Resource Adequacy in the Brave New World of High Renewables and Dispatchable Demand

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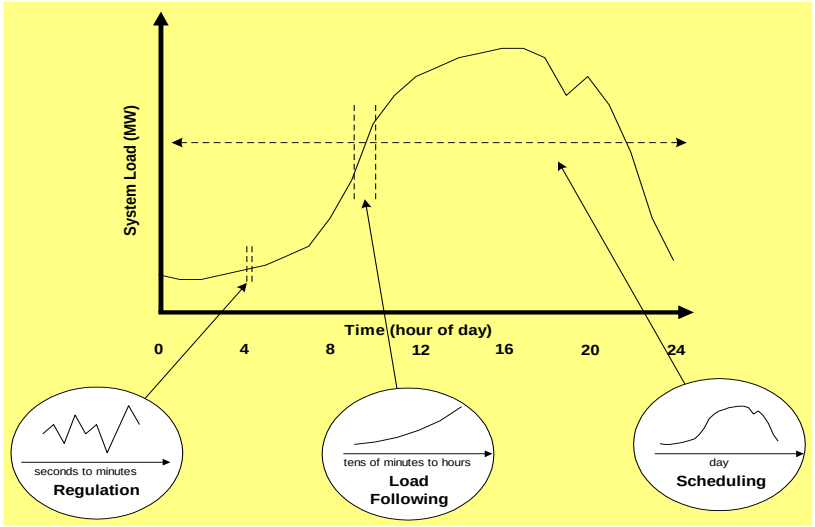
GridLAB

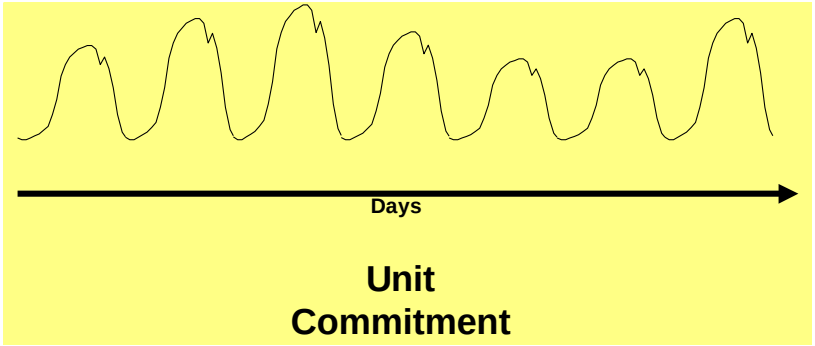
Outline: What do we need to do?

- **The Brave New World includes "lots" of new DR/dispatchable demand, wind/solar, storage**
- **Clean up terminology**
- **Dump planning reserve margin calculations**
- **Alternative metrics – how much new info do they provide?**
- **Run the models for multiple *different* years**
  - Incorporate latest methods, data into practice
- **Data: how much and what kind do we need?**
- **Recognize that transmission matters – a lot!**
- **What about probabilistic flexibility assessments?**

What are characteristics of LOL event?

- **What is an LOL event?**
  - Run with lean reserves?
  - Dump load and maintain reserves?
  - Lagging frequency?
- **How fast does it happen?**
  - Slower than contingency event
  - Ramping time frame?
  - Can emergency imports help?





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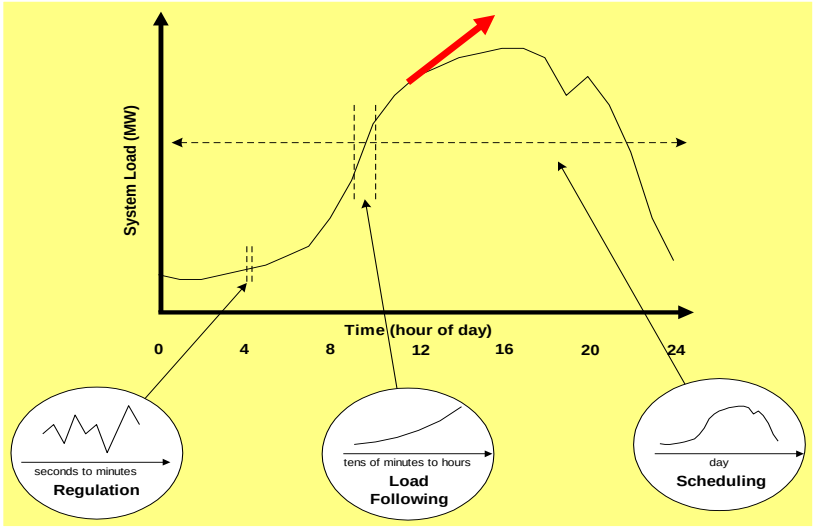
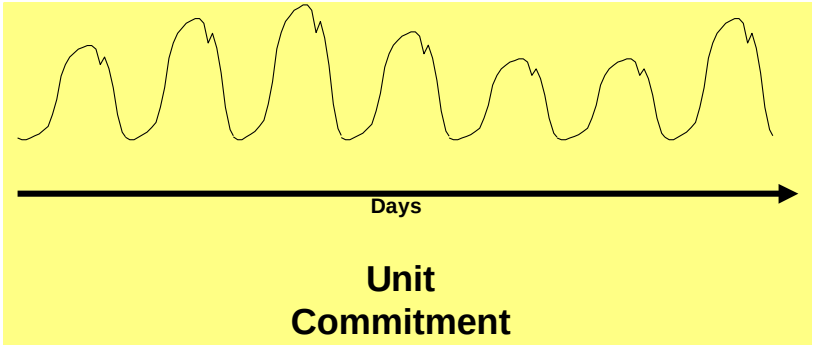
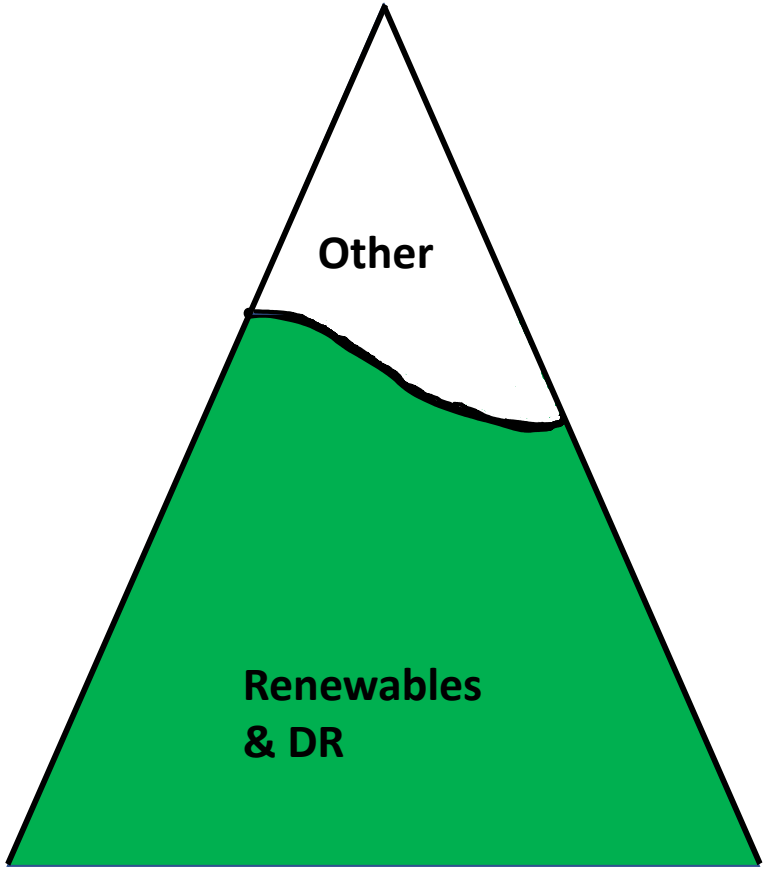




