SMART ISLANDS, LABORATORIES OF SMART GRID TECHNOLOGIES

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ABSTRACT

Islands are territories with specific characteristics, which make them ideal laboratories to test, demonstrate and deploy smart grid components and systems so that these technologies can be deployed at larger scale in the continental European grid.

INTRODUCTION

Smart grids are very much bound to new paradigms in the balance of the system increasingly impacted by sustainability issues. In island territories, the electrical system is impacted by very specific aspects that should be dealt with carefully in order to guarantee its stability while keeping the safety and the security of the grid and the quality of its operation. Due to its geographic features, physical connections to other electricity grids are not possible or very limited and so are the opportunities of benefiting from interconnections that could ensure higher security and reliability. In addition, efforts are made to reduce the carbon footprint incurred by the current fossil fuel plants used. In this respect, the main French overseas departments and Corsica are privileged areas for the deployment of renewable energy such as geothermal, biomass, hydraulic, marine energy, wind and solar plants. However, some of these energy sources are intermittent sources and high penetration rates can endanger the stability of the grid. Finally, the consumers should be considered as a critical element of the system, even more than in continental grids, since the electricity demand is usually growing faster and the social environment is very sensitive.

Fig. 1 - French non-interconnected territories

A VERTICALLY INTEGRATED ORGANISATION WHICH FACILITATES THE DEPLOYMENT OF SMART GRID PROJECTS ON THE ENTIRE VALUE CHAIN

French non interconnected areas benefit from an economic and organisational model which is adapted to the islands characteristics. The territories operated by Electricité de France (EDF) in the Island Energy Systems (SEI) benefit from tariff equalisation with continental France: the tariffs in these zones are the same than those in continental France although the production costs are much higher. The market organisation is based on the single buyer model keeping competition at production level. An integrated structure guarantees the management functions for supply-demand balance, network operator functions and supplier functions in accordance with the derogations foreseen in the European Directives (the obligation to unbundle transmission and distribution to a separate legal entity from the one generating and supplying the electricity does not apply in these specific cases).

Smart grid benefits are located at the different levels of the electricity value chain while most of the investments are needed at the distribution level. Hence, the vertically integrated organisation simplifies the business cases of smart grid projects.

In the territories operated by EDF SEI, a comprehensive smart grid approach has been defined in order to address these great energy challenges. It takes into account the specific context of island territories and includes a series of actions aiming at:

- integrating intermittent renewable energy while ensuring the balance of the network,
- deploying energy storage systems at various voltage levels,
- enabling the deployment of demand side management and demand response,
- encouraging the deployment of innovative offers and services from the energy suppliers that meet the customers' needs and behaviours,
- piloting and monitor the power grid and increasing

its resilience,

- anticipating maintenance efforts and maximizing grid performance.

BEST PRACTICE FROM SMART GRID DEMONSTRATORS

Two years after the start of the smart grid approach in overseas departments and Corsica, about ten projects are on-going with new projects in preparation.

First results and hands-on experience are currently being collected among different projects in the deployment phase. Among the different projects, a classification could be made as follow:

- **Type 1** project concerning refurbishment or renewal of old equipment or systems for smarter ones like the on-going renewal of EDF SEI SCADA systems,
- **Type 2** project imposed by external causes, like the growth of intermittent energy sources boosting the deployment of a real-time metering system to control the share of this sources in the production mix (Push system),
- **Type 3** project responding to industrial opportunities (Sigma project),
- **Type 4** dedicated to a voluntary anticipation of the future and the test of possible future new solutions (Millener, Pégase, *etc.*) [1].

Need for a vision of Telecommunication and IS

These projects are strongly connected with the development of information and telecommunication systems. The objective is to get coherent and flexible systems enabling the access to a resilient and well-matched support for all projects. The issue is complex for several reasons including:

- nobody starts from scratch and the evolution needs a progressive road map consistent with operating systems,
- it is difficult to know in advance all the data exchanges that may create added value ,
- standardisation of data exchanges is a long term process. Meanwhile, proprietary IS are proposed by vendors but might be binding for the future,
- telecommunication quality of services is needed,
- tools enabling data exchanges are management tools (CRM, Billing, *etc.*) but also operational tools (SCADA, AMM, *etc.*). In that field, needs for tertiary and industrial operations are getting closer and closer.

This crosscutting reflexion on telecom and information system is a "*must have*" to build a smart grid program. For EDF SEI, the first step is to build a strong telecommunication backbone between all its primary substations and to foster the ability of its information system to exchange data between applications.

An integrated system tested on Millener project

The Millener project is focused on residential customers and has two targets:

- the first one is to work on residential customers demand side management and power demand,
- the second one is to facilitate integration of renewable energy through storages installed in residential houses.

