ENEDIS APPROACH FOR THE ROLL-OUT OF TECHNICAL SMART GRID INDUSTRIAL SOLUTIONS

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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. It will help them face the various challenges related to energy transition and answer the expectations from public authorities, such as the development of renewable energy sources and electric vehicles.

This paper details first the approach adopted by Enedis to elaborate and implement its roadmap of Smart Grid technical solutions, from R&D concept to their industrial roll-out. It then describes Enedis roadmap and its two main objectives, which are to modernise network management processes and infrastructures and to provide assistance to stakeholders of the electric power system and regional territories in the French energy transition. Finally, the first industrialised solutions, aiming at bringing tangible benefits for all users of the distribution system, are detailed with their large-scale deployment strategy.

INTRODUCTION

DSOs are today facing several challenges which impact the way they manage their networks. Enedis, the French DSO that is operating 95 % of the distribution grid in France, is particularly concerned by these challenges, which include among others the growing penetration of renewable energy sources onto the grid or the development of electric vehicles. These latter evolutions are changing the nature of power flows. Distribution grid operations are therefore becoming more complex and will have to be more active and dynamic than in the past.

90% of DG are today connected to MV and LV networks in France. In September of 2016, 9.9 GW of wind farms and 5.6 GW of PV plants were connected to the networks operated by Enedis. In October of 2016, 110 000 charging points for electric vehicles were available, corresponding to nearly 670 MW. These volumes will dramatically increase in the years to come as a result of recent legislative and regulatory evolutions. The Energy Transition for Green Growth act, which has been adopted in 2015, has indeed set ambitious objectives:

- ncrease the share of renewable energy sources to 32% of the final energy consumption in 2030 and 40% of the electricity production,
- offer 7 million recharging points for electric vehicles by 2030.

In the context stated above, Enedis has decided to develop Smart Grid solutions [1] to face these challenges, while continuing improving continuity and quality of supply, and fulfilling their contractual and legal obligations in a cost-efficient way. These solutions under development by Enedis also represent opportunities to answer the strong expectations from public authorities, such as the French Energy Regulator (CRE), the Ministry of Ecology, sustainable Development and Energy, the Ministry of Industry and the European Commission.

In order to prepare the future of distribution networks, Enedis 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. All these projects contribute to the development and experiment of innovative tools, materials and processes designed to improve the reliability of the grid. Enedis is currently participating in 19 Smart Grid demonstrators, including 5 European projects. As results of these experiments are becoming available, the DSO is progressively shifting from the experimental phase to the roll-out process.

I. A STRUCTURED APPROACH BASED ON INNOVATION

Enedis has adopted a 3-steps approach to develop a technical base of smart grid solutions (see Figure 1) :

- **Develop and scope new solutions using R&D** studies and start-up innovations,
- **Experiment and evaluate new solutions on the field**, in particular through the programme of demonstrators in which Enedis is participating,
- **Prepare the roll-out of solutions** which are technically and economically relevant, based on evaluations and lessons learned from the experiments.

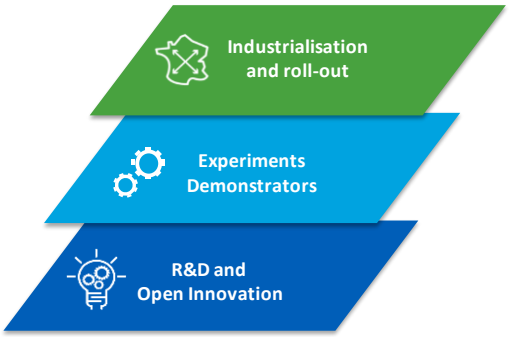

Figure 1 Enedis approach for Smart Grid roll-out

Step 1: R&D and Open Innovation

The first step aims at exploring a large scale of technical possibilities, as well as accelerating experiments using Proofs of Concept. In addition to its R&D programme, Enedis has organised since 2015 contests with start-ups and innovative small-and-medium-entreprises, which may propose innovations to improve network management on various themes (big data & data analytics, new "3.0" connected tools for field technicians, observability and commandibility of the grid…). The solutions are then evaluated by a jury and the most promising ones receive a prize from Enedis.

