ASPECTS RELATED TO WIND POWER PLANTS OPERATION IN ROMANIA

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Abstract – The European Union's (EU) vision implies tremendous changes in the power systems. These should contribute to sustainable development and protection of the environment by enabling the EU to achieve its targets of a 20% reduction of greenhouse gas emissions, 20% increase in energy efficiency and 20% of renewable energy in final energy consumption by 2020. Encouraging of the renewable energy sources (RES) by the Romanian Government through different incentives lead since 2007 to a large volume of projects. Nowadays, the installed wind power in Romania is about 1140 MW, most of them (1103 MW) being concentrated in the south-eastern part of the country, called Dobrogea. Taking into account the different specificity of the WPP operation in different countries, based on recorded data in Romania, a couple of analyses have been performed in order to understand and try to better predict it for medium and long term network planning. These analyses were focused on full load hours, average loading of WPP, particularity of operation at night and depending on seasonal conditions, variability of WPP output for short time periods and implications on daily load curve.

Keywords: WPP integration, full load hours, short time variability of WPP, grid reinforcements

1. INTRODUCTION

The EU's energy and climate policy objectives consist in completing the internal market in energy, guaranteeing security of supply, notably for gas and oil, reducing greenhouse gas emissions by 20%, increasing the share of renewable energy in the final energy consumption to 20% and achieving a 20% increase in energy efficiency by 2020.

Romania as one of the State Members has to fulfill its obligations related to EU's targets in terms of RES integration. The incentive support scheme for RES has been enacted by Law no. 220/2008 for establishing the promoting scheme for energy produced out of RES, Law no. 139/2010 (modifying Law 220/2008) and a series of four governmental orders dated November 2011. As a result of the supporting scheme mainly based on green certificates, since 2007, the National Grid Company – Transelectrica, received a large number of applications for connection. Most of them are located in Dobrogea, Moldova and Banat areas as in Fig. 1.

Fig. 1. Areas with large projects in Romania

This concentration of interest from the private investors coincides with the wind potential map as in Fig. 2 [1].

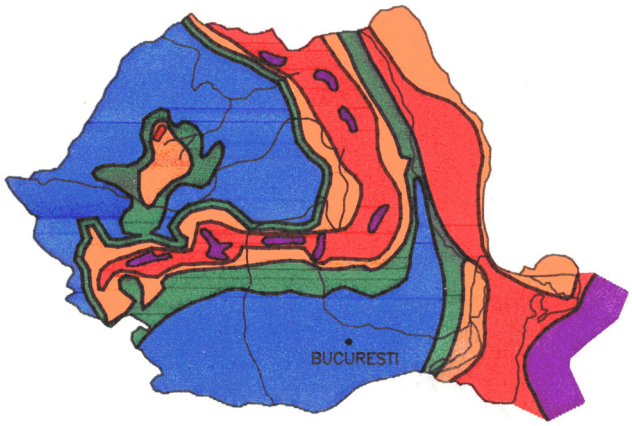


Fig. 2. Wind potential in Romania

Starting from 2010, installed power increased from 13 MW to 400 MW by the end of the year. In 2011, the installed power was almost double (700 MW) compared with the previous year. The first project and most developed one is connected in the new substation 400/110 kV Tariverde.

	Mountain		Off-shore		Coast		Plain		Hills	
	m/s	W/m^2	m/s	W/m^2	m/s	W/m^2	m/s	W/m^2	m/s	W/m^2
	>11,0	>1800	>9,0	>800	>8,5	>700	>7,5	>500	>6,0	>250
	10,0-11,5	1200-1800	8,0-9,0	300-800	7,0-8,0	400-700	6,5-7,5	300-500	5,0-6,0	150-250
	8,5-10,0	700-1200	7,0-8,0	400-600	6,0-7,0	250-400	5,5-8,5	200-300	4,5-5,0;	100-150
	7,0-8,5	400-700	5,5-7,0	200-400	5,0-6,0	150-250	4,5-5,5	100-200	3,0-4,5	50-100
	<7,0	<400	<5,5	<200	<5,0	<150	<4,5	<100	<3,5	<50

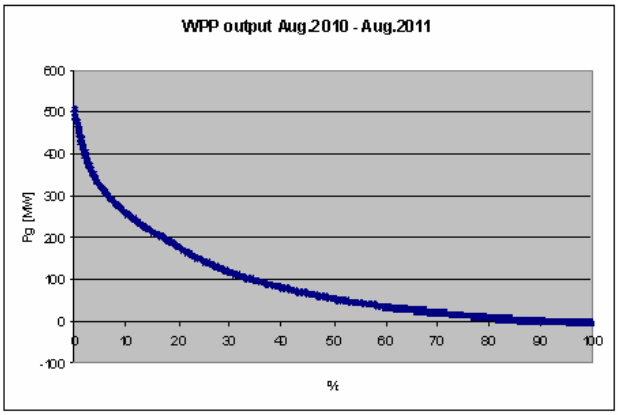
These figures are given in Table 1. Due to the fact that the installing process is very dynamic, the total figures are approximate.

