# Mind the Gaps: Weather Data Inputs for Power System Modeling

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Sharply Focused
Understanding Renewable Resources

ESIG
ENERGY SYSTEMS INTEGRATION GROUP

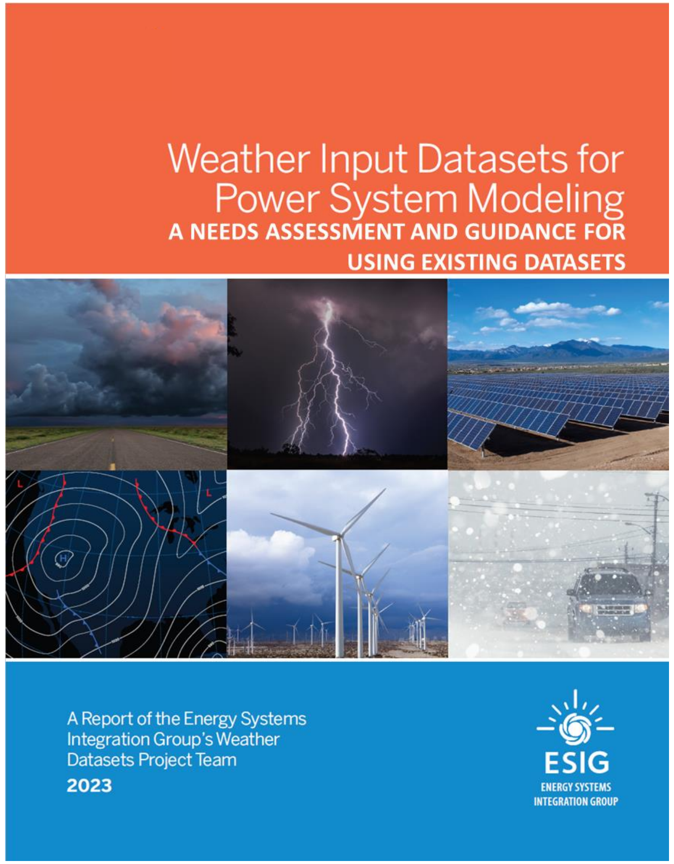
***Your assumptions are your windows on the world. Scrub them off every once in a while, or the light won't come in.***

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

# Acknowledgements/Disclaimer:

I'd like to acknowledge the help of the ESIG Weather Inputs Task Force team, especially to those contributed to the writing and/or deep review of the report that is discussed in the presentation.

The project was convened and supported by ESIG. Additional funding was provided by GridLab and in kind by Sharply Focused.




Report Landing Page

- Executive Summary
- Main Report
- Summary Report
- Meteorology 101

While largely objective, some of this presentation represents my own views, some of which may not necessarily be the official views of task force members or member organizations.

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# Agenda

- **The imperative of handling increasing weather dependence**
- Weather complexity => trans-disciplinary disconnects
- The attributes of the data we need
- Validation: A look at a critical gap
- Other gaps and limitations and their impacts
- A roadmap to the future

# Big Picture Motivation:
# Increasing Electric System Weather Dependency Due To The Energy Transition

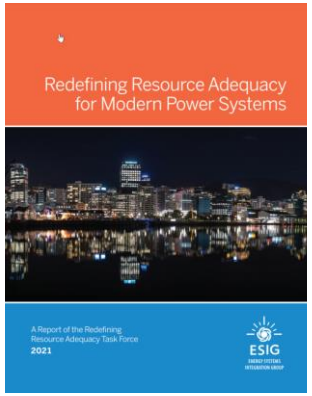
THE ELECTRIC SYSTEM IS CHANGING

**…RADICALLY…**

AND IS FULL OF UNCERTAINTY

THE SECTOR WILL NEED TO EVOLVE

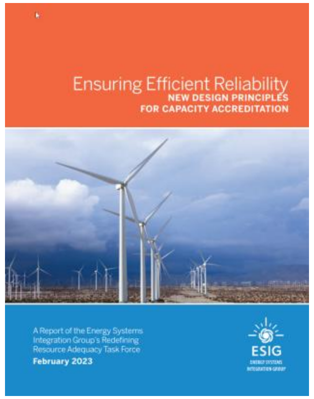
ITS METHODS ACCORDINGLY



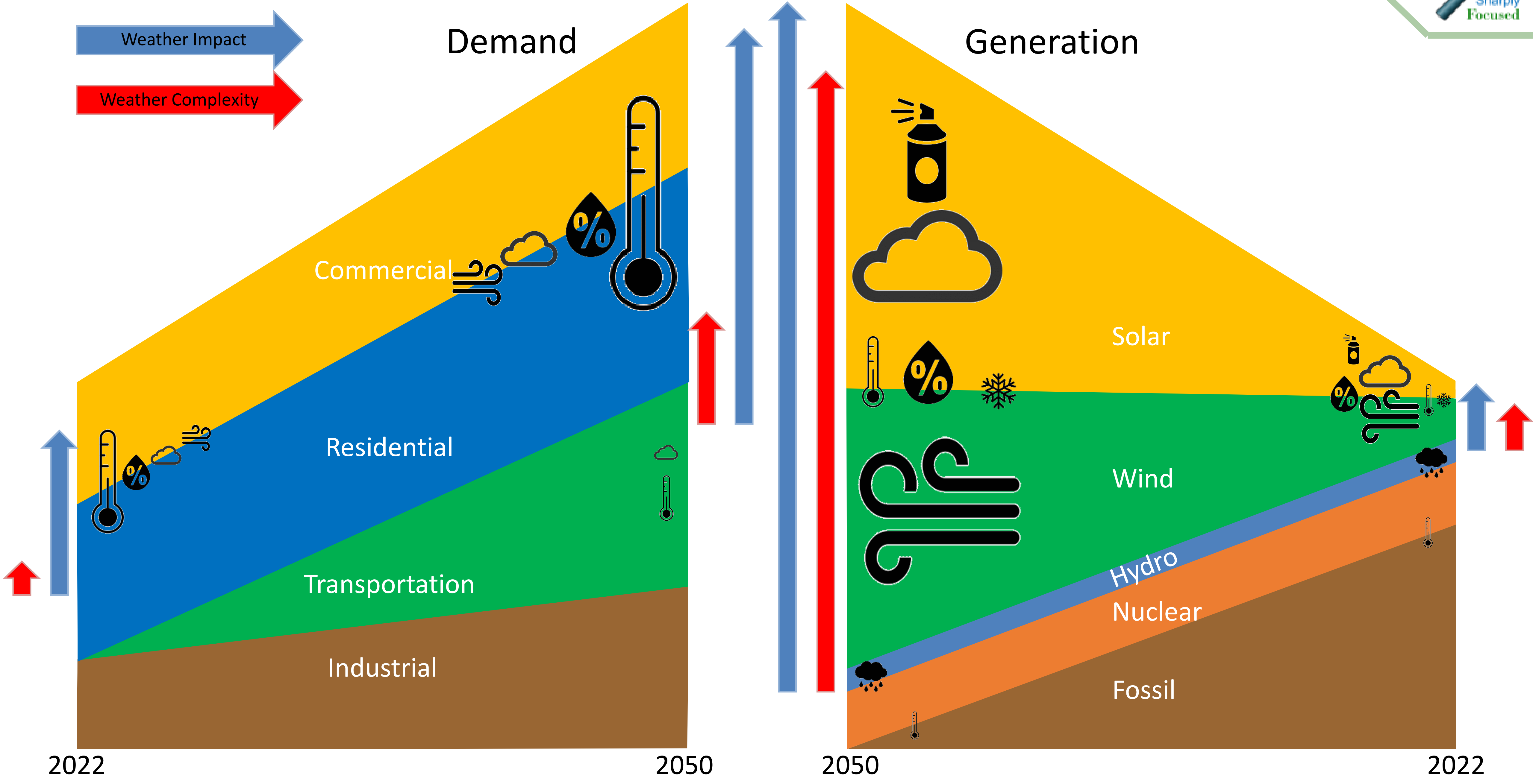

## Findings included in seminal consensus-based reports from the ESIG Rethinking Resource Adequacy initiative

The quality of power system studies becomes increasingly dependent on characterization of weather

Methods must evolve to more completely incorporate weather data



# The Evolving Weather - Energy Nexus



# • Our Weather "Intelligence" is Inadequate

Producer(s)

Create initial and ongoing gridded archives

Bias correction

Ongoing generic R&D

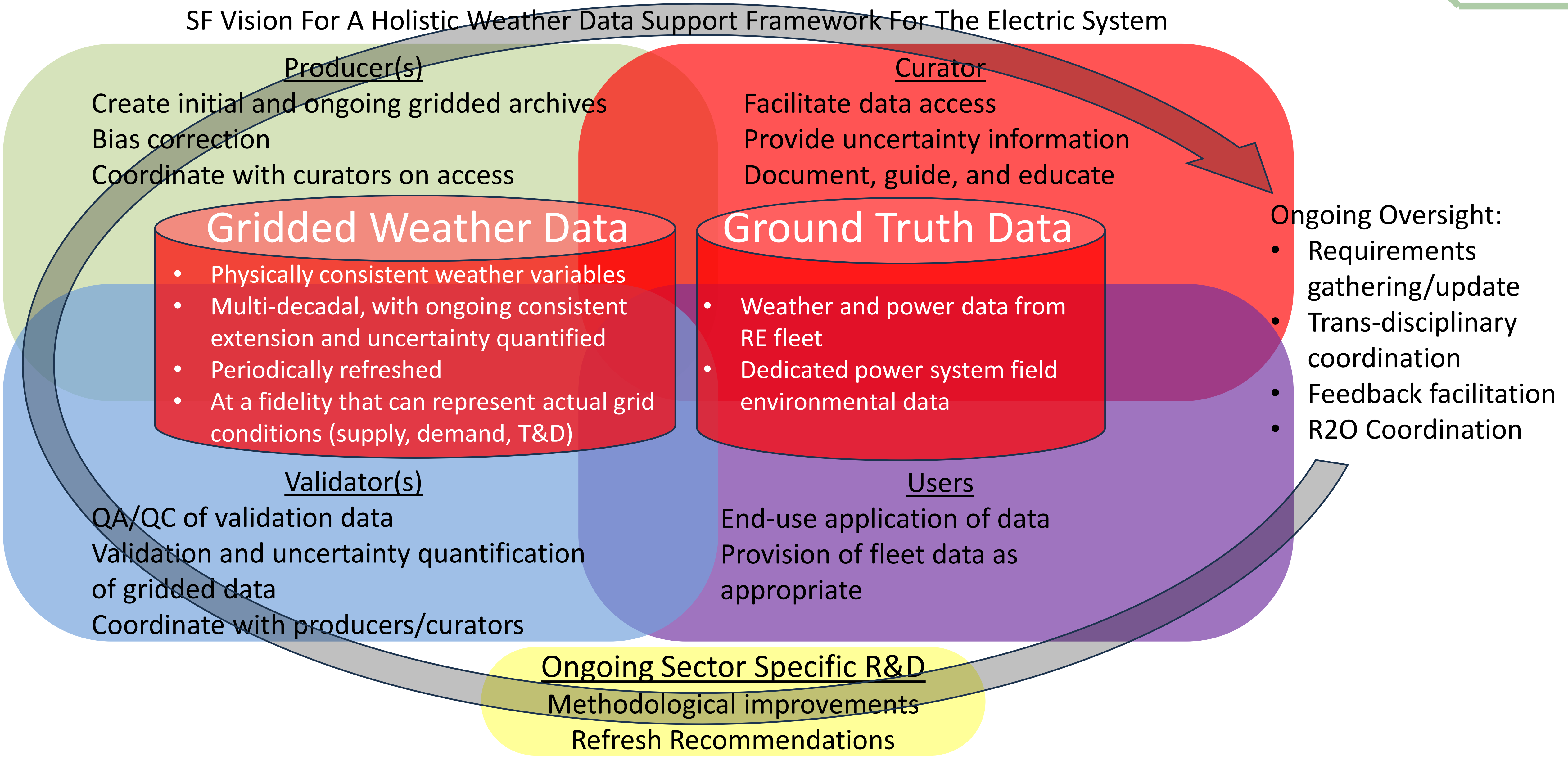
## Gridded Weather Data

- Physically consistent weather variables
- Multi-decadal, with ongoing consistent extension and uncertainty quantified
- Periodically refreshed
- **Insufficient resolution for general power systems use**

