Lessons Learned from NREL Integration Studies

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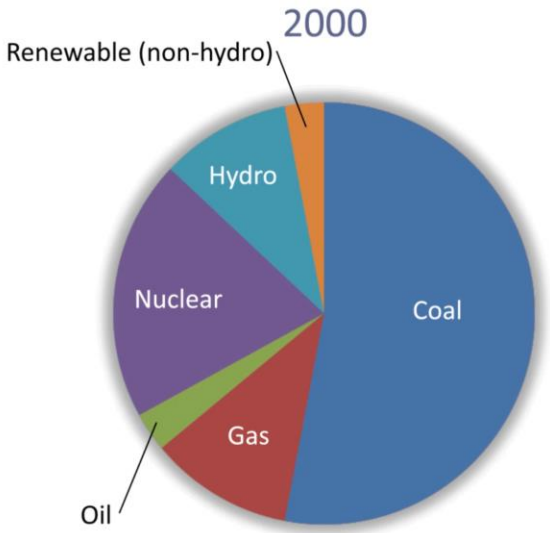
"Integrating variables renewables in the grid" webinar

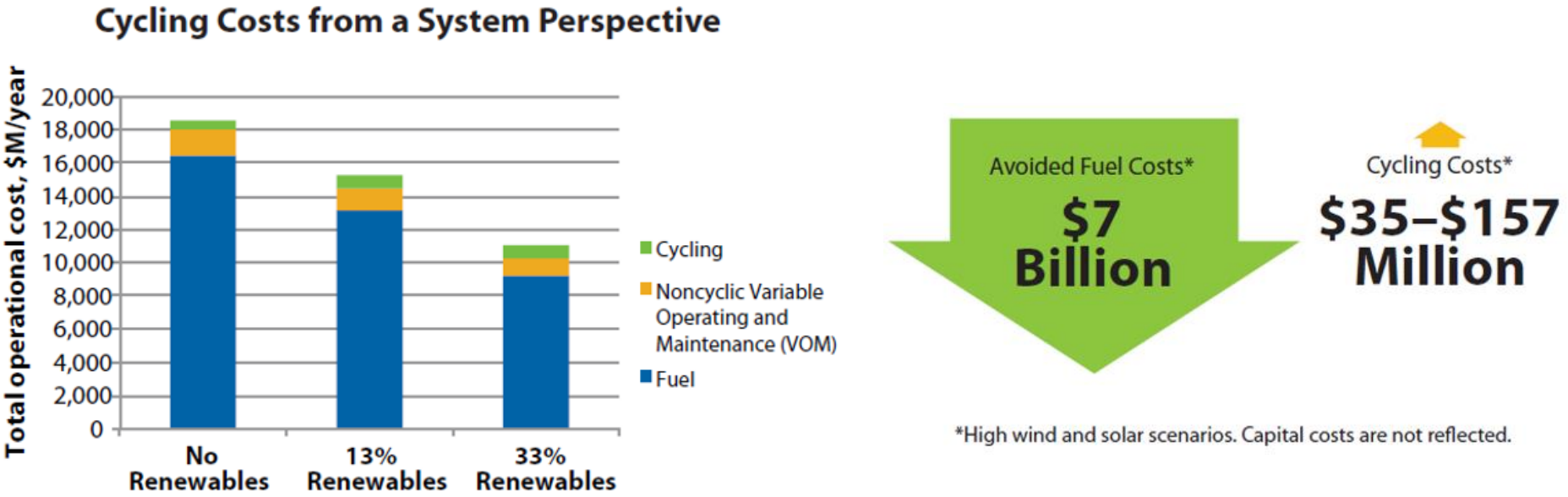
October 10th, 2018

The U.S. power system is changing

- Natural gas has been growing
- Variable generation has been growing
- Coal has been shrinking



