DSO TSO COORDINATION NEEDS INDUCED BY SMART GRIDS: THE ONGOING FRENCH PROJECT BETWEEN RTE AND ENEDIS

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ABSTRACT

The integration of Distributed Energy Resources (DER) is impacting the global electrical System behavior (HV and MV networks) by adding more variability and introducing bidirectional power flow, potentially triggering new technical constraints (voltage rise or drop, thermal constraints in lines and transformers,…). Meanwhile, these changes also bring out new opportunities for players to offer flexibility services by managing a diverse portfolio of usages and equipments. Theses evolutions are politically driven at the French level by the "Energy Transition Law" and handled at the European level by the "Network Codes".

In this context, French TSO and DSO (namely RTE and Enedis) are facing new specific constraints impacting voltage and reactive power transit, forcing them to launch coordination initiatives to strengthen their network operations at the various stages of networks life cycle (from network planning to network Operation and maintenance).

This paper describes the specific initiatives rolled out since 2014 in the frame of Operation and Control coordination between RTE and Enedis in both Operational Planning and Real time.

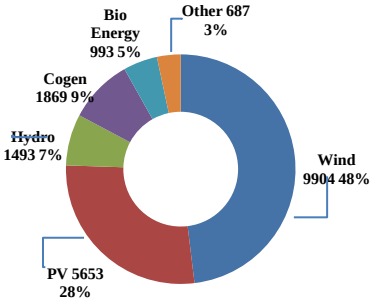
The ongoing studies scrutinize on one hand the operational planning detailed coordination needs and subsequent data exchanges starting at the works planning phase 2-1 years in advance continuing with anticipated operational constraints exchanges 1-2 months in advance (anticipated transit limitation on RTE networks side; or specific needs on Enedis side so as to allow generation power flow), pursuing with Work Access management (to adress common works security) and consequences, finishing with day-1 and intra-day necessary operational planning exchanges for anticipated network operation.

This paper presents the status of ongoing studies in this frame and presents the different implementation orientations to date.

INTRODUCTION

In the pace towards European Smart Grids and energy transition, the French context is quite particular with 95% of Wind and Photovoltaic Distributed Energy Resources (DER) sites connected on the DSO networks (*see fig.1 for details on DER connected on the DSO networks in France*). Compared to other EU countries, the proportion of "fatal" renewable generation in the consumed power is still limited with, by the last quarter of 2016, 1.7% of consumed power covered by Solar generation, 4.6% by wind, 1.4% by Bio energy [1].

fig1: Installed DER generation capacity on DSO networks (MW) in Nov.2016



However, despite the "low" DER penetration, its particular impact on RTE (French TSO) and Enedis (the main French DSO) networks is far from being negligible. Few but recurrent high voltage phenomenon occur on TSO networks without any latitude on DSO side to solve them with HV/MV transformers OLTC (lower tap reached). These are symptomatic of an upcoming situation where the local consumption/generation imbalance on the DSO side impacts the HV and MV networks. Both voltage and transit issues arise on TSO lines (due to power re-injection from DSO to TSO) and on DSO HV/MV transformers . Moreover, a constant increase of reactive power level on the DSO networks within the last decade is currently amplifying the phenomenon and questions the reactive power transit at the TSO-DSO interface.

This situation leads RTE and Enedis to launch in 2014 a proper Working Group which aimed at addressing the related issues. In parallel, *Smart Grid Vendée* a French Demonstrator under ADEME initiative (French Governmental Agency for Energy Mastering) performed a joint TSO-DSO analysis of upcoming real time and Operational planning coordination needs induced by the *energy transition [2]*.

These two approaches along with on one hand, the European Grid Codes declination necessity at the French level, and on the other the emerging Operation Planning tools at Enedis, gave finally rise in June 2015 to the

setting up of a common TSO-DSO initiative meant at strengthening coordination in electrical system operation & maintenance in Operational Planning and Real Time.

This Paper presents the status of this coordination project between RTE and Enedis so far. It details the project Objectives, the adopted works methodology, the major project milestones and focuses on its outcomes along with the IT/OT impacts identified so far.

RTE - ENEDIS COORDINATION PROJECT AT A GLANCE

Common Objectives and methodology

The coordination project between RTE and Enedis ambitions, in the frame of evolving French Smart Grid context, *to tackle existing and future common issues regarding electrical system operation in the most efficient way* with a commitment to fully participate in the development of renewable for energy transition.
Methodologically, the project works consisted so far in the study of new and evolving operational needs at the TSO-DSO interface induced by the energy transition, the declination of these needs into processes and organizations and the working out of their impact on IT/OT tools and exchanges. The proximity of the project with ENTSOE approach in Grid Codes elaboration also allowed comparing outcomes and finally adapting some of the Demand Connection Codes requirements.
The domains scrutinized were typically those of network operation ranging from the planning of the works at the interface between TSO and DSO to real time operation, with the will to emphasize on Operational Planning.
Moreover, the opportunities on both sides to adapt ongoing projects related to common operational impacts were systematically scrutinized.

