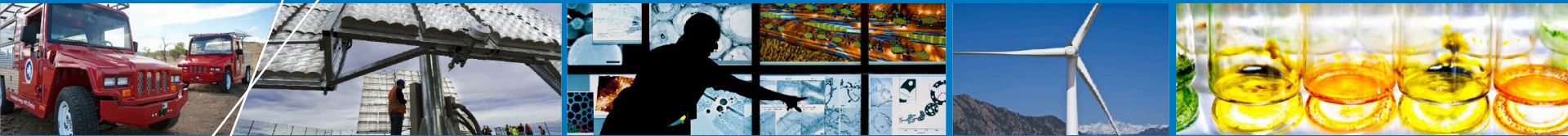


The Integrated Grid Modeling System (IGMS) for Combined Transmission and Distribution Simulation

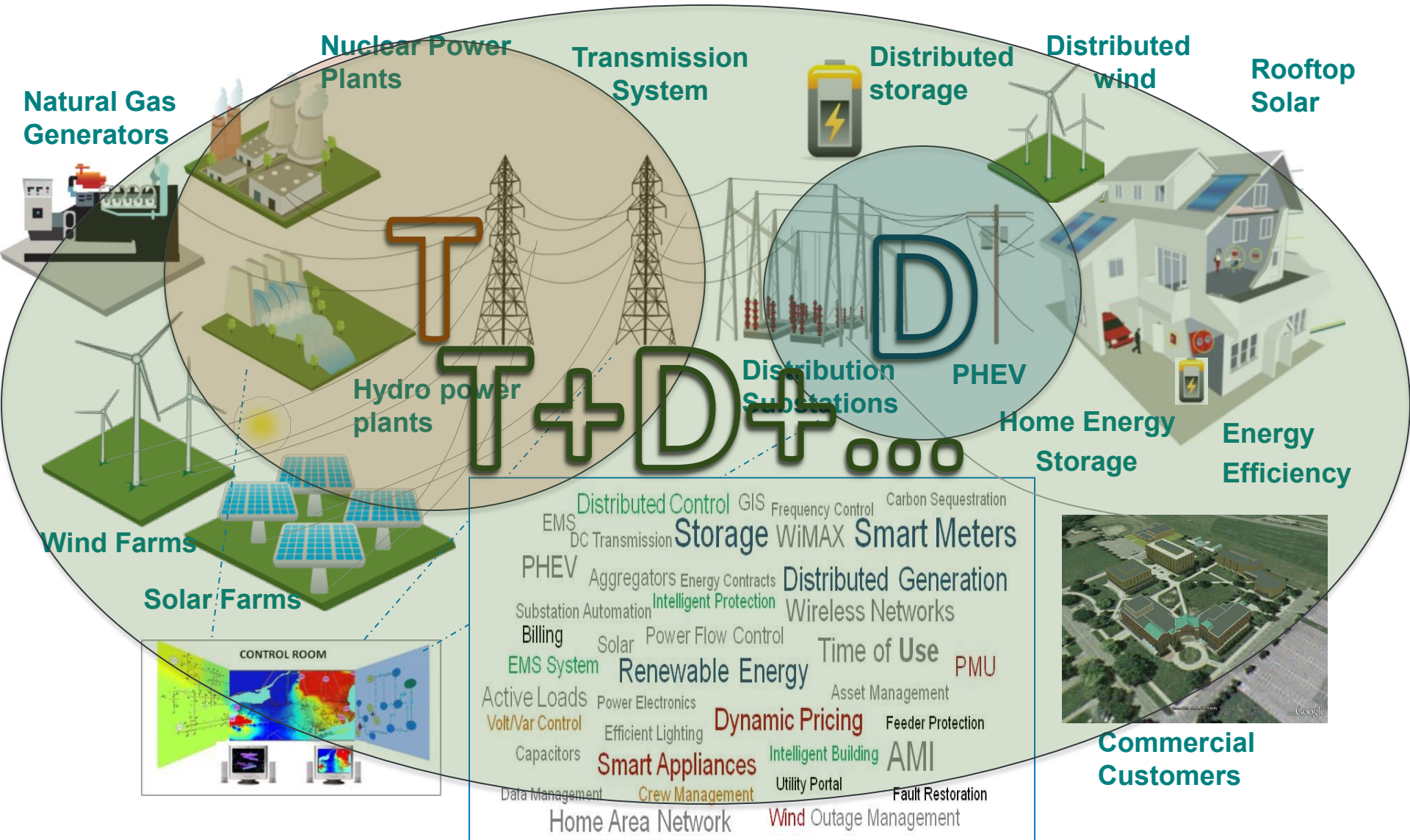


Bryan Palmintier, PhD.
Senior Research Engineer, NREL

Team: Elaine Hale, Tim Hansen, Bri-Mathias Hodge, Hongyu Wu, Dave Biagioni, Wes Jones, Kyri Baker, Julieta Giraldez, Monte Lunacek

HPC in Power Systems Planning Panel
IEEE PES General Meeting
July 28, 2015

The Emerging, Integrated Grid



NREL's Integrated T&D Grid Modeling System (IGMS)

Summary:

A **next-generation analysis framework** for full-scale transmission and distribution modeling that supports **millions of highly distributed energy resources**.