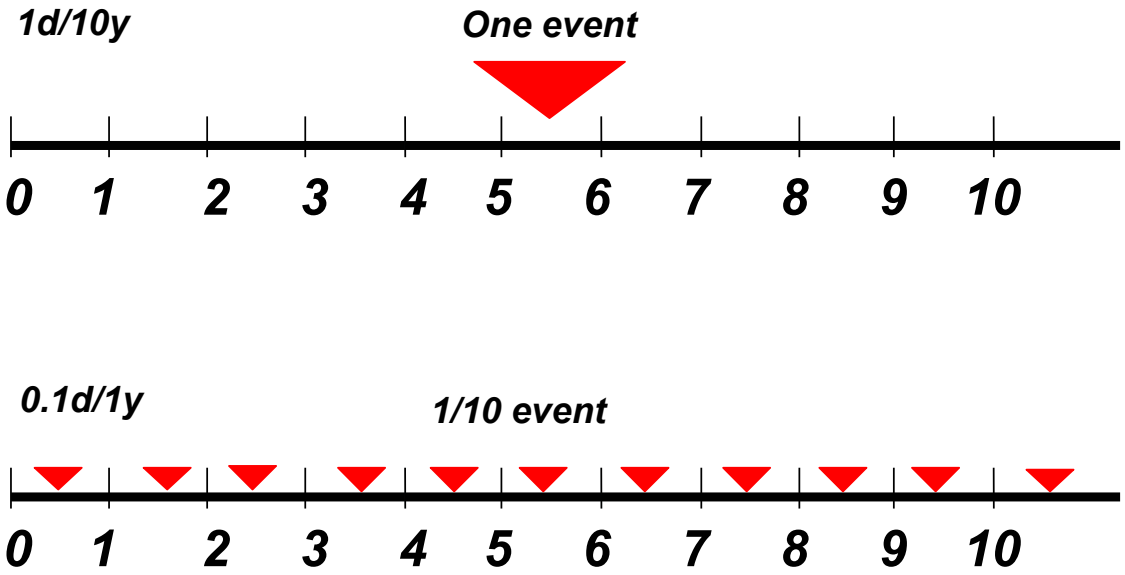
In the Brave New World we still need some form adequacy analysis

- **But it may change**
- **Who is in charge?**
- **”energy-first” planning**
  - Focus on clean energy first
  - Then “fill in” to achieve RA (energy adequacy?)
- **Fill in with**
  - Storage
  - DR – or dispatchable demand
  - Quick-start thermal
  - Other
- **Move away from “peak only” and focus on energy adequacy**



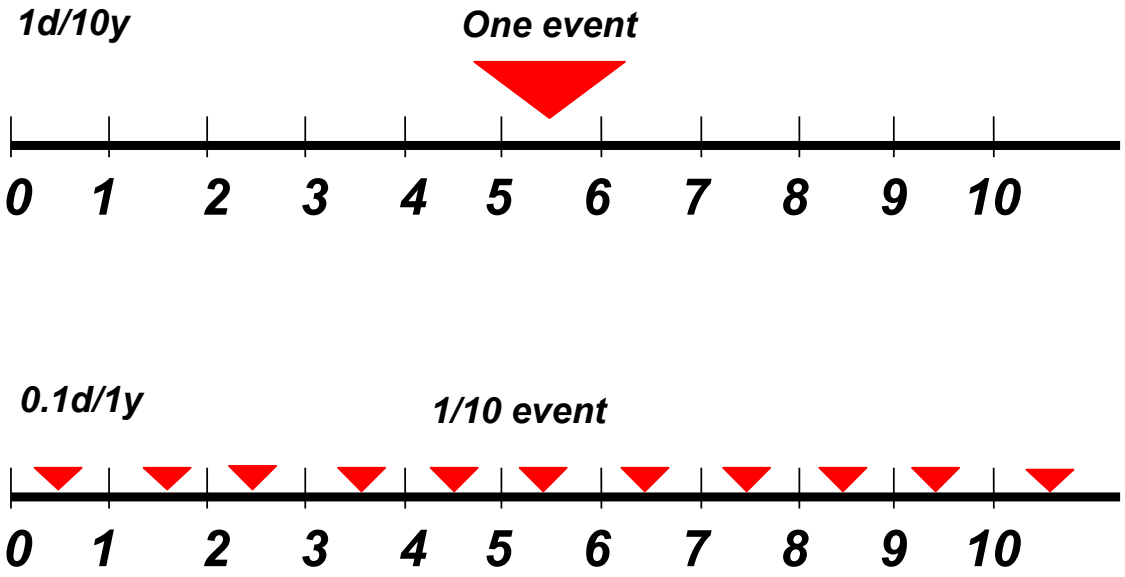
Clean up terminology

- **ELCC is typically in units of “UCAP”**
- **PRM is usually in units of ICAP**
- **What is a UCAP + ICAP?**
- **LOLP is not LOLE; 1d/10y is not a probability**
- **1d/10y is not 0.1d/y is not 2.4 hours/year**



Clean up terminology

- **ELCC is typically in units of "UCAP"**
- **PRM is usually in units of ICAP**
- **What is a UCAP + ICAP? *An inaccurate PRM***
- **LOLP is not LOLE; 1d/10y is not a probability**
- **1d/10y is not 0.1d/y is not 2.4 hours/year**



