

Modeling for the Smarter Grid

Roger C. Dugan
Sr. Technical Executive

EPRI, Knoxville, TN

Presented at

“Tools for the Smart Grid”

BNL/ISGAN Workshop
on Modeling Simulation and More

April 14-15, 2016



EPRI is at the Forefront of Advancing Computer Tools and Methods for Supporting Utility Grid Planners

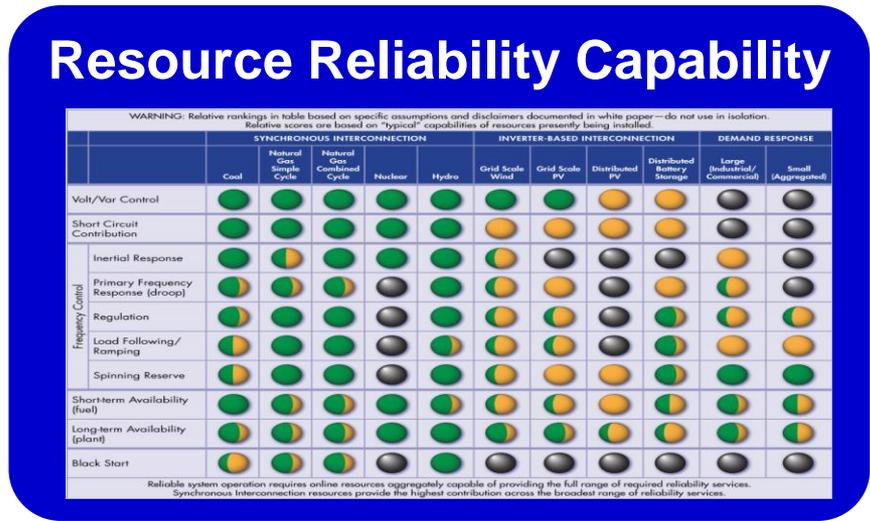
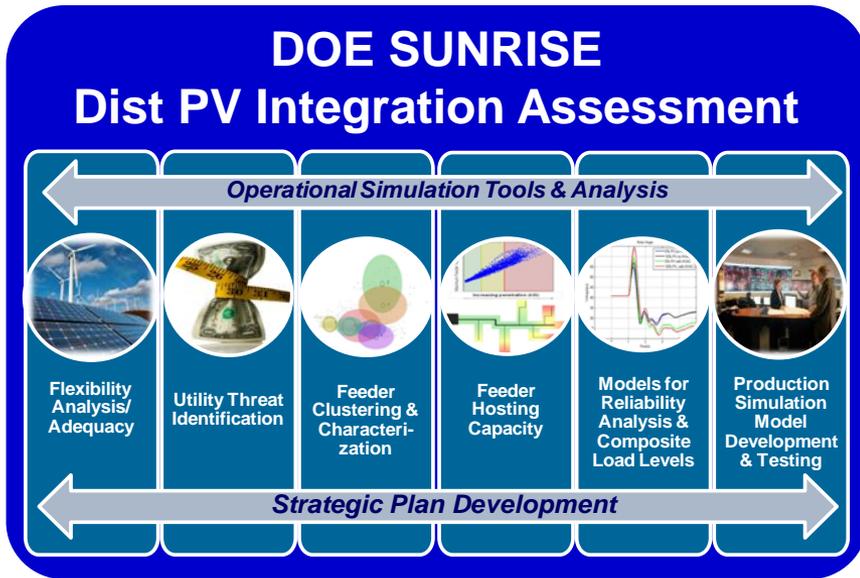
- Utility grid planners require improved computer tools
 - To assess benefits and impacts of solar PV, storage and other DER
- There have been advancements in commercially-available tools within the last decade but gaps remain
 - For both transmission grid tools and distribution system analysis tools
 - Combined simulation of transmission and distribution
- This presentation gives an overview of recent and continuing research

Topics Addressed in this Presentation

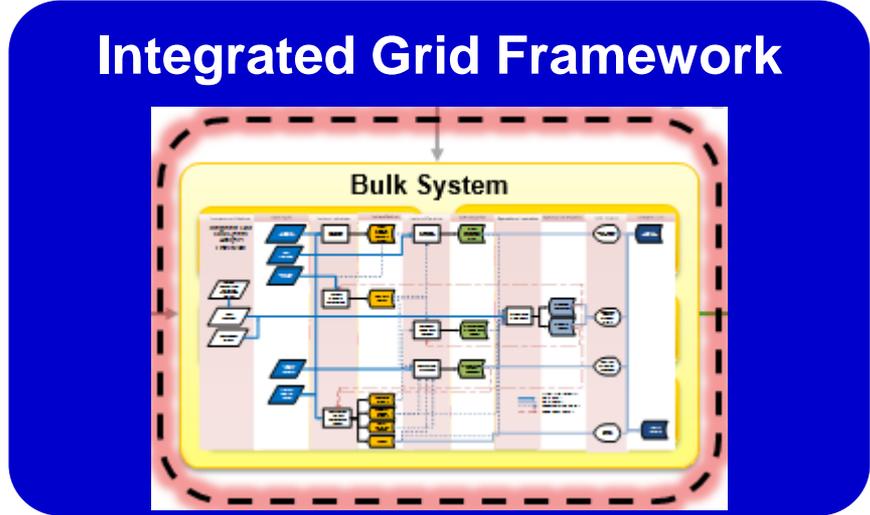
- Transmission grid performance with renewables
- Probabilistic approaches to planning
 - Planners are accustomed to static, deterministic analysis
 - Utility planners are often uncomfortable with probabilistic methods
 - Renewable DER naturally requires probabilistic approaches
- Modeling Storage for distribution planning
- Quasi-static time series analysis
- PV system modeling
- DMS modeling
- Dynamics analysis for microgrids

Transmission Grid Tool Research

Overview: Distributed Resources & Renewables Integration to the Bulk System



Forecast Value & Integration
Reserve Determination
System Flexibility Adequacy



Issue: Maintain bulk system operational reliability with large penetration of non-synchronous resources

Key Recent EPRI R&D Results

- DER Ride-Through Req. White Paper / IEEE P1547 Facilitation
- Reliability Contributions White Paper
- Analysis of voltage and frequency performance of BES with DER
- Comparison of various modeling approaches for DER in bulk system studies