Operation Coordination between RTE & Enedis: actual status.

In France the TSO operates all HV networks while DSOs operate MV networks at 20kV mosty and some 10, 15 and 30kV portions. The boundary or *interface* between TSO and Enedis is located upstream the HV/MV transformers.
In this frame, the operational coordination between RTE and Enedis actually consists in:

- *Electrical system safety and security management*: load shedding measures on Enedis network requested by RTE (apart from automatic load shedding) , real time transit limitation at the interface either via generation automatic decoupling (Generation disconnection Automatism) via or requests, reactive power management,
- *Operation and Control of all boundary equipment throughout their operational life*: Works/maintenance planning (yearly, monthly) for all RTE works impacting Enedis; coordinated operation, monitoring and control,
- *Operation and Control in real time and in Operational Planning with a potential impact the other System Operator Operation and Control activities*: i.e. transit limits anticipated by RTE (e.g. by Demand-Response mechanism) and impacting Enedis Operation and control; Enedis needs for Load transfer from one Primary Substation to another either planned for works /maintenance /network optimisation, or unplanned in case of fault, (incl. specific request to RTE for MV networks parallel/ loop operation),
- *Management of concurrent "Permit to Work" in the same interface premises (primary substations).*

On the short term, RTE takes advantage of powerful Operational Planning tools (Convergence) interfaced with SCADA systems at National and Regional levels and operating on day ahead - intraday timeframe. These tools participate in the Demand/Response Balancing process, network operation optimisation as well as its security & reliability. These tools are interfaced with performing forecasting modules (IPES) partly fed by Enedis SCADA (i.e. for MV connected DER).

THE OPERATIONAL PLANNING TOOLS DEVELOPMENT AT ENEDIS: A NEW OPPORTUNITY TO ENHANCE RTE – ENEDIS OPERATION COORDINATION

As depicted above, the French DER connection context induces new operational constraints on DSO and TSO networks. It forced Enedis to develop Operational planning tools so as to facilitate DER power evacuation in an optimal way in various operational circumstances i.e from works planning – up to two years ahead- to the operation optimization in the vicinity of real time – day ahead and intraday. Operational Planning on the distribution networks is also necessitated by the upcoming Smart Grid context which will definitely change network operation handling in the future. Enedis is convinced that Smart Grids operation will be mostly based on anticipation tools backed up by powerful automatisms in real time to overcome faults and unplanned situations.
The Operational Planning Tools developed for these purposes by Enedis are build around a comprehensive software package made of (a) local power forecasts (consumption and generation) tools feeding (b) a simulation platform detecting constraints (transit, voltage, protection plan issues, contractual thresholds overshooting, etc.) and electrical system weakening at various time frames (ranging from two years in advance

to few minutes before real time) and (c) optimization tools which aim at:

1. *for works planning optimisation*: identifying the optimal works periods inducing the least impact on DER generation (what also reduces penalties for Enedis), allowing the feeding of all end-customers in the most reliable conditions,
2. *for operation optimization*: identifying the optimal internal and external levers combination and schedule that allows to alleviate constraints (technical, contractual and financial).

Operational Planning: a way to smoothen and improve TSO-DSO operation coordination.

Operation Coordination does not have the same meaning and impacts on electrical system Operation improvement depending on time frame. This is the reason why, in the following we depict the particular coordination issues for each of the 3 operational planning time frames i.e. long term, medium term and short term.

On the long term coordination means schedule elaboration for major construction and maintenance work with a mutual impact on DSO and TSO operation. , Operational planning tools on DSO side help to plan in an optimized way the works schedules for primary substations. At that stage engineering and construction teams of both TSO and DSO are keen to get the related OP output information to plan their activities in the most efficient way. The relevant benefits are numerous: by example, an early optimized planning for construction works (which tries to minimize technical and financial issues via an optimal schedule) might decrease substantially external resources costs via early Call for tender procedures. Additionally, the determination by DSO OP tools of the most favorable periods allowing technical feasibility, minimization of potential n-1 impact and maximization of DER injection capacity facilitates Energy Transition and participate in the global reduction of energy costs

On its side, RTE is currently designing a renovated work scheduling process.

TSO and DSO chose to benefit from the new possibilities offered by DSO OP tools for works optimization and from RTE project, in order to fully redesign a coordinated process in this matter covering all the maintenance works management issue from works schedule to work permit. The relevant work is under progress but TSO and DSO are already convinced of the benefit of these common works. These studies forced the two operators to perform a deep reflexion on the related issue, with a proper modeling elaboration and a global improvement on the "Works processes" on both sides.