Unlikely to be systematic relationship between metrics

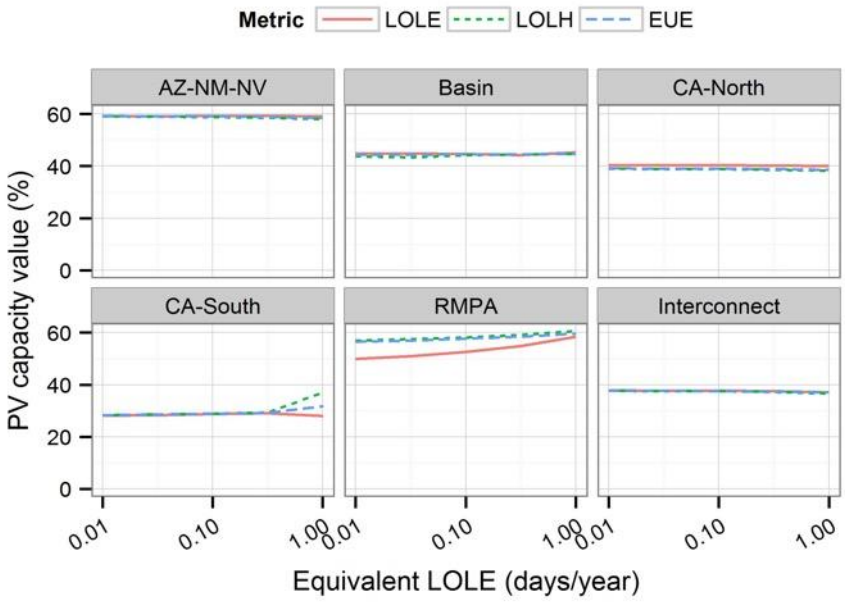
	Case 1		Case 2		Case 3	
	EUE	LOLEv	EUE	LOLEv	EUE	LOLEv
1			20	1	10	1
2			20	1	10	1
3	100	1	20	1	10	1
4			20	1	10	1
5			20	1	10	1
6					10	1
7					10	1
8					10	1
9					10	1
10					10	1
Total	100	1	100	5	100	10

- **It isn't a question of *which* metric is best**
- **They all have a message**
- **More wholistic approach, emphasizing energy adequacy, supplemented by other metrics**

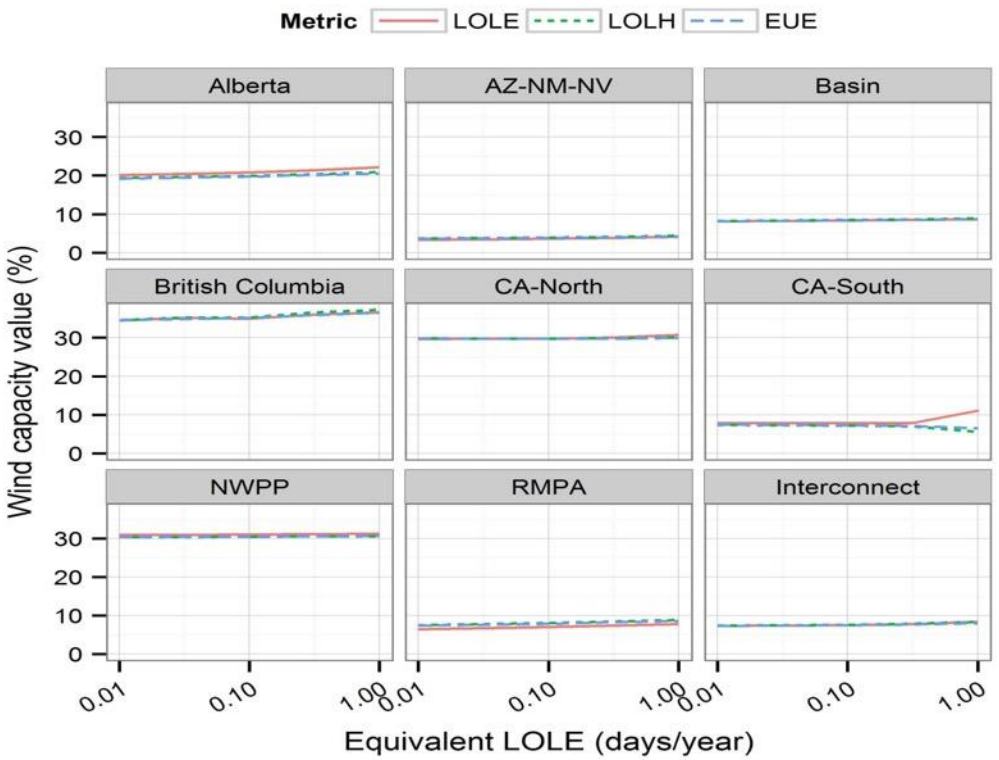
Some potentially useful metrics

- **LOLH – counts hours with LOL events**
- **LOLE – loss of load expectation (i.e. expected value). Can be measured in days, hours, or …**
- **LOLEv – counts events**
- **LOLH/LOLEv – average length of LOL events**
- **EUE – expected unserved energy (MWh, GWh)**
- **EUE/LOLEv – average energy lost in LOL event**

Increasing interest in different metrics



PV in the West

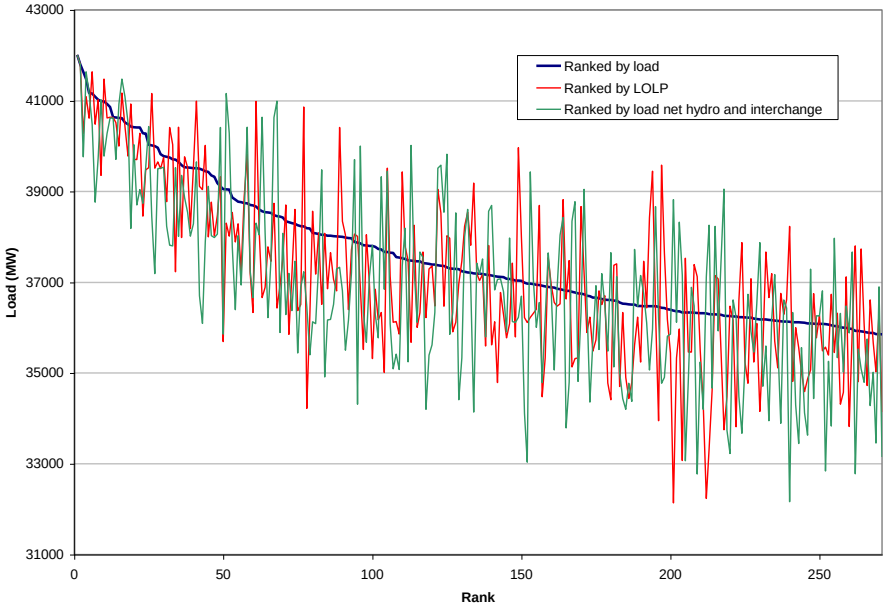


Wind power in the West

Timing of LOLE/EUE events may be similar, but magnitude may not be. Move to energy/EUE and family of metrics

