FLEXIBILITY VEHICLES FOR DISTRIBUTION ACTIVE MANAGEMENT

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ABSTRACT

Distribution networks and system undergo a series of evolutions as regards their development that raises the question of the use of flexibility (eg management of distributed generation, demand or storage) as an alternative or compliment to network reinforcement. The first challenge is to house a significant amount of distributed generation, electric vehicles loading and peak demand growth. In France, the current peak management using Peak/Off-Peak tariffs positioning could be insufficient. New sources of flexibility, such as cascado -cyclical load shedding or process management in the industry with short notice, could develop and offer new opportunities.

To support current work on national mechanisms (Adjustment mechanism, Notification de Blocs d'Effacement - NEBEF, capacity market... and to define blueprint for flexibility management by 2030, ERDF conducted a study in 2013. Nine vehicles were identified as being used or implemented to manage these issues. This identification of the "possible vehicles" is based on a benchmark of the other advanced DSOs located in Great Britain, Germany and the USA.

INTRODUCTION

To reach the new European goals by 2030 (the proposal of the Commission are a reduction of greenhouse gas emission by 40% and an increase of the share of renewable energy to at least 27%), the power systems have faced and will face an increasing challenge to manage new generation [1] and new consumption power patterns.

If investments and modernization of the network infrastructures are one of the primary conditions to reach these targets, the energy policies are of paramount importance to secure the financing of such infrastructure and enable a coordination of these new market mechanisms.

Market mechanisms are currently put in place in France in order to complement the organization of the electricity market. First of all, a capacity mechanism is under construction, to ensure a long-term adequacy between demand and offer.

Moreover, there is a strong political will in France to give demand side management access to the market. In particular, the NEBEF mechanism (Notification d'Echanges de Blocs d'Effacements – Valorisation of demand side products on the electricity market) allows aggregators to sell "curtailed energy" on markets.

However these new vehicles have been created without consideration of their potential impact on the network. Most, if not all, of these flexible consumers will be physically connected to the distribution network. How will it affect the forecast of demand? What will then be the role of DSOs in the development of such flexibility? What would be the consequences on the distribution grid of massive synchronous flexibility activation?

On the other hand such flexibility could technically be activated for local purposes. In that case would it provide a value to Distribution System Management? [2] If positive could they be substituted to or compliment grid adaptation? Could DSOs be entitled to procure such flexibility in conformity with their regulated obligations?

WHAT IS AT STAKE FOR DISTRIBUTION?

Two main things are at stake for distributors: the technical impact of flexibility vehicles on the network they manage, and their role in the customer management process.

Technically and economically, Distribution Network Operators are in charge of providing access to the grid with an excellent security, a high level of reliability at an affordable cost. Those missions have been maintained untouched throughout the tremendous regulatory evolutions of the last two decades. However the development of demand side flexibilities brings new interrogation and potentially new risks into the technical field.

How to assess and prevent undesirable load synchronization? Simultaneous activation or deactivation for energy market reasons, of numerous individual loads might, if not properly dispersed on the network, trigger an aggregated load variation on a given portion of this network beyond its design capability, possibly resulting in non-conform voltage, or even damage or premature aging of components.

How to assess and prevent the anticipation/bounce back effect? For each voluntary load modulation there is an alteration of the "natural" load curve before or after the modulation. Before, it's an anticipation of consumption (let's heat up the house before the peak shaving is in effect), after it's the bounce back (let's get back to normal temperature ASAP). Of course these effects depend intimately on the process behind the load modulation (is there any fuel substitution or storage?) and the way it is managed (is it smoothly spread across time and space?). Both effects are known for existing flexibilities, but are poorly or un-known for new developments. DSOs must know where, when and how they are activated to check that there are no undesirable effects on the system either retrospectively or in forecast

How to identify the customers involved in flexibilities and to assess the impact of activations effectively? To assess the consequences of activations of flexibilities on their network, DSOs have to know the localization of those flexibilities. It is then necessary to identify each connection point where flexibilities will be delivered through the DSOs references. Analysis during market rules consultations in France have shown that to ensure this, it is efficient that the DSOs are the entry point for aggregator's perimeters management. Thus DSOs should help aggregators to clearly identify the connection points, qualify them according to market rules and prepare the data needed to assess the quantities curtailed.

DSOs should also be involved in assessment of the curtailed energy, through the provision of metering data for DSOs playing that role and/or through a participation in the assessment processes put in place. That should bring confidence to market players (BRP, suppliers, aggregators) regarding the quantities curtailed and that should help DSOs progress in their comprehension of the effect of flexibilities on the network.

WHAT VALUE FOR A DSO?

