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Energy Storage for Wind Integration, a Conceptual Roadmap for California

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Fourth Annual Carnegie Mellon Conference on the Electricity Industry

FUTURE ENERGY SYSTEMS: EFFICIENCY, SECURITY, CONTROL

March 10, 2008

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Presentation Outline

- Introduction
- Market and Regulatory
  Roadmap to Energy Storage
- Energy Storage System Impact
- Conclusions

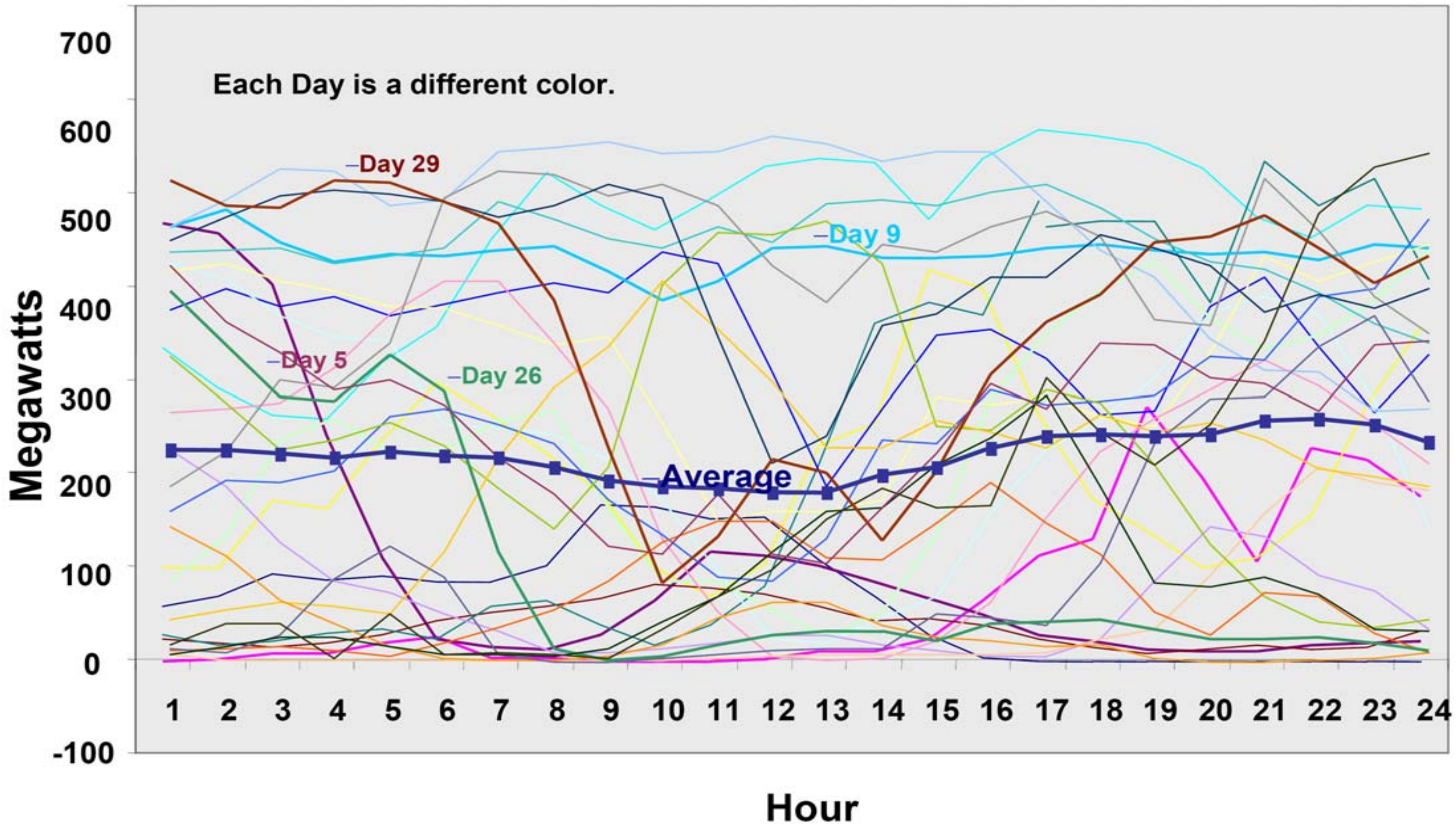
Introduction

- Storage meets challenges of intermittent wind output
- Storage provides multiple system benefits
  - But, storage costs are relatively high
  - Therefore, need multiple value streams to justify
- Markets should value and attract beneficial storage-based products
- Market development needed to attract desirable storage projects and products
- Better understanding and mapping of storage attributes vs. system needs will support market development

