THE NEW ROLE OF DSOs: ANCILLARY SERVICES FROM RES TOWARDS A LOCAL DISPATCH

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ABSTRACT

Distributed generation (DG) and resulting increasing system unbalances, congestions and need for timely connections in distribution grids are issues more and more critical for modern power systems. The DG units entering the grid at MV and LV levels change power system architecture and functioning, and many distribution networks are becoming active networks. Today's power systems need to face new challenges, such as reverse power flows from the MV to HV level, increased volatility of net demand and peak demand fluctuations in times of higher variability of DG. This paper focuses on the new business models that can be implemented to change the structure and organization of power systems, in order to exploit DG resources to cope with the issues depicted above. By means of these new models, both TSOs and DSOs will have the opportunity to make efficient use of the services that DG technologies may offer.

INTRODUCTION

A high degree of Distributed Generation (DG) penetration has considerable impact on operation, control, protection and reliability of the existing power systems, and involves a complete redeployment of both active and reactive power flows along the distribution network. In a distribution network operated radially, the energy flows mainly from the Primary Substation (PS) to the lower voltage levels; such architecture, which was chosen when DG was very rare, can entail several problems: today's power systems need to face new challenges, such as reverse power flows from the MV to HV level, increased volatility of net demand and peak demand fluctuations in times of higher variability of DG. Furthermore, DG units, which have been treated as negative loads, are neither required to provide any ancillary services nor to participate into frequency and voltage control. These phenomena increase the quantity of operating reserve needed for ancillary services.

Ancillary services are provided by generators connected to HV networks, used to support and to ensure the power system in safe, secure and reliable operation. In new deregulated electricity markets, these services are mandatory and should be competitive; the Ancillary Services Market (ASM) is where the Transmission System Operator (TSO) procures the resources needed for managing, operating, monitoring and controlling the power system. In the ASM, TSO acts as a central counterparty; accepted bids/offers are valued at the offered price (pay-as-bid).

The ancillary services consist of: frequency regulation, voltage control, spinning reserves, standby reserve, backup reserve, load following, real-time balancing, reactive power service, etc. Adequate, efficient and available ancillary services for the system help TSO to control system frequency and voltages within operating limits, to maintain the stability and to prevent from any black-out. In electric power systems, TSO is fully responsible for the ancillary service management and control. These activities are monitored to guarantee the transmission system in a stable and secure operation mode. Distribution networks are benefited from those activities as they are stable as long as the transmission systems are stable. This paper focuses on the new business models that can be implemented to change the structure and organization of power systems, in order to exploit DG resources to cope with the issues depicted above. By means of these new models, both TSOs and DSOs will have the opportunity to make efficient use of the services that DG technologies may offer.

The paper is based on a recent Consultation Document of the Italian Energy Regulator, which foresees that DG units provide dispatching resources (DCO 354/2013/R/eel) [2], and is organized as follows. After this introduction, we describe the current ancillary service market and the impact of RES on system stability. Then, we focus on the innovative dispatching models in order to enable DG units to participate in energy markets and provide dispatching resources. Finally, we provide some concluding remarks.

ANCILLARY SERVICE MARKET: INTERMITTENCY AND RES IMPACT

In the current situation, in Italy as in most EU countries, a central dispatch is in place, in which the TSO exploits by the ASM the regulating capabilities of conventional plants above a given size limit (for Italy, above 10 MVA) and carries out the commitment process based on selected criteria (usually minimum production cost) [2].

The ASM is controlled by the TSO, who is the single buyer on this market. Access to the supply side of the ASM is limited to the large power producers. As for unbalance, the TSO undertakes an ex-post comparison of market participant forecasts against the relevant results, to determine which players are not complying with their forecasts and, consequently, who has to pay for restoring the balance.

Intermittent electricity supply can disturb the system balance. RES can be variable (i.e., PV plants) and unpredictable (i.e., wind plants): the combination of these two factors along with the behaviour and uncertainty of the demand contribute to situations with balance feasibility difficulties due to lack of downward reserve and higher levels of reserve. RES forecast uncertainties increase needed provisions of reserve: variability influences the rest of the electric system that must compensate such variations to keep the system balanced. Predicting this variability, and being aware of uncertainties, is crucial for efficient operation.

Although prediction of wind and PV energy is improving, the timeframe in which weather conditions can change is smaller (i.e., 1 hour) than the timeframe for which electricity supply forecasts are made (i.e., 6 to 24 hours). Therefore, the system balancing mechanism has to respond to unanticipated changes of intermittent electricity supply; the TSO balances the system by procuring additional electricity (upward adjustment of production units), making use of demand response (in case of a shortage) or by adjusting production units downwards (in case of a surplus). In fact, an inadequate response can endanger the stability of the whole system and can cause a system wide black out.

