Data-Enhanced Hierarchical Control to Improve Distribution Voltage with Extremely High PV Penetration

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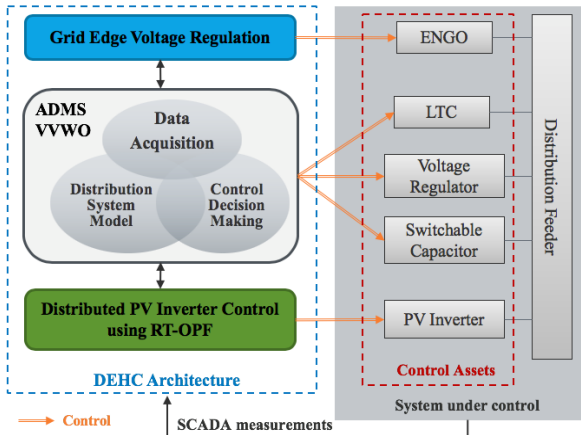
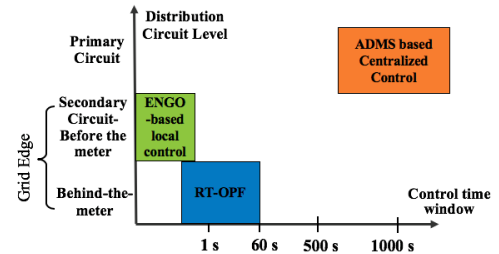National Renewable Energy Laboratory

Abstract

Dynamic, scalable, and interoperable control paradigms are required to enable efficient, secure, reliable, and resilient distribution grid operations with widespread grid integration of renewable energy resources. This paper presents our recent research on developing a novel, holistic, data-enhanced hierarchical control architecture that addresses the formidable challenges faced by emerging distribution grids with increasing penetrations of distributed energy resources. The proposed architecture integrates centralized monitoring and control with distributed grid-edge control and thus effectively deals with multi-spatiotemporal dynamics existing in the grid. Simulation results are provided to demonstrate the effectiveness of the proposed control architecture.
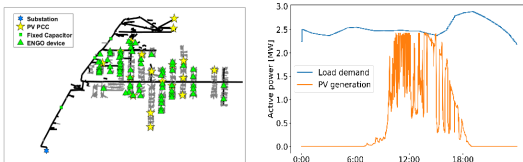
DEHC Architecture

- Centralized volt-VAR-watt optimization (VVWO) using ADMS
- Distributed PV inverter control based on real-time optimal power flow (RT-OPF)
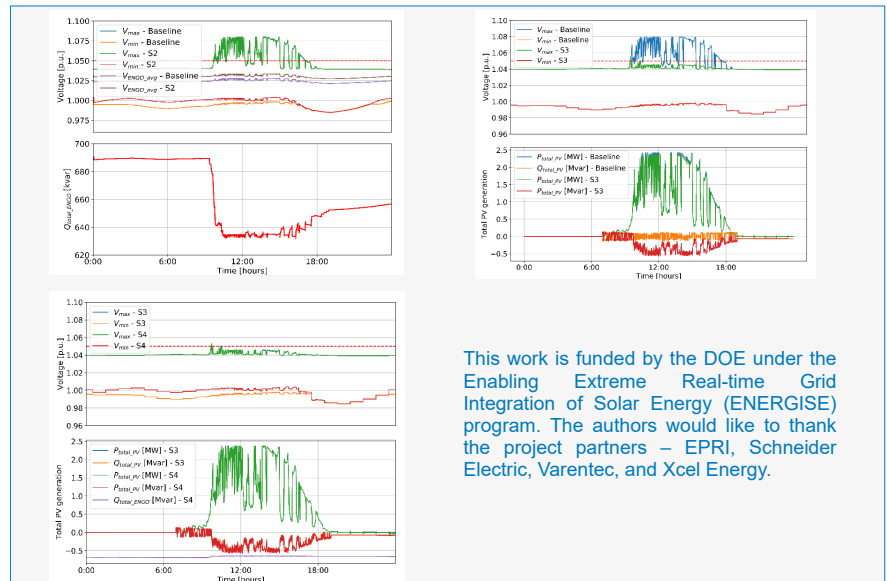- Grid-edge voltage regulation using the Edge of Network Grid Optimizer (ENGO)

Results and Analysis

Scenario	Description
S1	• ENGO devices: disabled • PV systems: unity power factor
S2	• ENGO devices: enabled and operating with a fixed voltage-regulation set point of 1.033 p.u. • PV systems: unity power factor
S3	• ENGO devices: disabled • PV systems: dispatched using the RT-OPF
S4	The RT-OPF dispatch of the PV systems is employed while the ENGO devices are in service.