Active Distribution Systems and Distributed Energy Resources C6

10393

EPRI's Digital Twin SPIDER Testbed and Benefits

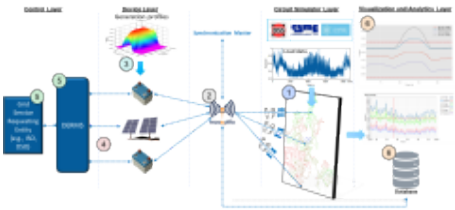
Aditie Garg, Jithendar Anandan, AHM Jakaria, Rayhan Mithu, Ajit Renjit

Electric Power Research Institute, USA

Motivation

Commercial implementation and evaluation of software control systems – such as DER gateways distributed energy resources management systems (DERMS), have advanced the state of such operational technologies to effectively utilize the capabilities of DER installations. Through a series of research projects spanning almost 10 years, EPRI developed SPIDER – an end-to-end DER integration testbed to evaluate and study the benefits of new DER integration technologies.

Architecture



SPIDER Testbed Architecture

Applications

- Perform comprehensive evaluation of functional capabilities and performance of commercial DERMS, ADMS, VPP controllers, and other grid edge technologies in a standards-based, vendor-neutral and realistic setting
- Test and develop different DER optimization and control algorithms that fit the grid operators' operational goals and grid needs
- Quantify the impacts and benefits, to both customers and the grid, by deploying such new DER integration technologies for a wide range of operational scenarios and various use cases
- Perform hardware-in-the-loop simulation, replacing software instances of DER with real hardware devices like PV inverters in the testbed
- Perform interoperability testing of DER technologies for conformance to open communication standards
- Test the scalability of DER managing entities to monitor and control thousands of DERs, different DER types and multiple DER aggregators
- Evaluate capabilities of local DER gateways that hosts advanced grid-edge intelligent functions (e.g., fail-safe operation, recurring schedules)

Conclusion

- EPRI's SPIDER testbed is a unique combination of tools that allows users to simulate varying field conditions and test DER technologies with minimal cost and effort
- A wide range of real-world scenarios, diverse feeders, various DER types, penetration levels, load conditions, weather conditions, etc. can be simulated and studied
- One of such scenarios where the transformer is overloaded due to high generation is tested and evaluated for a DERMS solution deployed in EPRI's SPIDER testbed

Active Distribution Systems and Distributed Energy Resources C6

10393

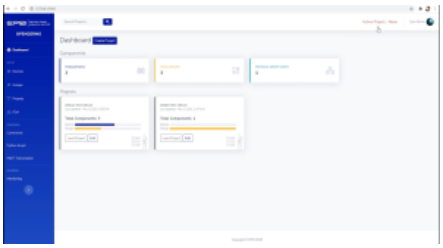
EPRI's Digital Twin SPIDER Testbed and Benefits

Aditie Garg, Jithendar Anandan, AHM Jakaria, Rayhan Mithu, Ajit Renjit

Electric Power Research Institute, USA

Control Layer

- The control layer actively manages the devices available in the device layer
- This could represent a DERMS or DMS control layer
- The control strategies can be a user-built system or a commercial solution



OpenDERMS Dashboard

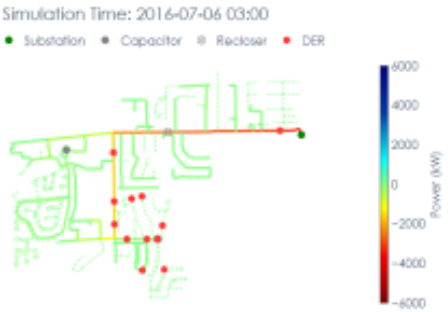
Device Layer

- All the devices which are controllable can be real devices or can be defined and emulated, using simulators
- DER and DAD (Distribution Automation Devices) simulators like PV, Energy storage, Load, Metering, Capacitor bank, Rotating machinery etc. emulate realistic device behavior
- Supports inbuilt standard communication protocols

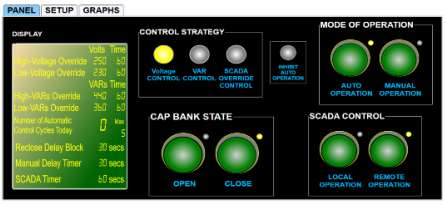
DER Simulator

Circuit Simulation Layer

- Circuit simulator layer emulates the distribution feeder model that can be modeled in various circuit simulators like OpenDSS, CYME or Synergi



Circuit Simulator



Cap-bank Controller

Visualization and Analytics Layer

- The testbed has a real time visualization layer that allows the user to analyze and verify the state of the grid in real time
- Visualize voltage, current and power waveforms

Active Distribution Systems and Distributed Energy Resources C6

10393

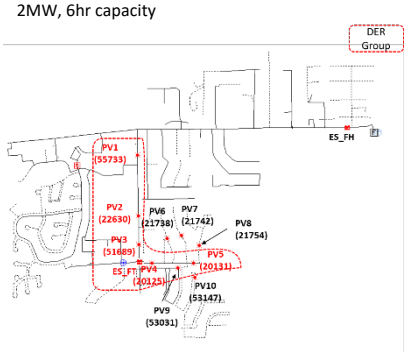
EPRI's Digital Twin SPIDER Testbed and Benefits

Aditie Garg, Jithendar Anandan, AHM Jakaria, Rayhan Mithu, Ajit Renjit

Electric Power Research Institute, USA

Feeder

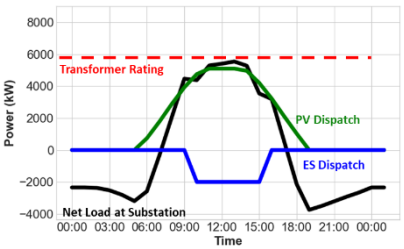
- The feeder substation transformer was rated at 6MVA with existing peak load of 4.7MW
- The feeder consisted of 10 PV plants with a total capacity of 17MW and 2 ES (Energy Storage) units of 2MW, 6hr capacity



Distribution Feeder Under Test

Managed Case Simulation

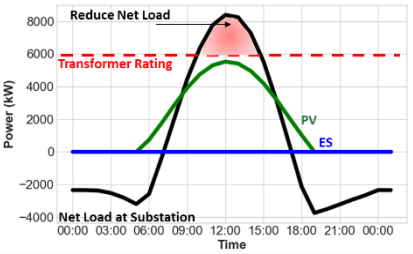
- Group service request was sent to OpenDERMS to reduce the net load during daytime hours
- To reduce the DER generation the control strategy defined in OpenDERMS disaggregated the incoming service request prioritizing ES dispatch over curtailing PV
- It was observed the algorithm successfully maximized PV generation and dispatched ES to ensure the net feeder load was below transformer's rated capacity



Managed Case Simulation Results – No Substation Overload

Base Scenario

Substation was observed to have overload issues during daytime hours due to excess DER generation



Base Scenario Simulation Results – Substation Overload

Conclusion

- PV units curtailed by a small amount i.e., 1.8% of daily full generation capacity while ES was utilized to its full capacity of 2MW for 6 hrs
- The algorithm minimized PV curtailment and charged ES to its full capacity
- SPIDER platform successfully dispatched group service request