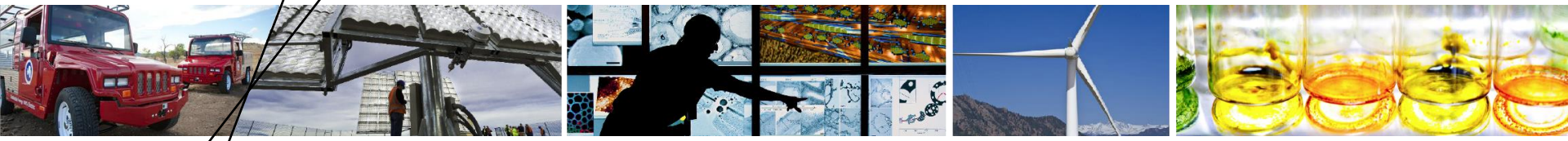
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Accounting for Renewable Energy in System Planning: Operational Impacts and Reliability



IEA Workshop - Delhi

David Palchak

September 16th, 2015

Agenda

Part 1: Greening the Grid

- India high RE grid integration study

Part 2: Lessons learned from other studies

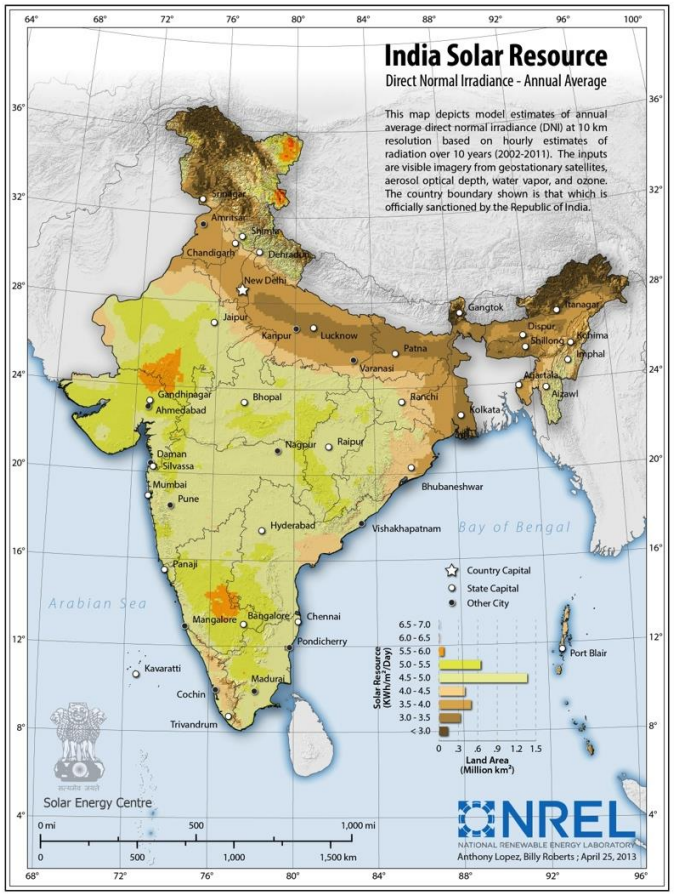
- How other grid integration studies have led to real outcomes

