Integration of Loads and Electric Storage Systems into Advanced Flexibility Schemes for LV Networks

Synopsis: *leafs evaluated the effects of increased costumer and energy market driven utilization of energy storage systems and load flexibility on power distribution grids. Technologies and operation strategies were developed that enable optimal use of distribution grid infrastructure by activating flexibilities using direct or indirect control also by the local grid operator or even incentives. The consumer benefits from more flexible integration of distributed energy resources at minimum network reinforcement costs as well as achieving a higher self-consumption level for customers operating their own DG-unit.*

Starting point & motivation: Significant changes can be expected in the way end customers will behave from a power distribution grid perspective. Today, layout and dimensioning of distribution grid infrastructure is based on statistical assumptions and historic data for load and generation behavior over time. New technologies, distributed storage systems and aggregation of demand flexibility by virtual power plant operators, can result in market-driven load profiles based on price signals with potentially high synchronous behavior in a given distribution segment. Without consideration of the local distribution system limits this might cause thermal overload or voltage band violations. In return a grid relieving operation has the potential to relieve power grids.

Content & goals: The project leafs proactively tackled the above-mentioned challenge by developing technologies and operation strategies that minimize network reinforcements required from the integration of renewable energy sources and dynamics resulting from the market. Approaches in the project for activation and control of flexibility included both active control of storage systems and flexible loads also by the grid operator (technical solution) and evaluation of monetary incentives and motivation (organizational solution). The end costumer benefits in a long term from minimized network reinforcement costs and even higher self-consumption levels in case of operating their own DG-unit.

Methodological approach: To reach this aim, leafs combined three central activities:

1. Impact Assessment – Simulation with representative sets of model networks to determine the potential effects of increased energy market driven utilization of energy storages and load flexibility on power distribution grids were conducted. Surveys among relevant end customer groups assessed end-customer perspective were carried out.
2. Technology Development – Solutions for flexibility activation by the local grid operator for better grid integration of renewables and market service provision were developed and evaluated with extensive simulations and laboratory trials. All relevant control solutions are analyzed in three generic use cases including
    a. direct control of central components (e.g. central storage) where components belong to the system operators (first use case)
    b. direct access of decentralized components (decentralized storage, heat pumps, second use case)
    c. indirect access of decentralized components through a customer energy management system (CEMS), where component belongs to the customer (third use case).

3. Field Validation – The developed solutions and operation strategies were implemented and evaluated in different field trials. Each use case was validated in a separate field trial carried out in Eberstalzell (Netz Oberösterreich), Köstendorf (Salzburg Netz) and Heimschuh (Energienetze Steiermark). In the municipal area of Eberstalzell an additional field trial with monetary incentives, depending on the local actual power from PV is carried out for the determination of user based flexibility activation. R&D infrastructure as well as research results of previous projects can partly be reused in these areas, reducing costs and engineering effort required for the leafs project.

Economic and regulatory analyses are performed for all solutions and will give additional inputs for the final simulation-based investigation of replicability and scalability of the solutions.

Results: The project consortium was able to comprehensively work through the defined objectives and contents. The following list summarizes the most important results and highlights of the project:

- A clear framework was created for the integration of PV storage systems and other flexibilities, enabling grid operators to avoid local limit violations. However, depending on the setup, a significant amount of work may be required for the intelligent integration of these systems into the grid operator's systems.
- The community storage system developed within the project has proven to be technically feasible. In a further step it will be further developed into a product and offered to new customers. However, regulatory adjustments are necessary before such a system can be offered as a product.
- With the end customer app an innovative system was developed to encourage grid-friendly behavior of end customers. The great positive feedback and the very broad participation of customers in the field test indicate a great potential.
- For the first time, the project was able to quantitatively determine the future grid reinforcement requirements for a large-scale rollout of PV and electric mobility. It has been shown that the need for grid reinforcement increases massively with a wide-spread, market-based operation of the systems. On the other hand, the need for grid reinforcement can be reduced visibly in some cases by various, sometimes very simple measures or grid-friendly operating modes of flexibility.
- With the large-scale survey of more than 13,000 end customers their perspectives could be comprehensively evaluated. A great deal of interest was identified in the areas of electromobility, electric space heating and community facilities.
- The project clearly demonstrated the economic added value of different storage systems. The additional use for further services can make a small positive contribution to such systems.

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