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BIOMASS COMBINED HEAT AND POWER DFIG CONCEPT CIGRE BENCHMARK NETWORK IMPACT

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***Abstract**: The following paper has been done in order to analyze the impact of DG penetration in MV CIGRE benchmark network and analyze the medium scale biomass CHP concept impact over the MV grid.*

***Keywords**: Biomass, Combined Heat and Power, CIGRE Benchmark Network, DFIG, Distributed Generators*

1. Introduction

The market of distributed energy resources (DER) is growing continually and powerfully. Because of this intense growth, the electric power system of centrally located generation, transmission networks and distribution networks is expected to evolve into an infrastructure where small-scale distributed energy resources and loads, connected through local micro grids, are common. Available and reliable methods and techniques are most needed to enable the economic, robust and environmentally responsible integration of DER and to ensure the successful change of the present electric power system. Research and development are active in the whole world in industry, universities and research institutes due to the importance of DER [1].
The power obtained from renewable energy sources has quality problems caused by intermittent and uncontrollable nature of these sources. Among these quality issues there are disturbances in the voltage, oscillations in power flow through the lines, etc. All of them can generate inconveniences. E.g., the voltage disturbances can cause the disconnection of the sensitive equipment and may lead to huge economical loss due to the damaged products. VSCs are largely utilized in most of the DGs (Wind power, Photovoltaic, etc.) and these inverters are very sensitive to voltage disturbances. A disturbance in the voltage can cause disconnection of the inverters from the grid that leads to the loss of energy [2].

2. CIGRE Benchmark Network model

The real network supplies a small town and the surrounding rural area. It has a rated voltage level of 20 kV, being supplied from a 110 kV transformer station, with cable connections for most of the situations, but having some overhead lines sections, too. The network has 30 nodes. This number had to be reduced in order to reduce the size of the network to a required level for DG integration studies but in the same time, maintaining the realistic character [3].

The benchmark network is designed for studying the impact of diverse DG at the medium-voltage level. The list of studies that can be carried out with this benchmark includes the following [3]:

- study of the impact of DG units on the power flow of MV distribution lines;
- study of the impact of DG units on the voltage profile in the MV distribution network;
- study of energy management systems (DEMS) for DG in the MV distribution network;

- study of power quality issues such as harmonics, flicker, frequency variations, and voltage variations;
- study of small signal stability;
- study of voltage stability;
- study of the impact of MVDC coupling on the power flow of MV distribution lines;
- study of the impact of MVDC coupling on the voltage profile in the MV distribution network;
- study of the impact of DG units on transmission capability of the sub-network 1 feeder;

study of the protection of the MV distribution network.

Figure 1 shows the resulting network proposed as a benchmark. This study is used only sub network 1 that starts from TN2.