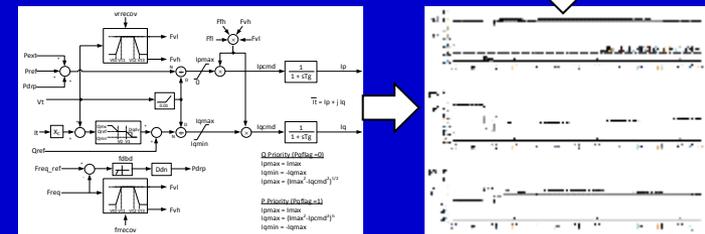
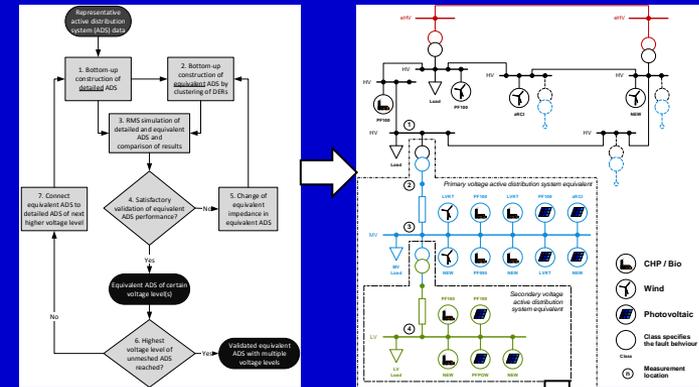
Current Work

- DER modeling in BES studies
- Transmission 'hosting capacity'
- Frequency response with high levels of variable generation

Value

- Understanding implications of high penetrations of distributed PV
- Bases for planning strategies for high penetration futures

Various approaches to model active distribution systems



- Minimum level of modeling detail
- Data needs
- Automation of creation of equivalent models

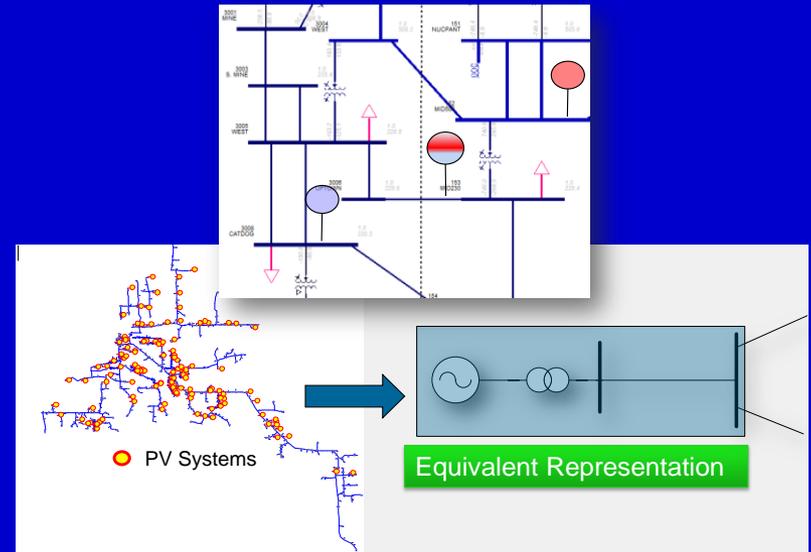
Distributed Energy Resource Impacts on Transmission

DOE SUNRISE Strategic Planning for Distributed PV



- Strategic plan & operational impact analysis tools for integrating PV
- Southern Company & TVA
- Voltage, Frequency, Flexibility, and Operating Reserve Impacts

Evaluation of DER Impacts on Transmission Performance

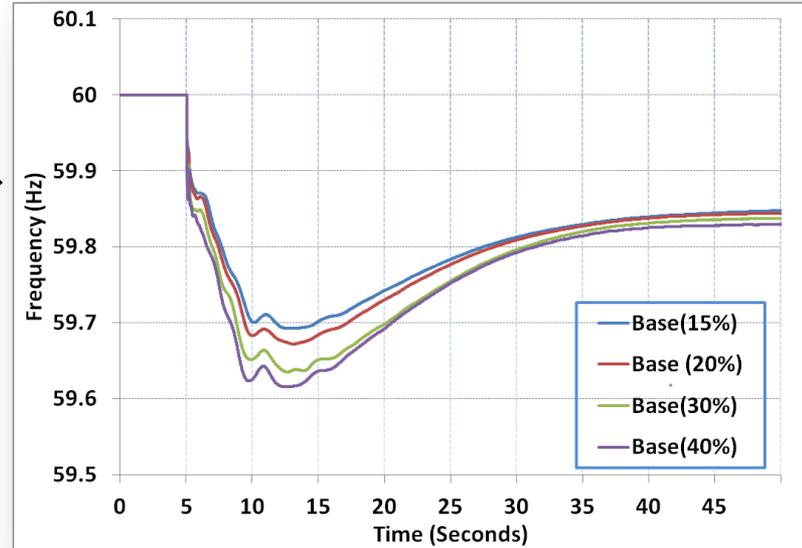


- DER aggregation for bulk system studies and modeling guidelines
- Interconnection Recommendations based on system studies

Transmission Performance Impacts of Distributed PV

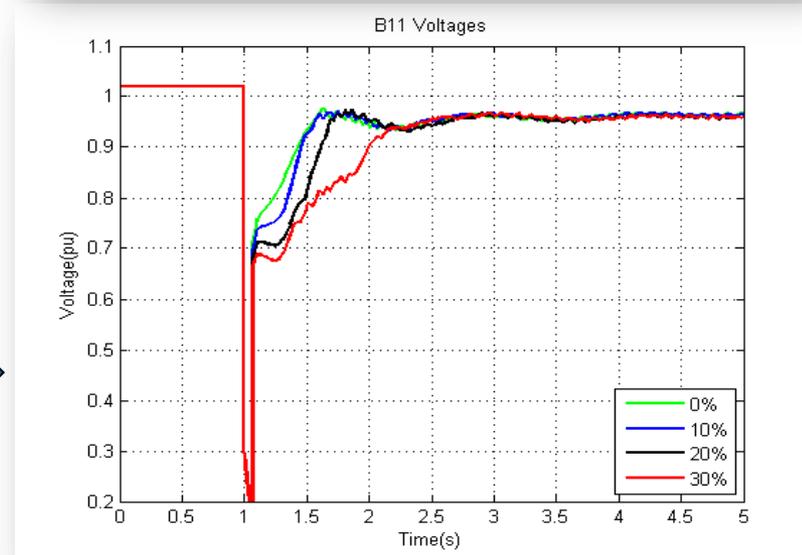
Impact on Frequency:

