ADMS Test Bed Use Case 5: Federated DERMS for High PV Systems

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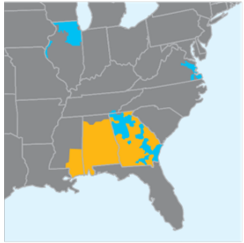
December 12, 2024

ADMS Test Bed and FAST-DERMS Workshop

Photo by Dennis Schroeder, NREL 55200

Southern Company Overview

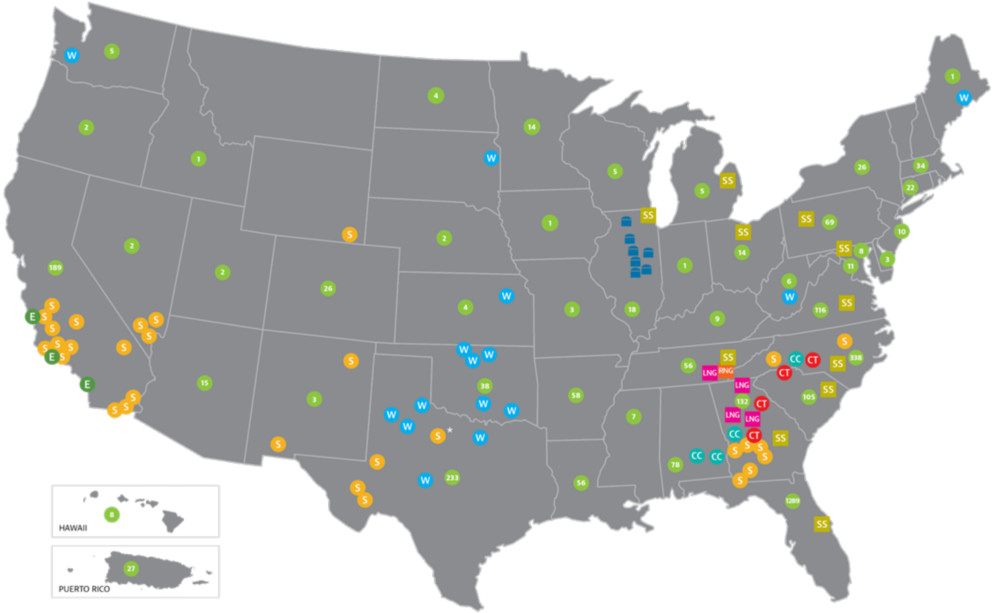


Service territories

- Electric
- Gas

Gas pipelines

- Southern Natural Gas
- Southern Company Gas



Southern Power

- CC Combined-cycle facility
- CT Peaking facility
- S Solar facility*
- W Wind facility
- E Energy storage

Southern Company Gas

- LNG LNG facilities
- SS SouthStar
- Natural gas storage
- RNG Renewable natural gas

* Under Development

PowerSecure

- # Owned and/or managed sites per state

Capabilities in
50 States

7
Electric & Natural Gas Utilities

9 Million
Customers

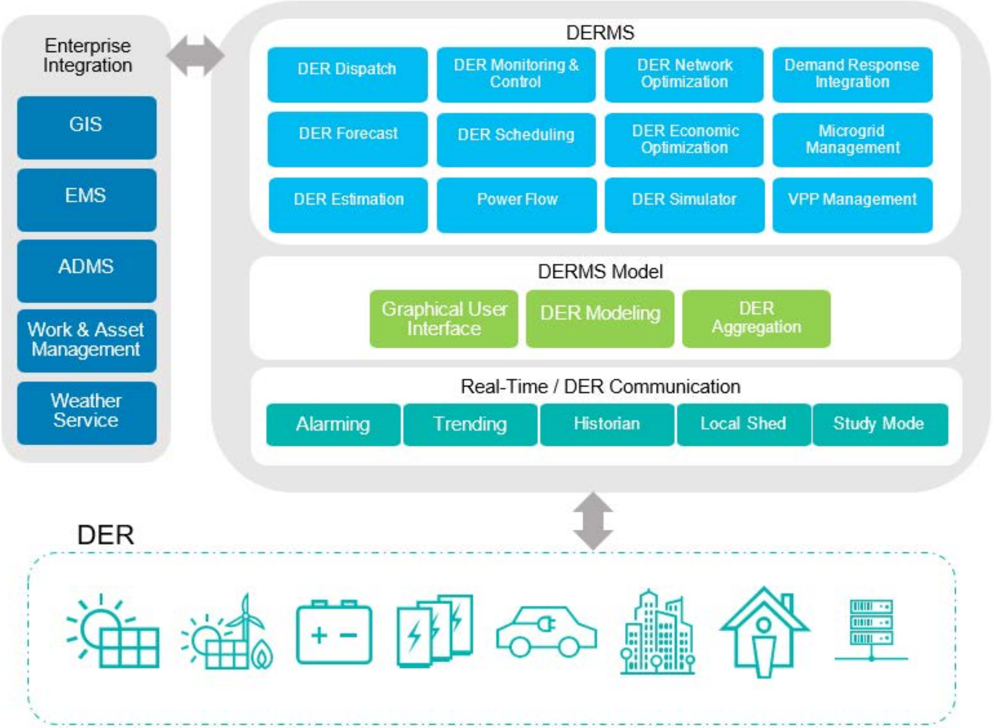
More than
28,000
Employees

Approximately
44,000 MW
of Generating Capacity

May 2024

Southern Company's Engagement in FAST-DERMS

- Southern Company's distributed energy resource management system (DERMS) request for proposal (RFP) completed:
  - Driving factor: Increasing daily load projection uncertainty
- Different DER types and use cases will be phased in over years
- FAST-DERMS helped inform Southern Company about DERMS architectures



Schatz Grid Visualization & Analytics Center (SGVAC)

- The SGVAC is a grid simulation and operations lab
- DERMS, distribution management system (DMS), and energy management system (EMS) will be deployed in SGVAC
- Current SGVAC applications:
  - Synchrophasors
  - Advanced power system modeling
  - Cybersecurity