Users

End-use application of data

# • We Need Vision, Investment & Leadership



# Weather Dependence and Complexity are Increasing Rapidly

## Weather/Climate Are Becoming Central

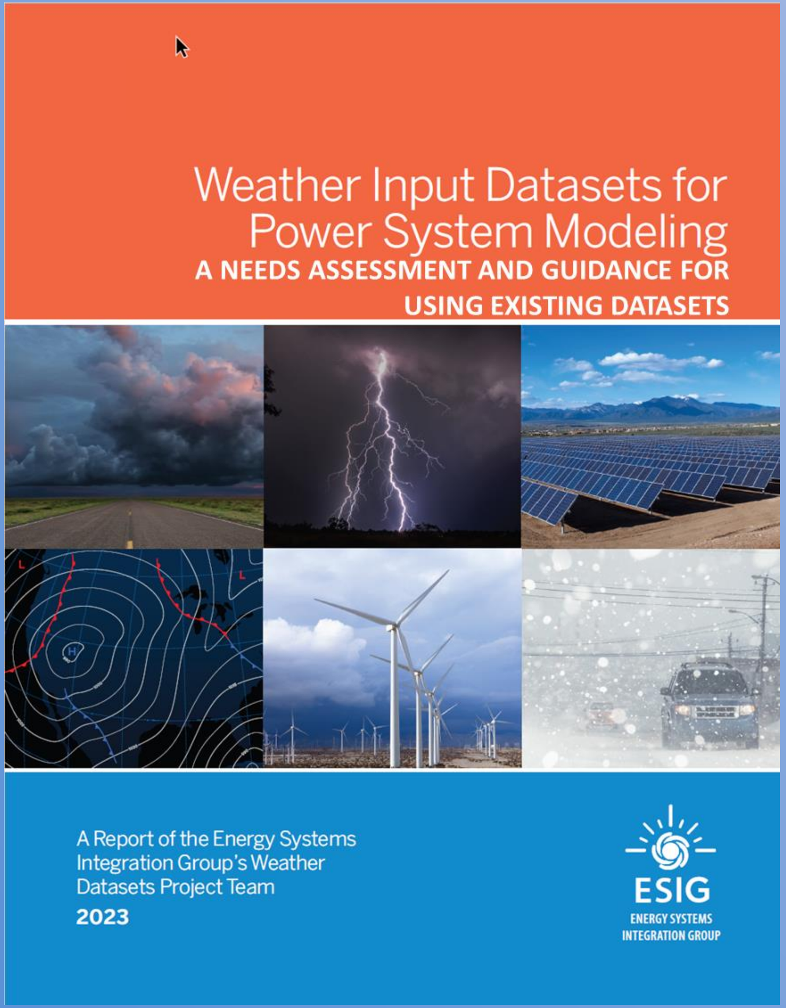
## Yet We Are Largely Flying Blind

There is an Imperative for Dedicated, Accurate, and Expertly Curated Weather Information to Support the Energy Transition!

The risks resulting from inaction:

- Reliability issues tied to renewables
- Slowed/halted decarbonization
- Inefficient system design and planning

**Risk $$$'s are orders of magnitude higher than task investment $'s**




Scan for report landing page

# It's not just me saying this…

Critical review of renewable generation datasets and their implications for European power system models

Alexander Kies[a,*], Bruno U. Schyska[b], Mariia Bilousova[a,c], Omar El Sayed[a,c], Jakub Jurasz[d], Horst Stoecker[a,c,e]

A B S T R A C T

In the process of decarbonization, the global energy mix is shifting from fossil fuels to renewables. To study decarbonization pathways, large-scale energy system models are utilized. These models require accurate data on renewable generation to develop their full potential. Using different data can lead to conflicting results and policy advice. In this work, several datasets that are commonly used to study the transition towards a highly renewable European power system are compared. Significant differences between these datasets are found, resulting in cost-differences of about 10%. These findings indicate that much more attention must be paid to the large uncertainties of the input data.

- Bloomfield *et al* 2016 *Environ. Res. Lett.* "Quantifying the increasing sensitivity of power systems to climate variability"
- Pfenninger 2017 *Appl. Energy* "Dealing with Multiple Decades of Hourly Wind and PV Time Series in Energy Models: A Comparison of Methods to Reduce Time Resolution and the Planning Implications of Inter-Annual Variability"
- Bloomfield *et al* 2018 *Environ. Res. Lett.* "The changing sensitivity of power systems to meteorological drivers: a case study of Great Britain"
- Collins *et al* 2018 *Joule* "Impacts of Inter-Annual Wind and Solar Variations on the European Power System"
- Zeyringer *et al* 2018 *Nat. Energy* "Designing Low-Carbon Power Systems for Great Britain in 2050 That Are Robust to the Spatiotemporal and Inter-Annual Variability of Weather"

- **Not all shortfalls are alike**… need to characterize size, frequency duration, and timing of events
- **Risk is shifting**… periods of concern longer occur during gross-peak load, need to look across an entire year of operation
- **Weather** is the single most important driver for resource adequacy…
  - Cross-disciplinary power systems and meteorological expertise is necessary
  - We need a North-American Weather Dataset for correlated wind, solar, and load
  - Climate trends should be considered
  - Correlated events are the issue!
- **Resource sharing** is critical, transmission is a capacity resource

T E L O S   E N E R G Y   www.telos.energy   11/17/2021   5

***Monte Carlo vs. Weather-Synchronized simulation:*** Weather-Synchronized simulation offers greater transparency and improved treatment of weather correlations, but is limited by data availability. The report explores the benefits and drawbacks of both methods using a deep dive on the No Additions Scenario.

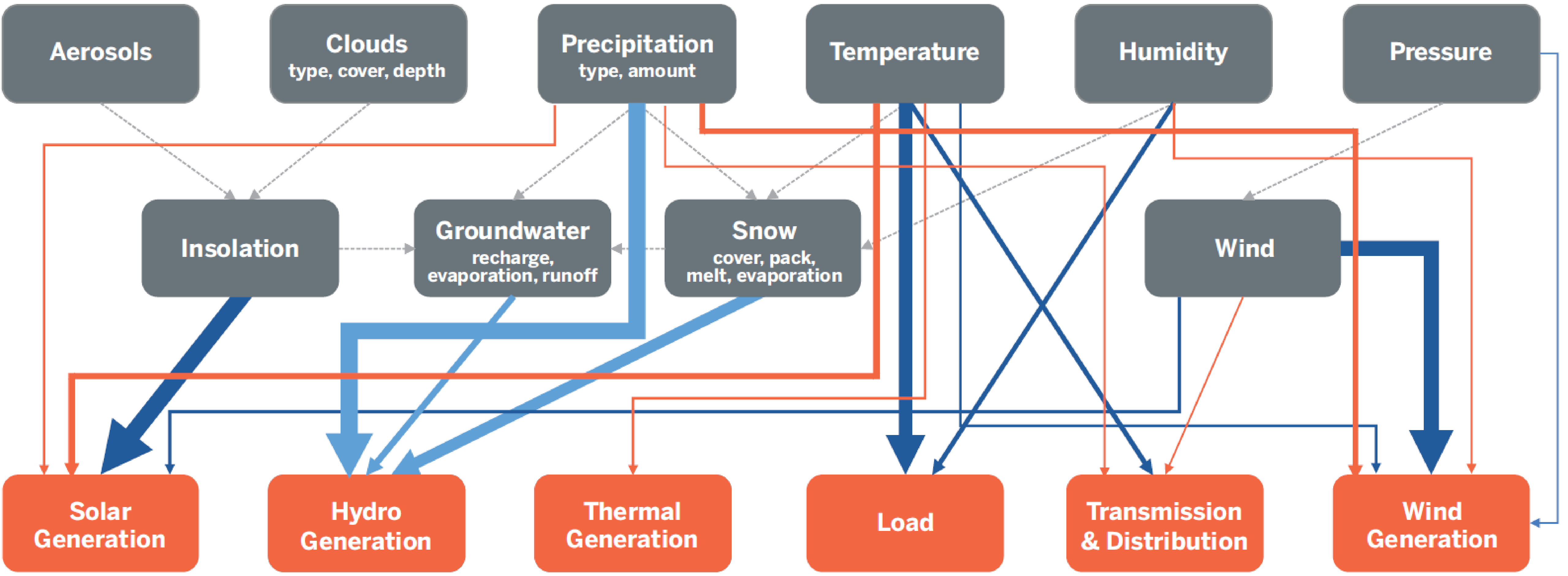
***Data needs:*** Regardless of the RA analysis approach, the availability of more high-resolution hourly power system data as well as information about likely future weather conditions would greatly improve our understanding of RA challenges. In particular, **the expansion of publicly available hourly wind power datasets to more recent years is a high priority**.

ADVANCING RESOURCE ADEQUACY ANALYSIS WITH THE GRIDPATH RA TOOLKIT | **FACT SHEET** | **3**

# Agenda

1. The imperative of handling increasing weather dependence
2. **Weather complexity => trans-disciplinary disconnects**
3. The attributes of the data we need
4. Validation: A look at a critical gap
5. Other gaps and limitations and their impacts
6. A roadmap to the future

