A STEP BEYOND FRENCH DEMONSTRATORS: FIRST APPROACH IN TERMS OF SMART GRID SOLUTIONS INDUSTRIAL DEVELOPMENT. THE EXAMPLE OF VOLTAGE REGULATION SOLUTIONS TESTED IN VENTEEA DEMONSTRATOR

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ABSTRACT

The development of smart grid solutions offers new opportunities for DSOs to ensure continuity and quality of supply in a cost-efficient way. Some of these solutions (physical components, information systems or telecommunications infrastructures/equipments) are currently being tested on the field within national and local projects or experiments throughout Europe. These projects aimed at preparing the transition towards future distribution networks bring together various partners, such as industrials, academics, and system operators – ERDF being one of them.

This paper outlines the process and steps ERDF intends to follow to assess which Smart Grid solutions tested in ongoing French demonstrators or other proof of concept will be industrialised. The objectives of this screening process are to assess from a technical, economic, social, and organisational perspective if some solutions should be industrialised and elaborate recommendations for their roll-out. This paper also details two examples of smart solutions related to voltage regulation and experimented within the VENTEEA demonstrator[1].

INTRODUCTION

DSOs are today facing several challenges which impact the way they manage their networks, such as the growing penetration of renewable energy sources or the development of electric vehicles. Smart Grid technologies bring new opportunities to utilities to face these challenges and continue fulfilling their contractual and legal obligations in a cost-efficient way. In order to prepare the future of distribution networks, ERDF is involved in a series of Smart Grid R&D projects and demonstrators in France and Europe, with more than 100 academic and industrial partners. These projects aim at developing and experimenting innovative tools, materials and processes designed to improve the reliability of the grid, but also cover various issues (technical, economic, sociological, and regulatory). More specifically, these experiments allow the DSO and its partners to deploy “smart solutions” on the field and evaluate their benefits for the system and its stakeholders. These solutions may include physical components (bidirectional fault detector, energy storage batteries…), information systems (probabilistic load flow calculations tool, advanced state estimator…), and telecommunications equipments (radio communications between control rooms and remote controlled switches…).

In order to fully benefit from these experiments’ results and prepare the integration and industrial roll-out of Smart Grid, ERDF will implement two processes (see Figure 1 below):
- the screening of solutions suitable for industrialisation, knowing that only technically and economically valuable smart solutions will be proposed to be industrialised,
- the preparation of their roll-out on the field (roll-out strategy, specifications, volume, ...).

This paper studies the first process, which objective is to help top management and domain experts assess whether smart solutions proposed by Smart Grid projects may be deployed at an industrial scale, and potentially elaborate first recommendations for their industrialisation.

OVERVIEW OF THE SCREENING PROCESS

The screening process is composed of 3 main steps:
1. Inventory the smart solutions tested as part of a Smart Grid project,
2. Pre-select “promising” smart solutions and evaluate their industrial maturity from a technical and economic perspective, based on the results of the experiments and the cost-benefit analysis,
3. Analyse the selected smart solutions to decide if they should be industrialised and elaborate in that case first recommendations, in particular by defining a roll-out target for areas where the solution is needed.

To be generalised, a solution needs to pass 3 steps, which correspond to as many rating levels:
1. The first “step” indicates its industrial maturity on the basis of technical and organisational criteria,
2. The second “step” confirms the potential of the “promising” solution on the basis of Cost Benefits Analysis and new business models assessment,
3. The third “step” validates the industrial roll-out hypothesis of the solution and details the associated recommendations for its industrialisation.