Milligan, Michael; Bethany Frew; Ibanez, Eduardo; Kiviluoma, Juha; Holttinen, Hannele; Söder, Lennart, Capacity Value Assessments for Wind Power: An IEA Task 25 Collaboration. Wiley Wires. 2016

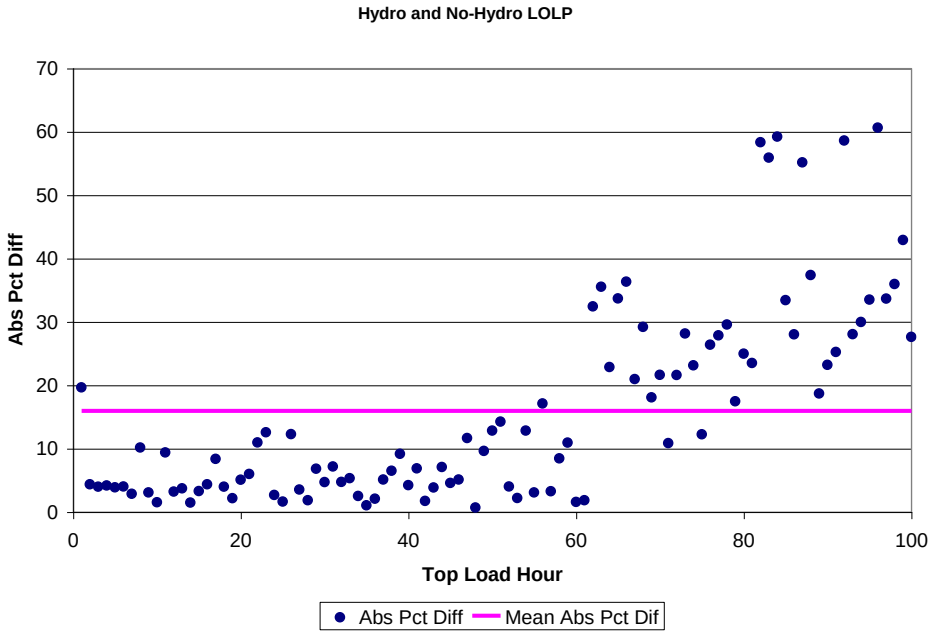
We need to run models for *full year (s)*



- **Uncoordinated maintenance scheduling may shift risk – big time**

LOLE is function of

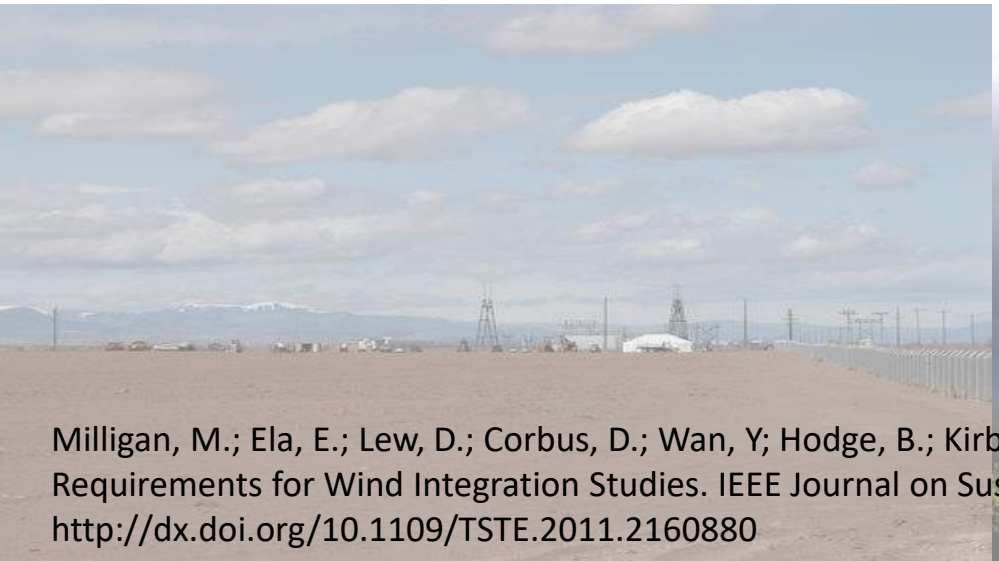
- **Demand**
- **Forced outage rates**
- **Interchange**
- **dispatch**

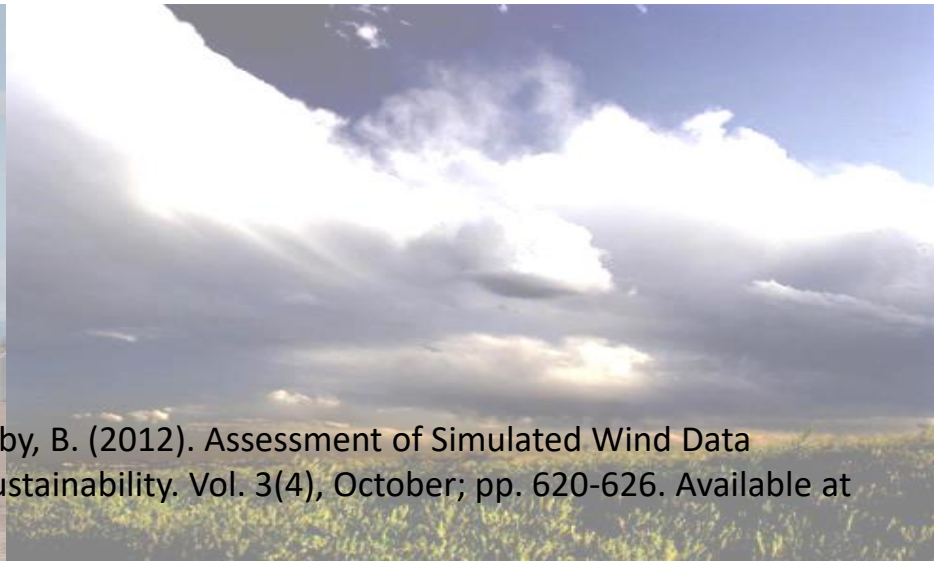


Kirby, B.; Milligan, M.; Makarov, Y.; Hawkins, D. (2003). California Renewables Portfolio Standard: Renewable Generation Integration Cost Analysis. Prepared for the California Energy Commission. California Wind Energy Collaborative, December. http://www.consultkirby.com/files/RPS_Int_Cost_PhaseI_Final.pdf

