# THE IMPACT OF THE CONSUMPTION FORECAST ON VARIATION OF THE BAND OF REGULATION IN TERMS OF DEVELOPING THE WIND ENERGY MARKET

NEAGU A.
National Dispatch Center, CNTEE Transelectrica SA
Alina.Neagu@transelectrica.ro

**Abstract – At the National Dispatch Center (NDC) one of the parameter monitored daily is RM (the Average Regulation) that can be defined shortly as being an hourly average error. This average regulation is particular to the secondary regulation band and it has to fit between ± 20 MW. Because the RM has to have the values between the limits (inferior and superior) mentioned above, this becomes a factor of evaluation of the activity of the chief dispatcher.**

**In the paper it is analyzed how the consumption forecast can influence the RM. Will be considered the contribution brought by the wind farms on system functioning and, more precisely, it is being studied the effect that it has the wind power forecast in what concerns dispatching in safe conditions of the National Power System.**

**Keywords:** average regulation (RM), secondary regulation band, load forecast, forecast of the wind power production.

## 1. INTRODUCTION

Factors as the liberalization of the Energy Market in 2005, the accession of Romania at the Europe Union (EU) at January 1st 2007 helped to a strongly development of the National Power System and, in the same time, to the growth of the economic and social level of Romania. The accession of Romania to EU implied assimilating certain principles and implementing some development projects on medium and long periods of time. Thus, according to "Energy – Climate changes" settled by EU for 2020, Romania and the National Power System implicitly, must insure a growth with 20% of the renewable energy share in the total energy production nationally.

Since always, the operative management of the National Power System represented a basis activity and a very important one in what concerns the safety and the continuity of supply the consumers with electric energy. However, amid new challenges appeared as a result of the accelerated development of the society and because of the high requirements of the people, this activity of operative management of an energetic system became increasingly complex and complicated.

In Romania, National Dispatch Center is responsible of the operative and operational management of the National Power System. Among the attributions of the NDC we can include: the control of the power flows in the electric grid, the management of the capacities on the interconnections lines, the compliance of the criteria "N-1" of safe functioning of the National Power System, the scheduled energy generation for the next day and, not least, operating the system in real time. [1]

Speaking administratively, in NDC we find the Central Dispatch Center (CDC), represented by the chief dispatcher and the power dispatcher that have to operate in real time the system to ensure a safe and correct functioning of the National Power System.

Because NDC is an interconnected system, within it must be maintained the frequency between the limits that are imposed by ENTSO-E (European Network of Transmission System Operators for Electricity). For this, within NDC there is the central controller of frequency that has the role of maintaining the frequency and the power on the interconnection lines at the programmed values. [2]

## 2. DEFINITION OF THE AVERAGE REGULATION (RM)

The power systems work interconnected, which implies maintaining the balance between the production and the consumption of electric energy at a programmed frequency and respecting the schedule of the cross-border exchanges on the interconnection lines.

Maintaining the frequency at the reference value is made through the regulations of a power system (primary regulation, secondary regulation, tertiary regulation), more precisely through the modification of the power generated by the electric generators. For monitoring the system performances in what concerns maintaining the frequency between the established limits, it is used an indicator like error signal which is called ACE (Aria Control Error) and has the next formula [2]:

$$ACE = \Delta P_{sch} + K \cdot \Delta f \qquad (1)$$

where: $\Delta P_{sch}$ – the cross-border exchanges;
K – balancing factor;
$\Delta f$ – frequency deviation.

While for ΔPsch and for Δf are registered values per second, the balancing factor K has a fixed value that for

2012, for Romania, is 534 MW/Hz. The working group "System Frequency" from ENTSO-E is responsible for calculating the value of the K factor, value that is valid a year and it is characteristic to only one country. For calculating the balancing factor is taken into account the annually average consumption from the last year. For example, the value of 534 MW/Hz for 2012 it was obtained considering the average value of the consumption in 2010.

The integral on an hour of the average value of the ACE in that hour represents the so called hourly average error, symbolized by RM (average regulation). The RM values must fall between ± 20 MW (limits that are established after system calculations), and the exceeding of these limits marks the fact that, within the National Power System, it couldn't be maintained the secondary regulation band at an optimum level.

