GridSense SoloGrid Pilot Project – Using Decentralized Artificial Intelligence for Making Distribution Grids Resilient

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ABSTRACT

In the following, the SoloGrid pilot project in Solothurn, Switzerland is presented. As part of this distribution grid pilot project the GridSense solution, an innovative decentralized energy management scheme for prosumer households based on artificial intelligence and machine learning concepts, is deployed in the distribution grid of a residential neighbourhood and shall act as a cost-effective alternative to conventional grid reinforcement such as line and transformer upgrades.

INTRODUCTION

The SoloGrid pilot project, a lighthouse project of the Swiss Federal Office of Energy (SFOE), demonstrates the use of decentralized energy management schemes based on artificial intelligence and machine learning concepts in electric distribution grids [1].
SoloGrid is a partnership project by Alpiq, a leading Swiss utility and energy services provider, Landis+Gyr, a world-market leader of SmartMetering solutions, AEK, the utility of the Swiss Canton of Solothurn and Adaptricity, an ETH spin-off focusing in SmartGrid simulations and electricity grid analytics. SoloGrid is co-funded by the Swiss Federal Office of Energy (SFOE) and the Canton of Solothurn (Energy Office).
As part of this recently started pilot project, GridSense control boxes are currently being installed in a residential neighbourhood of the community Riedholz, Canton Solothurn. This is done in order to showcase the performance of the GridSense solution, an innovative decentralized energy management scheme for prosumer households (Fig. 1), developed by Alpiq together with *Scuola universitaria professionale della Svizzera italiana* (SUPSI) [2]. The core of the GridSense technology consists of several algorithms that continuously measure parameters such as grid load, electricity consumption and generation, including weather forecasts as well as electricity prices. Thereby the GridSense algorithms learn the behaviour of electricity consumers through artificial intelligence methods. Using this information, GridSense optimises the utilisation of power consumers and generators. The technology reduces peak loads in the power grid, balances the loads and stabilises the distribution grid.

The goal is to analyse how the GridSense solution can help mitigate distribution grid problems such as over- and under-voltage events and grid overloading that are becoming increasingly commonplace due to the wide-spread deployment of residential PV installations but also due to the likewise on-going electrification of the residential heat demand sector via heat pumps and electric water heaters as well as the mobility sector via electric vehicles. The real-life grid and household measurements as obtained over the course of the pilot project serves as the basis for performance validation of distribution grid operation.

The performance of the GridSense solution, i.e. the positive grid effects as gained by intelligently shifting load demand as well as controlling local PV power production and household battery storage units, is compared to conventional distribution grid reinforcement, i.e. line and transformer upgrades, as well as to already established SmartGrid technologies such as On-Load Tap Changing (OLTC) transformers. The obtained measurement data also serves as a starting-point for subsequent larger-scale simulation-based distribution grid operation analysis.

Figure 1: GridSense– Decentralized Energy Management Scheme based on Artificial Intelligence

DISTRIBUTION GRID AREA

Riedholz is a political community in the vicinity of Solothurn, the canton's capital. AEK [3] as the electric utility of the Solothurn region is responsible for the overall distribution grid operation and management. The completely residential neighbourhood consists of about 40 households, both single- and multi-family houses, all connected to one transformer feeder, i.e. a transformer unit (secondary substation) with an apparent power of 400 kVA. The vast majority of households possess heat pumps and electric water heaters.

Several roof-top solar PV units were already installed in individual households. In the scope of the SoloGrid project, electric vehicle chargers and home battery systems were additionally installed in some of the participating households by Alpiq in order to test the specific operational behaviour of these novel power system unit types (Fig. 2).

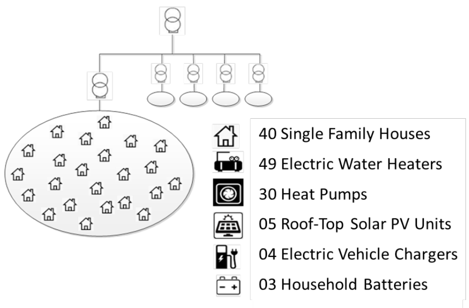

Figure 2: Configuration of Distribution Grid Topology (Pilot households are all connected to one feeder)

All households are equipped with modern SmartMeters (Type L+G E350), provided by Landis+Gyr [4] and installed by AEK. The SmartMeters allow the measurement of overall household electricity consumption, i.e. active power (P) and reactive power (Q), of which however only active power values are effectively read-out. All households are also equipped with GridSense boxes that can both measure and control flexible thermal loads such as heat pumps and electric water heaters as well as roof-top PV units, home battery systems and electric vehicle chargers (Fig. 3).

