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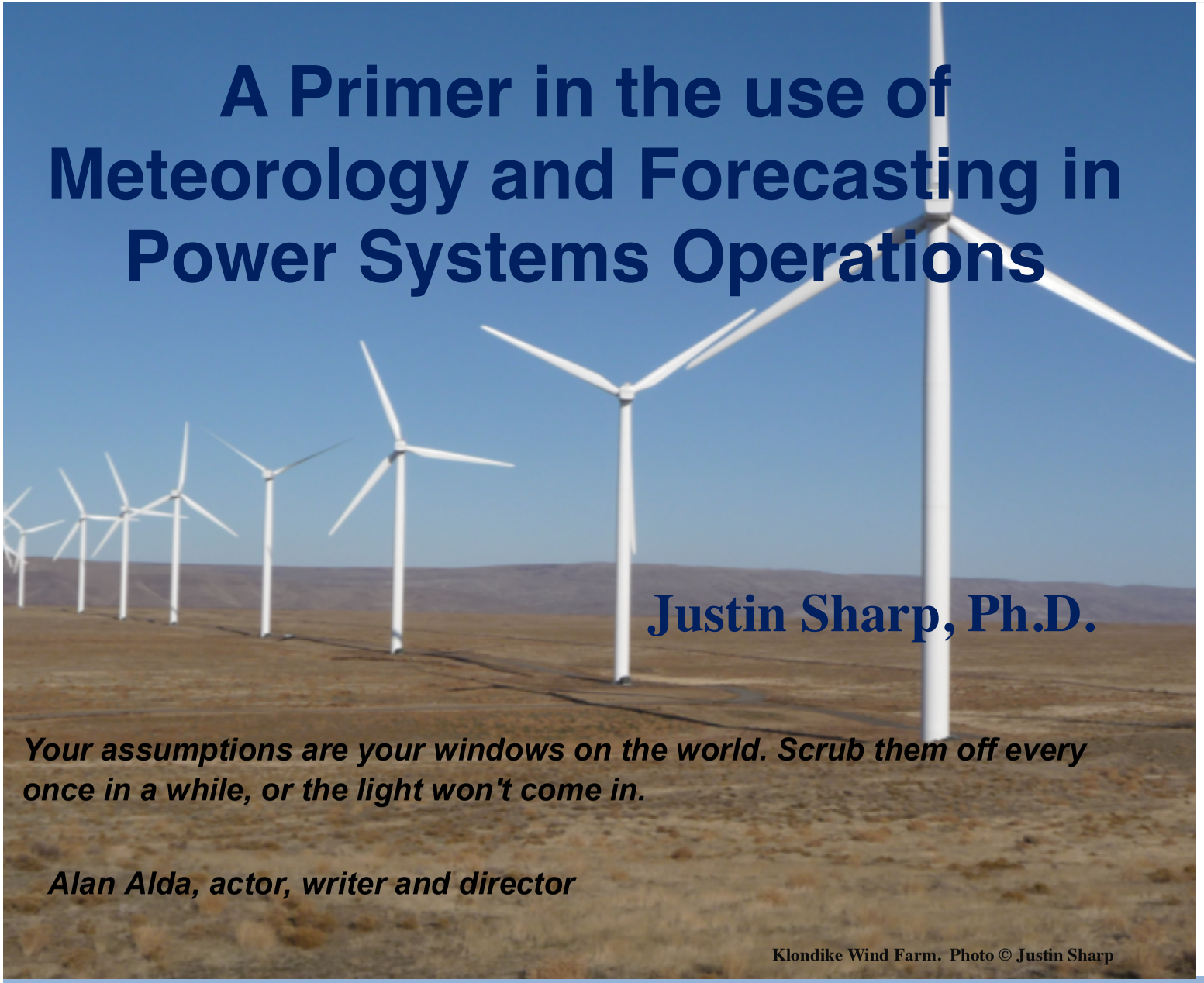
A Primer in the use of Meteorology and Forecasting in Power Systems Operations



Justin Sharp, Ph.D.