In the view of an ever increasing presence of RES over the system (and of DG on distribution networks), it is necessary to define a multi-level process involving TSOs and DSOs, in which DG units actively participate in energy markets and provide dispatching resources.

To ensure the proper functioning of power system, and a better management of energy flows, it is also possible to use the resources provided firstly by FER connected on HV and EHV transmission networks and, secondly, by DG connected to the MV and LV distribution networks.

This involves a review of dispatching rules that must be coordinated with the development of network infrastructure. According to this requirement, RES plants must be able to participate in controlling the system, at the same level as conventional power plants.

RESOURCES FOR INNOVATIVE DISPATCHING

The ancillary services that could be provided from the RES and DG are:

a) resources for solving congestion during the planning phase;
b) resources for the primary power reserve;
c) resources for the secondary and tertiary power reserve;
d) resources for balancing;
e) reactive power reserve for voltage regulation;
f) active power reserve for voltage regulation;
g) island operation of part of the network.

Other resources for the proper functioning of the system, with a future possible application, could be:

h) demand response and load rejection;
i) availability for use of the intertripping;
j) participation in the recovery of the electricity system.

These ancillary services can be offered both during normal operation and in emergency situations, and can also be offered to address local problems as well as global problems .

Dispatching resources can be divided into (Table 1):

- technical requirements/obligations that have to be adopted by DG plants: voltage regulation; overfrequency regulation; ride through capabilities; curtailment of DG power injection;
- ancillary services that could be offered on the ASM and that the TSO (and/or the DSO) could use to operate the networks wrt both global issues and local issues.

The impact and control scope of ancillary services on the power system can be local or system-wide (Table 1).

- Local ancillary services, f.i. voltage regulation and reactive power, which are provided and controlled locally where needed.
- System-wide ancillary services, f.i. frequency control and active power reserves (spinning or standby), that have a global impact and are provided anywhere in the power system.

Dispatching resources	Type	System services	Local services
Resources for solving congestion during the planning phase	Market service	YES	YES
Resources for the primary power reserve	Technical requirement Market service	YES	NO
Resources for the secondary and tertiary power reserve	Market service	YES	NO
Resources for balancing	Market service	YES	YES
Reactive power reserve for voltage regulation	Market service	YES	YES
Active power reserve for voltage regulation	Market service	NO	YES
Demand response and load rejection	Market service	YES	YES
Participation in the recovery of the electricity system	Technical requirement	YES	NO
Availability for use of the intertripping	Technical requirement	YES	YES
Island operation of part of the network	Technical requirement	NO	YES

Table 1. Dispatching resources from RES and DG.

INNOVATIVE DISPATCHING MODELS

Depending on the size and on the specific technology, DG plants can provide a range of services required by TSOs and DSOs. However, it is only through aggregation and integration into power system management and operation that DG will be able to displace the same capacity and flexibility of the conventional power plants. In fact, the majority of existing DG has been installed following the fit&forget approach and, therefore, very few generators are equipped with the infrastructure necessary to provide ancillary services. Another important issue is the generation control and supervision; visibility and controllability by the system operator requires real-time tele-measurements and the possibility to issue instructions (and to get feedback). When properly integrated (f.i. with the development of smart grids [3]), DG could provide ancillary services required by TSO such as real-time balancing, frequency regulation, power reserve, congestion management, and voltage control. As regards distribution network, in addition to voltage and power flow control, new services are possible in order to improve the security of supply and the quality of service.
However, some studies [4] suggest that the value of the most feasible ancillary services will be relatively low. Consequently, such services will represent incremental revenue opportunities for DG, usually in circumstances without incentive schemes (i.e., in grid parity context) and where constraints restrict network development, e.g. environmental and planning constraints.
For this reason, it is important to provide market access to DG by new market structures and regulatory arrangements [5]. This includes the incorporation of advanced information exchange between generation and consumption, the provision of ancillary services at the distributed level, management of the network to provide network reliability and controllability, and improve customer benefits and cost-effectiveness.
In this paper, three different models for dispatching DG are presented:

- ✓ model 1: *Extended Central Dispatch*;
- ✓ model 2 *Local Dispatch by the DSO*;
- ✓ model 3: *Scheduled Program at HV/MV interface*.

