GE
Energy

US Western Wind and Solar Integration Study: Power Grid Operations with 30% Wind and 5% Solar Energy

Kara Clark

Advanced Energy Center Conference

November 8-9, 2010

GE imagination at work

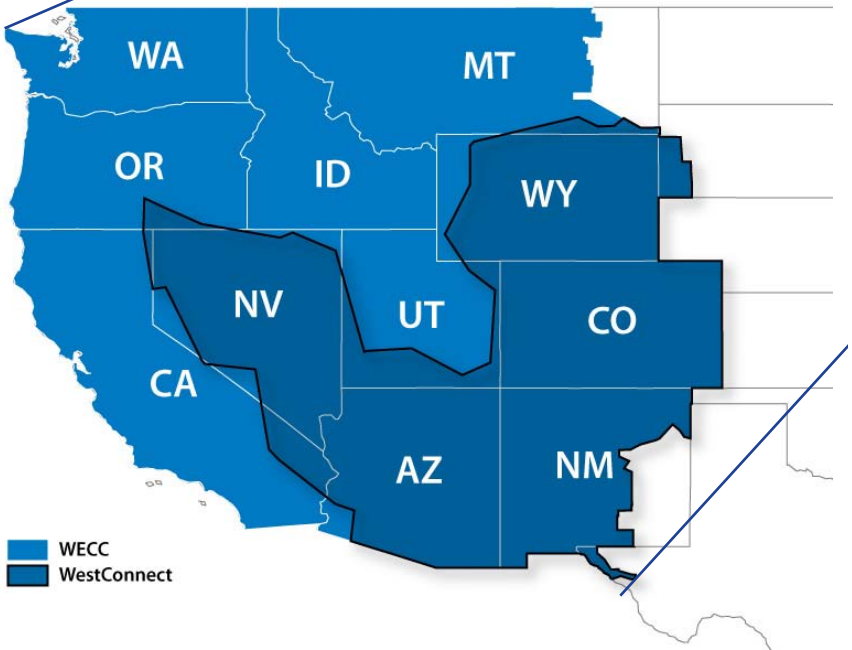
A national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy

NREL National Renewable Energy Laboratory

Innovation for Our Energy Future

Can 30% wind and 5% solar energy be integrated in the western US?

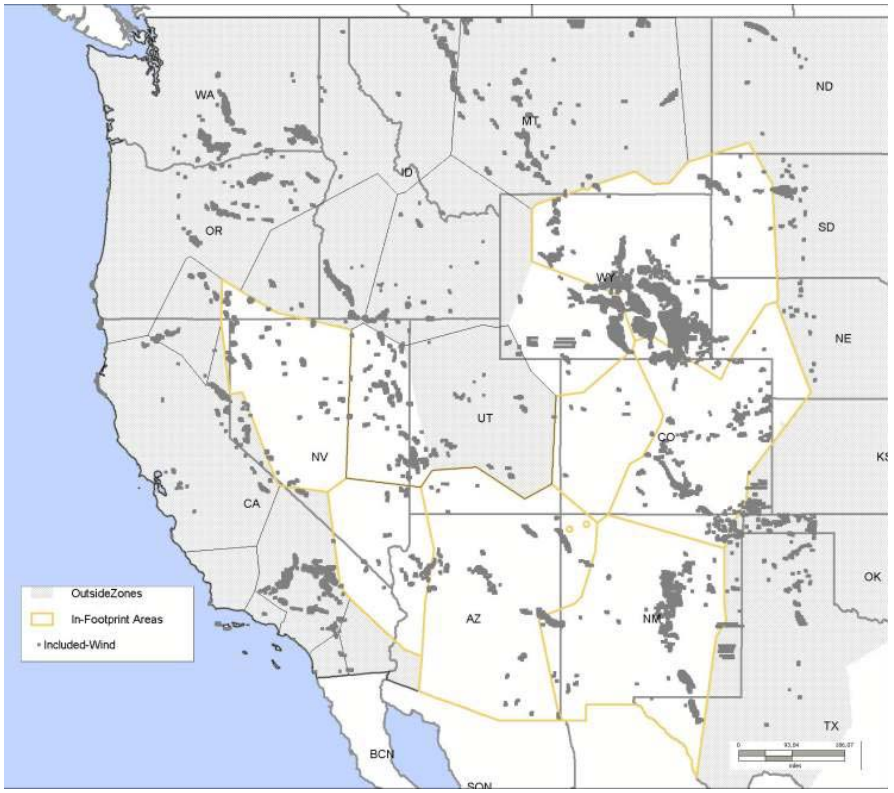
Goal: Understand the costs and operating impacts due to the variability and uncertainty of wind, PV and concentrating solar power (CSP, with storage) on the WestConnect grid



- How do local resources compare to remote, higher quality resources via long distance transmission?
- Can balancing area cooperation help manage variability?
- What is the role of storage?
- Increased reserve requirements?
- Geographic diversity – how much is there and does it help?
- How can hydro help?
- What is the value of forecasting?