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

Sharply Focused

Understanding Renewable Resources

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CREA Energy Innovations Summit

Denver, Colorado I October 29, 2018

About Dr. Justin Sharp and Sharply Focused

- Energy meteorologist since 2004
- Built Avangrid Op-Met. Group
- Owner Operator of Sharply Focused LLC since March 2012
- SFLLC bridges the electric utility/meteorology knowledge and culture divide
- Consulting, research, training
- Major clients include EPRI, DOE, NREL, MISO, NOAA, Vaisala, PGE and Lockheed Martin.

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The Renewable Energy Transition

Today

Weather moderated load and generation
Largely thermal
Dispatchable
Centralized
N-1 contingency
Lots of inertia but little storage
Slow to moderate ramping rates

The Future

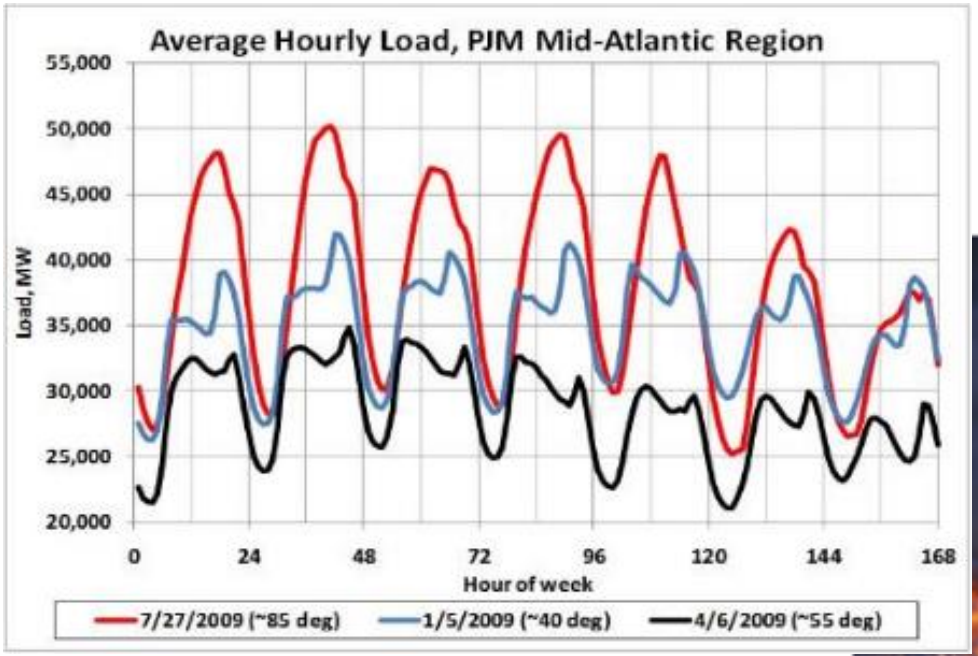
Strong correlation between weather generation
Weather modulated load and Wx driven response
Mostly weather driven generation
More storage but less inertia
Fast ramping rates
More distributed
RE penetration and thus gas use ultimately depends on generation planning.

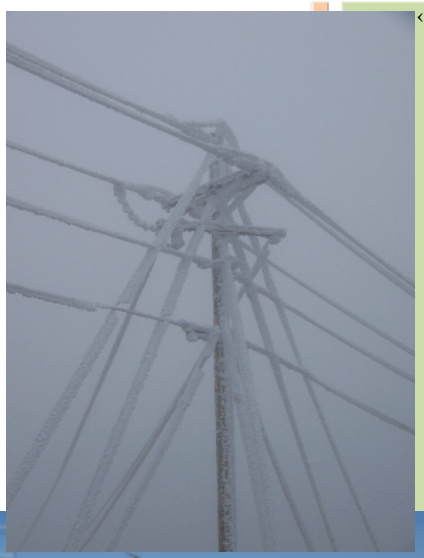
Objectives

- To convince you all of the importance of meteorology in the energy system of the future by providing high-level insight into:
  - The changing way that weather and climate affect the sector
  - The importance of Atm. Sci. to successful electric system decarbonization
    - We MUST educate and engage each other in the important multi-disciplinary challenges of renewables integration
- Provide the basics of forecasting to tee up Stan and Skip
- Provide background that will trigger directed curiosity by non-meteorologists

A Weather Dependent System Before VRE

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





It's the meteorology stupid!