End-to-End T&D Modeling Capability

- detailed multi-period wholesale markets (including LMPs)
- generator/reserve dispatch (AGC)
- AC Powerflow (bulk transmission)
- Full unbalanced 3-ph power flow for 100s-1000s of distribution feeders
- Physics based end-use models of buildings and end-use loads.

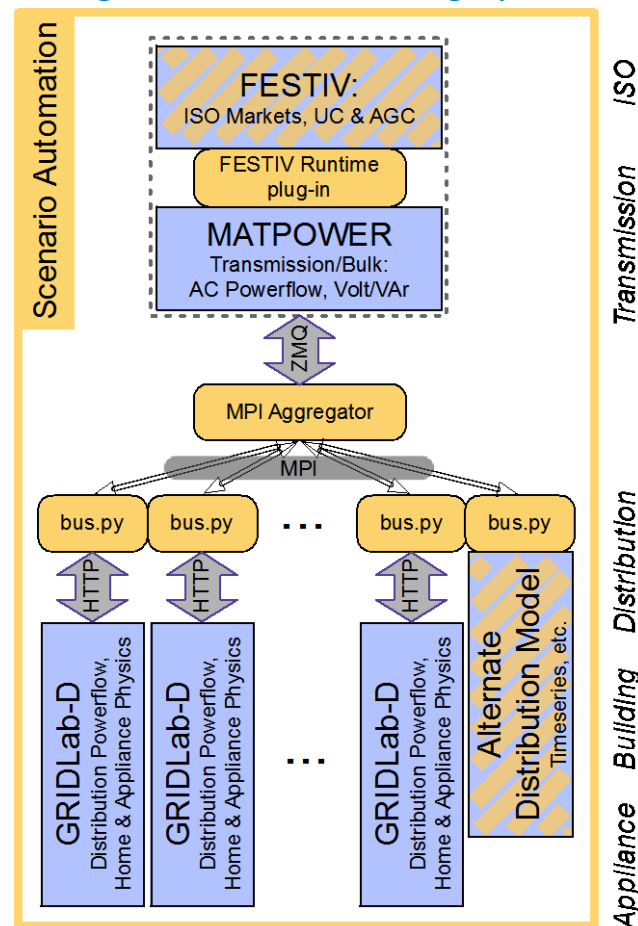
Example Applications

- **Current:** Analyze distributed PV support for grid operations
- **Future:**
 - Simulate smart grid storage, PV, and demand response
 - Simulate alternative market and service architectures
 - Co-simulation with Hardware via PHIL
 - Connect to Advanced DMS/EMS systems

Status

- **Successful Medium Scale Run(s): 118 Transmission buses, 743 Distribution Feeders** (PNNL taxonomy), **>1M total buses, >600k homes**
- **FY15 Development to Date:**
 - Automated output processing and visuals (pull from 1000s of files)
 - Semi-Automated data import from PLEXOS, SynerGEE, & CyME
 - Comparison of IGMS to stand-alone tools
- **Next Steps:** Scale-testing (run time for 10-1000+ feeders), High-Pen PV Scenario development, DGPV for Grid Operations Research

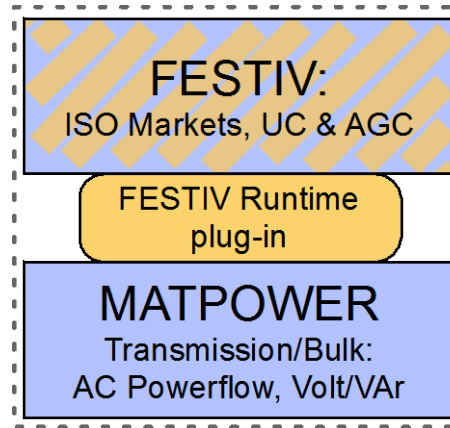
Integrated Grid Modeling System



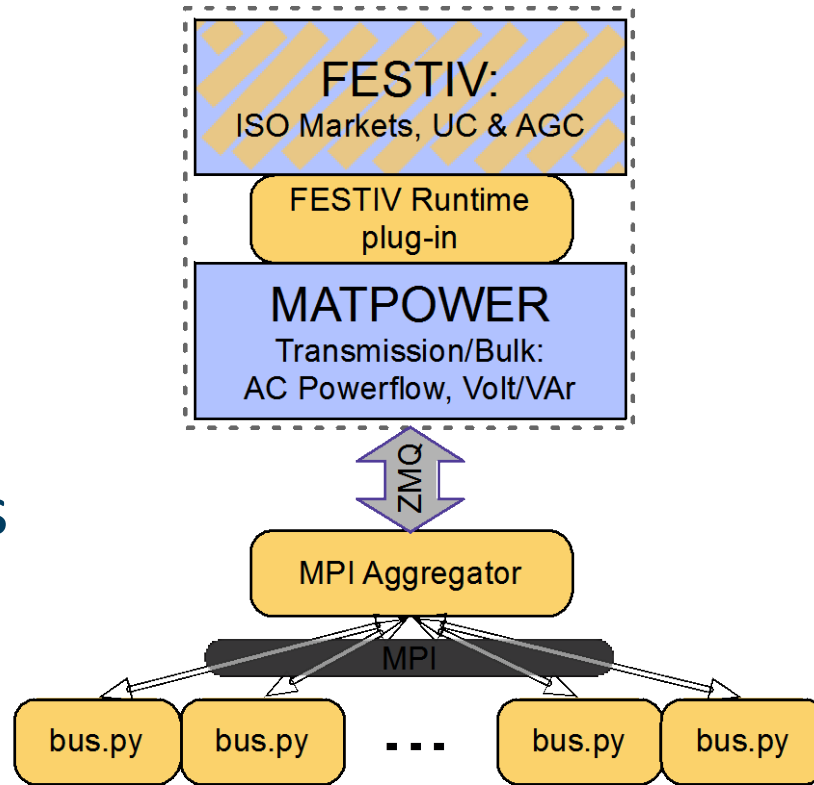


- Day-Ahead Commitment
- Real-time Commitment
- Real-time Dispatch
- AGC reserves