Is one year of data sufficient? (no)

- **Weather is common driver**
- **Hourly wind, solar, and load data must be from same year for consistent analysis and plausible results**
- **Use of meso-scale weather models or actual VG production is state of the art (same as integration studies)**
- **Preserves underlying correlations between wind, solar, and load with temperature, other weather phenomena**





Milligan, M.; Ela, E.; Lew, D.; Corbus, D.; Wan, Y; Hodge, B.; Kirby, B. (2012). Assessment of Simulated Wind Data Requirements for Wind Integration Studies. IEEE Journal on Sustainability. Vol. 3(4), October; pp. 620-626. Available at http://dx.doi.org/10.1109/TSTE.2011.2160880

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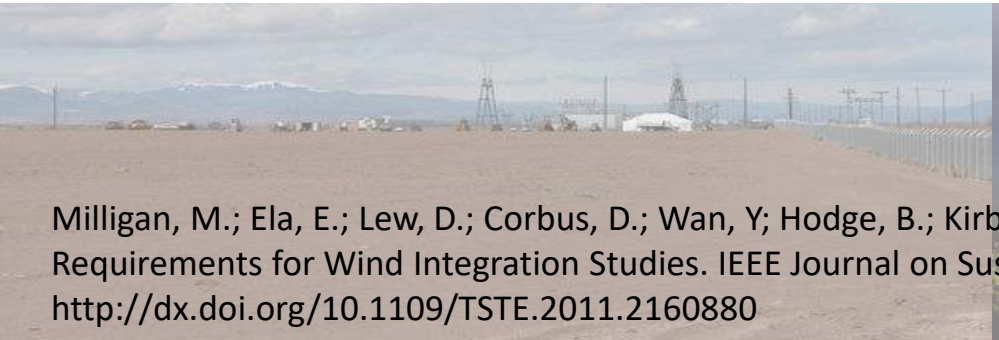
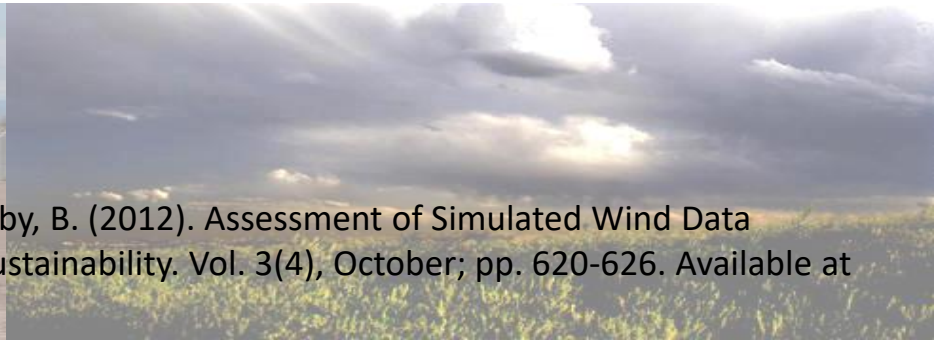
Complicated by wide-area geographic dispersion of demand, wind, solar





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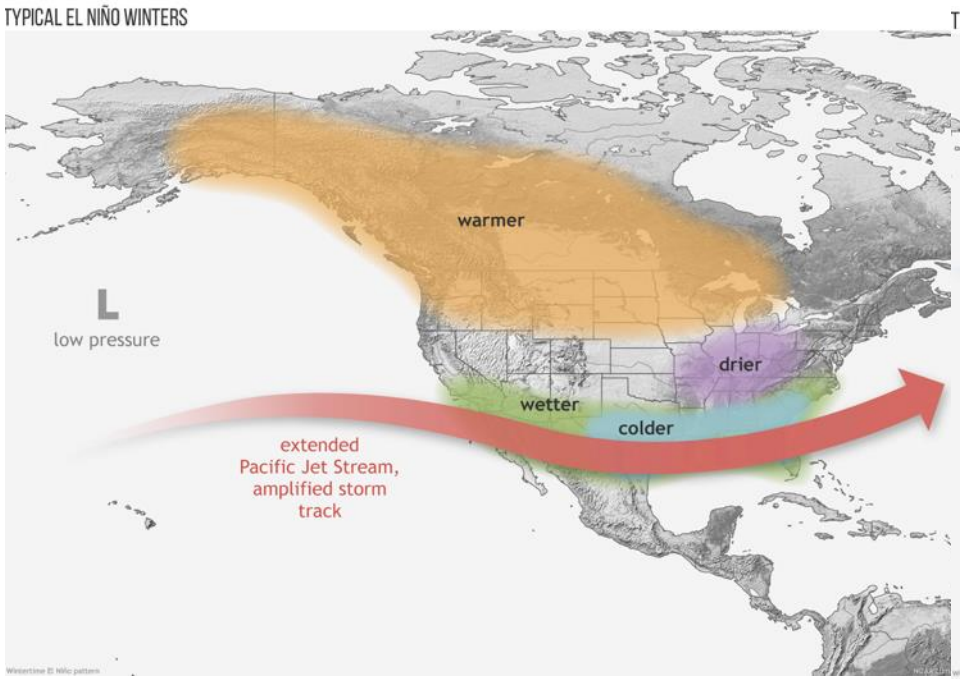
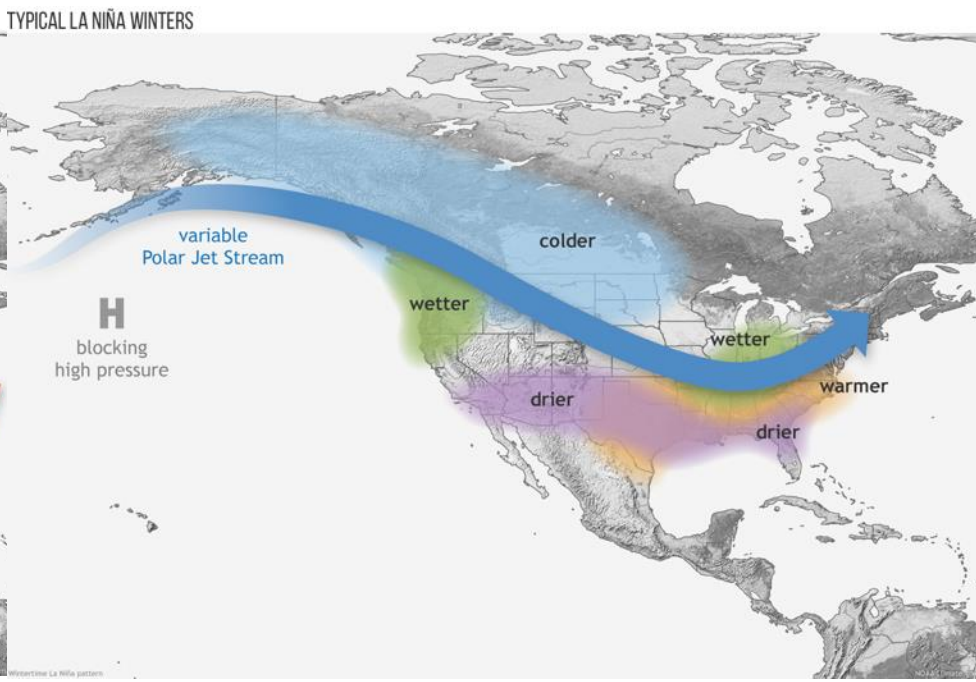
How does weather affect RE? Emergency Reserve?





