NEW SOLUTIONS FOR A BETTER DISTRIBUTED GENERATION INTEGRATION TO MV AND LV NETWORKS

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ABSTRACT

The French DSO (ERDF) is currently studying production flexibility both on active and reactive power in order to help a better integration of Distributed Generation on the MV and LV networks.
In order to maximize the hosting capacity of existing MV feeders, since February 2016 ERDF allows Generation facilities connected to medium voltage to perform a local voltage dependant reactive power regulation (Q=f(U)).
Likewise, as an alternative to the "standard method" which consists in designing network facilities to evacuate the full production of DGs at any moment, ERDF is studying and testing on real generation sites connection contracts which includes active power curtailment. ERDF is also launching the development of an on-line simulation tool in order to help the connection request on LV networks, by allowing the requesters to fine-tune their connection power and location.

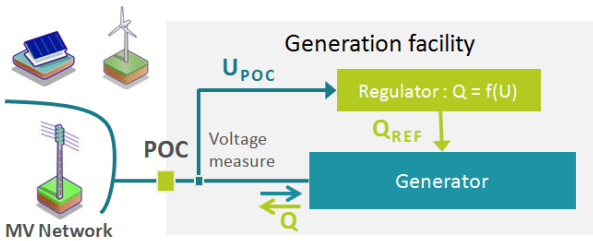
INTRODUCTION

Knowing that around 90% of DG are connected to MV and LV networks in France, and in order to meet the targets set in the French energy transition law in terms of share given to renewable energies in the energy mix, designing new, simpler and cost effective ways to connect Distributed Generation is obviously one of the main industrial goals of ERDF, the main French DSO.

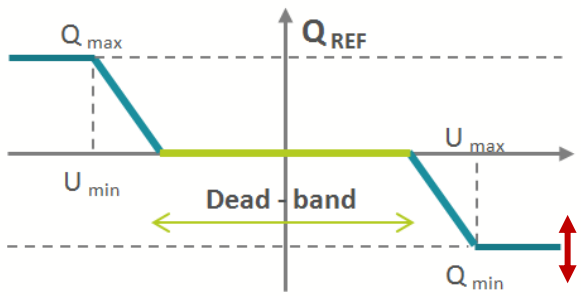
This paper describes the new connection solutions which are being or will be developed by ERDF in the next years, both on Medium and Low Voltage networks in order to facilitate the integration of renewable energies on distribution networks.
Several type of solutions are currently under development ([4]): local and centralized voltage regulation on MV networks ([1], [3]), active power curtailment of Distributed Generation ([2]) and new services to customers to help them better sizing their installation according to available local network capacity.

LOCAL REACTIVE POWER MANAGEMENT AND CENTRALIZED VOLTAGE REGULATION ON MEDIUM VOLTAGE NETWORKS

Since February 2016, ERDF industrialized a new technical smart solution and adapted its technical guidelines, in order to allow Generation facilities connected to medium voltage to perform a local reactive power regulation depending on the voltage (Q=f(U)). It is a first step towards the evolution of the French distribution system into a "smart grid".
After several experiments and economical studies, this solution has been established in agreement with the unions of producers in a Working Group lead by ERDF, taking into account the reactive power capacities of the various technologies connected to medium voltage networks (PV, wind, hydro...).
It consists in an optimal management of the absorption of reactive power by generation facilities: a measure of the voltage at the POC (point of connection) is sent to a local regulator, which gives a reactive power set point to the generation facilities which will absorb reactive power - which lowers increasing voltage - when the voltage is close to the upper limit.



ERDF chose a dead-band regulation law, allowing the generation to go further in reactive absorption without increasing the network losses.



The dead-band regulation law is explained below:
- if the voltage U is below the lowest limit U_{min} of the dead-band, generation machines inject reactive power;

- if the voltage U exceeds the upper limit U_{max} of the dead-band, generation machines absorb reactive power;

- within the dead-band limits, generation machines do not absorb any reactive power and have no effect on the reactive power on the network;

- Q_{min} limit is adjusted to the optimized level : allowing the DG integration on existing network without creating useless reactive power losses.