Study Approach

- High resolution, time-synchronized wind and solar databases
- Combination of statistical analysis and detailed simulations of power system operations
- All of WECC modeled, but focus on WestConnect footprint
- Economic commitment and dispatch of generators, while respecting transmission limits and generator minimum turndowns
- Extensive balancing area cooperation
- Extensive review and feedback by technical review committee and stakeholder group



- 3TIER Group provided 10 minute wind power output for **960 GW** of wind sites in WECC on 2km grid
- Power profiles based on Vestas V90 3MW turbine at 100m height
- Three historical years (2004-2006) scaled to 2017
- Time-synchronized data to capture load/weather correlations
- Hourly day-ahead power output forecasts
- 1.2 million wind profiles for 10 minutes for 3 years… lots of data

imagination at work

http://www.nrel.gov/wind/integrationdatasets

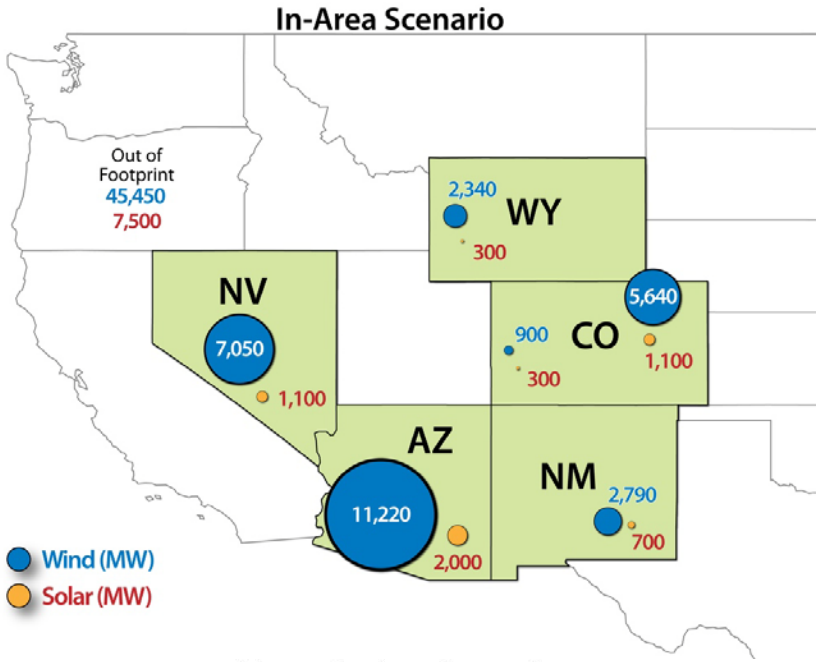
Scenario Overview

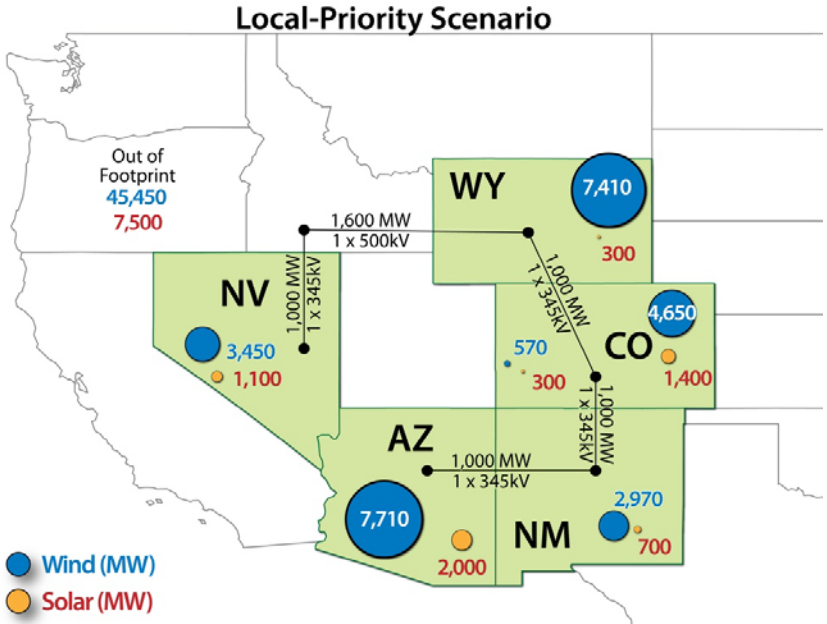
Four levels of renewable energy penetration* in Westconnect:

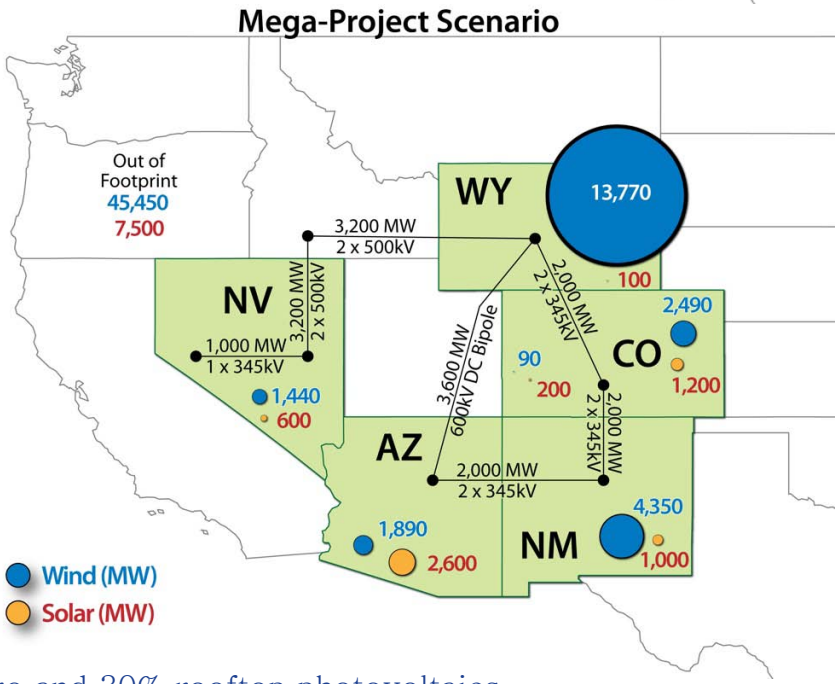
Base - existing wind, solar embedded in load
10% - 10% wind, 1% solar**
20% - 20% wind, 3% solar**
30% - 30% wind, 5% solar**

Three geographic scenarios:

In-Area - each state meets energy target from sources within that state
Mega-Project - concentrated projects in best resource areas
Local-Priority - balance of Mega-Project and In-Area sites