Market and Regulatory Roadmap to Energy Storage

- Operating the CAISO system with 20% Renewables - 6700 MW of wind presents significant challenges

Tehachapi – April 2005



From “Briefing on the CAISO Renewable Integration Study”, October 17,2007

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Market and Regulatory Roadmap to Energy Storage

- Role of Battery Storage On The Grid
  - Ramping and energy balancing
  - Time shifting of wind
  - Over generation mitigation
  - Frequency regulation
  - System capacity
  - Local capacity and reliability
  - Dynamic stability support
- Typically viewed to transmission and generation
  - 75% round-trip efficiency
  - Readily available – short lead time & moveable
  - Clean and urban compatible
  - Very fast response up and down

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Market and Regulatory Roadmap to Energy Storage

- No current incentives for storage – no tax or prod credits
- Storage best deployed as a grid rather than project asset
- Spot energy prices – volatility necessary to storage dampened by
  - Price caps
  - Price floors
  - Start-up and no-load payments for thermal unit commitment
  - Out-of-market transactions
  - Load following as an ancillary service might provide compensation for ramping and availability of storage
  - Fast response of storage reduces forecasting error

Market and Regulatory Roadmap to Energy Storage

- Regulation Markets for Storage
  - CAISO study 20% RPS
    - "Up Reg" increases from about 350 MW by 170 to 250 MW
    - "Down Reg" increases from about 350 MW by 100 to 500 MW
  - Batteries can immediately switch from full charge to discharge
  - Regulation compatible regulation signal needed
  - Higher price for regulation or "fast regulation service" would reduce needs for regulation and increase incentives for storage
- CASIO suggests "first commercial deployments of storage will need a grid services performance contract to share financial risk"

Market and Regulatory Roadmap to Energy Storage

- Capacity and Local Reliability Benefits of Storage
  - Storage for wind can often be located in urban areas
  - Local resource adequacy (capacity) rules need to compensate storage for capacity, fast response, and VAR support
  - Local reliability can be enhanced with storage close to the load

- The Energy Security and Security Independence Act of 2007
  - Envisions and encourages Smart Grid
  - Designates storage as a Smart Grid characteristic
  - Envisions barriers to storage will need to be identified and lowered to achieve the Smart Grid

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Energy Storage System Impact

- DYNAMIC STABILITY CHOSEN FOR OUR PAPER's ILLUSTRATIVE SIMPLE STUDY OF STORAGE IMPACTS
  - Longer Term Storage Impacts Somewhat Intuitive: Load/Resource/Delivery Capacity Balancing
  - Dynamic Stability Is Beyond Intuitive Understanding: System Performance Is Product of Interactions Between All Machines on Interconnected System
  - An Example of Supplementary Value that Could Be Valued and Compensated (albeit likely via grid-upgrade offset payment vs. market mechanism)
  - Dynamic Stability + Intertia + Power Imports ***+ Wind***: CA NEEDS MORE INSIGHT (SCE Comments to CAISO Report)