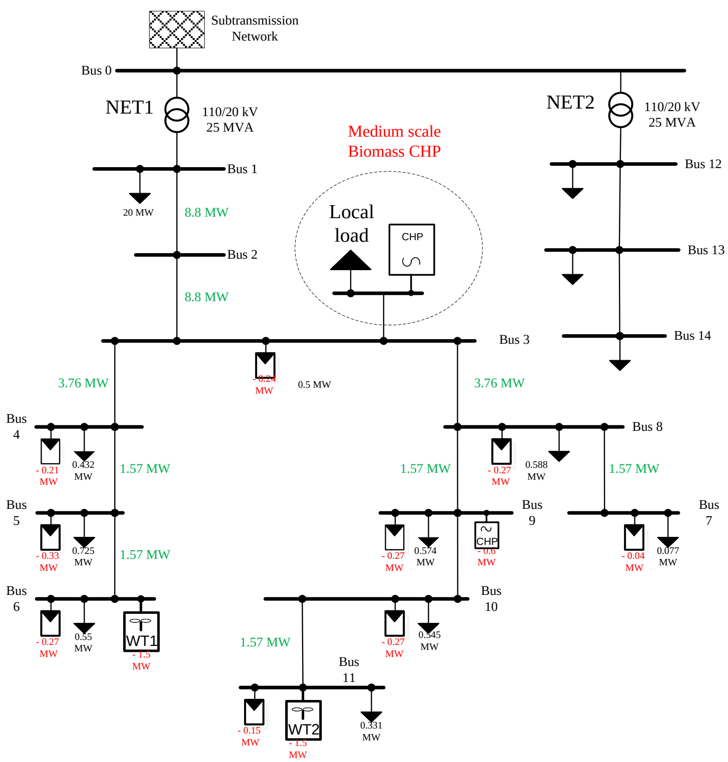

Figure. 1 Benchmark network plus Biomass CHP DFIG concept

3.Benchmark Overview

A benchmark overview is necessary as a first step in analyzing the impact of DG penetration MV CIGRE model.

Several simulation studies are discussed on the basis of data containing classical MV profiles compiled with profiles of DG's integration in to the grid. All this data has been colected from the grid model using Matlab Simulink.

The studies were carried out using distribution line as follow:

- industry three-phase dynamic load grid connected on Bus 1
- biomass CHP concept grid connected on Bus 3
- house hold three-phase dynamic load grid connected on Bus 11
- PV power plants grid connected on Bus 1, Bus 3 and Bus 11
- wind turbine grid connected on Bus 11
- internal combustion CHP grid connected on Bus 11

The Three-Phase V-I Measurement block is used to measure instantaneous three-phase voltages and currents in the circuit on each Bus line.

The Three-Phase instantaneous active and reactive power is used on transformer terminal strip in oreder to compute the values associated with a periodic set of three phase voltages and current.
The following section are presents simulation result of classic medium voltage substation without the integration of DG's. In the classical representation, the feeders are populated only with loads and the power is delivered in a unidirectional manner. In its initial layout the MV substation provides energy to its end consumers (industrial and residential) and the voltage profile has a descending nature from the MV transformer down to the end consumer located in the last feeders . for this purpose the solution to provide voltage condition was realized by capacitor bank which had the purpose of delivering the needed reactive power to maintain the voltage within the limits.

Figure 2 displays the household consumption profile for 24 hours. As it can be seen the profile follows a normal path of human consumption. It starts ascending at 4:00 AM when people use to wake up and decreases at 9:00 when they are at work. The maximum load is achieved in the afternoon when the characteristic reaches its maximum peak consumption. Figure 3 present the industrial consumption profile for 24 hours. Compared with the household consumption, the industrial load characteristic proves to have its maximum peak in the middle of the day. The figure shows that the profile starts ascending at 5:00 when industry sector starts and decreasing at 16:00.