Step 2: Experiments and demonstrators

The purpose of the second step is to assess the technical and local economic value of smart grid solutions, through experiments on the field. The technical evaluation consists in analysing their performances, security aspects, or degree of integration/maintainability for instance.

Step 3: Industrialisation and roll-out

The results of these tests and analyses are studied in the third phase, for the promising solutions. Then, Enedis coordinates the necessary actions for the roll-out these solutions on the field, which include:

- a cost-benefits analysis on the basis of 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) – and the target cost of the industrial solution;
- the deployment strategy of the solution and the estimated annual volumes according to the cost-benefits analysis,
- the compliance of the solution deployment with the legal and regulatory framework,
- an analysis of the industrial policy (including sourcing, intellectual property...).

ENEDIS SMART GRID ROADMAP

Using this approach, Enedis has elaborated a **roadmap of technical Smart Grid solutions**, to be implemented by 2020 [2] (see Figure 2). The DSO has mapped the most promising solutions according to their level of maturity and their position in the previous three-stage process (R&D, experiment, industrialisation), and defined their implementation trajectory. Made by Enedis technical experts and top management, the roadmap has been validated by the executive committee.

The roadmap covers all business domains (network operations, maintenance, assets and infrastructures) and is built around two objectives:

- **Modernise network management processes and infrastructures**, with predictive maintenance solutions (big data & analytics, monitoring of primary substations…), the improvement of its quality of service using new sensors, data, and automations, and the modernisation of its network assets,
- **Provide assistance to stakeholders of the electric power system or of regional territories in the French energy transition**, with innovative grid connection solutions and processes/automations for facilitating the integration of DRES [3].

To achieve these two objectives, Enedis has chosen an organisation based on a portfolio of projects, with their own governance structure.

The different technical solutions included in the roadmap are listed on the graph above.

