



Design and Implementation of an Educational DC Microgrid

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DC Microgrids

DC microgrids, have higher efficiency than AC microgrids, and the integration of loads and distributed generation units is easier. Technically, renewable energy sources such as photovoltaic cells, fuel cells as well as loads can be connected to a common DC bus with fewer levels of power conversion. Consequently, there is less energy wasted and possibly lower cost than in AC microgrids. In addition, multiple generation units can be connected in parallel to the same DC bus while the AC system requires voltage magnitude, frequency and phase synchronization.

A typical islanded microgrid is composed of the following major components:

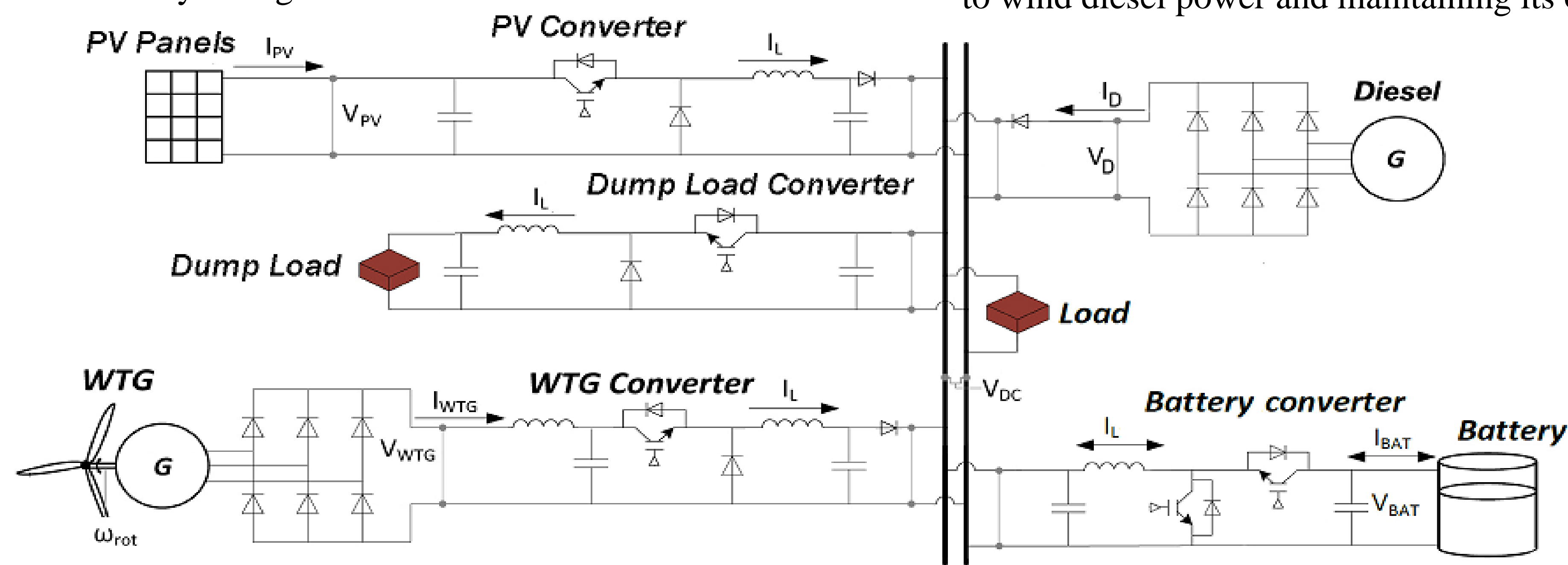
- Distributed Generation Units
- Dispatchable Backup Generation Units
- Loads

In the case of a grid-connected microgrid, a grid-tie converter should be added to this list. Additionally, sometimes, a dump load is provided to accommodate excess generation in the grid.

