FLEXIBILITY FOR DSO ON A LOCAL SCALE: BUSINESS MODELS AND ASSOCIATED REGULATORY QUESTIONS RAISED IN THE INTERFLEX PROJECT

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ABSTRACT

The use of flexibilities for the needs of DSOs raises new questions.

This article tackles some of the major issues regarding the use of flexibilities for the management of embedded microgrids or islanded electric systems. The solutions currently investigated within the InterFlex project, are put into the perspective of the French energy regulator's analysis.

THE USE OF FLEXIBILITIES, A SOLUTION TO COPE WITH THE NEW CHALLENGES THE DSO ARE FACING

The electricity system is currently facing disruption on three key fronts: demand, technology and business models.

A shift from consumer to prosumer

All the evidence shows that consumers have a growing appetite to move toward self-generation. Attracted by a mix of expected economic benefits, environmental sentiments, a desire for greater energy self-sufficiency and, in some cases, simply keeping up with neighbors' and friends' social dynamics, many consumers are preparing to take the step to become "prosumers" Accenture's New Energy Consumer research [1] shows that more than half (57 percent) of consumers would consider investing in becoming power self-sufficient. Close to the same proportion (45 percent) say that they are planning to sign up for rooftop solar in the next five years.

Towards a digital and distributed future

On the one hand, the rise of distributed renewable power generation is likely to increase the physical constraints on the grid infrastructure. On the other hand, decreasing costs of some technologies such as storage and smart solutions offer new solutions to grid operators to cope with this new challenge. Enabled by digital technologies, distributed flexibility can be provided by a wide range of solutions: modulated generation, storage management, demand response, electric vehicle charging, cross-energy interactions (gas / electricity / heat), etc.

New services for DSOs and new models to be invented

The use of flexibilities offers the prospect of advantages. One benefit of the use of smart solutions is the potential substantial reduction in grid reinforcement. A recent Accenture study [2] estimates a potential reduction in grid reinforcement for the integration of renewable production in Europe thanks to smart grid solutions (flexibilities and other optimization levers such as storage).

Moreover, flexibility brings additional benefits for the real time operation of the grid, for instance, when used in case of an incident or during scheduled maintenance, repair or other works.

The use of flexibility for the DSOs on a local scale raises new questions related to the regulatory and market framework. How to define and monetize the services offered to grid operators in order to support grid operation? What should be the roles of the different market participants and who should support the risks? What are the responsibilities in the event of a failure? How can we reach residential customers and unlock the latent flexibility at their level?

NEW POSSIBILITIES AND ASSOCIATED BUSINESS MODELS ARE CURRENTLY BEING INVESTIGATED WITHIN THE INTERFLEX PROJECT

New solutions are developed to increase the hosting capacity of distributed energy resources

Distributed generation such as photovoltaic (PV) injects active power into the grid and lead to local voltage increase. Grid operators must take this phenomenon into account and ensure that voltage remains within regulatory limits. In order to find a cost effective solution for PV integration, secure supply and power quality for customers, CEZ Distribuce focuses on innovative smart solutions which have a strong potential for large scale development.

CEZ Distribuce aims at increasing the distributed energy resources (DER) hosting capacity in low voltage (LV) grids by implementing:

1. Smart PV inverters
2. Smart PV inverters in combination with smart energy storage

The first approach is focused on testing and implementing new generation smart PV inverters equipped with reactive Q (V) and active power P (V) control functions. These functions work autonomously without the need of communication towards DSO and are used for voltage stabilization in LV grids and thus for a significant increase of the DER hosting capacity. In case voltage is higher than a threshold, PV inverter switches to the under-excited (inductive) mode thanks to Q (V) function as it is shown on Fig. 1, in case the voltage rise even more, PV inverter starts to reduce active power generation thanks to P (V) function – see Fig. 2. In case voltage is lower than a threshold, PV inverter switches to the over-excited (capacitive) mode thanks to Q (V) function.

