EPRI | ELECTRIC POWER RESEARCH INSTITUTE

CEC IEPR Workshop
July 31, 2008

Renewable Energy Integration: Grid Reliability Impacts and Solutions

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Grid Planning and Operations

Integration of Renewables

requires effective

Grid Planning

EPRI's 2009 Grid Operations and Planning Portfolio

Grid Operations and Planning

EPRI's Grid Operations and Planning programs encompass advanced visualization and prediction of cascading outages using phasor measurement unit and energy management system data, providing grid operators with the tools and training for system restoration and more accurate load modeling and stability assessments. This research area also provides solutions on how to integrate renewable esources and meet reliability standards.

P39 Grid Operations

- **39A** Situational Awareness
- **39B** Online Stability and Control
- **39C** Controlled Separation and System Restoration

P40 Grid Planning

- **40A** Modeling and Standardization
- **40B** Reliability Assessment and Standards
- **40C** Engineering Study and Economic Assessment

P173 Enabling Transmission for Large Scale Renewable Integration

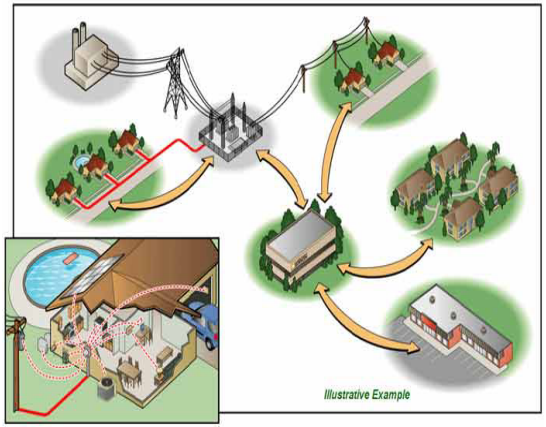
P8 Power Markets and Enterprise Risk

PSAPO R&D Portfolio P173 Renewable Energy Integration: Grid Reliability Impacts and Solutions

Integration of Renewable Energy: Grid Reliability Impacts and Solutions program helps system operators and planners with knowledge, methods and tools to handle the emerging integration of renewable energy issues for preparation of the future.

P173.001 Determination of planning and operating cost for integrating wind generation

P173.002 Adjustments to traditional transmission planning required to fully integrate intermittent generation

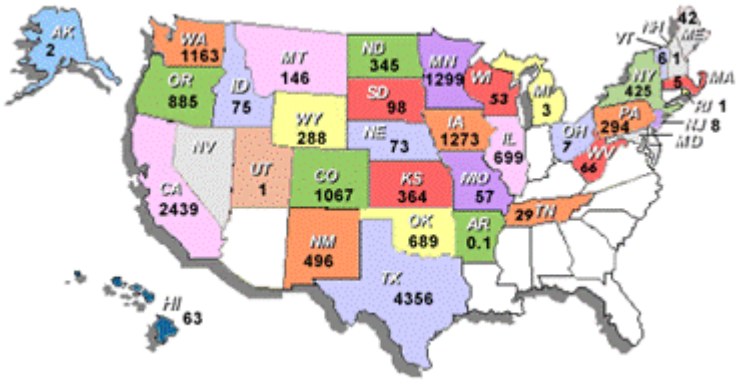


P173.003 Methods of determining supply capacity on reserve requirements for high wind penetrations

P173.004 Development of new operational methods and tools for accommodating high penetrations of wind generation

P173.001 Determination of cost of planning and operating a reliable system under high penetrations of intermittent generation

- Industry Issues
  - The existing cost evaluation methods may not consider all of the potential costs that should be considered
- Work Scope
  - Evaluate existing wind integration study methodologies and assumptions
  - Develop methods for evaluation of all intermittent generation cost impacts
- Deliverables (Technical Report)
  - Intermittent Generation Cost Impact