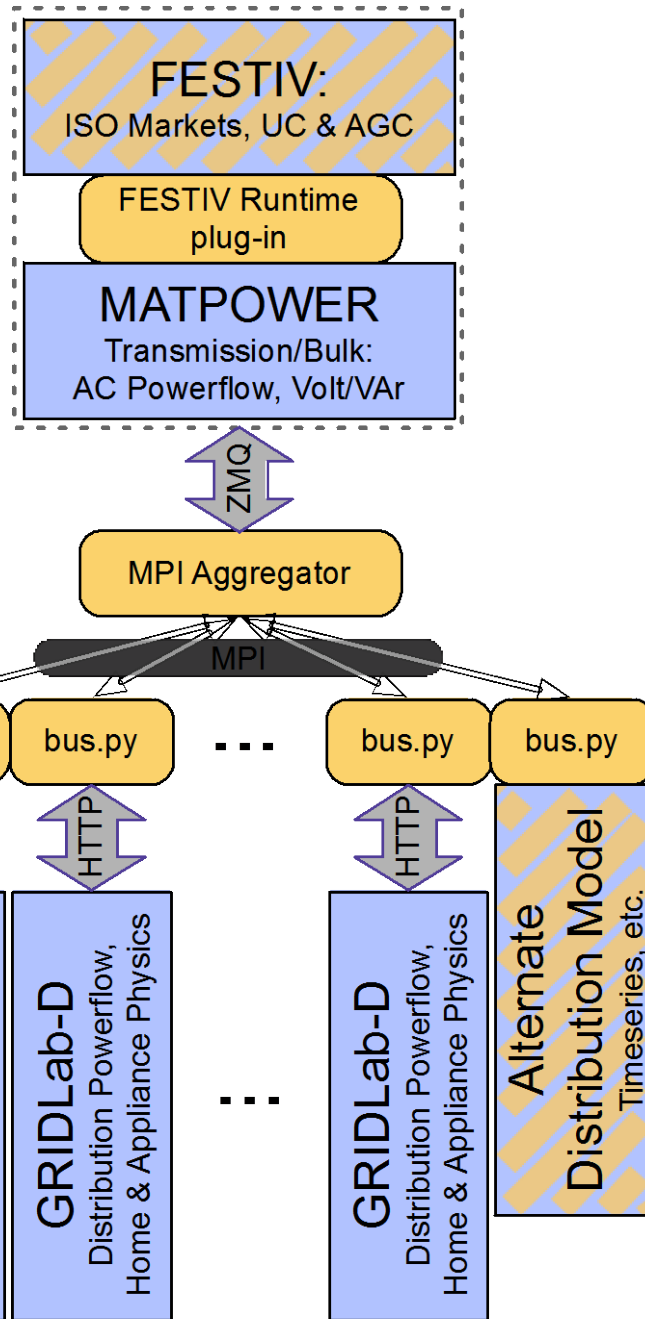
- AC Powerflow
(pos-seq,
balanced)



