WILL SMALL-SCALE PV CONTRIBUTE TO FRENCH INSULAR GRID OPERATION ?

Nicolas BURIEZ
EDF SEI – France
nicolas.buriez@edf.fr

Joseph MAIRE
EDF SEI – France
joseph.maire@edf.fr

Yves BARLIER
EDF SEI – France
yves.barlier@edf.fr

Stéphane LASCAUD
EDF R&D
stephane.lascaud@edf.fr

ABSTRACT

In the French overseas territories, PV production is no longer marginal and does play an important role in the balance of the system : in case of intermittency, the risk of blackout is a real issue as the insular electric systems are small and could not rely on interconnections.
To prevent such a failure, the operator is allowed to disconnect part of the intermittent renewable production when the percentage of this production is reaching 30% of the total production. A monitoring system has been installed to control this limit.
By 2020, renewable energies should provide 50% of the electrical insular needs. In addition to the development of non intermittent renewable energy sources (biomass, geothermal, hydro...), solutions should be found to integrate a higher percentage of intermittent energy sources: several innovative projects have been launched like Pegase and Millener projects. The purpose of this last pilot project is to contribute to:

- *the improvement of the integration of private household renewable energy sources within the system ;*
- *the enhancement of the stability of power grids by real-time electricity supply and demand balancing;*
- *the development of enduring economic mechanisms to achieve endogenous development and energy self-sufficiency whished locally.*

All these projects are aiming to transform the PV production (including the small one) into a real contributor to insular grid operation in a mid to long term perspective.

SITUATION

EDF – IES (Island Energy System) is the Direction of the EDF group responsible for the electric supply of Corsica and the French overseas departments and authorities of St Pierre and Miquelon, St Martin and St Bartelemy.
The organization of the electricity market in these territories was designed to fit the geographical, economic and social characteristics of these isolated or poorly interconnected networks and guarantee public services.

In these islanded networks, EDF-IES generates, buys, transmits, distributes and sales power. IES is a vertically integrated company and has the monopoly of the transmission, distribution and supply of power. Only the generation sector is liberalized, and IES is the single buyer of electricity in the islands.

For years, EDF IES has been developing and implementing strategy based on two pillars: proximity with its customers and sustainable development. Due to their particular situation, islands appear as front runners for smart grid issues :

- The kWh produced is often expensive and its CO2 contents generally high, opening interesting perspectives for energy efficiency policies and the development of renewable energy.
- The electric power system is more fragile and insertion of local energy intermittent sources is more difficult. This leads to a special interest on smart mitigation techniques, load management and storage.
- The customers' involvement is probably easier to gain in an islanded context.

Resulting from specific strong incentives, the PV penetration level in the French overseas territories is really higher than in mainland. In these islands, PV production is no longer marginal and does play an important role in the balance of the system. For instance, in La Réunion Island and Guadeloupe, it may already reach 30% of the global production in the middle of the day during certain periods of the year. Beyond this limit, in case of intermittency, the risk of blackout is a real issue as the insular electric systems are naturally very weak because of their small size and the lack of-power interconnection.

FIRST APPROACH TO MANAGE INTERMITTENT PRODUCTION

Monitoring Dispersed production : Push system

Due to this weakness, a decree has been issued on the 23 rd of April 2008 enabling the system operator to disconnect intermittent power productions as soon as the active power injected by them is reaching 30% of the total active power needed by the island.
To be able to proceed to such disconnections, the system operator need to have a real time view on the production share. The Push system should enable to measure at a 5 min interval the ratio of the sum of the total intermittent power produced to the total power produced. This system has been developed with Itron.

A meter is installed by every producer having a production power above 36 kVA. Every 5 minutes, this meter sends the value of the power produced to the dispatching through a private APN using GPRS. There, an information system sums the power produced by the different category of equipment, evaluate T the average total power produced during the period and compares it with R the average total power produced by intermittent renewable energy sources (fig 1).