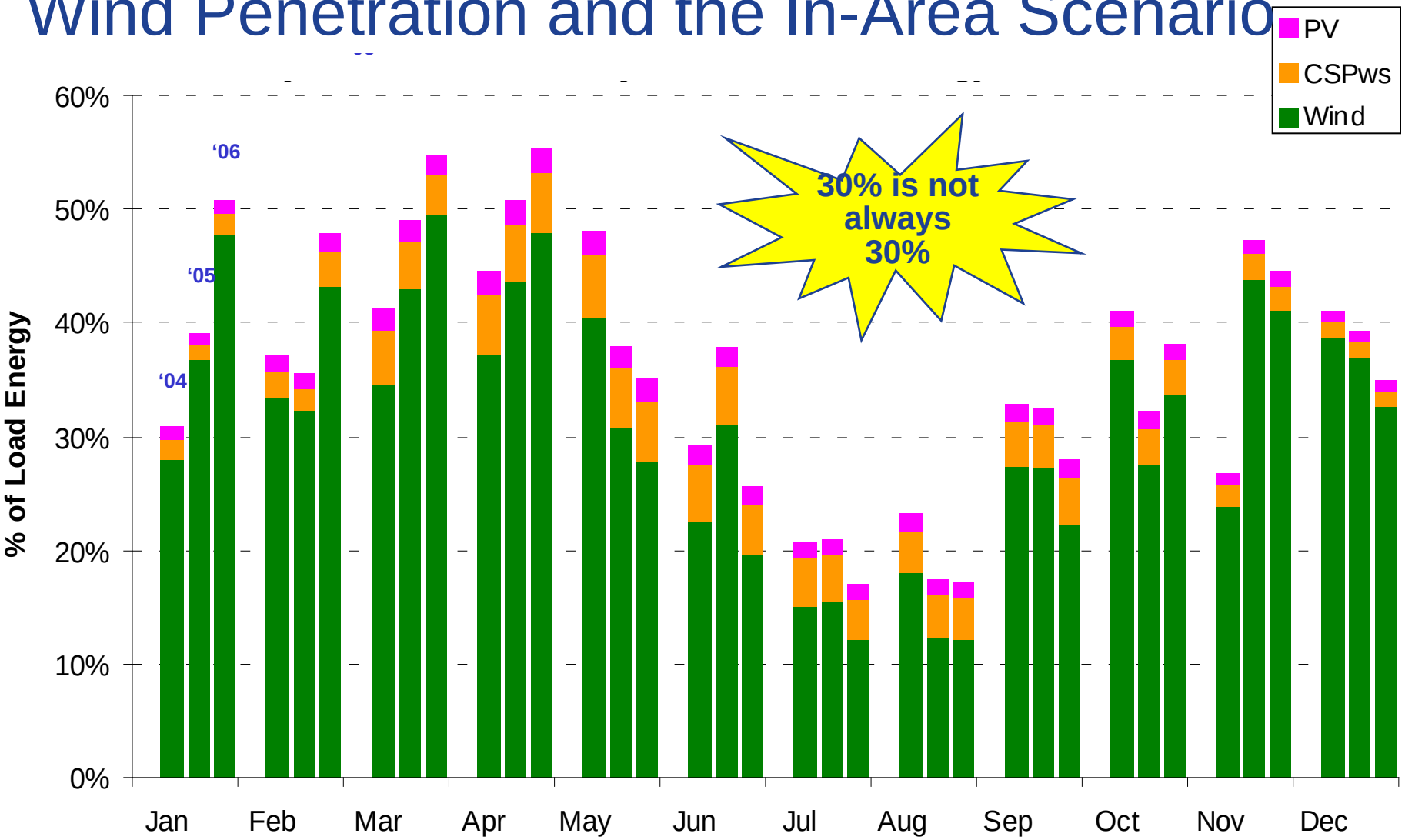






* Penetration is by energy, not capacity.
**Solar is 70% concentrating solar power with thermal storage and 30% rooftop photovoltaics.

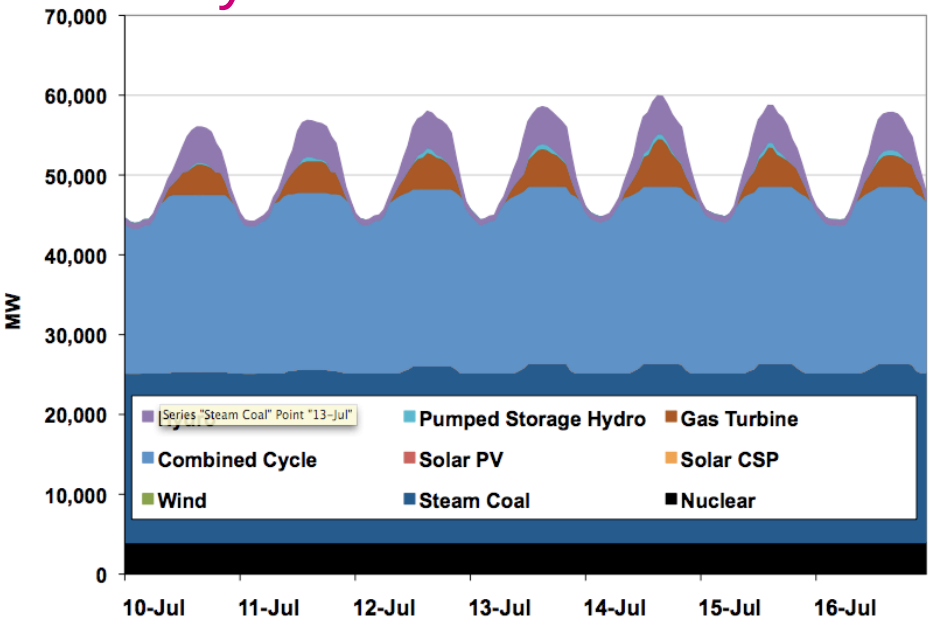
Monthly Energy (%) in Study Footprint for 30% Wind Penetration and the In-Area Scenario