As mentioned earlier, this project is an example of a type 4 project. It is funded by Europe, France and the regions of Corsica, Guadeloupe and La Réunion. The partners of the project are EDELIA, BPL Global, Delta Dore, Tenesol, Sunzil, Schneider Electric, SAFT and EDF as a leading partner.

Since the end of 2012, energy gateways are being installed with a target of 1 000 by the end of 2013. Connected with the system control room, these boxes are monitoring and controlling client's equipment (electric heaters, air conditioning units, water heaters…) to help to maintain balance of the network (frequency, power at period of peak demand...). Simultaneously, information will be delivered to the customer on its consumption in order to raise his awareness on energy conservation.

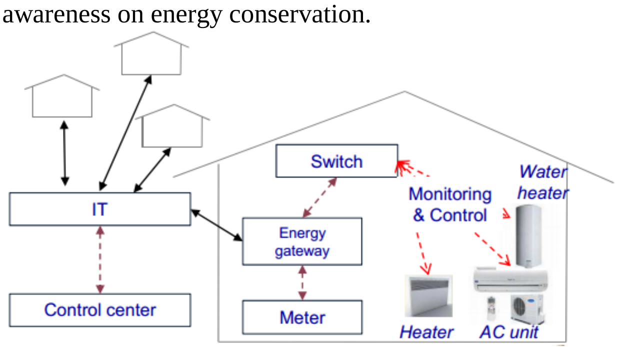

Fig. 2 - Millener energy gateway configuration

The second type of system associates photovoltaic systems (3 kWc/home) with storage devices (Li-ion battery of 6 to 8 kWh), customer load management system, and communication and software systems enabling the direct control by the dispatching centre of all these aggregated loads and photovoltaic productions. This system is planned to be deployed in 500 residential houses from mid-2013. It allows to shape the electricity produced by the PV panels, contributes in maintaining the balance of the network (frequency, power at period of peak demand…) and enables the client to consume mainly its own electricity and have access to energy during a cut-off. Although there are already some customers ready to experiment the solution, the whole system is tested in EDF labs.

This first phase already brings some feedback:

- Finding voluntary clients should not be underestimated ;

- Deployment potential is limited by several aspects including technical ones ;
- Customers may understand the interest of such a project and will agree to be implied if there are interests without much constraints ;
- Clients are generally suspicious when contracting for experimentation. The conditions of the end of it have to be clearly defined in the contract.
- Due to regulation rules, solutions should be found to incentivize clients without using tariffs ;
- It is important to take into account local habits and the recruitment phase brings a lot of information especially on how to approach clients depending on cultural particularities (awareness for environment questions, attraction for new technologies, *etc.).*
- The experimentation brings useful exchanges between manufacturers and utility in order to propose future solutions that will work economically.

VERT project: study of the conditions of charging electric vehicles (EV)

In islanded territories, electricity generation relies, still for some years, mainly on fossil fuel-based plants which emit greenhouse gases. Hence, the deployment of electric vehicles has to be carefully handled in order to guarantee the overall environmental objectives. EV project can be considered of type 3, responding to a possible external change. In this context, VERT on La Réunion will study how to charge EV in a way free of CO2 emission, for instance with PV parking shade structures.

The project started at the end of 2012 and is gathering the following partners: RENAULT who is leading the project, SUNZIl, SCHNEIDER ELECTRIC, ADAMELEC, TOTAL, GBH et EDF. It is addressing professional fleet of vehicles. This project is funded by Europe, France and the region of La Réunion.

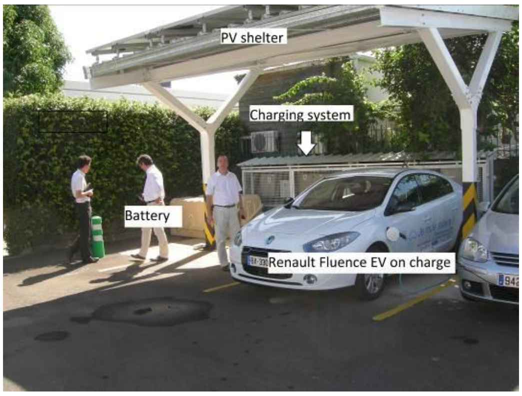

Fig. 3 - VERT PV shelters installed in EDF Reunion facility

Anticipating the beginning of the project, EDF has installed parking shade structures with a buffering battery in his facility (fig. 3). The objective of the system is to work by its own, without using the grid. Two electric vehicles were lent by Renault. Vehicle reservation, geolocation and local measuring systems gave some information regarding the use of the charging system. It showed that the system can work without needing any energy from the network.

