# The Importance of Effective Use of Meteorology in the Energy Transition


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***Your assumptions are your windows on the world. Scrub them off every once in a while, or the light won't come in.***

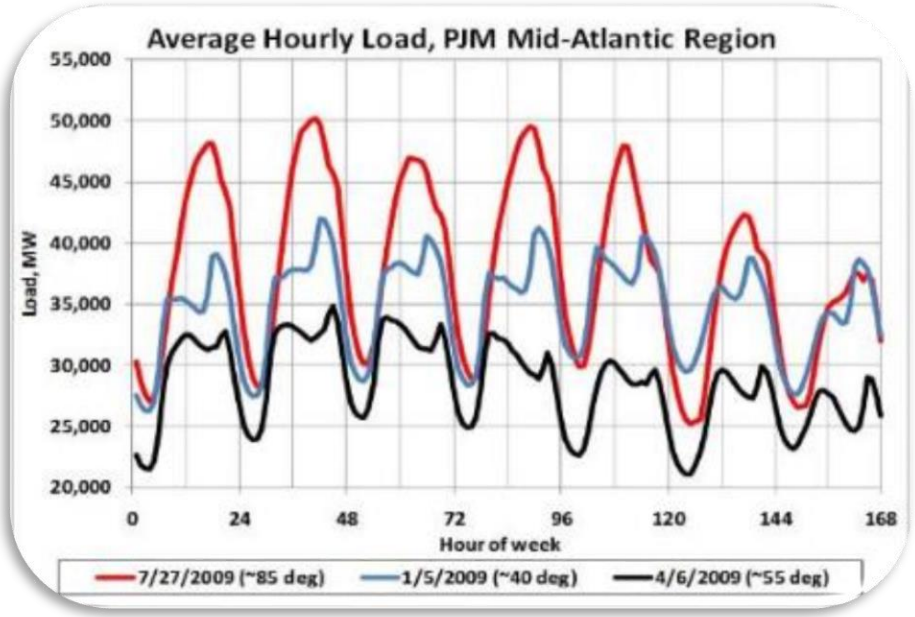
***Alan Alda, actor, writer and director***

Klondike Wind Farm. Photo © Justin Sharp

DOE/SETO
Solar Forecasting Workshop
May 6, 2021

# A Weather Dependent System Before Renewables

- Load: temperature, humidity, wind
- Distribution: wind, snow and ice
- Transmission: temperature, fire, ice, wind
- Generation: temperature and extreme temperature events




# The Energy Transition

Today, fossil fuels are the primary fuels. Tomorrow, the weather will be the main fuel.

Personal long held opinion: Shoehorning renewables into the existing system design simply will not work!

RADICAL CHANGE IS NEEDED

“If you have always done it that way, it is probably wrong."
-- Charles Kettering, inventor

# Meteorology and the Energy Transition

- Load: More weather modulation (electrification of heat and transit)
- Transmission & Distribution: Same variables, much more complexity in loading and power flow direction
- Generation/Storage:
  - Weather defines the maximum output of renewable power plants
  - Apart wind and solar being the "fuel" renewable plants meteorology has a big role in modulating output
    - Wind: Icing, high/low T cutout, high wind cut out, air density, soiling and cleaning, lightning pitting and damage
    - Solar: Efficiency (T, wind), soiling/cleaning, aerosols/smoke, snow/ice cover (ground and panel)
  - All other generators/storage more impacted by renewable resource
- Then throw in Climate Change!
  - Wildfires: T&D, smoke impacts on solar
  - All parts of the system are becoming more weather dependent. Common mode failures will compound especially in extreme weather

# Siloed Meteorology Use In The Electric Sector

## Mid- to Long-Term Utility/SO Planning

- Future demand: How much (extreme peak and average by season)
  - Temperature and load observations. Simple models to extrapolate the time series.
- Generation expansion: What type? How much? When?

  Scheduled outage planning: What? When?
  - Typically utilizes stochastic methods. RE expansions utilize crude resource averages, usually datasets that are TMY and/or non-coincident and parameterizations like ELCC

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Utility/SO Transmission Planning

Infrastructure engineering. Line capacity by expected use time.