## 3. THE INFLUENCE OF THE LOAD FORECAST ON RM

The realization of the load forecast in the National Power System helps, on one side, to program the hourly needed power for the next day and to determine the variation of the prices on the Energy Market [3], and on the other side, by forecasting the energy consumption is intended to simplify and to improve the activity of the chief dispatcher.

Performing a load forecast is made taking into account the next aspects:

- ✓ The average temperature of the forecasted day;
- ✓ The nebulosity level of the forecasted day;
- ✓ The type of the day;
- ✓ The religious character of the forecasted day;
- ✓ The operational structures of the National Power System in the forecasted day (switch on/switch off the big consumers that can influence the variation of the consumption).

As we mentioned, RM can become a parameter in the dispatching activity at NDC, activity that wants to be facilitated through the realization of good load forecast, close to what happens in reality. In this paper is wanted to highlight the connection between RM and the load forecast, or better said the influence that the load forecast has it on RM.

Thus, there are situations when RM exceeds either the superior limit or the inferior limit, and the load forecast is similar to reality.

### 3.1. Case study

- December 16th 2011

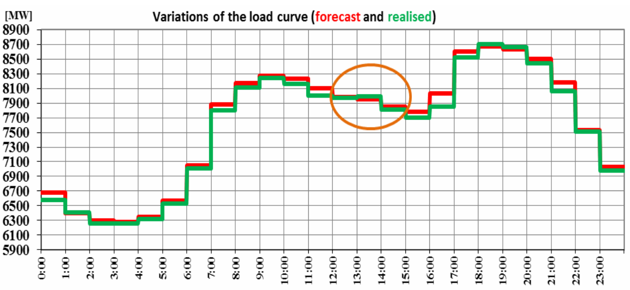


**Fig. 1 - Chart of the load curves (forecast and realized) from 12.16.2011**

In table 1 are presented the recorded values for the energy consumption (forecast and realized) and for RM from December 16th 2011.

**Table 1 - Recorded values**

| Time interval | NDC Consumption forecast [MW] | Realized consumption [MW ] | RM [MW] |
|---|---|---|---|
| 1 | 6680 | 6575 | **6.2** |
| 2 | 6400 | 6411 | **-9.4** |
| 3 | 6300 | 6260 | **-8.5** |
| 4 | 6280 | 6257 | **-29.5** |
| 5 | 6350 | 6320 | **5.9** |
| 6 | 6570 | 6532 | **-11.4** |
| 7 | 7050 | 7008 | **-17** |
| 8 | 7880 | 7802 | **-11.9** |
| 9 | 8170 | 8112 | **-8.8** |
| 10 | 8270 | 8241 | **-19.7** |
| 11 | 8230 | 8159 | **9** |
| 12 | 8100 | 7998 | **-9.2** |
| 13 | 7980 | 7967 | **2.1** |
| 14 | 7950 | 7990 | **-19.1** |
| 15 | 7850 | 7807 | **-28.8** |
| 16 | 7780 | 7701 | **-5** |
| 17 | 8030 | 7850 | **-7.7** |
| 18 | 8600 | 8528 | **1.2** |
| 19 | 8670 | 8701 | **0.3** |
| 20 | 8630 | 8668 | **-5.5** |
| 21 | 8500 | 8447 | **10.6** |
| 22 | 8180 | 8064 | **-24.8** |
| 23 | 7530 | 7506 | **8.8** |
| 24 | 7030 | 6982 | **15.9** |