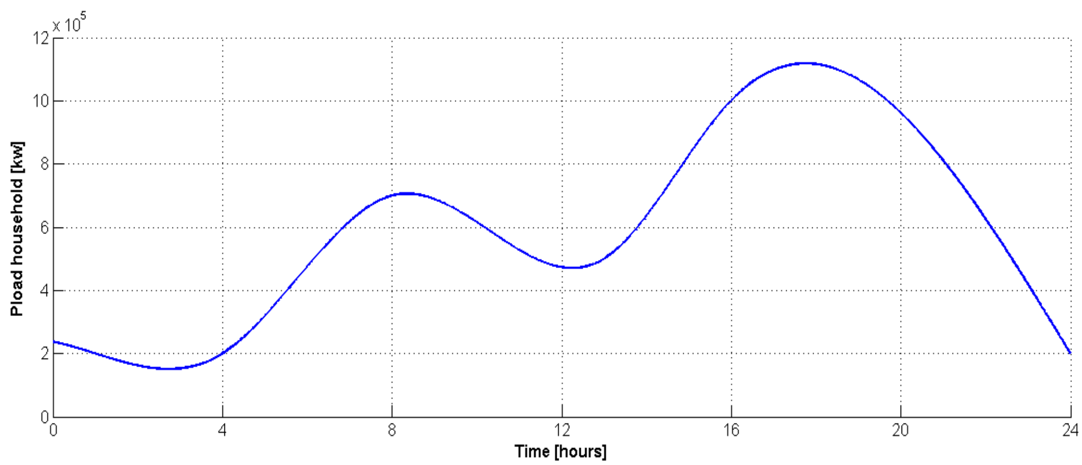

Figure 2: Household consumption profile over one day

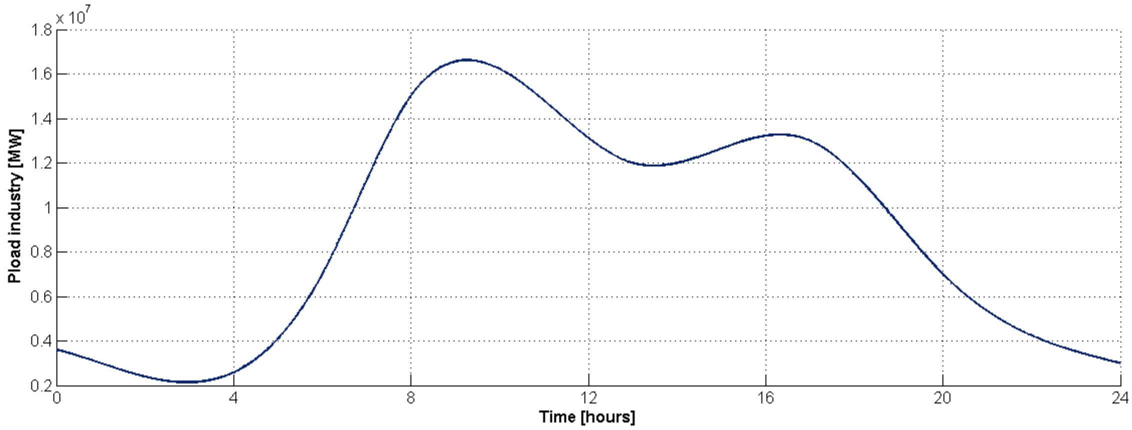

Figure 3: Industry active consumption profile

Figure 4 shows the industry reactive power consumption over one day. It start increasing at 5:00 PM until midday and result of this consumption can be seen also in the voltage falling on the same period from Figure 6

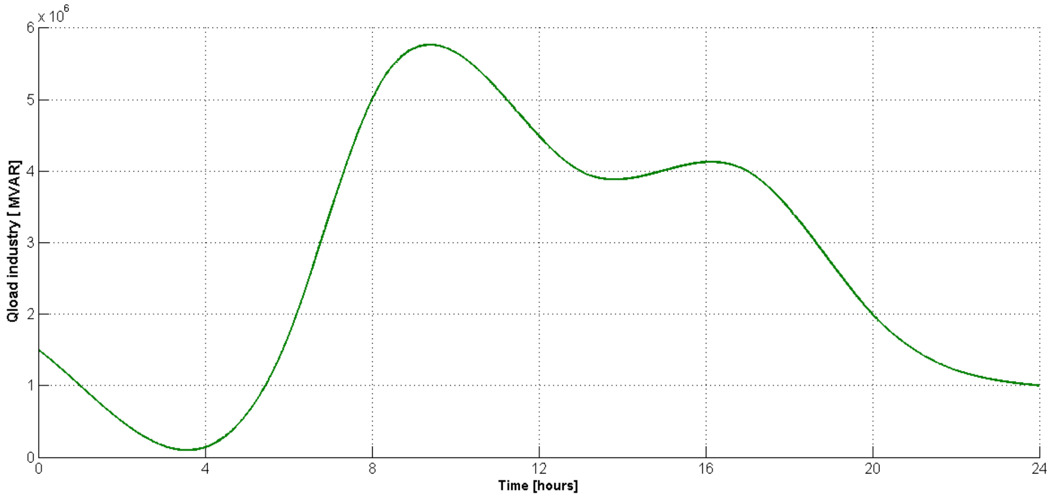

Figure 4: Industry reactive power consumption for 24h

In a classical medium voltage substation, the voltage profile encountered in the feeders have a descending nature. Thus, proving once again that only loads are present in the system. To boost up the voltage in the end feeders usually capacitor bank are used to provide the necessary reactive power which is used to support the grid voltage. It can be observed that the value is falling during the peak hours (Figure 6). and the system transformer load is up to 0.92 p.u. Figure 5