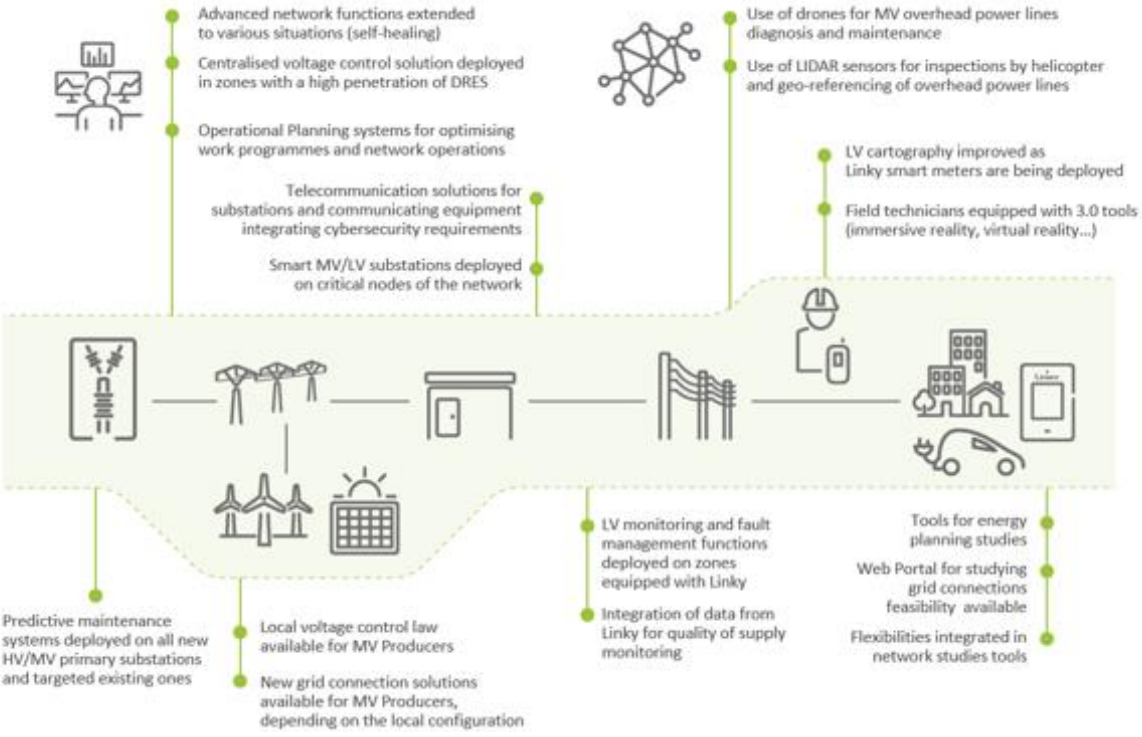

Figure 2 Enedis Smart Grid Roadmap

Objective 1: modernise network management processes and infrastructures

By 2020, Enedis will have integrated **technological advances in sensors, telecommunications, and digital processing**, in order to improve its industrial performance.

Maintenance will become more predictive and adapted to each kind of equipment, based on their health index. Sensors in primary substations, with data monitoring combined to big data models will help optimise maintenance operations. Drones equipped with optical sensors will facilitate the maintenance of overhead power lines. Thanks to enhanced reality and mobile solutions, Enedis staff will also have access to real time information on the field to operate networks more effectively, with higher safety standards.

New sensors, data, and automations will help improve quality of supply for all customers. New sensors and connected objects will be installed in various places on the grid. Network operations will become more dynamic, thanks to the data collected and to an increased number of information regarding the state of the network and assets. New solutions based on the Linky infrastructure will facilitate fault management on MV and LV networks. Advanced network functions will be extended to various situations, to manage fault in presence of important shares of DRES for instance.

Network assets will be modernised and will integrate technological advances (connected objects, LIDAR, data from Linky Smart meters…), in order to be more efficient and to take into account new requirements such as cybersecurity and data protection.

Objective 2: provide assistance to stakeholders of the electric power system or of regional territories in the French energy transition

By 2020, Enedis will have developed **tools and technical solutions to support producers, consumers, prosumers, and regions to meet the energy transition goals**.

Innovative grid connection solutions will be available and adapted to the needs of each user: producer, storage facility, self-consumer, and electric vehicle supply equipment. MV Producers will be able to benefit from alternative grid connection solutions, with lower connection costs and delays in return for the capacity to modulate their power injection in case of network constraints.

Different solutions will be available to integrate production from distributed renewable energy sources. They will enable to manage dynamically network constraints and thus avoid systematic grid reinforcements, thanks to:

- an increased observability of production and consumption power flows which helps identifying potential constraints in operational planning, from annual works programme to real-time operations,
- new means of managing active/reactive power and voltage in order to solve constraints on MV networks, with local solutions or system-coordinated ones,
- reinforced coordination with other stakeholders of the electric power system.

Enedis will support regions in their projects and energy transition. They will be able to rely on new network development tools for implementing urban planning policies. Enedis will help regional authorities to make the most of their energy resources, by optimising the development and the real-time management of the network at a local level.

In conclusion, **by 2020**, Enedis will have industrialised **technical smart grid solutions to achieve the two objectives described above**.

FIRST INDUSTRIALISED SOLUTIONS AND LARGE-SCALE DEPLOYMENTS

Technical Smart Grid solutions already available

Several solutions are already industrialised by Enedis in order to modernise network management processes and infrastructures (objective 1):

- **A solution based on the Linky infrastructure** called “Ping Linky” enables Call Centres to remotely interrogate Linky meters and consequently to distinguish faults on the network from faults inside the house (see Figure 3).

Figure 3 Enedis “Ping Linky” solution

- **HV/MV transformers’ monitoring systems** based on various sensors (hydrogen, temperature…) have already been deployed in 30 primary substations in order to detect anomalies, anticipate failures, and optimise their operations (see Figure 4).

Figure 4 Enedis HV/MV transformers monitoring solution

Drones can be **operated by Enedis** staff to facilitate the maintenance of overhead power lines and punctually examine an asset hardly accessible from the ground, or make a diagnosis more quickly (see Figure 5).