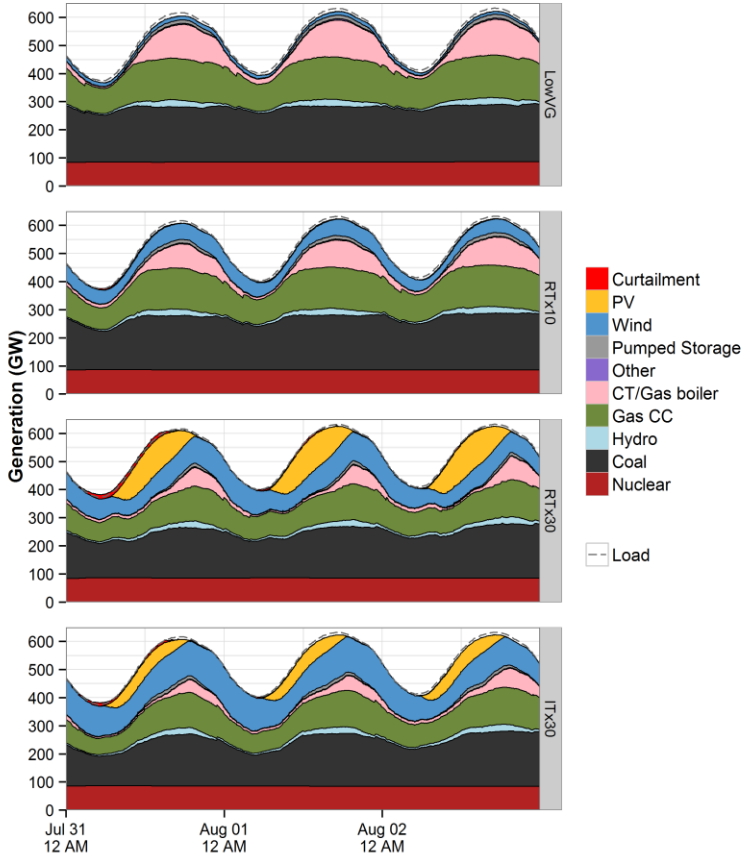
U.S. Western Wind and Solar Integration Study: Phase 2



- Almost all the wind and solar can be used (very little curtailment)
- Storage would "help" but is not needed, and the integration costs would not justify storage technologies at current costs

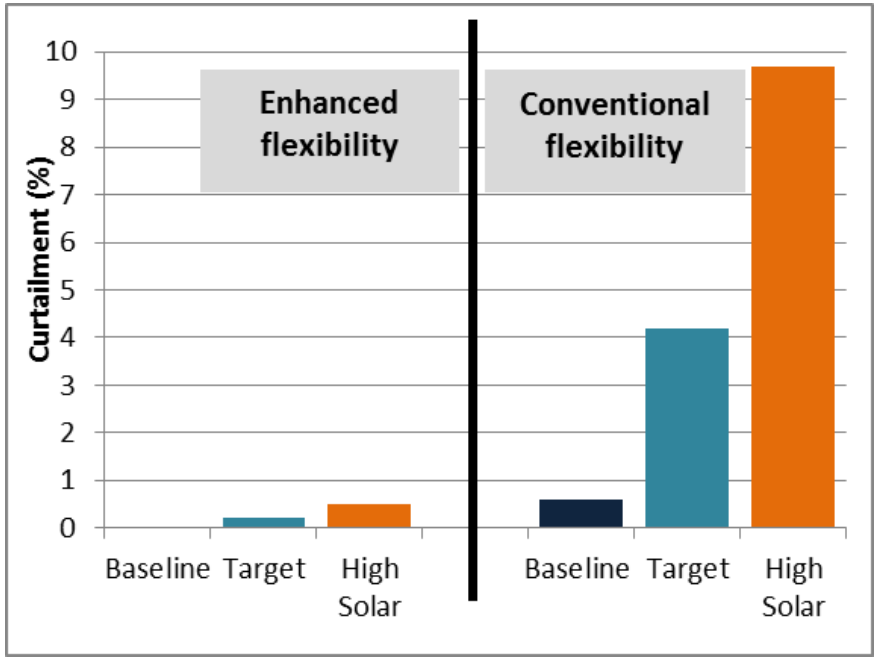
U.S. Eastern Renewable Generation Integration Study