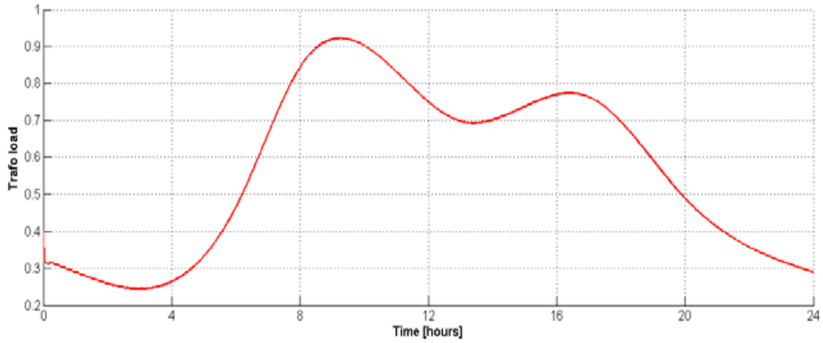

Figure 5: Transformer Load for 24h

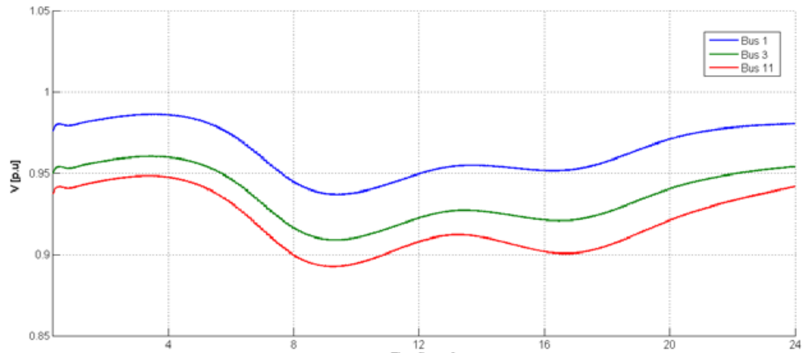

Figure 6: Voltage profiles for classic power system

4. Biomass CHP DFIG concept and DG penetration in MV grid

After collecting the results from the classical layout of the MV substation, several changes were made to analyze the impact of DG's Biomass CHP DFIG concept integration. The following section presents another set of simulation results proving the changes that are present due to their location and their variability knowing the fact that their primary energy resource is characterized by high intermittency.
The new layout of the MV substation which now is populated with different DG's in its feeders start to change the nature of all characteristics presented in the subchapter above. Beside the classical loads, the feeders are now populated with DGs such as wind turbines, combustion engine CHP and PV systems. As a result the MV substation starts to be more active and leading to a bidirectional power flow. The purpose for this study case is to evaluate the behavior of the entire MV grid under the integration of medium scale CHP giving the fact that unit becomes one of the most important players in the substation.

The Figure 7 displays the values of voltages for 3 different busses encountered in the MV substation. Bus 1 is the closest to the MV transformer and as it can be seen is a heavily loaded bus since the effect of the industrial and residential lower has a major effect on the voltage profile. Bus 3 is located in the middle of the MV substation and has a light loading character. Beside this section of the MV substation is located most of the DG generation and as a consequence the voltage profile is boosted up due to the injection of active power which is supplied by the DGs. Bus 11 is the bus which is the lowest in the MV substation hierarchy and it can been that the voltage profile has the same nature as in Bus 3.
It can be seen voltage profile in the above mentioned busses which are analyzed.