- Reduction in system inertia due to change in generation mix
- PV drop out due to large voltage disturbance (as per IEEE 1547)



Impact on Voltages :

- Delay in voltage recovery
- Degradation of load power factor
- Change in Active/Reactive Power Margins



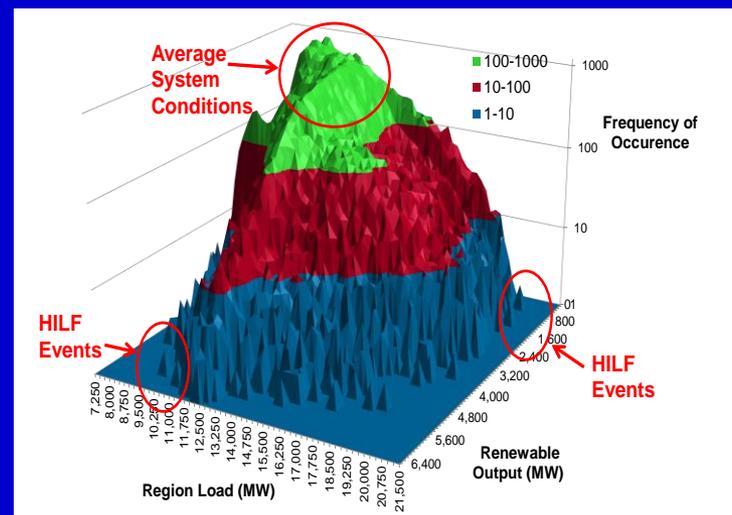
Risk Based Planning

- Recent EPRI R&D Results
 - Load, Dispatch, & Outage Uncertainty tool provides Planning case /probabilities
 - TransCARE software provides probabilistic Trans reliability
- Current Work
 - Develop grid resiliency assessment framework

Risk-based planning tools treat uncertainties to ensure reliability and economic investment

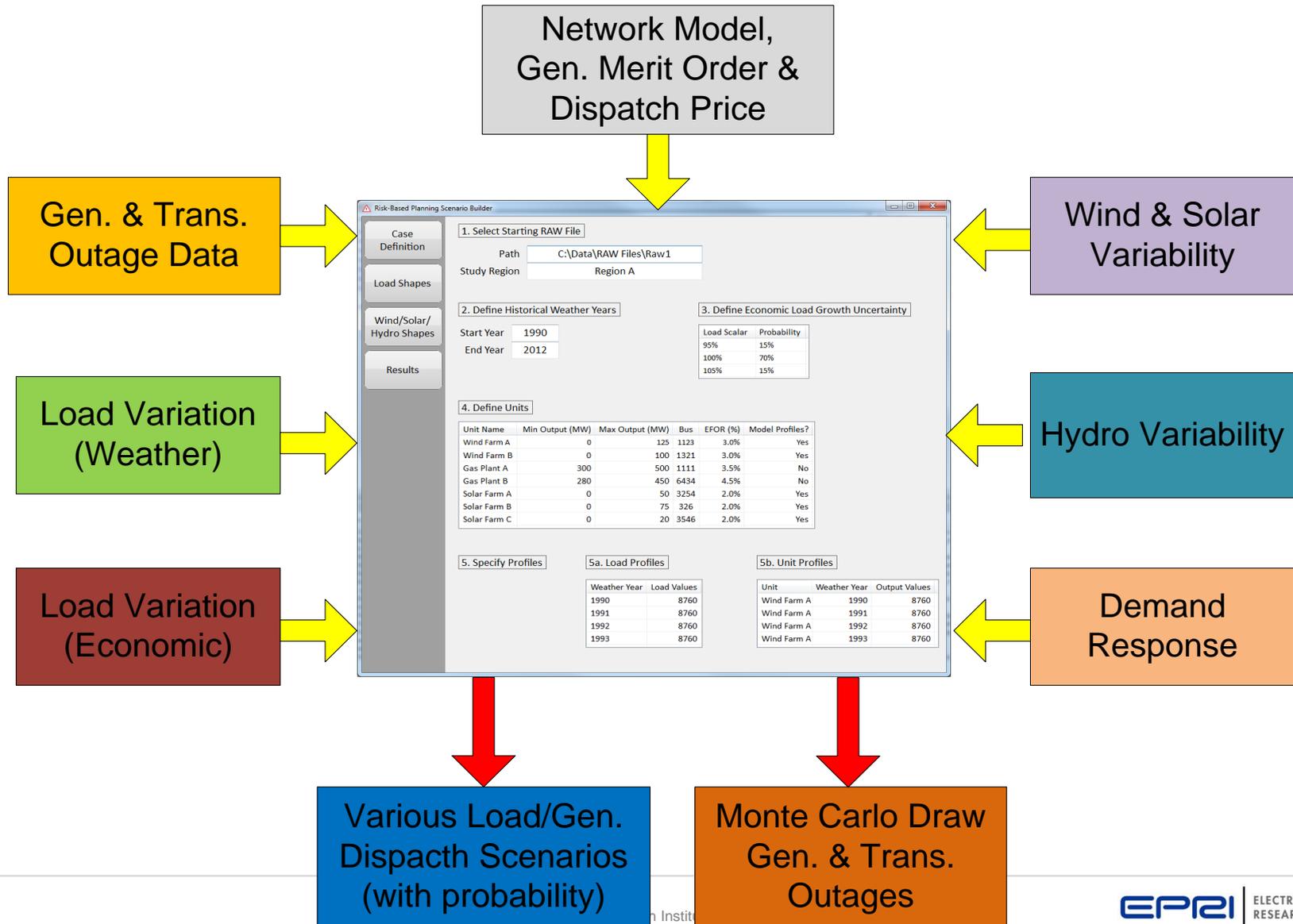
Illuminate value of transmission

Risk-Based Planning



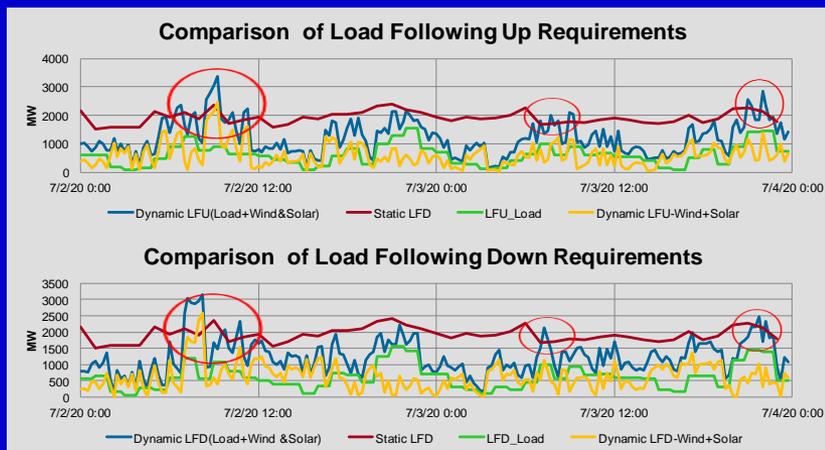
- TransCARE analysis software
- Load, Dispatch, & Outage uncertainty model for setting planning cases
- EISPC Risk-Based Planning primer, application, & R&D gaps whitepaper

