FUNCTIONAL SPECIFICATION OF THE DSO SCADA SYSTEM TO MONITOR AND CONTROL ACTIVE DISTRIBUTION GRIDS

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ABSTRACT

The paper deals with the functional specification of a DSO SCADA and Distribution Management System able to give to control room operators the possibility to monitor and, afterward, control the power generated by DG in real time as well as the short term forecast. It will be possible to aggregate the information at different power system levels (single DG, LV feeder, MV/LV substation, MV feeder, MV busbar; HV/MV substation; Control Center and so on) and various primary energy sources (wind, sun, hydro, thermal, etc.).
The ICT system will play a fundamental role in the DSO control systems of the next future since it will deal with thousands of meters/measurement sensors to be monitored in real time.
The information exchange between DSO and TSO SCADA systems will be also addressed in order to ensure the interoperability of distribution and transmission networks and the security of the whole power system.

INTRODUCTION

The requests to connect dispersed generation (DG) to MV and LV distribution networks are increasing as a consequence of government policies aimed to incentive the use of renewable energies.
In 2009 Enel Distribuzione received about 45.000 requests to connect 15.000 MW to its distribution networks. In the same period 35.000 were connected to MV (3%) and LV networks (97%) with a rated power of 1000 MW. The 2010 will register figures more than doubled. A further trend increase is expected in 2011 as well.
This means that many distribution networks supplied by HV/MV and MV/LV substations will become "active" being the power generated higher than the loads during part of the day.
The distribution network operation has to be improved since, at the time being, is tailored to "passive" networks with unidirectional power flows.
At the same time the TSO is not aware of the power generated on distribution networks and sees the virtual load of HV/MV substations. Since the wind and PV production can vary randomly the power system security has to be evaluated carefully.

The first step toward active grid operation is the real time knowledge of the power produced by DG connected to MV and LV networks; the second one will be the dispachment of this power.

DISPERSED GENERATION

The number of connection requests of dispersed generation in the quarters of years 2007-2010 to LV and MV networks are shown in following figures [1].

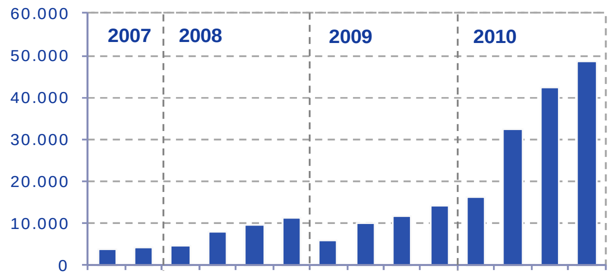


Figure 1 – Number of connection requests at LV network.

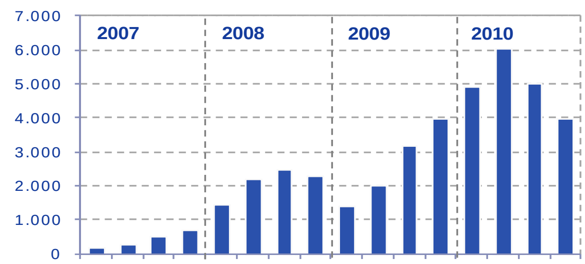


Figure 2 – Number of connection requests at MV network.

In the period 2007-2010, the increase of requests has been + 670 % and the relevant rated power +200%. In 2010 the total amount of DG connection requests in absolute value is higher than Italian peak power demand (54 GW).
Figures 3 and 4 show the power of dispersed generators connected to Enel Distribuzione networks between 2005 and 2010 at LV and MV network.

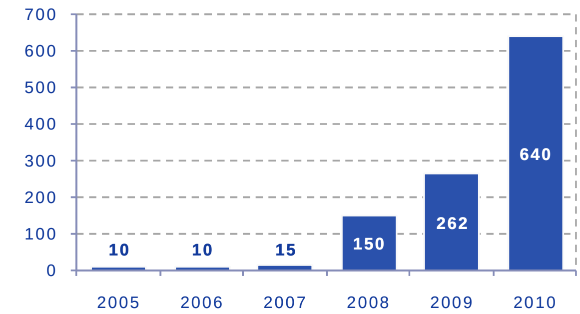


Figure 3 – total amount of dispersed generation power (MW) connected on LV network per year.