Energy Storage System Impact

- SCE Comment to CAISO Renewable Integration Report

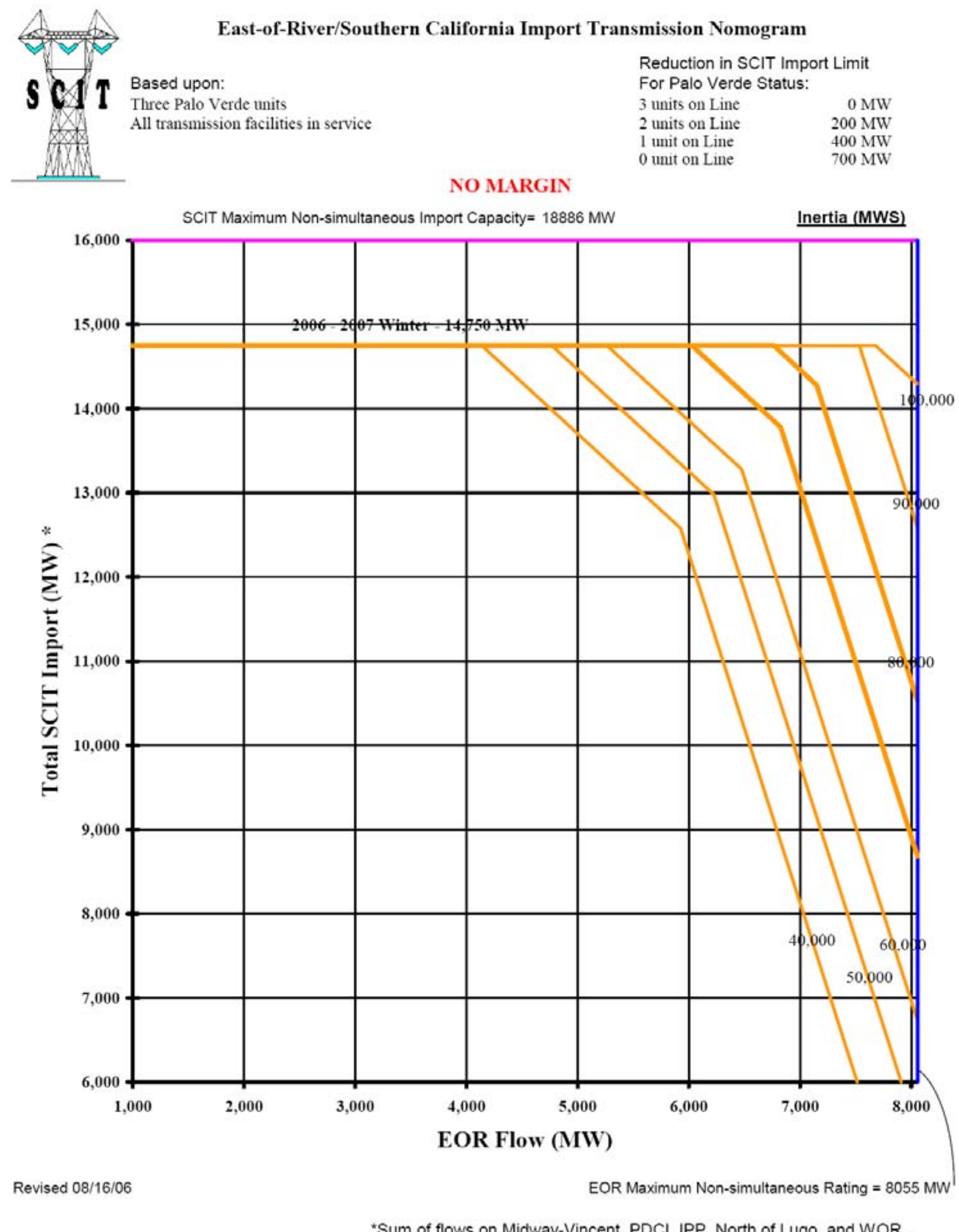
"These issues are critical to understanding how integrating intermittent resources affect SP15. Such issues include

a. Impacts of large amounts of wind resources on the Southern California Import Transmission (SCIT) nomogram since wind generation does not contribute significant amounts of inertia to the electric system."

- GREAT INTEREST IN <u>SYSTEM'S RESPONSE</u> TO WIND OUTPUT LOSS (vis-a-vis ERCOT Feb 2007, Feb 2008)
- Paper Extends 'System Response' Question to 0-10 Second Dynamic Stability Timeframe

Energy Storage System Impact

- SCIT NOMOGRAM
  - Dynamic Stability <u>and</u> Transient Voltage Constrained
  - Constraint Based on Total MW-S Inertia in So Cal Load Center
  - RELIABILITY, AND COMMERCIAL, IMPLICATIONS



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Energy Storage System Impact