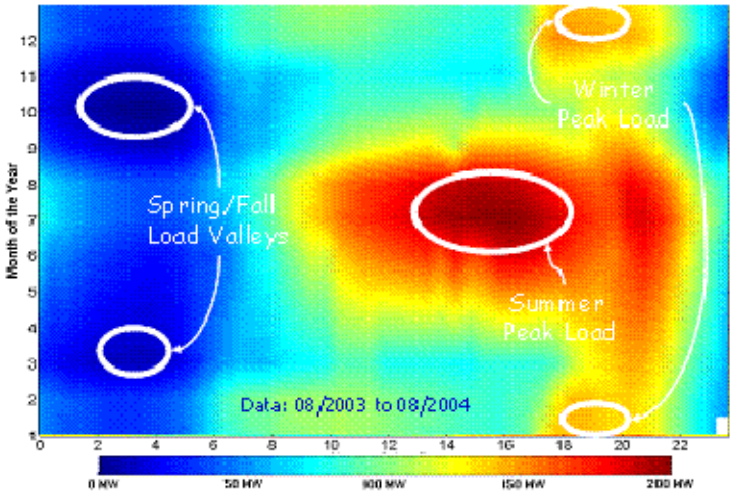


Study	Penetration Level (%)	Regulation	Intra-Hour Load Following	Inter-Hour Load Following	Scheduling/Unit Commitment	Total
NYSERDA-NYISO	10	-	-	-	-	
Xcel-20%	0.3	-	0.41	1.44		1.85
Xcel-1500	15	0.23	0.00	4.37		4.60
AESO	13	7.37	-	3.64	-	11.01
BPA	11	0.19	0.28	-	1.00	1.47
SPS	20	1.00 - 2.25	0.01	-	-	1.01 - 2.26
UWE	14	1.08	0.14	-	1.61	2.83
GRE	16.6	1.28	0.18	-	3.08	4.54
Pacificorp	20	-	-	2.50	3.00	5.50

Source : EPRI, Survey of Wind Integration Study Results, Technical Update, March 2008

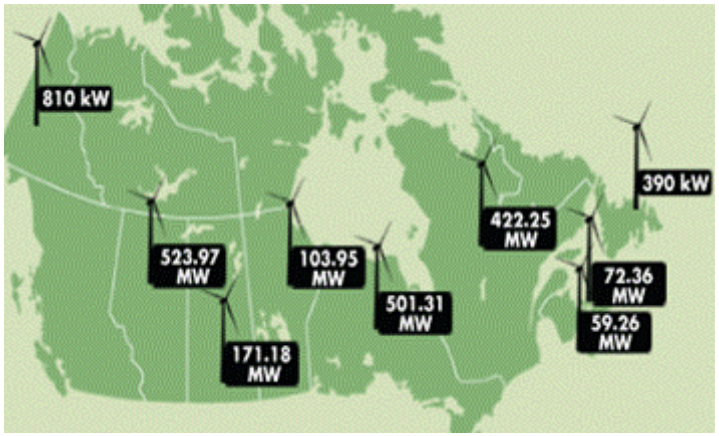
P173.002 Adjustments to traditional transmission planning required to fully integrate and accommodate as much intermittent generation as possible

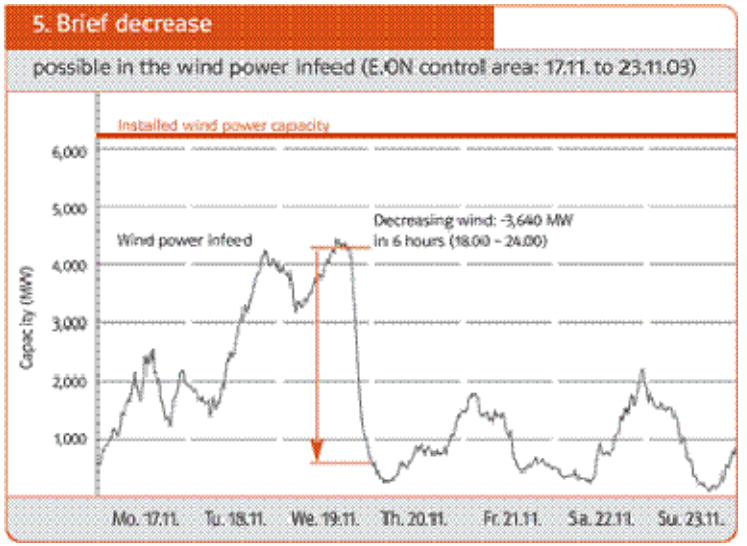
- Industry Issues
  - To meet the Renewable Portfolio Standard (RPS), transmission infrastructure need to be expanded.
- Work Scope
  - Develop wind plant models
  - Investigate the required transmission capacity
- Deliverables (Technical Update)
  - Transmission Infrastructure to Integrate Renewable Energy



P173.003 Methods for determining supply capacity recognized intermittent generation and impacts on reserve requirements for high wind penetrations

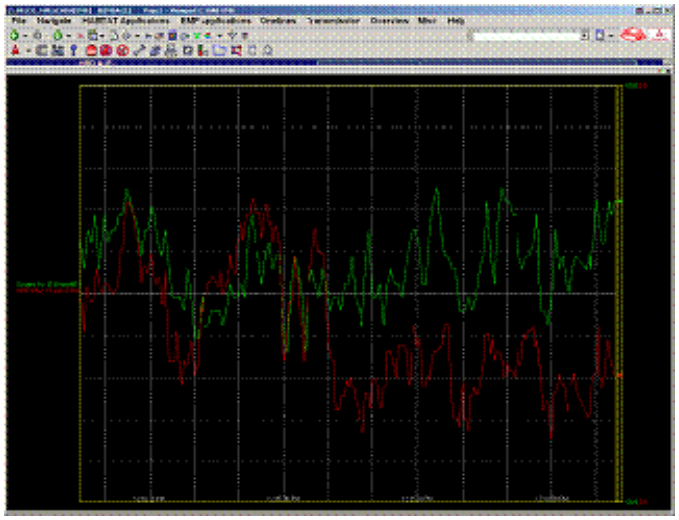
- Industry Issues
  - – Need an analytical method for determining planning and operational reserve requirements
- Work Scope
  - – Evaluate existing capacity evaluation methods
  - – Examine stochastic optimal power flow method
- Deliverables (Technical Update)
  - – Determination of Planning and Operational Reserve Requirements for Intermittent Resource Integration with Case Studies