Scenario Builder Tool to Determine Trans. Planning Cases across Uncertainties



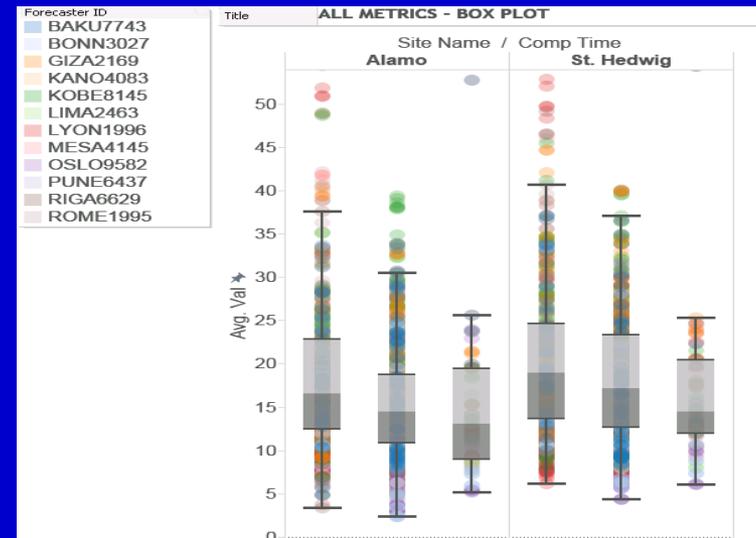
Managing Uncertainty in Operations with high VG

Applications of Stochastic Optimal Power Flow



- Determine operating reserves based on uncertainty in wind/solar forecasts
- Advanced operational simulation tools to investigate system operations
- Applying at CAISO and engaging vendors

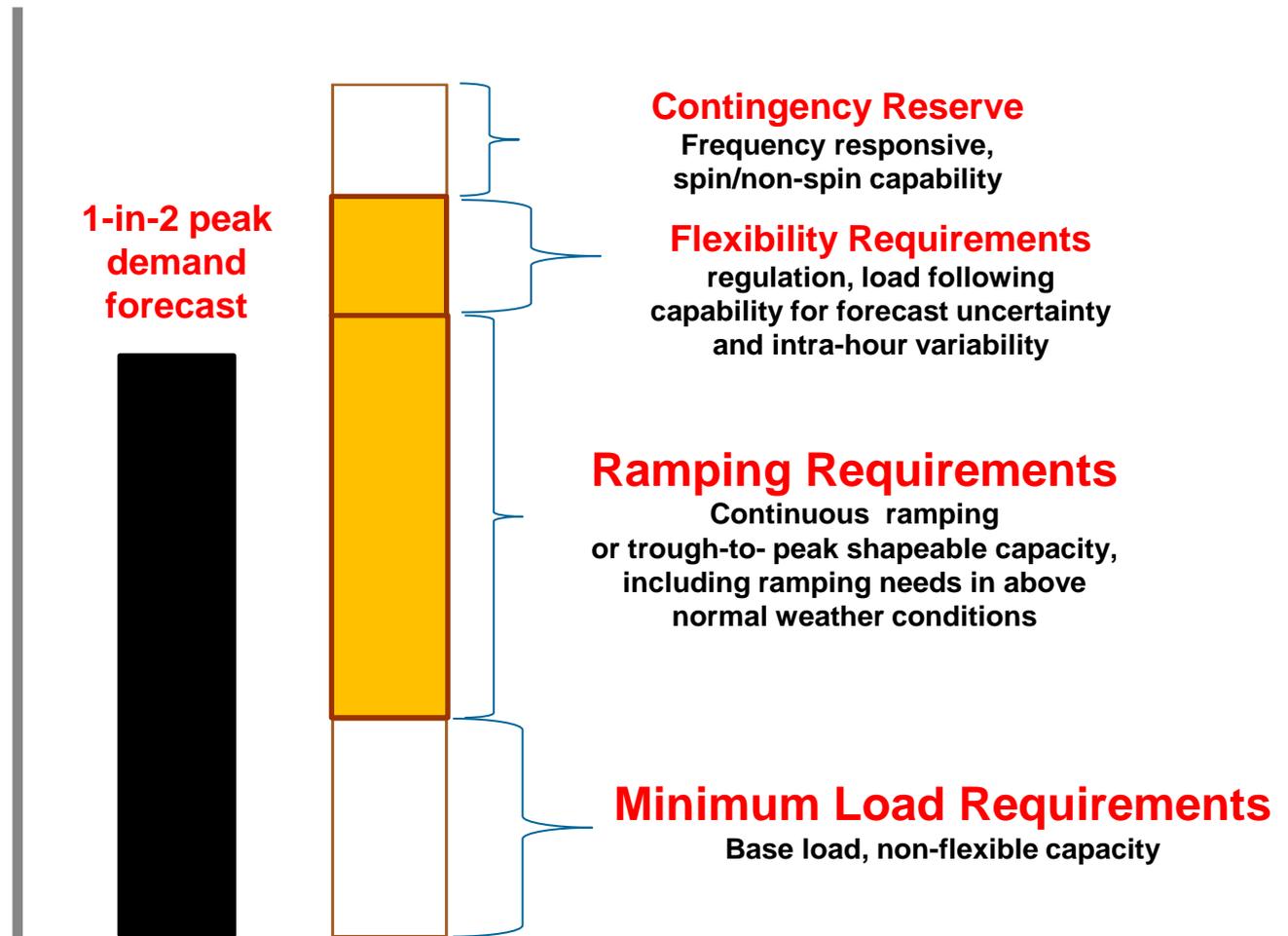
Integration of Wind/PV Forecasts into Operations