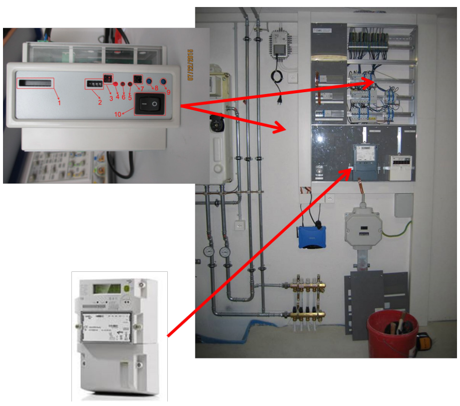

Figure 3: Installation of Prosumer Household Measurement and Control Equipment (above: GridSense box, below: L+G 350 SmartMeter)

VALIDATION OF GRIDSENSE OPERATION PERFORMANCE & GRID SIMULATIONS

All measurement data obtained as part of the SoloGrid pilot project is fed into the SmartGrid simulation platform DPG.sim (Distributed Prosumer and Grid Simulation), developed and maintained by ETH Zurich spinoff Adaptricity [5], for the purpose of operational performance validation. The time-series-based simulation platform for active distribution grids (Fig. 4) allows the evaluation of operational performance of SmartGrid elements, such as controllable Renewable Energy Sources (RES), dynamic Demand Response schemes, energy storage, SmartMetering, and within the scope of the SoloGrid pilot project of the GridSense solution for all grid operation and grid planning aspects. The simulation platform is server-based and amenable to cloud computing and massive parallelization of simulation and optimization tasks, as is needed for simulating large numbers of prosumer households dispersed in fine-grained electricity grid models.

After the initial validation phase of the GridSense solution for the pilot project region and it's about 40 households, DPG.sim's grid simulation will have been calibrated to the obtained real grid measurements.

In a second phase, DPG.sim will be used to augment the scope of the pilot project by simulating much larger household groups, i.e. a few thousand households having the GridSense solution, dispersed on several distribution grid feeders. This allows the assessment of the aggregated impact of the GridSense solution on the distribution grid and on distribution grid operation.

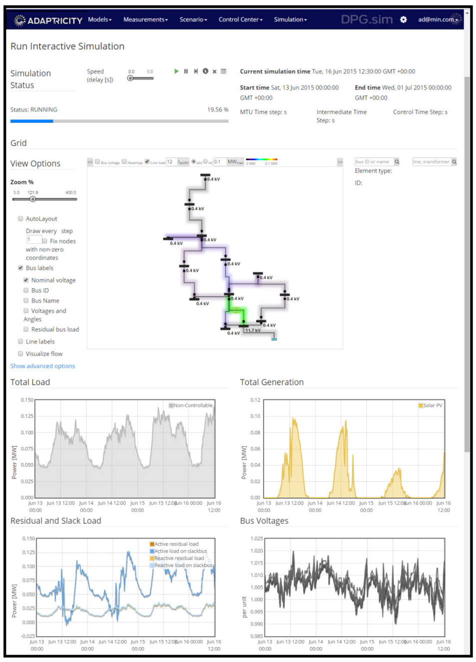

Figure 4: SmartGrid Simulation Platform DPG.sim

Thereby a simulation-based yet realistic validation of a large-scale deployment of the GridSense solution in distribution grids is achieved. The approach for such large-scale distribution grid simulations using the GridSense algorithm in conjunction with DPG.sim is illustrated below (Fig. 5).

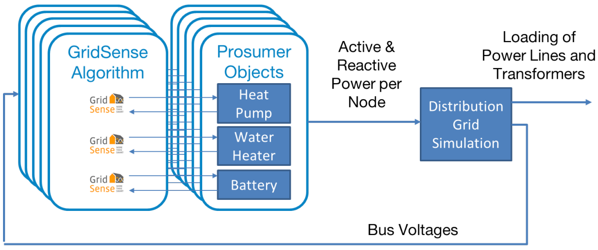

Figure 5: Approach for Large-Scale Distribution Grid Simulations using GridSense Algorithm in

PROJECT PLAN

Hardware installations, i.e. SmartMeters and GridSense boxes in all participating households as well as electric vehicle chargers and home battery systems in selected households, are taking place in early 2016. Relevant reference measurements, i.e. active/reactive power (P, Q) and voltage level (V), at the local distribution grid feeder (transformer station) are already being collected in high resolution since the fall of 2015. The GridSense boxes are being activated successively over the course of spring 2016.

The test phase lasting 18 months will investigate how GridSense controls the primary electricity consumers such as heat pumps, boilers, home battery systems, and charging stations for electric vehicles, and how it integrates measurement data from photovoltaic systems for optimal grid operation. GridSense shall ensure that the distribution grid is operating at optimal conditions, while also optimising customer energy consumption.

First performance validation results of the behaviour of the GridSense solution with respect to the 'base case', i.e. fully passive distribution grid operation, will become available by the summer of 2016. Full validation results as well as the simulated-based extension to larger-scale distribution grid simulations, assessing aggregated effects of GridSense-controlled households, will be available by early 2017. By then sufficient operational measurement data will have been created to also study seasonal effects of, for instance, PV power production during summer months and heat pump demand during winter months.

PROJECT RESULTS

All project results will successively be published on the SoloGrid project website (www.sologrid.ch) until the project's official ending by mid-year 2017 and beyond. In addition to this, selected result highlights will be made available as part of both national and international scientific publications.

REFERENCES

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