Extreme Events

Resource Diversity

Forecasting

Uncertainty
- Climate scales
- Weather scales

Variability
- Seasonal
- Diurnal
- Ramping

Resource Assessment

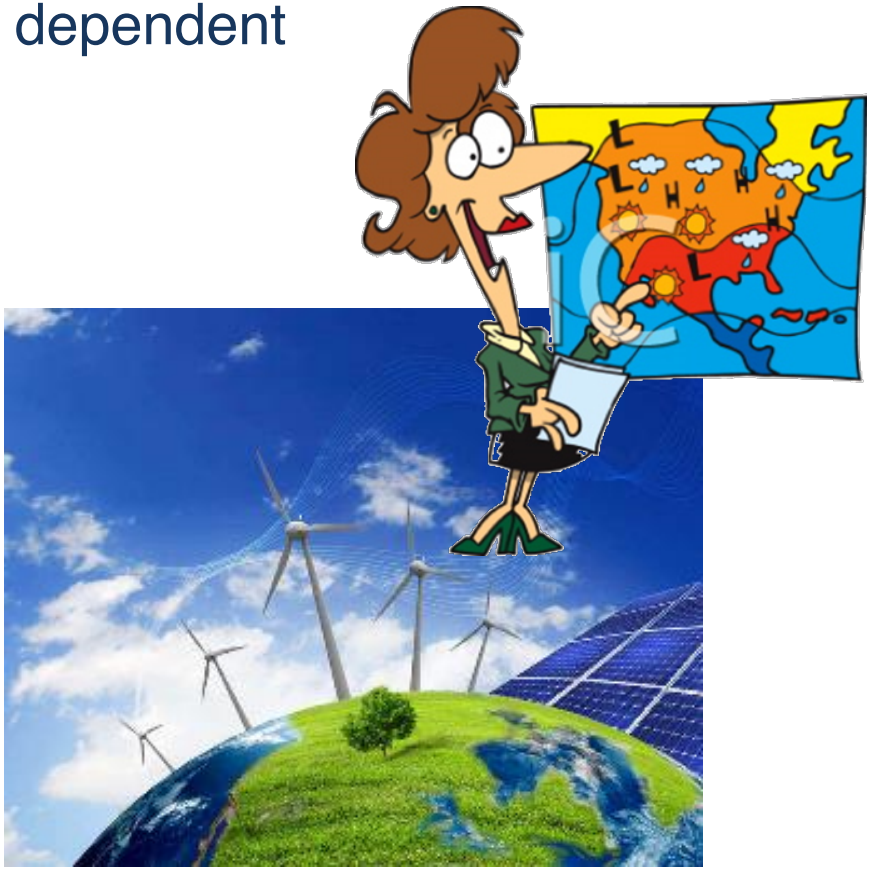
Correlations:
- Wind↔Solar ↔Load ↔Hydro

Forecastability

Climate Change

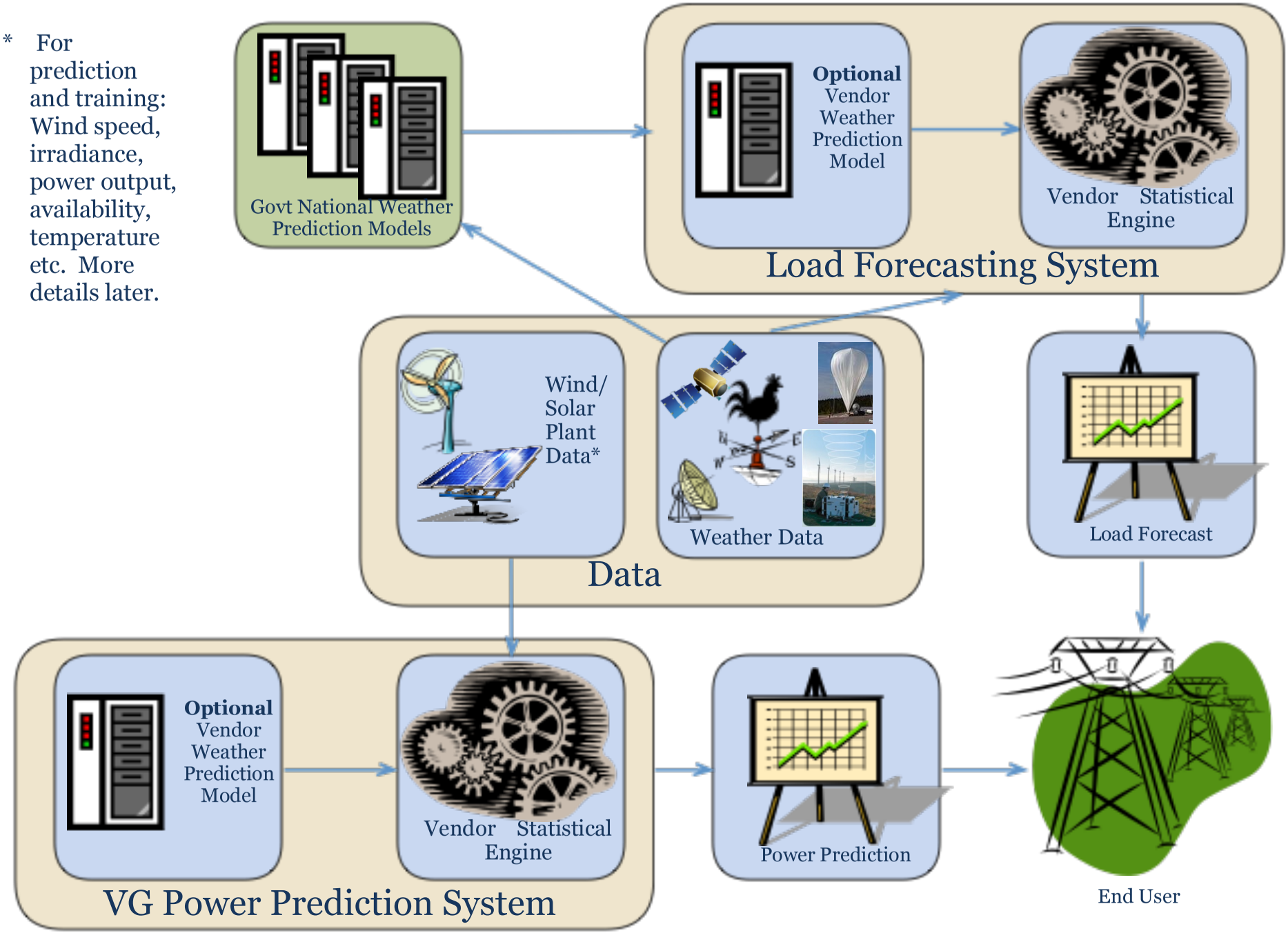
Geologist is to Oil and Gas as…?

- Uncertainty and variability are a function of foot print and weather
- Wind, solar, load and to some extent hydro are all interdependent
- Even imports and exports are weather dependent



Forecasting Electricity Supply and Demand

* For prediction and training: Wind speed, irradiance, power output, availability, temperature etc. More details later.