- Using pioneering modeling techniques to study (arguably) the largest power system in the world, NREL found that 30% wind/solar is possible in the eastern interconnection
- Instantaneous wind and solar penetration near 60%
- Flexibility from **greater geographic coordination**, cycling thermal units, and adjusting thermal unit and storage dispatch patterns



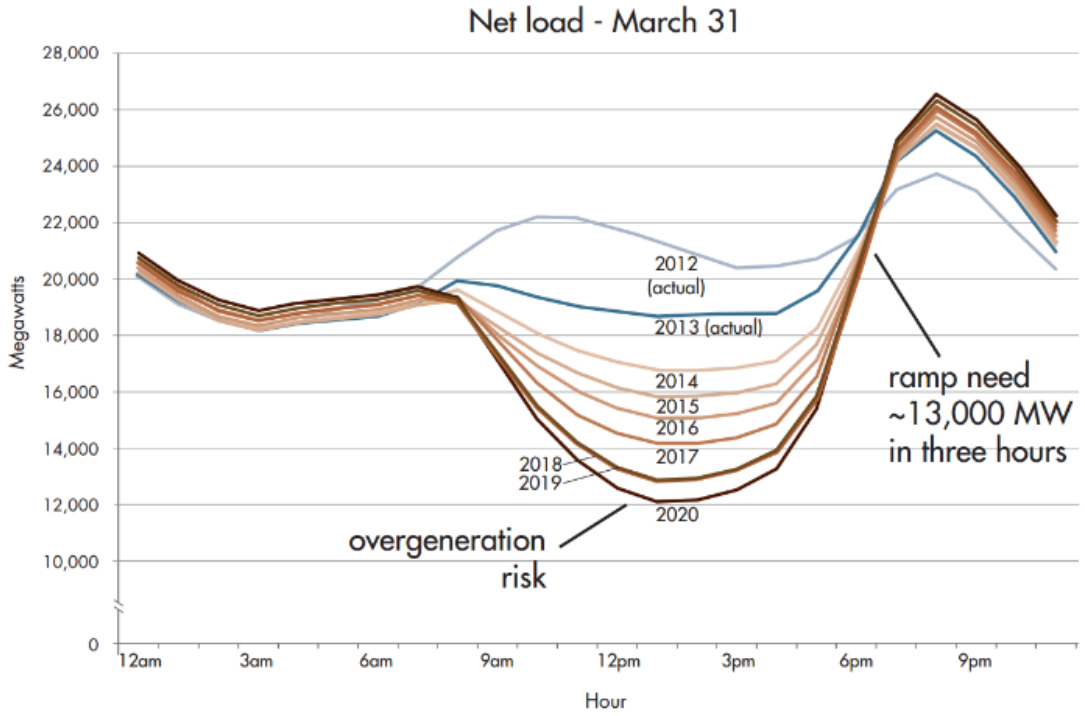
California 2030 Low Carbon Grid Study

California can exceed 55% renewable penetration on its trajectory to meet long-term emissions goals – with limited curtailment, if operational practices adapt