[1] www.venteea.fr

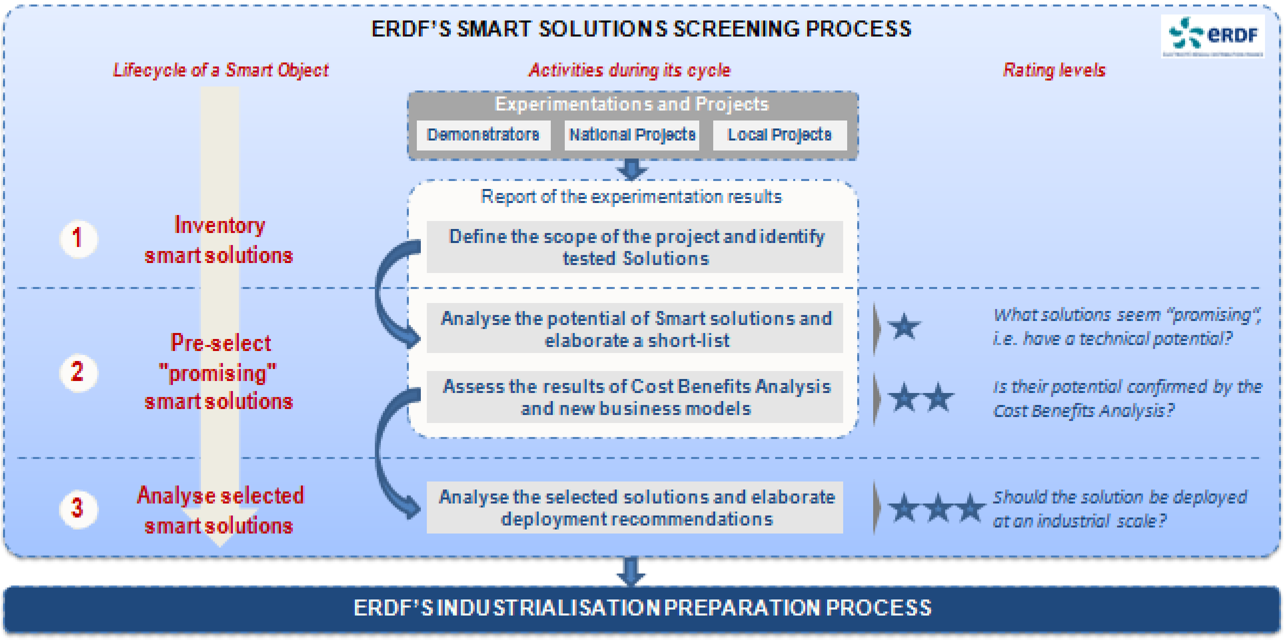

Figure 1 ERDF's Smart Solutions Screening Process

Step 1: Inventory smart solutions tested as part of smart grid projects

The first step consists in starting filling out a report of the experiment results. The document details the scope of the experiment, i.e. the strategic goals of the project, the Use Cases that have been described and tested, the functions and information systems, as well as their maturity and level of integration within the company's computer architecture.

The report also lists the smart solutions (to be) deployed (physical components, information systems, telecoms) and indicates their nature, number, and vendor/editor. This list is then integrated within ERDF Smart Grid roadmap, which includes an inventory of all Smart Grid solutions tested on the field.

Step 2: pre-select "promising" smart solutions

Once this inventory is complete, the potential of each solution is assessed in order to evaluate its industrial maturity and technical value. The goal is to elaborate a short-list of "promising" Smart solutions, meaning that tests of some smart solutions will not always lead to a generalised solution. This analysis is based on two perspectives:
- aspects related to intellectual property rights and risks,
- aspects related to the technical potential of the solution.

Regarding intellectual property aspects, the report indicates existing warranties (is the property unique or shared), whether the solutions will be decommissioned or maintained at the end of the experiment, and if any other experiment or project is testing the same solution.

The technical potential of the solution is analysed on the basis of the following criteria:
- Operability/performance, with an analysis of the solution performance and potential operational incidents,
- Security, with the collection of the experiment technical validation certificates and the reporting of potential security/safety risks,
- Integration/maintainability, with the identification of potential engineering and maintenance risks,
- Contracting, with the assessment of the risks related to contracts with vendors and/or customers.

Each of these criteria is rated in order to help determine whether the solution can be considered as "promising", i.e. should be deployed at an industrial scale. In this case, it passes the **first "step"**. This assessment is complemented by an analysis of the external stakeholders' acceptance and the perceived impacts for the workers on the field in terms of organisation, business process, or skills.