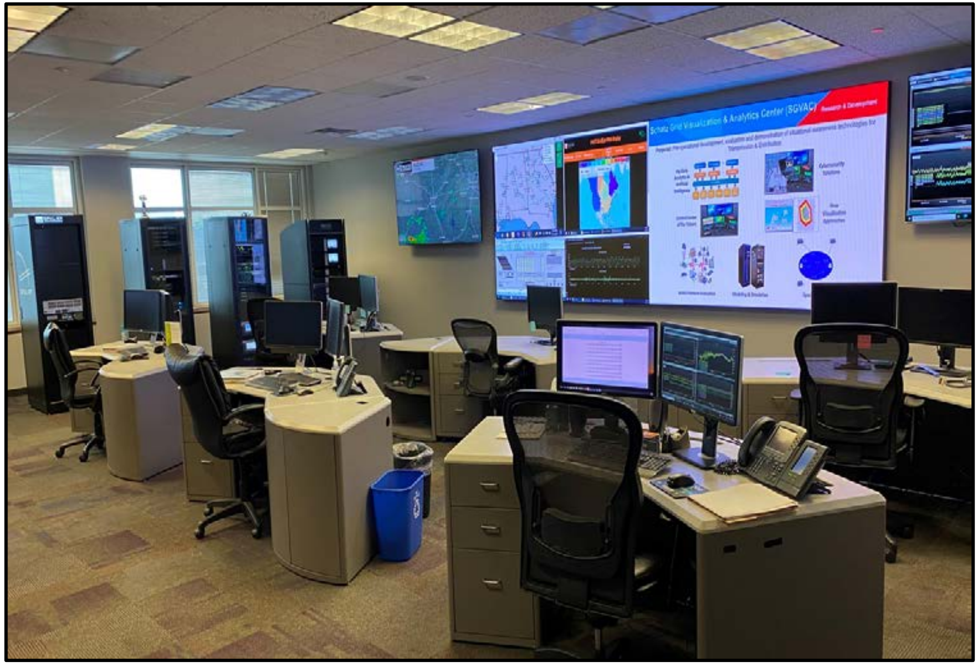
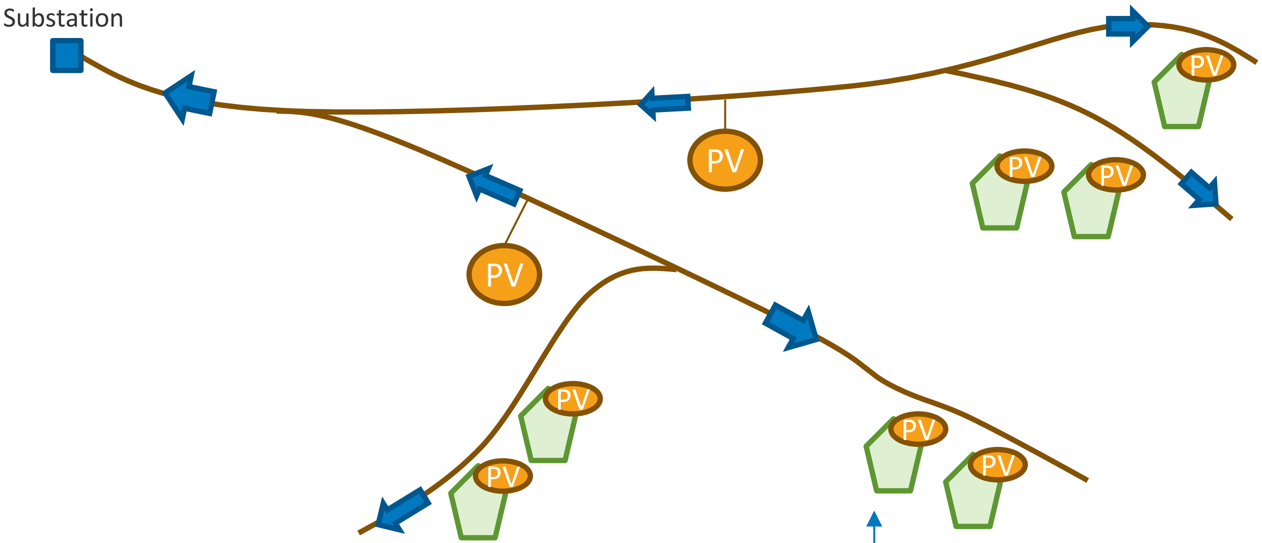


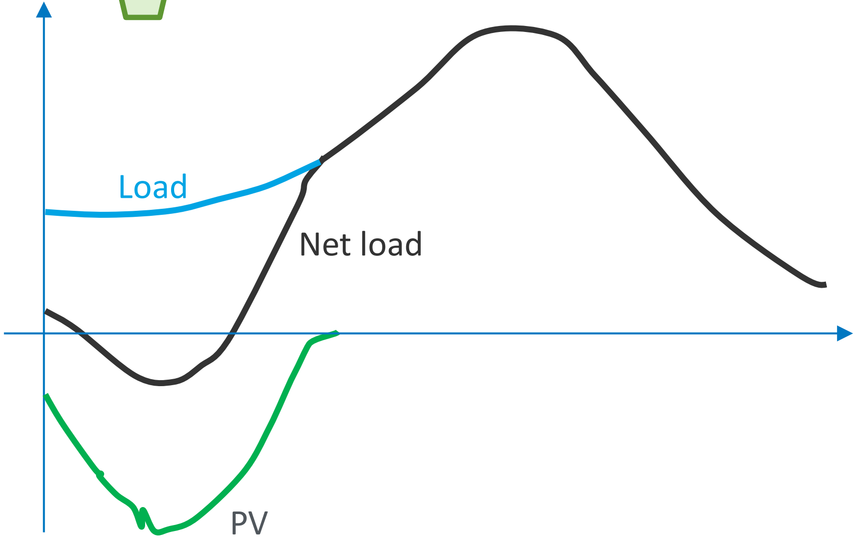
Photo from Southern Company

Project Goals

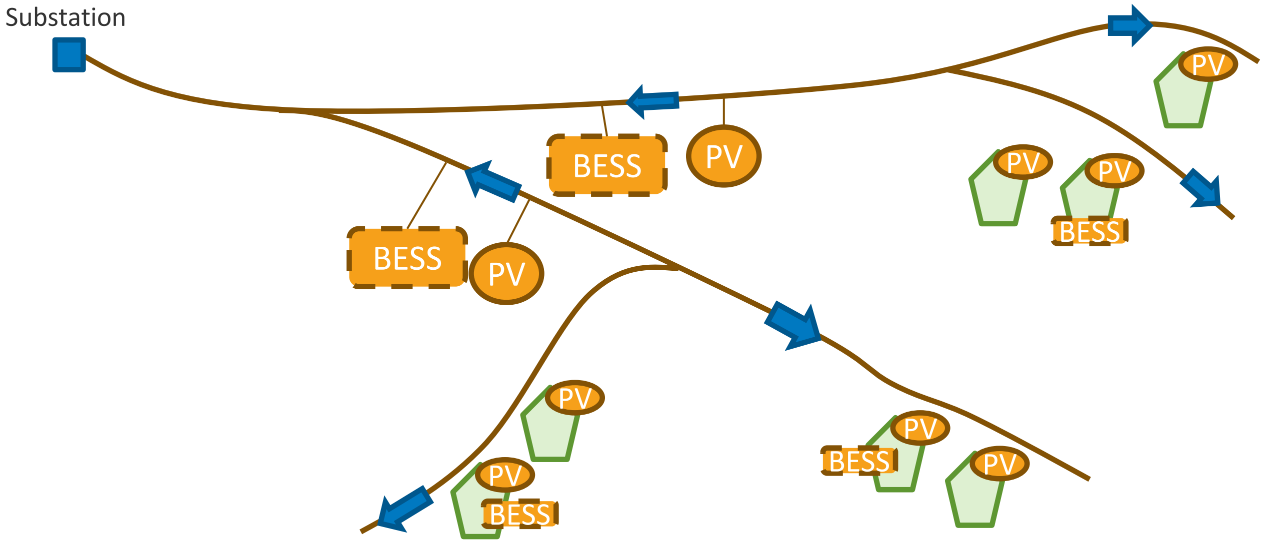
Demonstrate federated DERMS managing utility-scale and behind-the-meter (BTM) storage on a high-photovoltaic (PV) feeder to maximize local power consumption.

- Evaluate addition of utility-scale battery energy storage systems (BESS)
- Evaluate support from the BTM batteries.
- Direct control of utility BESS
- The BTM BESS are managed through an aggregator.