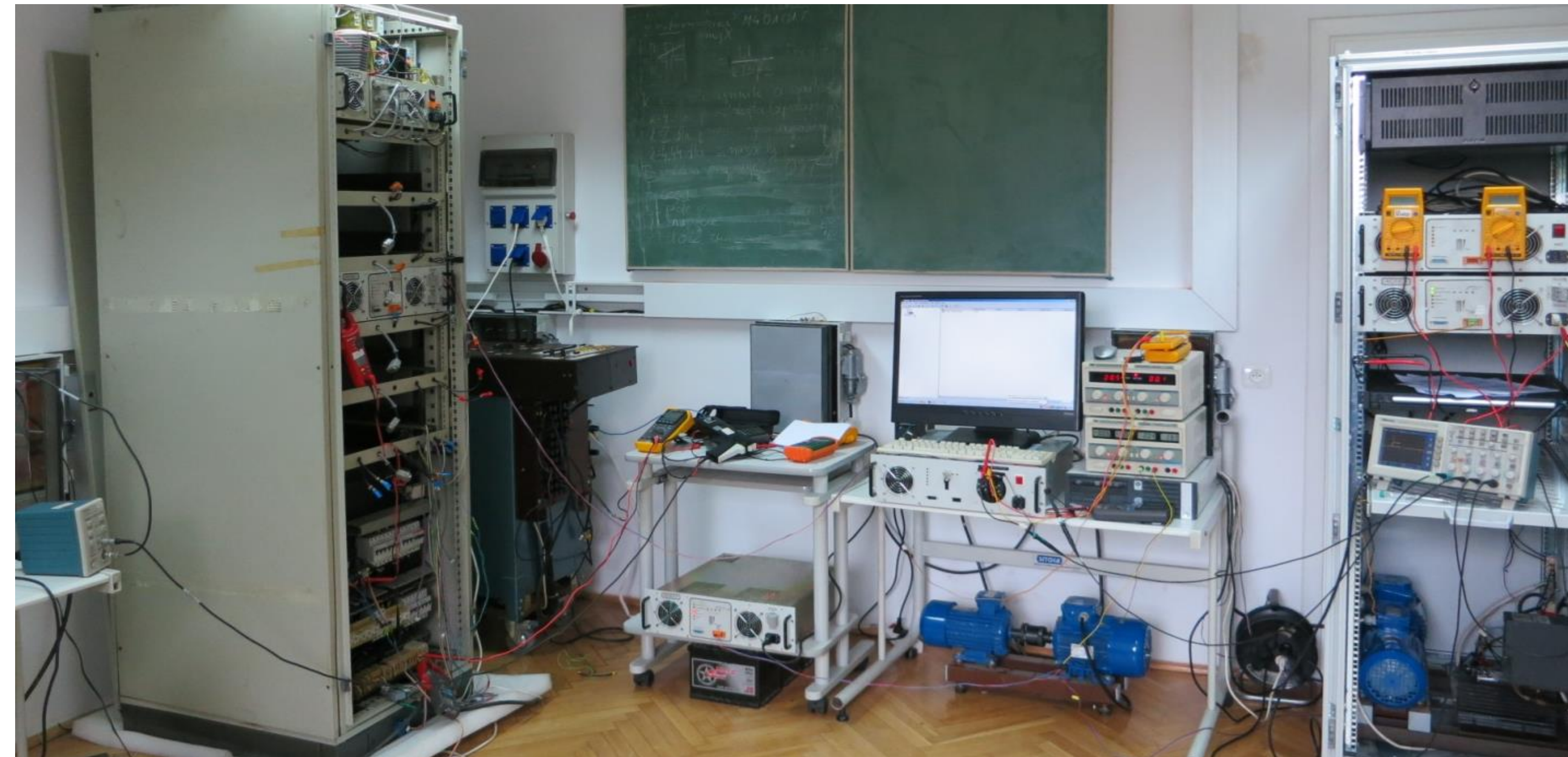
Physical Layout

Our system is a DC microgrid that accommodates:

