AN INVESTMENT VERSUS FLEXIBILITIES COMPARISON FRAMEWORK

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ABSTRACT

The fast growth of low carbon technologies such as RES or EV has a major impact on distribution networks reinforcement need. At the same time, flexibilities on both demand and generation sides are being developed for system and market use at the moment. Their possible ability to differ some reinforcements is currently investigated by ERDF.

This paper presents the general approach to establish the ability of flexibilities to postpone reinforcement. A special emphasis is given to the techno-economic framework to compare flexibilities and reinforcement. Finally, some issues which need more investigation are highlighted.

INTRODUCTION

When demand (load and generation) is expected to generate lots of thermal or voltage (both high and low) constraints, the conventional planning approach consists in assessing the opportunity to reinforce the network in order to reduce the amount and the severity of those constraints.
The new strategy, considered in this paper, consists in using demand (load and generation) flexibilities to reduce the amount and the severity of those same constraints.

GENERAL FRAMEWORK

The methodology, represented in Figure.1 starts with a traditional analysis on the opportunity of realizing a reinforcement considering the present network and demand and generation forecasts. **Then, if, and only if, reinforcement is justified, we evaluate if that flexibilities are cost effective from a network planning perspective.**

This comparison is made, on the basis of:

- the characterization of the Expected Energy Not Supplied (EENS) without reinforcement in terms of load curve and not only in terms of load probability (this issue will be developed in the last part of this paper),
- an analysis of the availability of flexibilities able to reduce this EENS, depending on its shape and location, (e.g. the number of industrial customers or the number of electrical water boilers in the area, etc.) but also depending on the market and regulatory vehicles the DSO can use to activate the flexibilities and the ability to anticipate the constraints faster than to activate the flexibility,
- the cost of those flexibilities versus the amount EENS they managed to reduce.

The choice has to be made between a network reinforcement or an activation of flexibility to postpone the investment. The criteria used is a cost evaluation which integrate quality of service. If the flexibility is proven to be cost effective, the number of year before an investment is estimated to minimize the cost function. The value for public welfare can be then calculated, as explained in the next part, by addition of the benefits of the delayed investment minus the difference on quality of supply (compared to reinforcement).

TECHNO-ECONOMIC ARBITRATIONS

Techno-economic framework

The aim of every public service is to maximize its cost-effectiveness. When considering network planning, it consists in making the right investment at the right time.
Once estimated non-quality cost (through valuation of EENS, for example) and time preference for present (a discount rate), cost-effectiveness is maximized by establishing the investment strategy that minimizes the total actualized cost (operational costs + investment cost + non-quality cost).