- Evaluation of Wind/PV Forecast accuracy and value in operations
- Methods to integrate forecasts into key operations functions
- Use of Probabilistic Forecasts

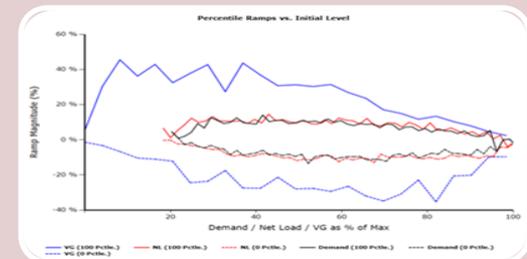
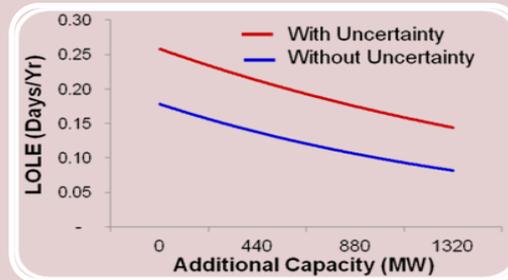
Planning Challenges of Renewable Integration

Future procurement must satisfy operating flexibility in addition to traditional capacity requirements



Source: CAISO, Resource Adequacy Flexibility Workshop

EPRI Flexible System Planning R&D



Flexibility Assessment Software Tool

- Flexibility metrics
- Screening analysis
- Detailed flexibility evaluation

Resource and Transmission Flexibility

- Resource adequacy considering flexibility
- Transmission and flexibility
- New resource types

Utility/ISO Flexibility Case Studies

- Insights as to time horizons concerns
- Order of magnitude of possible risk

EPRI flexibility metrics for system planning

■ Multi-Level Approach

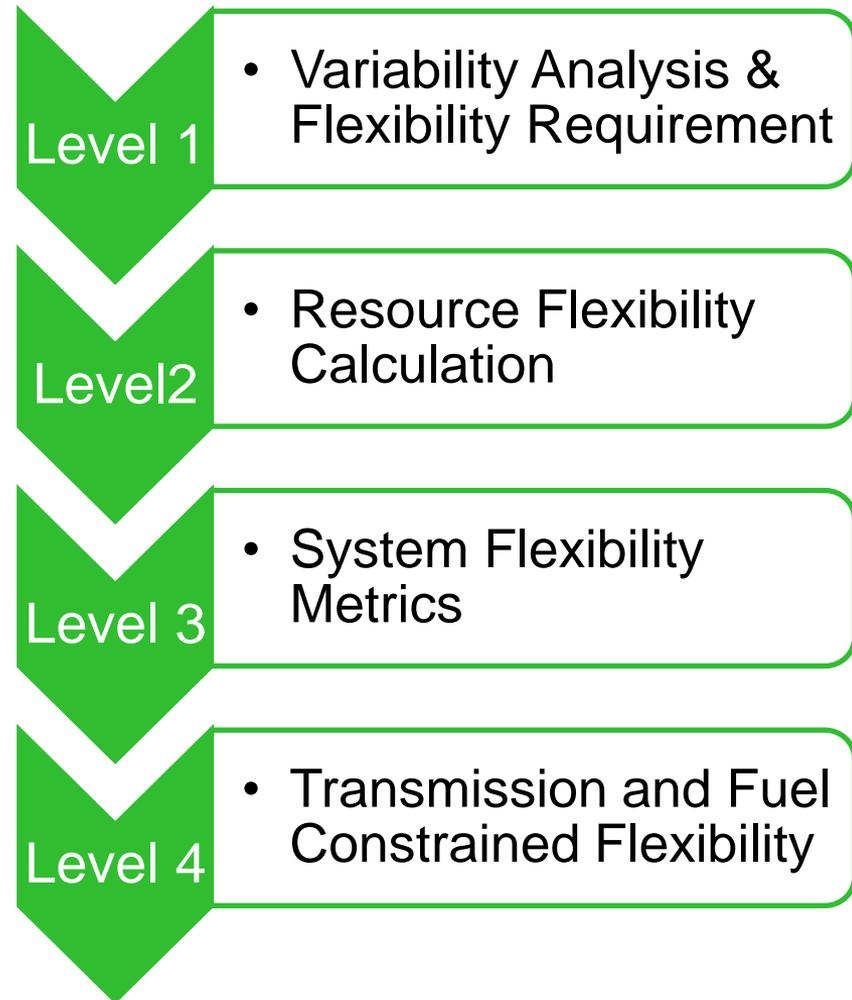
- Levels 1 and 2 → screening
- Levels 3 and 4 → detailed metrics
- Post-processed metrics based on simulated or historical data

■ Three detailed metrics:

- Periods of Flexibility Deficit
- Expected Unserved Ramping
- Insufficient Ramping Resource Expectation

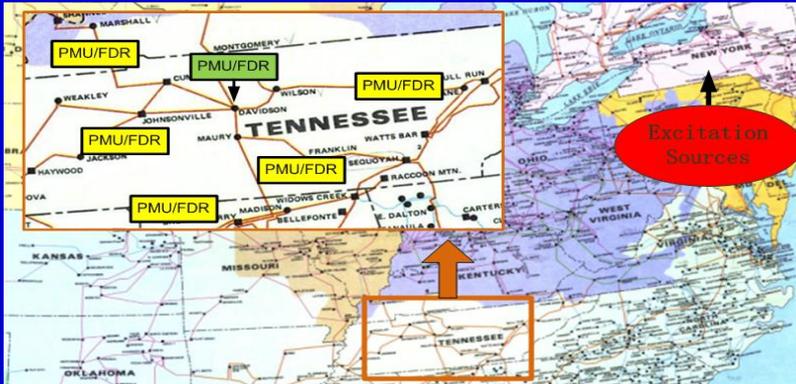
■ Currently benchmarking various systems