Part 3: Reliability with Wind and Solar

- Capacity Value

Greening the Grid

U.S. – India partnership to advance clean energy deployment

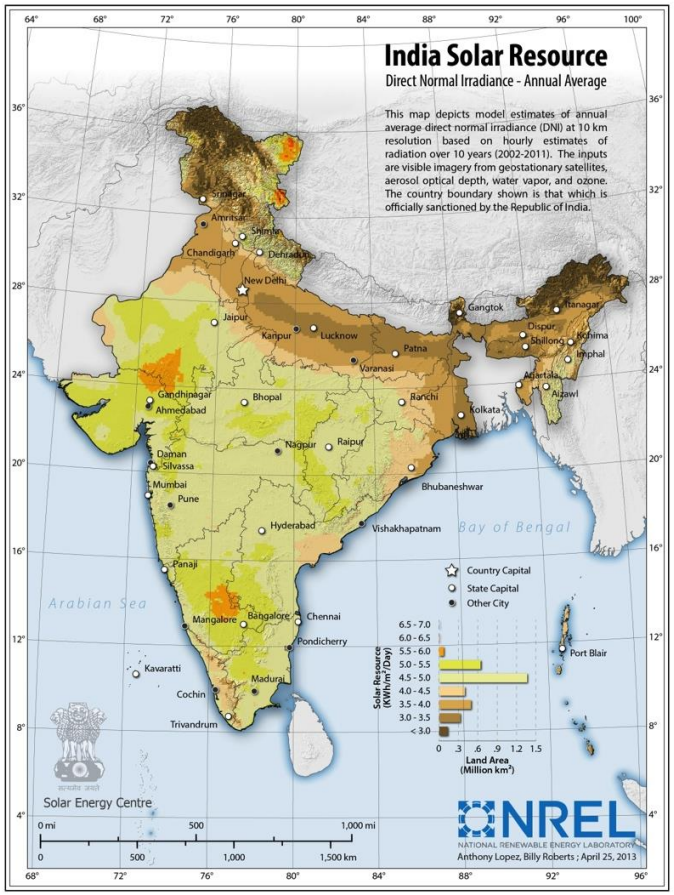


Project components:

- Modeling for large-scale RE integration
- Pilots for reform
- Peer exchanges with regulators

Greening the Grid

U.S. – India partnership to advance clean energy deployment



Project components:

- Modeling for large-scale RE integration
- Pilots for reform
- Peer exchanges with regulators

Tools Developed in Greening the Grid

A **resource assessment of wind and solar** at hourly time resolution for a whole year will be made publicly available (multi-year for solar)

- *3 km by 3 km grid of wind and solar power potential*

A **production cost model** is currently being developed with the help of grid planners and operators from all over India