Table 1. Installed power in 2010 and 2011

Interval 2010-2011	Pi Tariverde [MW]	Pi Total [MW]
01.01.2012	**387.5**	**1140**
November 2011	300	780
August 2011	300	563
June 2011	300	518
March 2011	300	518
February 2011	300	424
January 2011	300	424
Total 2011		***About 700***
October 2010	264	322
September 2010	222.5	n.a.
August 2010	166	n.a.
January 2010	0	13
Total 2010		***About 400***

2. FULL LOAD HOURS

Based on the recorded data between August 2010 and August 2011 and between December 2010 and December 2011, two duration curves describe the behaviour of wind generation in these relatively short time intervals as in Fig. 3.



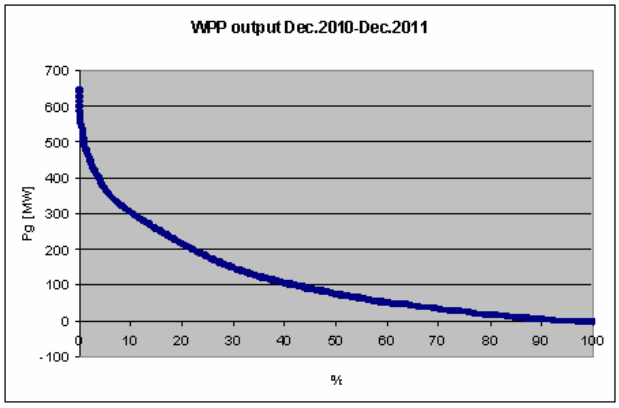


Fig. 3. WPP output in August 2010-2011 and December 2010-2011

Due to the dynamic process of WPP installation, installed power was roughly estimated at different time intervals. Therefore it is difficult to draw very precise conclusions, but roughly in 50% of the time in the first interval, WPP output was less than 55 MW, while in the second interval considered, 50% of the time their output was less than 75 MW. These figures represent less than 10% of the installed power in both intervals (considering 563 MW installed power in the first interval and 800 MW installed power by the beginning of December 2011).

10% of the time WPP output was more than 50% of the installed power in both time intervals. For different percentages of the time, the results are given in Table 2.

Table 2. Full load hours

	First interval		Second interval	
% of the time	**MW**	**% of the Pi**	**MW**	**% of the Pi**
10%	>258	45.83	>303	37.88
30%	>117	20.78	>147	18.38
50%	>55	9.77	>75	9.38
70%	>21	3.73	>31	3.88

3. WPP OUTPUT VARIATIONS

Based on the same recorded data in the interval August 2010 – August 2011, from ten to ten minutes (consisting of almost 52000 data), the maximum variation of WPP output, from moment t to moment t+1, was +180/-214 MW as in Fig. 4.

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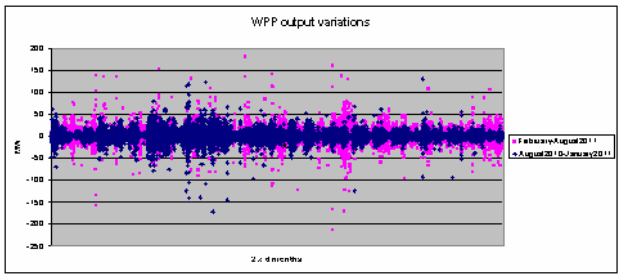


Fig. 4. WPP output variations

It can be easily noticed that in most of the cases variations are concentrated in -50 and +50 interval. Only few values are out of this range.

Tabel 3. WPP output – large variations

Variations more than	dif >50	dif >100	dif>150	dif>200
No. of variations	128	22	3	0
%	0.247	0.042	0.006	0.000
Variations less than	dif<-50	dif<-100	dif<-150	dif<-200
No. of variations	136	18	5	1
%	0.262	0.035	0.010	0.002

Very short term variations of more than -50/+50 MW in ten minutes were recorded in about 0.25% of the total number of 51914 records.