- White paper available on epri.com

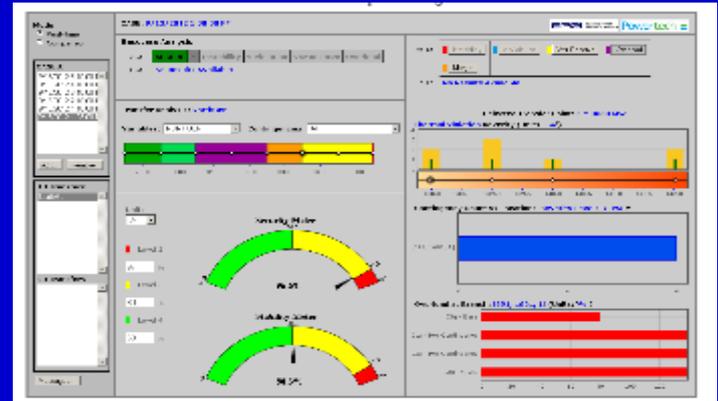


Situational Awareness

Synchrophasor Applications



Ops Visualization/Awareness



- Tools to identify most critical Op Limit and recommendations for Op action
- Operator visualization/awareness of equipment health & protection status

Alarm Management Processes

Cost of Poor Alarm Management

Operator's job: keep process running at optimal



Improved Operator Awareness & Decision Making

Improved Real-Time Assessment

R&D effort to examine linking tools across different domains

- System is expected to change at a faster pace than before
- Also greater change in resource mix – Variable Generation, Demand Response, Energy Storage
- Consider impact of resource mix changes on reliability and impact of reliability constraints on resource mix buildout
- Gaps in long term economics
 - Resource adequacy
 - Flexibility
 - Ancillary services
 - Reliable transmission
 - **Distribution modeling**

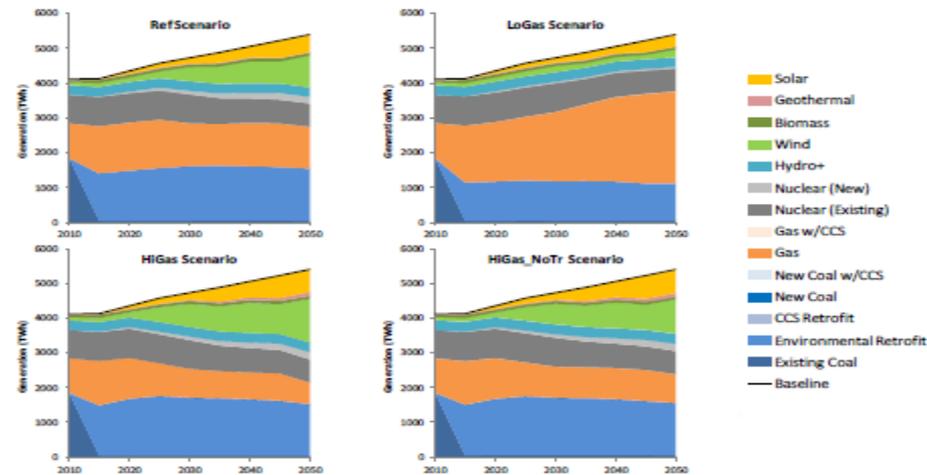
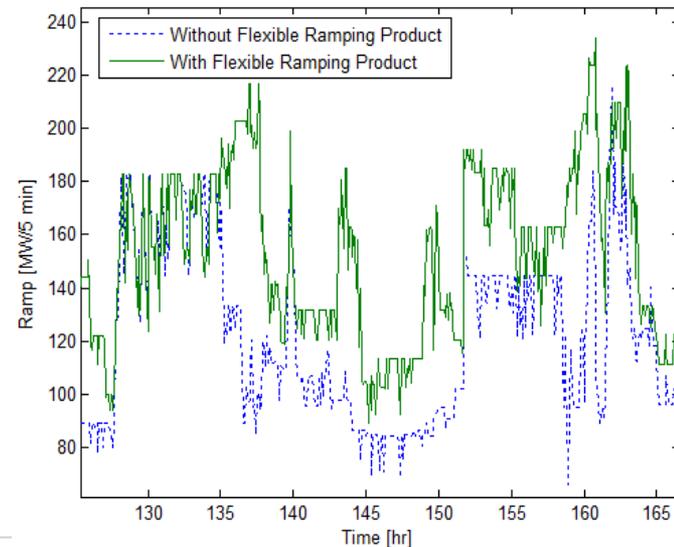


Figure 3
US Electricity Generation 2010-2050 by Generation Technology

How to pass relevant info between high level to detailed results??

Available Ramping Capacity



Distribution System Tool Research

Impact of Smart Grid on Distribution System Analysis (DSA)?

- What DSA framework is needed to support all features of the SG?
- Will there be a need for DSA if everything is monitored thoroughly?
- What could we do if we know more about the system?
- How will merging of planning, monitoring and DSE change DSA tools?

