



Emerging Transmission Technologies to Increase Capacity, Enhance Stability and Mitigate Congestion

Presented to
California Energy Commission
Staff Workshop: Emerging Technologies
for the Integration of Renewables

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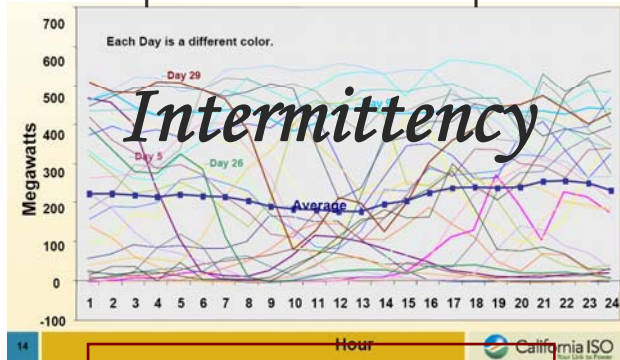


Project Team: Lloyd Cibulka, Jim Cole, Larry Miller, Gilda Garcia

The Saga of Renewable & Transmission Integration



Tehachapi Wind Generation - April 2005



Accommodate
Renewable's Unique
Behaviors

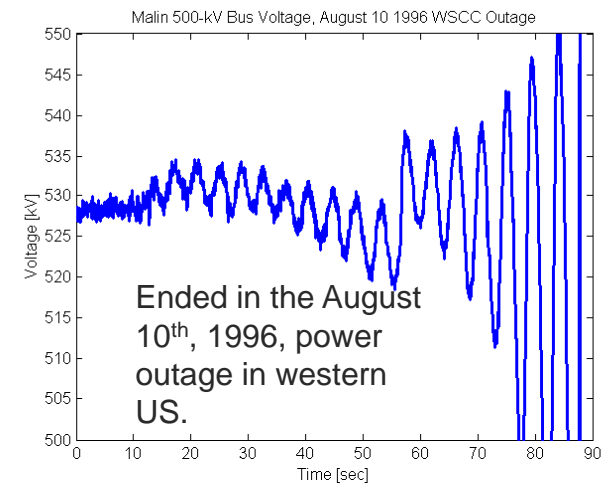
Provide Access

Thermal Limits

Increase Capacity

Instability Deratings

Example of North – South Oscillation



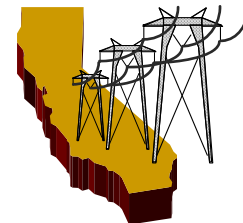
**Renewable
Power Plant**

To fulfill its renewable integration mission,...



...transmission must achieve three broad objectives:

1. Provide physical access for each new power plant,
2. Reliably accommodate any unique renewable generator behaviors, and
3. Increase its power carrying capacity to handle the additional electric power flows.