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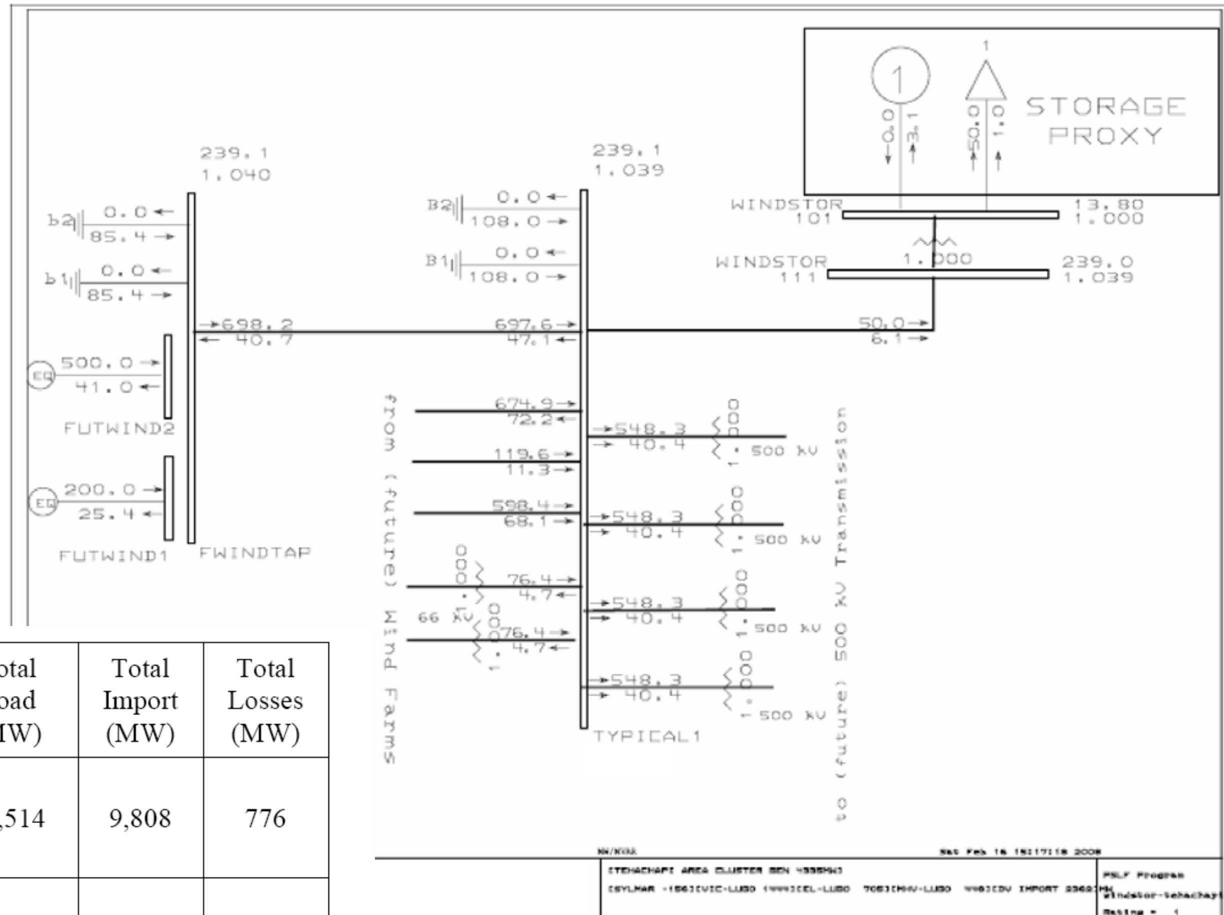
- THE MODEL



location of modeled storage device.

Area	Number of Generators	Total Generation (MW)	Total Load (MW)	Total Import (MW)	Total Losses (MW)
SCE Service Territory	433	19,482	28,514	9,808	776
WECC System	2,964	182,251	175,610	N/A	6,641

Table 1: System model key statistics by area

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- MODELED DYNAMIC RESPONSE
  - 700 MW Wind Out Following ‘T-1’
  - 250-750 MW Fast-Acting Storage 5 Cycles After Wind Out
  - SUBSTANTIAL IMPROVEMENT TO SYSTEM FREQUENCY RECOVERY

