FLEXIBILITIES AT CUSTOMERS PREMISES: NICE GRID PROSUMERS

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ABSTRACT

NICE GRID demonstrator experiments in Carros an alternative to the historical power system management, which is to match consumption and the local photovoltaic generation. For this, the customer is asked to play a much more active role: prosumer. PV generation, dependent on the weather conditions and not controllable, may be asynchronous with the daily consumption of the inhabitants of Carros. One of challenge of the NICE GRID project is to optimize the balance between generation and consumption of electricity at the neighborhood level. Three experimental offers were proposed to residential clients of the "solar districts" in Carros to balance production and consumption in order to optimize the use of the solar resource. These offers, tailored to different consumer profiles, allow everyone to participate according to their consumption habits and equipments.

INTRODUCTION

The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n°268206. The project is also funded by the French Environmental Agency ADEME.

NICE GRID is a smart grid demonstration project led by the French DSO ERDF and developed with nine partners: EDF, GE Grid Solutions, SAFT, RTE, ARMINES, SOCOMEC, NKE, NETSEENERGY and DAIKIN. NICE GRID demonstrator experiments in Carros an alternative to the historical power system management, which is to **match consumption and the local photovoltaic generation**.

1. OBJECTIVES AND TECHNICAL REQUIEMENT

Context

PV
PACA is the French region that has the second largest installed photovoltaic (PV) capacity after Aquitaine, with **766 MW$_p$ at the end of 2014**. This capacity will need to triple in the coming years, as the region's *Climate, Air and Energy Regional Plan* has set a target of **2,300 MW in photovoltaic capacity by 2020**. Given that the vast majority of installations are connected to the distribution networks managed by ERDF, a "bottom-up" injection from this intermittent and decentralized power source could be the cause of these **power and voltage constraints**.

Use case
Massive feed-in of renewable energies like solar PV into the grid leads to the emergence of new issues for the electrical system (local output/demand balance) that needs to adapt in order to accommodate these new forms of electricity output which are **intermittent** and **uncertain**. **Reinforcing the grid** is a possible solution, but costly for local authorities. NICE GRID in the town of Carros experiments an alternative option to traditional management of the electric system. The idea consists in **adapting the consumption to the local solar power output**, by inviting customers to play a much more active role. Because solar power output is **dependent on the weather** and **uncontrollable**, there may be a time lag between its production and daily use by the town residents. When sunshine is highest in summertime (between noon and 4:00 PM), solar panels generate a high level of electricity but the power is consumed primarily outside of this time range. One of the challenges of NICE GRID is therefore to **optimize the correlation between power output and power consumption at the scale of an urban district.**

On peak/Off peak hours in France[1]

Figure 1 - Regulated tariff for customers with subscribed power below 36 kVA

Hot water tanks in France
Hot water tanks constitute a significant potential since **11 million** French households are equipped with electric tanks, including **8 millions** effectively controlled under the Peak Hours/Off-Peak Hours tariff. With a total consumption of **20 TWh**, they provide a flexibility potential of around **8,000 MW** (equivalent to 7 to 8 nuclear units) every day.

[1] Prices as for 01/07/2015

EDF offers

Under the NICE GRID project, **three experimental trials** were offered to residents of solar districts in the town of Carros to attempt to balance output and demand and optimize the solar resource. These offers are adapted to various consumer profiles, enabling all residents to participate **according to their consumption habits and electrical appliances**.

- ***Solar Bonus* (SBO) offer**: During the 40 **solar days** in summer 2014 and 2015, indicated by alerts sent on the previous day via text and/or e-mail messages, EDF invited its volunteering customers to shift their electricity consumption during **solar hours** between 12:00 noon and 4:00 PM. At the end of each summer, EDF sent the customer a gift-voucher for a tariff equivalent to the off-peak tariff for their power consumption during **solar hours**.
- ***Smart Water Tank* (SWT)**: As a complement to the previous offer for equipped consumers, the system provides for optimum remote control of the hot water tank based on the local solar power output, without any impact on comfort.
- ***Smart Solar Equipment* (SSE):** offer includes the generation of solar PV power via panels installed on the roof and energy storage in a battery.

In the context of NICE GRID, *EDF Retail* provided support to experimental customers with assistance from NKE Watteco and EDELIA, two suppliers of housing energy solutions, via the following measures:

- **Promotion of solar power installations via technical support** and strict monitoring of the installation of solar PV panels, with assistance from the *Centre Scientifique et Technique du Bâtiment* (CSTB), thereby preventing any "counter-references".
- **Solutions to control home appliances,** designed to shift or reduce power consumptions, supported by the **Linky smart meter.**
- **Display solutions** to visualize summer production peaks and regulate consumption.
- **Recognition by the network operator of the value of all individual efforts** to contribute significantly to the balance of the electric system and also deliver benefits for the consumer (extra remuneration).