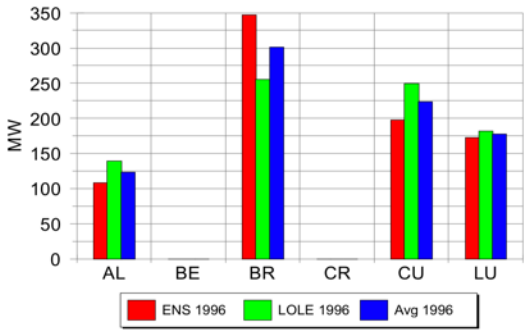


Figure 10. Optimal distribution of wind capacity using 1996 data

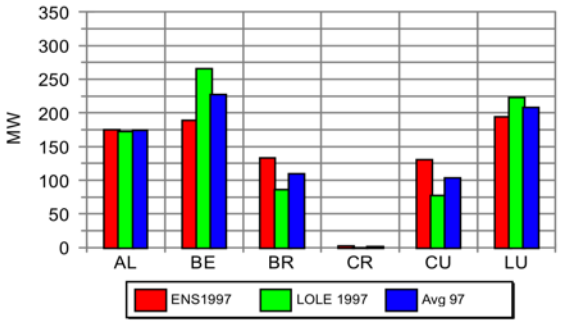
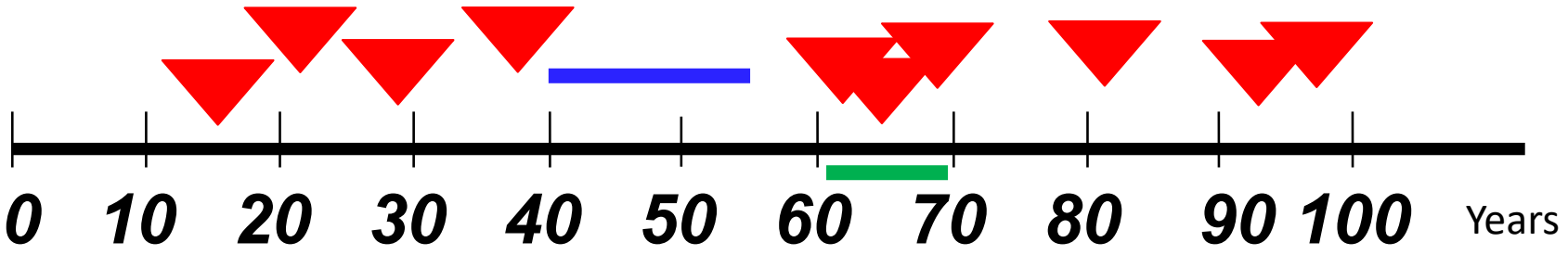


Figure 11. Optimal distribution of wind capacity using 1997 data

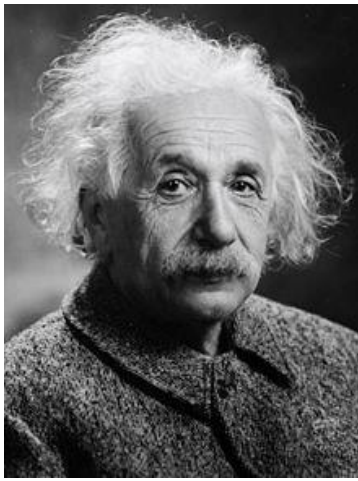
- **Inter-annual variability impact on RA**

A Theory of Special Relativity for Power System Modelers

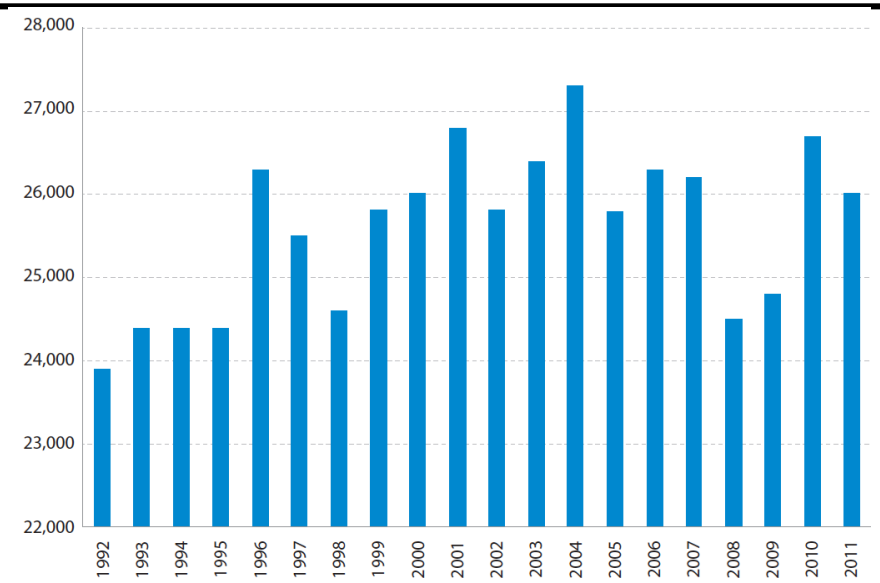
- A modeler in year 55 with 15 years of data would conclude 0d/15y reliability