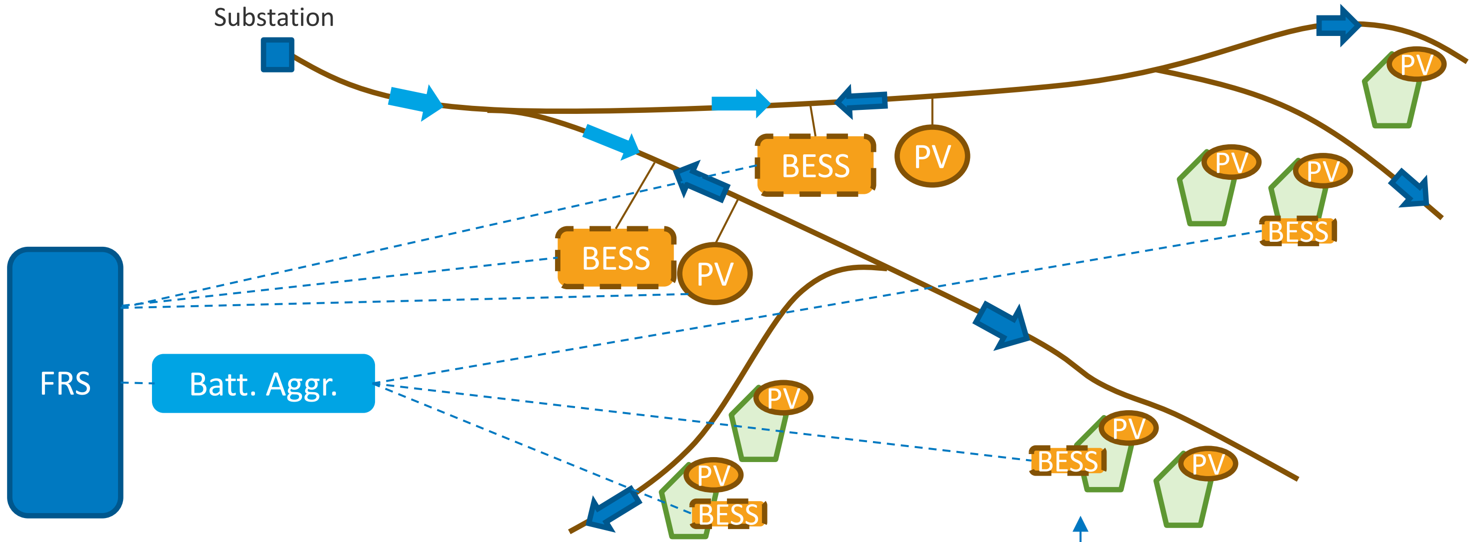


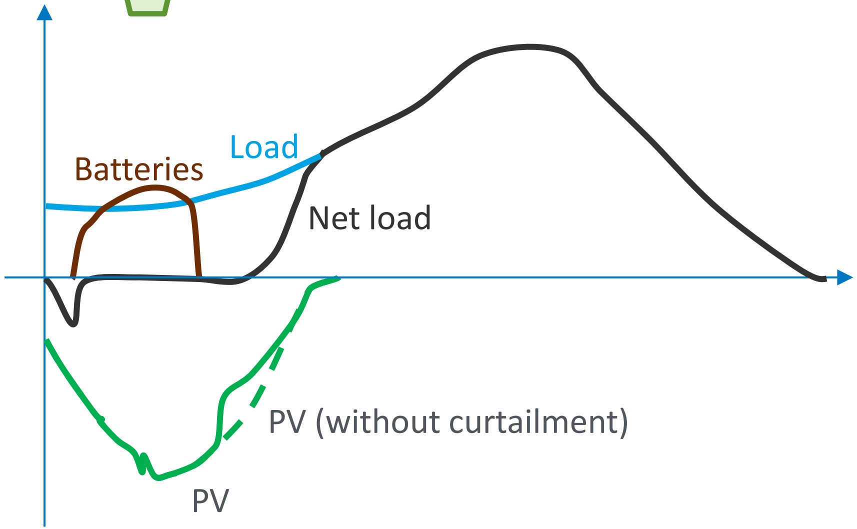


Baseline with reverse power flow



With the addition of utility-owed + customer-owned BESS





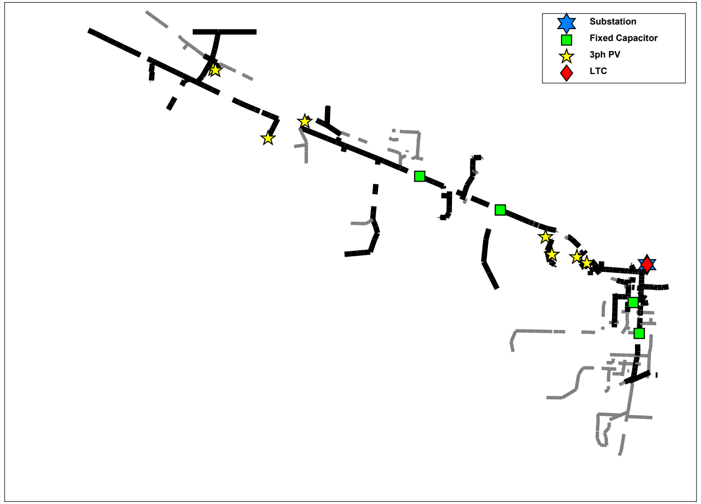
With the addition of utility-owed + customer-owned BESS; and controls

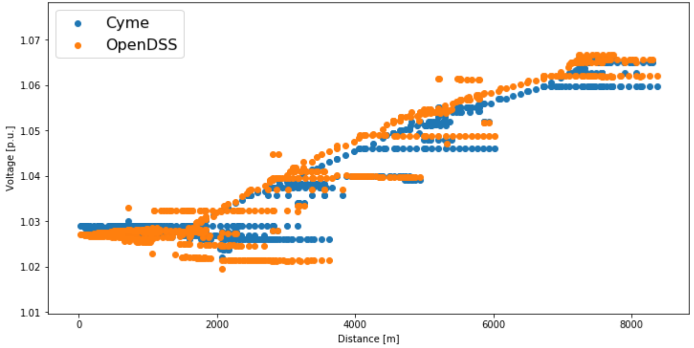
Feeder Co-Simulation

Feeder Model

Feeder in Southern Georgia:

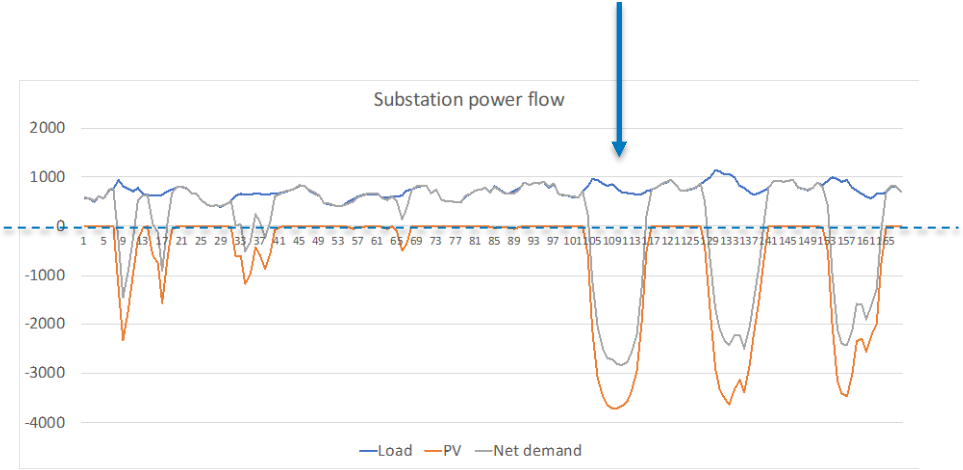
- 215 load nodes
- 4.4-MW peak load
- 9 utility-scale PV systems
- 3.7 MW of total PV generation capacity
- Load tap changer (LTC) at feeder head
- Four three-phase capacitors
- Converted to OpenDSS
- Validated against CYME model and feeder head SCADA system data from 2020.