Variations in between +10/-10 MW and +20/-20 MW are much more frequent (8% of the total number of records for variations between +10 and -10 MW, 2,5% of the total number of records for variations between +20 and -20 MW). In other words, small amplitude of variation is more frequent as in Table 4.

Tabel 4. WPP output - Smaller variations

Variations more or less than	dif>10	dif<-10	dif>20	dif<-20
No. of variations	4339	4179	1332	1274
%	8.358	8.050	2.566	2.454

However we need to be aware of the fact that the time interval is not enough to complete this analysis. The obtained results are based on a relatively short time interval, but in the future, more data will be used and the results will be more precise.

The trend of variations in case of the biggest farm, WPP Fantanele+Cogealac is very similar. We expect many variations around +/-20 MW, but cases of variation around +/-100 MW can be found.

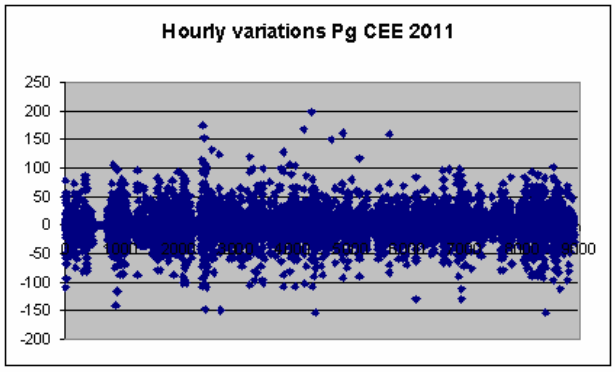


Fig. 5. WPP Fantanele+Cogealac output variations

From other WPP operation in Europe, it could be noticed that if the WPP was spread over a large area, these variations tend to diminish (Fig. 6), due to the fact that wind conditions are slightly different [2].

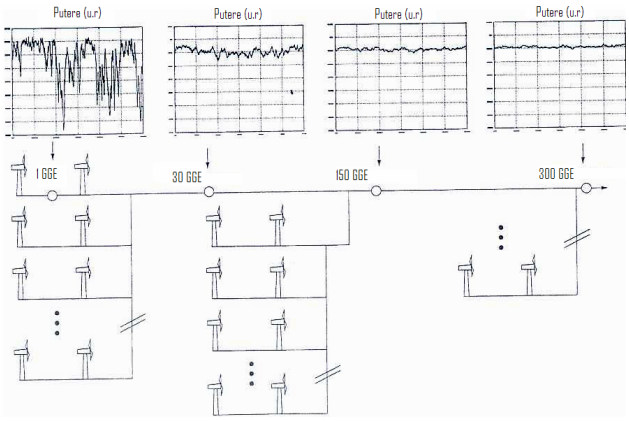


Fig. 6. WPP output for different size of the plant

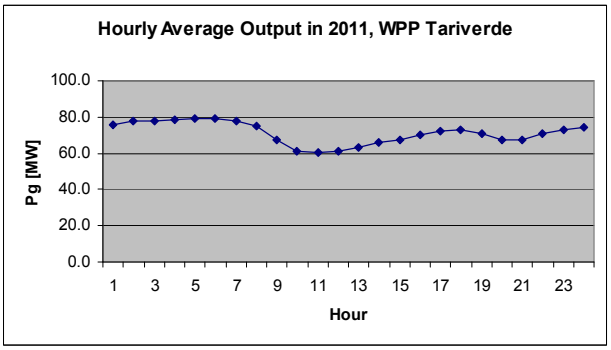
4. HOURLY AVERAGE OUTPUT

WPP Fantanele+Cogealac is the biggest WPP in Romania (located in Dobrogea area). Based on the hourly recorded data provided by OMEPA – Metering Operator, it was found that at the off-peak WPP Fantanele+Cogealac produces more than at peak consumption. Each hourly mean value for WPP Tariverde and total WPP in Dobrogea is given in Tabel 5.