Today, when constraints appear, investments are planned to adapt the network architecture to the new energy flows and to reinforce the infrastructure where customers and producers settle. Tomorrow, this solution will be challenged by alternative options offered by smart technologies [3, 4]. Optimal solution may be conventional, smart or a combination of both to optimize jointly the security, quality and costs.

This could prove an opportunity since constraints are likely to be more frequent, more elusive, or more complex to manage due to RES intermittence, mobility of appliances like EVs, and behavior of new usages such as Heat Pumps.

The first challenge will be to represent and forecast power patterns at local level. Demand and intermittent generation forecasting methods are proven and reliable at large scale (country or even region), however the quality and robustness of forecasts get weaker for shorter time (intraday) frame and smaller territory (portion of network).

Improving these forecasts is necessary both for constraints analysis and smart contingency management tools. And it is all the more complex at distribution level that the problems and solutions are not a simple translation of what has so far been done on TSOs networks. They surely are not comparable in numeric complexity, since DSOs may count users and feeders in millions, but neither they are in logic, since Distribution System already incorporate processes observable and controllable by DSO, but will more and more include appliances activated by suppliers on non network logics and local automatism.

The second challenge is the integration of the solutions at local level: reinforcements, modulation of generation, and consumption… in a continuous and consistent management scheme from operation to planning and vice versa. The flexible solutions that will be needed to match this time horizon should also cover different time horizon from real time to a few days.

It will be necessary not only to describe the constraints and solutions in probability, depth and duration, but also to be able to say when, how and under what conditions it is acceptable in planning to delay a reinforcement thanks to a set of flexibilities, without jeopardizing the operations, and when, how and under what conditions in operations the previously designed set of flexibilities is contracted, activated, monitored and economically compensated.

The balance of the trade-off between flexible solutions and reinforcements remains largely to be explored: when does a given flexibility become solid enough to trigger reinforcements delay? Are there flexibility not tradable for reinforcements but still providing operational value to manage out of design situations for example? How much do we need of a given flexibility? Those are but a few of the questions in front of us.

We already know three key parameters for distribution networks: location, firmness and power.

As opposed to flexibility for balancing purposes, flexibility for distribution network must be located close enough to the place it is expected to provide its benefits. That means for example that the lower the voltage level we consider, the smaller the combinations are, and the more sensitive we are to non firmness. This is a key characteristic which has impact on the pool of flexibility, and on the firmness that can be offered by aggregators.

To be substituted to an investment in infrastructure, flexibility should have an equivalent level of reliability, with for some difficulties to offer such firmness if low level of aggregation is possible as explained just before.

Finally, DSOs are interested in flexibility in power rather than energy, as it corresponds to the parameters of the provisioning of their networks.

Technically speaking, the most obvious flexibility interesting DSOs are power modulation both for generation and consumption, and reactive power regulation, provided by large customers or widely enough aggregated. Because these levers could also be used by market actors and by TSOs, the use of these flexibility levers will have to be economically justified in terms of public welfare.

MARKET DESIGN

If flexibility were required, the DSO could procure such services from service providers that would represent one or several, large to small customer/producer.

DSO's activity is regulated and complies with neutrality and transparency obligations as well as obligations that protect commercial and private information of customers and market stakeholders.

Therefore the market design for procurement of flexibility should comply with the DSO's regulated and market neutral activity and fulfill transparency obligations. It could range from tariffs including flexibility, reduced connection fees, local contracts or auction, local market for flexibility (in the form of local balancing markets to solve distribution constraints), depending on the extent of the need and pooling locally, national regulation, and the cost of implementing these new market mechanism.

The market for local flexibility must be carefully designed to be compatible with national mechanisms - through interaction between the DSO and the TSO not jeopardize national generation/consumption balance, and respect BRP's capacity to be balanced -, to fit DSO's granularity in terms of location, power and format, to allow sufficient value locally in order to enable the offer of flexibility to emerge, all whilst remaining cost-effective.

9 economic vehicles have been considered:

- Network tariff as it is the logical economic vehicle for a DSO, although it tends to dilute value that can be accorded to flexibility among all customers, and is not always directly seen by customer (but through supplier price),
- Supplier's Tariff, as they are directly and easily seen by customer,
- National energy and balancing markets, which are already vehicles for flexibility in the system, but not necessarily adapted to distribution localization and granularity,
- Local distribution constraints markets for flexibility in a disruptive scenario, where frequent use of flexibility is required locally,
- Flexibility tenders or contracts, directly between the DSO and Flexibility Service Suppliers, according to precise local needs,
- New connection contracts, with new methodology of calculating fees, taking into account flexibility obligations,
- Bonus for flexibility sold on the national energy market depending on its localization and activation according to DSO's needs,
- Feed-in-tariffs with obligations of flexibility and dispatchability,
- Direct investment by the DSO in flexibility means. This last vehicle has soon been judged non compatible with the DSO role in the market as neutral regulated party, as our flexibility means would be in competition with other market players like generators.