- Nodal:
 - Prices
 - Services
 - Voltage



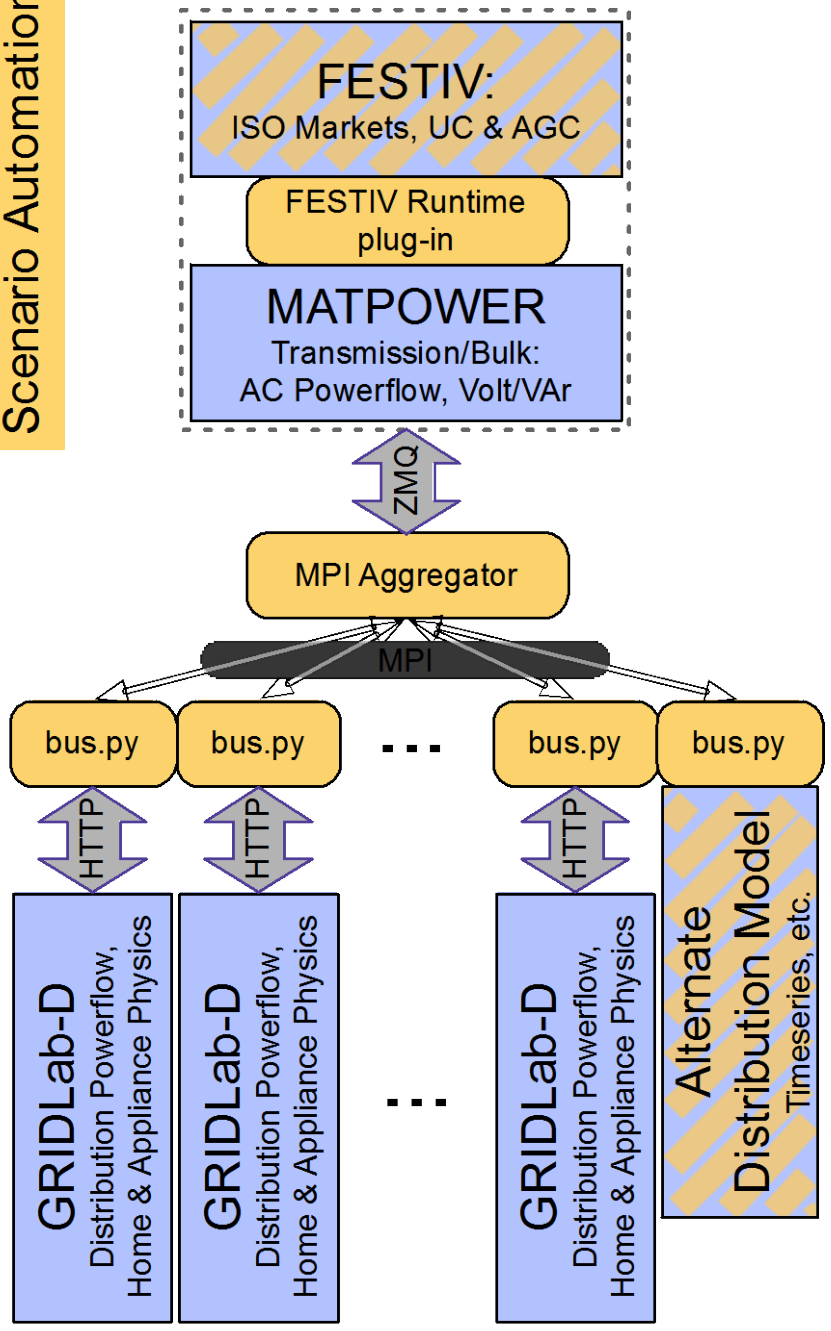
- Return:
 - Power
 - Reactive
 - (Bids)



- 3-ph unbalanced powerflow

- Physics:
 - DERs
 - Load

Scenario Automation



ISO

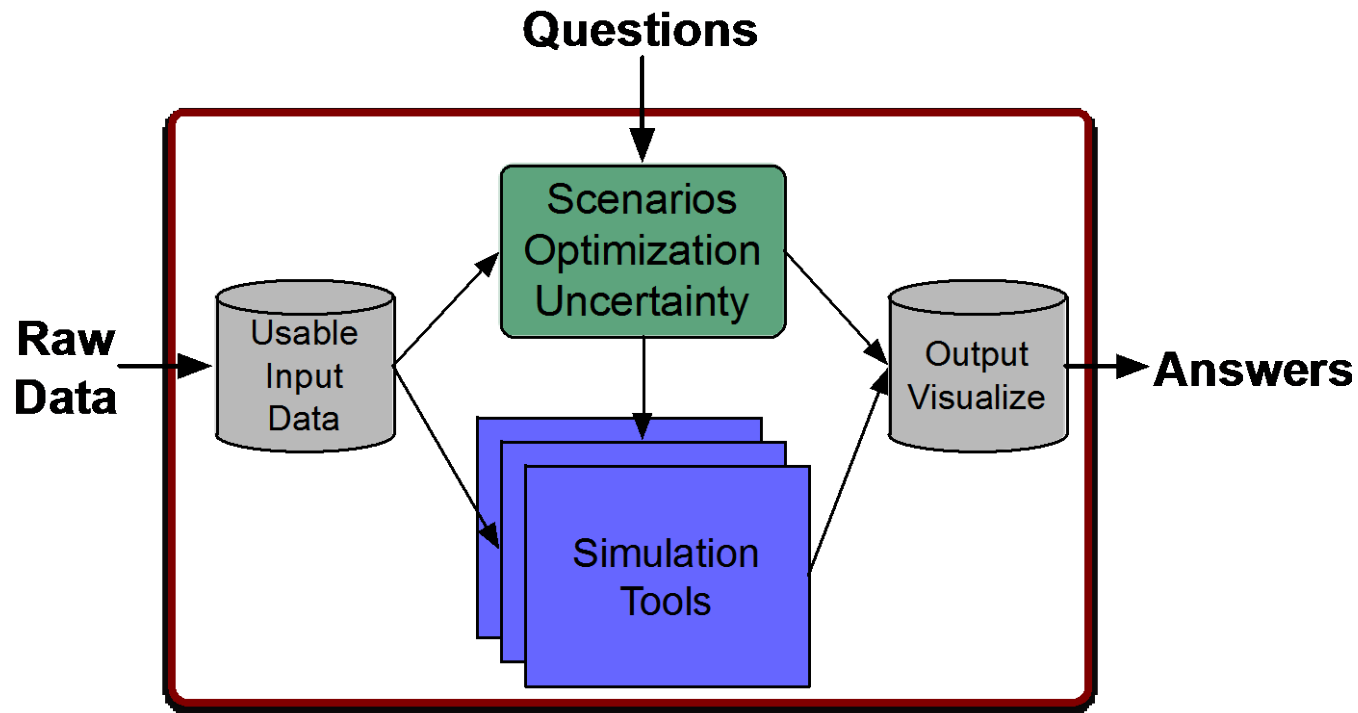
Transmission

Distribution

Appliance Building

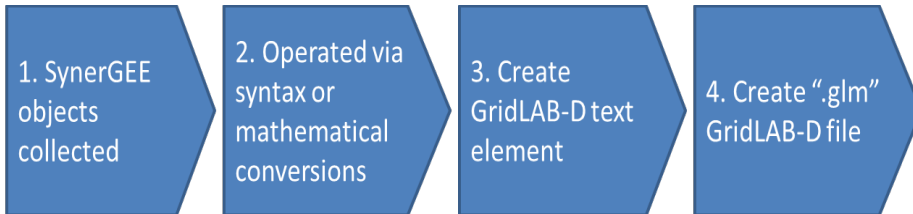
Analysis Workflow

Often the simulation itself is the “easy” part, compared to set-up and output analysis