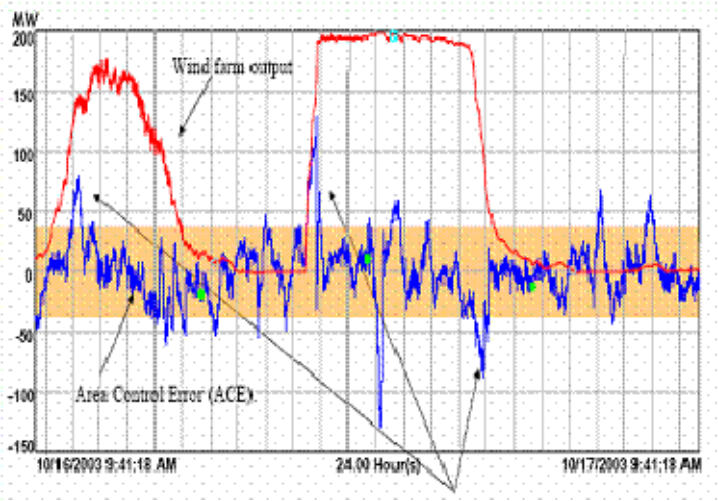




P173.004 Development of new operational methods and tools for accommodating high penetrations of wind generation

- Industry Issues
  - – Variable generation can influence system operations on all time frames from regulation/frequency control to operational scheduling
- Work Scope
  - – Investigate new operational scheduling methods such as stochastic unit commitment
  - – Recommend changes to AGC models to provide for better system control
- Deliverables (Technical Update)
  - – Operational Tools and Methods for High Penetration Wind Systems





Summary of Key Deliverables

P173 – Integration of Renewable Energy: Grid Reliability Impacts and Solutions

- Intermittent Generation Cost Impact
- Transmission Infrastructure to Integrate Renewable Energy
- Determination of Planning and Operational Reserve Requirements for Intermittent Resource Integration with Case Studies
- Operational Tools and Methods for High Penetration Penetration Wind Systems

Other Specific Research Opportunities

- Probabilistic Congestion Forecasting (PCF)
- Critical Operating Constraints Forecasting (COCF)

What is the single most important gem for what was completed in Phase 1 for COCF and PCF?

PCF:

- Probabilistic Congestion Forecasting, is ***a new approach that accounts for significant uncertainty caused by load and generation (including renewables, such as wind power) forecasts*** as well as random unplanned equipment outages. Focus is on the confidence levels of making transmission congestion forecasts, so that a window of forecast-ability is defined, beyond which any forecast would be considered to contain little actionable information. Improved forecasting of transmission congestion in both the short term and the long term can increase the reliability and efficiency of the California electricity system.

COCF:

- Critical Operating Constraints Forecasting, is a new concept developed by EPRI in 2005 and is the core technology proposed to the California ISO for ***making short-term*** (next 24 hours) ***prediction of critical post-contingency line loadings and voltage profiles***. EPRI has developed a methodology for visualizing the synergistic effects of such an alternative based on its CAR (Community Activity Room) technology. This technology has been tested and proven in two previous PIER projects involving CAISO.

Why do we think we need to do further research (phase 2) for each of these projects?

PCF:

- The CEC/State of California would be a beneficiary of this research for its value as guidelines for public policy. ***Having a better and probabilistic forecast of the extent and the relative severity of congestion*** in various bottlenecks will bring useful information in advance of potential crises, such as the precipitous increase in wholesale electricity prices, intermittent power shortages during peak demand periods, and the deterioration of ***the financial stability of California's three major IOUs***. Therefore, right decisions should be made to avert future short term or long term effects on the California economy due to the inability of the transmission grid to deliver electricity to where it is needed.

COCF:

- This research project will ***test and demonstrate the potential alternative of reshaping intermittent wind generation with compressed air energy storage*** (for which California has many excellent sites and which has the potential of providing hundred hours of storage capacity) before delivering the firm 24x7 energy into load centers. This synergistic solution will reduce the requirement for transmission capacity, thus helping to overcome the first barrier. It will also result in firm capacity for the reshaped wind generation, thus enabling wind developers to obtain project financing with firm power purchase agreements. This approach will also reduce the operating and reliability problems for California ISO.