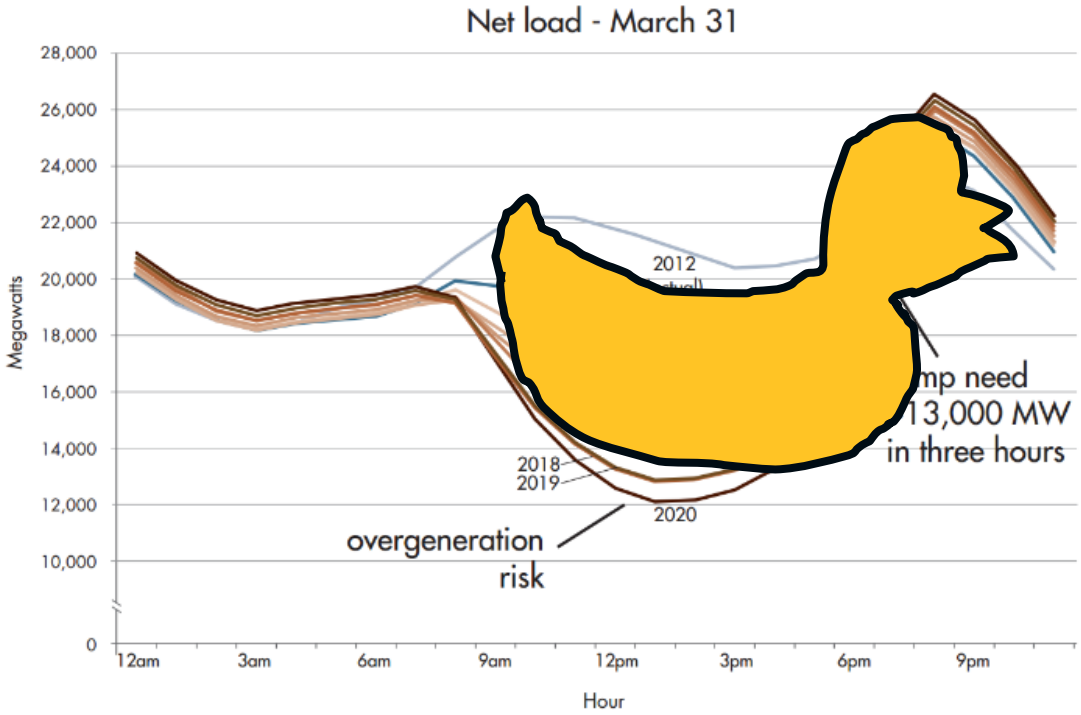
Overgeneration from Solar Energy In California

- California has ambitious RE goals as well as a good solar resource
- Increased PV during the day leads to new shape in the net load curve: a duck



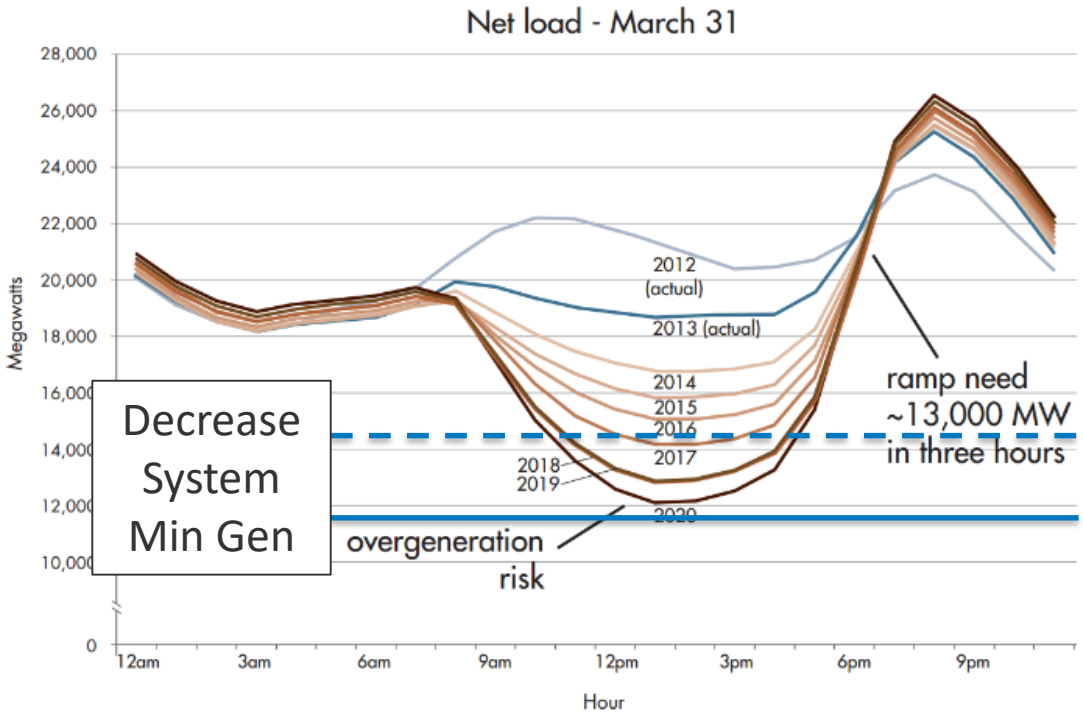
Overgeneration from Solar Energy In California