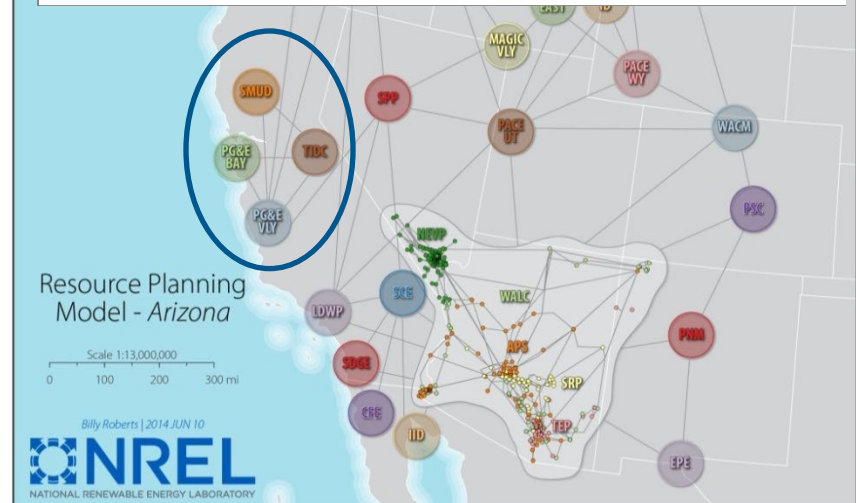
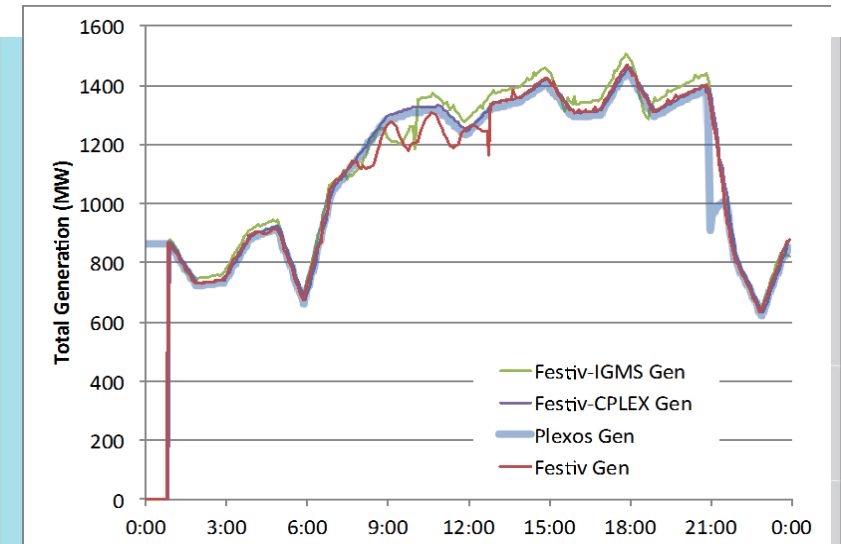
IGMS-Input Data Conversion

