MICROGRID OPERATION AND CONTROL

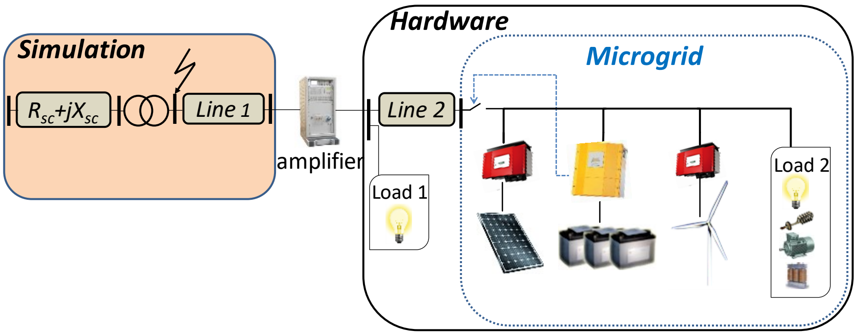

Figure 1. Setup for microgrid experiments (PHIL simulation).

The laboratory microgrid is used in a PHIL configuration (Fig. 1). At first, the microgrid [1] operates in grid-connected mode and the students note the active power of the PVs, wind turbine, storage and load of the microgrid from the SCADA developed at NTUA and also the active power flow at the secondary winding of the transformer in the DRTS (concrete experience). The key role of the storage system as the most controllable unit is highlighted and its applications, such as balancing the PV and wind turbine production, peak shaving, voltage control, self-consumption etc, are discussed. For the experiment it is assumed that the network or market operator requires a specific amount of active power from the microgrid as a controllable entity for technical (e.g. congestion, voltage violation) or economic reasons [2]. The students take the role of the microgrid operator which has to implement the required set-point by controlling the storage system and potentially the controllable loads. Based on measurements of the active power of the PVs, wind turbine, and load of the microgrid, the required active power of the battery inverter (absorption or production) is calculated, in order to achieve the required set-point (reflective observation). The set-point is implemented in the commercial battery inverter via software developed in-house (active experimentation). Fig. 2 shows the active power of the different components and the upstream network, where the set-point is received (at t = 35 s, the battery starts to absorb active power) followed by an irradiation reduction in the PV simulator (at t = 67 s, the battery decreases the absorption and starts to produce active power). The importance of different layers of control in the smart grid is explained (abstract conceptualization) accompanied with aspects of information and communication technologies.

Then a fault occurs at the transformer (in the DRTS at Fig. 1) producing a significant voltage dip which forces the microgrid to switch to island mode. Subsequently, the battery inverter becomes the grid-forming unit. The students have the opportunity to experience the seamless transition from grid-connected to island mode by observing that both the PV inverter and the load of the microgrid remain connected (hardware load 2: lights on), however the load outside the microgrid is disconnected (hardware load 1: lights off). The capability of microgrids to improve the reliability and maintain the power supply during external disturbances and grid interruptions is illustrated.

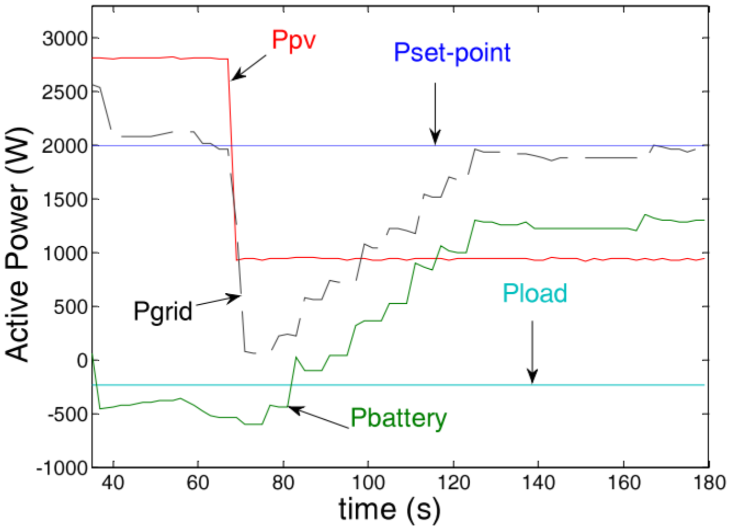

Figure 2. The students control the active power of the battery inverter to fulfil a set-point of 2 kW production from the microgrid. (The small deviation between Pset–point and Pgrid is due to the online approximate calculation by the students).

Island operation of the microgrid is examined next, where the voltage and frequency are defined by the battery inverter. The students observe the active power balance and confirm that the battery inverter balances the difference between the production (PVs and wind turbine) and consumption. Moreover, the capability of the battery inverter to operate with droop control, similar to a synchronous generator, is explained. This is particularly useful when more controllable units (e.g. battery inverters) are connected to the same islanded microgrid. The students learn that islanded microgrids are installed in remote off-grid locations, such as rural communities in developing regions, etc.

References:

[1] N. Hatziargyriou "Microgrids: Architectures and Control", Wiley-IEEE Press, NJ, USA, January 2014

[2] M. H. Gomes and J. T. Saraiva, "Allocation of reactive power support, active loss balancing and demand interruption ancillary services in MicroGrids," Elect. Power Syst. Res., vol. 80, no. 10, pp. 1267–1276, Oct. 2010.

source:

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