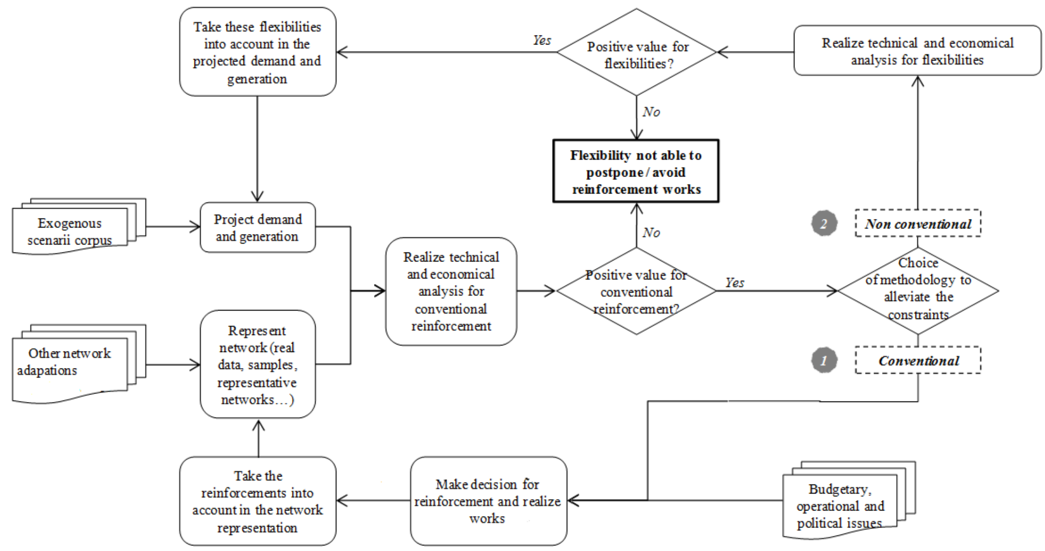

Figure 1. Methodology to analyse flexibilities ability to postpone investment and their values

Application to a single investment

Considering one network reinforcement, reinforcing rather than doing nothing is techno-economically justified if actualized savings of EENS allowed by the reinforcement exceed its actualized cost.[1]

In particular, the optimal year to realize the reinforcement is when annual EENS benefits of reinforcement just become to exceed financial savings allowed by postponing for one year the investment.

In formal terms, n is the optimal year to reinforce if n is the first year for which:

$$\textbf{(1)}\ \underbrace{\Delta C_{R(n)\ vs.\ R(n+1)}(n) = R\left(\frac{a}{1+a}\right)}_{\substack{1-year\ of\\ Reinforcement\\ postponing\ savings}} \leq \underbrace{\Delta Q_{R\ vs.\ DN}(n)}_{\substack{Annual\ EENS\ benefits\\ of\ Reinforcement\ versus\\ Doing\ Nothing\ in\ year\ n}}$$

where R is the reinforcement cost and a the discount rate.

Application to reinforcement postponing with flexibilities

As network reinforcement delivers high level of reliability and consequently high quality of service, in some cases, it might be difficult to reach similar level of quality with the use of flexibilities. Nonetheless, postponing reinforcement thanks to flexibilities can be justified if they offer a better cost-effectiveness, even if they do not deliver the same level of quality.

In formal terms, use of flexibilities can postpone reinforcement if:

$$\textbf{(2)}\ \underbrace{\Delta C_{R\ vs.\ Flex}(n) = R\left(\frac{a}{1+a}\right) - C_{Flex}}_{\substack{1-year\ of\ Reinforcement\\ postponing\ savings\ while\\ calling\ Flexibilities}} \geq \underbrace{\Delta Q_{R\ vs.\ Flex}(n)}_{\substack{Annual\ EENS\ difference\\ between\ Reinforcement\ and\\ calling\ Flexibilities\ in\ year\ n}}$$

where R is the reinforcement cost, a the discount rate and C_{Flex} the cost of flexibilities.

This inequality gives the maximal cost of flexibilities that will allow postponing the reinforcement for a year:

$$\boldsymbol{C_{Flex} \leq R\left(\frac{a}{1+a}\right) - \Delta Q_{R\ vs.\ Flex}(n)}$$

ISSUES TO INVESTIGATE

The need of load and generation load curve forecast

For conventional technical and economical studies, in particular for EENS estimation, load duration curve forecasts are sufficient, as the reinforcement works will be fully available almost every time of the year (except [N-1] situation). Also, as network reinforcements are not "taylor-made" but usually consist in upgrading to the next in range equipment (e.g. upgrading from one 20 MVA transformer to one 36 MVA transformer or two 20 MVA transformers), high precision on the peak forecast is not pertinent.

[1] In order to simplify understanding, differences between investments strategies in terms of operational costs and other non-quality cost than EENS will be overlooked.