On the medium term (one week to 2 months) coordination mostly focuses on works schedule finalization and works preparation i.e. engineering of works phases, focusing on security issues (incl. works permit management) and constraints detection on RTE side. These latter are communicated by RTE to Enedis as mandatory power thresholds on transformers. The management of these limits will be taken care of by Operational Planning on Enedis side via anticipated load transfers and / or generation curtailment (relevant developments are scheduled in 2017-18).These tasks are included in the aforementioned works management project commonly handled by TSO and DSO.

On the Short term (day ahead and intraday), the objectives of TSO and DSO Operational Planning tools are to optimize network operation in anticipation via an estimation of potential constraints and levers to solve them. The constraints anticipation is either triggered on regular basis (i.e. every hour) or systematically after non planned events (faults, etc) that might be followed by automatisms functioning (see next section). OP tools try then to optimize situations for which automatisms already solved the constraints but without any prospective view.

During this phase, the exchange of information (power forecasts, forecasted constraints, scheduled levers activation, etc) between TSO and DSO is fundamental so as to globally enhance operation anticipation for a better electrical system optimization.

The following examples emphasize on the importance of such exchanges.

RTE Short term OP improvement based on DSO forecasts: DSO operational planning allows getting an anticipated vision of DSO network behavior (via the knowledge of planned topology changes plus generation and consumption forecasts); it might thus easily compute the detailed forecasted flows at the DSO TSO interface what will help the TSO to improve its Operational Planning vision (compared to the existing TSO OP methods based on DSO network modeling enhanced in the vicinity of real time with DSO SCADA data - i.e. generated power, flow measurement on HV/MV transformers).

Active and reactive power reserve: Additionally, the DSO OP tools might also (in the future) provide the TSO with a prospective view of active and reactive power reserves which will help the TSO to optimize its Voltage and network security schedules thanks to a better DSO network modeling.

Regarding, HV voltage management improvement, another ongoing pilot project handled by Enedis and RTE intends to use the Enedis own reactive power reserve (capacitor banks in the primary substations) as well as DER[1]capacities to inject or absorb reactive power. Due to the fact that DER reactive power injection/absorbtion may vary depending on active power and gen-sites maintenance schedules, the operational planning coordination provides real advantages to improve

1 DER connected on direct feeders

operation in this frame.

Real time safety and network security coordination

In the vicinity of real time (from tens of seconds to few minutes) RTE and Enedis common reflexion focussed on the optimisation of network safety and security concerns. Centralized[2] disconnection automatisms actually limit the DER related flows at the interface so as to avoid any overflowing of HV lines capacity: RTE on flow constraints detection sends information to Enedis SCADA which disconnects within less than 1mn the DER topologically connected downstream the constraint location (primary substation). In this frame, Enedis and RTE decided to enhance the existing automatisms with generated power curtailment/limitation (for DER connected on Enedis Network) as well as the introduction of zone management (i.e. several Primary Substation connected to a specific HV zone) and of a more efficient backup function based on MV feeder tripping (in less than 20 seconds) and local automatisms implemented in the local digital Control systems of Primary substation (with an automatic tripping of CBs depending on transformer predefined limit settings updated from Enedis dispatching depending on the situation).

Additionally, real time data exchanges shall also partially alleviating "n-1" operation conditions on RTE side, with two major orientations:

- The consolidation of real time mutual observability in the vicinity of operation border,
- The strengthening of network safety with the implementation of specific automatisms.

Actions on DER connected on Enedis networks could also take advantage of the upcoming new observability means such as DLR (Dynamic Line Rating) or transformer monitoring experimented by RTE.

Project Schedule and Implementation ; IT and OT impacts

After the elaboration of the major outlines of the project and the review of related needs on the 1st semester of 2016, the 2nd semester focused on detailed consideration of data exchanges supporting the coordination needs.

First data exchange operational implementation (the most prioritary ones covering both operational planning and real time needs) will occur by the beginning of 2018.

These data exchanges also consider network asset and dynamic modelling at the TSO DSO interface to ensure the global efficiency.

Regarding IT and OT considerations, the data exchanges will preferably rely on redundant BtoB links (i.e. IT to IT and OT to OT) so as to ease cybersecurity and link supervision integration. The detailed impacts on RTE and Enedis OT and IT systems are currently under investigation.

2 Centralized in Enedis Dispatchings

CONCLUSION

Enedis and RTE are closely working on an enhancement of operation coordination in the frame of a dedicated project which focus on Operational Planning and real time automation in the Smart grid context.

The anticipated constraints on both sides at different time intervals by respective OP tools along with reinforced data exchanges should allow to make appropriate decisions to optimize HV and MV network functioning today and in the future. RTE and Enedis are convinced that networks optimization will definitely be eased by the implementation of IT and OT evolutions underlying this coordination project.

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