Title: Deliverable 2.4 “Benefits of adopting Storage Devices in LV networks”

Synopsis: This document presents a quantitative assessment on the benefits from adopting storage devices in combination with PV systems in LV networks considering different PV penetrations and locations.

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Executive Summary

This report corresponds to the final Deliverable 2.4 “Benefits of adopting Storage Devices in LV Networks” part of Work Package 2 “Control of Low Carbon Technologies” of the iCASE project “Active Management of LV Networks” jointly funded by EDF R&D and EPSRC.

The Active Management of LV Networks project has been established in order to investigate the effect of applying active management techniques to increase the ability of low voltage networks to accommodate higher number of low carbon technologies (LCTs), in particular photovoltaic (PV) systems and electric vehicles (EVs). The project will focus on the utilisation of on-load tap changing transformers and coordinated control of LCTs themselves and other technologies to control voltages and congestion in the network.

This report, Deliverable 2.4, provides a quantitative assessment of the benefits of adopting battery energy storage (BES) devices in combination with PV systems in order to maximise customer benefits while managing voltage and thermal issues. This assessment considers different locations and penetrations of PV system technologies on seven real French LV networks.

Normal operation of residential BES systems. This report first investigated the normal operation of residential BES systems considering a deterministic analysis of three consecutive summer days on the network LV_02779 assuming 70% of PV penetration level.

The following important drawbacks of the normal operation mode were found:

- **BES systems reach full State of Charge (SOC) very early.** This, due to the presence of PV exports from early hours (around 8am), limits the capability of the battery to reduce the exports at times of maximum generation (around midday). From a DNO perspective, this means that the corresponding PV impacts (voltage and thermal issues) continue to be a problem.

- **BES systems do not adequately discharge.** This, due to night time demand being lower than the stored energy, makes the battery have less available capacity to reduce exports in the following day. This issue becomes even more critical in cases where the household demand is significantly low.

Although the normal operation mode can reduce customers’ energy bills (less grid dependency), it does not have a significant benefit in neither voltage nor thermal issues. Consequently, there is a need to consider a more advanced BES system control method that can provide benefits to both customers (i.e., lower grid dependency) and DNOs (i.e., managing voltage and thermal issues).

Advanced operation of residential BES systems. To overcome the aforementioned limitations an advanced operation mode is proposed. Its performance is investigated deterministically and stochastically on seven French LV networks considering different PV penetration levels. Results in this report are discussed primarily based on the LV_02779.

The key advantages of the proposed operation mode are summarised below:

- **Voltage issues.** It is demonstrated that the proposed advanced operation mode can eliminate all voltage issues up to high PV penetration levels beyond which it can significantly reduce them.

- **Thermal Issues.** Although the proposed advanced operation mode does not directly manage thermal issues, results show that the reduction of reverse power flows, due to charging, is able to provide a satisfactory solution in terms of thermal issues in LV networks.

- **PV Energy Production.** The analysis clearly highlights that the adoption of residential BES systems along with the proposed advanced operation mode can help increasing the harvesting of PV generation (otherwise curtailed) while reducing voltage and thermal issues.
• **LV Network Imported Energy.** The adoption of residential BES systems with the proposed advanced operation mode significantly reduces the amount of energy imported by the LV network as they are able to store the unused PV generation and supply the household demand during the evening, night and early morning hours. In addition, these imports reduce as more storage comes with higher PV penetrations.

• **LV Network Exported Energy.** Results show that the amount of energy exported upstream the LV network is reduced significantly when adopting residential BES systems with the proposed advanced operation mode.

• **Grid dependence index.** The adoption of residential BES systems with the proposed advanced operation mode can significantly reduce customers’ dependence to the grid while still benefiting from the quality of service brought by the grid (e.g., supply always available). In general, without considering any capital and operational expenditures required for the uptake of PV and BES systems, results mean that customers will potentially pay less energy bills compared to the case where BES systems are not adopted.

• **State of Charge.** The proposed advanced operation mode is very effective in achieving the desired SOC at critical periods of the day (based on the investigated case), i.e., empty at the start of the charging period (8am) and full at end of the charging period (6pm).
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