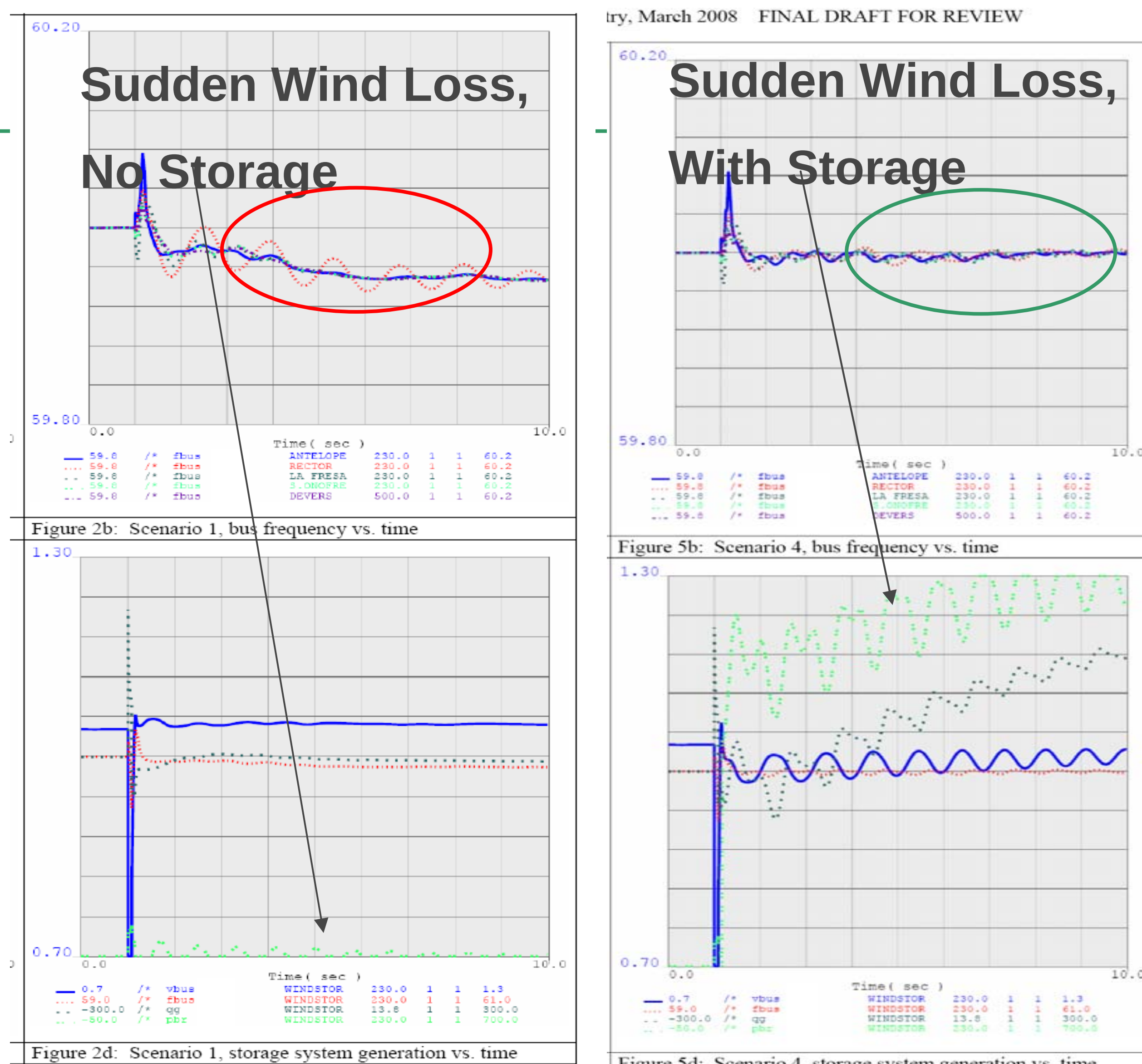

Figure 2b: Scenario 1, bus frequency vs. time

Figure 2d: Scenario 1, storage system generation vs. time

Figure 5b: Scenario 4, bus frequency vs. time

Figure 5d: Scenario 4, storage system generation vs. time

Energy Storage System Impact

Recommended actions that will accelerate technical understanding, and ultimately adoption of beneficial storage technologies and grid-supportive applications include:

- Develop explicit dynamic models of energy storage systems for use in transmission planning studies to illuminate device/system dynamic interaction in the 0-10 second dynamic stability transient timeframe.
- Perform further technical evaluation of system response and mitigation options for sudden loss of wind generation.

Conclusions

We provide an early conceptual roadmap outlining incentives and mechanisms needed to facilitate the introduction of energy storage into the California wholesale market. Dynamic simulations performed for this study also demonstrate one of several potential system benefits that drive our interest in:

1) Promoting better understanding of the potential significant system benefits available via this technology.

2) Promoting development of market and regulatory mechanisms to incent its utilization where beneficial to California's electrical market participants.