PIER Program on Transmission Research

Comprehensive Understanding of Transmission Congestion and Critical Constraints – Two Complementary Research Projects

Steve Lee
Senior Technical Executive
Power System Planning and Operation
July 31, 2008

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"Research Powers the Future"

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Acknowledgement

- Sponsored by
  CEC-PIER Transmission Research Program 2006-2007
- TRP Project Managers: Larry Miller, Virgil Rose
- EPRI Principal Investigator: Steve Lee
- EPRI Research Team Members:
  - Peter Hirsch
  - Guorui Zhang
  - Pei Zhang
  - Liang Min
  - Jian Chen
- CAISO champions: Jim Detmers, Armando Perez

PIER Program on Transmission Research

Probabilistic Transmission Congestion Forecasting

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Uncertainties Affecting Transmission Flows

Wind Power Presents Additional Large Uncertainties for Integration

- Operation Time Frame (seconds to hours)
  - Scheduled and unscheduled power transactions (market and economics)
  - Load forecasts and demand side options
  - Generation dispatch including renewable generation
  - Planned outages of transmission and generators
  - Unscheduled and forced outages of transmission and generators
- Planning Time Frame (months to years)
  - Addition and retirement of generators, including renewable resources
  - Load forecasts and demand side options
  - Addition of new transmission facilities
  - All uncertainties affecting Operation
  - Global climate changes and policies related to CO2 mitigation

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Scope of Project 1 – Probabilistic Transmission Congestion Forecasting

Statement of the Research Challenge

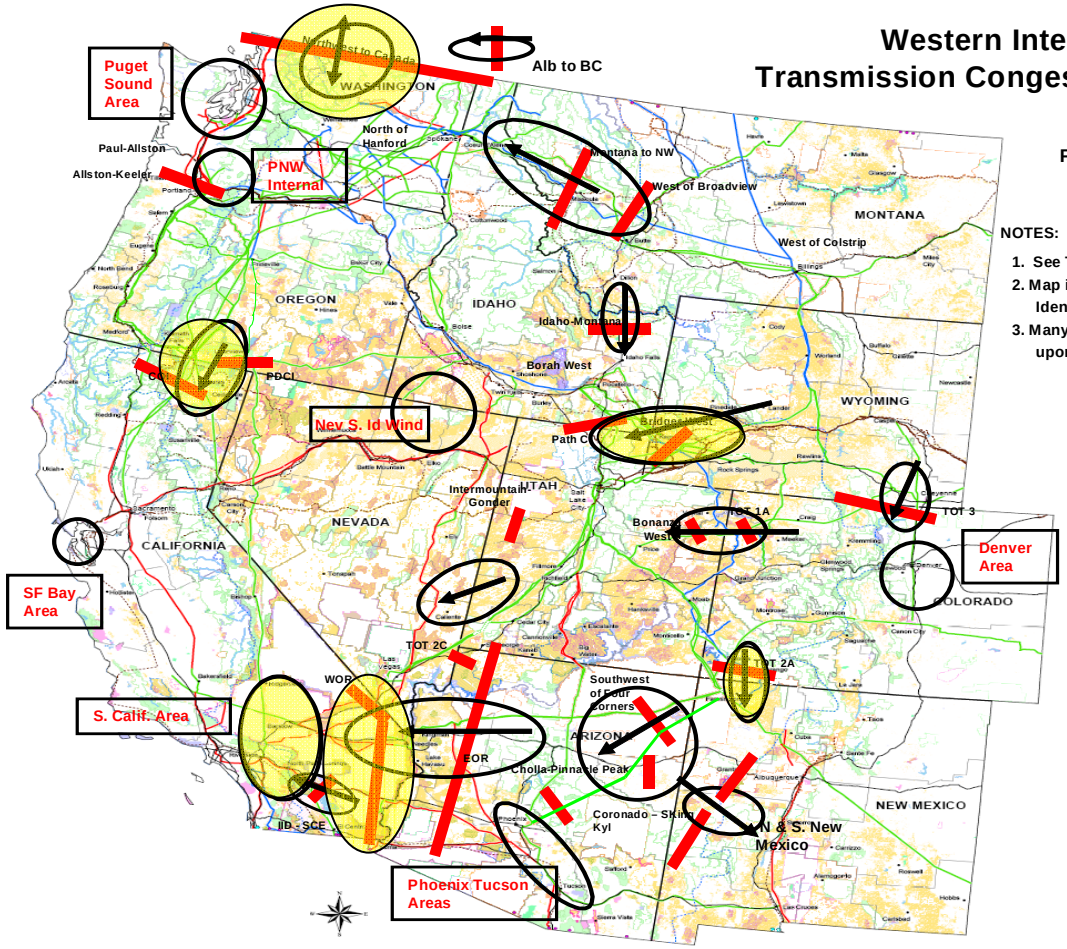
- Research Challenge
  - Uncertainties of short term and long term transmission congestion
  - Difficulties in siting and building more transmission lines
  - Effects of renewable generation and demand options on transmission congestion
- Solution Approach
  - Develop short term and long term probabilistic forecasts of transmission congestion
  - Use the tools to evaluate different scenarios
  - Conduct studies to assess policy implications to manage transmission congestion
- Phased Approach
  - Current project to develop methodology and prototype
  - Followed by future studies