Distribution: SynerGEE and CYME to GridLAB-D



POC: Julieta Giraldez

Transmission: PLEXOS to FESTIV – with RPM



IGMS-Populating Feeders with Houses & PV

Scenario

```
sim start: 4/16/2020  
sim duration: 1 d  
sim timestep: 1 min
```

Transmission

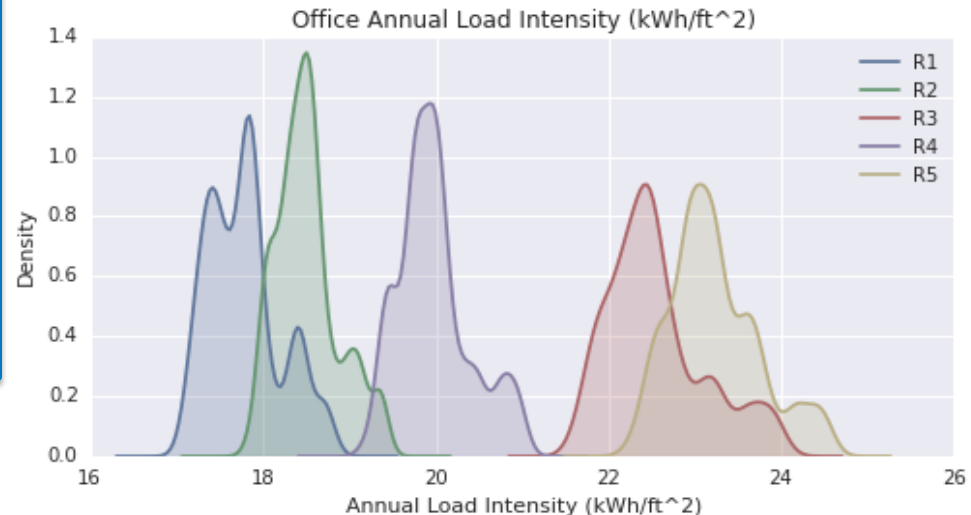
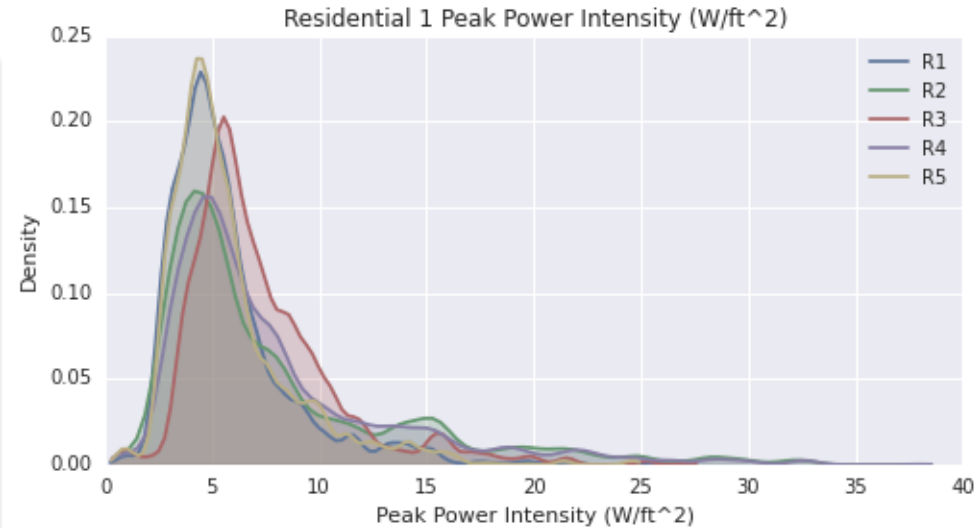
- FESTIV case
- IGMS-FESTIV model rules and configuration
- Startup .mat file

Distribution

- Assign feeder models to nodes
- glmgen options for populating GridLAB-D
- LHS sampling

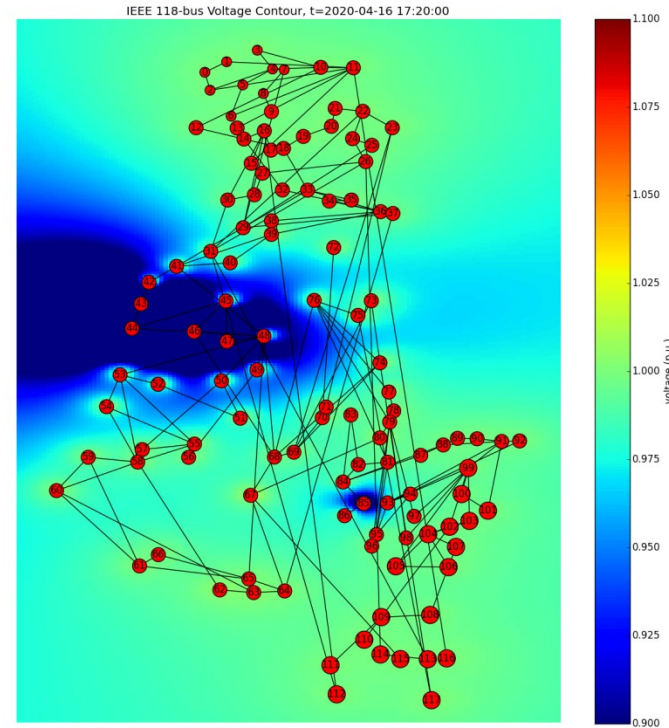
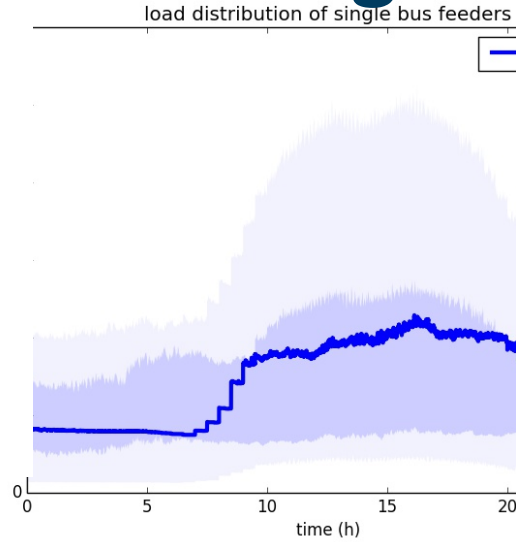
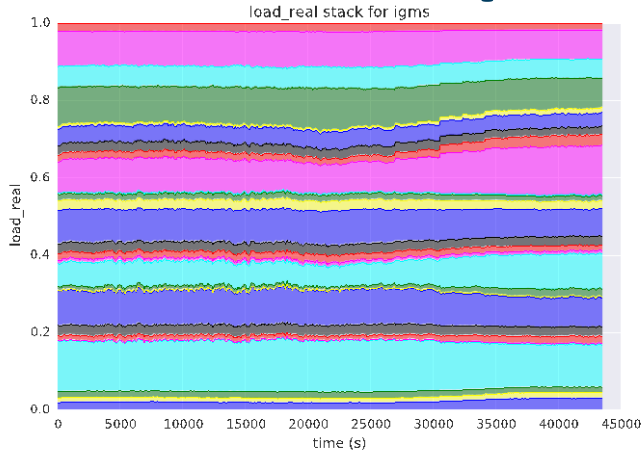
bus.py setup