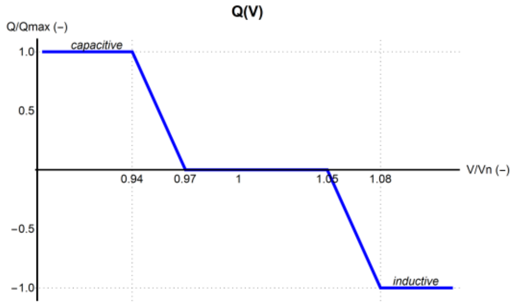

Fig. 1. Autonomous Q (V) function of smart PV inverters

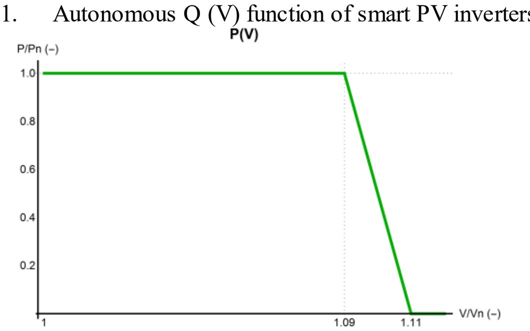

Fig. 2. Autonomous P (V) function of smart PV inverters

The voltage control functions were tested in the lab of the Austrian Institute of Technology in Vienna for Fronius and Schneider Electric PV inverters in order to prove their behavior before field implementation. Both tests showed very good results with only minor deviations from expected characteristics.

The second approach implements smart hybrid PV inverters in combination with home energy storage (batteries) which allow islanding. A basic function is to limit the maximum active power which can be fed into the distribution grid to 50 % of the installed PV capacity. Another function is discharging of the battery in case of under-voltage, under-frequency or in case of emergency, when receiving a ripple control signal (through one way simple PLC) from CEZ Distribuce's DMS. The first results will be available during 2018.

Beyond the technical aspects of the demonstration, CEZ Distribuce will focus on the identification of business models and highlight potential regulatory issues at a later stage of the InterFlex project. Business models will compare costs and benefits of the demonstrated solutions of key stakeholders and propose ways to enable cost effective utilization needed for DER hosting capacity increase. Regulatory issues will mainly tackle grid code updates which are needed for the future roll out of the demonstrated solutions.

Local energy communities are emerging

E.ON has built up and put in operation a microgrid in the South of Sweden during 2017. The microgrid is located in Simris, a small village close to the east coast. It was designed to be run autonomously in island mode as a Local Energy System (LES) with seamless transition from grid-connected to island mode and vice versa.

For electricity production in the microgrid there is a 440 kWp PV power plant, a 500 kW wind turbine, both connected to the medium voltage grid at the 10 kV level via their own 10/0,4 kV secondary substations. The PV plant and wind turbine controllers allow to limit the active power output if needed to ensure grid stability.

The third power source in the microgrid is the combustion engine driven generator with a rated capacity of 480 kW. The generator is connected to the microgrid on the low voltage level at 400 volts, sharing a secondary substation with other assets.

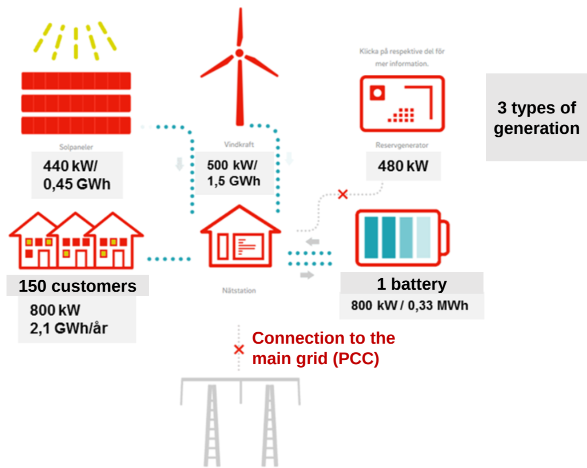

Fig. 3 – Schematic of the field test microgrid in Simris, Sweden

For voltage and frequency control in island operation, the microgrid is equipped with a 330 kWh lithium-ion Battery Energy Storage System (BESS).

On the load side the microgrid consist of around 150 mainly residential customers fed by five secondary substations located in or close to the village Simris. Local flexibilities will be provided by the villagers through different devices such heat pumps or residential PV-battery systems.

In island operation during most of the time the combustion engine driven generator is not in operation and therefore the system is purely fed by devices that are grid-connected by power electronics and without rotating mass.

The Local Energy System in Simris was designed to test and demonstrate that Battery Energy Storage Systems (BESS) as grid forming units are fully capable of maintaining frequency and voltage of a LES within the boundaries imposed by the operator (fully compliant with relevant standards and requirements) even for systems lacking conventional inertia provided by rotating machines. It is also shown that the LES can provide enough fault current to ensure relay and fuse operation and thus safe operating conditions for all grid users.

