

Energy, Environment and Material Sciences Business - Battelle Grid Systems

Battelle
The Business of Innovation

Electric Grid Systems and
Equipment Infrastructure

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BUSINESS SENSITIVE

Energy, Environment and Material Sciences - Mission

- Be essential to clients in energy S&T, environmental solutions, and material science
- Help industry access and use natural resources in a safe and environmentally responsible manner
- Help industry efficiently manage its energy and raw materials to become more competitive and energy secure

Expertise in:



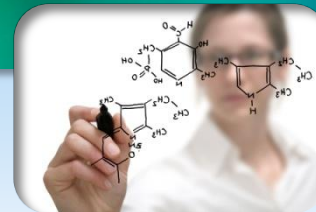
**Water
Management**



**Bio-Based
Products**



**Alternative
Fuels**

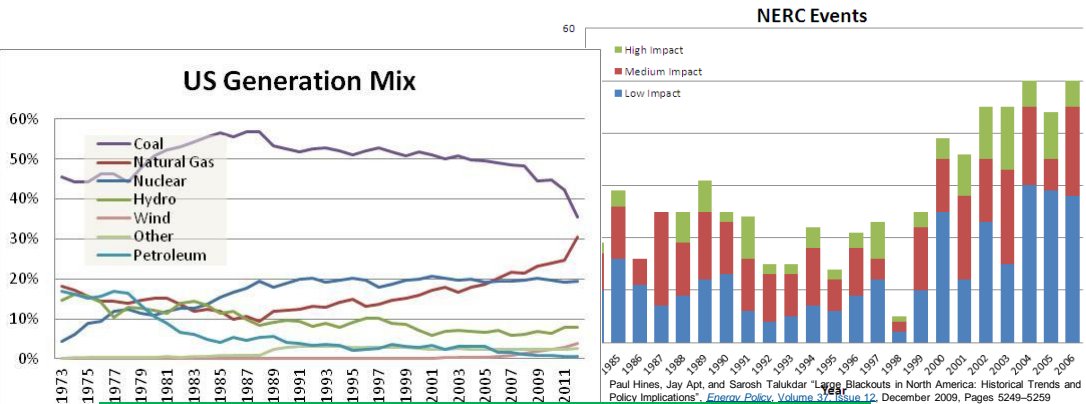


**Process
Improvement
and
Modernization**



**Energy and Grid
Management**

Supporting Industry Transformation

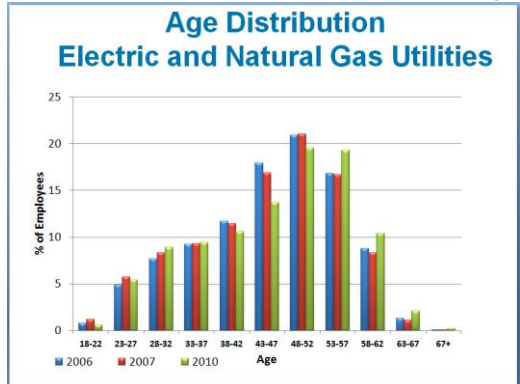


Operational Complexity



Emerging Technologies

36% Replacement in next 5 years*



*Center for Energy Workforce Development
"2011 CEWD Survey Results"