MultiNodeBus GridlabBus
ConstantBus FileBus



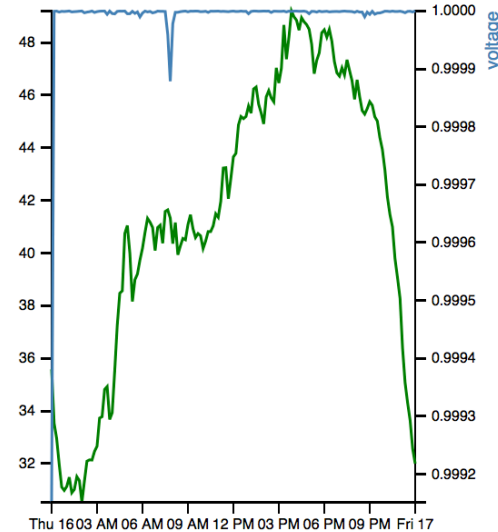
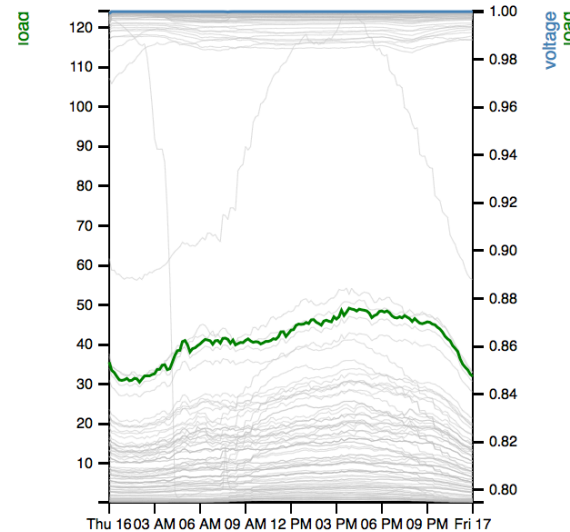
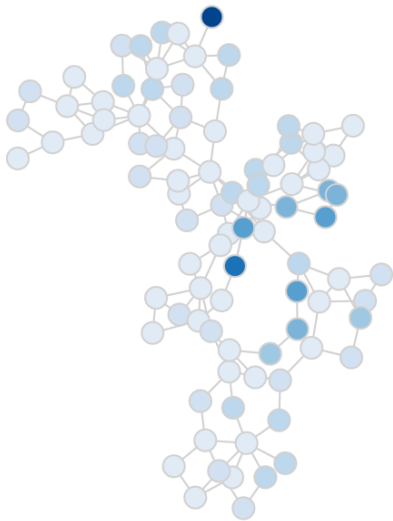
Core feeder processing built on evolved form of Open Modeling Framework

IGMS-Output Processing



Load and Voltage

The nodes in the graph are colored by their maximum change in voltage, where darker colors have a greater change.

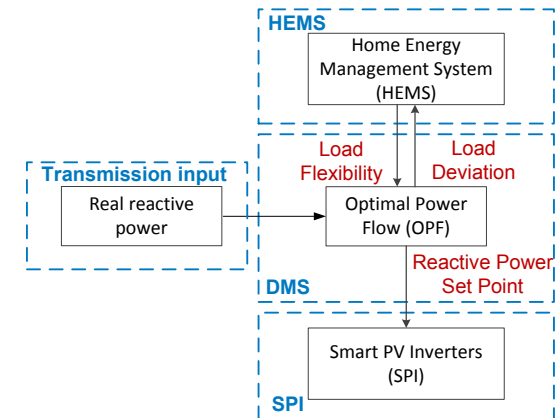
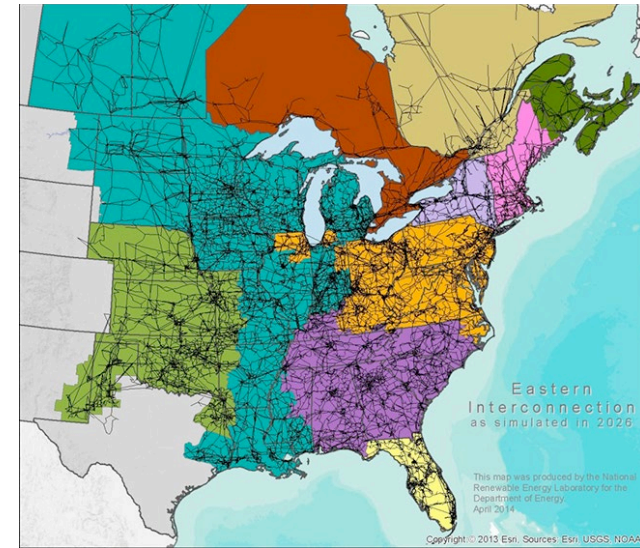


Current Research Questions

- *Can ISO-level visibility of DG PV reduce required bulk system reserve requirements while maintaining reliability standards? How does this change with PV penetration?*
- *To what extent can high penetration DG PV with advanced inverters contribute to bulk system reactive power and voltage support? How does this change with PV penetration?*
- *What are the bulk operational impacts of advanced distributed energy scheduling?*
- ...