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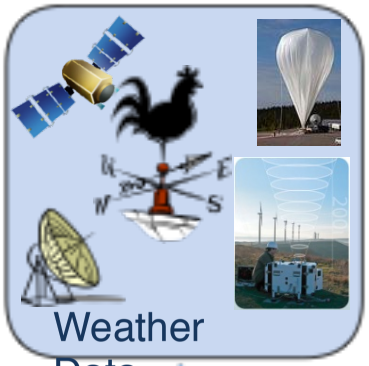
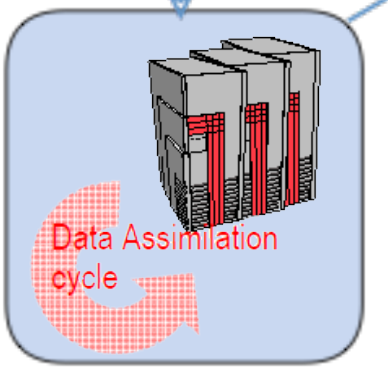
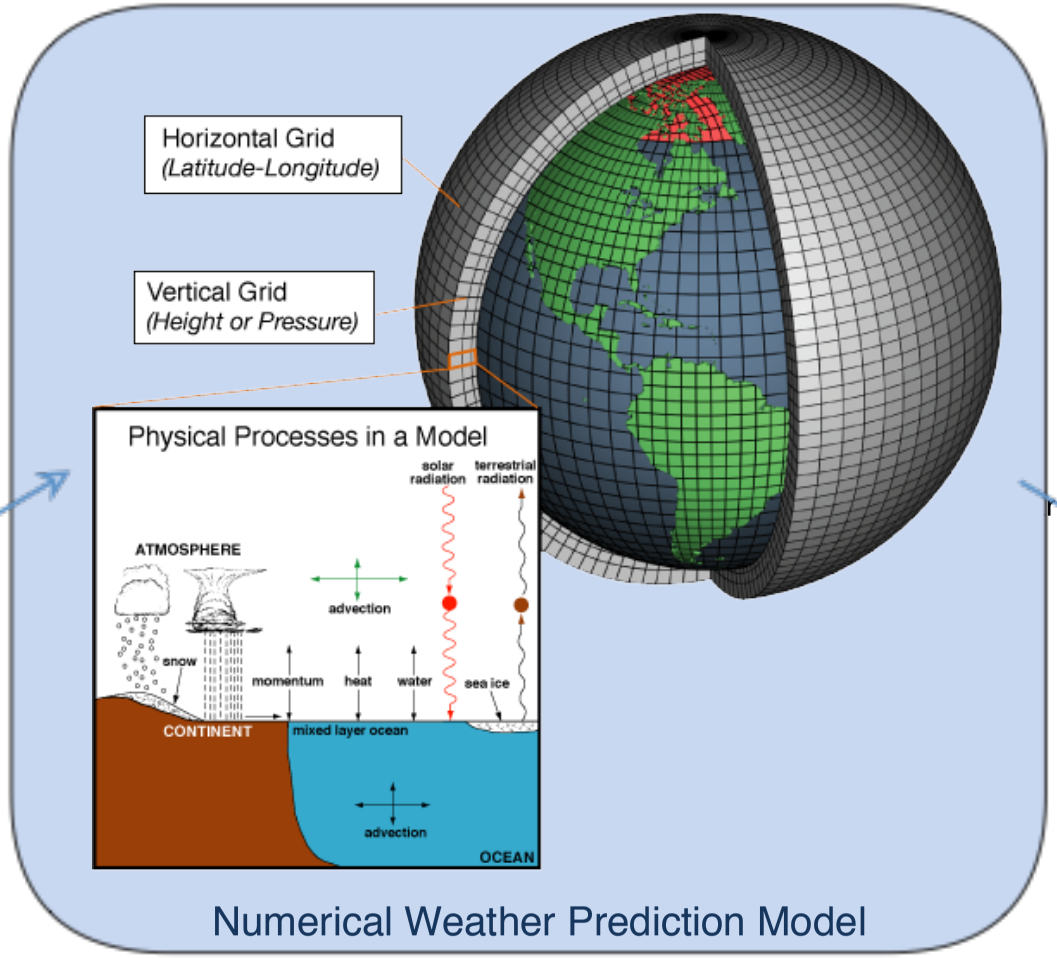
Foundational Numerical Weather Prediction

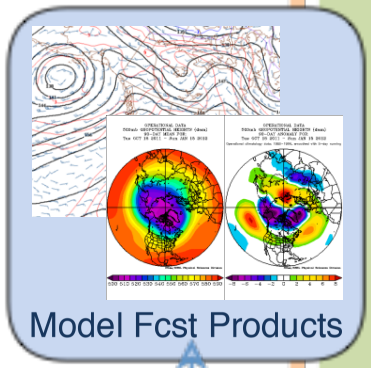


Weather Data

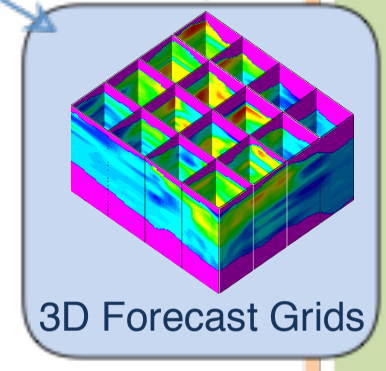




Numerical Weather Prediction Model



Model Fcst Products



3D Forecast Grids

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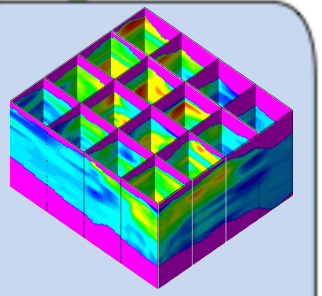
Renewable Power Forecasting System Detailed View