Furthermore, when connected to the main grid, the battery is able to provide ancillary services: mainly voltage control through reactive power injection and consumption in the Simris case.

Within InterFlex a second islanding experiment is conducted in the frame of the French demonstrator Nice Smart Valley. Two small islands, the Lerins islands, located in the Mediterranean Sea close to the shore of Cannes, are connected to the mainland via a submarine cable. In case of an incident on this single power line islanding will help to maintain the power supply to customers for a limited duration thanks to a Local Energy System comprising battery storage systems, local renewable generation and different levers of demand side flexibilities.

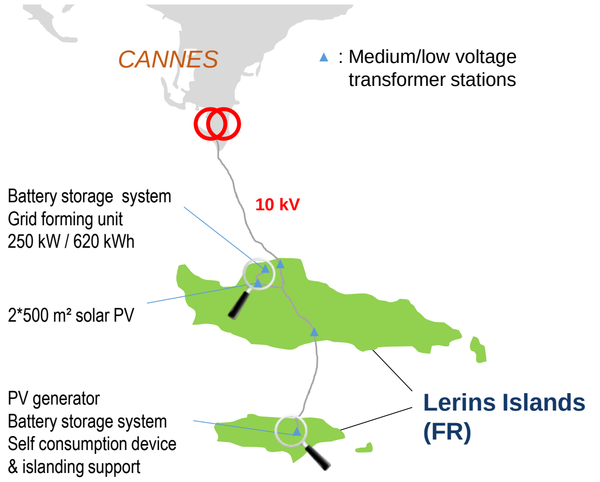

Fig. 4 – Islanding tested within the French demonstrator Nice Smart Valley (NSV)

There are about 50 permanent residents living on the Lerins islands.

The islanding operation will rely on 100% renewable energy sources. No auxiliary or fossil fuel generator will be deployed on the islands. Two aggregators and market players, Engie and EDF, will provide local production and flexibilities to the LES.

Two Battery storage systems are being installed on the islands. A 250 kW/620 kWh lithium-ion battery system will constitute the grid forming unit and be operated, remote controlled and supervised by Enedis. It will be located on the larger island of St Marguerite and provide frequency and voltage control during islanding. Two solar generators (IPPs) will provide local power generation thereby enhancing the potential islanding duration.

Furthermore, a second battery will be installed and operated by Engie (aggregator / retailer). In islanding mode, this battery will actively support Enedis' grid forming unit, whereas in grid-connected mode it will serve as a means to reduce the customer's energy bill, enhance local self-consumption of solar energy and provide ancillary services to the TSO.

Exploring innovative business cases

Islanding makes it possible to reinforce the resilience of areas where power supply is critical.

One of the major challenges is bound to the aim of identifying viable business models for resilience islanding. As mentioned above, in the frame of the French demo, Enedis operates a battery for islanding purposes. Nonetheless, incidents on the submarine power line are rather rare and so is the battery use for islanding purposes. As a consequence, an approach to mutualize storage capacities with other uses is being set up in the frame of the French project.

It is important to highlight that Simris does not have issues with the traditional supply of electricity, the interconnection to the main grid being very solid. The decision to create the LES in Simris was based on the favourable conditions in that location with existing renewable energy sources (RES) connected to the grid and a load profile which on an annual energy basis was equivalent to the RES generation. The primary goal of the LES in Simris is to demonstrate the technical feasibility of pre-defined use-cases and not to run in island mode at all times.

The TSOs are responsible for balancing and ensure that the frequency does not deviate from the nominal 50 Hz. When Simris or the Lerins islands are disconnected, an interesting situation arises since the respective microgrids are no longer part of the main network (Nordic network or continental EU network) and the TSOs cannot be held responsible for frequency deviations or anything else within the LES. The DSO operating the LES must in that case take over full responsibility. When the system is reconnected to the main grid, the TSO resumes responsibility.

Both in Simris and on the Lerins islands the Local Energy System's stability is guaranteed by a local battery. InterFlex' islanding experiments intend to show, how storage can provide valuable ancillary services (frequency and voltage regulation) as well as congestion management. While storage devices generally relate to market activities, the specific use cases tested within InterFlex show the interest in direct operation of storage by the DSO for local network operation purposes.

There are locations all over the world where solutions like this could become tangible in the near future. Rural areas with weak lines are present in numerous parts of Europe and it could make sense to build LES systems over traditional copper solutions as the new technology gets cheaper. Electrification is another use-case where systems like this could make sense.