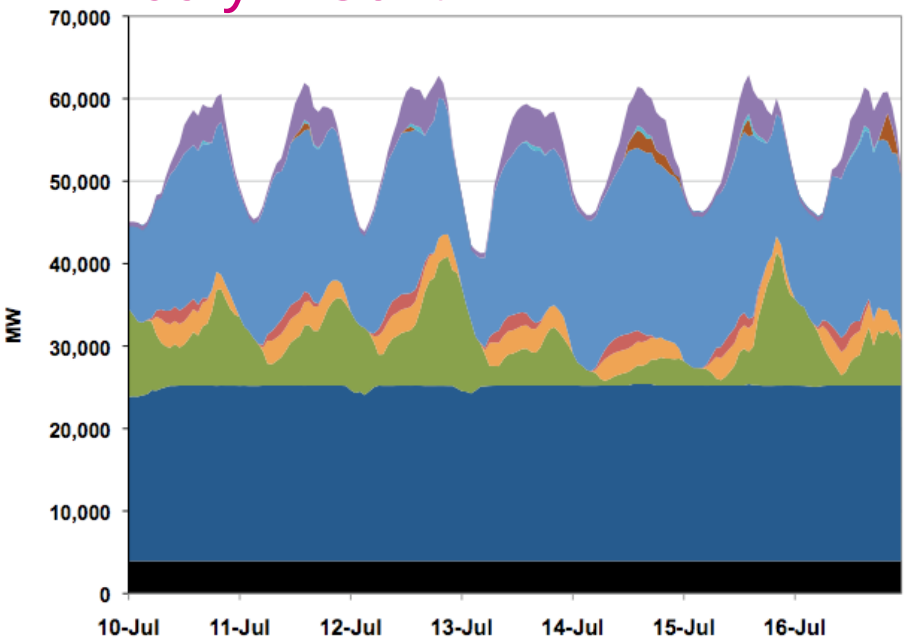
imagination at work

How does the system operate with 30% wind and 5% solar?

July - Base



July – 30%

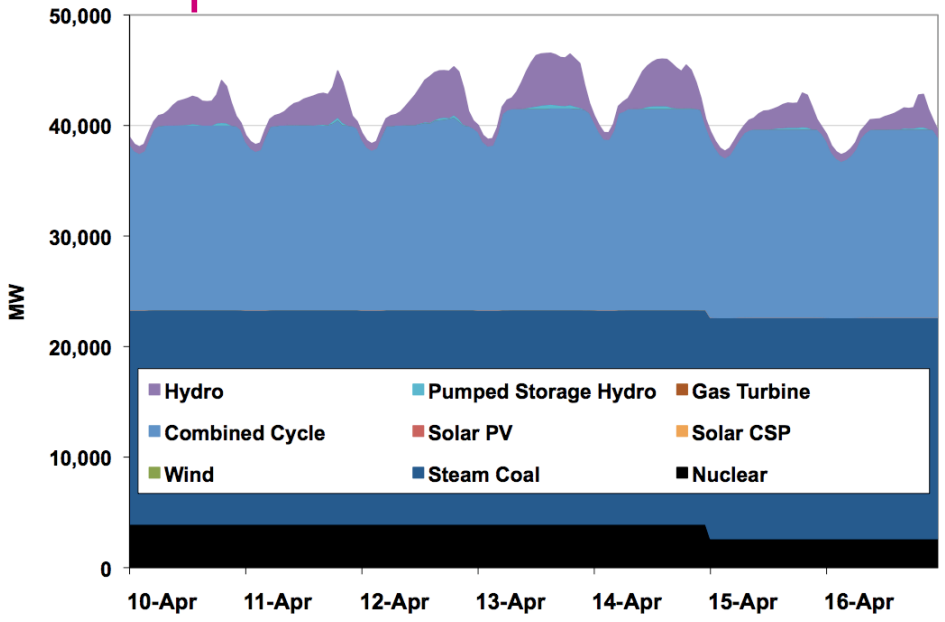


Significant renewable generation penetration does not dramatically change operations in July