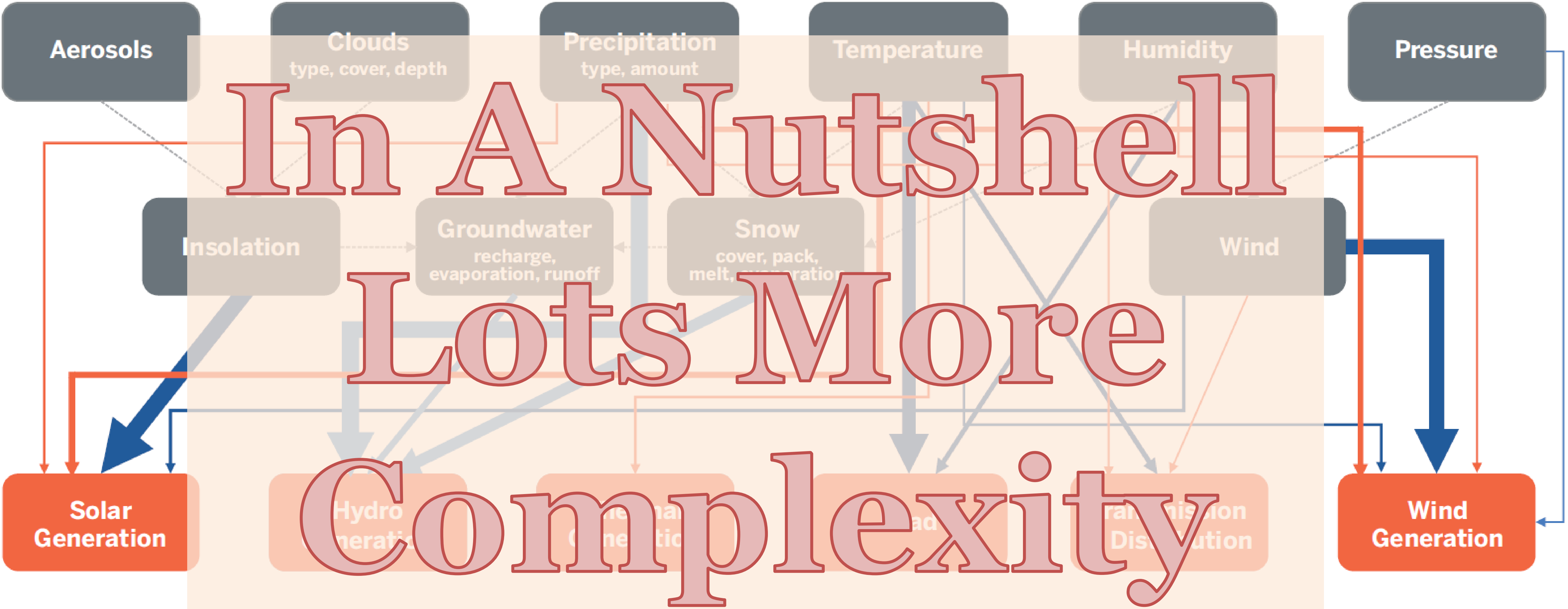
# Electricity System Weather-Dependence




**Typical magnitude is approximated by the thickness of the lines.**

- While all environmental variables are interdependent, these are some of the strongest internal links.
- Dependence of the electricity system on the climate system.
- Strength of dependence is highly variable and depends on asset type and location.
- Degree of dependence can be greatly amplified by specific weather and climate conditions.

# Electricity System Weather-Dependence

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Dependence of the electricity system on the climate system.

Strength of dependence is highly variable and depends on asset type and location.

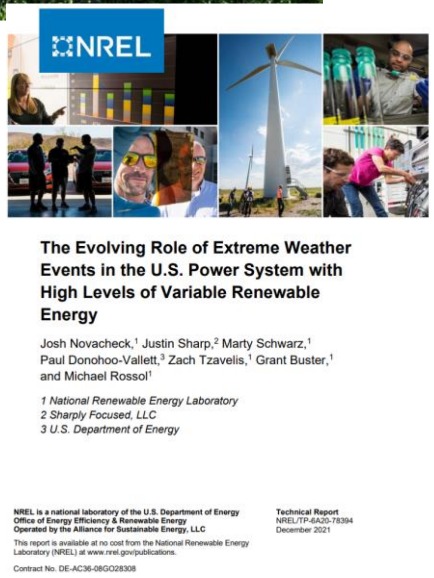
Degree of dependence can be greatly amplified by specific weather and climate conditions.

# Meteorology is Becoming Central



RISKS ARE SHIFTING

WEATHER DEPENDENCE AND WEATHER COMPLEXITY ARE INCREASING



The Evolving Role of Extreme Weather Events in the U.S. Power System with High Levels of Variable Renewable Energy

Josh Novacheck,[1] Justin Sharp,[2] Marty Schwarz,[1] Paul Donohoo-Vallett,[3] Zach Tzavelis,[1] Grant Buster,[1] and Michael Rossol[1]

*1 National Renewable Energy Laboratory*
*2 Sharply Focused, LLC*
*3 U.S. Department of Energy*

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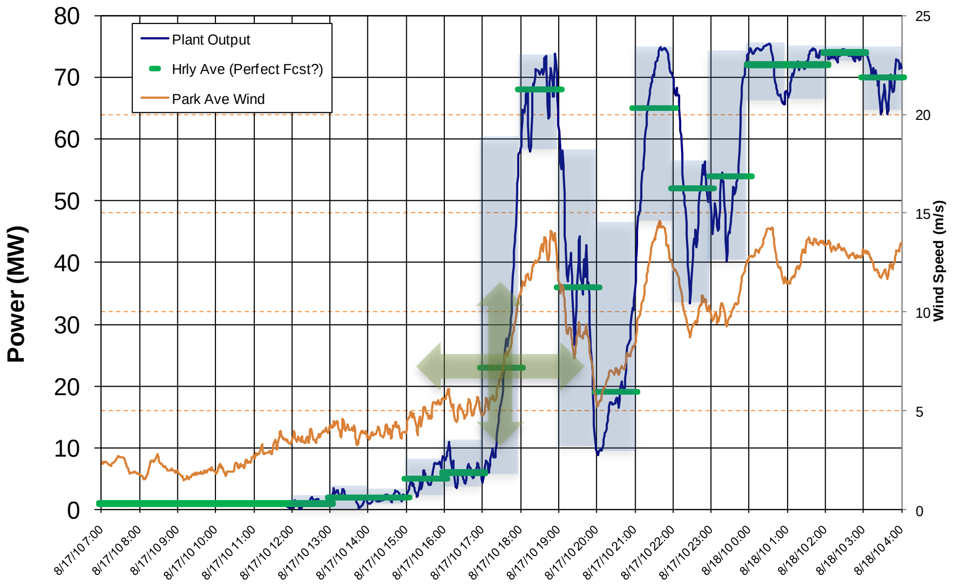
**Technical Report**
NREL/TP-6A20-78394
December 2021

NREL Transforming ENERGY

## The Evolving Role of Extreme Weather Events in the U.S. Power System with High Levels of Variable Renewable Energy

(Abstract: https://www.osti.gov/biblio/1837959 | Full Report: https://doi.org/10.2172/1837959)

# Weather Dependence Must Be Managed/Mitigated



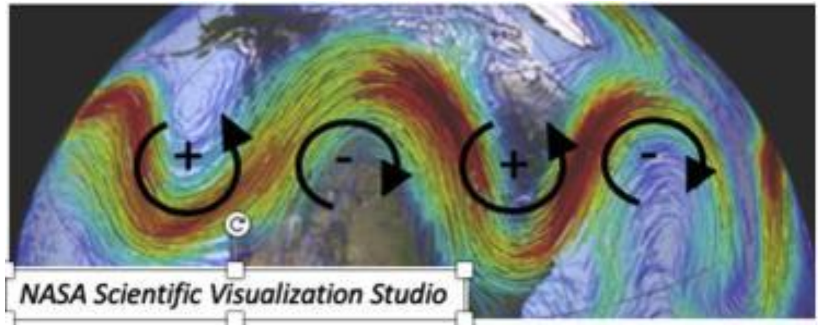

## Variability and Uncertainty

- Mostly due to weather at high RE penetration
- Operational forecasts reduce uncertainty
- Forecasts cannot reduce variability. Planning success depends characterizing and addressing variability ahead of operations.

## Ad-hoc Mitigation

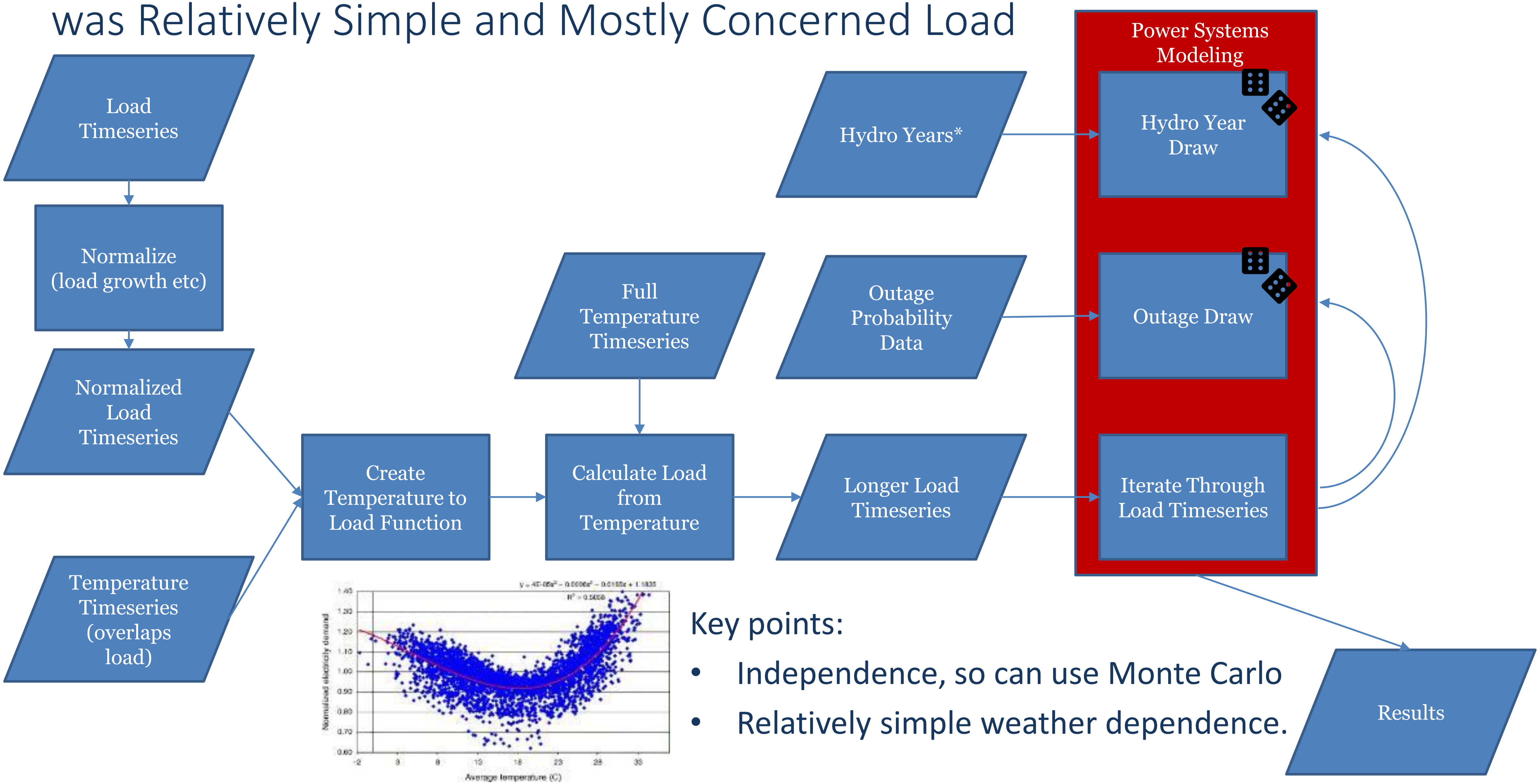
- Energy Storage/P2G
- Overbuilding/fossil backup
- Not efficient or cost effective.
- May not meet policy goals.

## Informed Mitigation




- Recognizes continental scale
- Builds T&G accordingly
- Requires high-quality, high-resolution, meteorological data
  - Current data is inadequate (pun intended) for the job.