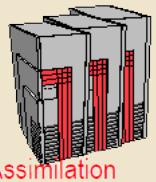
3D NWP Forecast Grids and Post-Processed Data

Weather Data

Plant Data

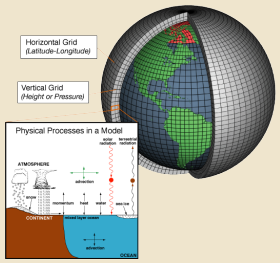
Transmission constraints, current capacity, output, weather etc

Optional NWP Layer



Data Assimilation cycle

Typically regional scale to downscale foundational forecasts
Data assimilation is currently unusual here



Optional NWP Post Processing

Attempts to get the best weather forecast possible to use as an input in power forecasting by removing model biases

Statistical Relationships

Examples:

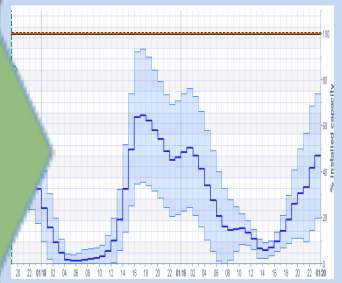
- NWP forecast to actual weather
- Output to weather
- Output to NWP

Power Forecasting Engine

Creates power forecast and confidence intervals based on statistical (often proprietary) methods (neural net, SVM etc)
Utilizes plant and weather data to tune the forecast to current conditions

Training Layer

Creates relationships between inputs and outputs using historical data



Power Forecasts

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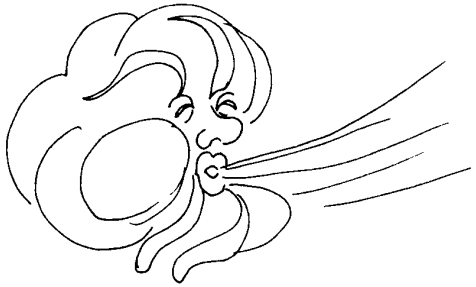
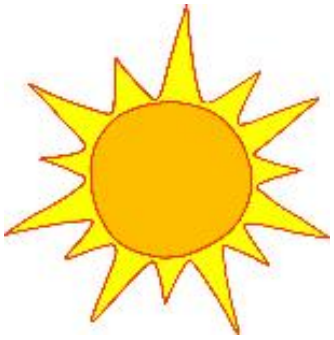
Renewable Energy Forecast End-Users

- System operators (including those that could be using them and often aren't)
- Vertically integrated utilities
- Power traders/marketers/aggregaters
- RE IPP's and traditional energy IPP's
  - Market participation
  - Operations and maintenance activities





Types of forecasts, their applications, and methods for producing them

	Type of Forecast	Time Horizon	Key Applications	Methods
Generation	Intra-hour	5-60 min	Regulation, real-time dispatch market clearing	Statistical, persistence.
	Short term	1-6 hours ahead	Scheduling, load-following, congestion management	Blend of statistical and NWP models
	Medium term	Day(s) ahead	Scheduling, reserve requirement, market trading, congestion management	Mainly NWP with corrections for systematic biases
	Long term	Week(s), Seasonal, 1 year or more ahead	Resource planning, contingency analysis, maintenance planning, operation management	Climatological forecasts, NWP
Decision support	Ramp forecasting	Continuous	Situational awareness, Curtailment	NWP and statistical
	Load forecasting	Day ahead, hour-ahead, intra-hour	Generation adequacy, Congestion mgmt, Demand side mgmt	Statistical