Tabel 5. Average hourly output WPP Fantanele+Cogealac and WPP total in Dobrogea in 2011

Average hour	Average Pg [MW] - Tariverde	Average Pg [MW] - Dobrogea
Average hour 1	75.4	123.76
Average hour 2	78.0	125.02
Average hour 3	78.0	125.27
Average hour 4	78.7	126.09
Average hour 5	79.1	126.37
Average hour 6	79.0	126.70
Average hour 7	78.1	125.69
Average hour 8	74.9	120.31
Average hour 9	67.3	106.92
Average hour 10	61.2	97.83
Average hour 11	60.3	97.25
Average hour 12	61.0	100.03
Average hour 13	63.1	103.51
Average hour 14	65.6	108.52
Average hour 15	67.1	112.64
Average hour 16	70.3	117.42
Average hour 17	72.0	120.69
Average hour 18	73.2	121.43
Average hour 19	70.6	119.66
Average hour 20	67.3	114.82
Average hour 21	67.6	119.56
Average hour 22	70.5	122.74
Average hour 23	72.8	123.24
Average hour 24	74.6	122.44

In both cases (WPP Fantanele+Cogealac and total WPP in Dobrogea), the lowest value was recorded at 11 a.m., while the highest value was recorded at 5 a.m. for WPP Fantanele+Cogealac and 6 a.m. for total WPP in Dobrogea. Comparing mean WPP Fantanele+Cogealac output values with a randomly chosen daily load curve [3], it is obvious that wind blows more at night and the daily generation curve of wind farmas increases stress on system operation as in Fig. 7.



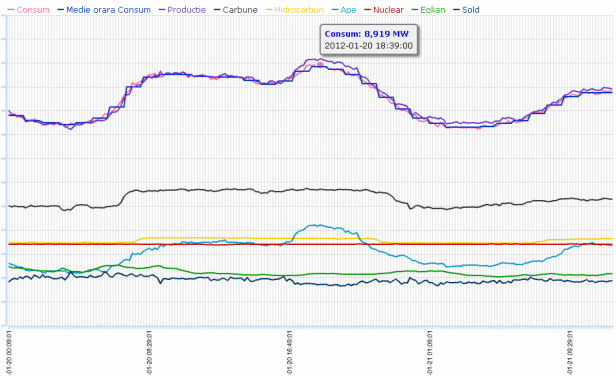


Fig. 7. Hourly average output WPP Fantanele+Cogealac and daily load curve

If we consider all WPP from Dobrogea area, the trend is similar, only the average is higher as in Fig. 8.

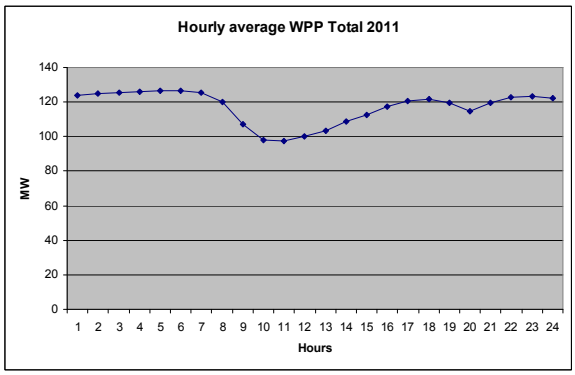
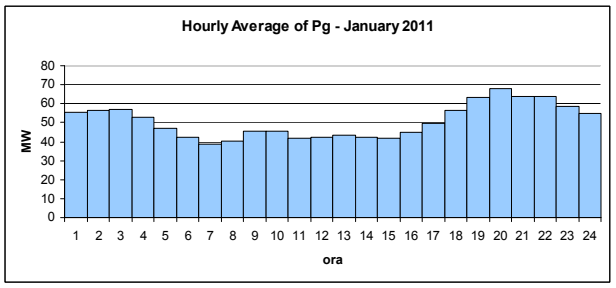
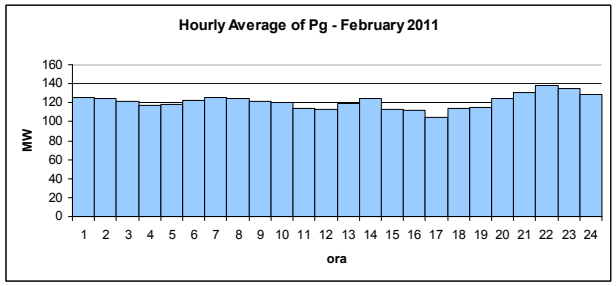
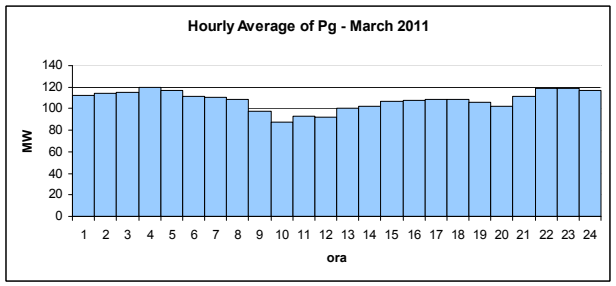