- January 10th 2012

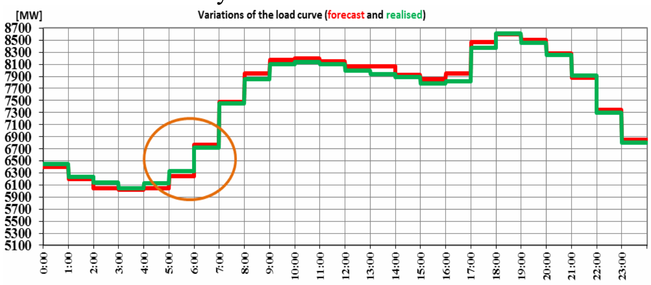


**Fig. 2 - Chart of the load curves (forecast and realized) from 01.10.2012**

**Table 2 - Recorded values**

| Time interval | NDC Consumption forecast [MW] | Realized consumption [MW ] | RM [MW] |
|---|---|---|---|
| 1 | 6400 | 6448 | **3.2** |
| 2 | 6200 | 6232 | **-1.2** |
| 3 | 6050 | 6142 | **-64.2** |
| 4 | 6020 | 6039 | **-11.8** |
| 5 | 6050 | 6124 | **-27.2** |
| 6 | 6250 | 6323 | **-21.6** |
| 7 | 6770 | 6718 | **-24.1** |
| 8 | 7470 | 7450 | **-3** |
| 9 | 7950 | 7849 | **-0.5** |
| 10 | 8170 | 8096 | **-0.6** |
| 11 | 8200 | 8134 | **-11.8** |
| 12 | 8150 | 8100 | **4.6** |
| 13 | 8070 | 7998 | **-7** |
| 14 | 8070 | 7933 | **10.3** |
| 15 | 7930 | 7890 | **-7.4** |
| 16 | 7850 | 7783 | **1.4** |
| 17 | 7950 | 7812 | **-7.3** |
| 18 | 8470 | 8377 | **-2.4** |
| 19 | 8600 | 8609 | **-2.4** |
| 20 | 8500 | 8457 | **2.6** |
| 21 | 8280 | 8259 | **0.3** |
| 22 | 7880 | 7912 | **8.8** |
| 23 | 7350 | 7302 | **11.3** |
| 24 | 6850 | 6801 | **-31.1** |


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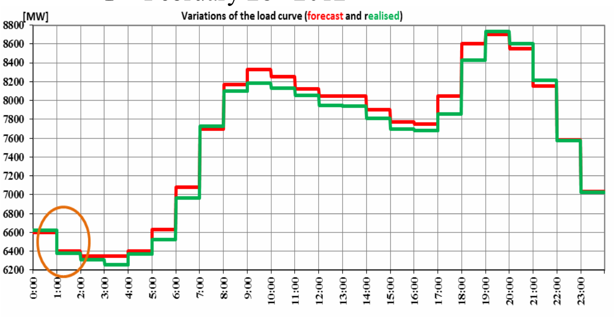

**Fig. 3 - Chart of the load curves (forecast and realized) from 02.28.2012**

**Table 3 - Recorded values**

| Time interval | NDC Consumption forecast [MW] | Realized consumption [MW ] | RM [MW] |
|---|---|---|---|
| 1 | 6600 | 6623 | **74,5** |
| 2 | 6400 | 6382 | **-34,4** |
| 3 | 6350 | 6310 | **10,1** |
| 4 | 6350 | 6253 | **-5,4** |
| 5 | 6400 | 6374 | **-30,7** |
| 6 | 6630 | 6527 | **-1,5** |
| 7 | 7080 | 6965 | **-11,9** |
| 8 | 7700 | 7729 | **1,4** |
| 9 | 8170 | 8097 | **-0,9** |
| 10 | 8330 | 8180 | **12,8** |
| 11 | 8250 | 8128 | **-13** |
| 12 | 8120 | 8053 | **4,8** |
| 13 | 8050 | 7947 | **10,4** |
| 14 | 8050 | 7938 | **-7,9** |
| 15 | 7900 | 7808 | **0,1** |
| 16 | 7770 | 7697 | **2,8** |
| 17 | 7750 | 7680 | **-5,2** |
| 18 | 8050 | 7853 | **-10,6** |
| 19 | 8600 | 8425 | **10,2** |
| 20 | 8700 | 8732 | **2,6** |
| 21 | 8550 | 8602 | **-6,7** |
| 22 | 8150 | 8218 | **1,4** |
| 23 | 7580 | 7573 | **-4,3** |
| 24 | 7030 | 7028 | **-20,7** |

### 3.2. Observations

Studying the influence that the load forecast has it on RM, has been noted that the situations in which RM is exceeded are either those in which exist considerable differences between the forecast and the realized consumption, or those in which the differences between the two curves are not so high, but the curves are crossing each other.