It is a self-adaptive response to changing network and can manage the emergence of new voltage constraints on the network, due to low voltage generation growth, amongst other things.

After two years of experimentation on a wind farm and two photovoltaic facilities between 2013 and 2014, ERDF launched in 2015 the latest industrialization step to allow producers to implement a local regulation:
- ERDF Technical Guidelines have been updated to include the specifics of this regulation;
- A new Q = f (U) function is now available in the simulation tool of ERDF, used for network development studies;
- ERDF Information Systems have been adapted to allow the management of these particular contracts;
- Network access contracts will integrate specific billing terms (according to a reactive and voltage-load curve).

The extended reactive power of the generators will be taken into account in the connection studies, thus creating hosting capacity on the existing MV networks. Moreover, by adjusting the Qmin threshold, the hosting capacity is increased while controlling network losses since DG's reactive power is less frequently requested.

This local reactive power management by DGs is the first step to improve voltage regulation on MV-feeders with generation and loads. A step beyond, which is tested in two French demonstrators (*Venteea* and *Smart Grid Vendée*) is a centralized voltage management implemented in ERDF Control Centers. It consists in precisely measuring voltage in different points of the network, establishing the MV feeders voltage profile via a Distribution State Estimator, estimating the optimal voltage set point and finally giving an order to the transformers' On-Load-Tap-Changers located in the primary substation in order to avoid high voltage situations all along the MV-feeders.

PRODUCTION CURTAILMENT: MANAGING PRODUCTION FLEXIBILITY FOR NETWORK OPERATION AND NEW CONNECTION NON-FIRM POWER OFFERS

ERDF aims at developing new ways of DG connection to the network, as an alternative to the "standard method" which consists in designing network facilities to evacuate the full production of DGs at any moment.

Thus, real on-site generation active power curtailment is about to be tested in 2017 in the frame of Smart Grid Vendée Demonstrator. It addresses several objectives:

- Minimize the DG connection costs while contracting with producers a curtailment volume to avoid network reinforcement,
- Improve the aforementioned technical solutions (local reactive power management & centralized voltage regulation) performance for MV voltage management with a new lever,
- Optimize and alleviate the power flow transit related constraints at the primary substation for the benefit of the DSO and TSO.

This active power curtailment lever, fitted in ERDF SCADA DMS systems, is planned to be used mostly in anticipation (Operational Planning) for a better efficiency; however its real time use will also be experimented.

Since in so called "non firm power offers" the network is not anymore sized to overcome all constraining situations that may arise due to DER generation, the MV network operational tools (SCADA tools) shall evolve so as to be able to detect constraints on the network and help to overcome them through an optimized curtailment.

In operation, constraints detection shall focus in priority on current (transit current in transformers and network feeder portions which have the highest potential consequences) and secondarily on voltage limits violation (with a priority associated to high voltage limit violation).

As far as curtailment actions are concerned, the best tradeoff shall be found between informing in advance the producers (period, level), elaborating optimized operation schedules in advance including curtailment, and finding out the way to minimize curtailed energy.

To achieve optimized curtailment, ERDF decided to implement an algorithm that takes advantage of forecasts, but also of real time measurements to minimize the volumes of curtailed energy, whilst ensuring correct and reliable operation of the active distribution network" and allows in particular curtailment releasing.

The relevant studies have been performed in the frame of ERDF ongoing Operational Planning Project which deeply relies on Smart Grid Vendée Demonstrator as "play ground" platform.