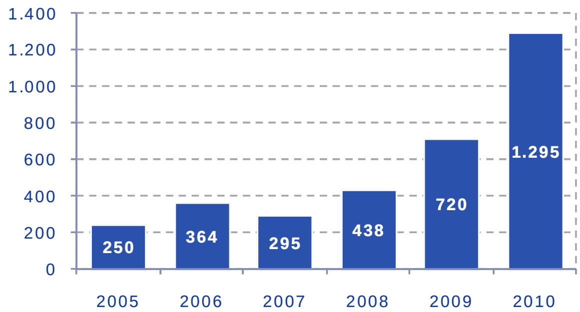


Figure 4 – total amount of dispersed generation power (MW) connected on MV network per year.

The dispersed generation power connected on MV network on 2010 is five times the 2005 ones and the whole dispersed generation power connected on LV and MV network is almost 2 GW i.e. the equivalent of two big nuclear power plants or one conventional thermal power plant.
In 2011 and following years similar trends are expected.
For these reasons many distribution networks will become "active" being the power generated higher than the loads during part or of the day.
So the network operation has to be substantially modified since the present one is thought for passive networks with an unidirectional power flow from HV to MV and from MV to LV.
Moreover, at the time being the TSO, is not aware of the power produced by Renewable Energy Sources (RES) below the HV/MV substations and the power system security can be taking care of the random variability of the primary sources.

SCADA SYSTEM DEVELOPMENT

It is necessary to develop the SCADA system in order to monitor in real time some parameters of the dispersed generation connected to the distribution network.
The "real time" definition is conventional: i.e. the time elapsed between the action in the network and the availability of the relevant information in the Control Centres has to be shorter than the time needed to react to the information itself.
With this tool the Enel Distribuzione Regional and National Control Centres will be able to manage in an effective way distribution networks with high penetration of dispersed generation and in particular:

- to provide to the TSO Control System the information about power produced by dispersed generation, aggregated below each HV/MV transformer connected to the transmission network;
- to provide to the Enel Distribuzione Regional and National Control Centres the same information aggregated at lower levels up to the single power plant;
- to adopt new operation modes of active grids allowing the dispersed generation dispatching i.e. the modulation of active power exchanged between the HV/MV substations and transmission network and the control of active and reactive power produced by the single power plants.

The SCADA system will be developed in various phases in order:

1. to monitor the power produced by DG gathering the readings, with a proper frequency the existing electronic meters;
2. to install new sensors "RGDM" (fault detector and measure) always on at producers premises;
3. to elaborate and give to the TSO the forecast of power produced below each HV/MV transformer connected to transmission network;
4. to send to MV producers signals to modulate active and reactive power and interface protection settings;
5. transmit the signals for logic selectivity.

