Project 2.8

Integrated Control Testing under Complexity

Evaluation of Control Methods Through Large-scale Interconnected Energy System Simulations

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CCSI Control of Complex Systems Initiative

Pacific Northwest NATIONAL LABORATORY

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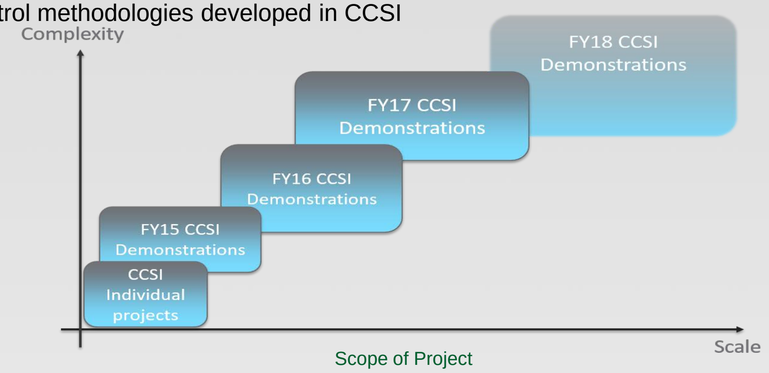
Objective

Investigate prototype-stage advanced control methods within large-scale complex interconnected energy systems using the CCSI test bed

- Complexity is increasing model fidelity and interactions across multiple timescales, to closer resemble a physical system capable of truly evaluating control methodologies developed in CCSI



Methodology

Use cases demonstrating CCSI control capabilities using the CCSI test bed

Wholesale - Retail Market Integration

- Retail and wholesale markets integration where demand is engaged using control methodology from CCSI 1.1
- Interconnection scale with geographically appropriate transmission system and distribution networks, including >10 Million controllable devices
- Higher fidelity load modeling including residential households with multiple thermostatically controlled devices and larger commercial loads

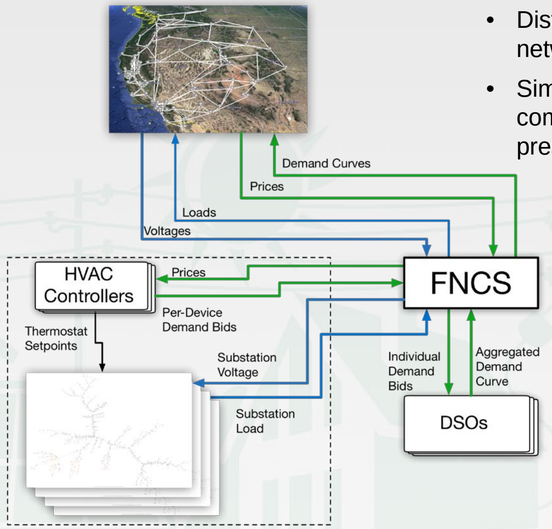
Distributed Economic Dispatch

- Investigate distributed economic dispatch (ED) control methodology proposed in CCSI 1.3 on a complex transmission and communication system model
- Applicable to large-scale markets with numerous participants, as in the western Energy Imbalance Market (EIM)
- Negotiations between 100+ generators and load serving entities (LSE) to solve distributed ED on detailed communication network

Simulation Platforms

Wholesale - Retail Market Integration

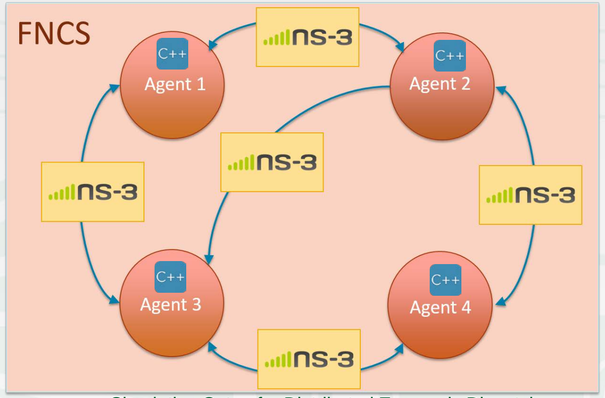
- Transmission System:
  - WECC 240 node interconnection scale model with market and control actuation every 5 minutes
  - Full AC power flow every 30 seconds
- Distribution Systems:
  - 10,000 prototypical feeders with diversified load patterns and device configurations based on geographical regions
  - Includes detailed residential household modeling for thermostatically controlled HVACs, water heaters, and pool pumps
- Distribution System Operator:
  - Coordinating HVAC controllers – bidding and price-responsive



Simulation Setup for Wholesale - Retail Market Integration

Distributed Economic Dispatch

- Distributed agents implemented as separate entities communicating through a network modeled in ns-3 by leveraging co-simulation tool from CCSI test bed
- Simulated the IEEE 118 node transmission system with varying communication technologies and achieved consensus between agents in the presence of delays and package drops



Simulation Setup for Distributed Economic Dispatch