Aging Workforce

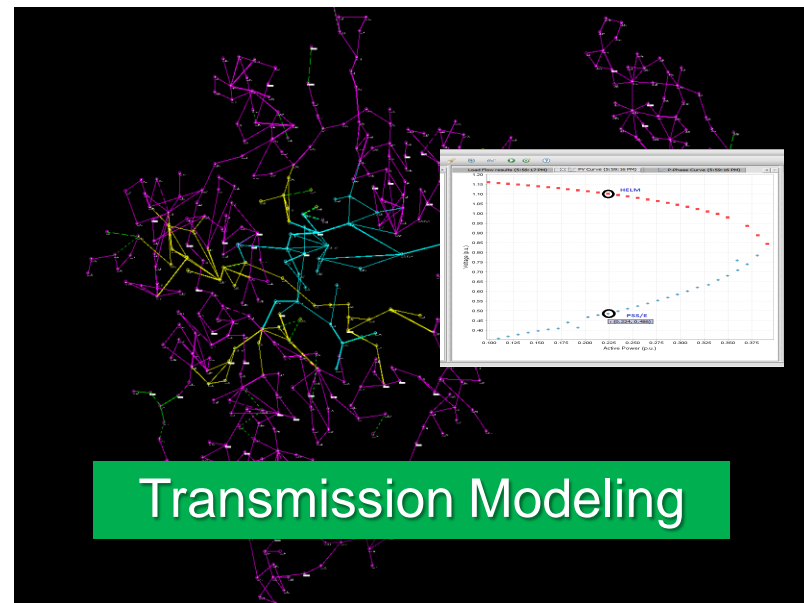


Fragmentation

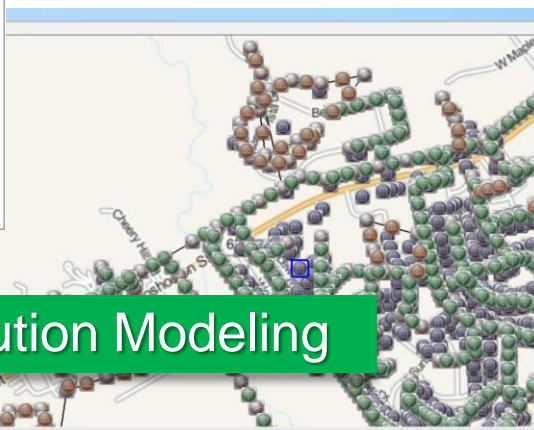
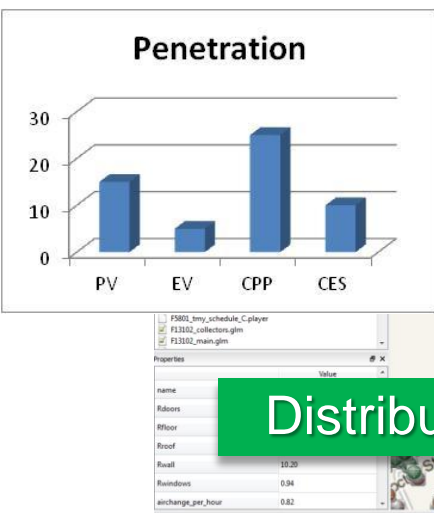
Battelle Grid Systems Offerings



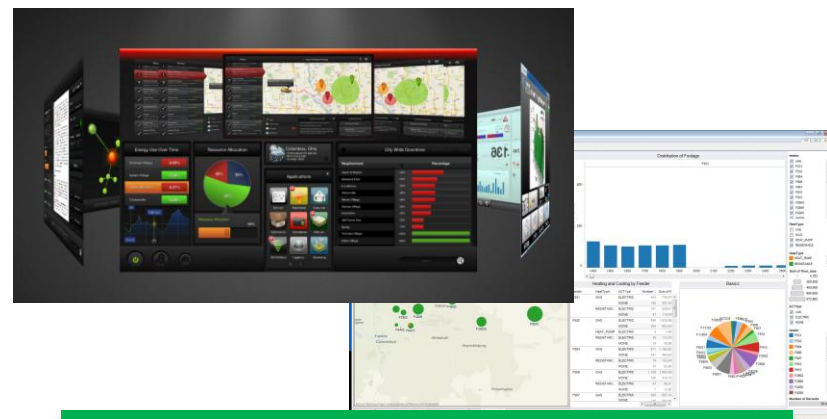
Active Demand Management



Transmission Modeling



Distribution Modeling



Analytics and Visualization

Battelle R&D Extends from Data Analytics to Pilot Production



Data Warehouse/Computing Center

Software Development Center

Modeling and Simulation Center

Smart Grid Integration Center

Production and Field Support Center



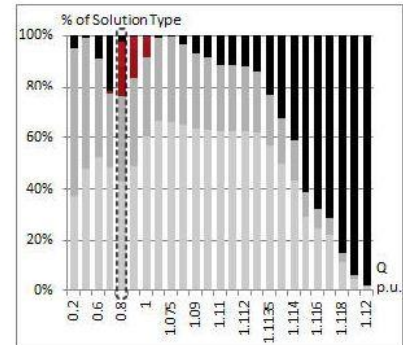
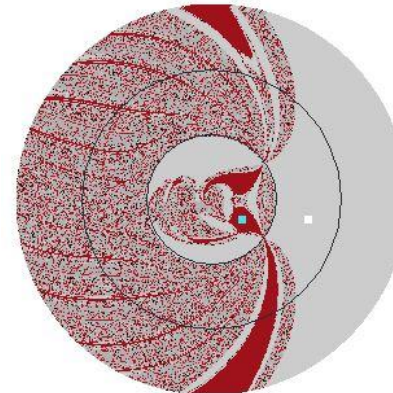
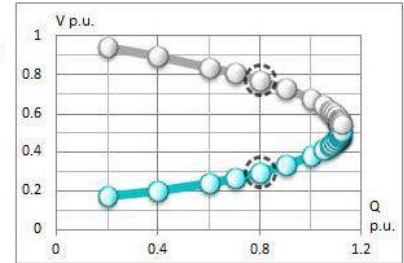
Transmission Modeling Services

Gridquant Overview

- Grid modeling software for
 - Operational awareness
 - Scenario analysis
- Breakthrough solution with unique attributes:
 - Non-iterative
 - No initial estimate needed
- New Capabilities:
 - Evaluation of complex scenarios
 - Solution under stressed conditions
 - Distance to collapse