POSSIBLE MECHANISMS TO CONSIDER TO EFFECTIVELY USE THE FLEXIBILITY FOR THE NEEDS OF DSO

Flexibility is of a great interest and innovations enabling it evolve quickly; it follows that some of the regulatory mechanisms must be adapted. This part will introduce an array of possible mechanisms. It is important to note that some of the mechanisms reported here are potential solutions, and thus should not be considered as official positions of the French regulator, the CRE.

The latter has been working on flexibility for a few years now. Back in 2013, the CRE carried out a public consultation focusing on the development of Smart grids that led a year later to the publication of a deliberation on recommendations on smart low voltage grid development. The main guiding principles were that: (i) the regulatory framework should enable the development of a vast range of flexible services, (ii) all sources of flexibility, including generators, storage and demand side response should be treated equally and (iii) DSOs should be able to access and use flexibility services to manage the distribution networks. Since then, the CRE publishes every year a deliberation to summarize the main actions undertaken by the network operators and, if needed, to add a few new recommendations to back the development of smart grids solutions. Nowadays, this work fits in a larger frame: the Clean Energy Package lead by European institutions.

In particular, the CRE published several recommendations to support self-generation, to develop renewable energy and storage and to promote distributed flexibility.

Flexible network connection agreements and flexible services proposed by municipalities bring benefits to grid users and DSOs

New grid connection schemes have been developed to take greater advantage of the flexibility grid users can provide. These so-called ‘flexible network connection agreements’ are based on financial incentives, such as cheaper connection costs and shorter implementation delays. In return, the producer accepts that its production may be trimmed under specific circumstances and during a specific number of hours per year, as agreed upfront within the connection agreement. Works to reinforce the network are done to a minor extent, if at all. To prevent potential constraints, the power injected is trimmed if necessary. This type of connection agreements will be proposed to consumers as well. Based on the same principles, consumers will get cheaper connections and reduced commissioning lead times if they agree to curtail their consumption when the DSO needs flexibility.

The French government also created a mechanism to experiment flexibility for the needs of distribution grids. If the distribution system is subject to constraints, municipalities can propose flexibility-based solutions to avoid grid operational costs or delay grid reinforcement under certain conditions. The flexibility service is paid for based on the respective avoided costs for the distribution network. In some situations this may lead to high financial incentives for the use of flexibilities as there is no direct correlation between the activation cost of flexibilities and avoided grid costs.

Self-generation enabled by French regulation, a first step toward local energy communities

As said earlier, self-generation is more and more appealing. Well aware of this dynamics, the CRE has been working on proposals to facilitate the process to become self-sufficient from the energy point of view and to encourage network users to alter their behaviour in favour of a more efficient use of the distribution network. Since the French Energy Transition for Green Growth Act has come into force in 2015, consumers can gather into a legal entity to perform collective self-generation activities under certain conditions. The legal entity must comprise producers and consumers connected downstream of a given electrical substation. Participants will benefit from special network tariffs designed by the CRE following a large public consultation.

Storage applications are promising at a local scale and their framework is being simplified

There is a wide range of energy storage applications bound to distributed renewable energy generation or for grid stability services. Energy storage is particularly interesting in small systems or microgrids, as shown in this project, where the aim is to prove its robustness. The CRE has been working on the simplification of the regulatory and contractual framework between the storage operators and the DSOs. It is essential to facilitate the integration of these storage infrastructures in the electrical system in order to address a wide range of applications which might be necessary to make storage solutions cost-effective. Ongoing discussions on article 36 of the European Clean Energy Package address the questions of the ownership and the operation of storage. By testing several schemes, the InterFlex project will bring valuable inputs to regulators and policy makers.

CONCLUSION

Based on real-scale demonstrators in 5 European countries the EU-funded project InterFlex investigates the use of various forms of flexibilities for the needs of DSOs. The works presented in this article identify economic and regulatory challenges bound to the use of flexibility and storage solutions in the context of islanded electric systems and high renewable energy integration.

The French regulator’s approach is presented highlighting how the regulatory framework is adapted to the changing energy environment to foster innovation.

REFERENCES

[1] Accenture research programs, 2017, “New Energy Consumer”, *Accenture*
[2] Accenture research programs, 2017, “Digitally Enabled Grid”, *Accenture*

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