# Power System Models Have Always Incorporated Weather but Treatment was Relatively Simple and Mostly Concerned Load

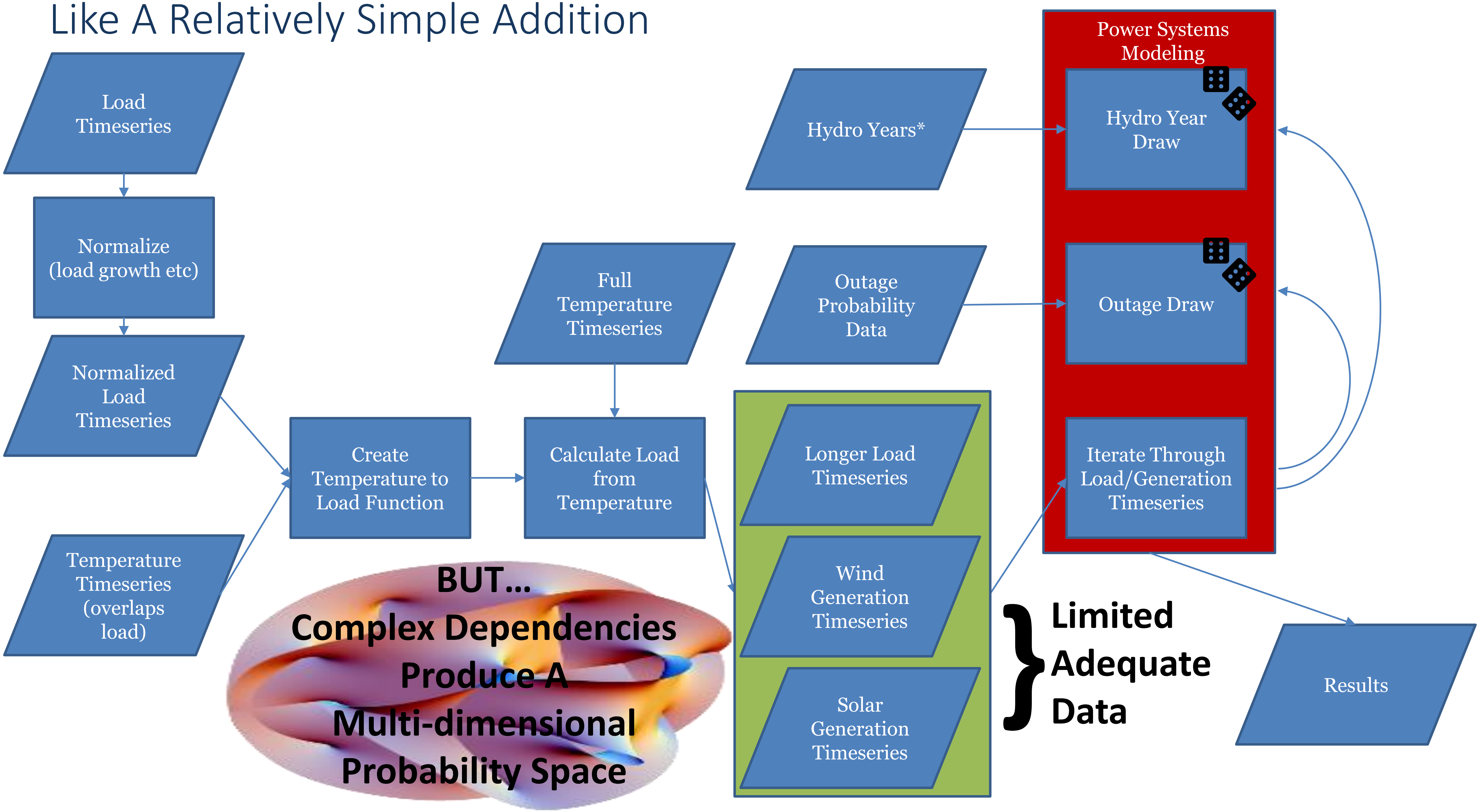



Key points:

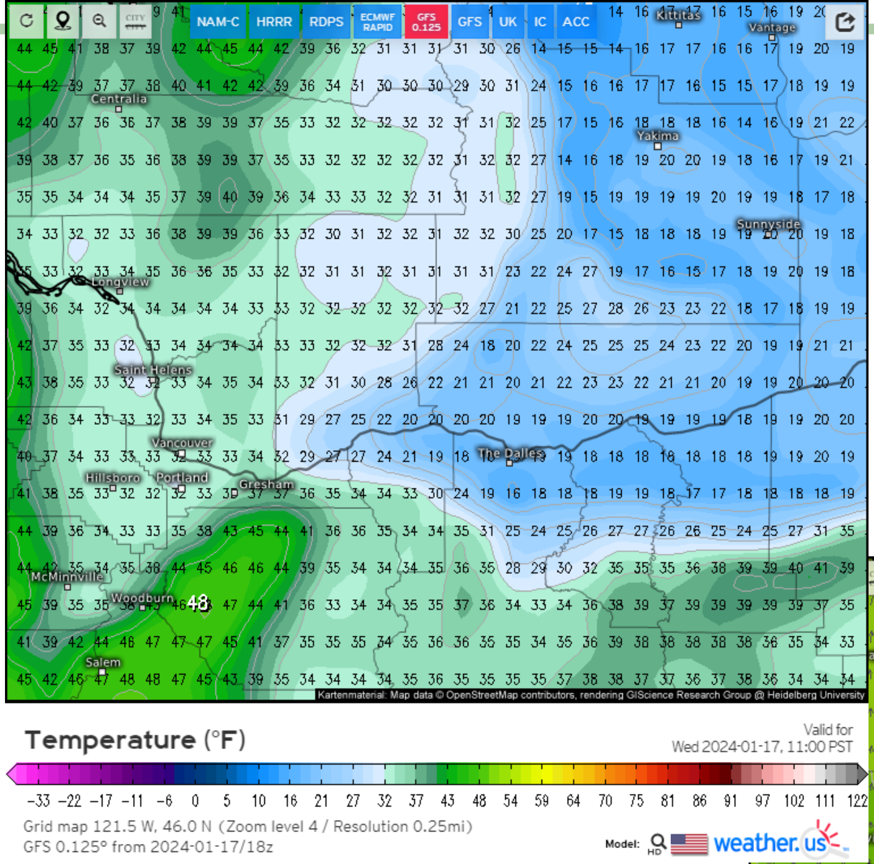
- Independence, so can use Monte Carlo
- Relatively simple weather dependence.

*Hydro years is illustrative only. Can iterate across other constraints. Nesting method can vary.

# At First Glance Adding Wind, Solar and Storage seems Relatively Seems Like A Relatively Simple Addition



- Modern weather datasets are increasingly complex
- They are typically NOT observations
- Let's illustrate this with very different model views of the same time in the historic January 2024 event
- The point: it's complicated
  - A trans-disciplinary approach is crucial
  - It needs to be coordinated and managed
  - It cannot be scattershot
  - Knowledge of all the needs, capabilities, and sources is needed




NOAA/NCEP GFS Model

0.125 degree

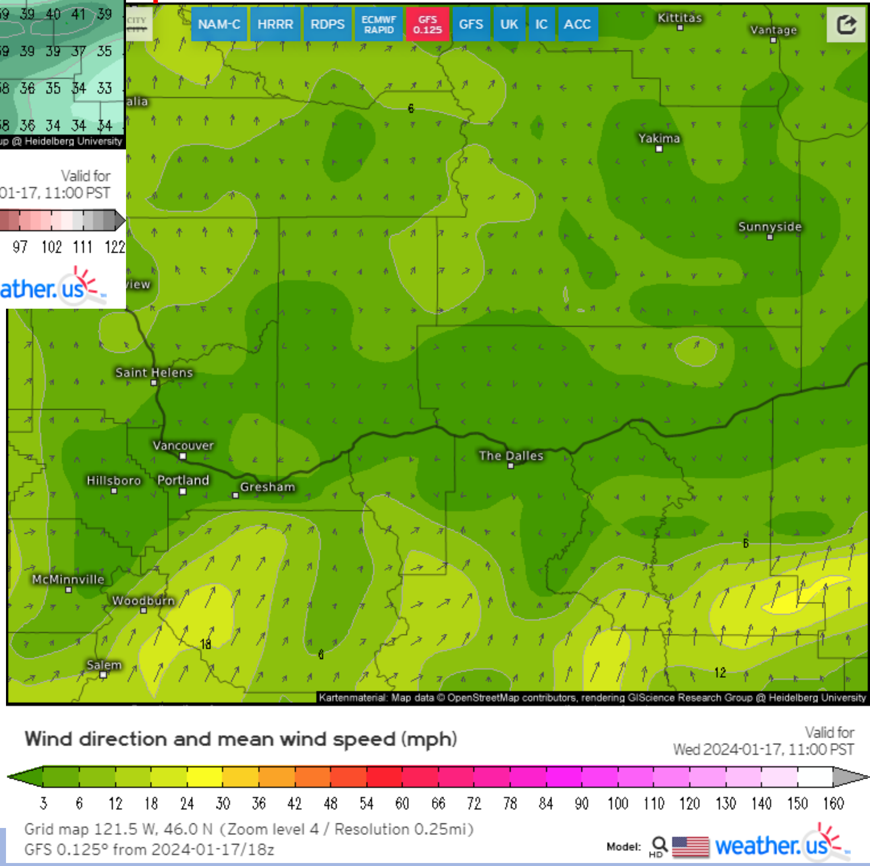
~13-km Grid Spacing

(>twice ERA5 resolution)

All 1-hr Forecasts

Valid 11 PST, 20240117

Differences in resolution of topography and the features driven by it, and in the model assimilation methods have profound effects



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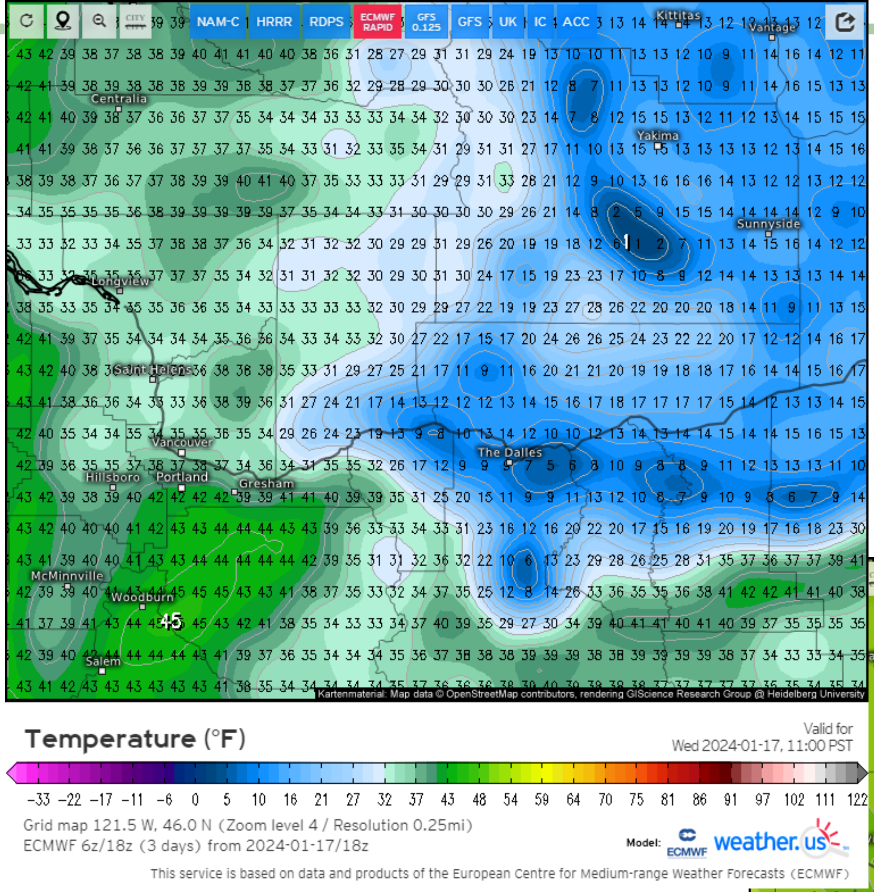
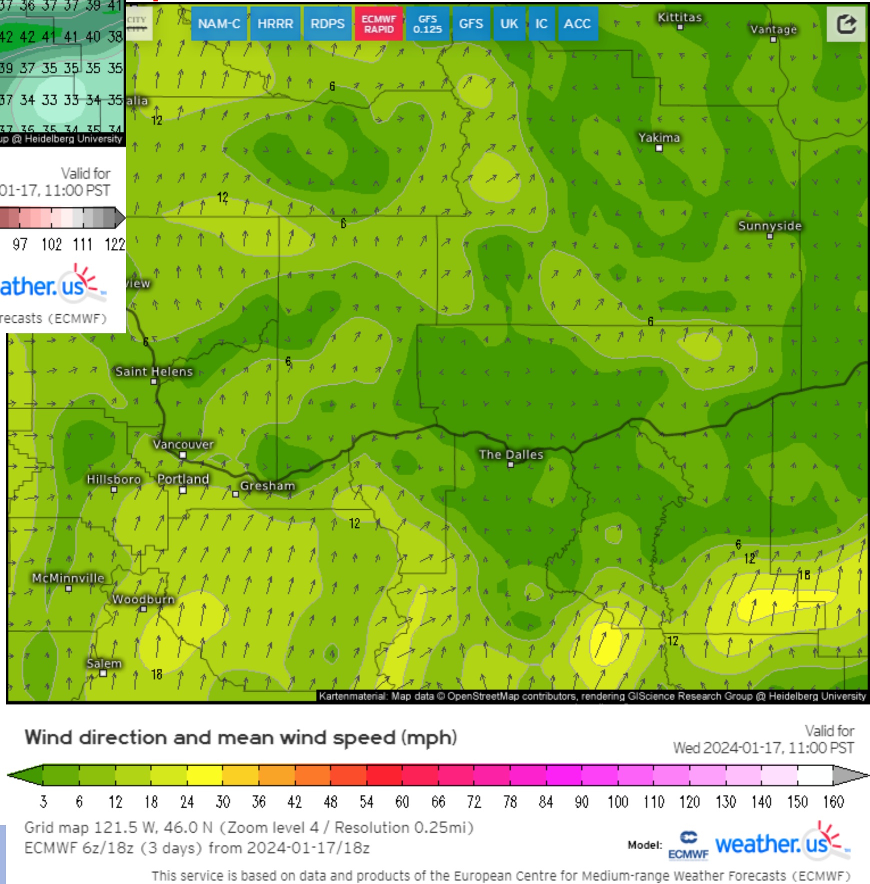