- Photovoltaic (PV)
- Wind turbine
- Diesel generator and
- Battery storage units



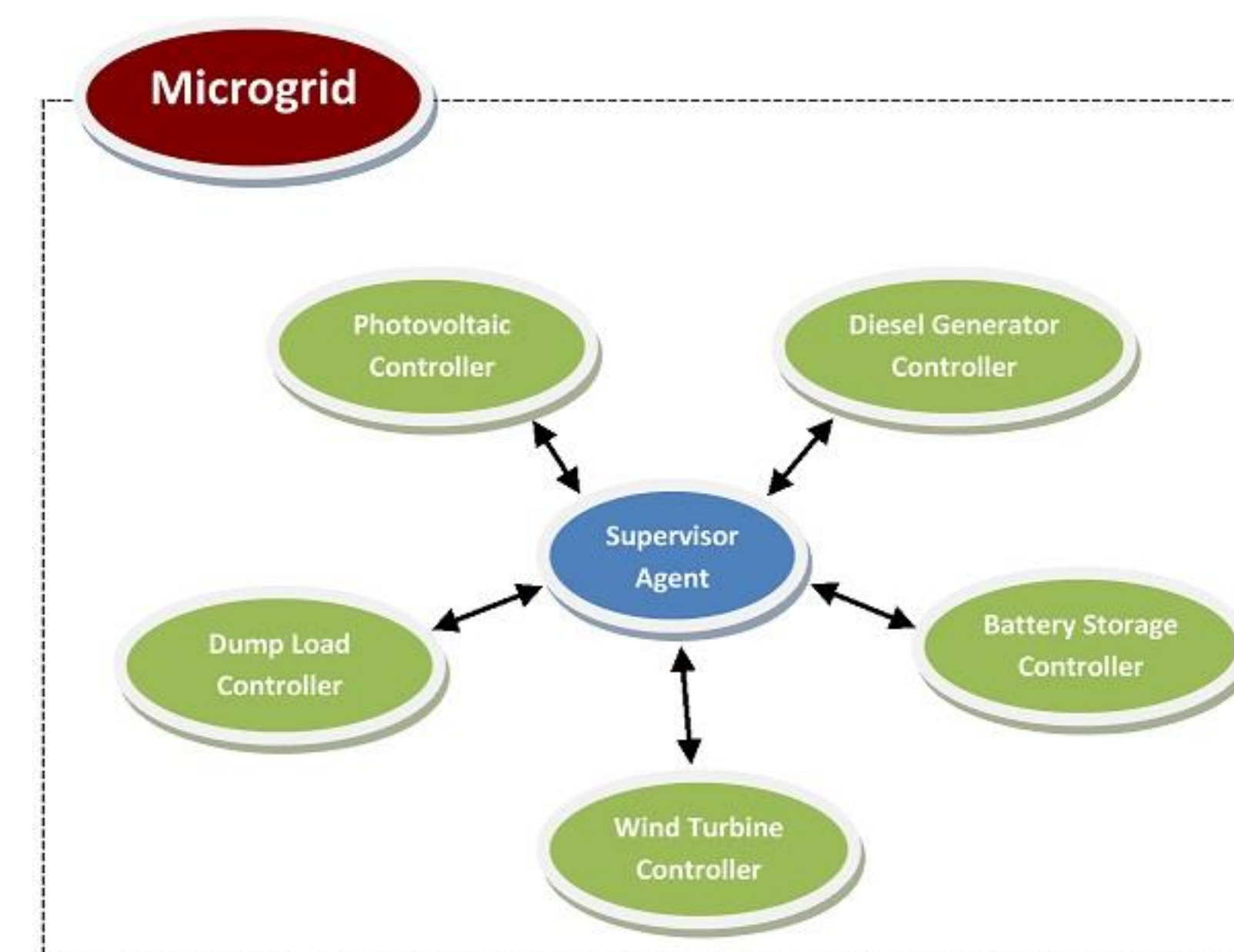
System Setup



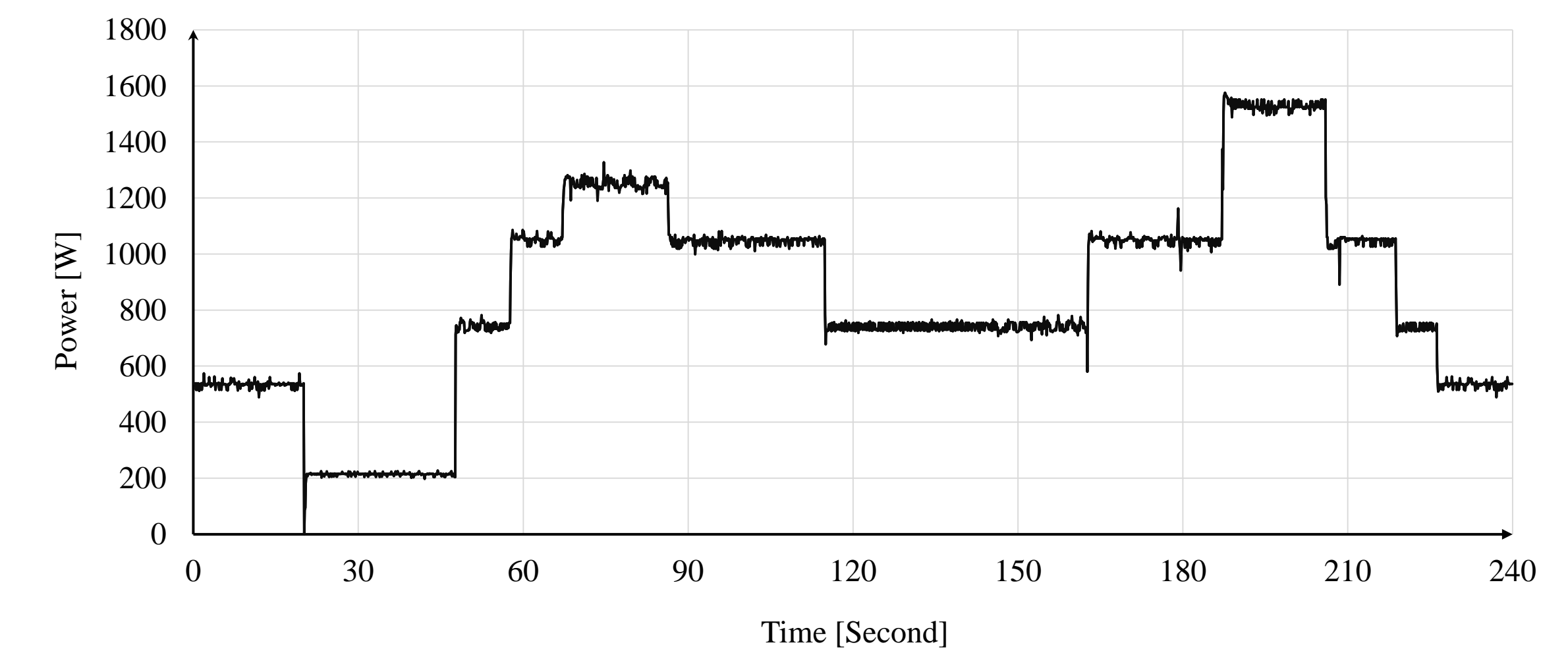
Control Layout

Each of these components has an individual controller that is capable of operating independently while the main controller maintains the balance between consumption and generation. As result of collaboration between the controllers, the system has the following features:

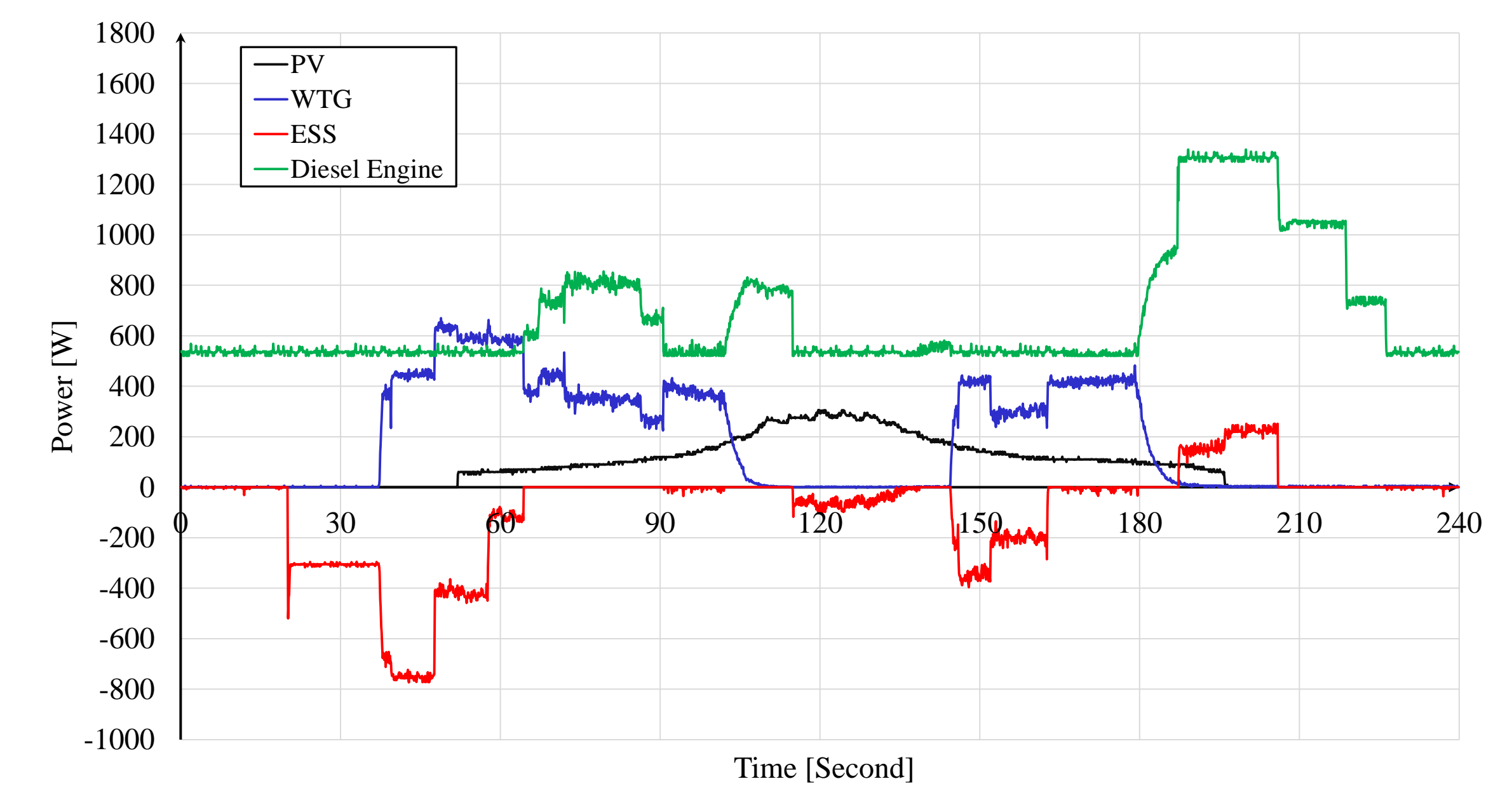
- (1) Performs MPPT for renewable energy systems,
- (2) Controllers are isolated from each other to prevent unfavorable interactions in the system,
- (3) Voltage regulation of the common DC bus,
- (4) Minimizes fuel cost and carbon emissions of the diesel generator with granting the least priority to wind diesel power and maintaining its operation level above 40%.