It must be noted that load curtailment by the DSO for safety issues (preventing black-outs) is not incorporated as a "flexibility management vehicle". Flexibility is an alternative to reinforcement in order to maintain the same failure rate – curtailment is a last resort, a form of failure management, to prevent black out when all commercial and competitive levers are out of stock.

EXPERIMENTATIONS

Experimentations are necessary to help us better understanding the use of these vehicles, the role of the DSO, the interactions and consequences for all market actors and the long term economics of such mechanisms.

Smart Grids projects often focus on the first issue which is to better define constraints which may be created by RES or new usages, and to specify the tools and processes the DSO will have to use to manage these constraints and technically make a flexibility service meet a constraint. These projects are thus technical experimentations which give us technical solutions (theoretical merit order of flexibilities regarding a given issue, specifications for provisional network management by the DSO). ERDF is experimenting Smart Grids in 18 projects in France with more than 100 academic and industrial partners.

To ease the collaboration between these projects and other European projects, and to cover both technical and regulatory issues, ERDF is using a methodology well known in the IT industry called "uses cases". This method enables a collaborative writing of specifications with all involved stakeholders.

Several of these use cases deal with both new constraints that will appear on the grid and new flexibility vehicle that may solve. Specifically, five projects develop the following issues that would feed flexibility solutions:

- Smart Grid Vendée use cases focuses on how energy and grid optimization could be managed at a local scale,

- ADVANCED (an European Commission FP7 project) aiming at evaluating and comparing different Active Demand solutions and assess their impact on the electricity system,
- Nice Grid deals with PV integration and active demand, especially with the use of electrical storage at different places in the grid,
- Venteea is located in a rural area, with a high density of wind farms and deals with the issues regarding the integration of these Renewable Energy Sources (RES) capacity in the grid,
- GreenLys (Lyon) use cases are focused on active demand effects beyond and above smart meters.

Experimentations are of key importance to identify DSO's role in adapting existing mechanisms or creating new national mechanisms such as capacity market. They are the perfect occasion to adapt DSOs' tools and processes to enable capacities connected in the distribution grid to participate in these mechanisms. They also allow the DSO to evaluate the impact of these participations on the distribution grid and, if needed, to adapt the rules to prevent the creation of new constraints. For instance, ERDF has worked with RTE (TSO) and the CRE (regulator) on experimental rules to allow capacity from 1 MW (instead of 10 MW in the non experimental balancing market) to participate on the balancing market.

Beyond technical issues, experimentations are also places to test and compare economic vehicles and market designs regarding flexibility and local constraints. Smart Grid Vendée is testing new concepts regarding distribution network optimization, concerted and shared by stakeholders. The project will cover the development and implementation of technical solution, organizational schemes between participants, the adaptation of distribution network at lower cost. Developed in partnership, the project will address the following issues:

- Market design solutions such as RES connection contracts, flexibility tenders and local distribution constraints market for flexibility. TSO and a flexibility aggregator are involved and will particularly focus on these market design issues.
- Integration of the offered flexibility by the DSO and choice of the merit order to solve the network constraints. The use cases include the anticipation constraints, the gathering of the information regarding available solutions, the merit order criteria, the technical solution to activate flexibilities and finally the needed controls on flexibilities.
- Links between national and local mechanism : ensure that national markets do not create local constraints and vice versa (verification that local mechanism are consistent with national markets)

CONCLUSION

Most of the new flexibility resources will be connected to distribution grid. Thus, DSOs should be fully involved to enable these new flexibility services: both to ease the development of new markets and to ensure a sustainable quality of delivery.

But these new resources could also benefit a DSO as a complementary solution to reinforcement. Before selecting and building the optimal market design for this procurement, DSOs must address the following issues:

- What is the need for flexibility, that is to say what are the constraints the distribution will meet and how will they evolve at different timeframes?
- What are the prerequisites for the management by DSO of these flexibilities (tools, smart grids)?
- How these mechanisms integrate with national market design (and vice versa)?
- What are the sound proofs that this is the optimal solution for the public welfare?

The answers to these questions will have major impacts on the choices about market design. This may also explain that choices may be different in different countries, for voltage levels (MV, LV) or for specific types of constraints (higher or lower voltage constraint).

The pivotal question will remain economical i.e. the social value of a new mechanism (regarding the available existing levers, including network reinforcement) and finally the selected market organization.

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