The industrial maturity of the solution is then evaluated by the project manager in close collaboration with relevant national experts from an economic and regulatory perspective, on the basis of the results of the cost benefits analysis and the business models assessment. The analysis of the benefits and costs allows ERDF to evaluate:
- the benefits that would be generated by the roll-out of the solution at a national scale, on different types of networks (rural or urban areas for instance),
- the target cost of the industrial solution, taking into account the cost of the prototype and estimated annual volumes to be deployed.

Finally, the compliance of the solution roll-out with the legal and regulatory framework is analysed.

The potential of the solution considered as "promising" may be confirmed. In this case, it passes the **second "step"**.

Based on the results of the technical and economic analysis, a summary file is elaborated to propose the industrialisation of the solution. The file includes risks reports, experiment technical validation certificates, follow-up actions to be taken at the national and/or local level (such as additional studies, communication plans…), and other relevant elements.

Step 3: analyse selected smart solutions

The summary file is examined with the support of the relevant domain experts. More specifically, the conditions for the transition to an industrial roll-out are analysed according to two viewpoints:

- A technical viewpoint, by identifying the actions recommended to secure the industrialisation of the proposed solution,
- An organisational viewpoint, by studying the impacts on the company's human resources and skills, processes, and organisation implied by the roll-out of the proposed solution.

Regarding the technical viewpoint, the conditions of the solution's industrialisation are evaluated and associated recommendations according to the criteria stated above (operability/performance, security, intellectual property, integration/maintainability, contracting) are elaborated.

Regarding the organisational viewpoint, the impact of the implementation of the industrialised solution on the company's organisation, business processes and skills are assessed, and mitigation actions and measures are proposed (such as modifications in existing business processes or training programs).

The industrialisation of the proposed solution may then be validated, which in this case means that it passes the **third "step"**. Recommendations regarding its industrial roll-out are also elaborated: development of specifications, roll-out targets in order to maximise the technical and economic value of the smart object, industrial policy proposals (search for partners, sourcing, pricing...).

EXAMPLES OF VOLTAGE REGULATION SMART SOLUTIONS

The increase in the penetration rate of Distributed Generation (DG) connected to the distribution network tends to generate operational problems on the grid (voltage rise at the connection node) which might only be solved until now through network reinforcement especially in rural areas. One of ERDF objectives is to deploy new voltage and reactive power regulation and control systems on part of the MV network, in order to mitigate the perturbations linked to the connection of large DG to the distribution grid, improve quality of supply, optimise network investments, and ultimately increase the hosting capacity. The DSO has been experimenting some of these solutions on the field, including within the VENTEEA project.

Experimenting a local voltage regulation system

VENTEEA is a Smart Grid Demonstrator located in the Champagne-Ardenne region which brings up various industrial, academic and research partners. The project aims at creating the best conditions to ensure an economically and technically efficient integration of large wind power plants in medium voltage distribution networks. In this area, ERDF has tested between June 2012 and July 2013 a local voltage regulation system based on reactive power management (see Figure 2), with wind power plants connected to the MV network via non-dedicated feeders. This system consists in a target value set by a reactive power/voltage characteristic Q(U) and aims at maintaining voltage at the grid connection point within admissible limits.

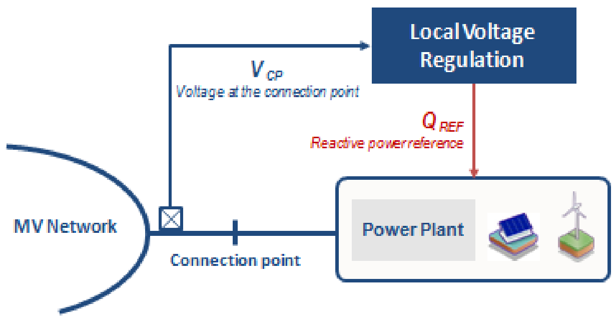

Figure 2 Presentation of the regulation concept [1]

More precisely, a dead band strategy (Q=0) was tested to adjust the voltage at the connecting point of the producer and enable the plant to adapt its reactive power demand in certain operational conditions (in case of voltage constraints). This ultimately allowed to optimise local voltage management together with the DG reactive power demand.