When big differences appear between the forecast and the realized energy consumption (due, for example, to a surplus of power in the system), the RM values are influenced and can exceed the imposed limits. The surplus of power appears when the realized consumption of energy is smaller than the forecasted consumption of energy. A particularity of the RM exceeding is that it happens, usually, at night when is the "off-peak hours" (the consumption of energy has the smallest values). On the "off-peak hours", most of the power plants, which can realize the regulation in the National Power System, function at the power of minimum technical and on them it cannot operate on the downside of the generated power, for bringing the production at the consumption level. The power produced additionally in those hours must be consumed because there are no energy storage devices with large capacity in our country. So, this power must be exported. Therefore, appears a modification of the balance on the cross-border interconnections that leads automatically to variations of the secondary regulation band

More difficult is the situation when the load curves (forecast and realized) are crossing each other (there are successive passages above or below of a curve compared with the other), the numerical differences between the two curves being small. The activity of the chief dispatcher is being made harder on that hour because he must increase and decrease successively the same power generator so he can maintain the production at the consumption level.

Given the last observation, in the study case, from the previously subparagraph, there were presented the days when it was reached a similar situation (the curves are crossing each other and by default the RM is exceeded).

## 4. THE INFLUENCE OF THE WIND POWER GENERATION ON RM

According to the European Union standards concerning the renewable energy in an electric power system, by 2020 each EU country member must produce at least 20% from the total needed power to cover the energy consumption in renewable sources. Therefore, in Romania have appeared many projects of developing the renewable sources of energy, most projects aiming the wind power.

Nowadays, the power installed in wind farms in Romania is 1140 MW. As a percentage, the highest value recorded was of about 10% from the total produced energy in the National Power System (the daily average value was 620 MW, and on an hourly interval was recorded in SCADA about 1000 MW).

The power obtained by wind sources is a priority power, defined in "Regulation from 12-13-2006 for qualification the priority production of electric energy from renewable sources" published in Official Journal, no. 1041, first part, from 12-28-2006 by the National Authority for Energy Regulation, as a uncontrollable priority production, meaning that it cannot be managed in an active way by the producer so it can be ensure the compliance with the contractual obligations notified. [4]

In the study case below was shown how RM was exceeded in days that the wind production was high, but the error between the forecast and the realized consumption was small.

### 4.1. Case study

December 23th 2011

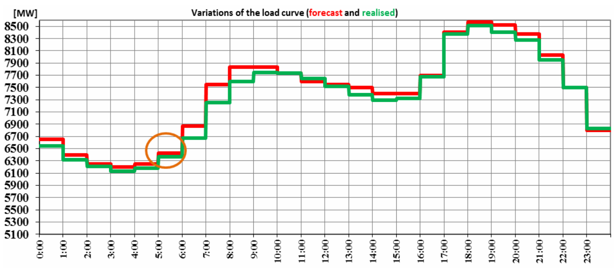

**Fig. 4 - Chart of the load curves (forecast and realized) from 12.23.2011**

In table 4 are presented the recorded values for the energy consumption (forecast and realized), for RM and the recorded values of the wind generation from December 23th 2011.

**Table 4 - Recorded values**

| Time interval | NDC Consumption forecast [MW] | Realized consumption [MW ] | Wind power production [MW] | RM [MW] |
|---|---|---|---|---|
| 1 | 6650 | 6543 | 559 | **14.5** |
| 2 | 6400 | 6319 | 561 | **11.7** |
| 3 | 6250 | 6211 | 515 | **2.6** |
| 4 | 6200 | 6132 | 532 | **5.3** |
| 5 | 6250 | 6177 | 517 | **-5.7** |
| 6 | 6430 | 6364 | 539 | **-88.2** |
| 7 | 6870 | 6670 | 563 | **-12.6** |
| 8 | 7550 | 7257 | 575 | **0.1** |
| 9 | 7830 | 7601 | 500 | **-6.3** |
| 10 | 7830 | 7749 | 467 | **-3.1** |
| 11 | 7730 | 7732 | 476 | **1.9** |
| 12 | 7600 | 7650 | 558 | **-9.2** |
| 13 | 7550 | 7522 | 617 | **3.3** |
| 14 | 7500 | 7384 | 600 | **-0.6** |
| 15 | 7400 | 7290 | 581 | **-3.1** |
| 16 | 7400 | 7323 | 624 | **-0.4** |
| 17 | 7700 | 7674 | 587 | **-4.8** |
| 18 | 8400 | 8373 | 606 | **-4** |
| 19 | 8570 | 8517 | 516 | **-6.6** |
| 20 | 8520 | 8408 | 432 | **-3.4** |
| 21 | 8370 | 8278 | 434 | **6.4** |
| 22 | 8030 | 7948 | 418 | **2.9** |
| 23 | 7500 | 7494 | 356 | **10** |
| 24 | 6800 | 6825 | 380 | **5.5** |