MEASURES

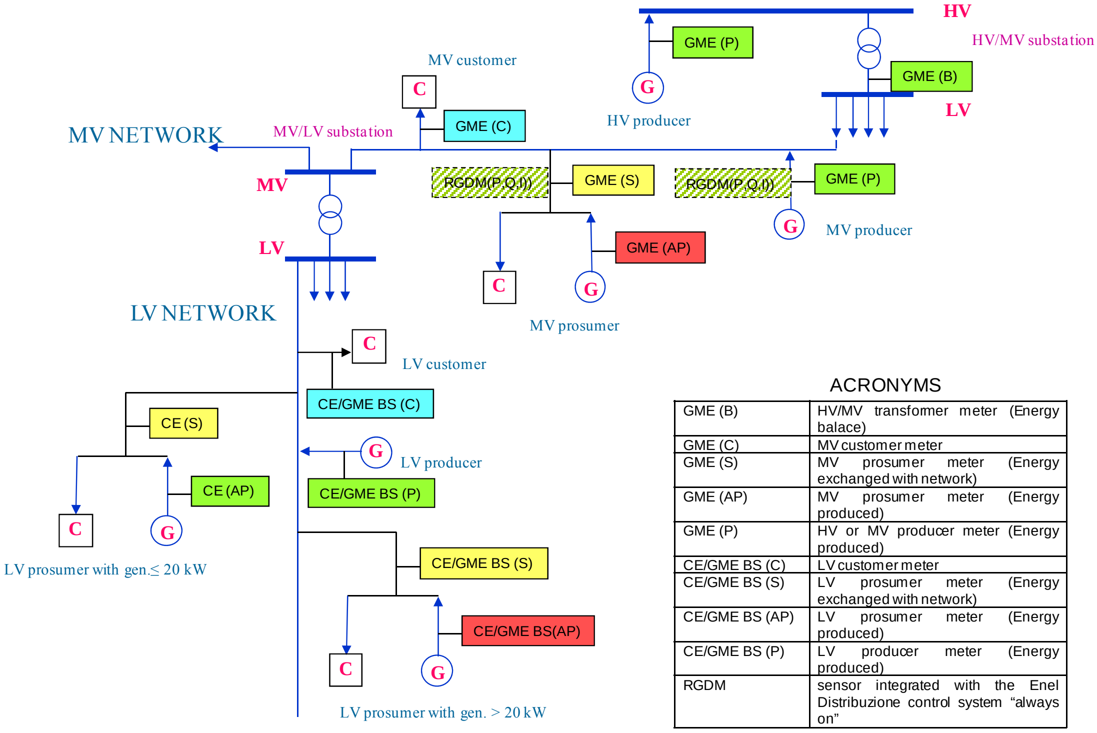
The measures needed are:

– active power absorbed and injected;
– inductive ractive power absorbed and injected;
– voltage, current and power factor.

Fig. 5 shows the measures that are available in the distribution network, at the time being and in the future.
Actually in the first phase the measures will be gathered from the meters because, at the moment, there are not specific sensors installed in the network.
The measures have to be available starting from generating plans above 55 kW (which are read with the highest frequency). The information relevant to producers with generating plants up to 55 kW will be aggregated at LV feeder level.
Starting from these basic information several aggregation will be available at different levels:

- Network: producer, LV feeder, MV/LV substation, MV feeder (whole or part), MV busbar, HV/MV transformer, HV/MV substation, Regional Distribution Control Centre.
- Enel Distribuzione organization: Zona (area like province), Regional Distribution Control Centre, Distribuzione Territoriale Rete, Macro Area Territoriale, Enel Distribuzione.
- Administrative: province, region, country.
- Primary energy source: photo voltaic, wind, hydro,

other renewable, thermal, other conventional.
The SCADA system has to refresh the measures at least every 15 min from meters and, in the future, will manage measures in true "real time" from RGDM.



ACRONYMS

GME (B)	HV/MV transformer meter (Energy balace)
GME (C)	MV customer meter
GME (S)	MV prosumer meter (Energy exchanged with network)
GME (AP)	MV prosumer meter (Energy produced)
GME (P)	HV or MV producer meter (Energy produced)
CE/GME BS (C)	LV customer meter
CE/GME BS (S)	LV prosumer meter (Energy exchanged with network)
CE/GME BS (AP)	LV prosumer meter (Energy produced)
CE/GME BS (P)	LV producer meter (Energy produced)
RGDM	sensor integrated with the Enel Distribuzione control system "always on"

Figure 5 – Measures in the distribution networks.

RGDM

The "RGDM" (fault detector and measure) are the new sensors integrated with the Enel Distribuzione control system "always on" [2] that will be installed at producers premises and will let:

- to measure the power produced by DG;
- to send signals to the power plant in order to modulate active and reactive power;
- to modify the interface protection settings and avoid unwanted shedding of DG in case of under frequency not due to fault in the distribution system and, vice versa, avoid islanding;
- to realize logic selectivity with other protective equipment by sending and receiving controlling signals.