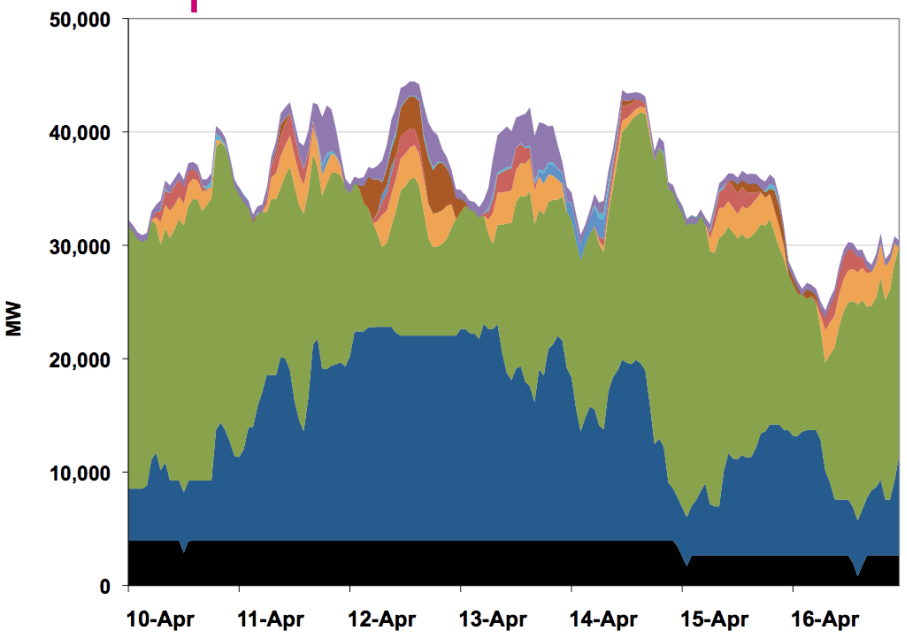
imagination at work

What about other times of year?

April - Base



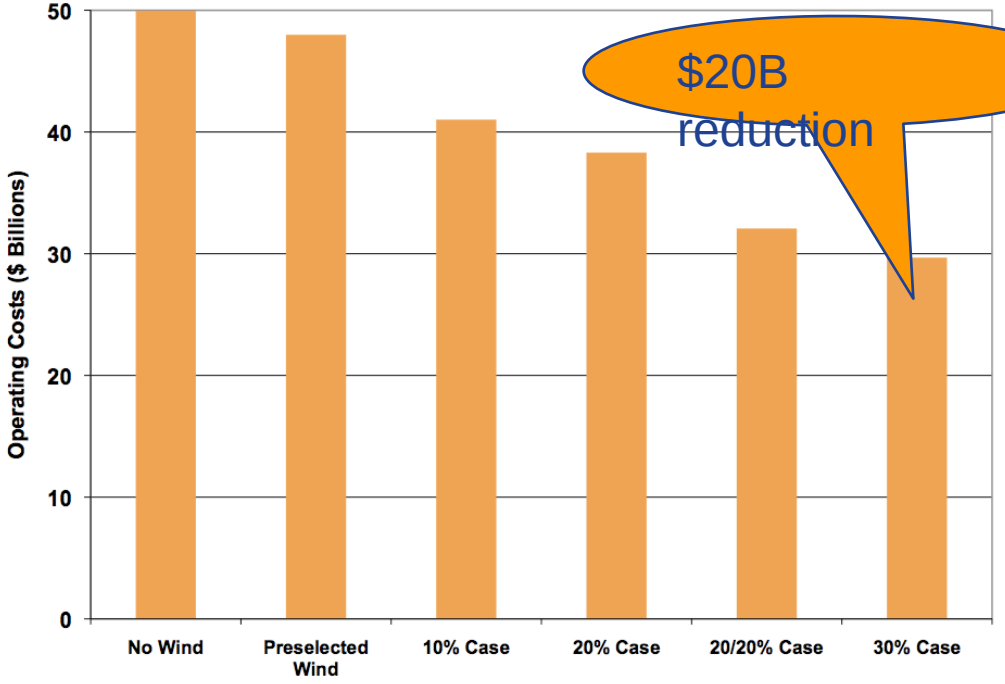
April – 30%

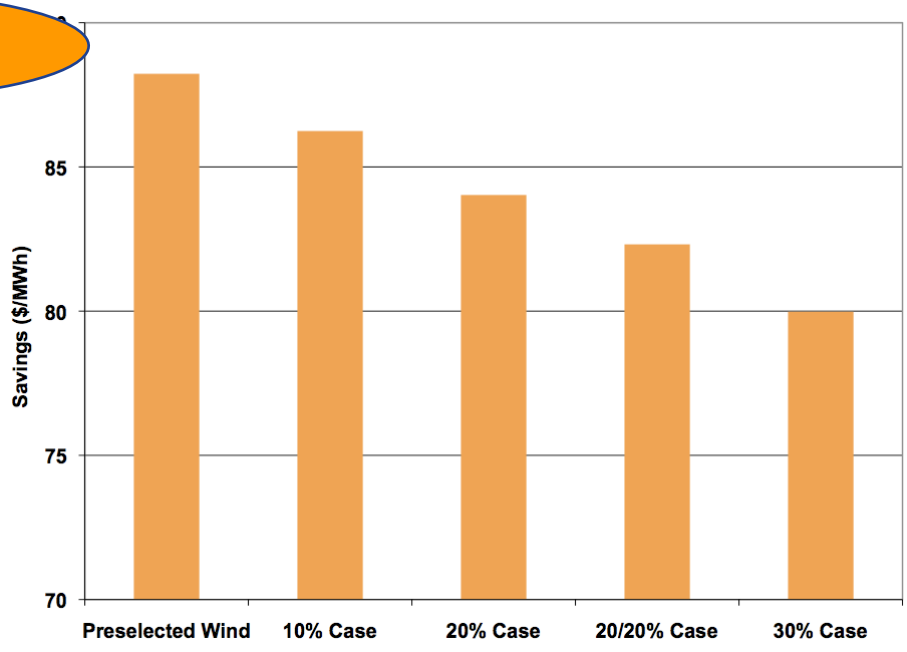


Operation is substantially different in April!

imagination at work

What are some of the benefits of 30% wind and 5% solar?