Key Smart Grid Features

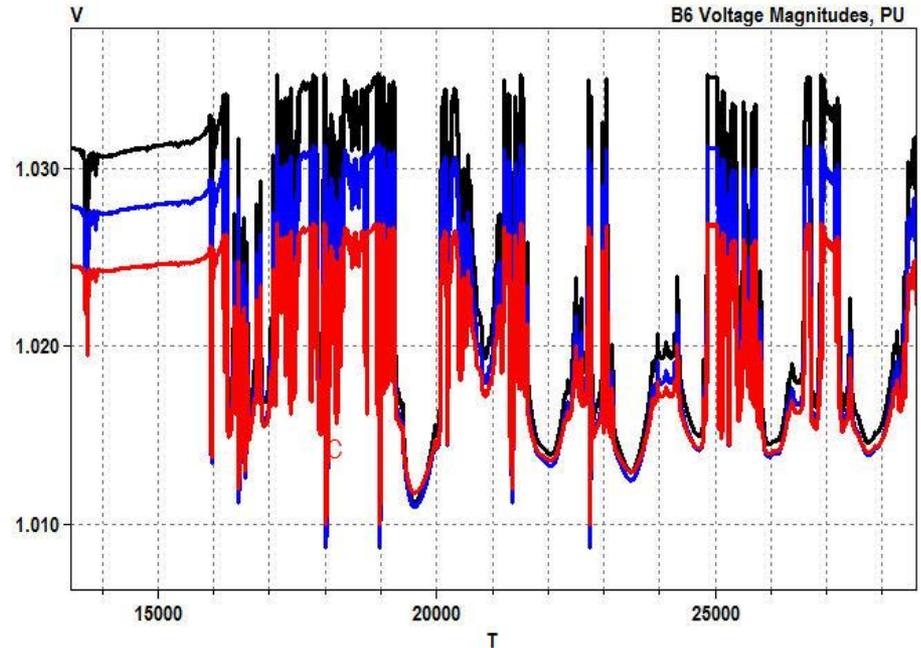
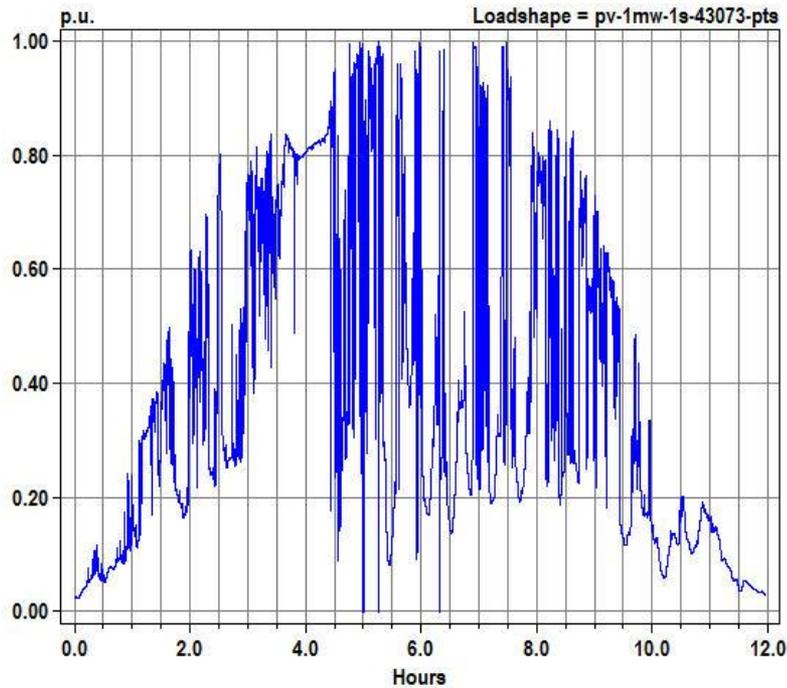
- Distributed Resources
 - Generation
 - Renewable Generation
 - Variable sources
 - Energy Storage
 - Demand Response
 - Microgrids for Resilience
- Communications and Control
 - DMS dynamically managing resources, voltage control, etc.
 - AMI deployed throughout the system
 - High-speed communications to Metering and Controls
 - State Estimation

DSA State of the Art

- Full 3-phase analysis
 - Some can do more than 3 phases
- Primarily peak demand capacity problem
 - A few perform QSTS simulations
- Tools designed for uniprocessors
 - Mostly satisfactory for now
- Support for many SG features is still in embryonic stage
 - Inverter modeling
 - Storage modeling
 - Probabilistic/Stochasting planning
 - Dynamics analysis is not common
 - LV system ignored

