Introduction to Forecasting and Operations

ESIG Meteorology & Market Design Tutorial

Aidan Tuohy, Erik Ela
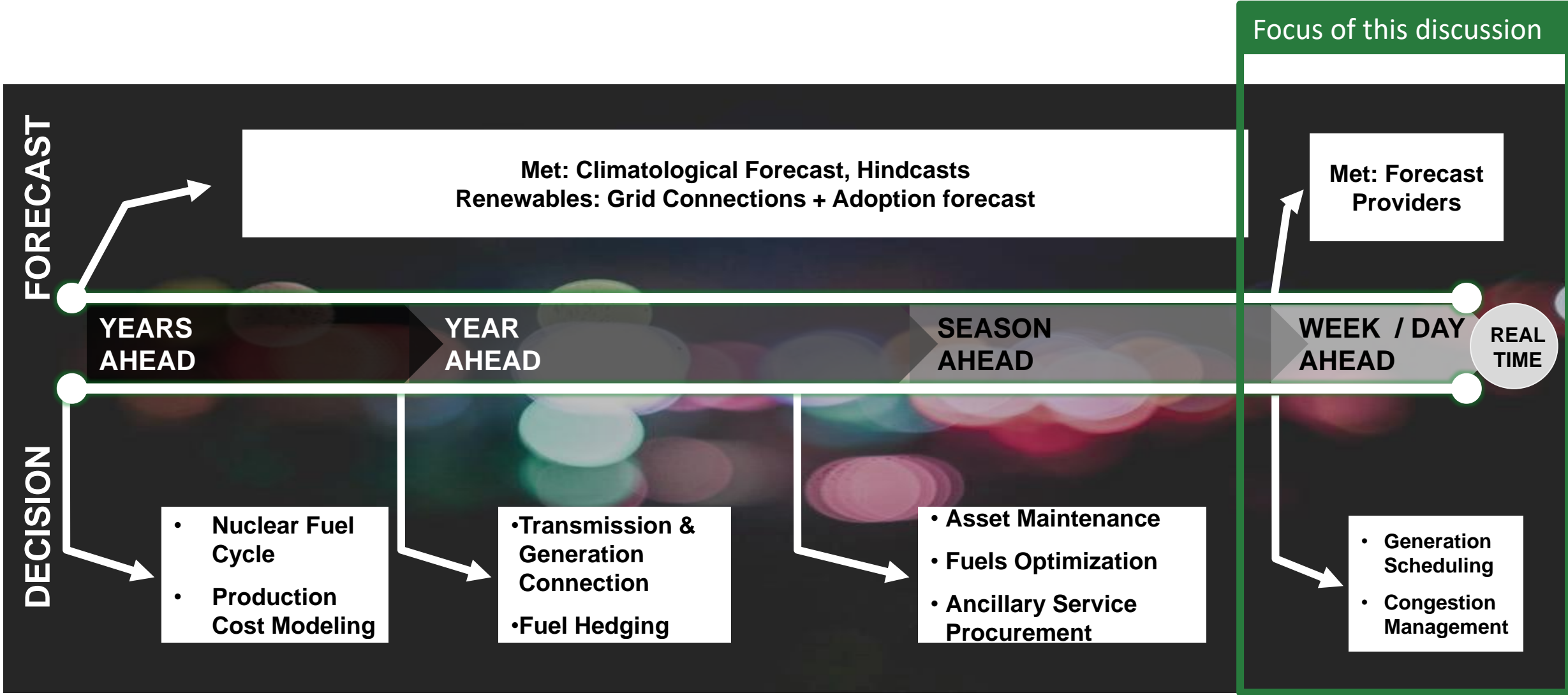EPRI Grid Operations and Planning

June 7, 2022
Denver, CO

Agenda

- How forecasting aligns with system operations (Aidan)

- Market Operations Overview and Role of storage, Hybrids and DER (Erik)