MAN MACHINE INTERFACE

The measures relevant to dispersed generation, gathered from the new SCADA system, will be available on the various network diagrams of the on-line distribution control systems.
Moreover a web application will let the Control Centre operators to surf on the network: clicking on the diagram it will be possible to aggregate the power generated on the network below. The measures will be grouped distinguishing between producers and prosumers (i.e. producers and consumers at the same time) and among different primary sources (PV, wind, hydro, thermal and others) and voltage level (MV or LV).
Actually, defining a time range, it will be possible to show the power generated along that time period. In case of real time representation, the forecast of the power that will be produced in the rest of the day will be shown on the basis of the historical data base.
The installed power with primary sources detail (PV, wind, hydro, thermal and others) and voltage level (MV or LV) will be available as well together with the equivalent utilization hours.
In case of prosumers, if the measure of the generated power is not available, the power exchanged (positive if injected into the distribution network) at the point of common coupling will be shown. The installed power together with the contractual load power will be shown as well.
When the aggregation is at MV busbar level, the measure gathered from the "balance" meter installed on the HV/MV transformer and exchanged with the transmission network will be available and the TSO/DSO Control Centre operators will be able to evaluate how the power exchange can fluctuate in case of sun or wind variation.
All the data will be available on table form in files exportable to spreadsheet software.
Fig. 6 gives an example of diagram relevant to power produced by DG below a HV/MV transformer during one day including real measures and forecast until midnight.

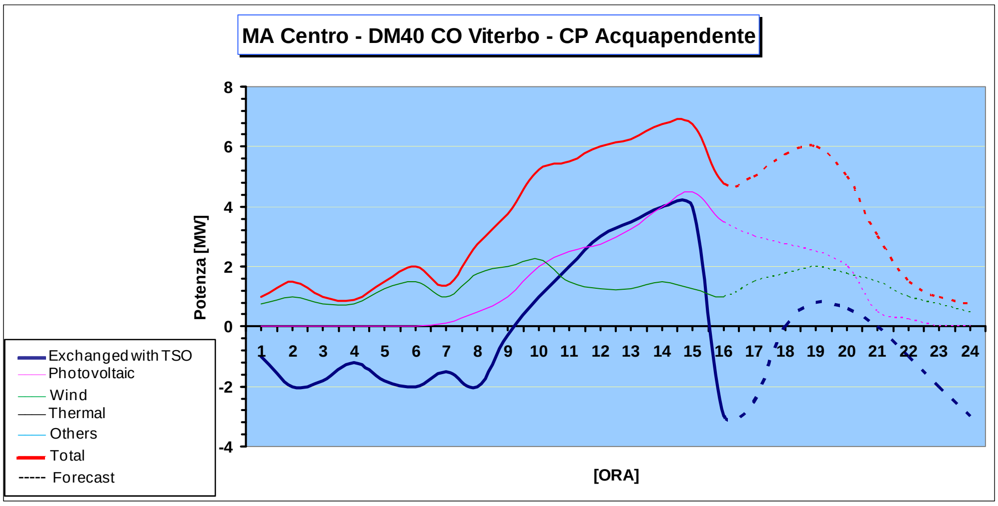


Figure 6 – Example of diagram relevant to power produced by DG below a HV/MV transformer during one day: measured + forecast

DISTRIBUTION AND TRANSMISSION NETWORKS INTEROPERABILITY

The present architecture of control systems already foresees an exchange of information between Terna (TSO) and Enel Distribuzione (DSO) but it is limited only to active power exchanged with the transmission network through the HV(MV transformers.

The SCADA system development will integrate these information with:

– inductive ractive power absorbed and injected;
– power factor;

Moreover the information relevant to the power generated and installed on the distribution network below the HV/MV transformer will be available grouped distinguishing between producers and prosumers (i.e. producers and consumers at the same time) and among different primary sources (PV, wind, hydro, thermal and others). These information will be updated in real time taking care also of the present network configuration.

So the TSO will be able to evaluate correctly the power system security and the reserve needed.

CONCLUSIONS

In the last years the DG connection requests end the connection themselves are increasing with an exponential trend. The same behaviour is expected in the future to address the 20-20-20 targets.

The smart grid paradigm imply a different way to operate distribution networks adopting concepts, like dispachment and voltage regulation, typical of transmission ones.

The SCADA system development, whose functional specification have been described in this paper, in order to monitor the power produced by DG in the distribution networks is a first step toward the operation of active grids.

REFERENCES

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