2. DEVELOPMENT AND IMPLEMENTATION

Architecture

EDF send alerts the previous day via text and/or e-mail messages and a **mobile peak** to the **Linky** Information System.

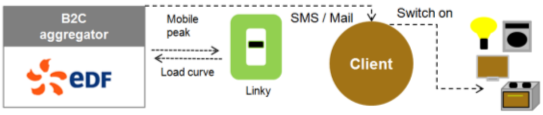

Figure 2 – *Solar Bonus* architecture

The heating or non-heating status of a servo-controlled water tank is linked to the dry contact.

- When the dry contact is closed, the tank is powered and heats up.
- When the dry contact is open, the tank is not powered and does not heat up.

The tank heating schedule is pre-programmed and depends on the **customer's contract** (for double tariff customers, the dry contact is alternatively closed and open, and for single tariff customers the dry contact is always closed)
To control the hot water tank, EDF sends a **Linky mobile peak signal** via the **B2C aggregation platform**, in order to modify the status of the dry contact during the desired time period

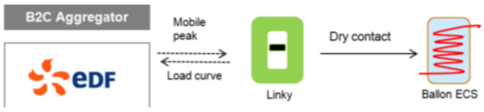

Figure 3 – *Smart Water Tank* architecture

Experimental users who signed a "***Smart Solar Equipment***" contract agreed for the installed battery to be automatically controlled by EDF Commerce (via EDELIA IT system).
This automatic control requires the installation of an Energy Box EDELIA gateway which receives a controlling signal from the **B2C aggregation platform**. It communicates with the SAFT battery via the SMA converter. It retrieves data from the MC11 TIC sensor in the off-take meter, and from the MC11 TIC sensor in the feed-in meter of the experimenter's PV system.

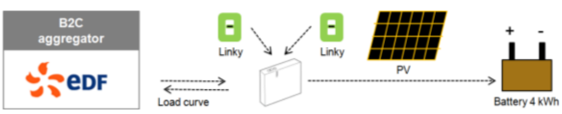

Figure 4 – *Smart Solar Equipment* architecture

Recruitment

Recruitment

Average recruitment rate of **15.3%** in 2015 for residential customers (475 prospects).
An analysis of the recruitment process for participants to the NICE GRID project reveals that **no communication channel should be neglected**. Each channel can contribute to the final outcome, although in varying proportions and degrees depending on the context.
As regards the prospects for PV panels installation, the **financial investment** frequently proved to be an obstacle for the engagement to materialize in spite of support from the supplier. Pay-back time[2] is a major parameter for people in the 50-60 age bracket
During the campaign for rolling out batteries, **insurance issues** were a concern for some potential participants. In addition, whenever the location of the battery was chosen outside their garage, the owners of villas with small land plots did not wish to visually impair their private environment, or even refused to take the risk of installing it next to their swimming pool.

3. TECHNICAL RESULTS

76 households participated in the summer trials in 2015 in the seven **solar districts** (i.e. **15%** of eligible households[3]). In households who tested the ***Smart Water Tank*** offer, a difference of **56%** on average was recorded in their consumption between a **solar day** and a "normal" day between the hours of 12:00 noon and 4:00 PM (i.e. **2.4 kWh**).

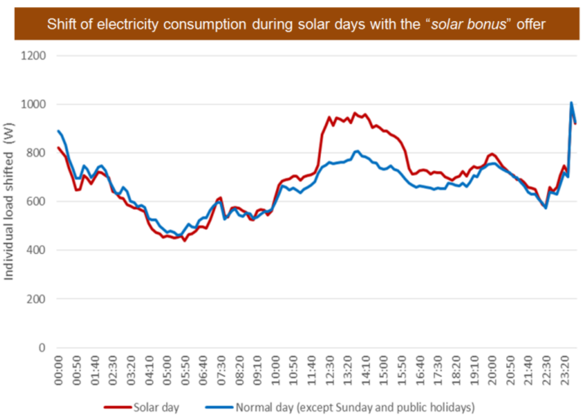

Figure 5- Averaged daily load curves with and without request for participants testing the Smart Water Tank (SWT) offer

In households who tested the ***solar bonus*** offer, a difference of **22% on average** was recorded in their consumption between a **solar day** and a "normal" day between the hours of 12:00 noon and 4:00 PM (i.e. 0.35 kWh).