Current methods: lack of convergence, need initial seed solution

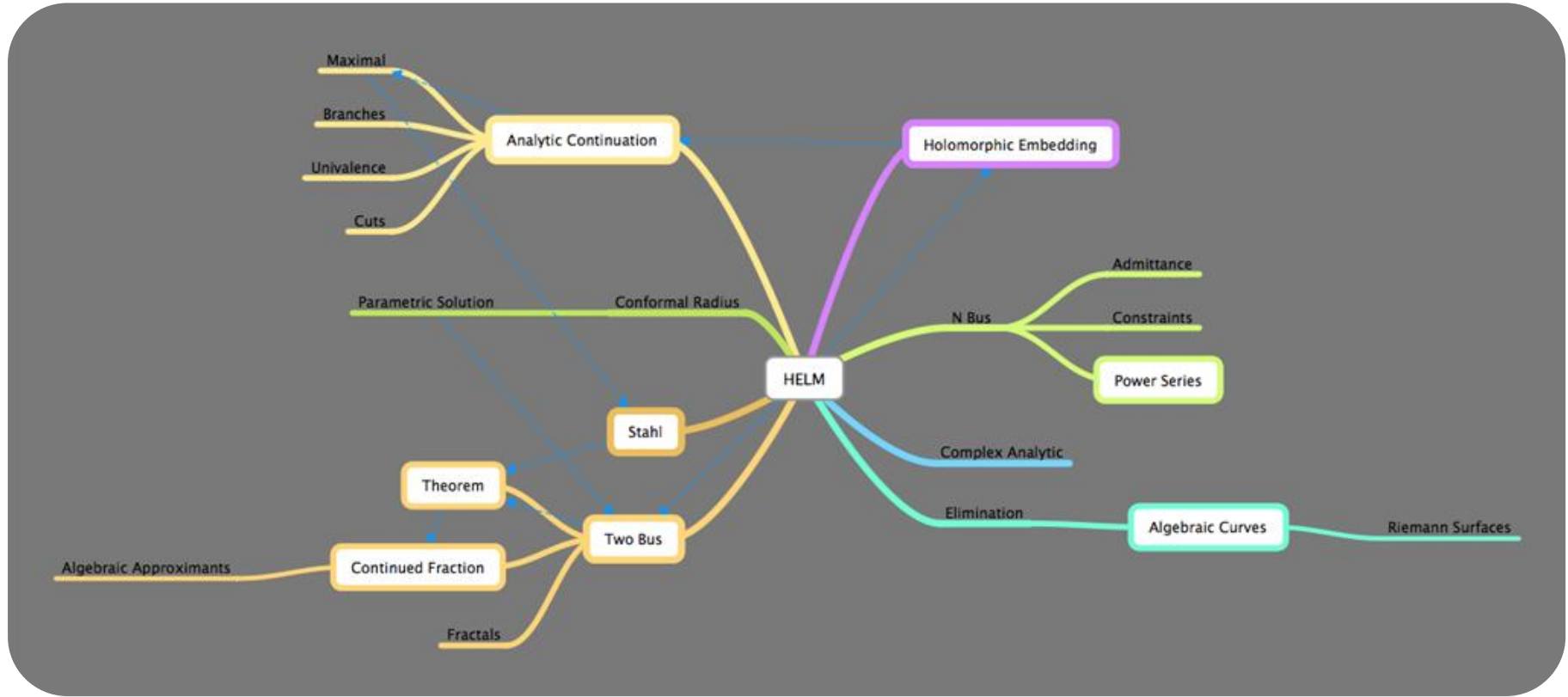
Move your mouse along the voltage collapse curve (top right). For each point along the curve, we've generated for over a million starting points, the load flow solution shown in the circular image (bottom left). The stacked histogram (bottom right) provides details of the frequency of each solution class.



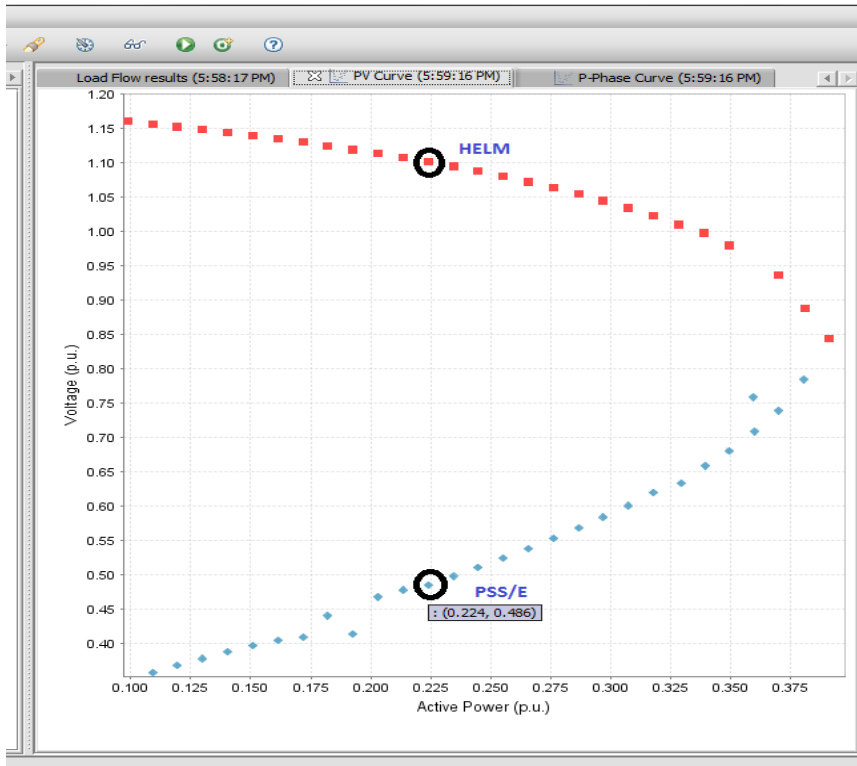
Solution to previously unsolvable problem creates new opportunities for grid management

Mathematical Basis of HELM

A modern foundation technology, 500 years in the making...