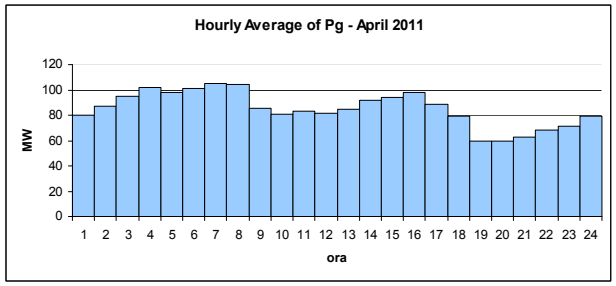
Fig. 8. Hourly average output of WPP in Dobrogea area

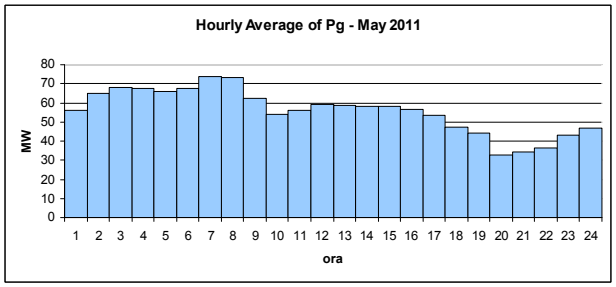
This trend of the wind behaviour is confirmed on monthly basis as in Fig 9. It can be noticed that summer months were less windy in 2011. In February and March mean output values were the highest and more constant compared with the rest of the year.

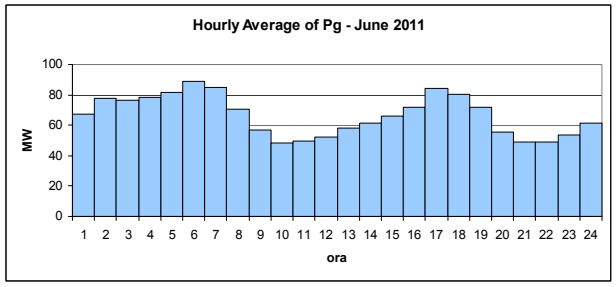












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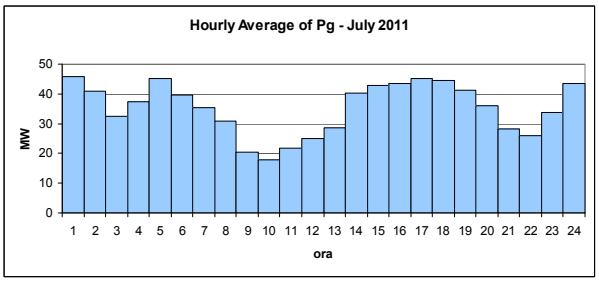