ECWMF IFS Model

~8-km Grid Spacing



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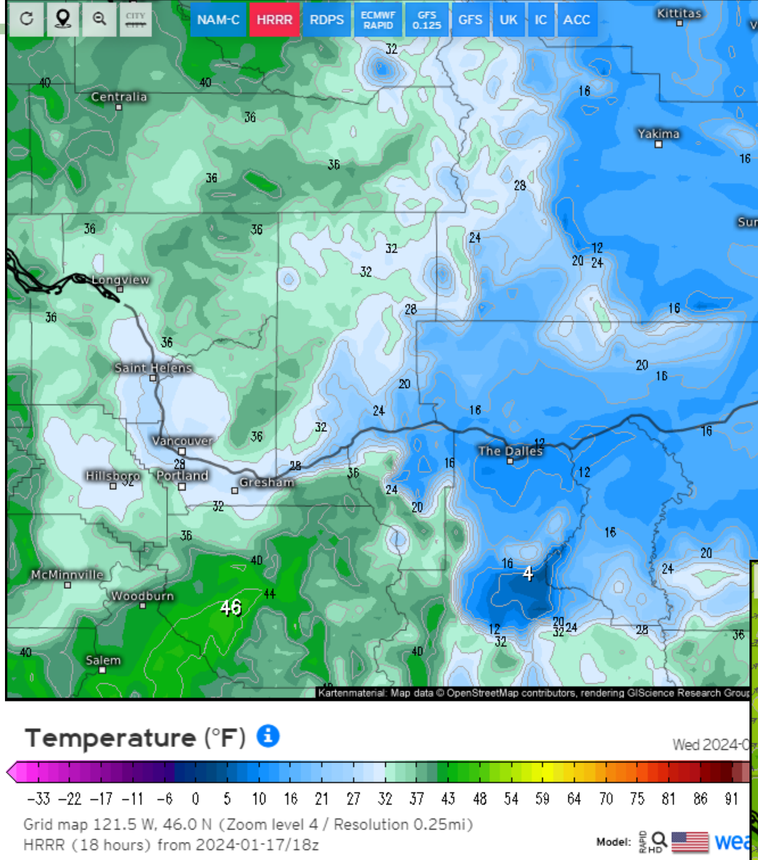
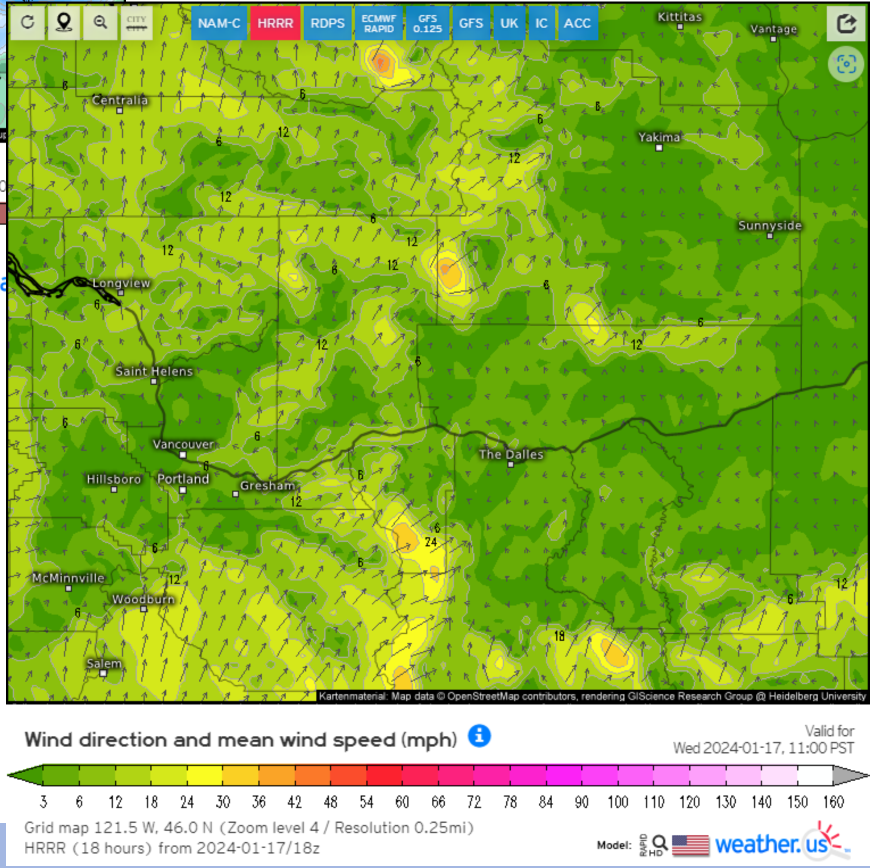
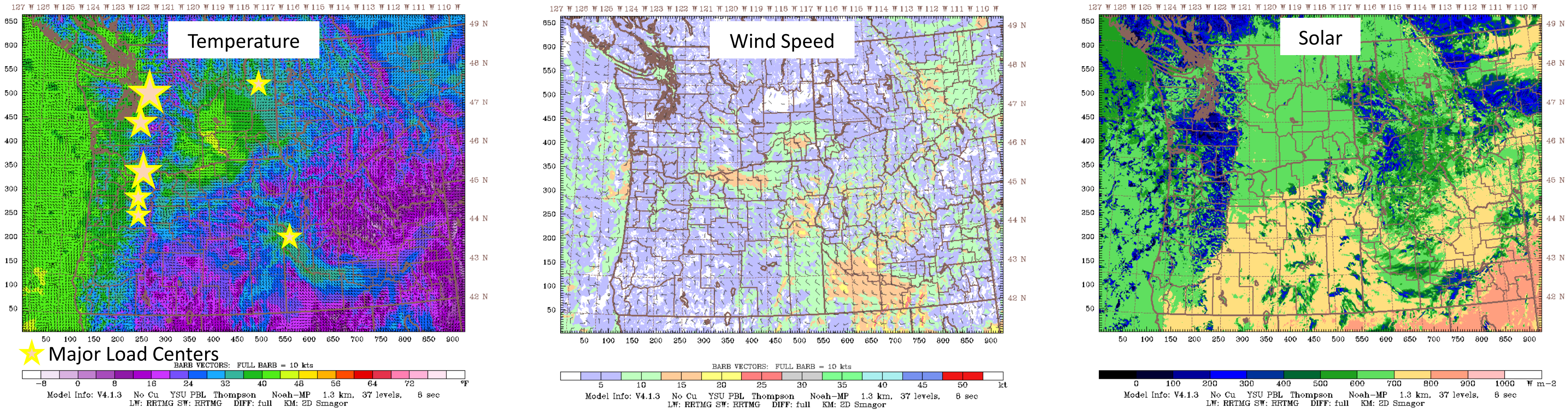



NOAA/NCEP HRRR

3-km Grid Spacing

Begins to resolve the Columbia Gorge.






- Power system models have always incorporated weather
  - Treatment mostly concerned with impact of temperature on load, and sampling of hydro years
  - Data needed from urban areas (with plenty of observations), and existing streamflow measurements
- Obs. of weather impacting wind and solar output are not widely available and MUST BE SYNTHESIZED
  - Fields vary rapidly across short distances and times, and are needed for remote areas
  - Data is sparse, has a short history, and where it does exist it is mostly **proprietary**
- The complex interaction between variables impacting load, wind, and solar MUST now be considered, and must be coincident and physically consistent (in time and space),and chronological.
- Interconnectivity in time and space yields complex, yet organized, multi-dimensional probability distributions that must be reasonable for accurate RA assessments.
- Storage, DERs, and weather impacts on G,T, and D add more layers of complexity.

# Agenda

- The imperative of handling increasing weather dependence
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- **The attributes of the data we need**
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- A roadmap to the future

# What is Needed: Ongoing Synthesis of Quality Representative Datasets

## Required Attributes of Weather Inputs for Power Systems Analysis

**Physical Requirements**

- Representative of Actual Weather
- Coincident, Physically Consistent Weather Variables
- Sufficient Resolution (<=2 km, <=15 min)
- Chronological

**Relevance Requirements**

- Covers Multiple Decades with Consistent Method
- Validated and Uncertainty Quantified
- Periodically Refreshed
- Regularly Extended

**Usability Requirements**

- Expertly Curated
- Publicly Available and Easily Accessible
- Transparently Documented

# The Main Attributes of Time Series Data Necessary to Meet General Power System Modeling Needs

Provided for Offline Use

| | |
|---|---|
| **Including the necessary variables** | Include the necessary variables at sufficient spatio-temporal resolution and accuracy to reflect actual conditions that define the generation potential at current and future wind/solar sites and temperature at load centers |
| **Covering multiple decades with ongoing extension** | Cover multiple decades with consistent methodology and be extended on an ongoing basis to capture the most recent conditions and allow climate trends to be identified |
| **Coincident and physically consistent** | Are coincident and physically consistent, in space and time, across weather variables |
| **Validated** | Are validated against real conditions with uncertainty quantified |
| **Documented** | Are documented transparently and in detail, including limitations and a guide for usage |
| **Periodically refreshed** | Are periodically refreshed to account for scientific and technological advancements |
| **Available and accessible** | Publicly available, expertly curated, and easily accessible |

Source: Energy Systems Integration Group.