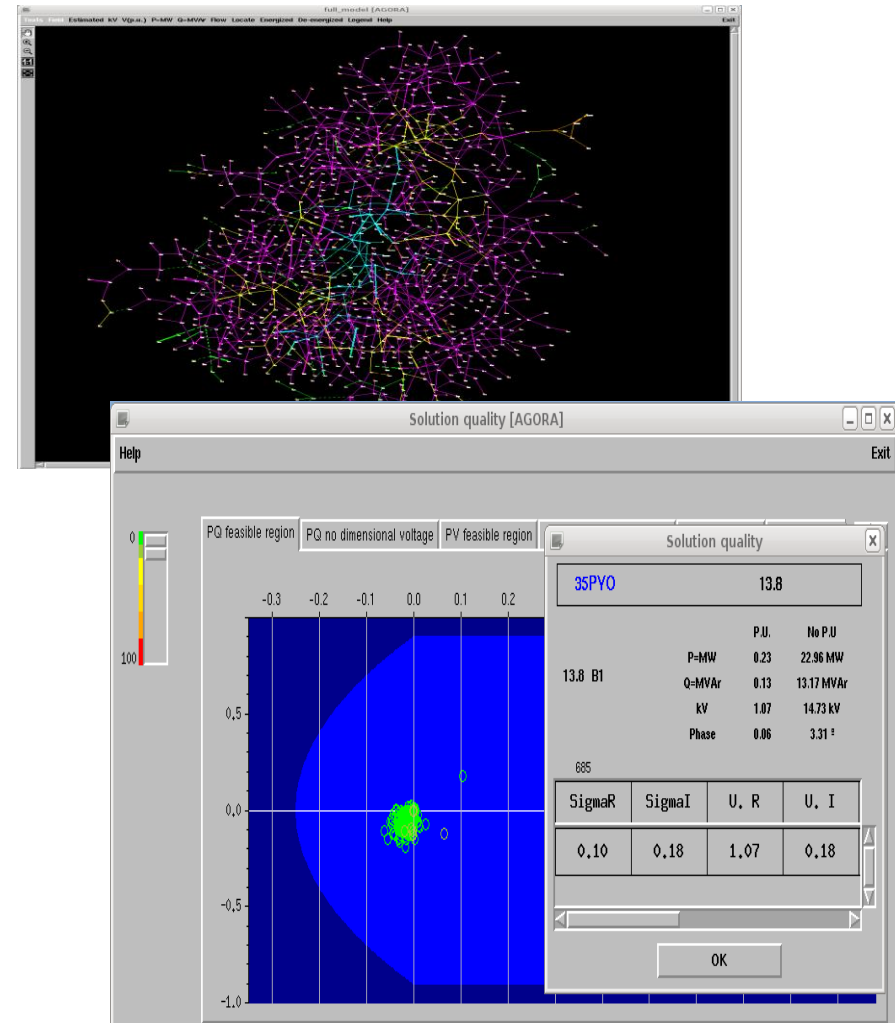
Know where you are ... at all times



Real Time PV/QV curves

- Accurate current state
- Distance to collapse
- Real time analysis of all contingencies

Automated One-line Diagrams

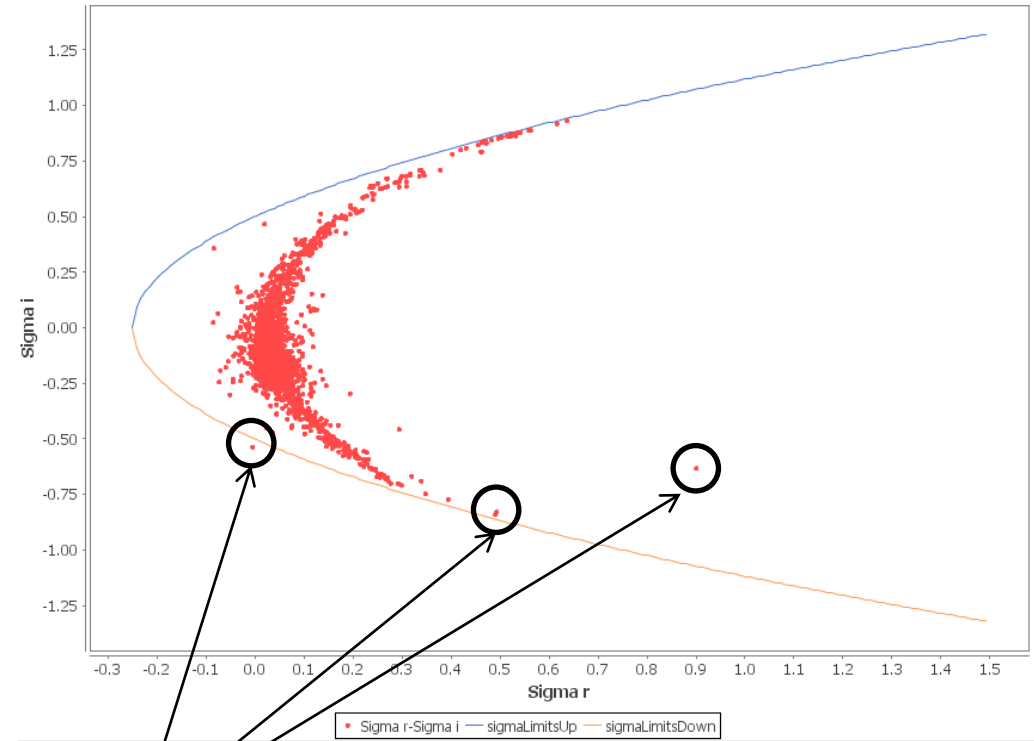
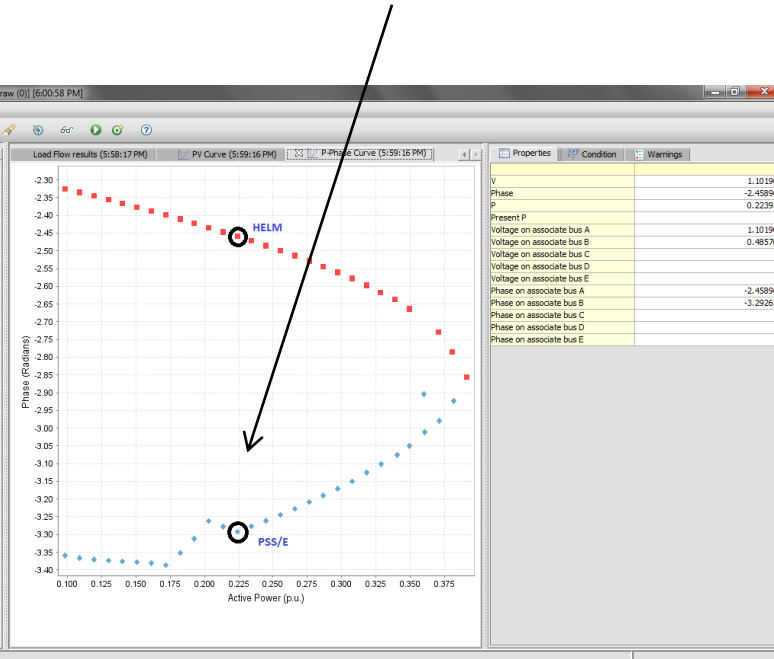