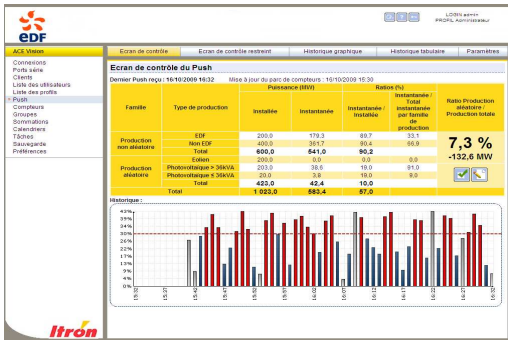

Fig 1 : Screen of ACE vision, the ASAIS software enabling the dispatcher to follow the percentage of production coming out of intermittent renewable sources.

When R > 30% T, a visual and acoustic alarm is generated and an application is helping the dispatcher to choose the production that should be disconnected. The first producers disconnected are the more recent ones who were aware on this risk when contracting for their connection. The disconnection is made individually for solar plants with a power over 1 MW, and by groups for the others corresponding to PV blocs of power.

To disconnect sources, an individual signal is sent to big solar plants and a low frequency PLC signal is sent to other ones, with a code indicating the bloc of producer that should be disconnected. All the producers are equipped with a RTU system able to collect this signal and to automatically and safely stop their production.

Naturally, there is a need to pass through this limit in the mid to long term perspective and to find a way to make value out of this production for the system. That is why several R&D project described below have been launched.

Pegase project

EDF IES and its R&D division were involved since 2006 in energy storage by exploring how to use this new technology to increase electric system flexibility. The EDF's NaS battery project started in 2006 and ended in November 2009. The aim was to install and commission 1MW sodium sulfur (NaS) energy storage system in the Reunion Island. It has required numerous works such as economic analysis to determine storage value in the Reunion Island energetic mix, functional specification, call for tender, commercial discussion, risk analysis to anticipate all the types of possible incidents (hurricane, flooding, sugar cane fire, worsening, lightning…) and work on accidental scenarios, civil and electrical work, acceptance test at manufacturer factory, dangerous goods transportation from Japan to La Reunion, tutorial to maintenance team, commissioning.

The NaS battery has been supplied by NGK Insulators (Japan) and is built by assembling 20 50-kW battery modules as depicted in the Fig. 1. It is capable of storing about 7.2 MWh of electricity, with a 1,2 MW charge and 1 MW discharge process. Since December 2009, the NaS battery has done more than 550 cycles for 2300 MWh delivered to the grid as shown in Fig.2. The NaS battery is used for daily load shifting. It means that charge is made during night and afternoon and discharge in the evening and at noon during austral summer.

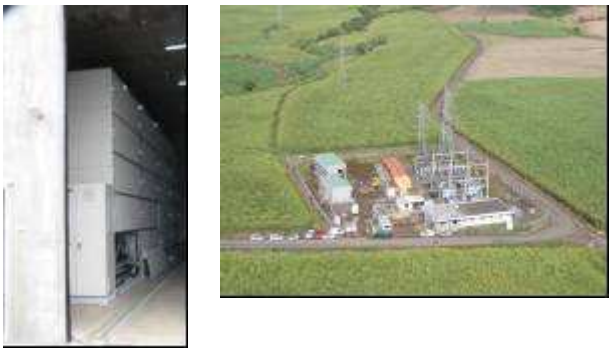

Fig.2: NaS battery module stacking. Internal view of the building. Substation view with the NaS battery and power conditioning system blocks.