To visualize better the situation of the renewable sources from that day, in the next chart is outlined the wind generation curves (forecast production and realized production).

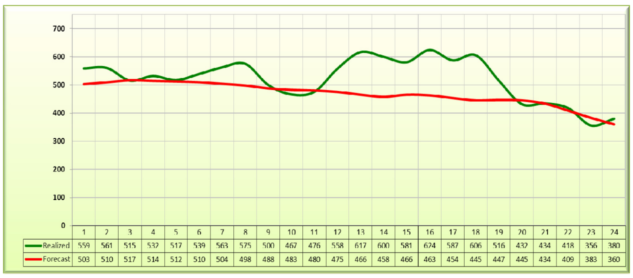

**Fig. 5 - Chart of the wind generation (forecast production and realized production) from 12.23.2011**

- January 31st 2012

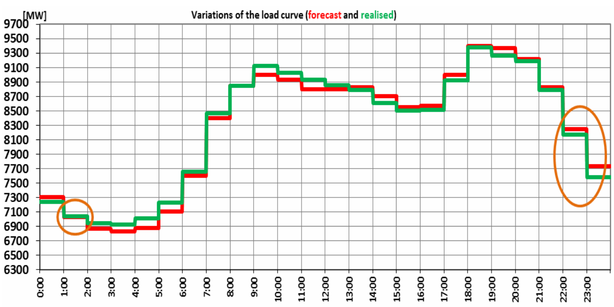


**Fig. 6 - Chart of the load curves (forecast and realized) from 01.31.2012**

**Table 5 - Recorded values**

| Time interval | NDC Consumption forecast [MW] | Realized consumption [MW ] | Wind power production [MW] | RM [MW] |
|---|---|---|---|---|
| 1 | 7300 | 7242 | 655 | **-7.8** |
| 2 | 7030 | 7034 | 643 | **-26.6** |
| 3 | 6870 | 6945 | 643 | **10.3** |
| 4 | 6830 | 6926 | 635 | **-9.4** |
| 5 | 6880 | 7006 | 636 | **-14.2** |
| 6 | 7100 | 7231 | 655 | **-18** |
| 7 | 7600 | 7657 | 661 | **4.4** |
| 8 | 8400 | 8466 | 651 | **-0.3** |
| 9 | 8850 | 8842 | 659 | **3.5** |
| 10 | 9000 | 9119 | 647 | **-3** |
| 11 | 8930 | 9030 | 613 | **-1** |
| 12 | 8800 | 8930 | 607 | **2.2** |
| 13 | 8800 | 8857 | 588 | **-1.9** |
| 14 | 8830 | 8787 | 568 | **0.4** |
| 15 | 8700 | 8608 | 551 | **-3** |
| 16 | 8550 | 8505 | 557 | **-15.8** |
| 17 | 8570 | 8509 | 588 | **-7.9** |
| 18 | 9000 | 8921 | 618 | **-10** |
| 19 | 9400 | 9384 | 599 | **7.8** |
| 20 | 9370 | 9267 | 592 | **0.7** |
| 21 | 9220 | 9193 | 571 | **0.1** |
| 22 | 8830 | 8790 | 580 | **-16.7** |
| 23 | 8250 | 8170 | 578 | **-23.8** |
| 24 | 7730 | 7576 | 581 | **-21.8** |