Node by Node Stability

Node by Node visibility of stability and emerging problems

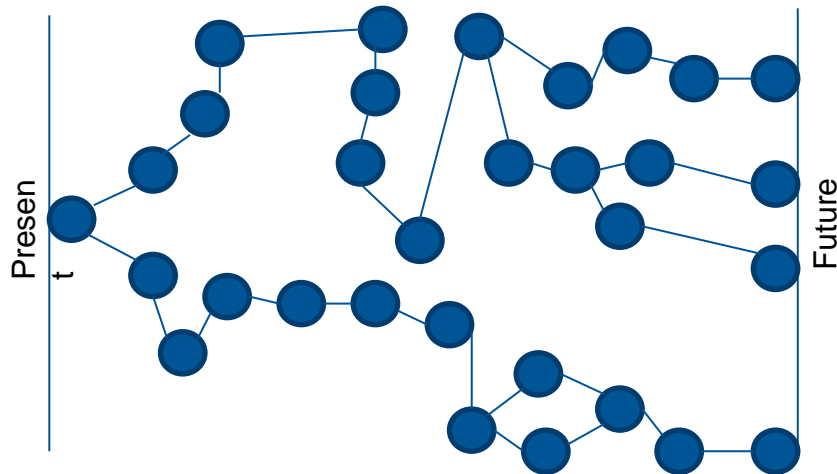
Current systems can resolve to non physical solutions

Stability plot (system with 1000s of nodes)

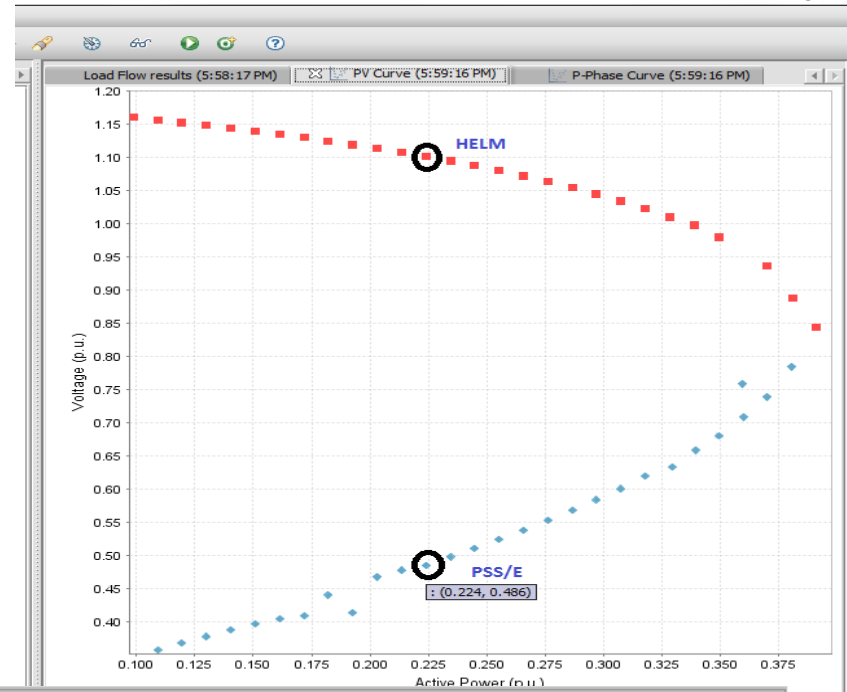


We not only identify non-physical solutions from other methods, we show why and what to do about it

Know where you are going and how to get there ... with certainty



- Automated exploration of future states
- Guided solutions to support operator actions



Case	Time	Active Power (p.u.)	Voltage (p.u.)	Frequency (Hz)	Angle (deg)	Phase (deg)	Power Factor	Losses (MW)	Generation (MW)	Load (MW)
1	0.000	0.100	1.150	60.000	0.000	0.000	1.000	0.000	0.000	0.000
2	0.125	0.125	1.140	60.000	0.000	0.000	1.000	0.000	0.000	0.000
3	0.250	0.250	1.120	60.000	0.000	0.000	1.000	0.000	0.000	0.000
4	0.375	0.375	1.080	60.000	0.000	0.000	1.000	0.000	0.000	0.000