Scope of Future Study Includes Wind Integration

Project Scope

- Task 2 – Literature Search
- Task 3 – Develop and Apply Mathematical Approach
  - Short-term Planning
  - Long-term Planning
- Task 4 - Outreach: Fact-sheet and Workshop

Simplified Study System



Western Interconnect
Transmission Congestion Areas/Paths

Identified by the WCATF
For Submission to US DOE
May 8, 2006

NOTES:

1. See Table 4 for Congestion Area Criteria
2. Map identifies all Congestion Areas Identified in DOE Tasks 1 and 3
3. Many Congestion Areas are dependent upon location of future W.I. resources

Congested WECC Path

Monitored Congestion Path

Direction of Congestion

Western Interconnect Congestion Areas, DOE Tasks 1, 3 and 4 Online:
http://www.wecc.biz/documents/library/WCATF/Report_to_DOE_050806_Tables1-2-3_and_Maps_ver2.ppt

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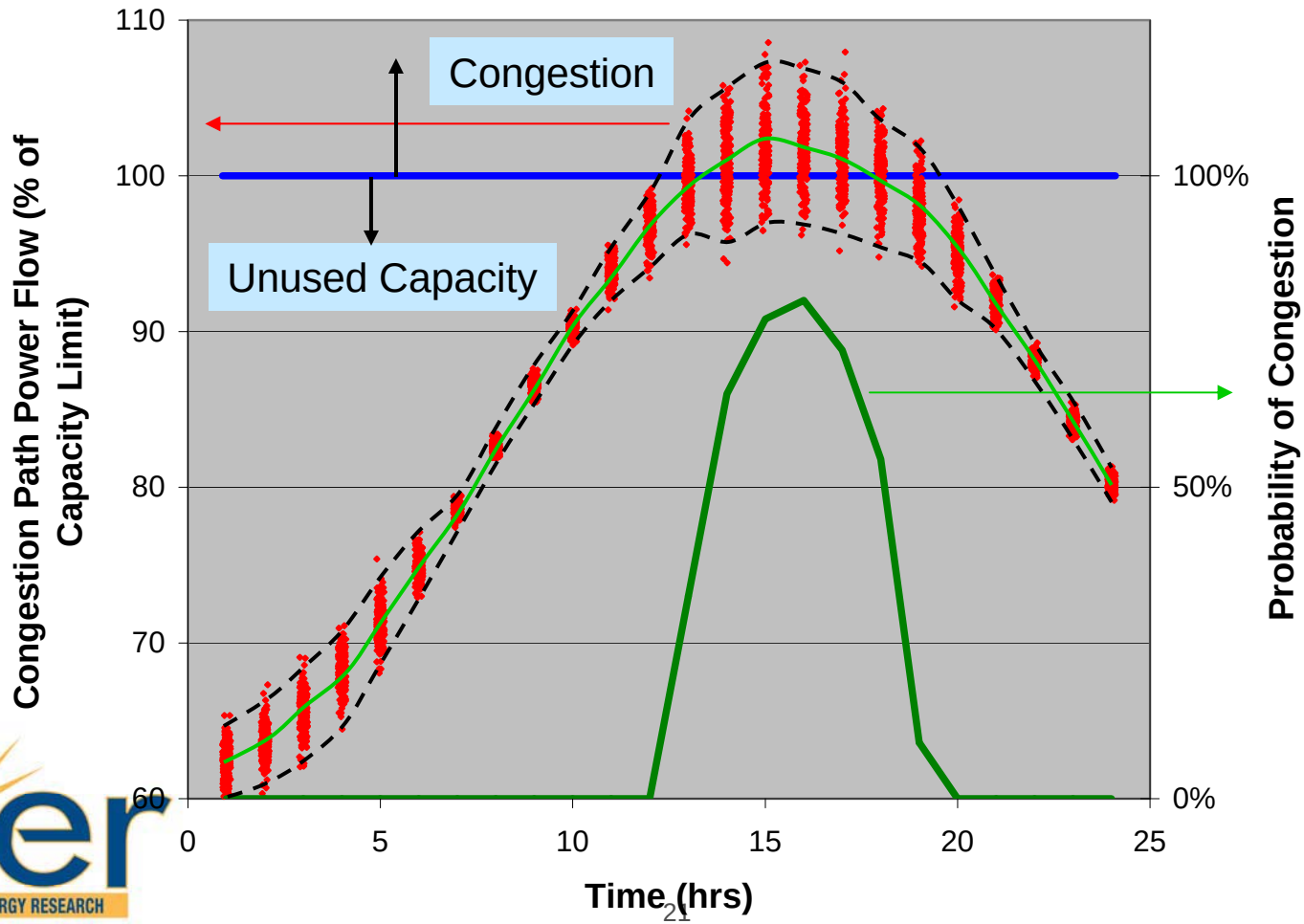
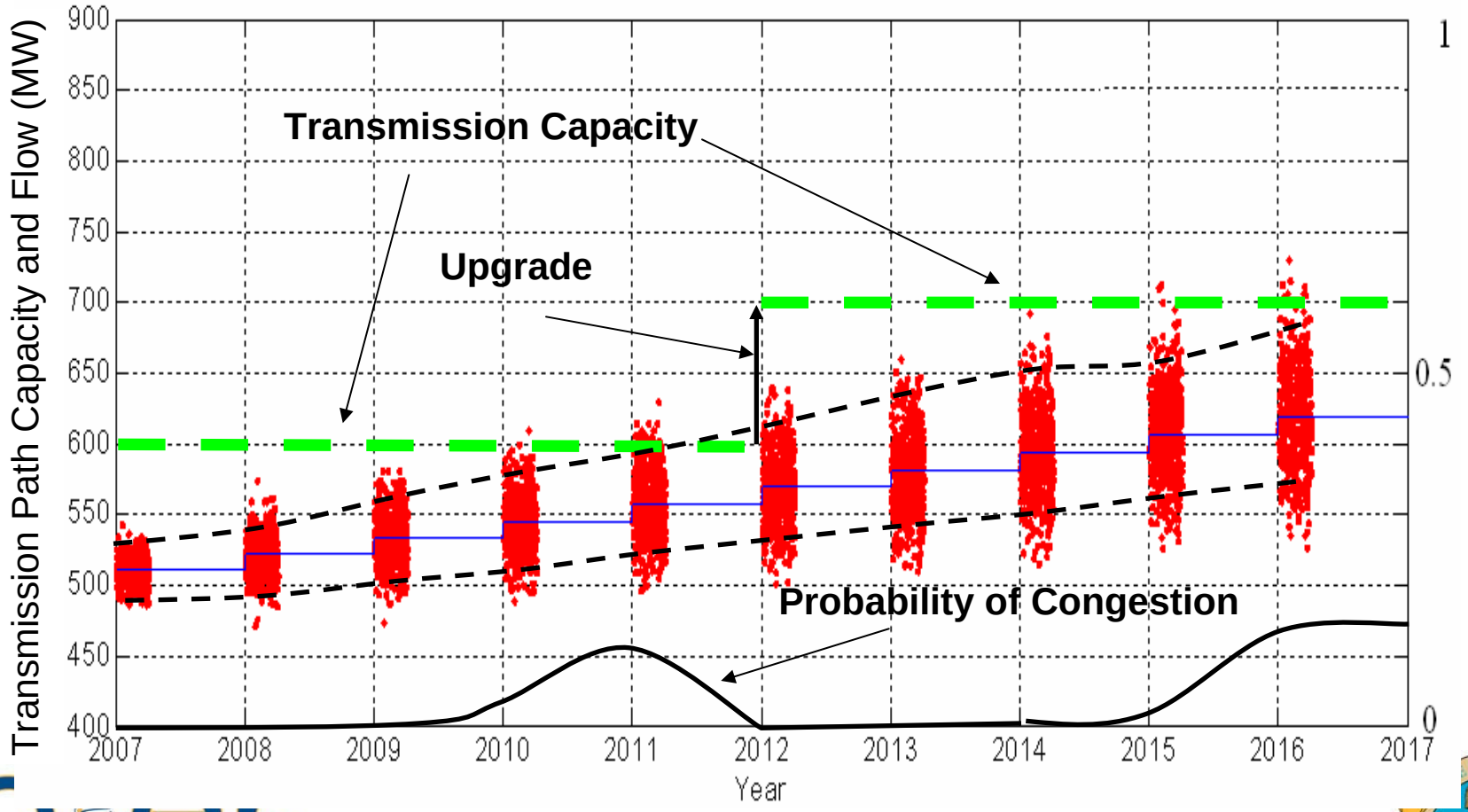
Graphic Output – Short-Term



Graphic Output – Long-Term



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Policy Implications from Congestion Forecasting

- How much of the uncertainty about congestion comes from load?
- How much reduction in congestion would come from managing load growth and demand side options?
- How much of the uncertainty about congestion comes from generator siting uncertainty, including renewable resources?
- How much of the uncertainty about congestion comes from generation construction or retirement uncertainty?
- Do market price uncertainty and CO2 mitigation policies, which may change the market dispatch of different types of power plants, affect congestion uncertainty?