- *Training and collaborations are already underway*

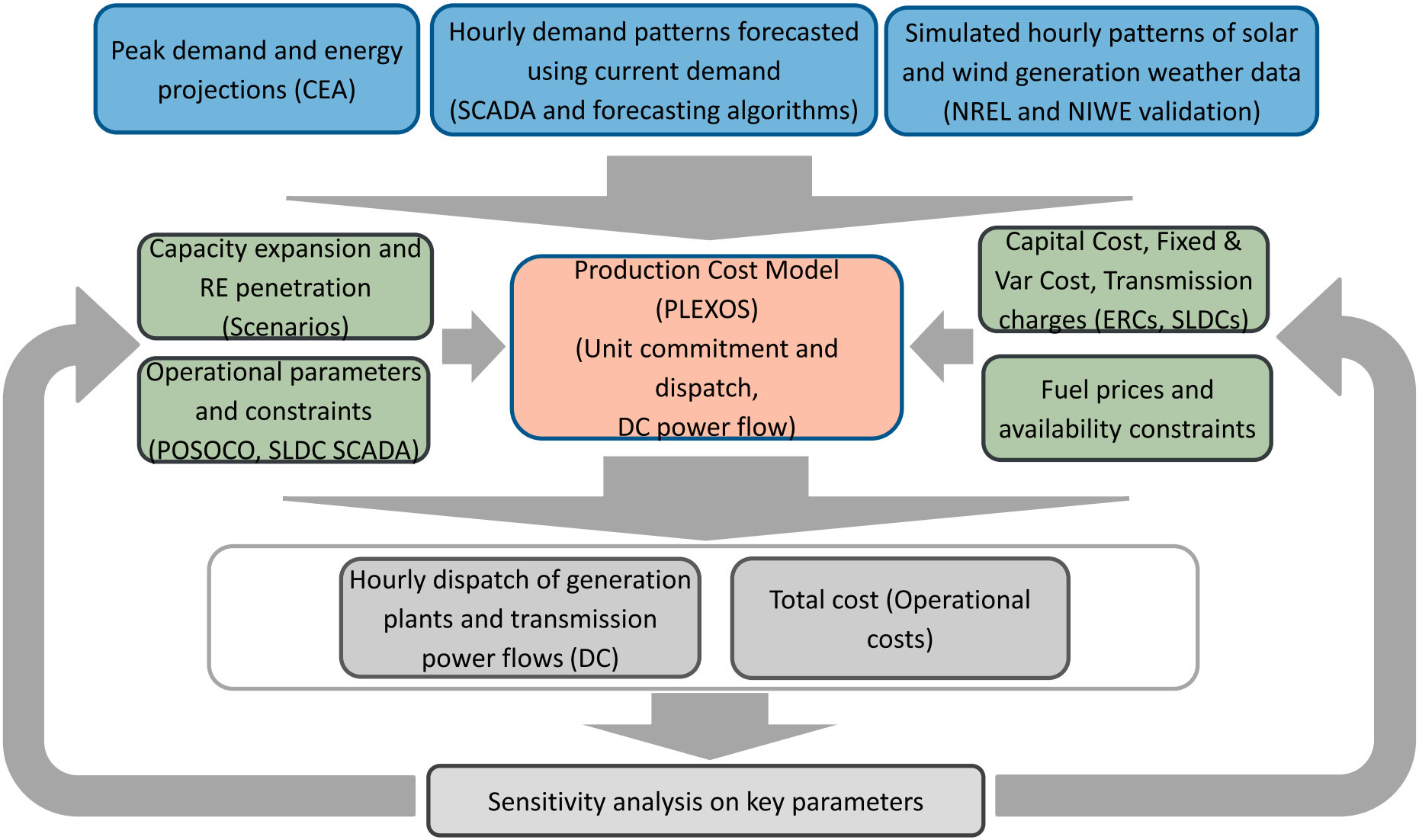
Greening the Grid – Grid Integration

Initial project consists of four main studies:

National Study	Questions of inter-regional coordination, national trends
Regional Studies: *Western* *Southern*	Focus on regional characteristics, state transmission constraints, and intra-regional coordination
Ultra – Mega Solar Parks	Shorter time scales analyzed; focus on impacts of solar parks to regions and local transmission

Studies will use a common database and look at India's goal of 175 GW RE by 2022

Greening the Grid



What will the models help identify?

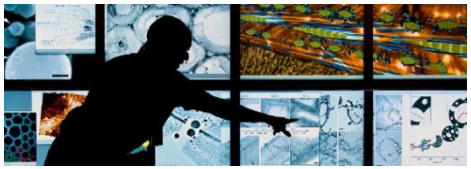
- Balancing needs: variability, ramping requirements, required inter-state transmission capacity
- Operating costs, emissions
- Technology characteristics (e.g., low turn-down, ramping, frequency support, response time)
- Market/regulatory actions to improve system flexibility, e.g., improved forecasts; dispatch of central power generating stations for balancing
- First-cut investment information for least-cost development (generation and transmission)
- Periods of stress, with dispatch information, for follow-up studies (e.g., transient stability analyses)

Potential Analysis of India Grid Integration

What is the cost and operational impact of:

- Changing minimum generation levels of thermal plants to 55%
- Coordinated scheduling and/or dispatch with neighboring states
- Varying site locations of wind and solar
- Incorporating RE forecasting in scheduling operations

