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INFLUENCE OF RENEWABLE SOURCES ON ROMANIAN POWER SYSTEM

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Fast development and integration of renewable sources (such as wind power plants and photovoltaic power plants) has implied significant changes in power system operation. Wind power plants are located into the areas with optimal wind speed, while photovoltaic power plants are located in areas with optimal solar radiation. The location and behavior of these green sources influence the electrical power system behavior. The main purpose of this paper is to show the influence of renewable sources on transmission power system. The Romanian Power System model, with renewable sources implemented, was used for operation scenarios.

Keywords: renewable source, power system, influence, congestion

1. Introduction

One of the main concerns of European countries until 2020 is to accomplish the UE target regarding the renewable sources (RES) [1]. In this context, by the end of 2012, according to [2] 109581 MW were installed in wind power plants (WPPs) across Europe, while at global level the WPPs installed power has reached 282587 MW according to [3]. Photovoltaic power plants (PVPPs) installed power according to [4] has reached 102156 MW at global level, of which 70043 MW at European level.

In Romania by the end of April 2013, there are signed technical connection contracts for over 15760 MW in WPPs and over 1215 MW in PVPPs and granted technical connection approvals for over 5020 MW in WPPs and over 2025 MW in PVPPs [5]. Nowadays, in Romanian Power System the installed power is 2325 MW for WPPs, respectively 449 MW for PVPPs [5]. The areas most adequate for connection of PVPPs are the ones with optimal solar radiation as the South, center and the West of Romania, while for WPPs the most adequate areas were identified to be Dobrogea, Moldova and Banat.

Starting with a short description of Romanian weather conditions and technical connection requirements for integration of RES in Romanian Power

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System, this paper analyses two comparative approaches of a study case, illustrating certain implications of renewable power generation in transmission system operation.

2. Renewable sources location and behavior

Following the industrial development from the last years, the available technologies for RES equipment give the possibility to have both more power stable WPPs and PVPPs and clean energy sources for environment. However, RES behavior has the important disadvantage to have a fluctuant generation level, which can stress the power system operation.

For a new renewable plant installation within the power system, the RES have to fulfill the technical requirements imposed by Romanian TSO [6], [7]. According to these technical requirements the RES have to implement controllers, such as: voltage control, reactive power control, frequency-active power control, fault ride through capability, etc. The required controller must be always in operation and has to action each time is necessary.

Taking into account the wind condition across Romania about 85% of WPPs installed power is in Dobrogea area and 15% are connected to Moldova and Banat areas up to now. A large WPPs scale in Dobrogea area leads to high power generation influencing the power system operation from the network adequacy point of view.

3. Study case

The case study aims to highlight the influence of RES on system operation from the point of view of transmission power operation. For this, a Romanian Power System model was used, including RES connected to the system. Computations were made at winter peak load around 9000 MW, considering around 1900 MW WPPs generation within Dobrogea area. Installed PVPPs are in small numbers and distributed within the distribution network up to now and they have not an influence on transmission system operation, yet.

Therefore, we focus on the WPPs behavior analysis within Dobrogea area.

Scenarios: **a)** comparative study between active power flows through transmission lines with the evacuating role from Dobrogea area of the generation, when WPPs generation power is 0 MW and 1870 MW respectively besides to other power plants generation. The analysis was performed in schemes with N and N-1 elements in operation, and its results are illustrated in fig. 1-3.

The results lead to the following conclusions:

- active power flow from Dobrogea area to the neighboring areas (the Bucharest and Moldova areas) increased significantly, compared with the situation when WPPs generation is missing;

- the active power flow from Dobrogea, depending to the fluctuating WPPs generation, establish the neighboring transit areas with main changes in power flow directions.

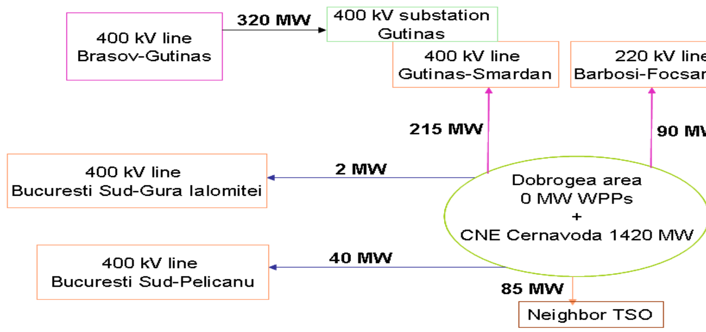


Fig. 1. Active power flow from Dobrogea area to the neighboring areas (0 MW WPPs)