Scope of Project 2 - Critical Operating Constraints Forecasting (COCF) for California ISO's Decision Support

Statement of the Technology Challenge

- Technology Challenge
  - Low Resource Margins in Southern California with Limited Transmission Capacities
  - California ISO Operators need a today's look ahead to prevent or mitigate power crisis during summer months
  - Existing EMS tools are not adequate for predicting critical operating constraints

Combining Model, Measurements and Simulation

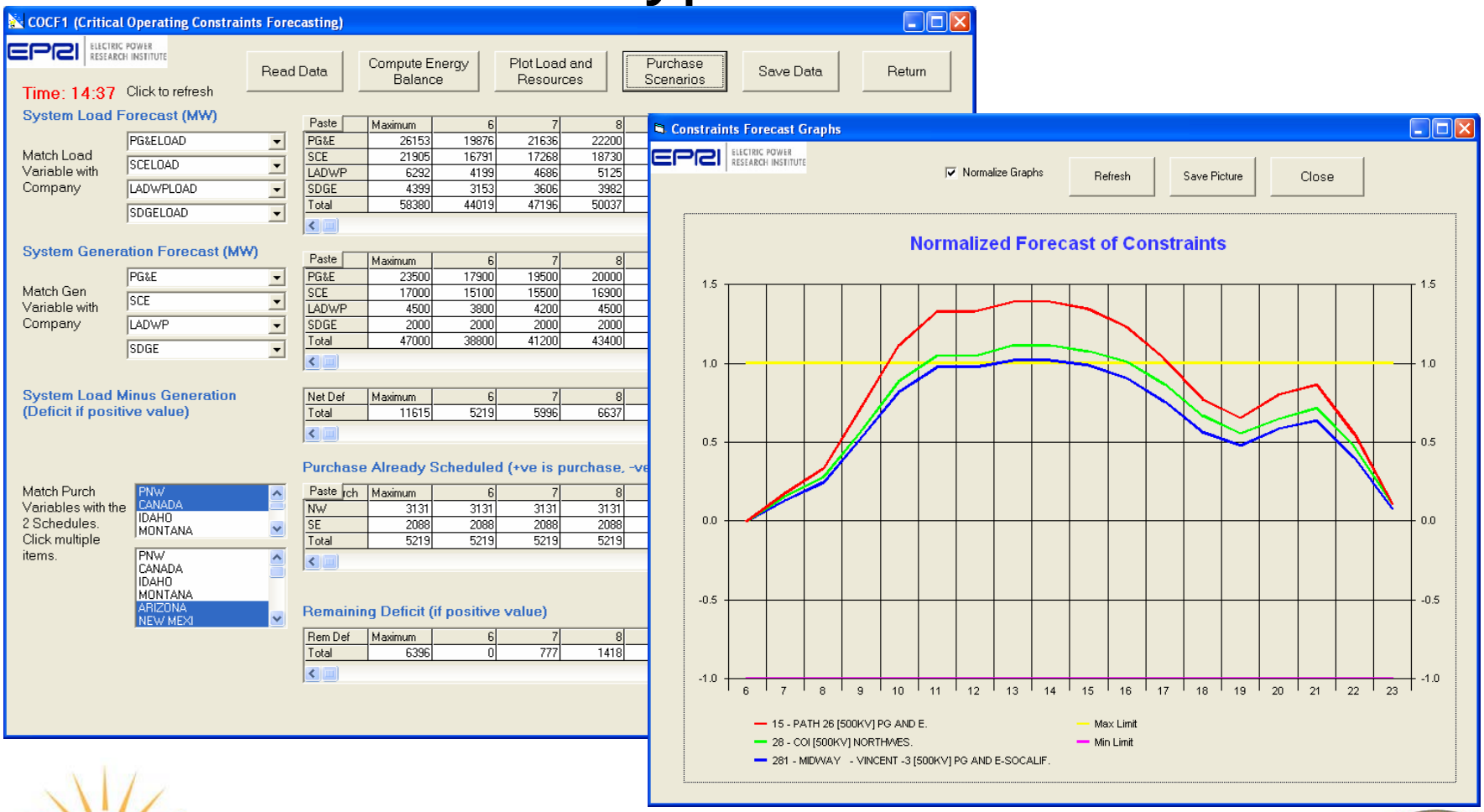
- Solution Approach
  - Develop trajectory forecasts of critical operating constraints
  - Simulate different import scenarios
  - If unavoidable, plan for load reduction in advance

Project Scope & Deliverables

- Task 2 -- Develop a Critical Operating Constraints Forecasting Prototype Tool
- Task 3 – Test and Develop Functional Specifications of COCF Tool
- Workshop - Summary Report
- Final Report with Functional Specifications