The average distance covered during the experimentation is generally less than 30 km. There is still a lack of confidence of users in the higher autonomy capability of EV. The number of users/day observed is also lower than the average one observed for thermal vehicles. In this situation, the PV shading system and its buffering battery are not sufficiently used and the challenge for the following is certainly to obtain that people use EV as they would do with classical thermal ones.

SCADA project: monitoring and control of the grid

The SCADA (Supervisory Control And Data Acquisition) system is a dispatching software which controls the entire network. It is equipped with modern means of monitoring and controlling the grid. This new dispatching information system will better take into account distributed and intermittent energy and controllable load.

In fact, four deployments are scheduled: first system in Réunion Island, then French Guyana, Guadeloupe and Martinique with an option for a fifth in Corsica to be decided later.

For EDF SEI, the first step is to replace the current SCADA with more or less the same functional perimeter without discontinuity in operation. When this will be done, a second stage will start to take more advantage of this new tool by integrating new functionalities as mentioned above. The new system (Alstom e-terra solution has been selected) is currently being adapted to EDF SEI’s needs: specific requirements, interface with existing systems, e*tc.* while parallel projects are going on in each territory. The objective of these projects is to fulfil the requirements needed for the new system: erection of a new building or adaptation of existing one, upgrade of telecom and telephone system (including adaptation to IEC 870-5-101 protocol), installation of redundant broadband links between the main dispatching and the emergency one, rationalisation of tele-information plans and update of geographical information system, *etc.*
All this is dedicated to ensure a seamless change on dispatching tool and prepare the future development of smarter functions as self-healing one in medium voltage network. This phase could take progressively place in five to ten years especially where the added value will appear to

be maximum and able to bring a reasonable payback time. The first phase of the project may be considered as a type 1 project while this second phase will be a type 4 project.

Sigma

During peak period, the dispatcher starts expensive means of production or even to cut off some feeders to keep the balance of the system. To avoid this, some contracts have been signed with big customers equipped with their own means of production (generally diesel engine) or able to postpone their activity to disconnect from the grid when asked. To evaluate the variable part of the remuneration based on the actual reduction of customers' electricity consumption, a control is made periodically through their load curve analysis coming from the metering system.

Fig. 4 - Sigma Tele-control box enabling the automation of the shedding process by the customer facility

EDF in Martinique, like in other islands, has concluded those types of contracts for many years. In the sigma project, a platform was developed for the dispatcher to automatically send requests of load reduction (up to one hour before the event), choose where the load reduction should take place (congestion management), get information on the load effectively curtailed (thanks to a link with the metering system) and build a return of experience.
The platform also gives to the customer a view on the load really shaded, a vision on the past events and a means to follow the payback earned for that. He can naturally use the platform to declare his unavailability for load shading.
A tele-monitoring option has been developed and tested at the end of last year (see fig 4) to automatically disconnect clients with backup generators. In that case, it is really important to test the complete technological chain before starting to propose the option to customers. In Martinique, this smart grid project might be considered as type 3.

SCALABILITY AND REPLICABILITY OF SMART GRIDS PROJECTS IS A KEY ISSUE

The scale of these projects enables to test the different components and systems in the field in strenuous environmental and operational conditions, while reducing the impacts of possible failures of integrating these systems into an existing infrastructure. Expected key outcomes of these projects are:

- to gather hands-on experience with new smart grid architectures in preparation of larger scale deployments,
- to help grid operators and suppliers optimize the requirements and design of these systems, hence the cost of large scale deployments,
- to propose and refine innovative business models and regulations enabling the deployment of these systems at acceptable costs for all stakeholders.

To evaluate the scalability and the replicability of these projects, their benefits such as level of sustainability, security and quality of supply, efficiency and service quality, *etc.* have to be properly measured. To complete the evaluation phase and provide quantitative feedback, key performance indicators should be defined from the very beginning and then calculated with the data collected throughout the project.

In French overseas territories, the locations chosen for implementation of the smart grids technologies provide various influencing conditions: population, climate, technical constraints, *etc.* This will help issuing more comprehensive final results, in terms of scalability and replicability potential in continental Europe.

CONCLUSION

In all, the first results from the projects carried out in French overseas territories show that islands are very interesting locations to demonstrate smart grid technologies interest in the field, and that the experience gained from these projects could be replicated in continental remote areas or extended in future large scale deployment.

REFERENCES

[1] N. Buriez, 2012, "WILL SMALL-SCALE PV CONTRIBUTE TO FRENCH INSULAR GRID OPERATION ?", *CIRED Workshop - Lisbon 29-30 May 2012*, Paper 261