- California has ambitious RE goals as well as a good solar resource
- Increased PV during the day leads to new shape in the net load curve: a duck
- Mitigating “the duck”:
  - **Fatten** the duck
  - **Flatten** the duck



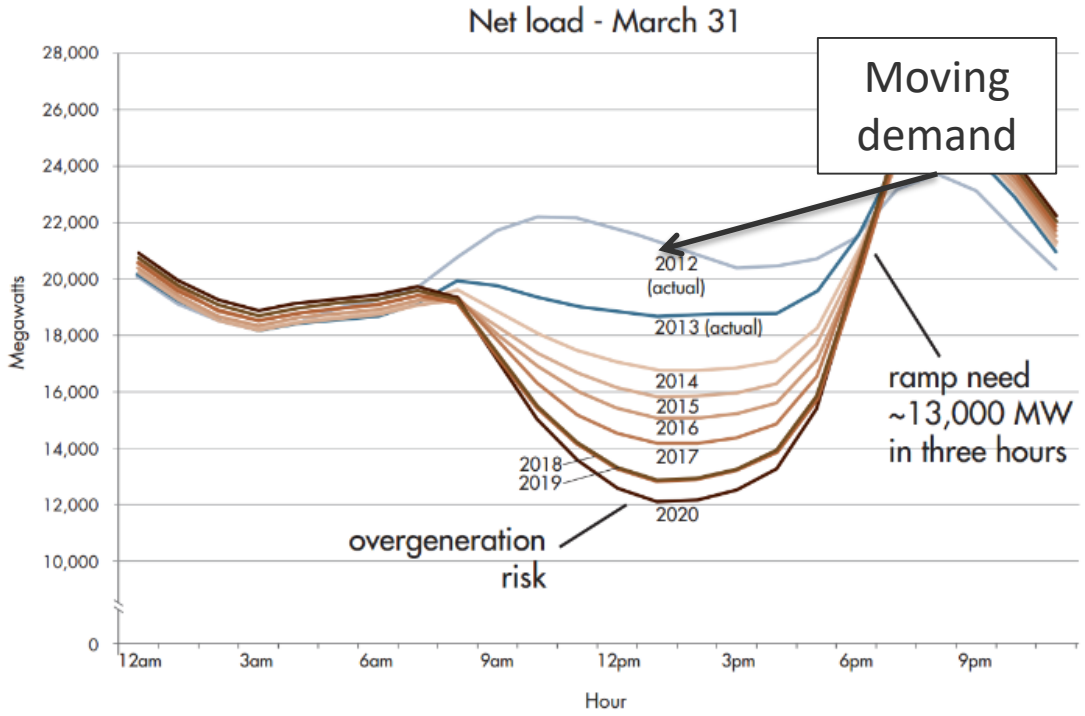
Overgeneration from Solar Energy In California

- **Fattening** the duck
  - Changing operational practices to allow more cycling
  - Minimizing the amount of thermal units on by improving PV forecasts and not holding excessive reserves – even letting PV provide reserves