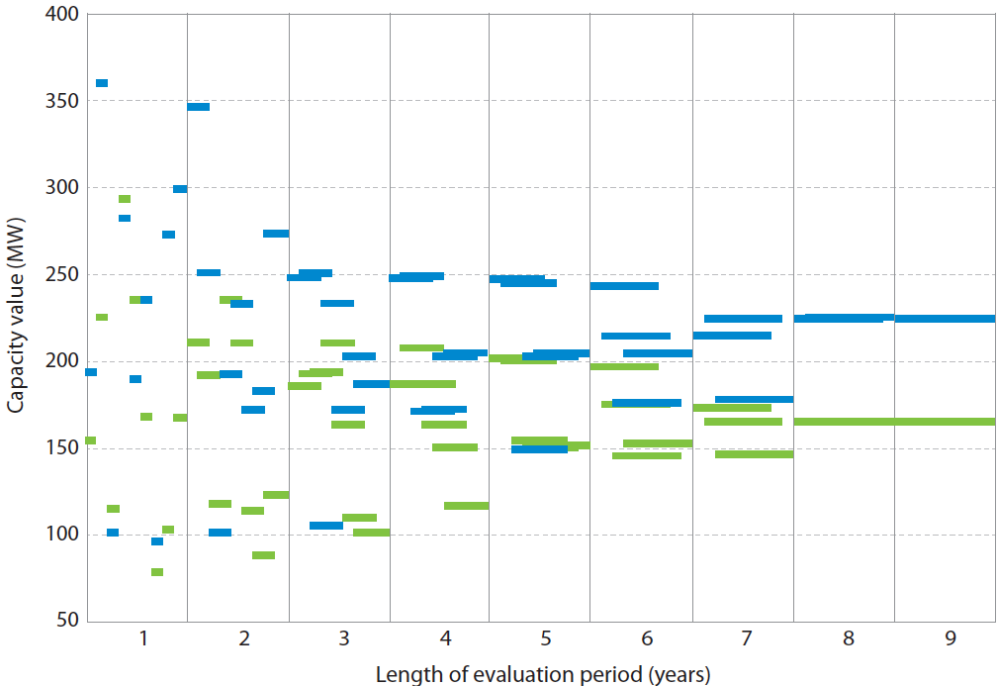
- A modeler in year 70 with 10 years of data would conclude 3d/10y



Long-term: how long is long enough



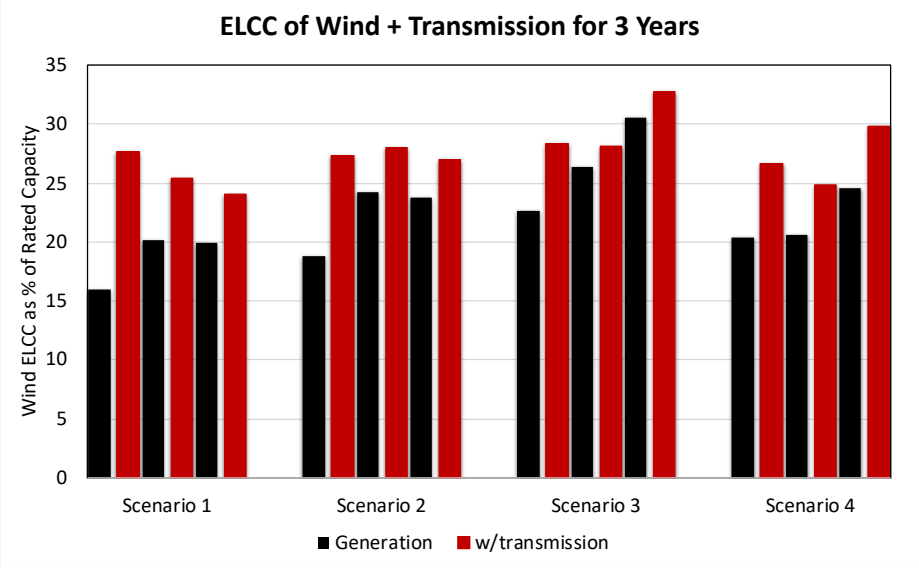
Peak demand (MW) for Sweden, 1991–2011



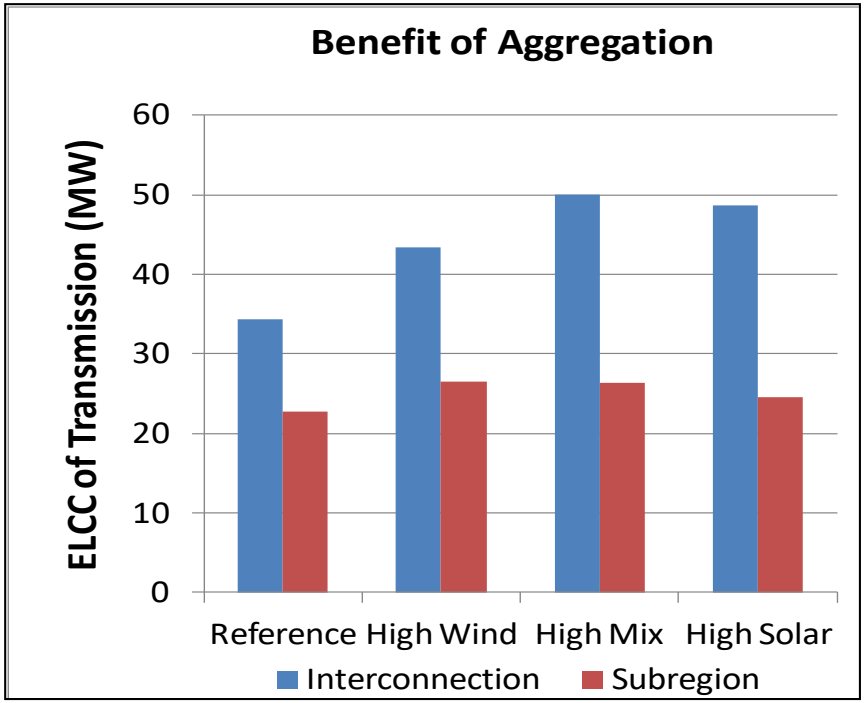
Multiple-year ELCC results from Finland using real data (green) and NASA/MERRA ReAnalysis-based data (blue) from 2005 to 2013 for 1,000 MW of installed wind capacity. J. Kiviluoma, VTT, Finland

Transmission matters – a lot

- **Increasing transmission links and associated operational coordination can reduce the need for installed capacity**



Adapted from Eastern Wind Integration and Transmission Study https://www.nrel.gov/docs/fy11osti/47078.pdf