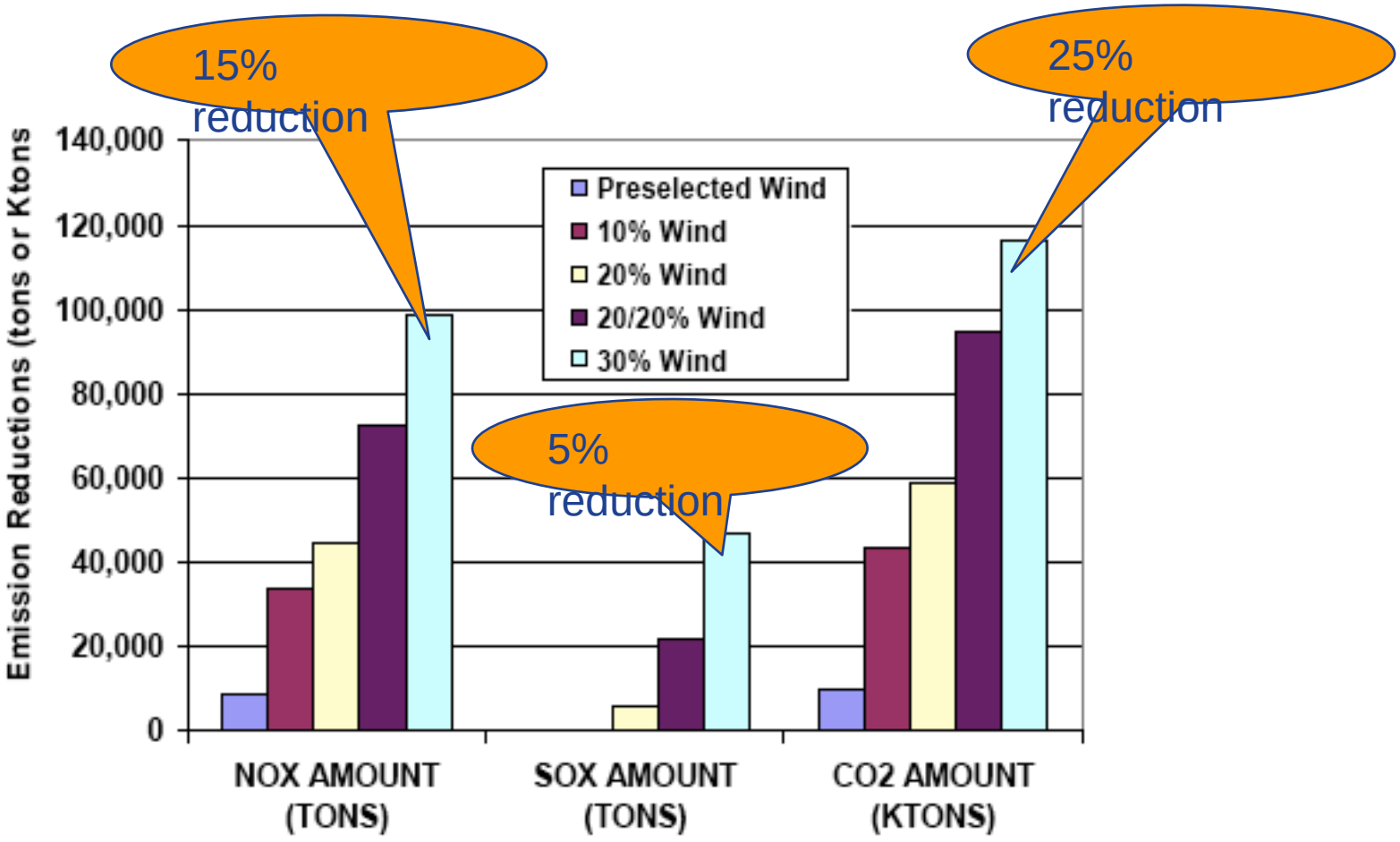


WECC saves 40% in fuel and emissions costs

(This does not include any capital costs, including payments to wind and solar generators. Presumably some of this savings would be used to recover other capital costs. 2017$ with $9.5/MBTU gas and $30/ton CO2 assumed.)