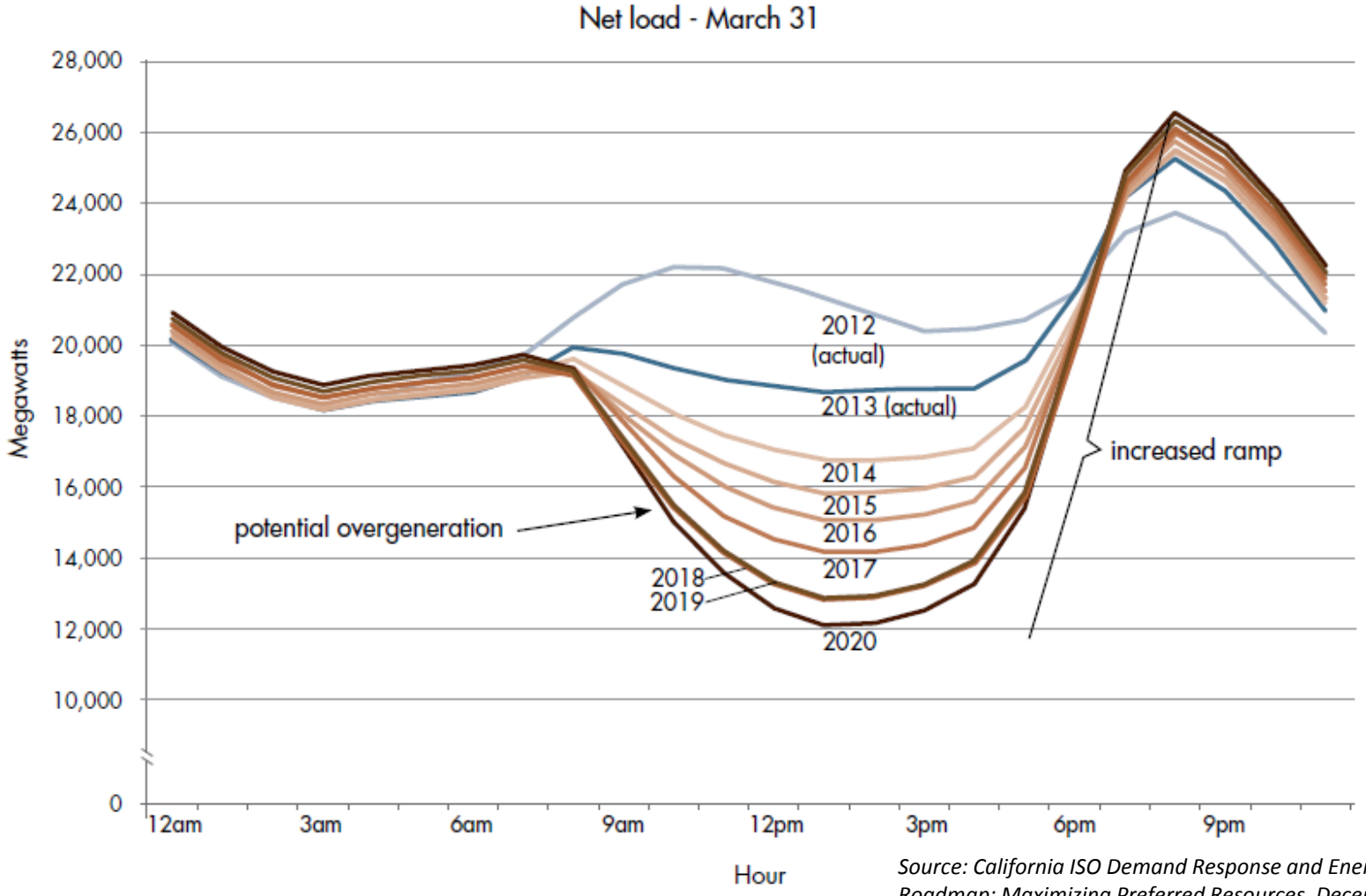
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Lessons Learned

California ISO

Installed Solar Capacity: 10.6 GW
Peak Load: 45 GW



Source: California ISO Demand Response and Energy Efficiency Roadmap: Maximizing Preferred Resources, December 2013

Integration studies help achieve RPS Targets

Example: California used integration studies to help meet its RE targets

Year Passed	Target	Integration studies to meet target
2002	20% by 2017	
2003	20% by 2010	California ISO (2007, 2010)
2011	33% by 2020	California ISO (2011)
Future?	50% by 2030	E3 (2014)

Key Findings:

- States have taken the lead in conducting analyses
- Strong stakeholder engagement is key to building confidence in the conclusions of the studies
- System operators were creative in solving challenges

ERCOT Integration Study

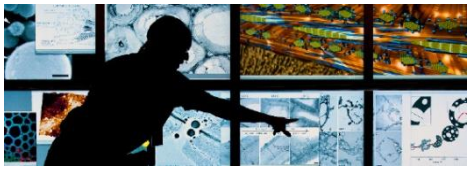
- **Objective: Measure the impact of 5000 to 15000 MW of wind (ERCOT peak load is 69 GW)**
- **Outcomes:**
  - Identified periods when extreme net-load forecast errors may occur
  - Estimated net load variability across time frames from 1-minute to 1-hour

Lessons Learned

Oftentimes, one study does not lead to one solution…

Mostly they point the way for needed action, and build the necessary analysis tools, for times when more wind and solar start to be developed

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Using Wind and Solar to Reliably Meet Electricity Demand

Adequacy of Power System

Is there sufficient installed generation capacity to meet demand obligations?

Long-term planning:

Forecast future peak demand and how much each generator can contribute to a reliable supply of energy

Capacity Value (or capacity credit)

Contribution of a power plant to reliably meet demand (% or MW)

Conventional generators – takes into account the probability of an outage; relatively simple