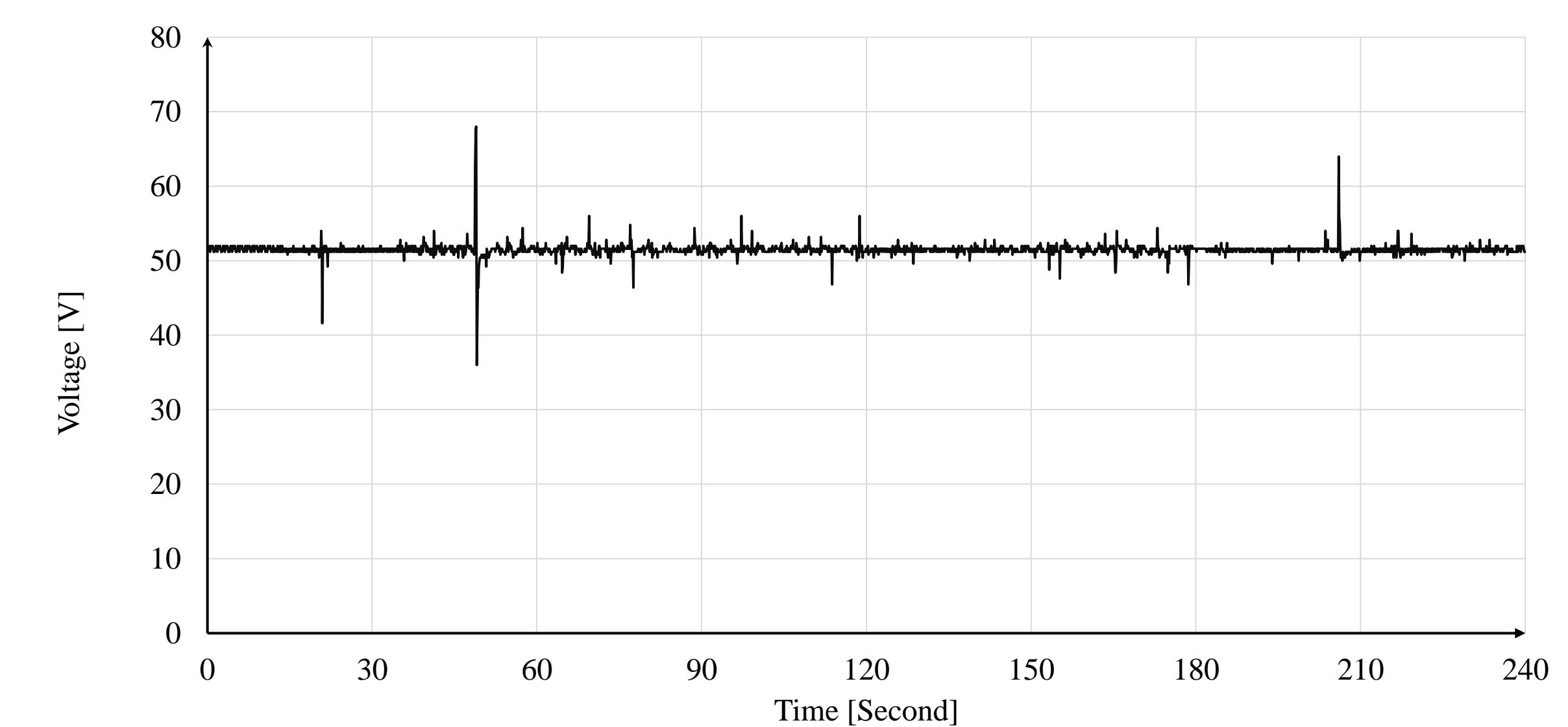
Operation



Emulated load profile for the system test



Contribution of the units to serve the load



Voltage profile on common DC bus