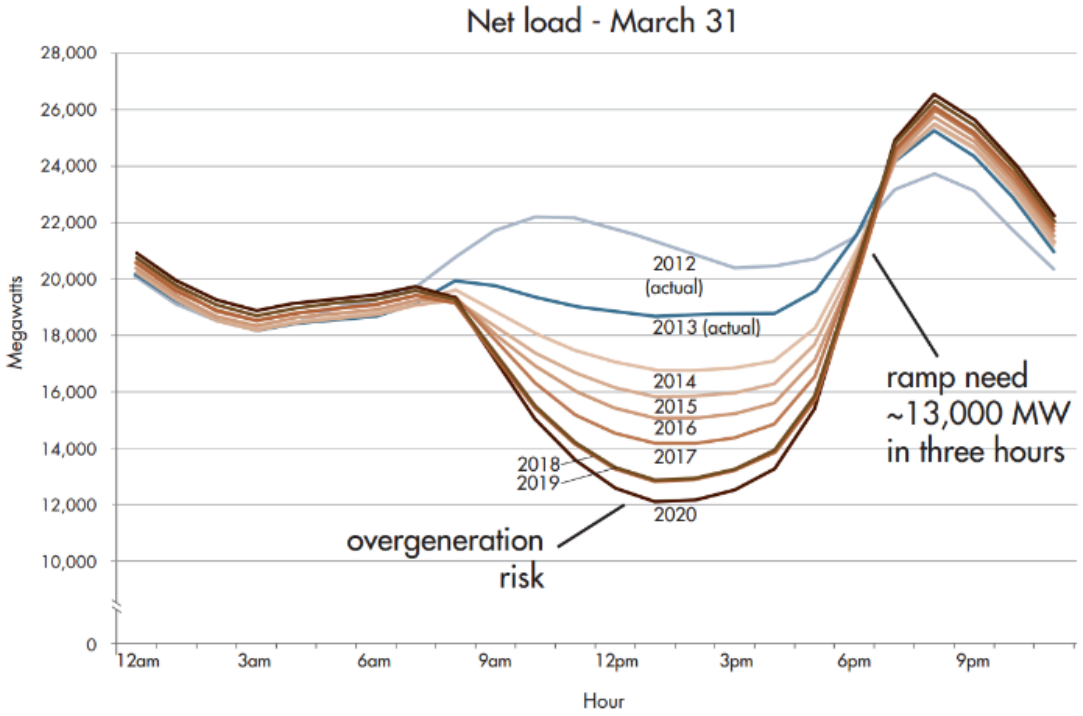
Overgeneration from Solar Energy In California

- **Flattening** the duck
  - Shifting supply/demand patterns to better align with PV availability
  - Responsive demand, or energy storage