Easy exploration of multiple, physically correct, potential future states (complex contingencies)

Differentiators of Gridquant Tools

- Holomorphic Embedding Load Flow Method (*HELM*[™])
 - Eliminates convergence issues and need for initial solution seed
 - Solves all the way to voltage collapse point (provides real time measurement of distance to collapse)
 - Provides a physically realizable solution every time (if one exists)
 - Enables exploration of any potential future state
- State Estimator
 - Provides automatic reports on data and model errors (improves fidelity)
 - Has a higher degree of accuracy, especially in reactive flows
- Additional Modules
 - Automated one line diagrams
 - Real Time PV/QV curves
 - Automated, guided solutions to events, violations, restoration

Distribution Modeling

- Distributed Energy Resource Modeling critical for microgrid design, control, and evaluation
- Unique capabilities for distribution modeling with physical load models and market mechanisms
- GridLAB-D platform

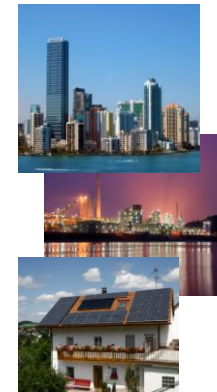


Capabilities
Renewables Integration
Distributed Generation
Demand Response
Electric Vehicles
Voltage Control
Energy Storage

