State estimation in low-voltage distribution grids for real-time congestion management

Supervisor Thierry Zufferey, thierryz@eeh.ee.ethz.ch
Christoph Hunziker, hunziker.christoph@ibw.ag

Type Master (with aliunid)

Background With increasing number of fluctuating, distributed generation sources as well as intermittent loads such as charging stations for electric vehicles, congestion management on grid level 7 will become a challenge in near future for many distribution system operators. Since this grid level comprises by far the most cabling kilometers and binds in total a tremendous amount of invested capital, finding efficient methods for grid monitoring is highly desirable. Establishing a monitoring system for low-voltage grids with sufficient quality, based on the smallest possible number of required measurement devices, is thereby one of the key challenges. In parallel to the described developments above, the demand for automation systems in public and residential buildings has grown in recent years. Often, measurement equipment for net electricity supply is installed for internal control of appliances or for information purposes only. In future, grid operators might gain access to such data in real-time or offer appropriate systems to their customers, respectively. Both of which could help in acquiring relevant data for grid monitoring in a cost-efficient way.

Description Load flow calculations are widely used today as means for offline grid analysis and network planning. On grid level 7, often only an aggregated load measurement at the feeding transformer is present. Typically, the aggregated load is then scaled proportionally to the fuse or yearly demand at the grid connection of individual customers to define the sourced power of all distributed loads in the grid. As the number of available real-time measurements at the level of individual customers grows, the load distribution in the grid could be determined more and more accurately. State-estimation methods, typically used on higher grid levels, shall be analyzed with the aim of determining its applicability of the described approach in real grid environments. For this purpose, the method shall be developed and validated based on real grid-topologies and measurement data provided by aliunid. The thesis may include the following steps, but is not limited to:

1. Define a simple grid for developing and testing the state estimation approach.
2. Model generation of distributed PV plants.
3. Develop a method for determining pseudo load measurements by scaling measured power flows on aggregated level to each building/grid load.

4. Use state estimation methods to determine the most probable grid state.
5. Validate the approach for real grid topologies and real measurement data provided by aliunid.
6. Analyze accuracy of the distribution of power flows in the grid based on the given (real) measurements.
7. Determine locations in the grid, where the installation of a real-time measurement equipment would lead to the largest increase in accuracy.

About aliunid aliunid (all you need) is a digital energy supply start-up. In the past two years the competence of measure real-time data in the distribution grid has been validated together with 15 utilities. Available data can be used for this master thesis and the installation of real-time measurement equipment in one of aliunids partner utilities is desirable. The most recent report on aliunid's development is available here: https://www.aramis.admin.ch/Default?DocumentID=67021&Load=true

Prerequisites The student should have solid power systems background (preferably including state estimation techniques) as well as coding skills in Matlab or python.