MODEL 1: Extended Central Dispatch

In this model (Figure 1) all RES units connected to HV, MV and LV networks will have to submit a forecast of their injection into the grid the day before the day of delivery, independently if the source is renewable or not. All production units will be enabled to provide ancillary services which will be provisioned by TSO as a market operator. The RES and DG producers will be responsible of maintaining their planned production avoiding unbalances, while TSO will be in charge of modifying the production plans and the market position of power plants in order to ensure the system security.
The participation of RES and DG in the ASM (run by the TSO) could lead to violate constraints in the distribution grid. In addition, when a DSO solves local constrains by resources provided by DG (congestion management), this could have repercussive effects on the transmission grid (and relevant operation). Given the complexity of the tasks, a hierarchical definition of the supervision and control actions is necessary: a clear hierarchy of functions between TSO and DSOs has to be established. In this sense, all RES (and DG) have to be monitored with respect to which product they are offering and at what time. These data should be given to DSO as soon as possible, so that the DSO can eventually react accordingly in emergency situations and curtail the most appropriate DG. Moreover, any action on distribution network users requested by the TSO should be agreed upon with the relevant DSO in order to collect new dispatching resources; if the DSO finds out that some network limit is being overcome, it will have to report to the TSO in order to modify the production plan (f.i., a DSO procuring voltage control services will have to rely on local resources within its distribution area, while system-wide services can be delivered by resources spread across different distribution systems).
For this reason, the system services are offered from RES or aggregators thereof[1] via ASM, while the local services are managed through DSO's direct call. In fact, given that some local constraints are managed only by some specific producers belonging to the same network (MV or LV), the DSO will have the capability to call only these specific users to provide network services at a fixed administrative fee.

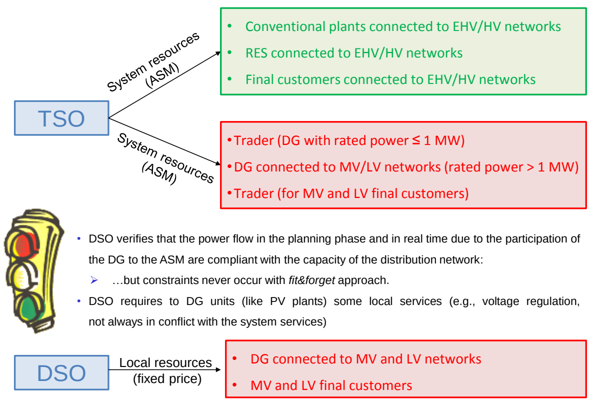


Figure 1. Model 1 – Centralized and extended dispatching.

1 In fact, larger DG (P> 1 MW) could be monitored and remote-controlled while other, especially small-scale, DG may not be dispatchable. The relevant injections should be forecasted and monitored by an aggregated basis at zonal level.

Model 2: Local Dispatch by the DSO

In this new model (Figure 2), the DSO could both procure services to satisfy its own needs and also manage resources on behalf of the TSO.

The TSO should not act on any individual RES connected to the distribution grid; but the orders from the TSO should be executed by the DSO. DSOs, when procuring system services, interact with the energy market in a more direct way than before; DSOs only buy flexibility offered from DG or aggregators thereof, and do not act like commercial players (i.e. using these resources for arbitrage possibilities instead of system services), only acting in absolute emergency situations in order to ensure grid integrity.

As regards system resources, the TSO accepts, both in the program phase and in the real time phase, bids/offers from conventional plants and DSOs in order to operate the power system (central dispatch): by the same resources, the TSO also solves residual congestions and creates secondary and tertiary reserve at minimum costs.

In the new "Ancillary Service Market for distribution network" (ASM_D), the DSO enters into purchase and sale contracts with a view to obtaining system resources by DG, and acts as central counterparty for the transactions. As for the dimension of this local market, the DSO could accept bids from resources connected to one primary substation or from several (or all) of its distribution areas. The DSO in this way can find the cheapest sources within a larger geographical area and pass them on to the TSO.

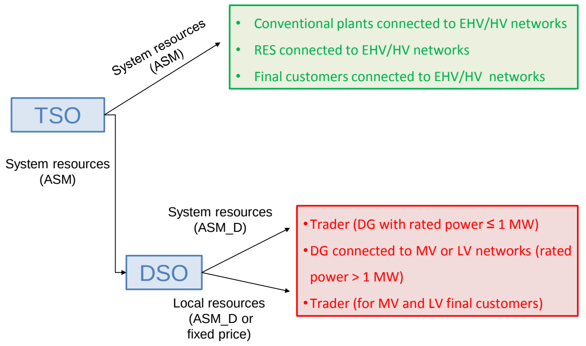


Figure 2. Model 2 – Local Dispatch by the DSO.

In addition, the DSO procures the resources necessary to operate the distribution networks respecting the relevant technical constraints (every DSO is responsible for the relevant local congestions). As regards the access to the market, the DSO assumes a twofold function:

- Dispatching Service User[2] in the ASM: provides for the availability of resources;
- responsible for a local dispatching (ASM_D): acting as a market operator establishing prices and quantities of ancillary services in every single distribution area (the DSO is the single buyer on the ASM_D).