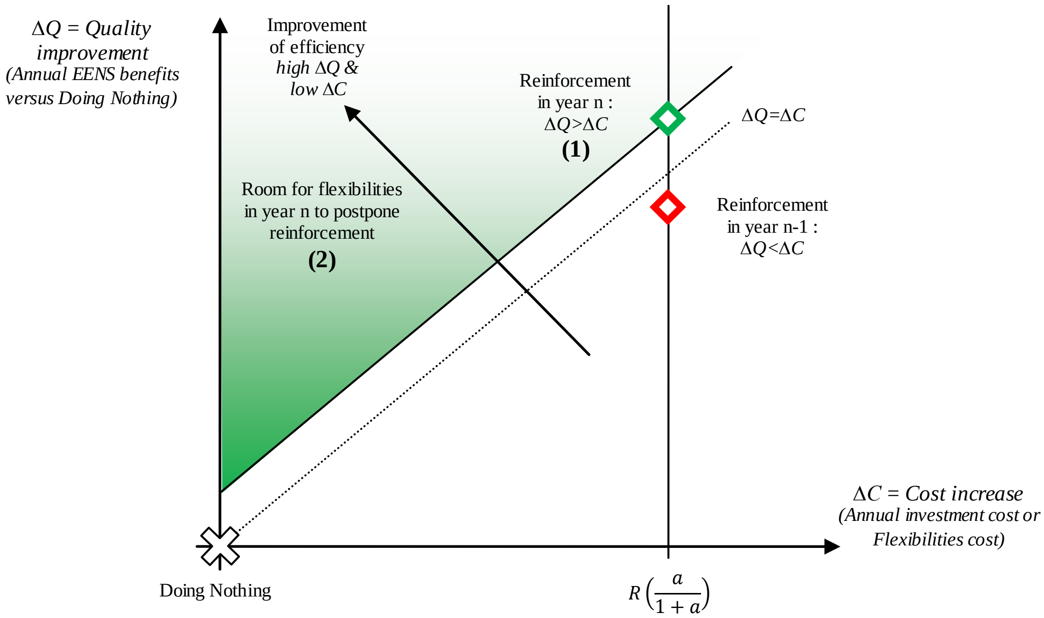

Figure 2. Graphical representation of techno-economic arbitrations

On the contrary, to analyze the availability and the cost of flexibilities improve quality, load duration curve forecasts are not sufficient. Indeed, **a sufficiently precise stochastic chronological load curve forecast approach is necessary** to define the pertinent flexibilities in terms of capacity, duration, frequency, etc. to reduce EENS but also to estimate their cost as they will depends of those parameters.

ERDF is working on a methodology to generate such load curves, taking into account the exogenous and temperature scenario, with a representation of the various possible hazards.

Flexibilities effectiveness in N-1 situation

Some network reinforcements are mainly justified by EENS occurring in N-1 situation. Considering flexibilities to postpone those investments raises the issues of the delay of response. As N-1 situation cannot be anticipated the flexibility will be called once the default already occurred which implies **very short delay of response for those flexibilities**.

Collateral effects of delaying reinforcement

Flexibilities will not have the same effect on the network as reinforcements. For instance, reinforcements typically contribute to network renewal. Moreover, network operability benefits from the low load period for instance to plan maintenance operations. Using flexibilities flattens the demand curve, increasing the duration of loaded periods and reducing both duration and depth of low demand periods. Those impacts should be investigated more carefully to fully understand the flexibility reinforcement arbitration.

Regulatory issues

Beyond technical and economical issues, postponing investment by paying users for their flexibility consists in replacing/delaying a capital expenditure by an operational expenditure. Such arbitration needs an adequate regulatory framework in particular in terms of network tariff design.

Market design issues

As the characterization of the pertinent flexibilities for DSO will become more precise, the choice for an adequate market design to ensure the possibility for DSO to use flexibilities should be easier.

Network planning and management tools

Finally, use of flexibilities should be fully integrated in network planning and management tools to capture their full potential.

REFERENCES

[1] Solène BOYARD, Christophe Gros, Jacques Merley, Céline Salon, Olivier Huet, "Flexibility vehicles for distribution active management", CIRED Workshop 2014, paper 0474