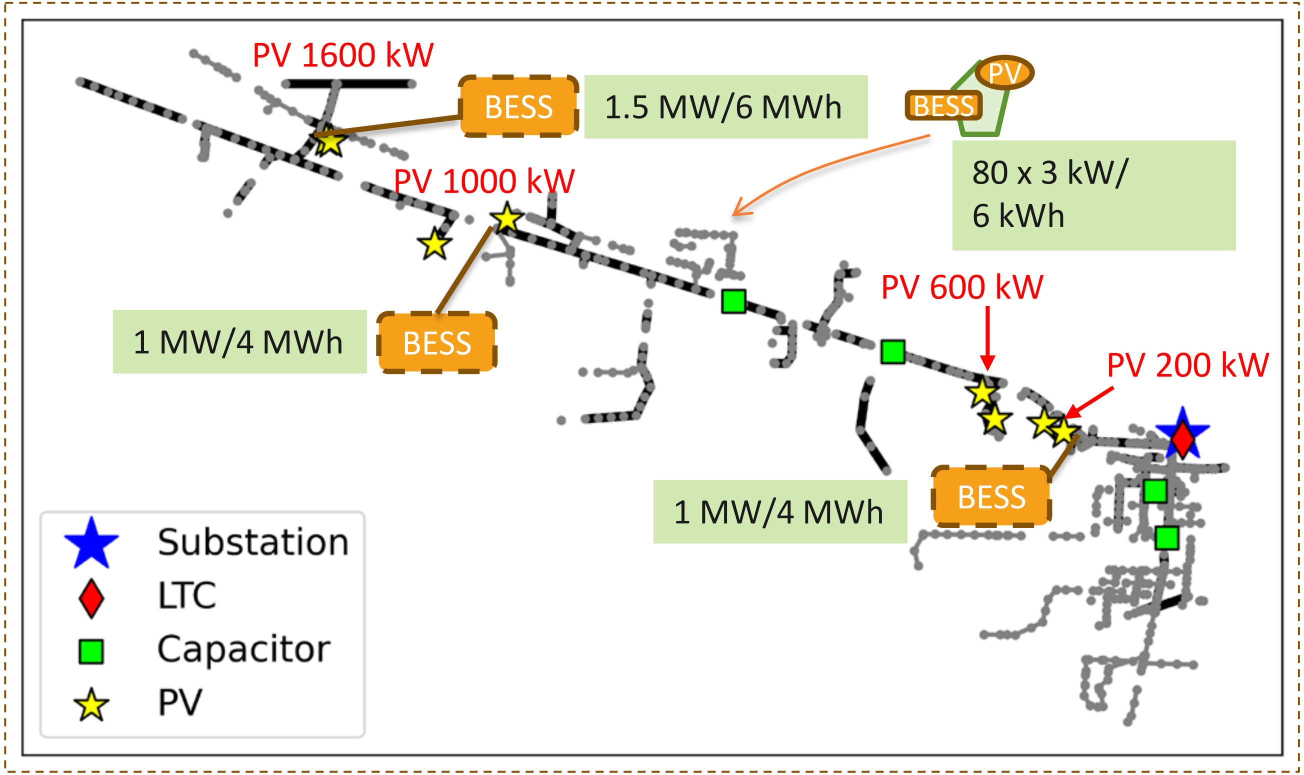


Power Flows Without BESS

- Model is interpolated to 1-min resolution for 1 week.
- High PV and low load (Monday 3/2/2020–Sunday 3/8/2020)
- Simulation day: lowest net load on Friday, 3/6/2020.



Feeder With Additional DERs



Bulk Grid Cost Data

- Used *total_cost_enduse* from NREL's Cambium tool as the market price (https://scenarioviewer.nrel.gov/)
- Estimate of the marginal costs induced by an increase in demand from least-cost optimization models
- Standard Scenarios 2021
- Mid Case 2022
- Weather from 2012.

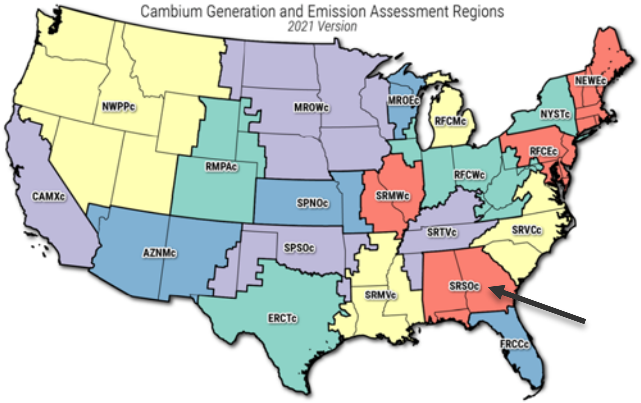
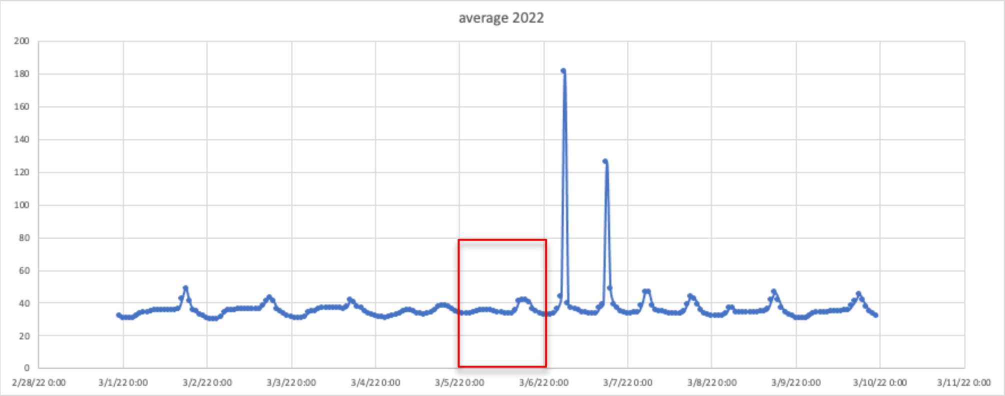


Figure 2: Cambium's Generation and Emission Assessment (GEA) Regions



GridAPPS-D Simulation Results

GridAPPS-D Simulation Results

- To be published in January 2025:

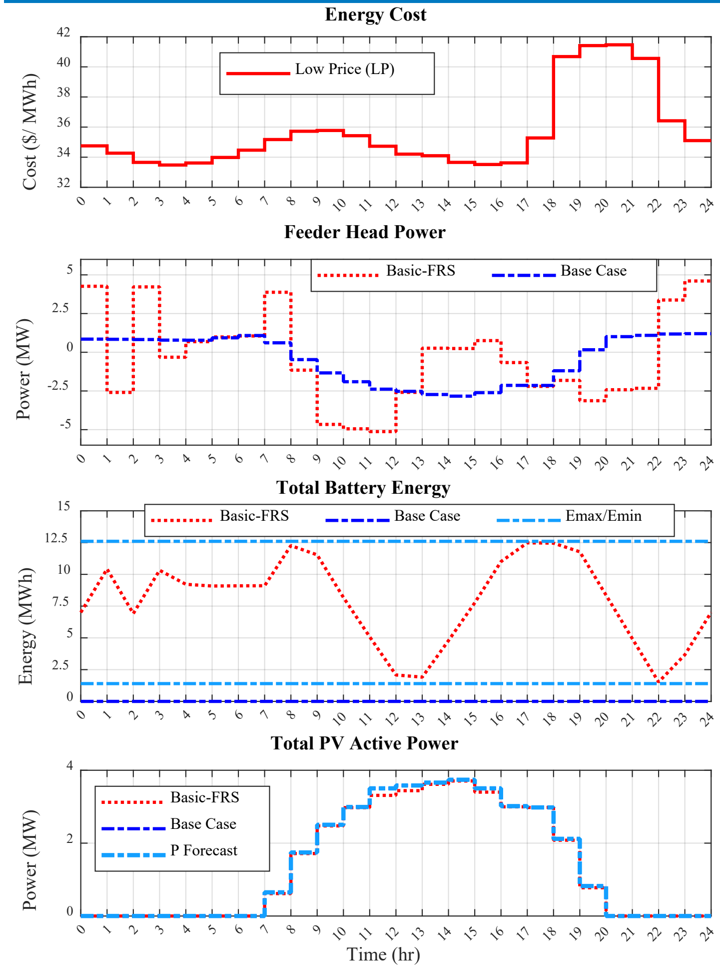
  Y. Lin, V. Motakatla, A. Pratt, J. MacDonald, M. Baudette, and A. Ingram, “Federated Controls for Distributed Energy Resource Management Applied to a Feeder with High Solar Generation and Battery Storage,” accepted to the 2025 IEEE PES Grid Edge Technologies Conference & Exposition.
- This section will not be included in the public version of the slides.