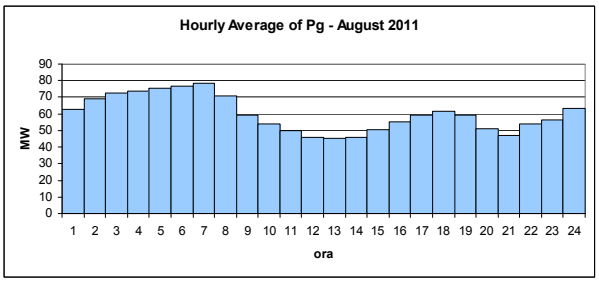

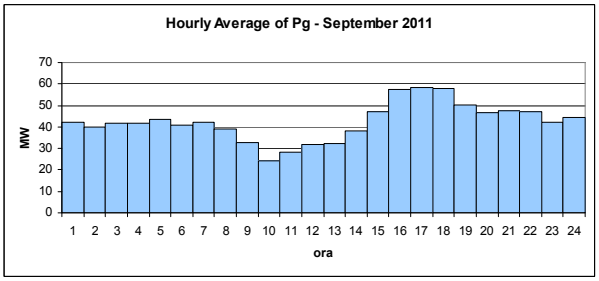

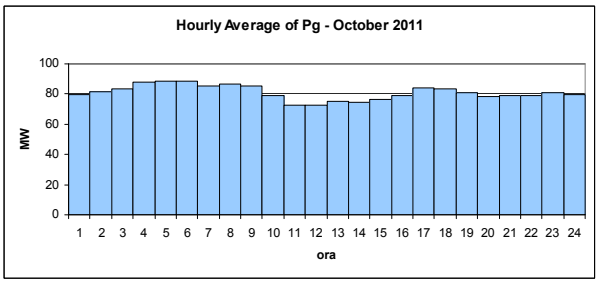

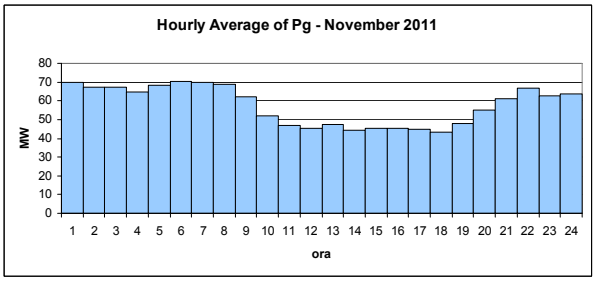

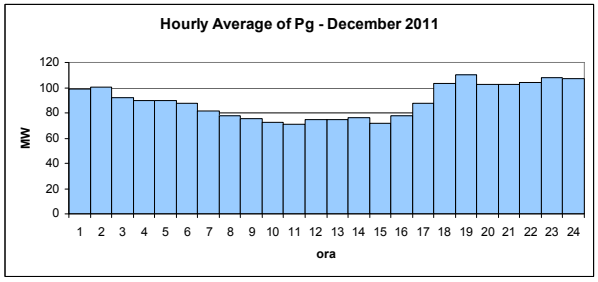

Fig. 9. Monthly Pg hour by hour

Daily variation between generation of WPP Fantanele+Cogealac at night minimum load hour and next day maximum load hour was also anaysed.

Duration curve of this variations (fig.10) show that in 10% of cases the increase of generation from night to day is more than 30% of the installed power.

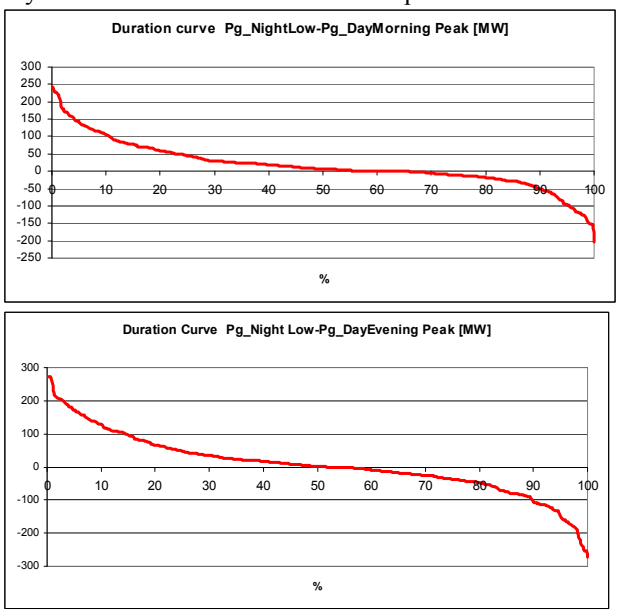

Fig.10. daily variation between generation of WPP Fantanele+Cogealac at night minimum load hour and next day (morning/evening peak load hour)

This situation is indicative on the necessary supplementary flexibility of the rest of the generation park needed to accommodate increased wind generation in the system.

It should be further studied, when enough data shall be available, the degree of correlation between generation in one farm and total generation in a neighboring area and in the whole system.

5. CONCLUSIONS

Taking into consideration the amount of connection requests, the grids must be urgently extended and upgraded, including through electricity highways, to foster market integration and maintain the existing levels of system's security, but especially to transport and ***balance*** electricity generated from renewable sources, which is expected to more than double in the period 2007-2020. At the same time, reaching the EU's 2020 energy efficiency and renewable energy targets will not be possible without WPP integration.

It is very important to know the particularities of WPP operation in a specific area in Romania. Based on the recorded data over a relatively short time interval, the results of a few analyses have been shown in this paper. Main conclusions are:

- 10% of the time WPP output was more than 50% of the installed power;
- the maximum variation of WPP output, in ten minutes, was +180/-214 MW

- in most of the cases variations are concentrated in -50 and +50 interval and only few values are out of this range;
- variations in between +10/-10 MW and +20/-20 MW are much more frequent;
- wind blows more at night increasing stress on the system operation;
- in 10% of cases the increase of generation of awind farm from night to day is more than 30% of the installed power
- summer months were less windy in 2011;
- in February and March mean output values were the highest and more constant compared with the rest of the year.

More data will be used and the results will be more precise.

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