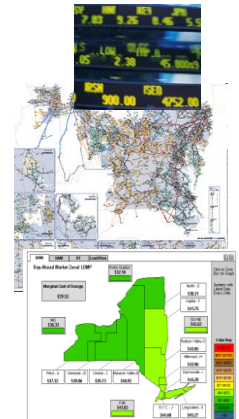
Power Systems



Loads

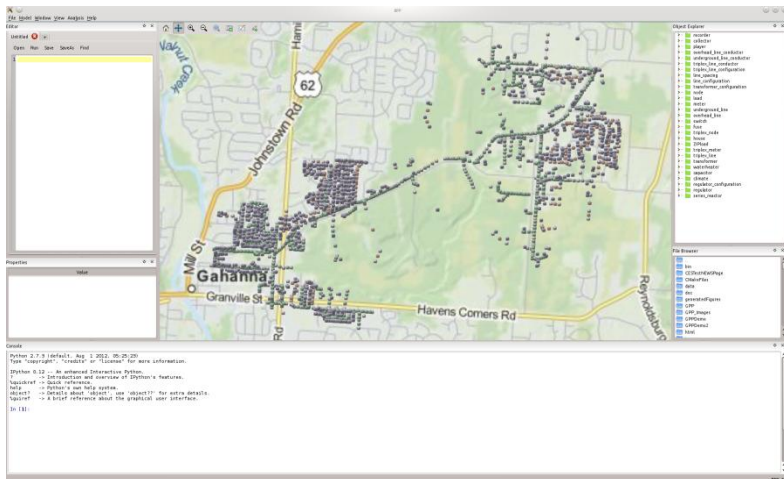


Markets

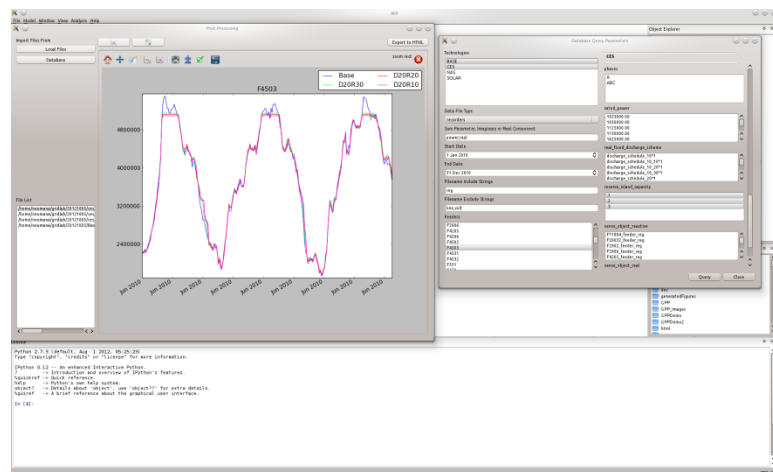


Offering maturing, developing approach for marketing roll out

GPP as a tool to support GridLAB-D

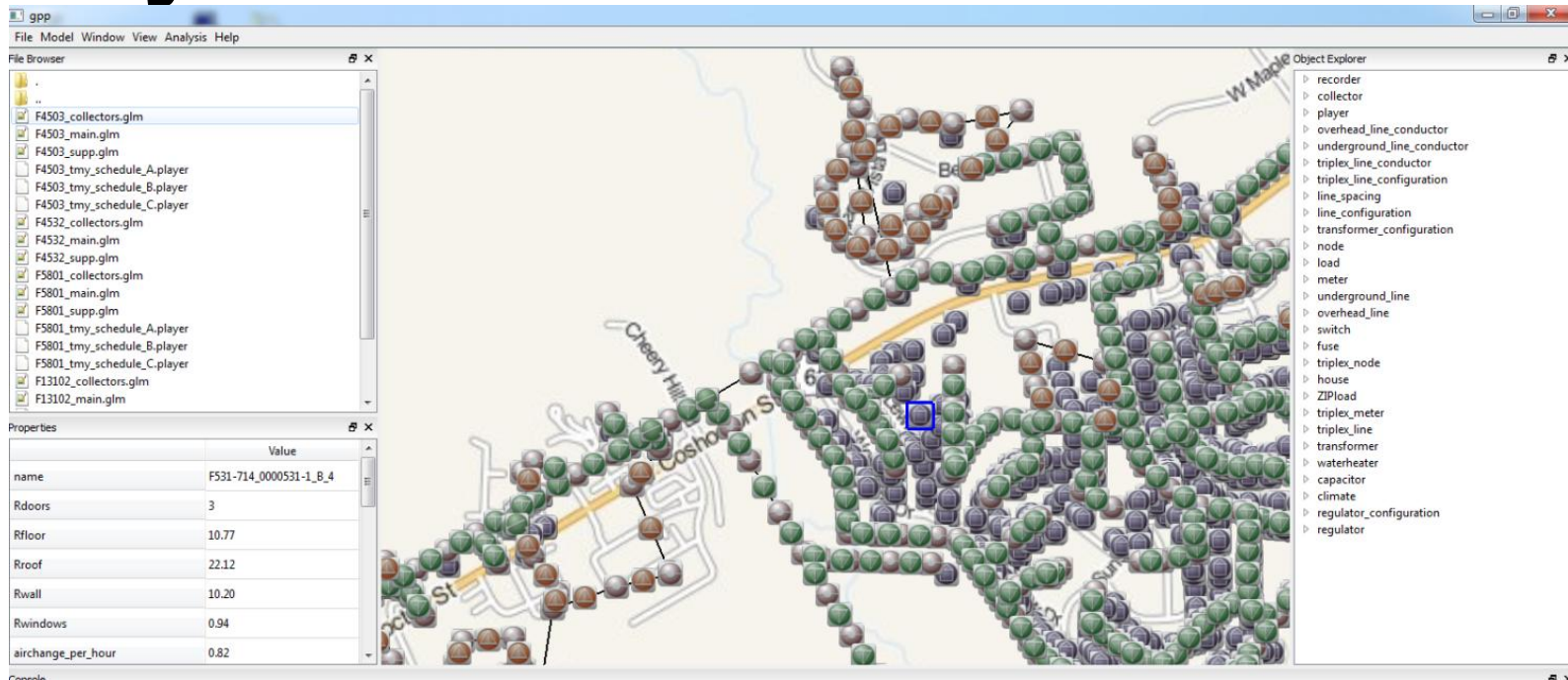


GPP creates GridLAB-D models efficiently.



GPP allows efficient post processing of GridLAB-D data.

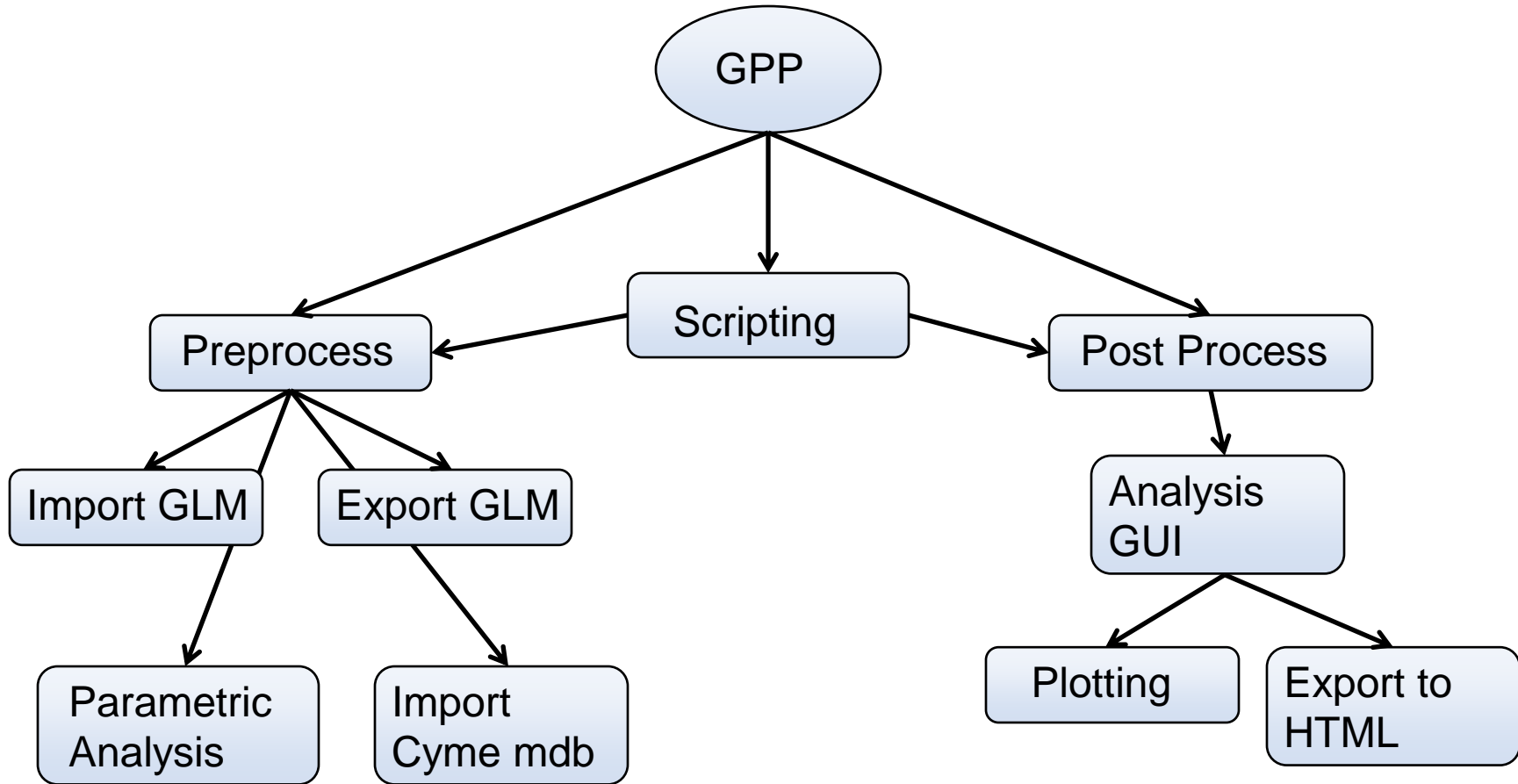
DoE Project with AEP: Parametric Analysis of DER