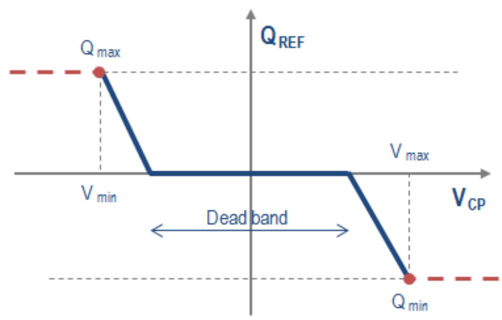

Figure 3 Dead band reactive power management strategy

The law was implemented at the producers' level, in the convertors or the power electronics of the installation. This system was also experimented in the Mediterranean region between September 2013 and December 2014 with photovoltaic producers connected to MV non-dedicated feeders. This second experiment allowed ERDF to fine-tune the voltage dead band values of the law and study the possible interactions between two producers connected to the same feeder.

In addition to this local system, the VENTEEA project is experimenting a centralised voltage regulation system, which consists in a state estimator coupled with a voltage control function. The State estimator evaluates voltage profile along the MV feeders while the Voltage Control Function optimises voltage target values at the primary substation.

Results of the experiments

The results from the field experiments and the technical and economic study confirmed that using local voltage regulation at the MV DG facility's connection point allows to keep the network's voltage within acceptable limits, as well as to optimise the DG reactive power demand [1]. The technical potential of the solution, which was considered as promising, was confirmed.

First of all, the solution was considered as promising from a technical perspective. The analysis of the intellectual property aspects has been performed by the partners of the project and showed that the intellectual property is clear between the partners and does not put any brake on industrialisation.

Besides, the costs-benefits analysis showed that the implementation of such local system presented various benefits for the system, such as the increase of the hosting capacity, the reduction of technical losses for the DSO and the Producer, and the optimised solicitation of DG's reactive power. The figure below shows that the Q=f(U) solution is for ERDF the most interesting solution for new MV producers connections.

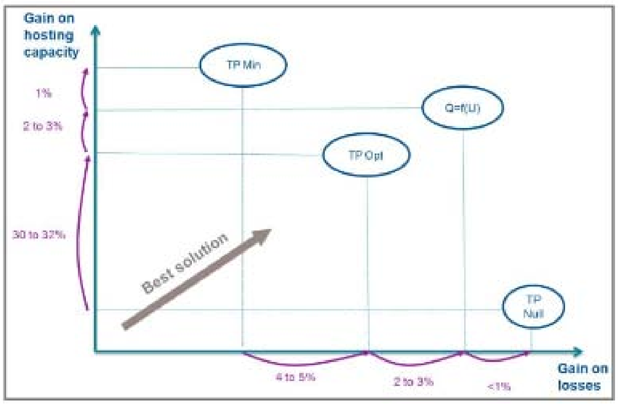

Figure 4 Merit order of reactive regulation laws regarding hosting capacity and technical losses [2]

The local voltage regulation system thus passed the first two "steps". It will be examined by relevant domain experts within the third step of ERDF's smart solutions screening process.

The simplified digital distributed control system: first component of advanced network functions

Another smart solution related to voltage regulation is also being tested within the VENTEEA project, i.e. a simplified architecture for primary substations supervision and control (so called digital distributed control system). This new concept for the adaptation of primary substations to remote control allows enriching the substation observability (with additional and more precise measurements) as well as substation controllability (control of the automation unit of the transformers OLTC) at a reasonable cost. It also contributes to the implementation of advanced network functions designed to solve constraints related to power quality.

The analysis of the solution technical potential showed satisfactory results in terms of operability – no major incident were reported after a year and a half of operation –, security, and integration/maintainability – with only one minor limitation related to the need to train workers on a new type of component, but without impact on existing business processes or the company's organisation.