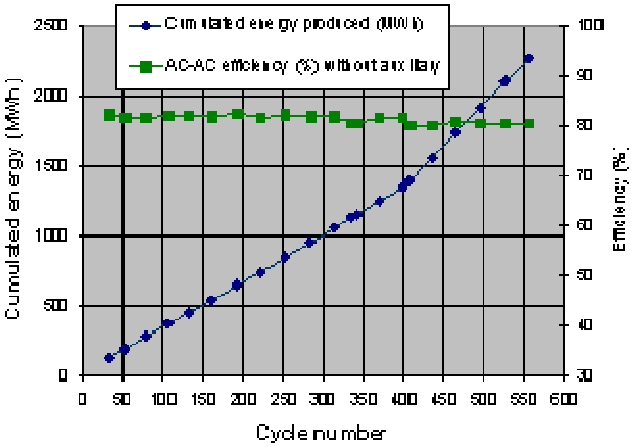

Fig.3: Cumulated energy and AC-AC efficiency of 1MW NaS battery under operation at la Reunion Island.

As photovoltaic production is purchased under feed in tariffs, it has the highest priority in the dispatch merit order and conventional combustion plants have to decrease their power to match the demand offer equilibrium. It leads to a lack of primary reserve (as conventional production is lowered) without any participation in frequency control by the photovoltaic production. In case of a sudden outage, as the frequency is lowering fast, this latter can decrease faster if the photovoltaic power plant's decoupling device is triggering

leading to an automatic load shedding to avoid frequency collapse.

Moreover, as PV or Wind power are difficult to be predictable, conventional production like hydro plant, diesel engine and turbine combustion engines must follow the electric power variability which can fluctuate up to 50% of the total installed capacity in few minutes. This situation leads to an unbalance of their economic optimization. Fast response energy storage facilities could therefore mitigate the photovoltaic power output fluctuation as Wakkanaï NEDO facilities demonstrated recently. [1]

EDF launched in 2011 Pegase demonstration project in order to tackle grid stability issues caused by a large-scale PV and Wind power generation system connected to the grid. This project aims to test capability of NaS to:

- Smooth or schedule PV farm (2MW and 10 MW see Fig.4a) and wind farm (see Fig. 4b) combined with day ahead and intraday forecast.
- Supply frequency regulation and spinning reserve.

Fig. 5a: 10 MW wind far Fig.5b: 2 MW PV farm

The following activities will be investigated

- New methods for day-ahead forecast renewable energy (PV or Wind) generation. A statistical model based on historical hourly solar power generation and numerical weather forecasts from the European Center and Meteo France with high spatial resolution will be developed. The performances will be analyzed in terms of forecasting errors according to the different spatial and compared to those obtained by a reference model based on historical means.

- New method for intraday forecast photovoltaic generation. Different ways will be explored to set up intraday forecast (up to 3 hours) by on-site sky imager and satellite image coupled to image analysing and RE production recorded. A real time meteorological sensors and sky imager network surrounding the La Reunion Island will be installed to generate a data flow able to feed PV intraday forecast software.

- Mathematical modeling and software will be developed to schedule a day ahead RE & storage plan production taking into account dispatch constraints like maximizing evening production, minimizing impact of RE generation forecast error and managing long term storage state of charge. A intraday optimization model and software will be developed to update every ½ h the RE & storage production plan with the intraday forecast.

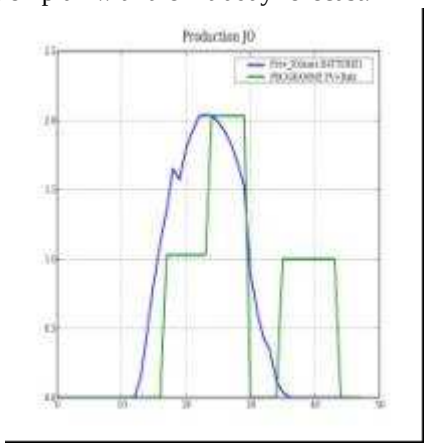

Fig.6: Day ahead PV forecast and production plan

- Development of a scada and information system for collecting in real time RE farm and storage generation datas.

- Development of an output control technology to suppress fluctuation and stick to the schedule production plan with lowest error.

Pegase project is carried out through collaboration with French national meteorological agency and dynamic meteorological laboratory.