Parametric analysis of various technologies:

- CES
 - NAS batteries
 - PV
 - PHEV
 - VVC
 - Tariff designs
- Determine **scale impacts** of technology implementation
 - Robust **Design of experiments** to evaluate multiple technology scenarios (>10,000 runs)
 - Built **baseline models** of 32 feeders (represents 96% of the 1700 feeders in AEP Ohio)

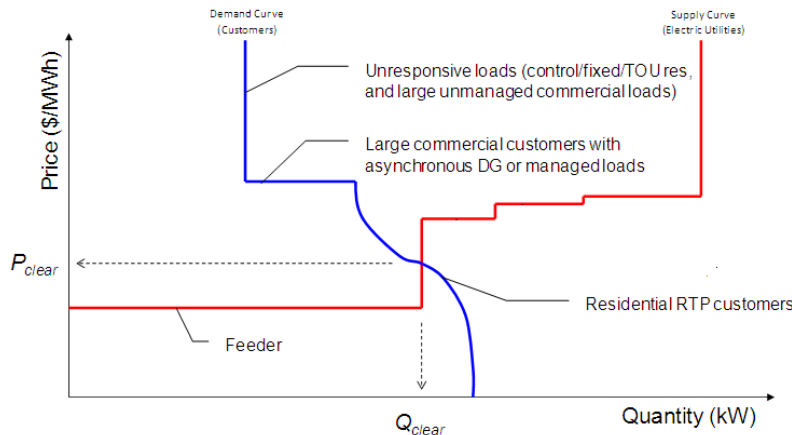
GPP has two main uses, pre and post processing.



Backup

DoE project with AEP

- Deliverables: End to end Demand Response System (DRS)
 - Smart Grid Dispatch software: at AEP
 - HEM, Thermostat, AMI meter: at customer's homes
- 1,000 Home Demonstration
- 5-Minute Real Time Pricing - Double Auction



Current Status

- System operational
- Delivered enterprise class software
- Components deployed at AEP Ohio and in customers homes
- AEP marketing program

Battelle's Active Demand Management Solution

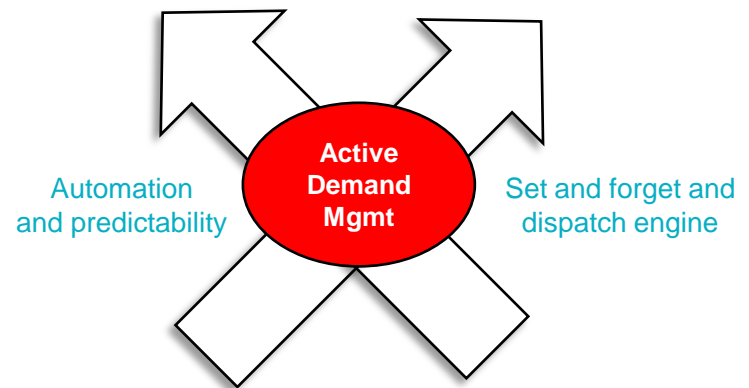
- Integrated system consisting of software that resides at the utility and an in-home energy controller that allows the consumer to **automatically** manage energy consumption in response to utility signals.

- Benefits to utility

- Consumers stay engaged with automation
- Reduces peak demand
- “intelligently” Dispatches distributed/renewable generation and storage
- Reduces transmission and distribution congestion

- Benefits to customers

- The consumer retains control and privacy
- Appeals to consumer's desire to “set-and-forget”
- Pilot studies have predictably shown reduced peak consumption and energy bills



Unique solution that allows utilities to precisely manage load, while maintaining consumer control.

Business Models

▶ Contract Research and Development

- This is currently our core business, but we need to focus on full recovery and fee bearing work to maximize our growth

▶ Product Development, Product Sales, and Licensing

- We primarily do licensing but need to do more up-front development to maximize IP value or convert to product sales for maximum value
 - Examples: skid-mounted pyrolysis units for biofeed to fuels; fuel cells with reforming technology; supercapacitors; etc.

▶ Commercial/Industrial Operations and Services

- This is a new area for us but has the most potential for fast growth
 - Examples: Oil and Gas Exploration and Production (frac water management, EOR, etc.); Utility Company Carbon Management (capture and sequestration); biofuel production (client site implementation of catalytic pyrolysis process); etc.