How to Meet the Three Objectives at 33%

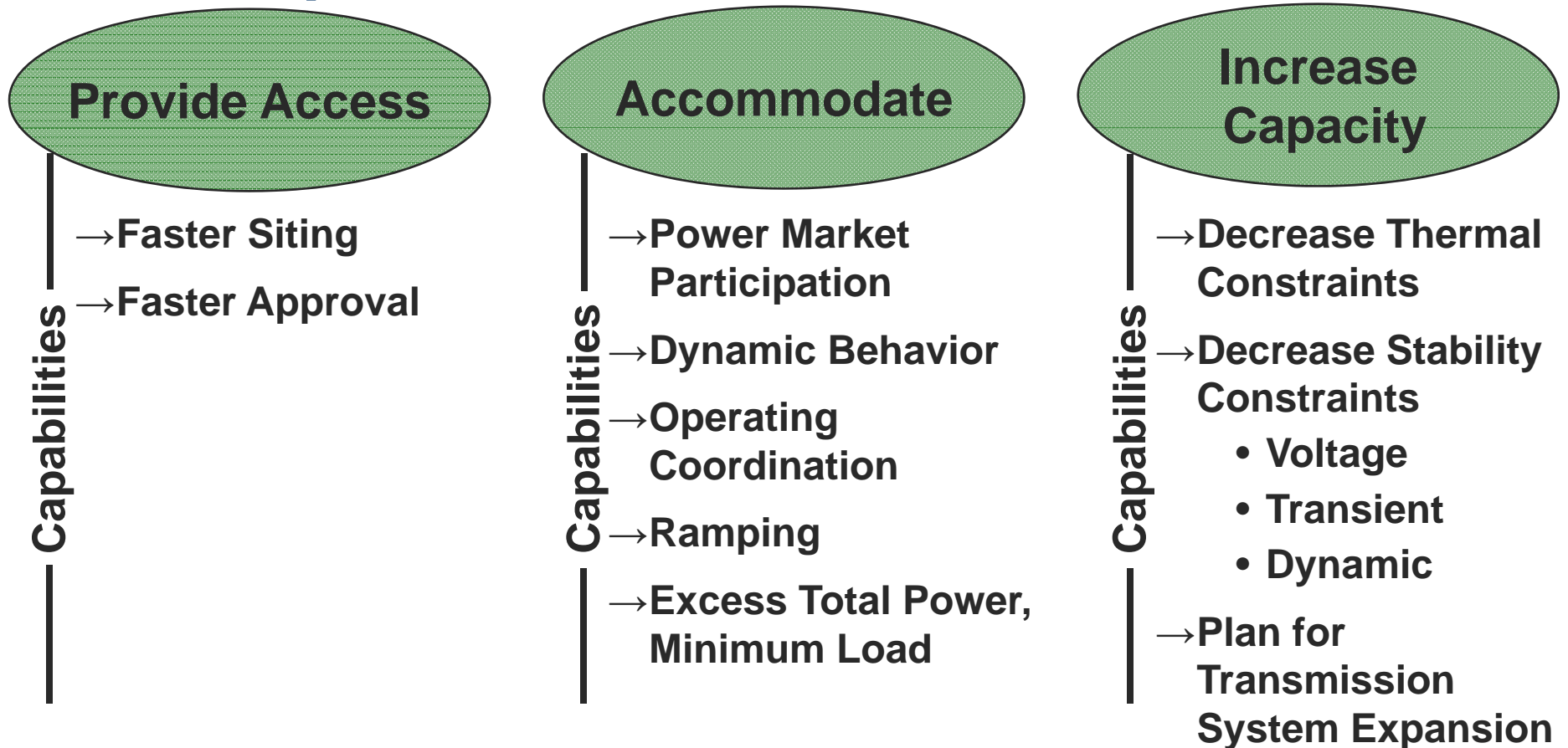


- Traditional “Build” solutions, i.e., investments in wires, towers and power plants, can’t do it alone.
- New transmission technologies at a minimum can make renewable integration easier and less costly.
- New technologies can endow transmission with improved and new capabilities...

To accomplish its 3 objectives,...