The green line is the Bus 3 where Biomass CHP concept is connected and as it can be observed, it has a good contribution on voltage profile compared with classic system (Figure 6) Bus 1.

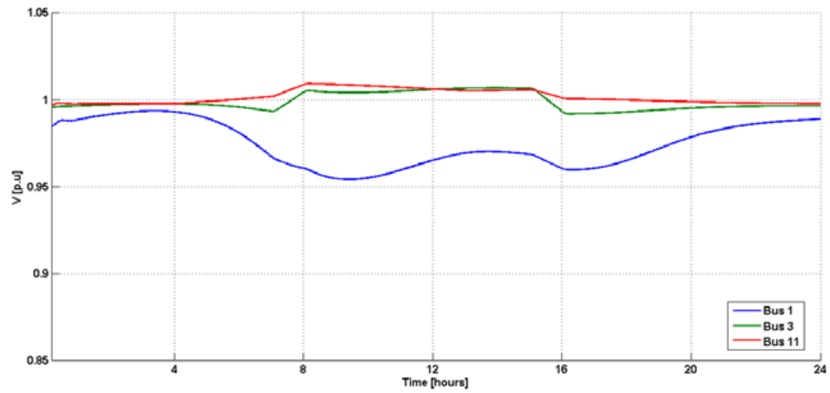

Figure 7: Voltage profiles after DG penetration and DFIG biomass CHP integration

In order to analyze the impact in the entire system transformer load is displayed in Figure 8 for all the cases and it can be observed the peak load value decrease.

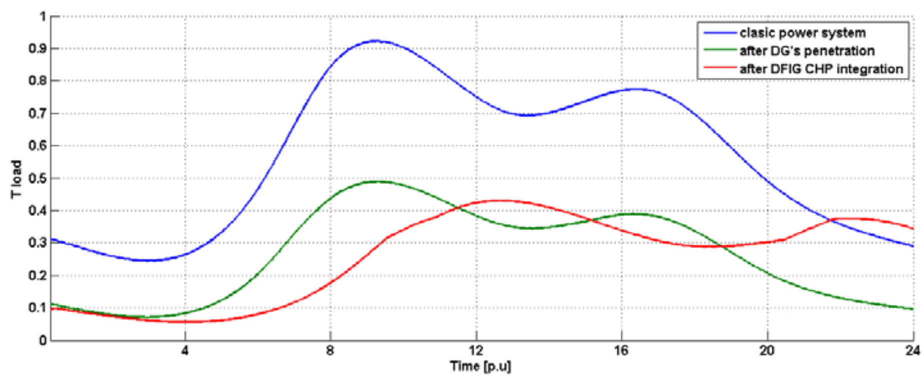

Figure 8: Overview of transformer load complete system

One of the advantages of DG's integration presented in Figure 8, is that the transformer peak load decrease significantly. As a proven fact, this shows once again the active nature of the substation, which starts to share the active power, consumed between its local generation and the power absorbed from the HV power system.

5. Conclusions

DG and Biomass CHP concept characteristics can influence voltage sag depending on their position in network (how far or close are from transformer of from big consumers) capacity and operation mode.
The transformer load capacity decreases significantly particularly because the Biomass CHP concept is connected on the same bus line and due to bidirectional power flow.
Both Biomass CHP concept and CHP have the same contribution with active power, the only difference being them capacity. On important aspect that should be taking into account is that

generation profile of both CHP's system can be changed by their system operator. Their main contribution to the system is made during working hours where most of the active power is consumed. Compared with the CHPs, wind turbines have the same behavior like the PV systems. While the CHPs can be operated in accordance with a presented schedule, wind turbines are producing the power only if their primary energy exists.

6. Appendix

Parrameters Of DG Units Used In Study Case

Node no	DG Type	P_{max} [kw]
1	PV	20
3	PV	20
11	PV	30
3	DFIG CHP	5000
11	Wind	1500
9	CHP	1500

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