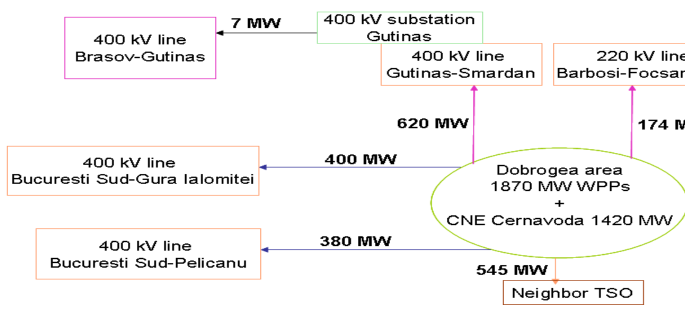


Fig. 2. Active power flow from Dobrogea area to the neighboring areas (1870 MW WPPs)

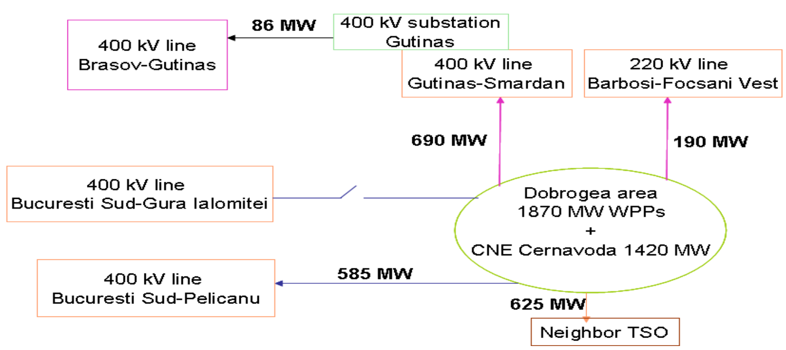


Fig. 3. Active power flow when 400 kV line Bucuresti Sud-Gura Ialomitei is planned disconnected

b) Comparative study between the limits of WPPs generation from both steady state and dynamic point of view after a transmission line tripping in a N-1 scheme elements in operation.

Following the results of **a** study case, when the WPPs has operating conditions at high power generation, the highest active power flow on line 400 kV

Bucuresti Sud-Gura Ialomitei is. This line which is the most influenced transmission line by high WPPs generation is considered further as planned disconnected in order to identify the operation measures to be taken to fulfill N-1 criteria after a 400 kV line tripping.

In Table 1, various scenarios are shown which have been identified with the planned disconnected 400 kV line Bucuresti Sud-Gura Ialomitei and the tripping of another element. To fulfill N-1 criteria, certain measures have to be taken as: network topology changes and / or other measures in order to maintain the power system operation within normal parameters.

Table 1

Power flow analyses

Grid conditions		No. of sensitive equipments and percentage of overloads	Measures to remove the congestion	
Planned disconnection of line	Tripping of second line		Topology changes	WPPs power Generation limitation
400 kV line Bucuresti Sud-Gura Ialomitei	400 kV line Gutinas-Smardan	- two 220 kV lines up to 125%	yes	yes
	400 kV line Bucuresti Sud-Pelicanu	- four 110 kV line up to 133%	yes	no
	400 kV line Lacu Sarat-Gura Ialomitei	One 400 kV line up to 112%	yes	yes
	400 kV line Pelicanu-Cernavoda	- two 110 kV lines up to 114% - one 400/110 kV transformer up to 120%	yes	no
	400 kV line Tulcea Vest-Isaccea	- one 400 kV line up to 119% - one 110 kV line up to 106%	yes	yes

For the further dynamic computation a relevant case was chosen which is leading to both network topology changes and WPPs generation limitation. The lines taken within the dynamic analyses are shown in the map (fig.4).

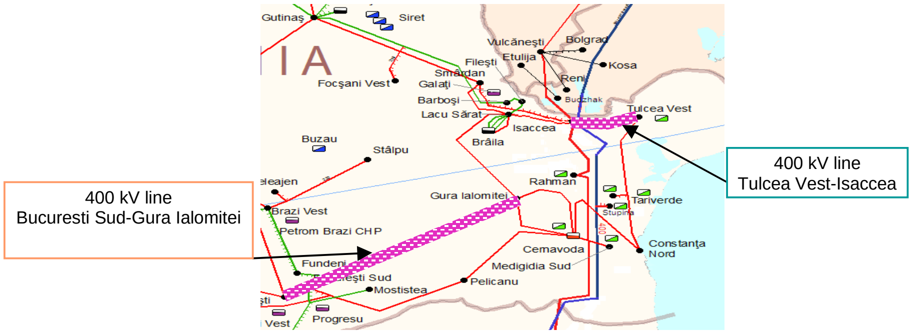


Fig. 4. The transmission lines from Romanian Power System used in dynamic study case b (ENTSO-E Interconnected Network System Grid Map, www.entsoe.eu)

The dynamic simulation conditions:

- The planned disconnected 400 kV line Bucuresti Sud-Gura Ialomitei;
- The tripping of 400 kV line Tulcea Vest-Isaccea caused by a three-phase short-circuit close to the 400 kV Tulcea Vest substation, occurred at time t_0=1 s, is cleared at t_1=1.12 s in 400 kV Tulcea Vest substation and by teleprotection at t_2=1.16 s in 400 kV Isaccea substation.