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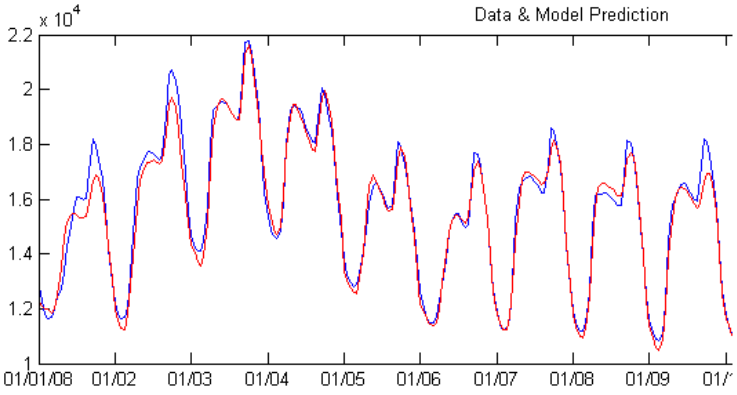
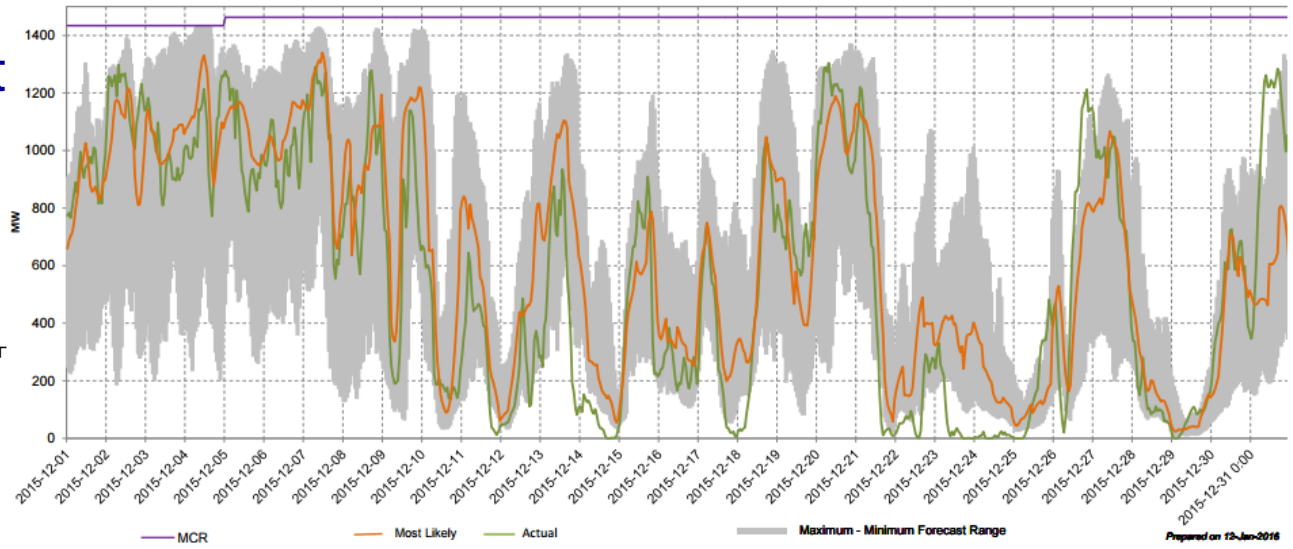
Source: http://greeningthegrid.org/resources/factsheets/copy_of_ForecastingWindandSolarGeneration.pdf

Wind/Solar Forecasts versus Load Forecasts

- Electricity demand follows a regular pattern that is modulated by weather…mainly temperature
- Variable generation forecasts are defined by weather
- Wind and irradiance harder to forecast than temperature and exhibit more spatial and temporal variability
- Thus, we should expect load forecasts to exhibit considerably lower errors.





The Weather Forecast Value Chain

Adapted for Energy. Original from Jeff Lazo, NCAR

Pretty Good Lots Of Room For Improvement

- VG and load forecasts provide enormous ROI
  - With appropriate use and expectations
- But value chain is not being fully utilized, esp. for VG
- More value can be extracted if there is more focus on the elements to the right
- These convert data into actions and outcomes