Climate data, engineering models, stochastics

Occasional consideration of expected variable generation volume (e.g. CREZ)

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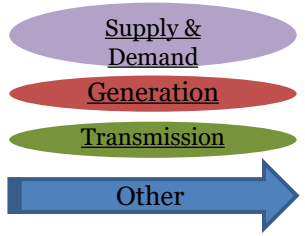

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Renewable Generation Development

Where, what? How much energy? When? Variability and uncertainty? Site suitability/engineering concerns

Moderately sophisticated these days! NWP for overall site selection, micrositing and climate normalization. CFD for micrositing, site suitability and wakes. In-situ and remote sensing for assessment of resource (inc. shear for wind). Massive improvements in last 15 years.

Typically, no local in scope and little consideration of forecastability, diversity or other meteorology attributes that impact operations.

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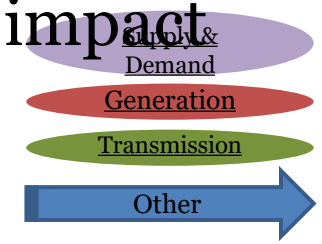

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## Utility/System Operations

- How much demand is expected and when?
  - Observations and NWP as input to load models (usually ANN/ML). Net-load forecasts. Meteorologist interpretation.
- Generation: Market ops, unit commitment, and dispatch. What, when, where? Infrastructure risk.
  - Renewable generation forecasts: NWP foundation with ANN/ML techniques to convert resource to expected output.
  - Weather forecasts.
  - In-house meteorology.

Other

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## RE Project Operations

- Short-term (mins to months) How much? When? Uncertainty? Used for maintenance planning, trading and scheduling
  - Renewable generation forecasts*.
  - Sometimes more input data and validation for project forecasts than RTO forecasts
  - Climate signals for seasonal time scales. Some human input.

Transmission

Other

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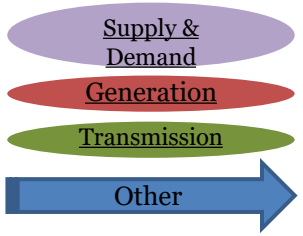
- Infrastructure risk (wind, fire, lightning, ice); dynamic line capacity (temp and wind)
  - NWP, in-house models, meteorologists

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R&D transects everything with reasonable sophistication (e.g. NREL studies like SEAM, NARIS and Tail Events)

Policy is informed by weather events but exhibits no meteorology sophistication at all (Example: PTC)

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Supply & Demand

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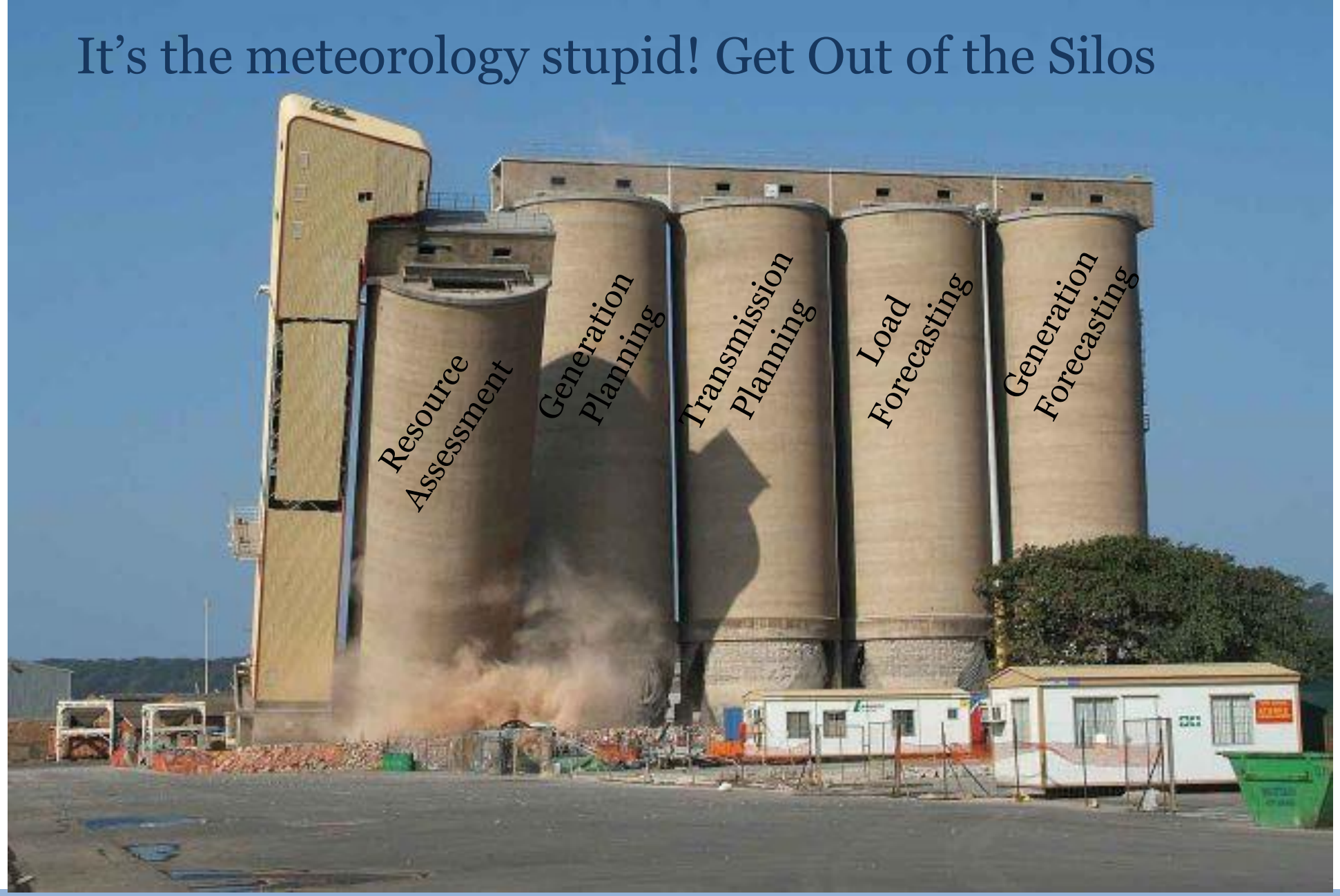
Sharply Focused