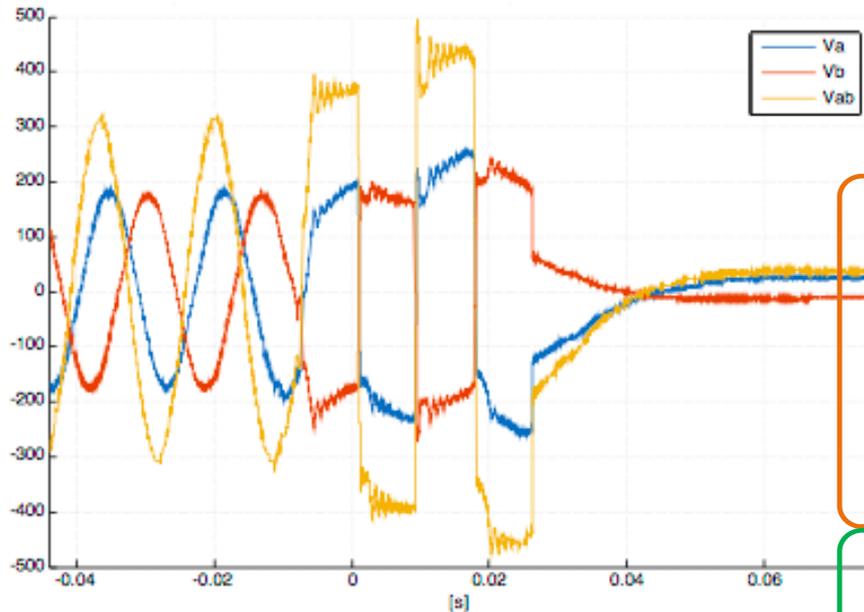
QSTS Simulations

- Particularly useful for Solar PV analysis

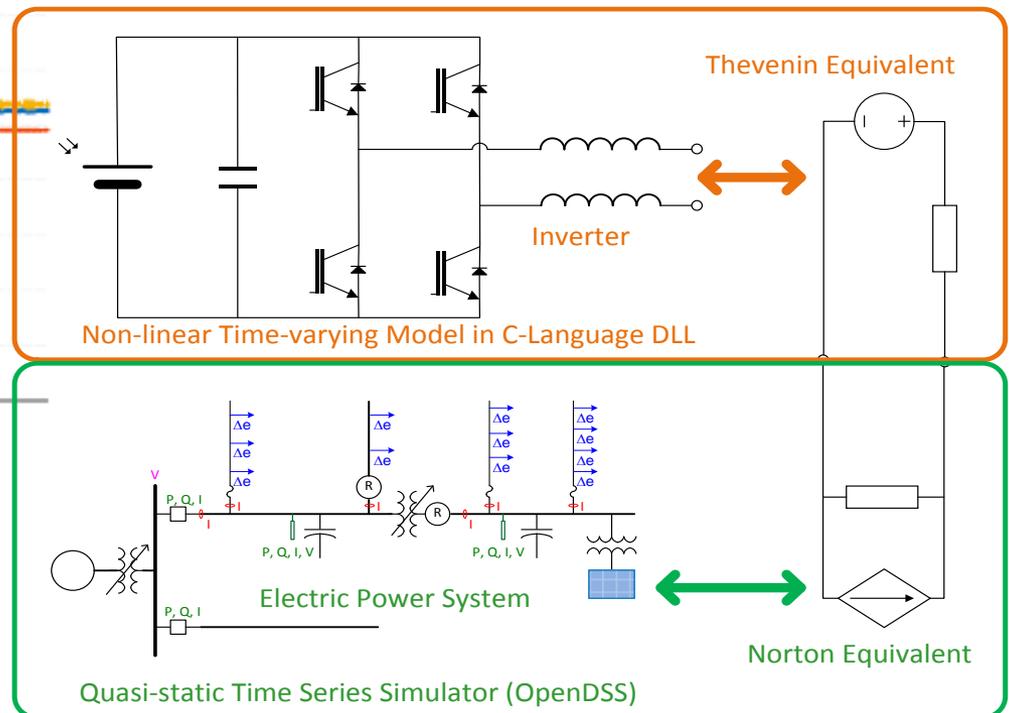


Inverter Modeling

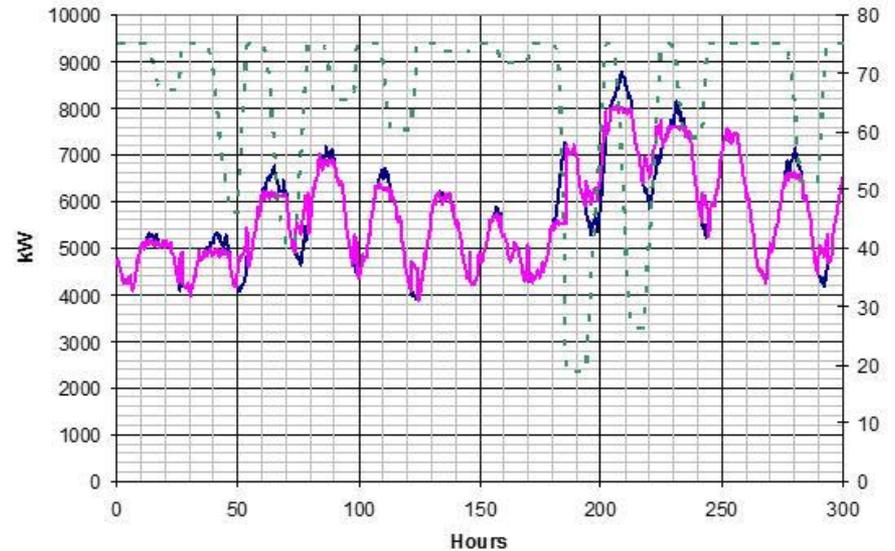
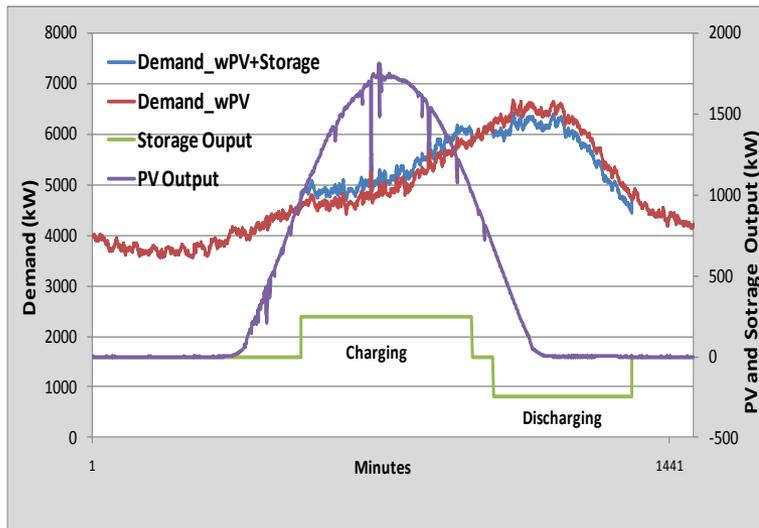
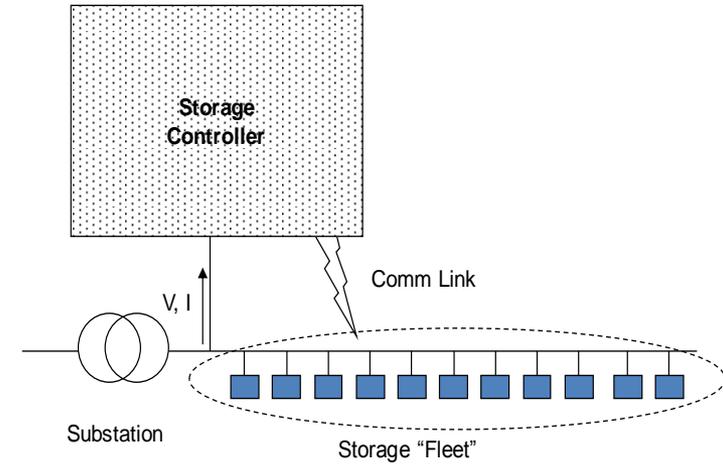
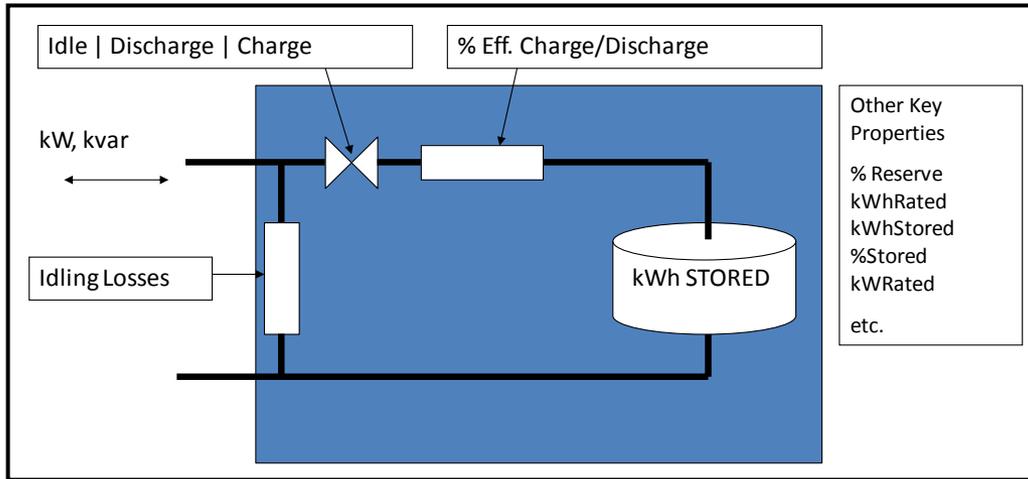
- Short circuit contribution and open-circuit overvoltages remain an concern for distribution planners



University of Pittsburgh testing and modeling results



Storage Modeling



EPRI vision

- Planning and DMS will converge into one set of tools
 - (Real time monitoring/control and planning will merge)
 - Emphasis of new EPRI research program

- Current research into modeling DMS algorithms ...

Modeling DMS with Python-based “Sandbox”