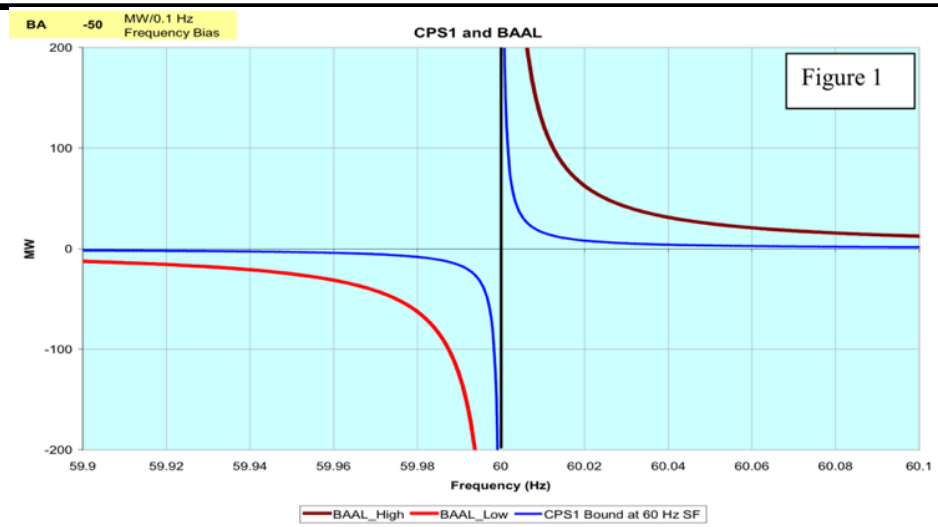
Ibanez and Milligan (2012), "Impact of Transmission on Resource Adequacy in Systems with Wind and Solar Power." IEEE Power and Energy Society General Meeting, Summer 2012. San Diego, and "A Reliability-Based Assessment of Transmission Impacts in Systems with Wind Energy". Available at www.nrel.gov/publications

Why applying LOLE to ramping can be problematic

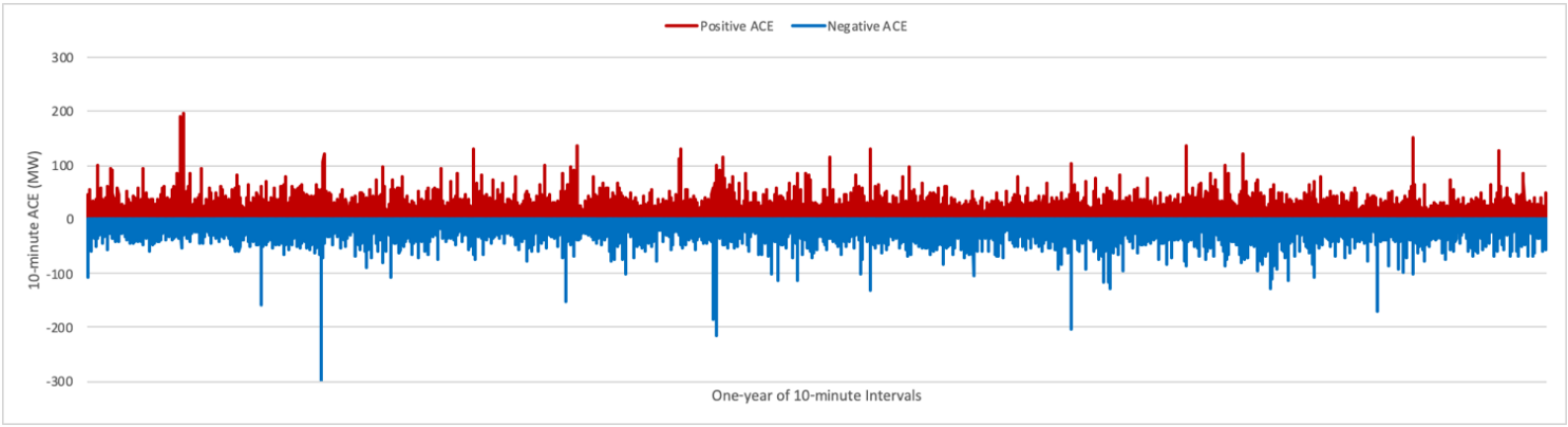
- **Proposal: Calculate LOLE resulting from inability to ramp fast enough to keep up with changing net demand – and apply 1d/10y or similar target**
- **This approach may have some value in comparing portfolio performance, but must be interpreted correctly (in context: CPS2, BAAL)**
- **All tools for maintaining balance, including dispatchable demand operator actions, and renewable curtailment should be considered**
- **Neither the (old) CPS2 nor the (new) BAAL require anything like a 1d/10y "insufficient ramp capability"**

1d/10y “LOLE-flex” isn’t compatible with how we operate

- No “LOL” is involved when ramp is missed
- ACE = area control error; measures unintended flows between neighbors
- Graph is from a SW utility that is aiming to a 0.2d/y ramp target, which is inconsistent with its historical operations
- BAAL or old CPS2



Meeting all ramps at all times means ACE=0 all but once/10 years

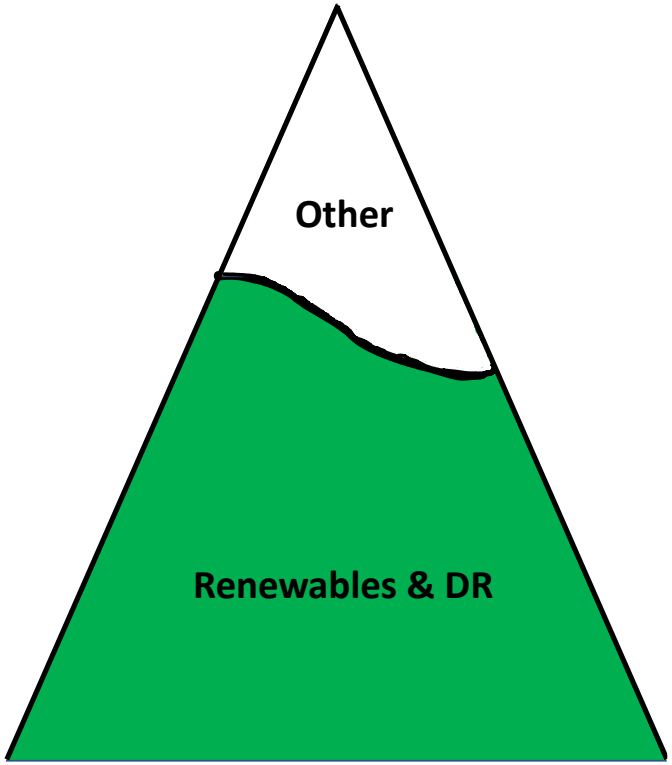


“LOLE-flex” should have a different name –ACE increase resulting from insufficient scheduled ramping capability (AIRFISRC).

What is changing: Very high RE penetrations, DR, storage

ESIG Workshop: 100% Renewable

- **What is needed for resource assessment?**
- **Consensus of the RA working group:**
  - Move to more EUE, LOLH, less on daily LOLE
  - Better multiple-year data sets for demand, wind, solar
  - Better accounting for DR
  - Better algorithms to match wind, solar, demand, hydro, chronological long-term data sets and ***ways to simulate them***



Summary: We have a lot of work to do!

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