BAP Proposal

Power flow control in a substation of a wind- and solar farm

There are several ongoing wind farm projects in the Netherlands. There are for example a lot of small and old wind turbines that are being replaced with fewer and larger turbines in Flevoland. Wind parks generally consist of several wind turbine generator (WTG) strings. The power cables of the strings are gathered in the substation and transformers step up the voltage to deliver the power to the grid. It is becoming a new case in the Netherlands that solar farms are also connected to this substation. The new farms have more generation capacity and thus substations should be scaled accordingly.

A central farm controller (CFC) gives setpoints to the local wind farm controllers (LWFC) and the solar farm controller (SFC) to manage the active and reactive power output of the WTG strings and the solar farm. The active power output of a string is set according to the setpoint of the respective power purchase agreement (PPA) contractors.

Several challenges are imposed in the following points.

- Power management should be optimally done in real-time in order to fulfil the transmission system operator's (TSO) grid compliance requirements at the point of common coupling (PCC). Power quality (PQ) has to be ensured; active power, reactive power, voltage and droop should fulfil the TSO requirements.
- The main transformers have a limited capacity and can not deal with the maximum production of wind- and solar energy.
- WTGs from different suppliers are implemented and will thus have different electrical characteristics.
- The farm control system should be expandable and flexible to manage varying operating conditions and topologies.
- Economical aspects and interests of different parties should be taken into account when designing the controller.

ABB will provide the outlines of a substation and the specifications of the generators.
The goal of this project is to implement a control system that manages power flows according to the description above. Simulations have to be performed in a program like MATLAB Simulink, ETAP or Vision to test the systems in the given context. Control schemes have to be programmed and tested in a remote terminal unit (RTU) acting as CFC.

The tasks can be divided in the following subgroups.

- Physical performance based design of the control scheme/architecture for power flow optimization.
- Determination of physical boundaries for the search of optimal set-points of controllable devices, optimal power flow objective function and system's technical constraints.
- Modelling of the power flows related to the generators and substation and validation.

This project touches on multiple subjects of the bachelor Electrical engineering. The main related courses are Systems and Control, Electrical Energy Conversion, Sustainable Energy Supply and Digital Systems. Systems and Control gives knowledge about controllers types and their performance and stability characteristics. Electrical Energy Conversion and Sustainable Energy Supply allow for modelling the wind farm and for example the power flow therein. Digital Systems is used for basic programming knowledge and hardware implementation.