The simulation results can be observed in the following figures, (fig.5-9):

- after a fault clearance on a 400 kV line from Dobrogea area, active and reactive power oscillations appear on the lines remaining in operation (fig. 5) and fig. 6). The oscillations are dumped in the range of 5-10 s, and the active power flow increases on the remaining lines in operation;

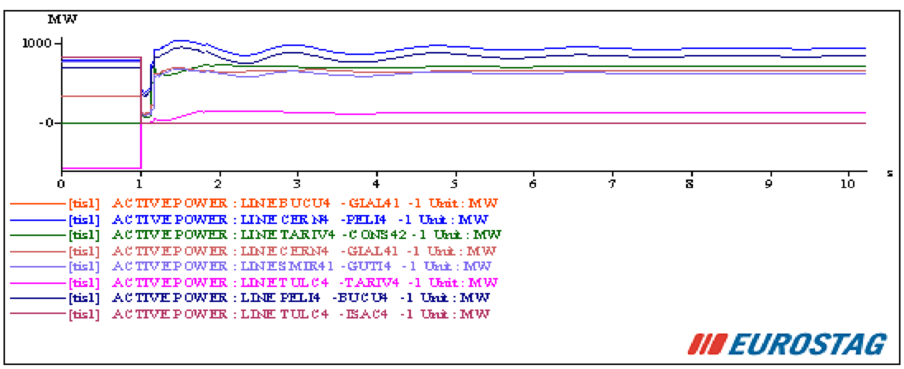


Fig. 5. Active power flow variation on 400 kV lines from analyzed area

- after a fault, the voltage drops fast in the 400 kV and 110 kV substations across the analyzed area, the deepest voltage level reached in the 400/110 kV Tulcea Vest substation till the fault clearance, (fig. 6). This voltage dip activates the voltage farm controller leading to reactive power injection into the system to support the voltage, (fig. 7).

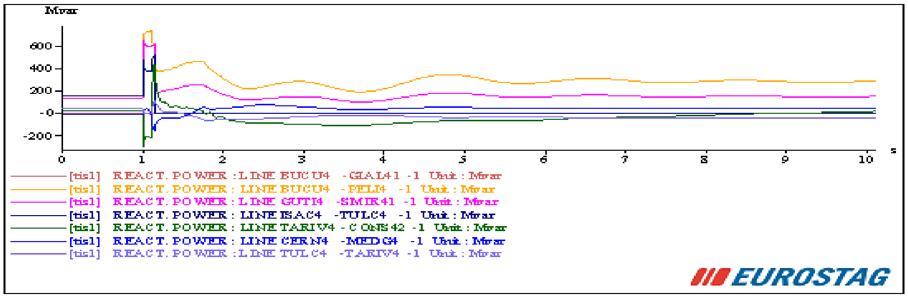
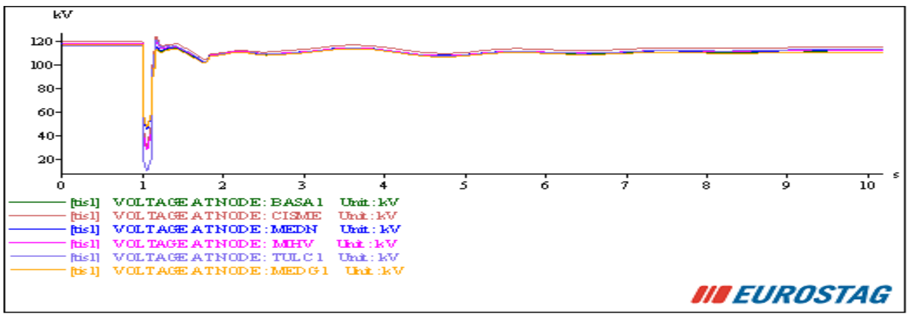
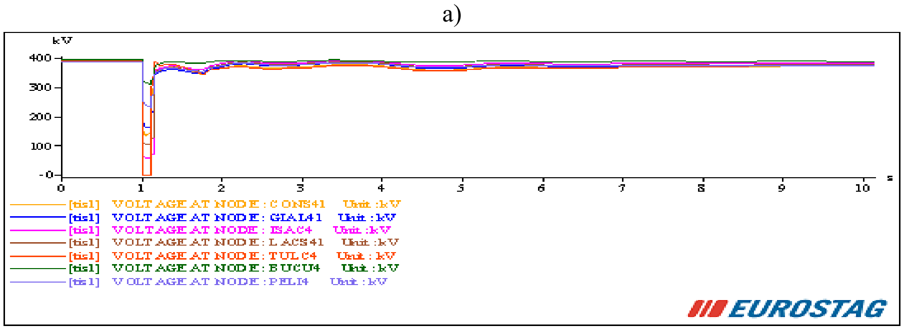