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# Don’t We Produce This Data and Use it in Operations???

## Yes, we do which leads to the radical statement that:

**Historical generation estimations used in power system modeling are currently less accurate than operational generation forecasts.**

Why? 1) Proprietary plant data are available and used for training/validation of operational forecasts, and more attention is paid to their accuracy. 2) Only need data for the next few days, versus for the last few decades.

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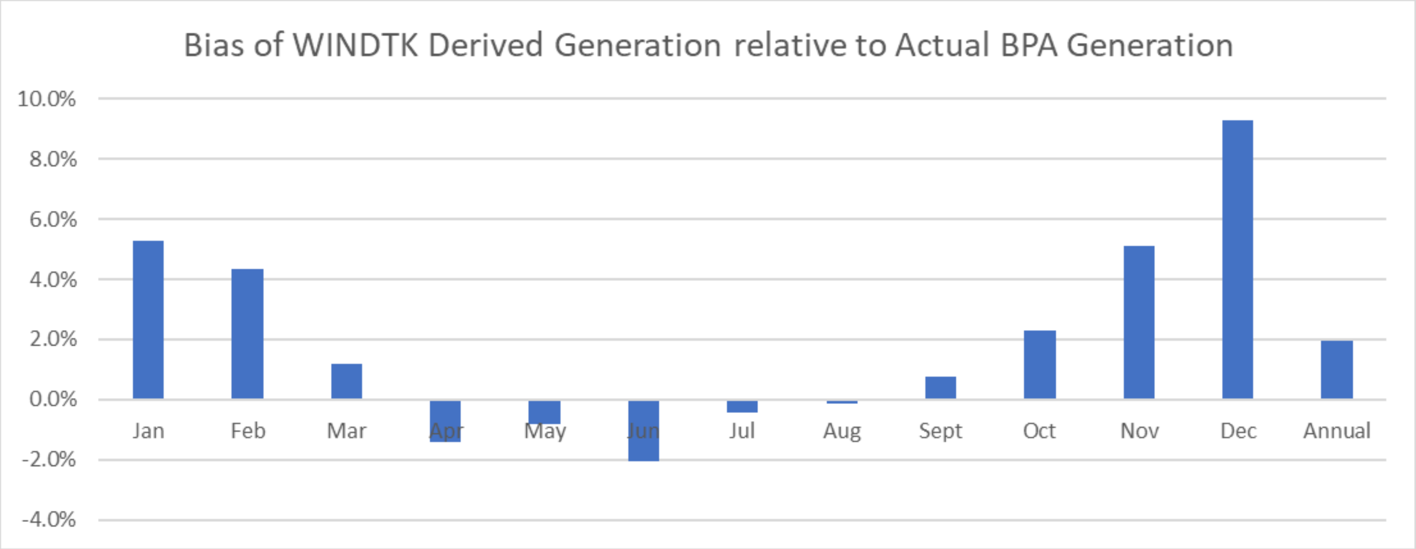
# What's Needed: Use Case Specific Validation

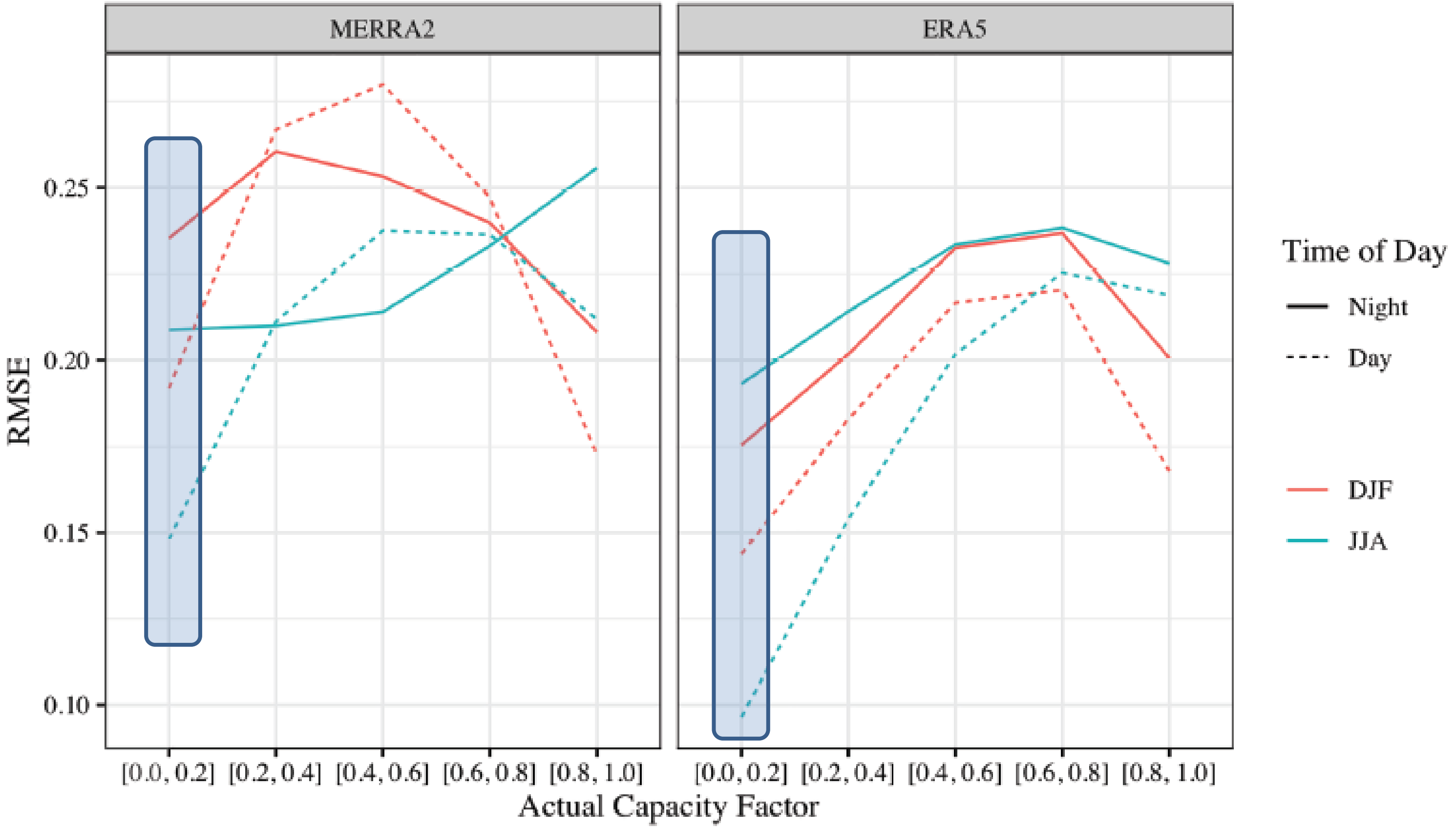
- We must validate according to the use case. E.g. For RA, the distributions, and especially the tails, matter more than the averages
- The distribution of coincident tail events MUST be close to reality
- Example:
  - WINDTK data in the BPA area
  - Wind resource in BPA BA is notoriously difficult to predict with NWP => WFIP2 Project
    - Complex terrain that needs a minimum of 1.33 km resolution to resolve
    - Stable boundary layer issues in the wintertime. => Low wind AND high load

These biased low wind speed events frequently coincide with high load events due to regional mesoscale meteorology



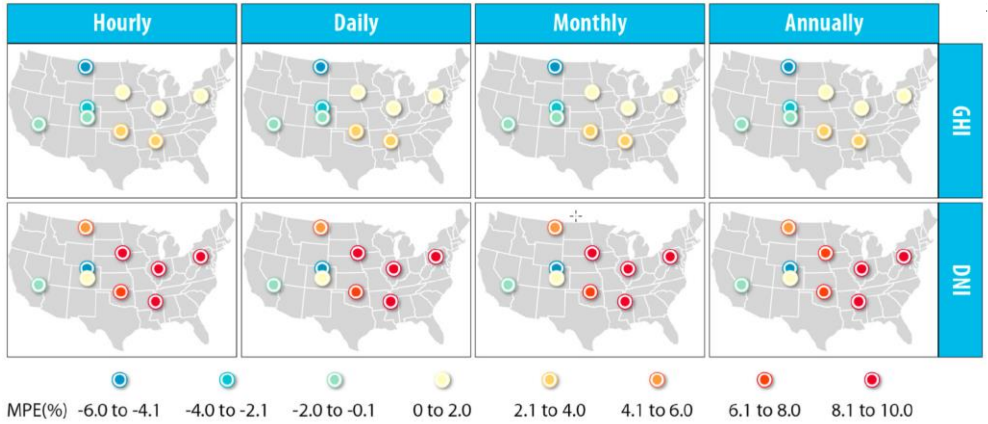

Tail event deviations can be >7x.
e.g. BA wide generation of 3% and model-based estimates of 23%!

# When Validated How Bad Is The Existing Data?




Average RMSE as a function of recorded CF bins for winter and summer divided into nighttime (8–1 h before sunrise) and daytime (1–8 h after sunrise) averaged across over 100 ERCOT windfarms over 7-years.

Figure: Davidson & Millstein (2022): Limitations of reanalysis data for wind power applications




NSRDB validated* against a handful (literally) of observations, because there simply aren't many quality surface solar measurements available. Note mean percentage error is significant on an hourly and even daily basis, especially for DNI. Despite not being created for this purpose, NSRDB is broadly used as the solar insolation input to estimate solar generation for PS modeling, generally without reference to data input uncertainty

*Sengupta et al (2018): The National Solar Radiation Data Base (NSRDB); Renewable and Sustainable Energy Reviews. *(Figure from paper)*

Note the errors at low CF's (boxed). These matter the most for resource adequacy studies.

# What is Needed: Comprehensive Industry Wide Data Transparency and Sharing

- What: Meteorology data, generation data, availability data
  - Little proprietary value per site but a tremendous untapped asset if made public across all generators
- Why: To validate synthetic meteorology and generation datasets, quantify their uncertainty, and improve their accuracy
- ERCOT is leading the way. Others should follow ASAP
  - Might require legislation/regulation.