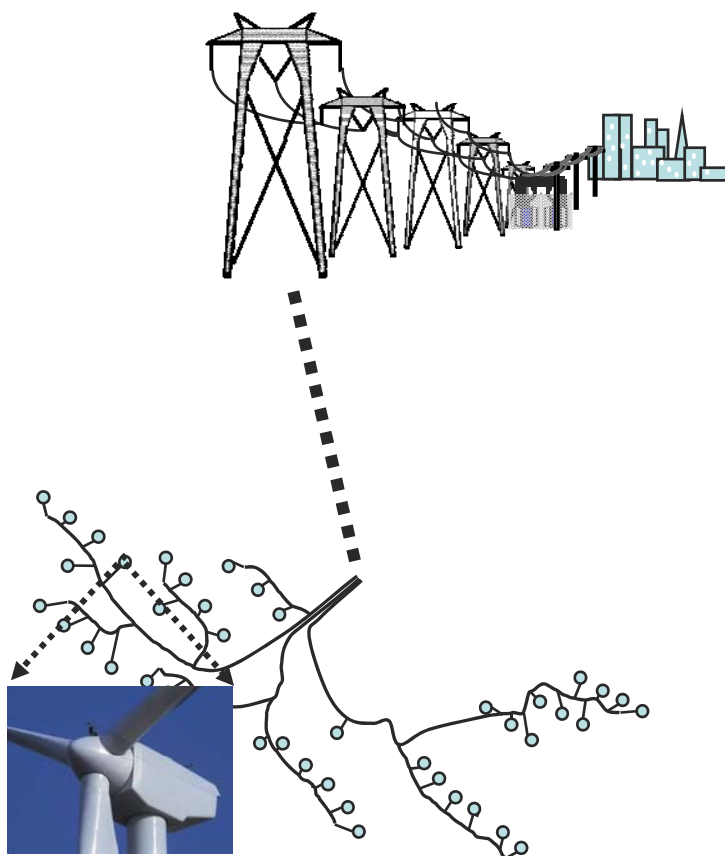
...transmission must obtain improved and new capabilities.



Some New Technologies to Provide Faster Access for New Renewable Plants...



... by putting new transmission lines in a better light.



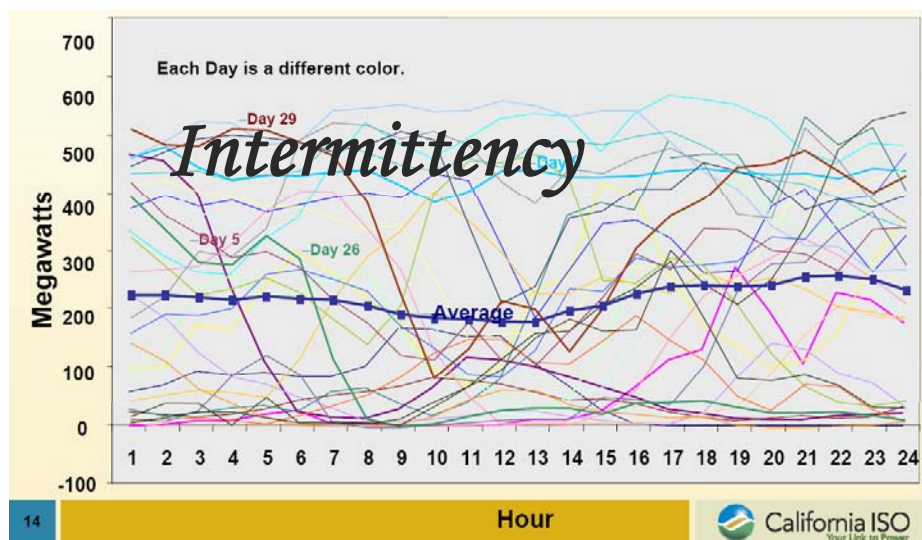
- Underground Transmission
- High Voltage Direct Current
- Advanced Transmission Line Conductors
- Engineered Compact Designs
- Web-based Interactive Stakeholder Siting Tools
- Cost Allocation and Strategic Benefit Analysis Tools
- Distributed Renewables

Some New Technologies to Accommodate Unique Renewable Generator Behaviors...



...through a smarter and more flexible grid.