Fig. 6. Reactive power flow variation on 400 kV lines from analysed area



a)



b)

Fig. 7. Voltage response in: a) 110 kV substation from Dobrogea area; b) 400 kV substation from Dobrogea and neighboring areas

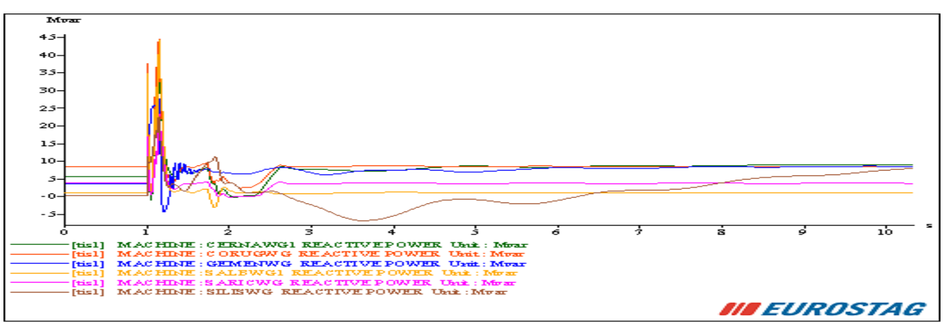


Fig. 8. WPPs reactive power injections for voltage support

- the dumping of the internal angle variation after the fault clearance indicates that the area (including all power plants) is stable on short and medium transient term (fig. 9).

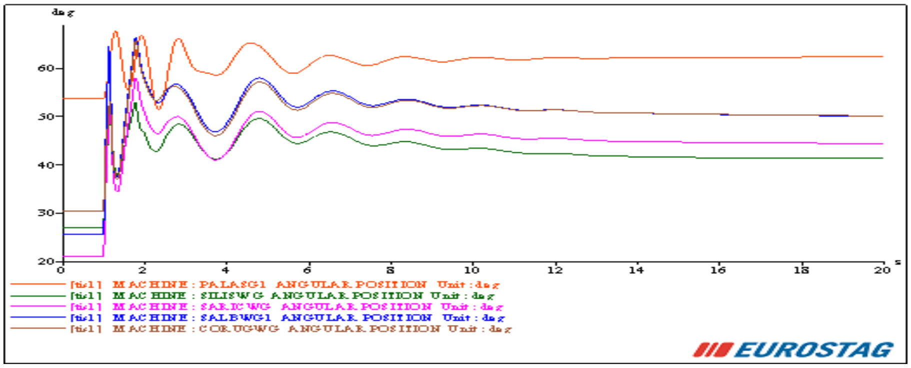


Fig. 9. Internal angles variation from WPPs generators to the a certain synchronous generator taken as reference

Following the results of the analysis for **a**, and **b** study cases, a limit of WPPs generation from Dobrogea area have to accomplish both the steady state and dynamic conditions. In the case of planned disconnection of 400 kV line Bucuresti Sud-Gura Ialomitei and taken into account the considered installed power in WPPs, the maximum WPPs generation level limit is done by the steady state analyses results, the dynamic limit being higher that the steady state limit.

4. Conclusions

In Romania, a large WPPs scale in Dobrogea area is becoming the predominantly generation sources, and this part of Romanian Power System operates in stress conditions under the N-1 criteria requirements. One of the possible worst scenarios for the network that can happen, from economical and technical point of view, is to have a wind forecast that predicts a slow wind speed for a long period of time. In such a case wrong wind forecast information is used to take the decision to disconnect the 400 kV line to perform maintenance works. Meanwhile the real weather conditions have been changed and the wind speed was growing quickly and the line must be put in operation to fulfill the N-1 criteria. This scenario influences the maintenance program. Also, wind forecast accuracy is very important to maintain the control of power flows with quick direction changes, and last but not least the balance between generation-consumption. Also, a wrong wind forecast can cause unplanned exchanges on interconnection lines. Nevertheless, the RES have a positive influence to the power system, through WPPs controllers which can be used further on a tertiary voltage control.

Acknowledgement

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