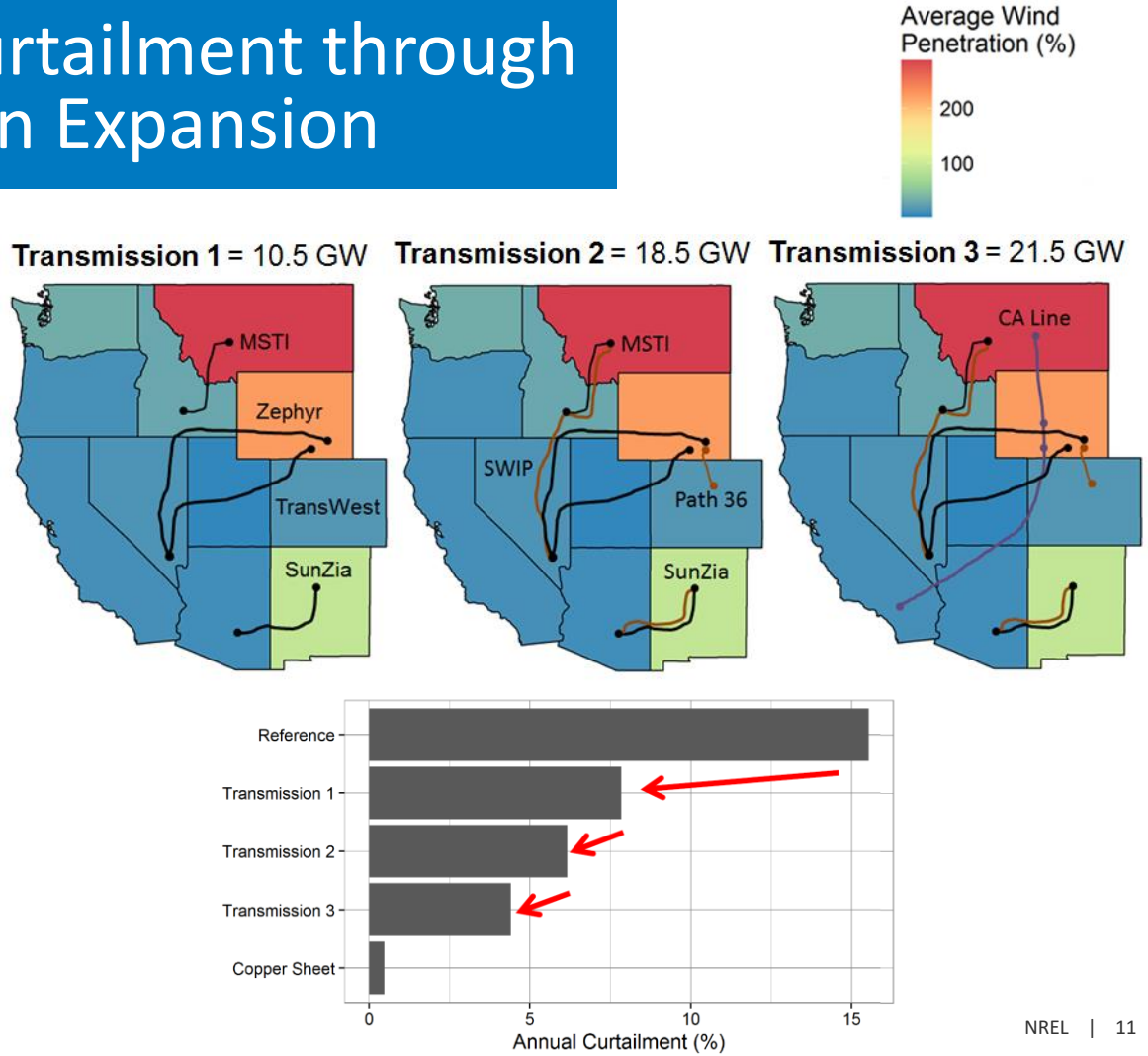
Overgeneration from Solar Energy In California

- **Other considerations:**
  - More balanced mix of RE (rather than PV-heavy)
  - Additional interchange with neighbors
  - The **cost** of these solutions need to be compared to the **value** to ultimately determine the best solutions



Reducing Wind Curtailment through Transmission Expansion

Transmission in the Western U.S. can unlock wind resources by connecting resource (in the Rocky Mountain States) to the load (on the West coast), however barriers facing long-distance transmission are formidable



Conclusions

- Integrating 30-35% RE on today's grid can be possible, even though the grid was not necessarily built with RE in mind
- Transmission is usually economical – but that doesn't mean it it's being built
- Storage can be helpful, but it's not "necessary" at lower levels of RE
- Integrating strategies are not a "one size fits all" solutions
- 50% can also be accessible – what about 80%? 100%?

What's next?

North American Renewable Integration Study

What if North America works together?

October 2019

Electrification Futures Study

What if the energy economy electrifies?

October 2019

Greening the Grid

Can India operate a system with high renewables?

June 2017

Los Angeles 100% Renewable Energy Study

Can LA operate on 100% Renewable Energy

July 2020

Thank you

www.nrel.gov

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