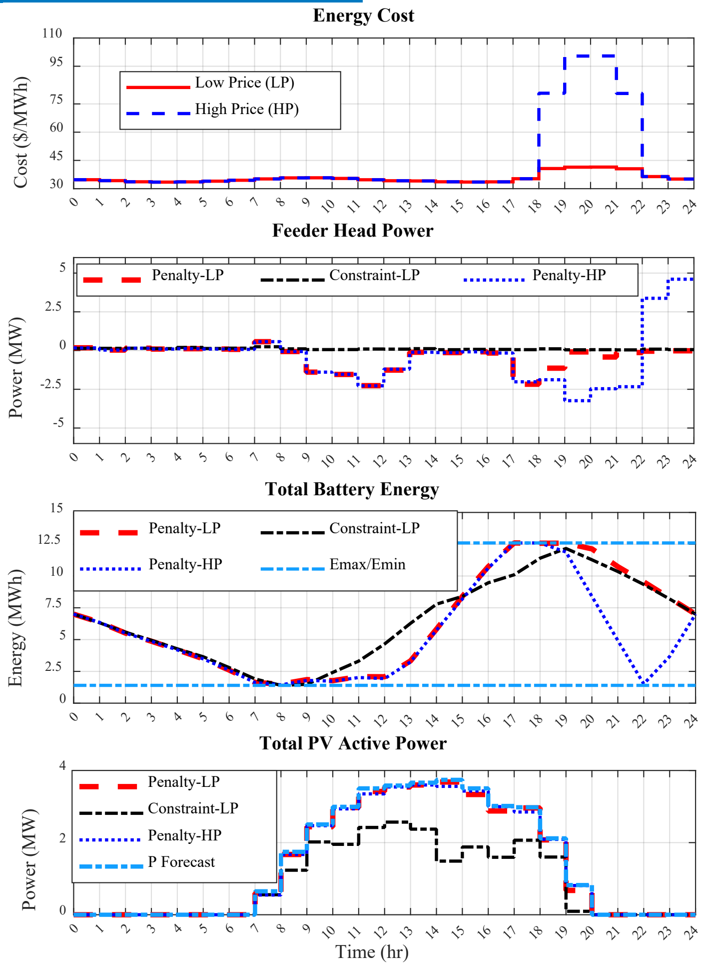
Optimize Local Power Consumption

Two approaches to optimize local power consumption:

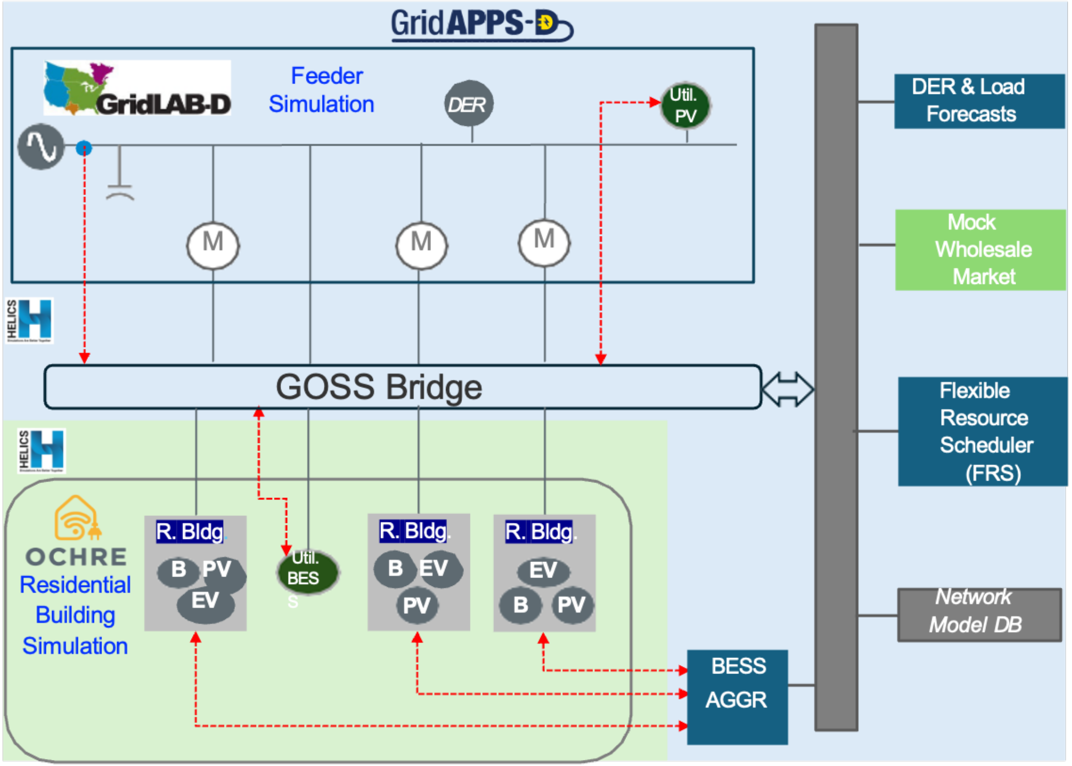
1. Reverse power flow constraint: Caps reverse power flow at maximum value.
    - Advantage: Easy to implement
    - Disadvantage: High costs are possible to satisfy the constraint, e.g., PV curtailment.
2. Penalty to reverse power flow.
    - Advantage: Avoids reverse power flow only if the cost of doing so is low, so it is less likely to curtail PV.
    - Disadvantage: Introduces integer into the optimization problem, harder to solve, and requires more computational power.