Scope of Future Study Includes Wind Integration

Prototype Screens



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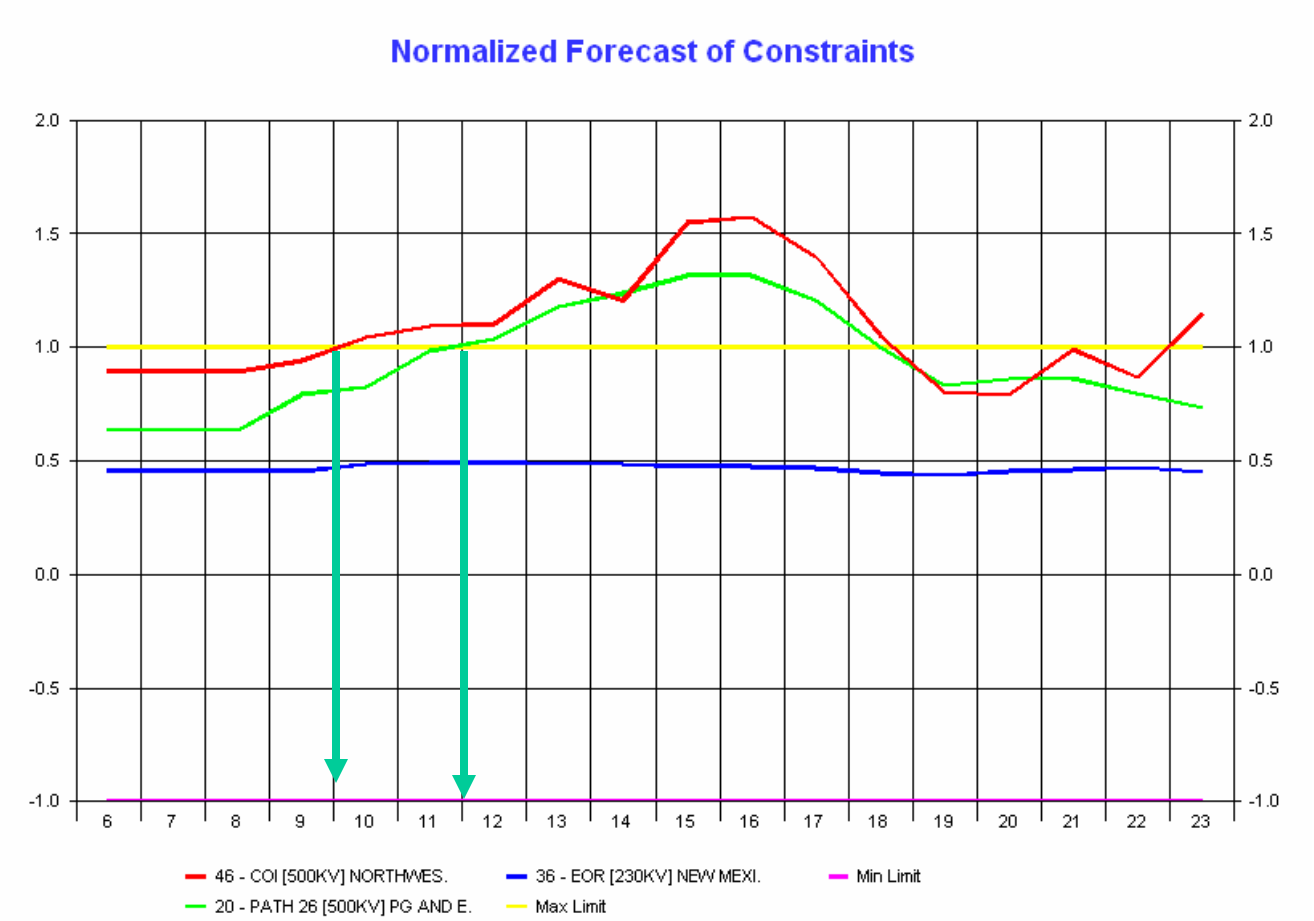
STATE OF CALIFORNIA ENERGY COMMISSION

Testing and Validation on May 31, 2006

- Data preparation – May 30, 2006 (2 pm to 5 pm)
  - CAISO: Jim McIntosh, Jamal Batakji, Tamara Elliott, Dave Hawkins
  - EPRI: Steve Lee, Peter Hirsch, Guorui Zhang
  - Day-ahead load and resource forecasts
  - Identified major line outage = Round Mountain – Table Mountain #2 (500KV) resulting in COI limit derated to 2750 MW from 4800 MW
  - Request study assumptions on Summer 2006 Assessment for 1 in 10 Forecast
  - Familiarize with major paths to be monitored and forecasted
- May 31, 2006
  - 8:00 am to 2 p.m., Put COCF to the test
  - 2:00 pm, 1 Hour Review and Demonstration (Jim Detmers, Jim McIntosh, Patrick Truong, Dave Hawkins)

First Snapshot at 8:05 a.m. 100% PNW



Conclusions

- Importance of both projects
- Benefits to California
- Valuable for Study of Wind Power