imagination at work

Emissions Reductions

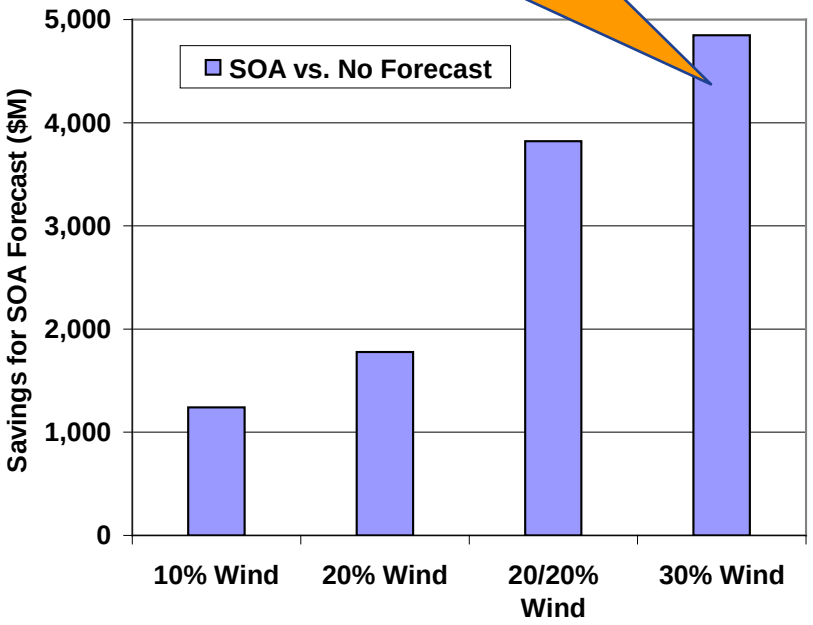


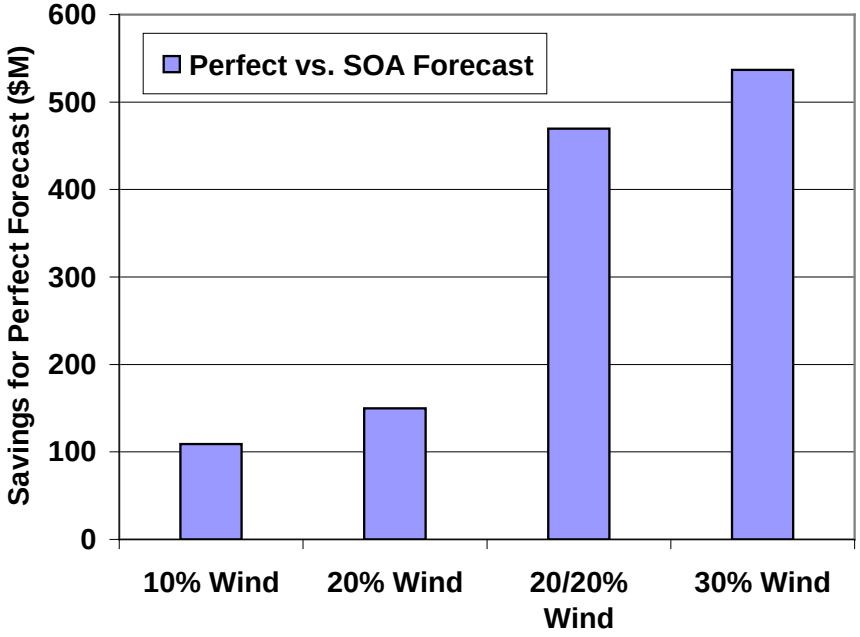
At $9.5/MBTU gas, renewables mostly displace gas. Coal starts to be displaced at higher penetration levels.

imagination at work

Impact of Wind & Solar Forecasts

$5B savings or 14% of operating costs





imagination at work

Key Finding - It is feasible to accommodate 30% wind and 5% solar

- What makes this possible?
  - Extensive balancing area cooperation
  - Sub-hourly economic dispatch
- What are the benefits?
  - Reductions in annual operating costs and emissions
- What factors have a large impact?
  - Use of wind and solar forecasts in unit commitment
  - Renewable energy penetration in the rest of WECC
  - Hydro and coal plant constraints
- Is long distance transmission needed?
  - Can integrate lower penetrations without long distance transmission
- Are more reserves or storage needed?
  - Reserve requirement for net load variability and load following increases but the system naturally provides these
  - Demand response is a more cost-effective option to meet the contingency reserve shortfalls
  - Additional storage is not justified based on price arbitrage