Day-Ahead Results

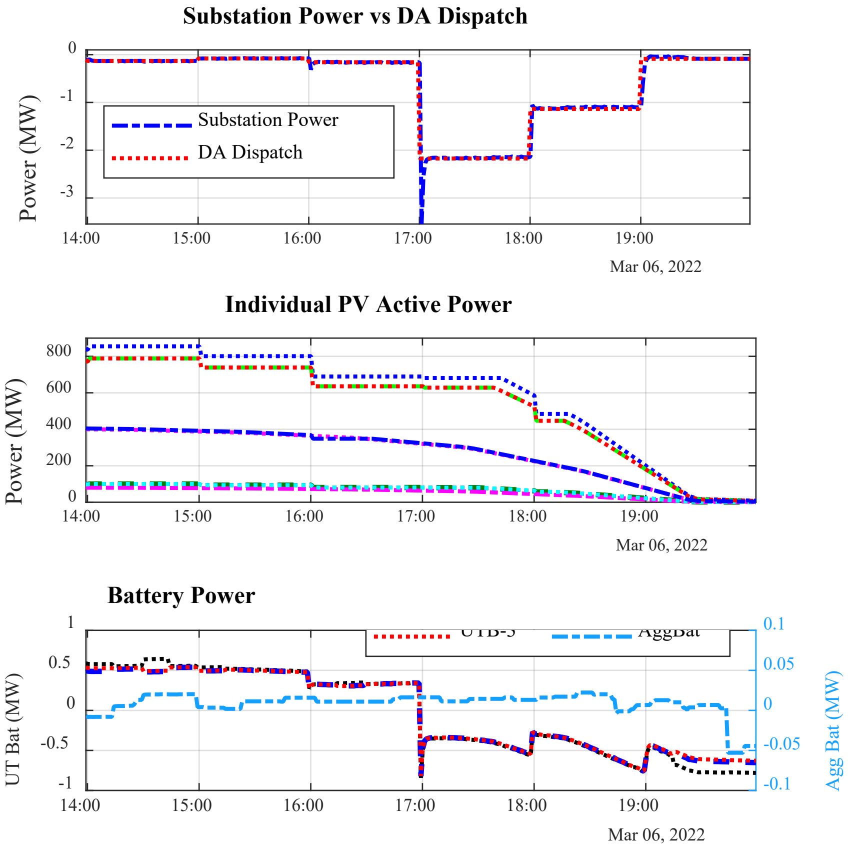




GridAPPS-D Simulation Setup



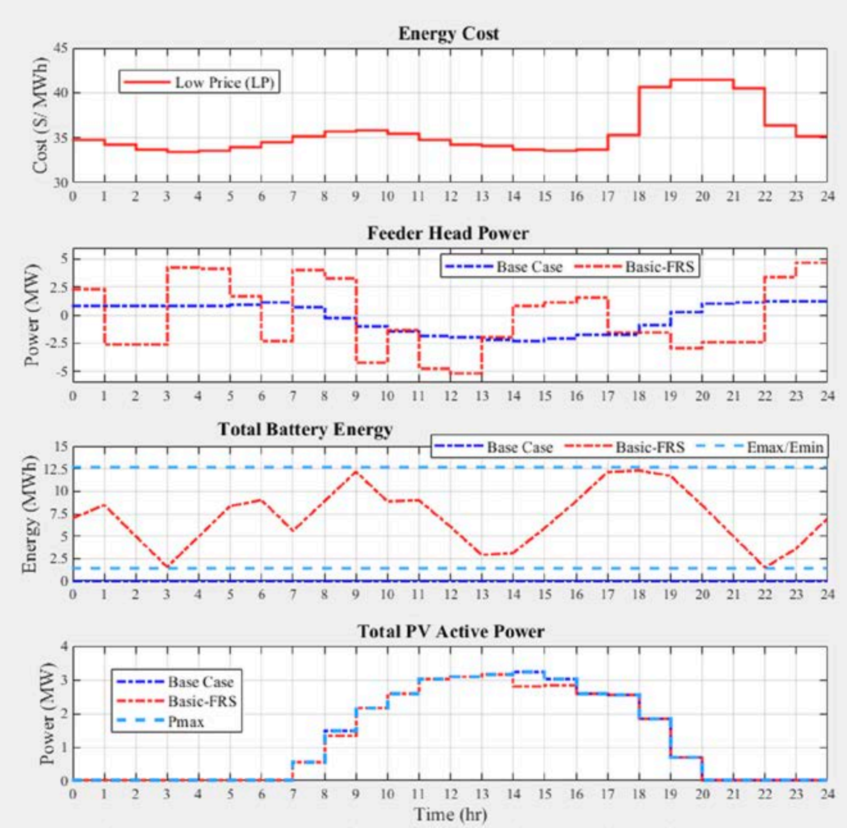
MPC and Real-Time Simulation Results



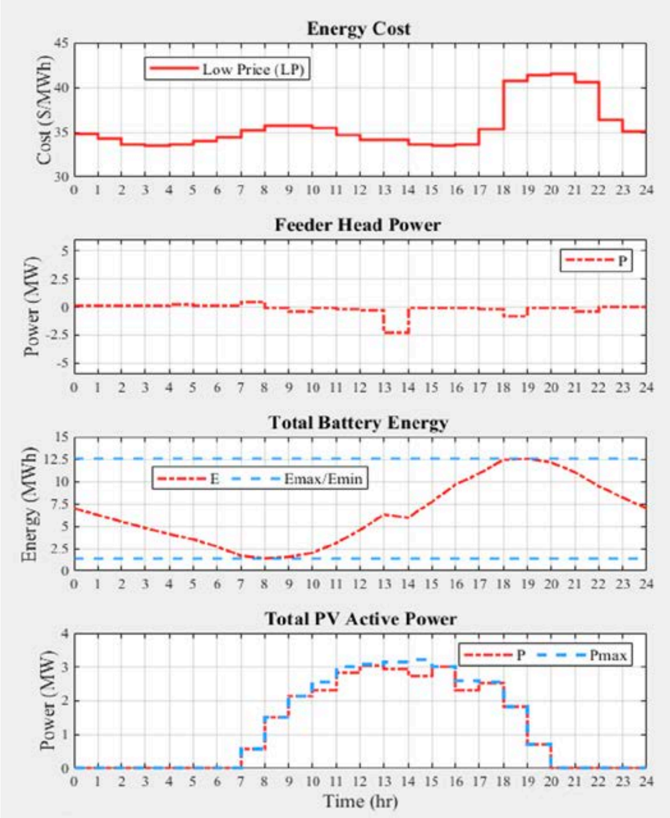
ADMS Test Bed Implementation

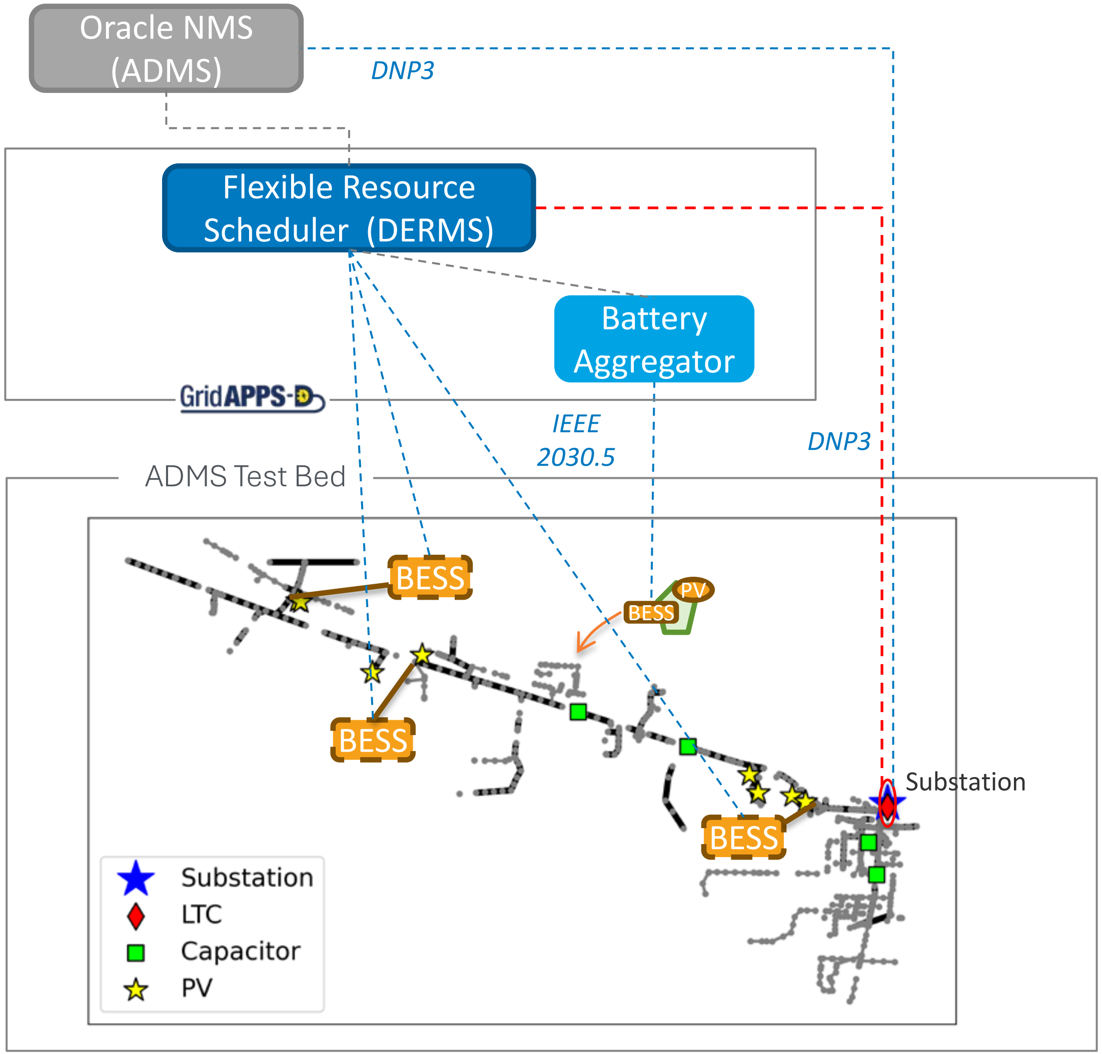