# It's the meteorology stupid! Get Out of the Silos



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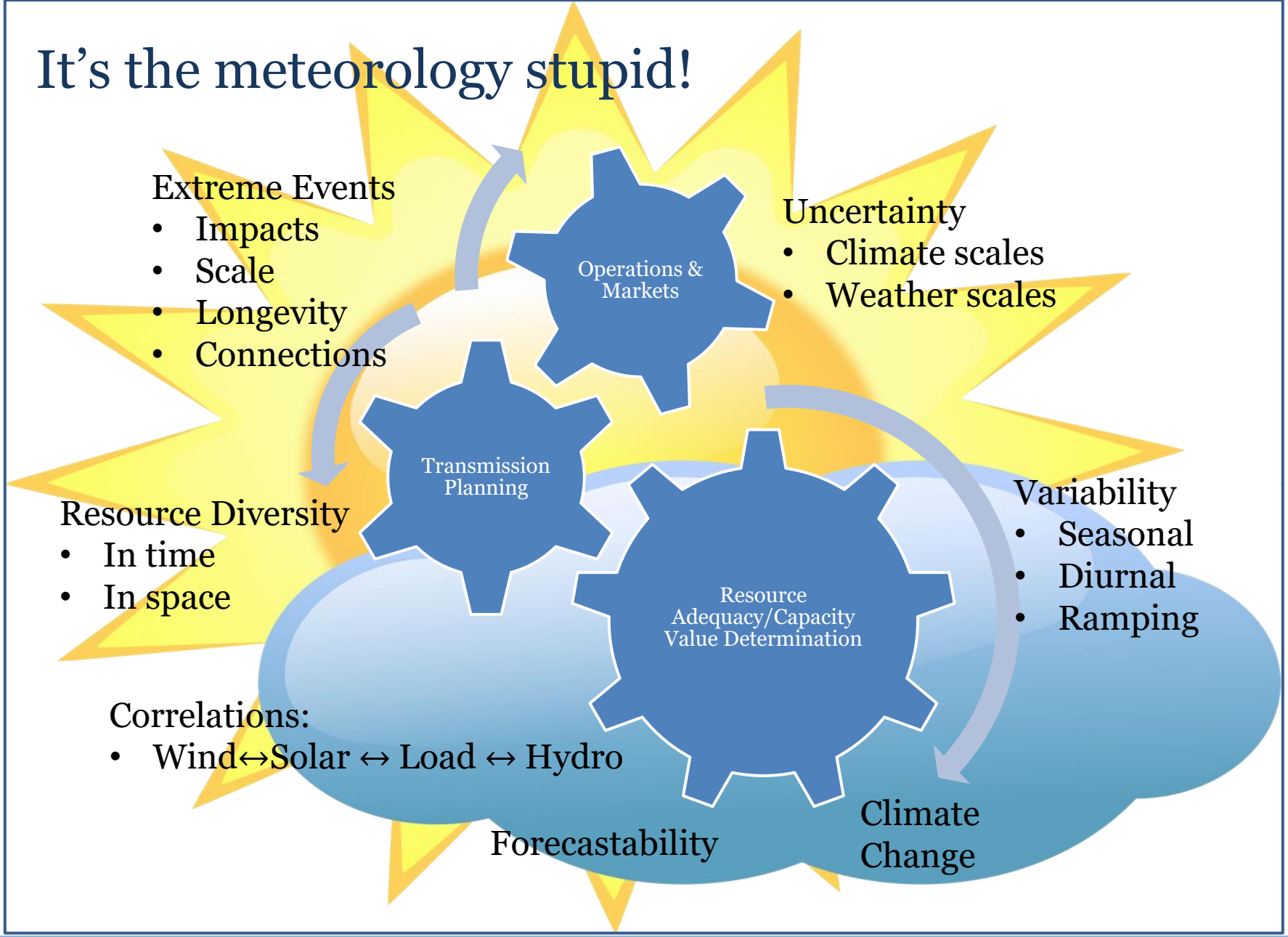
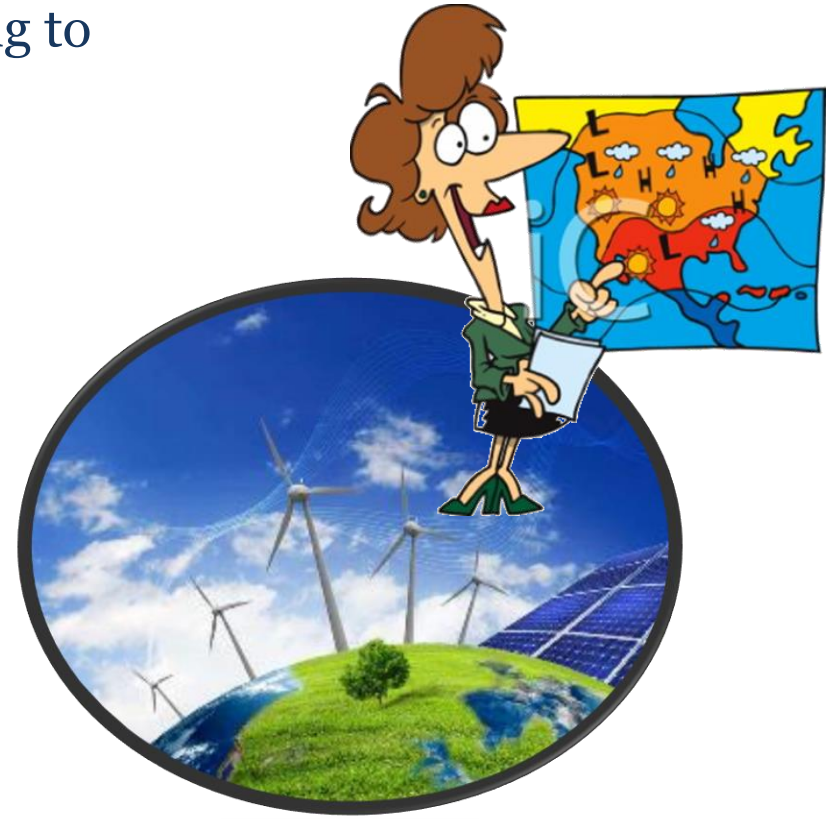


# The geologist is to fossil fuels as the … is to renewable energy?

- Uncertainty and variability are a function of footprint and weather
- Wind, solar, load and to some extent hydro are all interdependent
- Thermal generation/outage risk is weather dependent
- During extreme events, coupling increases leading to common mode failures.



# Key Takeaways

- Meteorology touches EVERY part of utility planning and operations and is becoming MORE important
- Climate change impacts on the electric grid are important but other meteorology considerations are larger at the present time
- Linkages and correlations are strong and pose major risks
  - Ignore them at your peril! MUST get out of the silos!
- Smoothing variability is critical. Consider it at every step from planning to operations, including policy decisions
  - Must understand the tails, and be able to mitigate them
  - Diversity, transmission, storage, load management
- High-quality holistic risk/forecast products are essential and markets/operating practices must be designed to utilize them