The solution thus passed the first "step". The next step, i.e. the study of its economic value with costs-benefits analysis, will soon be performed.

CONCLUSIONS AND PERSPECTIVES

The screening process currently being implemented by ERDF allows the DSO to assess the technical and economic added value of smart solutions tested on the field, via a comprehensive and structured approach. This rigorous and precise process allows ERDF to choose which smart solutions have enough technical and economic value to be industrialised. It helps Smart Grid project managers and domain experts ensure that these solutions would bring benefits for the distribution network and several stakeholders of the system if they were to be deployed at an industrial scale, as well as respect certain requirements and warranties in terms of performance, security, intellectual property, or maintainability. The target of roll-out will then be chosen in order to maximise the added value of such smart solutions.

Regarding the VENTEEA project, the steps of the screening process were relevant to study in a rigorous way how various voltage regulation smart solutions may allow the DSO to better integrate renewable energy sources onto the grid, and ultimately prepare the future of distribution networks. The local voltage regulation solution discussed in the second part of this paper, which is compliant with the French legislation, will lead to the publication of a new reference technical documentation in 2015. The implementation of a local voltage regulation system in French Grid Code will be a first step towards a more global DG integration strategy (see B in Figure 5).

A voltage regulation coordination will be necessary between local and centralised regulation (see C in Figure 4). Moreover, a Low Voltage regulation will be tested through MV/LV transformers with automatic tap changers (see D in Figure 1). MV and LV voltage regulation laws' interactions must be studied (see F in Figure 4). Finally, reactive power management at the Distribution and Transmission networks interface will be tested in another demonstrator (see E in Figure 1). The latter solution, for instance, has not yet complied with all the conditions described in the first part of this paper and cannot yet be industrialised.

If at the end of the screening process these solutions were to be considered as suitable for industrialisation (and pass the three "steps"), their roll-out would be prepared by ERDF and ultimately performed by domain experts with teams on the field.

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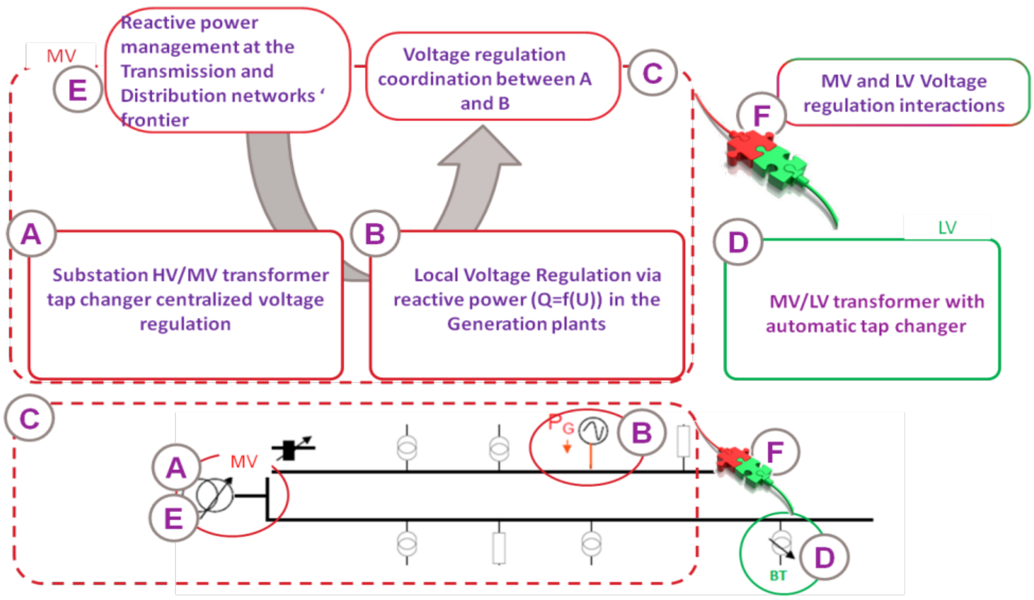

Figure 5 Voltage regulation smart solutions tested