Tehachapi Wind Generation - April 2005

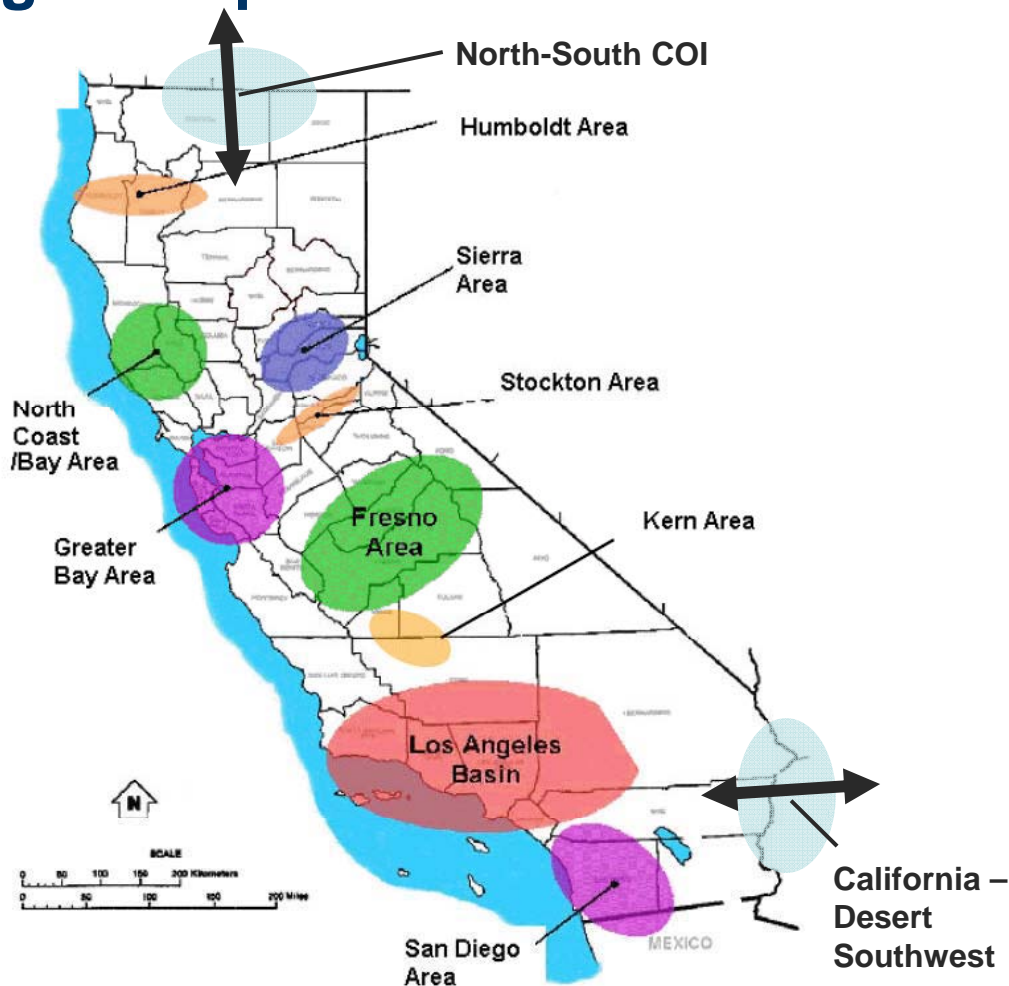


- Energy Storage & Intelligent Agent
- Solar and Wind Forecasting Tools
- Synchrophasor Measurement
- Power Flow Control (spatial)
- Demand Response
- Distributed Generation
- Generator and Load Modeling
- Statistical and Probabilistic Forecasting Tools
- Advanced Intelligent Protection Systems

Some New Technologies for Increased Transmission *Capacity*...