Day-Ahead Optimization Results

Energy Cost Only

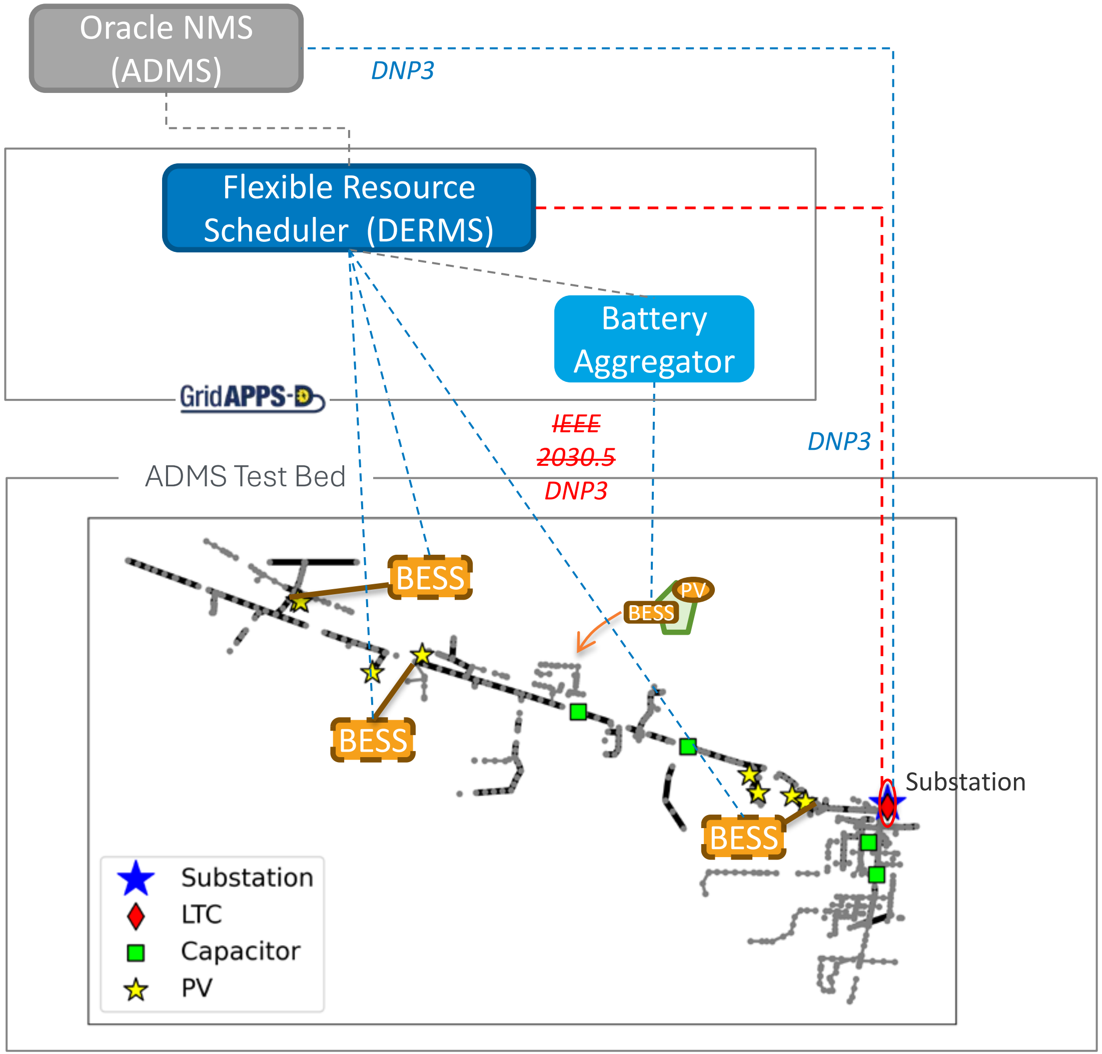


Energy Cost and Local Consumption




Oracle NMS (ADMS)
DNP3
Flexible Resource Scheduler (DERMS)
Battery Aggregator
GridAPPS-D
IEEE 2030.5
DNP3
ADMS Test Bed
BESS
PV
BESS
BESS
BESS
Substation
Substation
LTC
Capacitor
PV