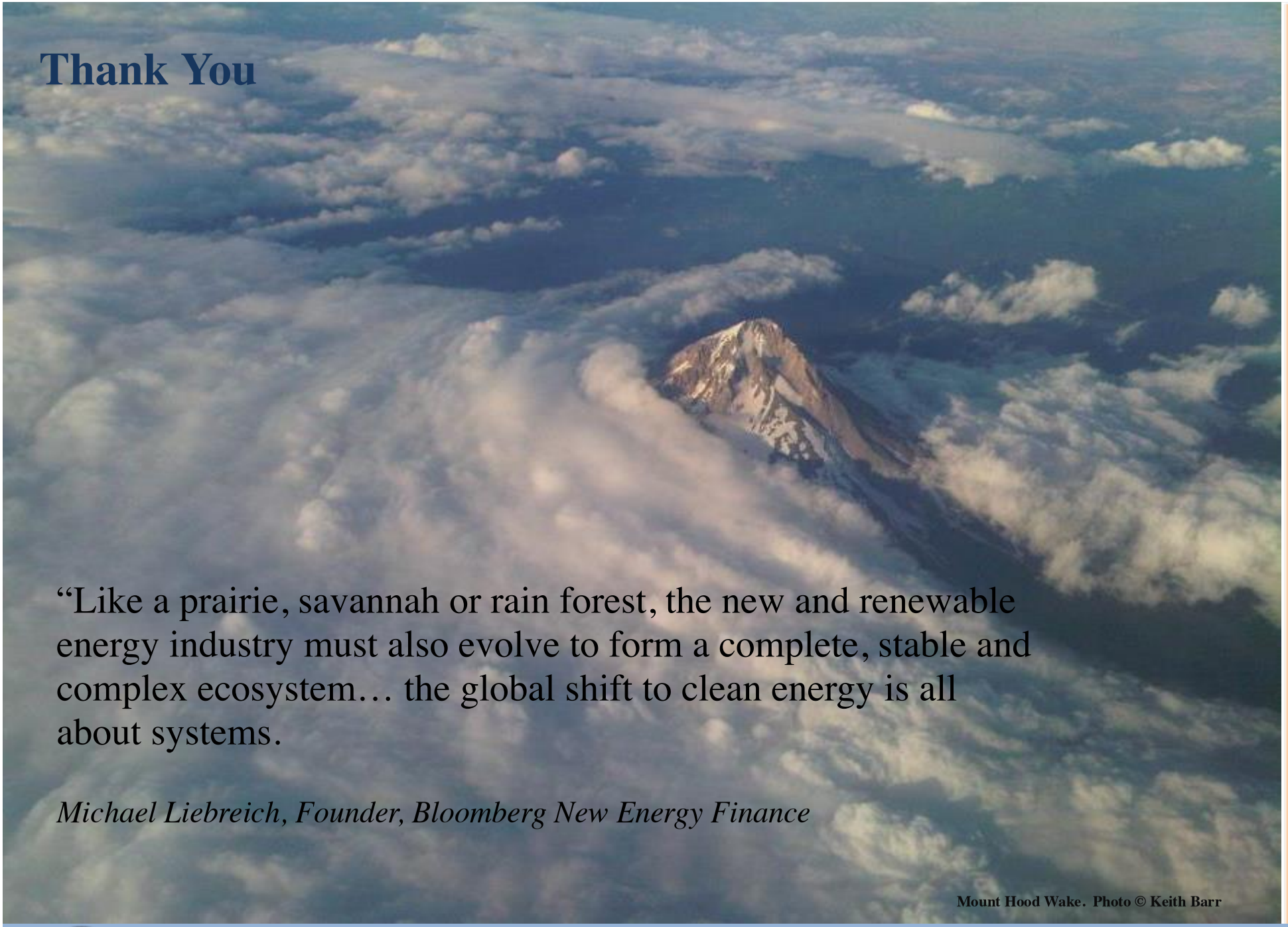
What determines VER and load forecast value?

- Market design/rules and operating practices
- System operator charges, incentives and penalties
- Forecast accuracy and reliability
- Forecast **confidence** and a reliable measures of it
- Variability of the RE resource in time and space
- How the forecast is communicated and used

Forecasting Is Not A Silver Bullet

It Needs To Be Melded With Market/System Changes That Maximize Benefits And Minimize Costs of VERs

Thank You



"Like a prairie, savannah or rain forest, the new and renewable energy industry must also evolve to form a complete, stable and complex ecosystem… the global shift to clean energy is all about systems.

Michael Liebreich, Founder, Bloomberg New Energy Finance

Mount Hood Wake. Photo © Keith Barr