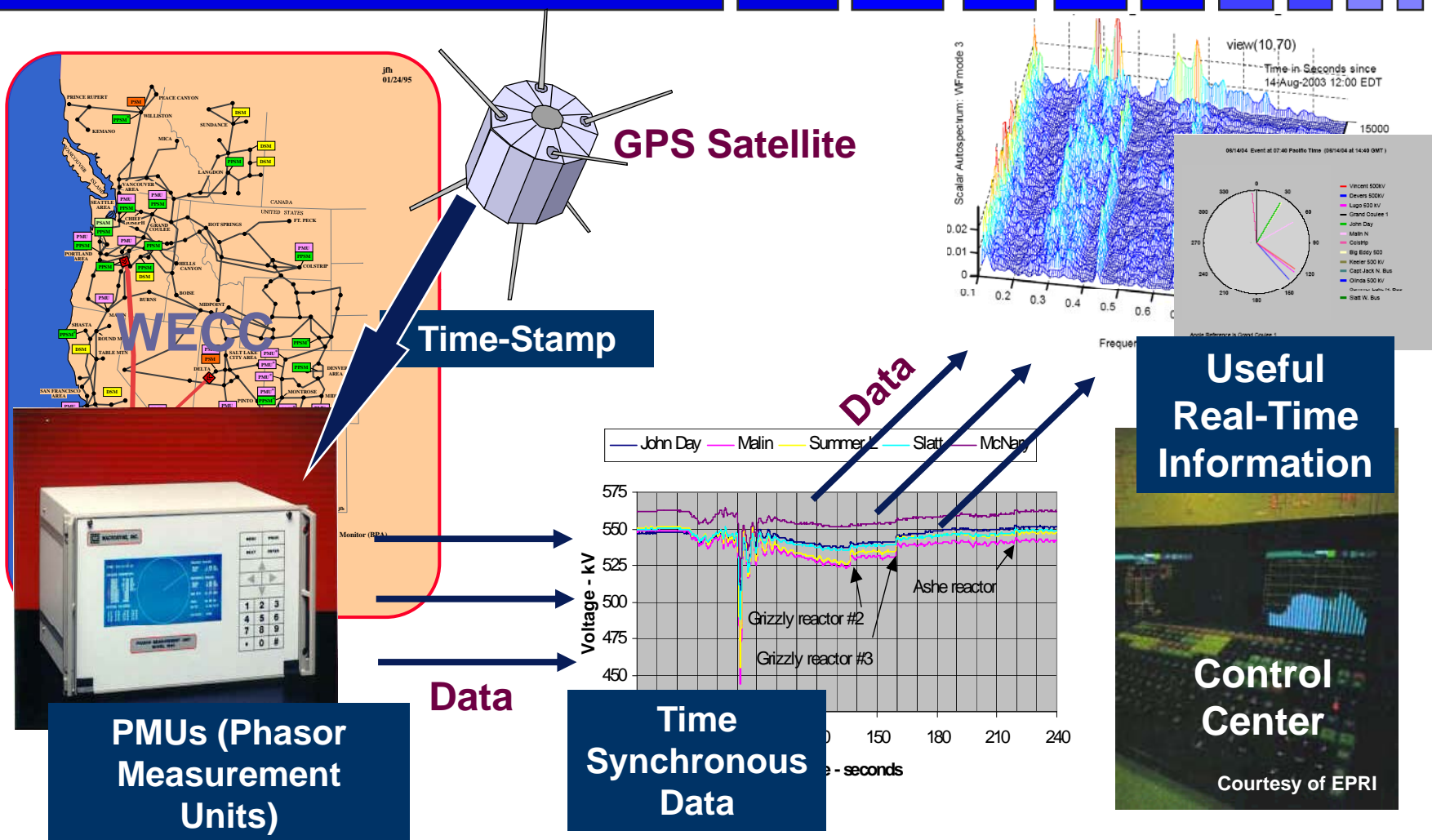
... by fine-tuning the grid for greater power flow.



- Dynamic Thermal Ratings
- Real-Time System Operations (synchrophasors & applications)
- Power Flow Control (spatial)
- Energy Storage
- Advanced Transmission Line Conductors
- High Voltage Direct Current
- Distributed Generation
- Statistical & Probabilistic Analysis & Planning Tools
- Advanced Intelligent Protection Systems



Synchrophasor Measurement – The Heart of the Smart Grid Transmission



Ultimately, Smart Grid required for maximum renewables deployment.