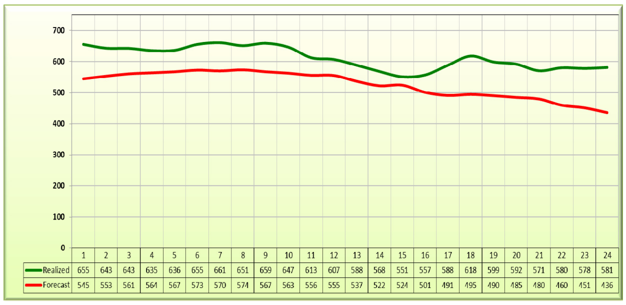

**Fig. 7 - Chart of the wind generation (forecast production and realized production) from 01.31.2012**

- January 25th 2012

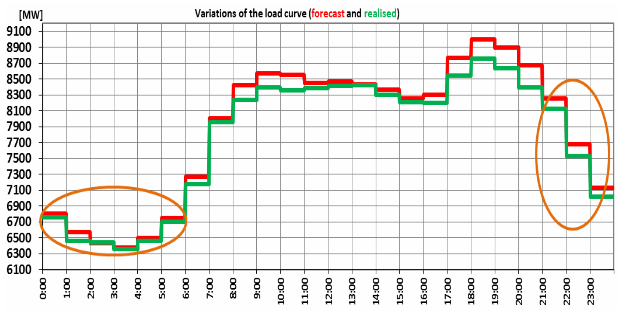


**Fig. 8 - Chart of the load curves (forecast and realized) from 01.25.2012**


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**Table 6 - Recorded values**

| Time interval | NDC Consumption forecast [MW] | Realized consumption [MW ] | Wind power production [MW] | RM [MW] |
|---|---|---|---|---|
| 1 | 6800 | 6760 | 664 | **-235.6** |
| 2 | 6570 | 6464 | 653 | **-41.3** |
| 3 | 6430 | 6438 | 660 | **-135.4** |
| 4 | 6380 | 6359 | 676 | **-40.7** |
| 5 | 6500 | 6463 | 659 | **-203.1** |
| 6 | 6750 | 6706 | 663 | **-24** |
| 7 | 7270 | 7174 | 681 | **3.3** |
| 8 | 8000 | 7960 | 713 | **1.1** |
| 9 | 8420 | 8234 | 713 | **1.3** |
| 10 | 8570 | 8395 | 708 | **1.6** |
| 11 | 8550 | 8355 | 724 | **-3.7** |
| 12 | 8450 | 8388 | 792 | **-1** |
| 13 | 8470 | 8416 | 801 | **0.3** |
| 14 | 8430 | 8419 | 810 | **-6.2** |
| 15 | 8370 | 8297 | 817 | **-10.2** |
| 16 | 8250 | 8207 | 817 | **-12.8** |
| 17 | 8300 | 8202 | 817 | **-9.1** |
| 18 | 8770 | 8539 | 817 | **-5.6** |
| 19 | 9000 | 8754 | 803 | **-0.7** |
| 20 | 8900 | 8637 | 803 | **9.3** |
| 21 | 8670 | 8397 | 800 | **4.9** |
| 22 | 8250 | 8120 | 804 | **-23.6** |
| 23 | 7680 | 7532 | 802 | **-122.3** |
| 24 | 7130 | 7021 | 805 | **-401.2** |

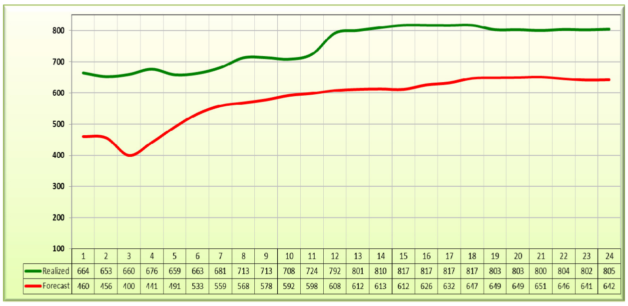


**Fig. 9 - Chart of the wind generation (forecast production and realized production) from 01.25.2012**

## 4.2. Observations

Analyzing the days in which RM was exceeded and there weren't observed situations like those mentioned in the previous paragraph, was noted that the functioning of the wind farms influences the variation of the secondary regulation band. The explication is that, because of the priority character that it has the wind power, this must be taken in the transmission grid before other types of produced energy, the compensation for this power being done using the other generators that are in the list of generator units that can make secondary regulation or fast tertiary regulation. The problem that appears is that, for our electric power system, the secondary regulation band consists, almost equal, both in thermo units whose functioning is slow down by the high start time, and in hydro units that are characterized by a fast load variation at the increasing or decreasing the power at generators. If, in what concerns the thermo units, the difficulty appears because of the high start time, at the hydro units it can be mentioned two special situations:

- ✓ The situation when the hydraulicity is reduced and so, there is no regulation reserve. Practically, at some point, the wind farms begin to function (the wind speed has grown sufficiently to produce energy) and the dispatcher has to compensate that power through the decreasing of the production in other zones, at other power generators. Most commonly used for these kinds of actions are the hydro units, but in this situation is not possible because the reservoirs are empty. Appear modifications of the balance and automatically variations of the programed values (power on the interconnection and frequency) that are registered in the central controller of frequency, whose final result is the exceeded of RM.
- ✓ The situation when the hydraulicity is increased may lead to a violation of the current standards that aims the production of energy from hydro sources which is considered an energy produced from renewable sources. Same as the previous case, at some point of time the wind farms begin to function and the dispatcher has to compensate this power. The thermo units have a high start time and therefore, they usually are not disconnected. If it would operate on the hydro units, it would mean that is necessary to reduce the production on hydro plants. This fact can be realized only by spilling the water, meaning that the renewable sources are being wasted.

In what concerns the fast tertiary regulation band, the problem concerns the fact that the increase of the power generator unit must be done with 15 minutes before the actual time interval. These 15 minutes, most of the times, are big enough to not be able to compensate the quantity of wind power produced and entered in the transmission grid.

Also, another reason why appear RM exceeds is the wind production forecast, more exactly the notified values send by the producers at NDC. The dispatchers encounter often with the situation in which the wind production notifications are smaller than the realized of wind production.

## 5. CONCLUSIONS

The maintaining and the safety functioning of the consumers is the main goal for which the power systems are developing continuously by using the most modern and the most efficient devices. The National Power System is managed operative and operational by the National Dispatch Center, where the chief dispatcher and the power dispatcher are those who monitor the good functioning of the system.

According with the analyze that has been made in this paper, we have reached to the conclusion that it is very useful both for facilitating the dispatcher activity and for obtaining correct results, that the load forecast must have a similar allure with the realized consumption (it must be avoid the situations in which there are interconnections between the two curves).

Nowadays we must take into consideration the impact that the wind power has it on the system, aspect that it was treated in this paper. The conclusion we have reached was that, because of the priority character of the wind power, this must be taken into the grid before other types of produced energy, and this situation, mostly, makes harder the activity of the dispatcher. It is very important that the producers of wind power to provide to NDC better forecasts of wind production, so that the differences between the forecast and the realized wind production decrease.

All of these exceeds of RM that appear when the central controller of frequency registers changes of the programmed values of the frequency and of the power on the interconnections, mean costs that the Transmission and System Operator – Transelectrica must incurs. In terms of the Commercial Code of the Energy Market, in the National Power System there is a BRP (Balance Responsible Party) which is called "Transelectrica – Inadvertent Deviations" which is responsible for the modifications of the power on the interconnection lines. These modifications are known as imbalances and they can be positives (when BRP "Transelectrica – Inadvertent Deviations" wins money because, inside this BRP was produced an surplus of power which was sold on the Day-Ahead Market) or negatives (when BRP "Transelectrica – Inadvertent Deviations" loses money because, inside this BRP was produced a power smaller than the notified power and so, the difference was bought from the Day-Ahead Market, to can honor the agreements closed with others BRP).

## REFERNCES


[1]. Constantinescu, J. – Unbundling power system operations and services, Ed. ROENP, Bucure□ti, 2011

[2]. Eremia, M., Bulac, C. – Dinamica sistemelor electroenergetice, Ed. Tehnică, București, 2000

[3]. Neagu, A. – The forecast of the gross energy consumption using artificial neural networks, MPS, Cluj, 2011

[4]. Official Journal no. 1041 F$^{\underline{ist}}$ part from 12-28-2006



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