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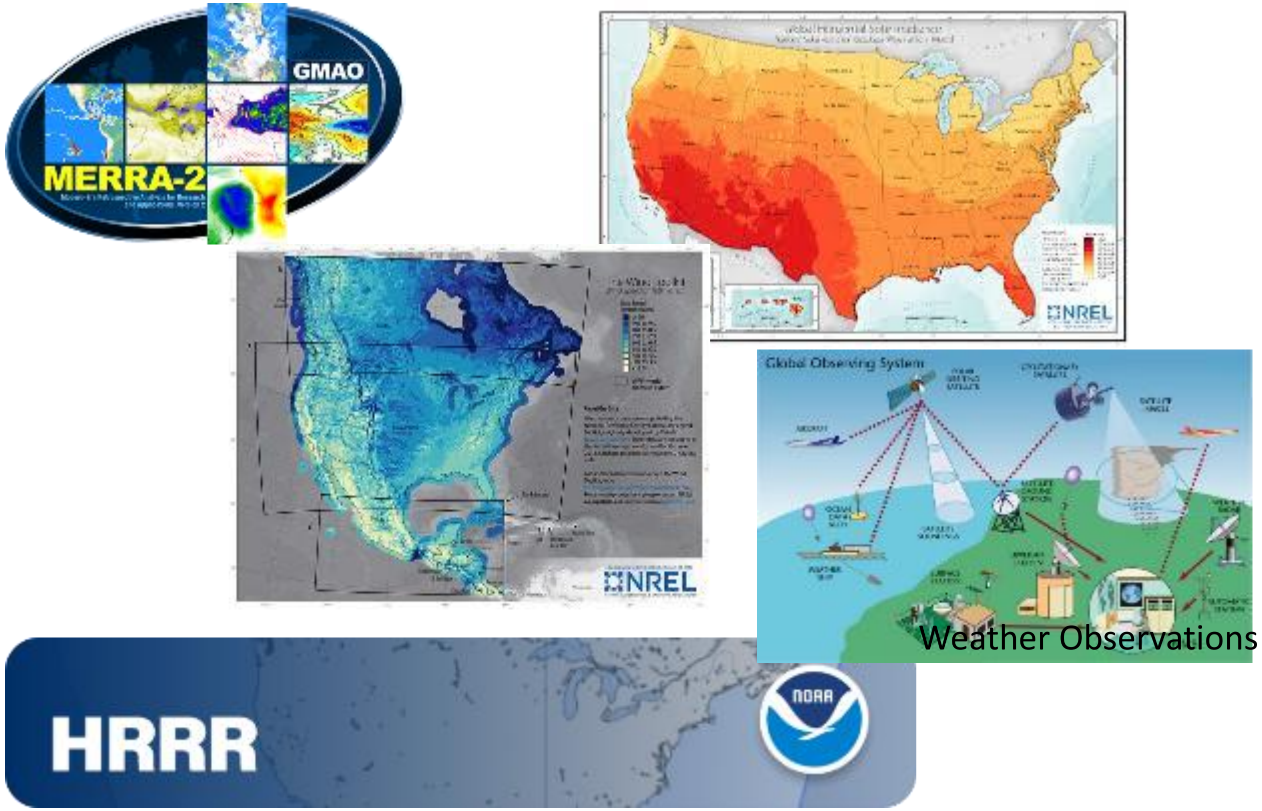
# What About The Data Available Today?

ERA5




The data currently available to the sector (on left) is not adequate for the task at hand. Main issues are one or more of the following:

- Insufficient spatial or temporal resolution
- Insufficient time history
- Insufficient validation
- Distributions don't match reality, especially for extreme events
- Sometimes proprietary and opaque
- Not coincident or physically consistent
- Archaic or not extended to present date
- Non-static modeling platforms

Why does it matter?

- You can't correctly predict the wind and solar generation if the weather data isn't good. Sometimes, you'll be WAY off.
- Load estimation is also more difficult

# A Closer Look at the Data Available Today

- Observations:
  - Closest representation of truth
  - Too sparse, and requires rigorous QC
  - And/Or Proprietary
- ERA5 (~30 km) (and MERRA2, ~60 km):
  - Longest, most complete consistent time series
  - Easy to use
  - Too low resolution for generation estimates
- WIND TK (2 km, 5 min/hourly):
  - Resolves most physical phenomena
  - Includes forecast database
  - Some temporal seams
  - Outdated model, esp. not great for solar
  - Only 2007-2013 using same set up. 2014 available using different configuration.
- NSRDB (4 km, 30 min):
  - Based on satellite observations and a physics based model
  - Continuous and consistent since 1998
  - Not originally designed for integration studies
  - Non-solar fields are misleading interpolations of MERRA2
- HRRR (3 km, 15 min):
  - Resolves most physical phenomena
  - Data from operational forecast archive
  - Model configuration inconsistent in time
- Data from proprietary models:
  - Opaque and often unscientific in basis

Common Issue: Lack of validation and examination of use case applicability

# General Issues with Today's Methodologies

- Provided for offline reference reading!
- Model data (even reanalysis data) is NOT the same as observations
  - Ability to represent features is limited by resolution.
  - LARGE deviations can exist between model data and reality
  - Models have limitations and weaknesses. These are understood by NWP experts but not by general data users
- Model data is being used as a black box
  - Gridded data is easily accessible and easy to use
  - Therefore, it is very attractive to data hungry users
  - But see bullet#1…users must understand the limitations and the impacts on downstream results
- Lack of validation:
  - Model data contains many (often millions) of data points.
  - There is very little validation of any of these points
  - Mostly because there are few observations available (but see below)
  - Validations are not targeted to RA needs (e.g. low resource periods)
- Lack of observations for validation, bias correction and generation estimation
  - Model data MUST be validated, and uncertainty quantified
  - Models will always be imperfect. Ground truth allows sophisticated bias correction to be applied
  - Generation data allows sophisticated models to be used to estimate generation time series from past met. Data
  - **The rapid build out of wind and solar means this data is available. But it is currently proprietary. This must change.**

# A Quick Word About Climate Change

- It isn't the focus here, but it is important
- Getting our house in order to address climate ***variability*** is the #1 priority
- By doing that in an ongoing fashion we implicitly begin to address climate trends
- We also begin to validate and quantify the uncertainty of climate change models
- While large, I believe the impact of climate change is second order compared to the massive impact of increased weather dependency and the need to properly quantify climate variability in this context

# Provided for Offline Use

**TABLE 2**

Summary of Current Power System Modeling Weather Input Data Sources

| | Spatial Resolution | Temporal Resolution | Length | Continuously Extended | Correct Variables/ Levels | Coincident and Coherent | Validated/Uncertainty Quantified for Power System Use | Detailed Documentation | Future-Proofed | Availability/ Ease of Access | Curation and Advice | Region Covered |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MERRA-2**[a] | ~60 km | 60 min | 1980–present | Yes | Yes/No | Yes | No | | Probably | | Basic | Global |
| **ERA5**[b] | ~30 km | 60 min | 1940–present | Yes | Yes/No | Yes | Some | | Yes | | Good | Global |
| **HRRR**[c] | 3 km | 15 min | 2014–present | Yes | Yes/No | Yes/No | No | | Unideal | | Basic | U.S. |
| **WIND Toolkit**[d] | 2 km | 5 min | 2007–2014 | No | Yes/Yes | Yes | Yes | | No | | Basic | Various |
| **WTK-LED**[e] | 2 km/4 km | 5 min | 3 year/ 20 year | No | Yes/Yes | Yes | Not yet | Not yet | No | Unknown, dataset not yet available | | Various |
| **NSRDB**[f] | 4 km/ 60 km | 30 min | 1998–present | Yes | Yes/No | Solar only | Yes | | Yes | | Basic | Most of globe |
| **CERRA**[g] | 11 km/5.5 km | 60 min | 1980–present | | No/Yes | No solar | Yes | | Possibly | | Basic | Europe |
| **CONUS404**[h] | 4 km | 60 min/ 15 min (precip) | 1980–2020 | No | Unknown/ Probably | Yes | Not the intended use | | | | | Continental U.S. |
| **BARRA**[i] | 12 km/ 1.5 km | 60 min | 1990–2019 | No | Yes/ Probably | Yes | | | | Fee-based | | Australia/ New Zealand |
| **Public Observing Networks**[j] | Non-uniform, variable density | 1 hr or less | Variable | Yes | Yes/No | Mostly | Varies. Not for power systems | Varies | Usually | Usually easy | Varies | Global |
| **Renewable Energy Project Data**[k] | Non-uniform, variable density | Usually minutes | Variable but rarely more than 10 years | Varies | Yes/ Usually | Yes | Usually | Varies, but usually poor | Varies | Usually poor | Usually none | Very limited |
| **Proprietary Statistically Derived VRE Shapes**[l] | Non-uniform, variable density | Usually hourly | Variable. Rarely reliable long records. | Varies | Usually incomplete | No | Partial | See note | No | | None | Very limited |

Fully Met · Close to Being Met · Partially Met · Met in a Very Limited Way · Not Met at All · Not Enough Info. for Determination

Summary of the most applicable datasets globally that are (or can be) used to provide weather inputs for power system analysis tasks, especially for providing estimate of site-level generation, and concurrent weather-driven load and generation outage risks. The degree to which the needs of each column heading are met is estimated with color coding. See documentation for each dataset for all details. Footnotes on next page. P76, main report.

Source: Energy Systems Integration Group a MERRA-2. The resolution of MERRA-2 (Modern-Era Retrospective Analysis for Research and Applications) is typically insufficient for weather input use in power system analysis.

b ECMWF (European Center for Medium-Range Weather Forecasting) Reanalysis v5. ERA5 has insufficient resolution to diagnose regional or local weather, yet it is widely used for power system analysis.

c High-Resolution Rapid Refresh (HRRR). The HRRR is an operational model and therefore configured to balance accuracy with speed. It undergoes regular configuration updates, so model skill is changing in time. Occasionally, major updates may occur that can create step changes in model biases.

d Wind Integration National Dataset Toolkit. The years 2007 through 2013 cover the U.S., and 2014 uses a different configuration that includes Mexico and Canada.

e WTK-LED (WIND (Wind Integration National Dataset) Toolkit Long-term Ensemble Dataset) is still in production, and there is little current documentation. There are three years at 2 km, and 20 years at 4 km that are downscaled to 2 km with the machine learning GAN (generative adversarial network) approach. In addition, one year of ensemble data is being produced to aid in quantifying uncertainty.

f NSRDB (National Solar Radiation Database). Irradiance resolution is 4 km. Other variables are interpolated from MERRA-2 data using an unvalidated method. These data are generally not appropriate as weather inputs to power system analysis, forcing NSRDB to be used in combination with other datasets, which creates consistency issues.

g CERRA (Copernicus Regional Reanalysis for Europe). Ensembles at 11 km. Does not include all weather variables.

h CONUS404. A 4 km, long-term regional hydroclimate reanalysis over the conterminous United States (CONUS), 1979–2020. Developed by the U.S. Geological Survey to assess hydrological climatology, but may be useful to repurpose for power system analysis.

i Bureau's Atmospheric High-Resolution Regional Reanalysis for Australia. A 12 km reanalysis with 1.5 km domains over four cities in Australia.

j Many public observing networks exist with variable density, quality, and applicability.

k Observed data from renewable energy facilities is of course applicable to variable renewable energy, but quality varies from site to site and is typically proprietary. Data across the upper portion of the rotor sweep is often not measured.