Figure 5 Drone operated by Enedis for MV overhead power lines maintenance

- **Advanced network functions** (FLISR SCADA System) for MV networks have been extended to manage faults in presence of Producers and deployed in more than half of Enedis Regional Dispatching Centres (see Figure 6).

Figure 6 Enedis advanced network functions

Enedis has also rolled-out solutions to provide assistance to stakeholders of the electric power system or of regional territories in the French energy transition (objective 2):

- A **local voltage regulation system** based on reactive power management is available for MV Producers since February 2016 to better integrate renewable energy sources onto the grid. This Q=f(U) law consists in measuring voltage at the point of connection and calculating reactive power absorption level, in order to lower voltage and respect contractual limits. It is integrated into the inverters or wind farm machines (see Figure 7).

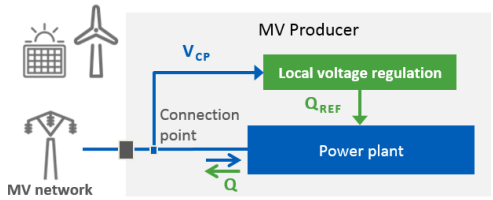

Figure 7 Enedis local voltage regulation solution

- An **operational planning system** consisting of forecasts, load flow calculation tools, and coordination portals has been deployed in all Enedis Regional Dispatching Centres to optimise work programmes with MV Producers and the TSO. It is based on a load and generation forecasts system deployed at an industrial scale. The DSO will be able to programme works in the MV network by taking into account MV producers' periods of low generation power and TSO works programme (see Figure 8).

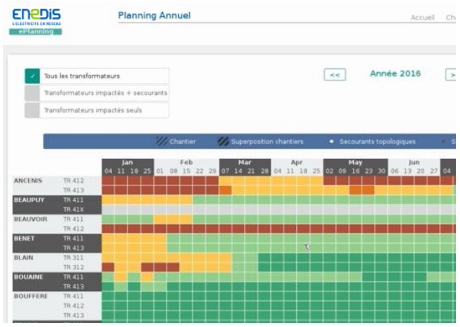

Figure 8 Enedis internal coordination portal for works programmes

Large-scale roll-out on different areas

The **deployments will be based on the regional needs, thanks to adapted technical solutions**. Smart Grid solutions will be rolled-out where their technical and economic value is optimal, depending on their use case(s), the type of network (rural/urban), and their associated costs and benefits. Industrialised solutions will be deployed at a national level or at a local one, in specific situations.

These solutions will be deployed in two large-scale industrialisation pilots adopted within the French Electric smart grid programme "REI 6", for a New industrial France and decided by the Ministry of Industry. The projects are Flexgrid in the West of France and SMILE in the South East of the country. They will start in mid-2017. They will rely on a basis of technical solutions for the network, as well as the collection and use of data, various projects with regions, and local optimisation of their electrical resources.

The large-scale roll-out aims at preparing and testing the integration of solutions onto Enedis networks, as well as the staff ability to use them, thanks to relevant training programmes. Lessons learned from REI6 will help consolidate a first level of Smart Grid at a national scale by 2020.

CONCLUSION

Enedis has started the industrialisation of Smart Grid solutions, by capitalising on lessons learned from first demonstrators before the end of all demonstrators in which Enedis has participated. **The DSO is already implementing its Smart Grid roadmap and has rolled-out first industrialised solutions**, using a three steps structured approach (R&D, experiments, roll-out preparation).

This **approach is dynamic** since the duration of each step

may change from one solution to another, according to its simplicity/complexity of implementation.
Moreover, new solutions may constantly emerge and become part of the industrialisation process. **Enedis Smart Grid roadmap is continuously enriched** with new use cases and new solutions. Among new solutions, the use of flexibility levers to solve network constraints is currently studied and will be tested in local experiments.

Besides, the industrialised technical solutions constitute a **pillar for smart grid offers to customers** (producers, consumers, prosumers, customers with storage).

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