The curtailment algorithm for network operation

The related strategy consists in the implementation of following steps:

1. A day before (at D-1) all constraints that may appear on the next Day (D) are analyzed by Operational Planning (OP) Tools, if among them one constraint is due to a producer with a "non firm power offer" contract, and this constraint might be solved by power curtailment, the producer is informed of the potential power reduction program (starting time, values of power limitation at a 10min time step, end time).
2. On D day, Operational Planning constraints computation is launched every 30min, if a constraint is detected within the next 30 min, curtailment program is established, provided the contractual thresholds in hours equivalent Maximum curtailed power are not reached, and after verification that the contractual terms related to network topology are applicable. Curtailment order is performed after real time conditions confirm a constraining situation. Curtailment release reverses the process while relying on initial curtailment program established in anticipation.
3. In real time, a dedicated follow up of all power limitation orders sent to the producers is performed; complementary levers such as Voltage Centralized Control and real time curtailment could be used if non anticipated constraints appear.

In order to keep a sufficient consistency between network development / planning tools and Operational Planning tools, the network development tools will emulate the capacity of Operational SCADA tools to proceed with curtailment.

ONLINE SIMULATION TOOL TO FACILITATE GENERATION CONNECTION ON LV NETWORKS

An online simulation tool accessible to producers is a quick and efficient way to provide them information about the capacity of local low voltage networks to integrate a new load or generator.

This tool will indicate the feasibility of such a connection and will give the opportunity to realize parametric simplified studies: these electrical studies will be done on demand, using the information about the new client (power and location) and the topology of the local network stored inside ERDF Geographical Information System.

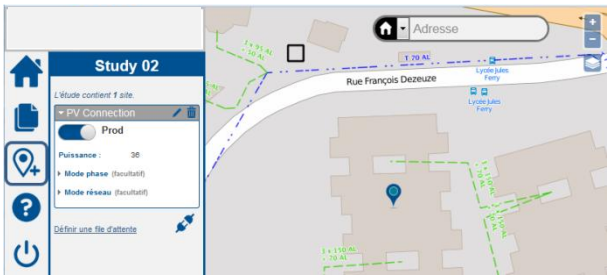


Figure 1 - Characterization of customer connection

The nature of the calculated constraints can be voltage drop or rise, exceeding of current thresholds, protection and transformer load. It will also detect the distance between the network and the customer point.

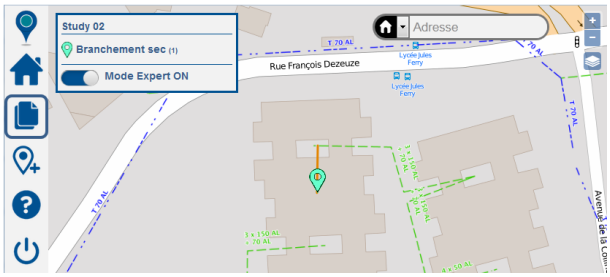


Figure 2 – Green = No electrical constraint

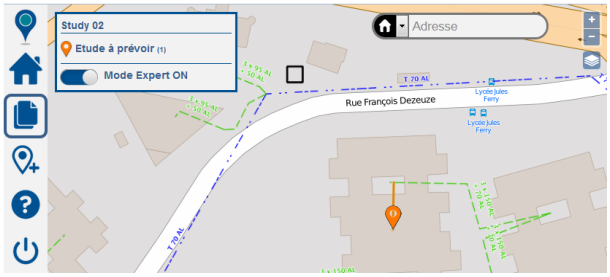


Figure 3 – Orange = Electrical constraint, a complementary study is needed

If any electrical constraint is detected, it means that the network has to be adapted to be able to welcome the new load/generator. This complementary study involved investment and complex network planning so it cannot be done automatically. Moreover if the connection requires a network extension over 250 meters, the study also becomes "complex".

Otherwise, when the connection is simple and without electrical issue, the use of such tool would maybe lead to the creation of cost estimation for small generator or the estimation of a price range at least.

It will also help to reduce the time needed for connection studies and decrease the number of unsuccessful one as long as the customers are able to evaluate the complexity of their connection demands.

CONCLUSION

ERDF is developing and testing several solutions in order to better integrate DG on MV and LV networks, from voltage management to non firm offers, but also online simulation tools. The demonstrators are a good opportunity to test several use cases and solutions in order to select the technically and economically best solutions and prepare their industrialization in the next years.

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