at unloading for previous year (2007)

III. Setting of the maximum power of the installed WP in NES

Transelectrica annually establishes the maximum installed power in WP, acceptable in terms of availability of rapid tertiary reserve (RTR) existent in NES, as in (6).

$$P_{i\max CEE} = \frac{RTR_{avail}}{k_{use}} \quad (6)$$

RTR is designed to ensure rapid recovery (maximum 15 minutes) of the secondary adjustment reserve, participating in adjusting the frequency and the balance to the direction value.

RTR must cover most power disconnectable almost simultaneously from NES, plus a maximum acceptable vagueness of the consumption prognosis (estimated value). It results that need of RTR in Romania, until the emergence of WP, is of 800 MW (to cover the trigger of a unit at Cernavoda NPP, at which it adds 100 MW for consumption prognosis impreciseness).

WPs in Romania will be grouped on the criterion of common operating mode due to coincidence conditions of wind speed for components wind groups. Each such group will be considered as a equivalent generator group, which will work on average with 30% of installed power. In the event that equivalent generating groups with production higher than the larrgest group in the system will result, they will become the reference for establishing the necessary RTR in the system.

Since the volume of indented installed power in WP is much higher than available RTR in NES, the RTR value is the limitation criterion of the power in WP.

Maximum installed power value in WP for which technical permission can be given, is determined so that the maximum estimated power to be on / off in WP almost cvasi-simultaneously ($P_{simultWP}$) to be able to be compensated by loading / unloading of the available RTR (RTR_{avail}) in NES, as in (7).

$$P_{simultCEE} = RTR_{avail} \quad (7)$$

RTR available in NES is periodically determined, because can suffer changes caused by the structure of the production park and market opportunities.

Since WPP is characterized by a low degree of utilization of installed power (kuse), the simultaneously produced power (estimated to be on / off) in all the WPPs is estimated as a percentage of installed power, which allows installation in NES of a power greater than the permissible one to be in operation at a time [3].

IV. Conclusions

As a result of the specific characteristics of wind generation, it is necessary in the system to be other generators for wind reserve generation, which should allow quick startup and loading up to maximum load and to have at any time sufficient primary resources (fuel or water).

This power reserve is required both in periods when wind generators are in operation (in this case is necessary an available of power that can be quickly started in the event that the wind speed comes out of the utility limits: less than 3.5 m / s to or greater than 30 m / s) and in decreasing, if they do not work (in this case is necessary an available power that can be quickly turned off if the wind speed falls in the utility limits mentioned above).

Since the volume of installed power in WP for which are expressed intentions of connection is much higher than available RTR in NES, the RTR value is the criterion of power limiting in WP. Thus, according to ANRE regulations, TSO annually establishes maximum installed power in WP, acceptable in terms of rapid tertiary reserve availability (RTR) in NES.

In this work were presented the following issues: setting the predicted loading degree of WP, RTR determination and maximum installed power of WP in NES establishing in terms of NES adequacy.

IV. References

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V. Biographies

Simona Oprea graduated from the Polytechnic University of Bucharest, Energetic Faculty in 2001 and Yokohama National University, Infrastructure Management Program in 2007. Her employment experience includes the Romanian Transmission System Operator “Transelectrica” joint stock company. She has been working with Transelectrica since 2002. Her current position is Renewable Integration Project Manager.

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