At first move, the project is more dedicated to bulk renewable plants but the forecast approach and the optimization results can be used with some adaptation for the smaller installation such as the one planned in the Millener project.

MILLENER PROJET

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 settled in residential houses

The whole project will include behavioural studies.

This project is funded by Europe, Regions and French State (the European Union, the Regional Councils of Corsica, Guadeloupe and La Réunion and the French state).

Main project goals

One of the pre-selected projects in the ADEME demonstrators' call for tenders [2], MILLENER is dedicated to the French islands' small customers. The goals of this project are :

- The development of methods and tools that could enable the integration of more distributed renewable energy sources at residential customer level through storage.
- In the context of fragile small island systems, the development of methods and tools to manage power demand (peak shaving) and energy demand.
- The study of customer's behavior regarding energy management boxes and displays, consumer devices and smart appliances.

In this context, it is expected to search and define appropriate conditions to:

- Maintain the balance between supply and demand in a small and isolated electric system.
- Fight climate change by decreasing carbon footprint through:
  - A higher integration of intermittent renewable energy sources in the production mix of an island,
  - A reduction of consumption, by improving customer information on costs and devices;
- Achieving a better involvement of customers on a long term basis regarding energy savings.
- Optimize power flow through existing assets to enable an high level penetration of intermittent local energy sources

Description of the project

The MILLENER project will cover in three territories the following solutions:

- in the Mediterranean island of Corsica 450 Energy Management Box solutions managing home devices such as electric heating system, electric hot water, etc.;
- in the Indian Ocean island of La Réunion 500 Energy Management Box solutions managing home devices such as air conditioning, cooling systems, electric hot water, etc.; 100 of these solutions will also be installed in the Caribbean Island of Guadeloupe
- in La Réunion, in Guadeloupe and in Corsica 500 photovoltaic systems associated to storage devices will be installed ; Fig. 7 shows such a system;
- in each island, communication and software systems enabling the direct control by the dispatching center of all these aggregated loads and photovoltaic productions.

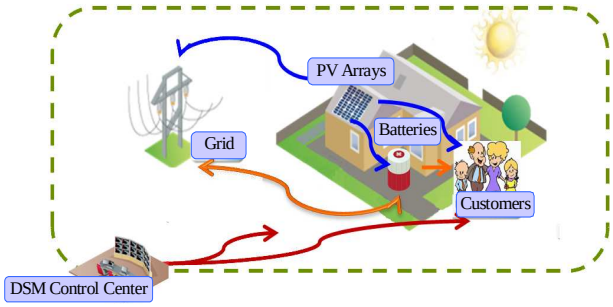

Fig. 7 : Combined PV and battery storage system

Project partnership

The partners of the project are :

- EDELIA: provider of Consumption measurement solutions and energy efficiency services;
- BPL Global: provider of smart grid energy software solutions for utilities;
- Delta Dore: manufacturer of products and services related to energy management and efficiency;
- Tenesol: provider of photovoltaic systems;
- Schneider Electric: provider of products, services and solutions for electricity distribution;
- SAFT: provider of storage devices;
- EDF SEI : EDF Division which manages overseas territories electricity systems and coordinates the project
- EDF Research and Development.

CONCLUSION

Through the development of Renewable monitoring system, the improvement of forecast tools, the merging of smart storage operation, and a better knowledge on the behaviour individual customers (including PV prosumers, Demand Side Management and power demand), EDF SEI is aiming to prepare a future where PV production and smart devices may become real contributors to insular system operation in a mid to long term perspective.

REFERENCES

[1] "Verification of Grid Stabilization with Large-scale PV Power Generation Systems" of the New Energy and Industrial Technology Development Organization (NEDO) new energy development program

[2] "APPEL à MANIFESTATIONS D'INTERET (AMI) DEMONSTRATEURS de RECHERCHE en NOUVELLES TECHNOLOGIES de l'ÉNERGIE (NTE) Réseaux et systèmes électriques intelligents intégrant les énergies renouvelables, Edition 2009