[2] 20 years feed-in contract
[3] Eligible household: resident of one of the **solar district**s fitted with Linky smart meters

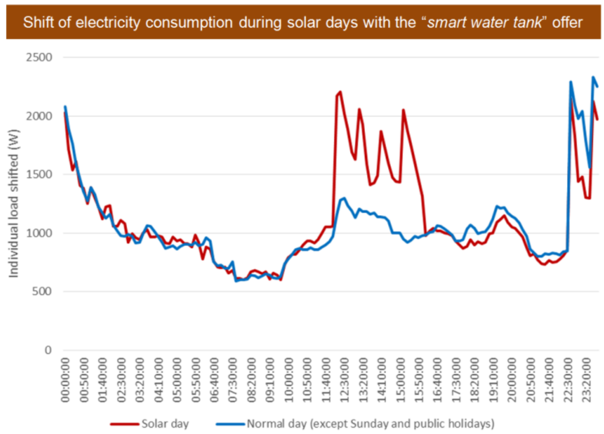

Figure 6 - Averaged daily load curves with and without request for participants testing the Solar Bonus offer

During the summer, the encouragement to postpone some daily household tasks to **solar hours** proved fruitful. The experimenters **played the game** fairly and **did shift some of their domestic tasks** to the 12:00 noon – 4:00 PM - time bracket. Efforts addressed essentially the use of household appliances (dishwasher, washing machine, etc.) and to a lesser extent ovens, vacuum cleaners, irons and swimming pool filtration systems.

The experimenters' decision to join the NICE GRID trials relies on **two main motivations:**

- **Economic benefit** guided by a desire to manage their consumption expenses and by the financial incentives of the **solar hours** offer,
- Desire to **act in favor of the environment.**

Financial opportunities therefore coexist with the wish to participate in collective efforts, to act as good citizens and contribute to improving the security of supply. The unpredictable nature of alerts was not perceived as a major constraint or an obstacle to postpone power consumption. The presence of someone at home and the ownership of programmable appliances were also factors facilitating participation.

NICE GRID was perceived by the **prosumers** as an experience that was "*interesting*", "*with few constraints*" (or at least a well accepted constraint), and "*positive*", even though the related financial returns remained low. They were sensitive to the collective and local nature of the project and considered that **this initiative contributes to a shift in energy generation and consumption modes.**

In an effort to adapt even better the power consumption of the hot water tank to the solar output, a so-called **"advanced" tank will be tested in 2016 with 20**

households.

CONCLUSION

Good understanding of the challenges of the Energy Transition by consumers

- **Participants were very engaged** (good understanding of issues)
- **Participants proved capable of shifting their consumption times** (20% to 56% with activation of hot water tank and 89% with a battery).
- **Easy control of domestic hot water tanks via Linky smart meter** (without any additional equipment)
- **More complex remote control of batteries**, **local control might be more promising**
- **Participants asked for a higher incentive**
- **Participants asked for individual and collective feedback**

Flexible electrical appliances

The **availability of flexible electrical uses** is a genuine asset in order to support the development of intermittent renewable energy sources.

The very first asset, in the technical and economic sense, is the electric domestic hot water tank that can be easily mobilised via the **Linky smart meter** without any impact on consumer comfort. It currently contributes to optimising the supply and demand balance by recharging during off-peak hours. In the future, it could be activated during peaks of renewable energy output. Hot water tanks constitute a significant potential, *as explained in section 1*. In the future, new technologies in domestic hot water heating – in particular the **thermodynamic water heater** – will be able to adapt to intermittent power generation, whether locally or routed through the grid. These technologies will be tested as early as 2016 in the context of the project.

Perspectives for optimising the management of flexibility drivers

The purpose for EDF was to look at the possibility of leveraging the value of “non-consumption” during demand peaks or of consumption during output peaks generated by its customers, for the benefit of the grid’s needs (Distribution and Transmission). EDF has learned the following lessons from this experiment on the use of customer flexibilities:

- Centralised activation of residential flexibilities at the scale of LV and MV applications does not appear to be suitable. **Residential flexibilities at the scale of a source station or even a HV/MV transformer might be suitable to respond efficiently and pragmatically to the DSO’s power requirements**. In the case of residential flexibilities, this would represent a minimum of around 5000 customers.
- At the LV scale, **the use of Nice Grid solutions seems relevant provided they are deployed at producers’ premises**. Activation of Nice Grid flexibilities at all distributed residential producers has a significant impact on the LV profile:
  - by addressing the (surplus) output at source,
  - by solving the issue of the constrained phase,
  - by allowing for the development of real-time local servo controls based on the effective measurement of sunshine or voltage (e.g. to store at each second only the surplus power generated).
- However, they could prove less efficient when a majority of customers are absent from their homes, and therefore do not consume or do not store power. Other drivers might then be necessary, such as a feed-in reduction of solar power.
- To improve the economic balance, **it would seem necessary to coordinate the local and national optimisation processes** and to look for value on existing or future market mechanisms.

Other lessons learned from the experiment:

- Flexible electricity uses support and will continue to support the development of renewable energy sources, whether local or on the grid.
- Such solutions are cost-efficient for the local authorities and residential customers since they relate to mature technologies. In addition, they can be activated remotely, for start-up or shut-down, based on various notification schedules.
- These uses currently address primarily air or water heating. In the future, they will evolve thanks to more connected objects and less electric heating (consequence of RT2012[4]).

4 New French regulations related among others to heating