Hierarchical Distributed Control Systems

High penetration levels of variable generation from renewable energy resources and increased variability of demand can have adverse impacts on the stability of distribution systems. The operations of distributed resources (DR) may significantly impact the voltages at different locations on the distribution system. The impact on voltage-regulating devices may have a potential of creating too high voltage; voltage imbalance; intermittent operations which may result in unacceptable voltage fluctuations; or improper regulation during reverse power flow conditions.

Hierarchical control schemes can be used to cordinate DR with voltage/var control devices; compensate for voltage fluctuations caused by intermittent operations of DR; and mitigate voltage fluctuations.

Operation and control strategies can adapt hierarchical control schemes that include an EMS, µEMS, DMS, µDMS, smart PCS and home gateways.

EMS, µEMS, DMS, µDMS, Smart PCS and Home Gateway Functions

EMS Functions

- System that monitors/controls the real-time network; includes generation control and load forecast functions.
- Monitors and controls transmission lines and substations via SCADA.

µEMS Functions

- µEMS (Micro Energy Management System) function monitors the status of the microgrid as an entity and its components, e.g. distributed generation, storage, load. The µEMS interacts with the area EPS, engaging in in cooperative control, including scheduling, dispatch and balancing functions.

DMS Functions

- Monitors and controls distribution feeders via SCADA. .
- Generation/Execution of Switching Procedures that automatically generate and execute switching procedures (after confirmation by DSO).
- Load Forecasts that calculates load forecasts for distribution feeders or sections between switches under its control. [Note: The load of feeder or section is Gross load and includes PV output.].
- Distribution Simulation System that simulates power flow for distribution feeders under its control.
- Demand Response Management that controls demand-side appliances through Home Gateways.

- Communications with μDMS for data exchange and to exercise cooperative control. (Exchanges data and exercises cooperative control with μDMS)
- Communications with EVECC, EMS, and MDMS for data exchange

μDMS Functions

- Monitors load and voltage of the LV transformer.
- Controls demand-side appliances and smart PCS directly through Home Gateways (in cooperation with the DMS and indirectly through the EMS). (Exchanges data and exercises cooperative control with the DMS and Home Gateway.)

Smart PCS Functions

- Connect/disconnect – anti-islanding
- Max Generation level control
- Smart VAR management and PF
- State/Status Monitoring
- Voltage sag ride-through

Home Gateway

- Communication with Remote CB attached to Home appliances, and EV Normal charger to exchanges data and controls Home appliances, and EV Normal charger.
- Communication with μDMS and smart PCS
- Communication with smart PCS
- Communication with Home Display (Customer Laptop PC or Cell phone)
- Management Asset Inventory data via Home Display