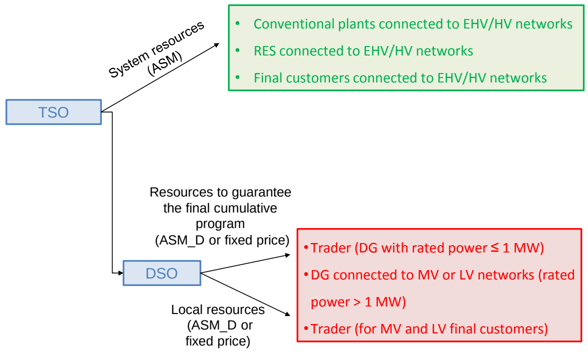
As in the model 1, the DSO will be able to make direct calls to specific units in order to solve local problems instead of using ASM_D, settling an administrative fee for the used services.

Model 3: Scheduled Program at HV/MV interface

In this new model (Figure 3), the DSO is responsible of maintaining the Scheduled Program at HV/MV interface. Differently from model 2, DSO will not offer ancillary services to the TSO; but it will only maintain the adequate program profile by solving the unbalances produced by the DG units connected downstream. As a consequence, the TSO will reduce the quantity of energy traded on ASM: theoretically, it will only manage unbalances related to power plants connected to the HV grid.

In order to reduce the unbalances at each primary substation, the DSO will have to use all balancing resources on the distribution network, while TSO will manage the system with a central dispatch including all users connected to the HV grid. In this case, the DSO will submit programs based on the demand and production forecasts and will send control orders to each production unit in order to ensure the planned profile at each primary substation. Additionally, the DSO will be able to acquire services via ASM_D, as in the previous model, in order to better manage the distribution network. This means that system services will be managed by the TSO, while the local services will be managed by DSOs separately, having as a unique common point the primary substations.

Even though the models proposed give the possibility of enlarge the set of production units that the TSO is able to control (adding production units up to 1MW), and enable RES producers to supply ancillary services which will end up in optimizing the resources for dispatching.



2 The Dispatching Service User is defined by TERNA (the Italian TSO) as the grid user involved in the dispatching activity. It could be a production unit holder or a consumption unit holder.

Figure 3. Model 3 – Final Cumulative Program at HV/MV interface.

COORDINATION BETWEEN TSO AND DSOs

Coordination between TSO and DSOs, and information exchange, will become more important as the amount of RES increases and as DSOs become more active as local system operators. Today, at the transmission level, conventional plants send schedules to the TSO for system balance purposes. On the distribution level, no systems are installed for acquiring data from DG (especially from domestic plants). Only in some cases, TSOs receive information from RES in real-time (f.i., wind plants connected to HV networks). In future systems, a well-structured and organized information exchange between relevant actors is necessary: the DSOs will need information about DG forecast, schedules and active dispatch to improve their visibility and to achieve a close to real-time management of the distribution network including local network constraints.

As regards the national context, the Italian Energy Regulator resolution 84/2012/R/eel approved the Annex A.70 to the Grid Code that introduce requirements for DG and allows the use of ICT for information exchange between TSO and DSOs. The Annex A.70 requires the development of a suitable communication system between TSO and DSO in order to exchange information on RES production. The possibility to communicate with DG for the purposes described above enables the acquisition of some interesting parameters of the DG too. In this way it is possible to collect "real time" information on the load and on the power generated by DG along the MV network (and, eventually, LV). The amount of generation aggregated by each feeder, transformer, and substation, (separated according to generation technology, solar, wind, biomass, etc) will be available. Through this system DSO's Operating Centres will be able to effectively manage networks with high DG presence. The system will also serve an interface with the TSO in order to provide data for transmission network control.

CONCLUSION

The DG units entering the grid at MV and LV levels change power system architecture and functioning, and many distribution networks are becoming active networks. Today's power systems need to face new challenges, such as reverse power flows from the MV to HV level, increased volatility of net demand and peak demand fluctuations in times of higher variability of DG. These phenomena increase the quantity of operating reserve needed for the Balancing and Ancillary Services Markets (BM and ASM).

In the view of an ever increasing presence of RES over the system (and of DG on distribution networks), it is necessary to define a multi-level process involving TSOs and DSOs, in which DG units actively participate in energy markets and provide dispatching resources.

In this view, DSOs will provide market access to DG by acting as market facilitators. Several ancillary services by DG will be enabled through intelligent management of the network (smart grids). This includes the development of advanced information exchange between generation and consumption, the provision of ancillary services at the distributed level, management of the network to provide network reliability and controllability.

This new role by the DSOs could lead to different business models; some possible models, elaborated for the Italian framework, were presented in the paper according to a recent Consultation Document of the National Energy Regulator.

As regards the application process, it is possible to imagine a first stage of implementation, based on Model 1that is more similar to the current situation, and requires less changes to the existing infrastructure and regulation, and in a further stage step the Model 2 (or the Model 3), which allows a real integration of RES in the system.

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