OPTION 1



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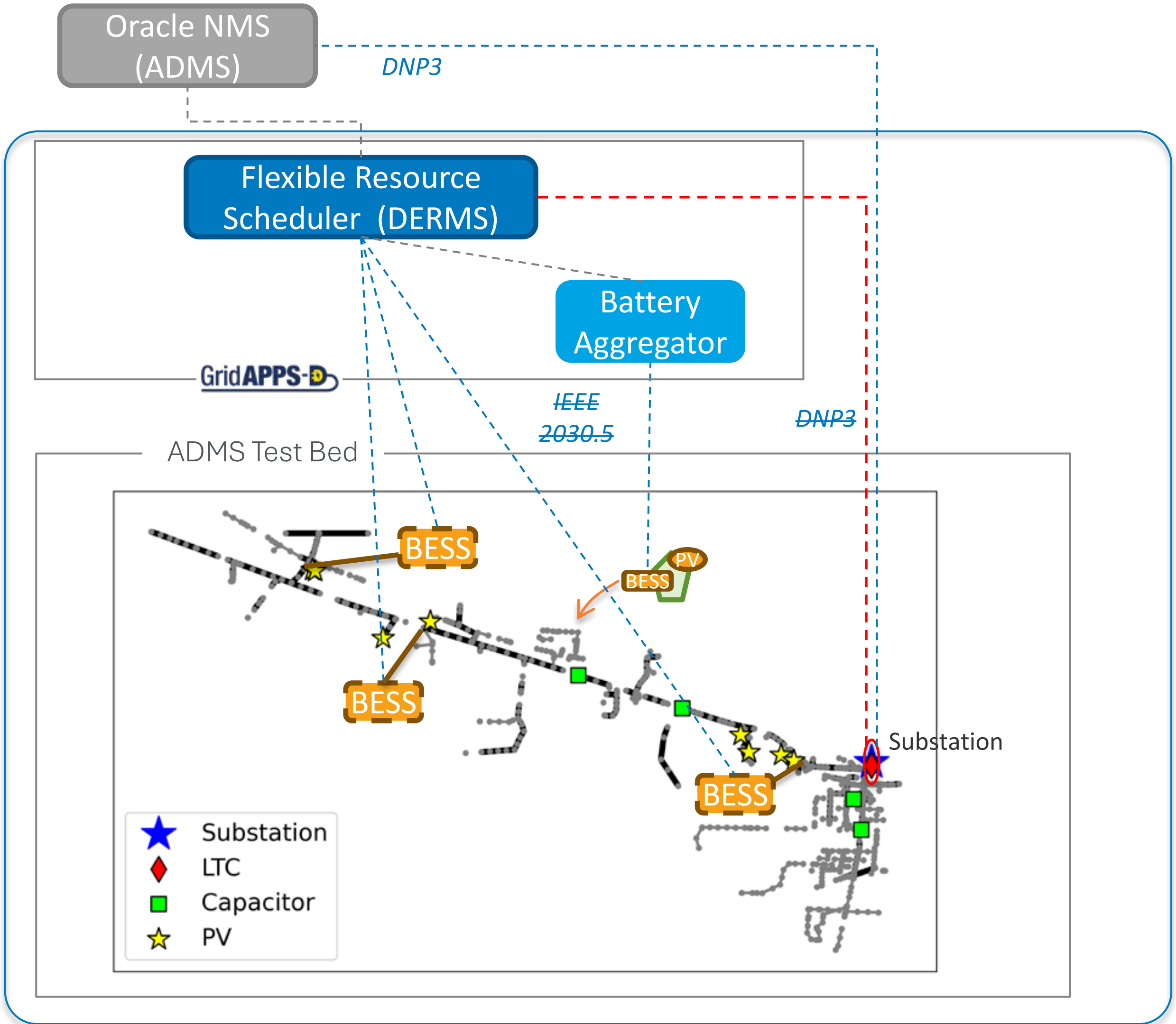
OPTION 2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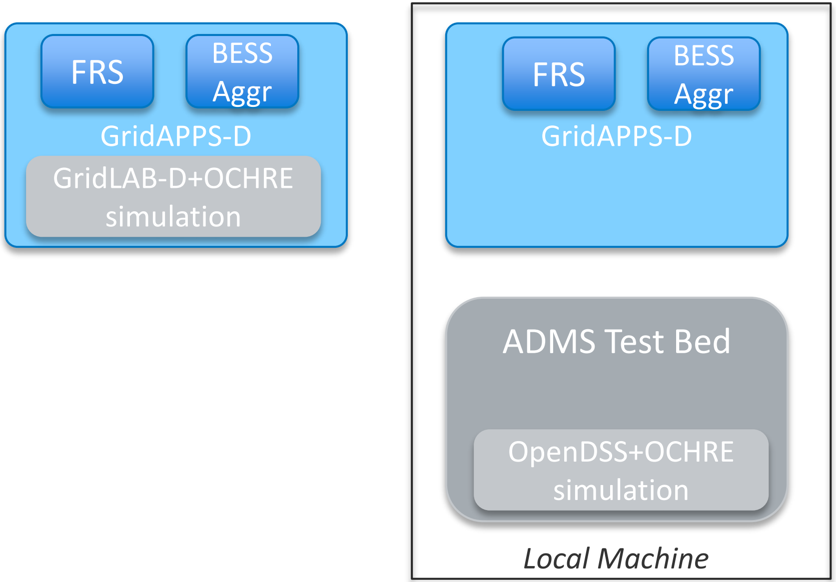
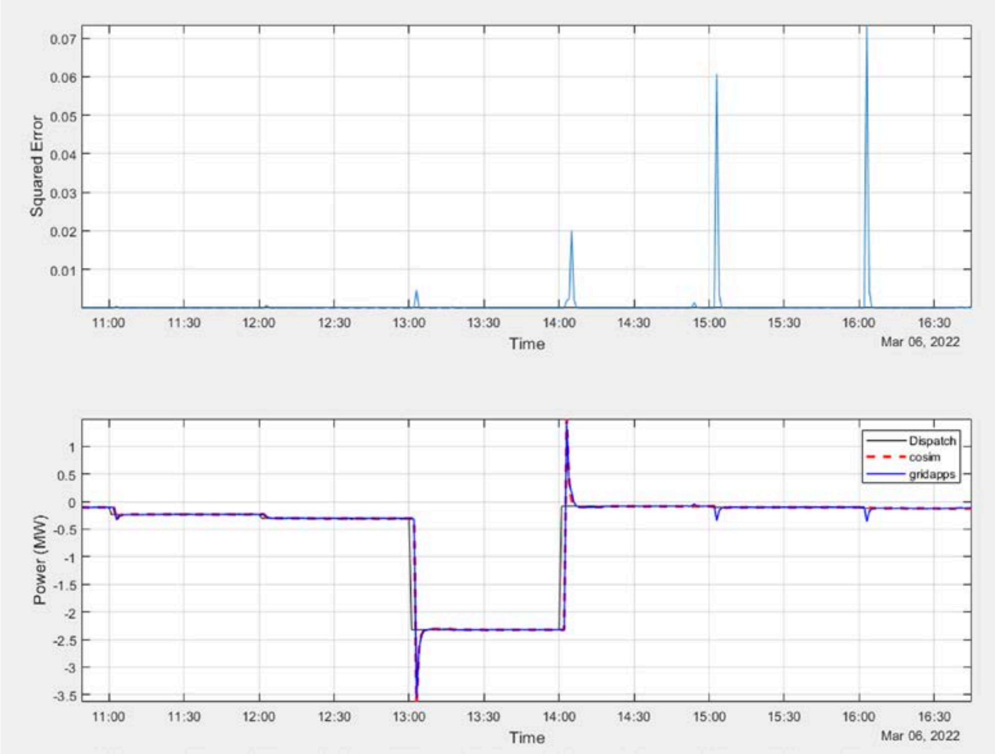
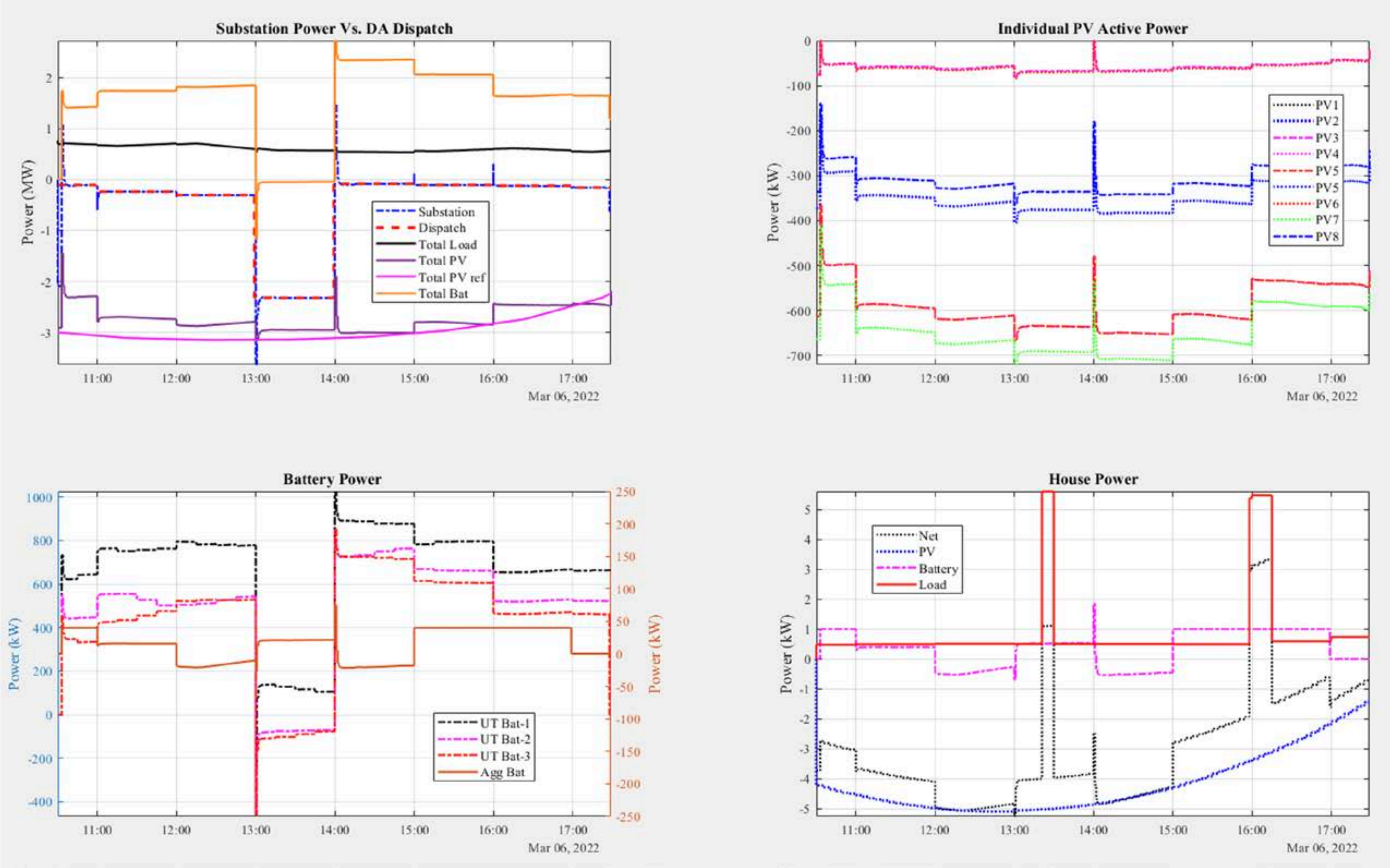
Comparison of GridAPPS-D to ADMS Test Bed

- Controls on GridAPPS-D






Substation Power Vs. DA Dispatch
Power (MW)
Substation
Dispatch
Total Load
Total PV
Total PV ref
Total Bat
11:00 12:00 13:00 14:00 15:00 16:00 17:00
Mar 06, 2022
Individual PV Active Power
Power (kW)
PV1
PV2
PV3
PV4
PV5
PV5
PV6
PV7
PV8
11:00 12:00 13:00 14:00 15:00 16:00 17:00
Mar 06, 2022
Battery Power
Power (kW)
Power (kW)
UT Bat-1
UT Bat-2
UT Bat-3
Agg Bat
11:00 12:00 13:00 14:00 15:00 16:00 17:00
Mar 06, 2022
House Power
Power (kW)
Net
PV
Battery
Load
11:00 12:00 13:00 14:00 15:00 16:00 17:00
Mar 06, 2022

Next Steps

- Present GridAPPS-D simulation results at the 2025 IEEE PES Grid Edge Technologies Conference & Exposition, San Diego, January 2025
- Complete ADMS Test Bed setup:
  - 2030.5 communications
  - Cosimulation on high-performance computer.
- Execute evaluation plan on ADMS Test Bed.

Thank You

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NREL/PR-5D00-92389

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This work was authored in part by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by U.S. Department of Energy Office of Electricity, Grid Controls and Communications division. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.