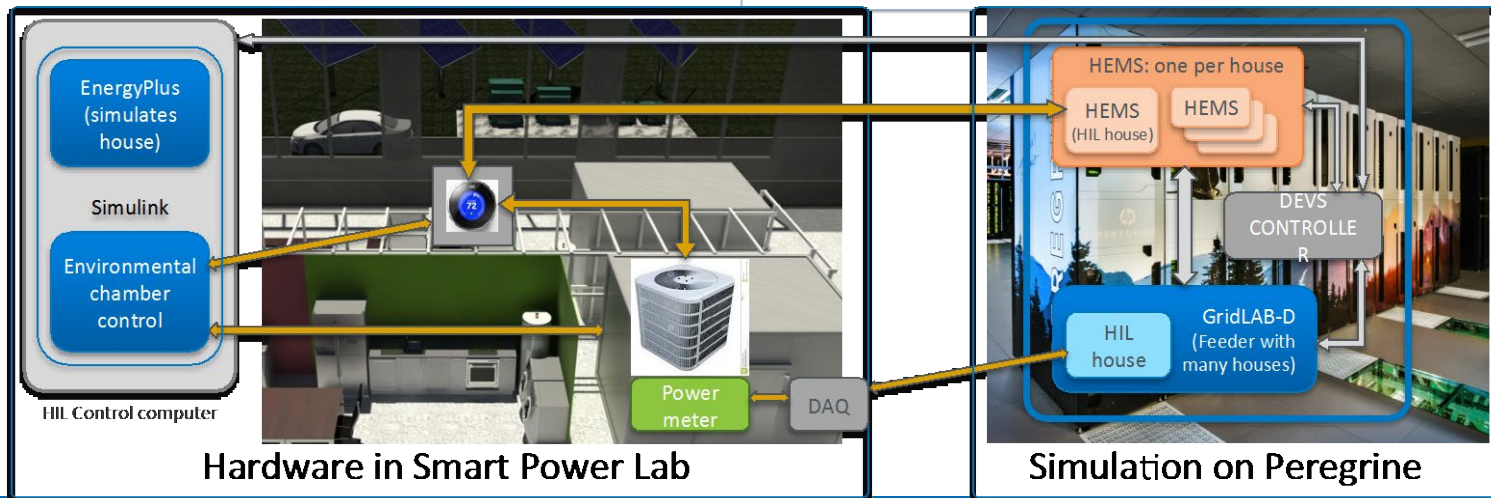
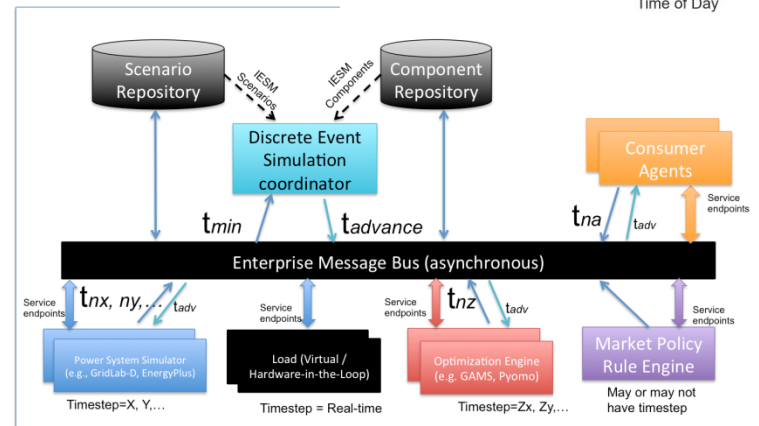
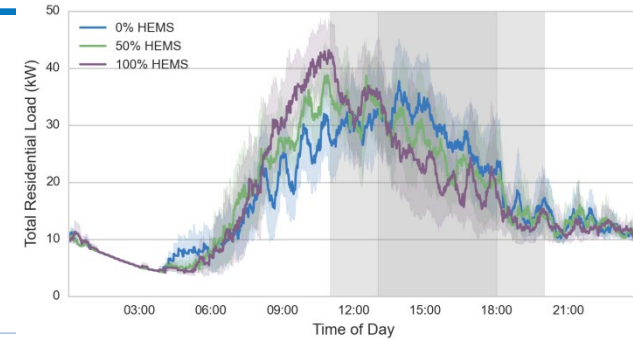
Other HPC for planning efforts at NREL

- Time domain parallelization of (very) large PLEXOS production cost—nodal EI: 60k (Clayton Barrows and Aaron Townsend)
- Distributed Energy Scheduler—control framework simulations in IGMS (Emiliano Dall'Anese)
- Energy+ and PLEXOS for DR (Elaine Hale)



Integrated Energy Systems Model (IESM)

- Distribution (GridLAB-D) co-simulation with many home energy management systems (HEMS)
- Retail tariff/market evaluation
- Hardware-in-the-loop
- (Proposed) link to IGMS



Future directions for T+D

- **IGMS + IESM = “Prosumer as price maker”**
- **Enhance economic analysis in IGMS**
 - Retail-Wholesale market interactions
 - Customer and utility accounting
- **T+D+... Comms, Loads, Markets, etc.**
- **Large-scale simulations for Power Hardware-in-the-Loop**

Questions

Thanks!



Bryan.Palmintier@nrel.gov