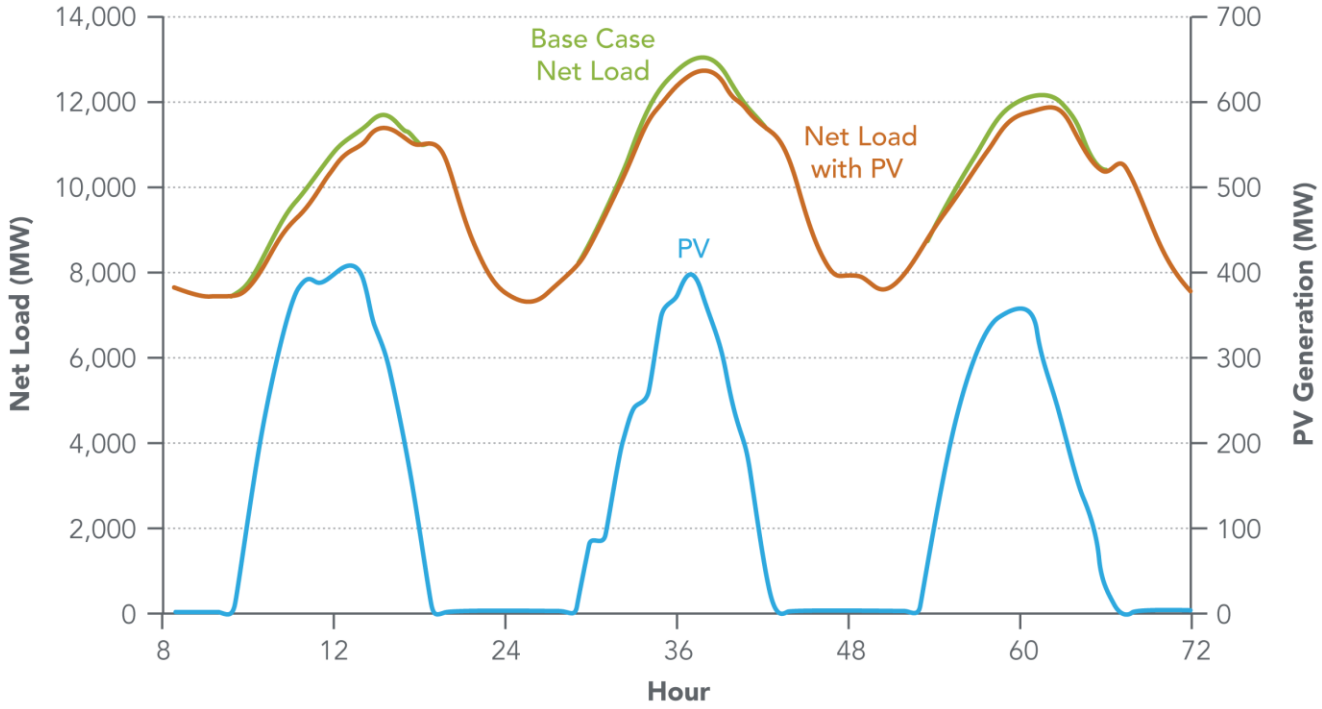
VRE (wind and solar) – more complex due to weather-dependent variability of generation

Calculating Capacity Value for VRE

- **How much does VRE contribute during peak load periods?**
  - Requires a lot of data on wind and solar generation ***and*** time-synchronized load
  - Tied to how well generation aligns with demand
  - This is not always aligned with the highest capacity factors

Solar Capacity Value

Where output is coincident with peak load, capacity value can be high



Solar example:

Examine high risk periods and assess solar output during those periods (often highest 10 or 100 net load hours)

Wind Capacity Value

Highly dependent on region due to variability of wind power

- Sometimes this is well aligned with load and sometimes not
- Regional diversity of wind sites can help to increase this
- Often depends on amount of wind on system

Calculating Capacity Value

More robust metrics using probabilities are often used by system planners

Effective Load Carrying Capability (ELCC)

- Amount of additional load that can be served due to the addition of a generator, while maintaining existing levels of reliability
- Captures other variables on system such as the probability of outages from other generators

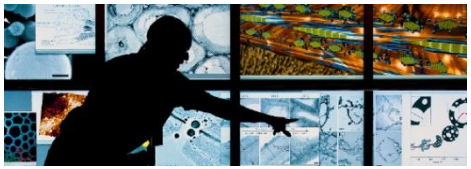
Wind Capacity Value

- **Methods vary widely between system planners**
- **Transmission can have a large impact on this as well**
- **Internationally, the range for wind capacity value as calculated by system planners is 5% to 40%**

Takeaways

- **Planning the power system takes many phases**
  - Capacity value should be part of this
- **Data is the key**
  - A lot of being prepared is having the tools, and mechanics, in place

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Questions