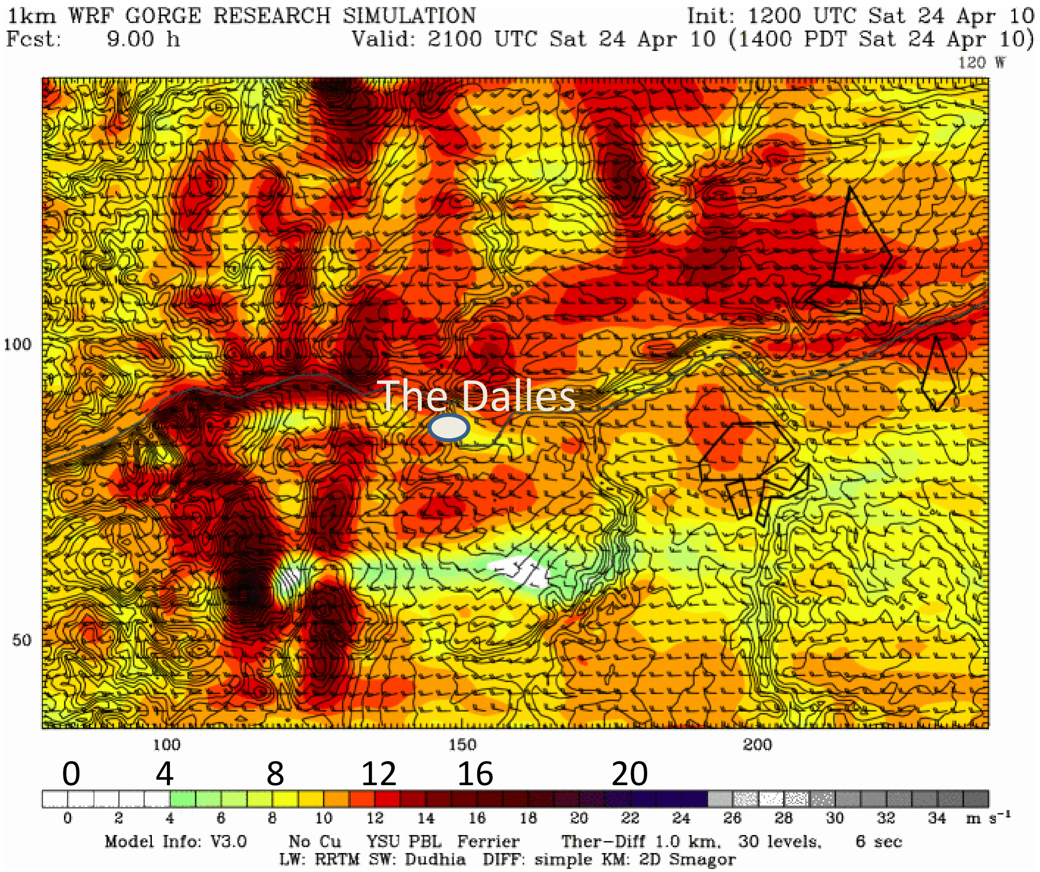
l Often used proprietary data. The same shape is often assumed across broad areas. Validations are not rigorous, and methodologies are usually not fully documented in a transparent way. Output usually includes only a single weather variable.

# Agenda

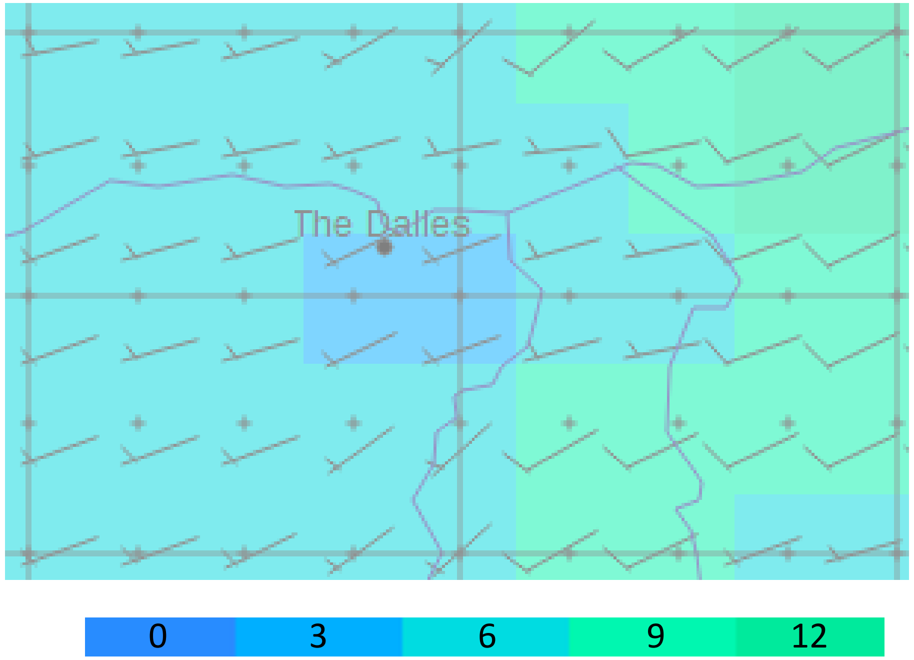
- The imperative of handling increasing weather dependence
- Weather complexity => trans-disciplinary disconnects
- The attributes of the data we need
- Validation: A look at a critical gap
- Other gaps and limitations and their impacts
- **A roadmap to the future**

# What is Needed: Behavioral Change and Trans-disciplinary Coordination

- Treating NWP model data as black box data is a recipe for disaster!
- Both meteorology and power systems are complicated. Let's stop assuming we understand each other's specialties and work more closely to meet each other's needs.




1 km WRF Forecast and ERA5 Reanalysis (~30 km) Valid Around the Same Date and Time



# How Do We Get To What We Need?

- Power systems experts need to working with NWP experts to ensure there is crystal clear requirements specifications. Meteorologists must be transparent about what is and is not possible
- At least three possible methods. Analyze cost benefit FIRST before expending large amount of effort.
  - Reanalysis + obs + machine learning (cheapest, my gut tells me it will be insufficient)
  - Moderate resolution NWP + GAN Downscaling (promising but needs validation)
  - High resolution NWP (will definitely work but still won’t be perfect)
- All methods require a comprehensive set of observations from industry. Start with ERCOT if we can’t get them anywhere else.

# How Much Will It Cost/How Long Will It Take?


OR

**<u>Rough</u>** ballpark estimates for 1-km CONUS dataset back to 1990 based on polling vendors specializing in high volume NWP work

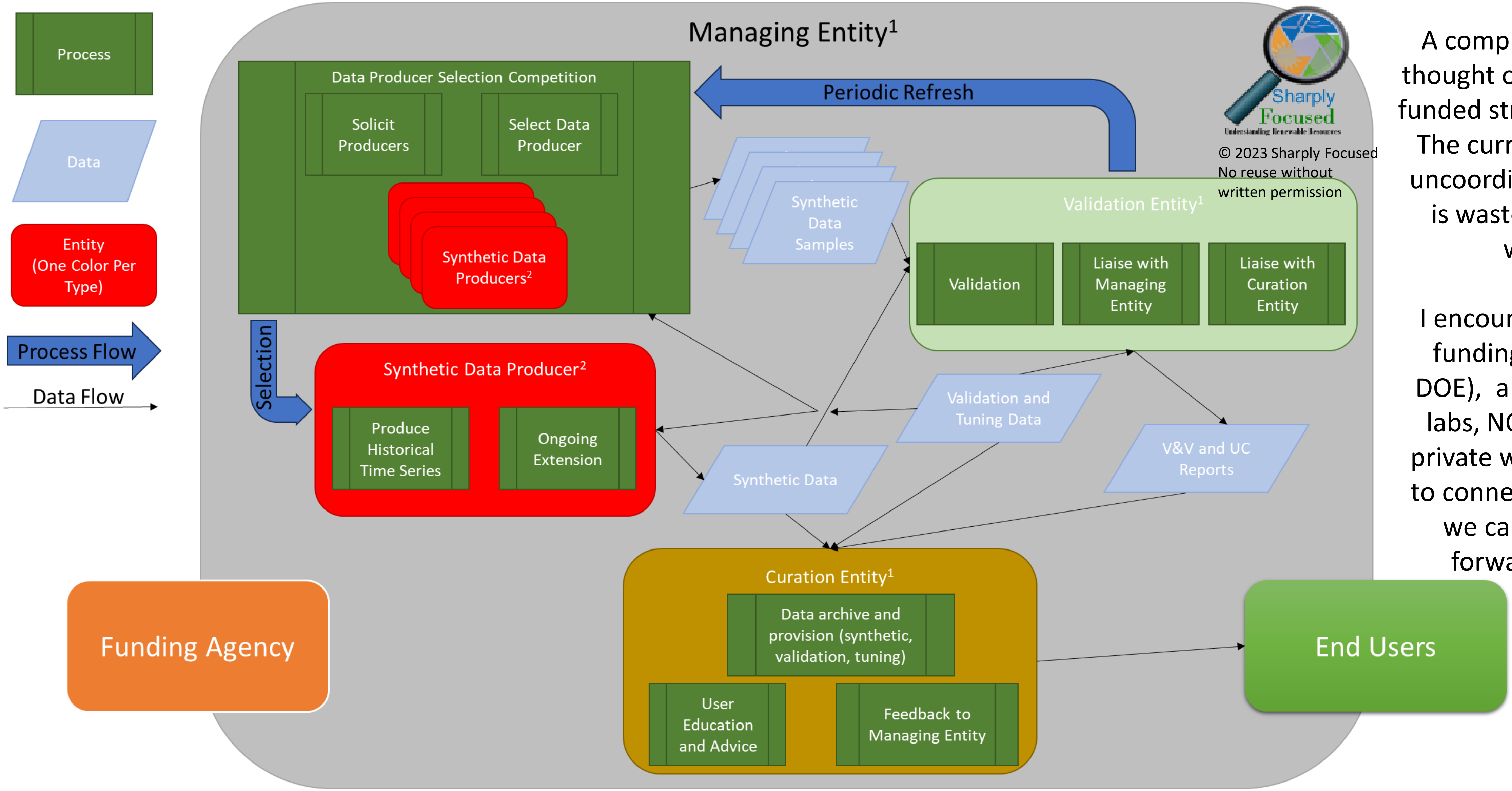
- Compute costs: Initial: $8-15 M. Ongoing $1-2 M/yr including storage
- People: Initial history: $1-2 M. Ongoing NWP: $300-500K/yr. Validation, dissemination, curation: $400-700K/yr
- Total for 1990-2035: $30-55M
- Includes overhead, but not profit.
- Probably conservative but detailed analysis is needed.
- Time: Six months on CPU for first 33 yrs. 1 ½ year project

Investment to decarbonize the grid by 2035: $330-740B[1]

Less than 0.01% and the potential cost of **<u>flying blind</u>** is…???

[1] NREL 2022: https://www.energy.gov/eere/articles/nrel-study-identifies-opportunities-and-challenges-achieving-us-transformational-goal

# A First Draft Proposal for Discussion with Potential Partners and Funders




A comprehensive, well thought out, and properly funded strategy is needed. The current scattershot uncoordinated approach is wasteful and is not working.

I encourage advocates, funding entities (e.g. DOE), and partners like labs, NOAA, EPRI and private weather vendors to connect to discuss, so we can roll the ball forward together.

[1]May all be the same organization. [2] Should *not* be the same organization; creates a conflict of interest.


# THANK YOU

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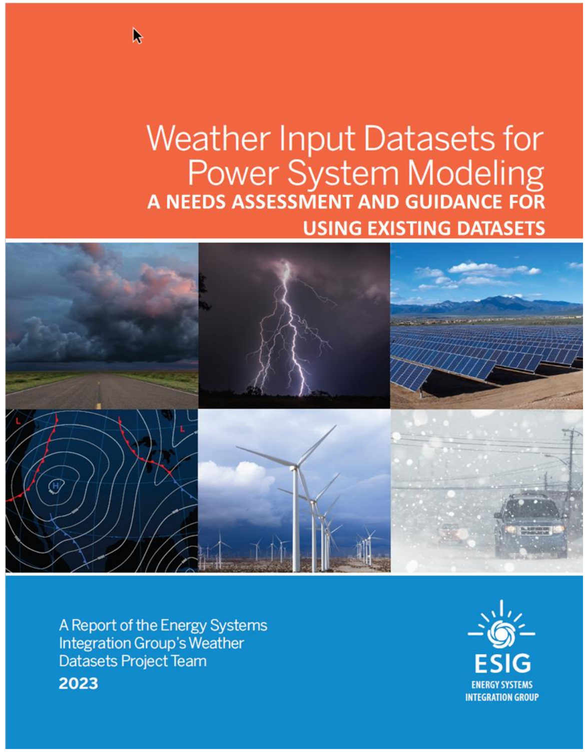


[Weather Input Datasets for Power System Planning]

**Scan for report landing page**