- Panel session
  - Forecasting Hybrid and Co-Locate Resources, Amber Motley, CAISO
  - Market participation of hybrid resources, Mark Ahlstrom, NextEra Energy
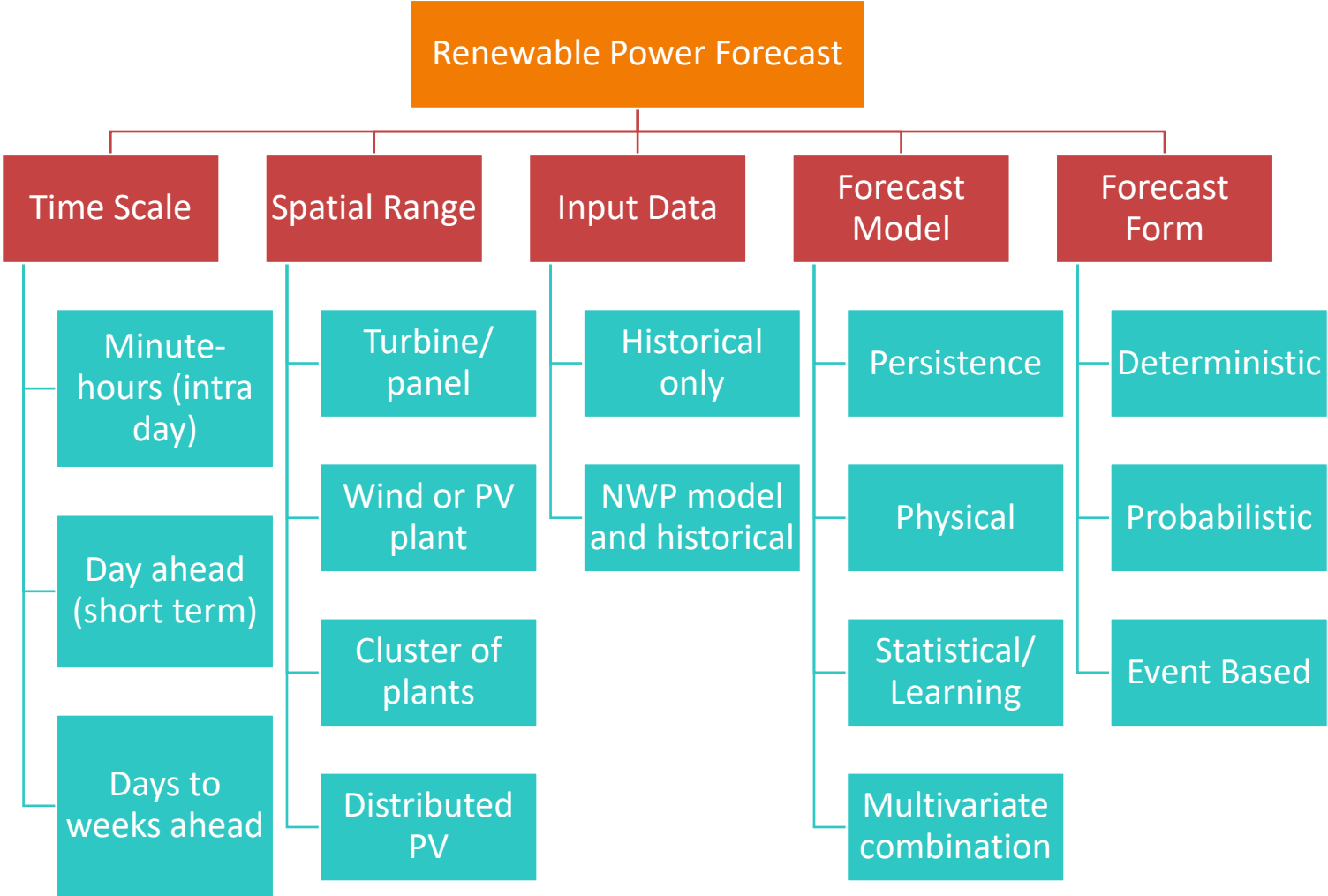
- Discussion, Q&A

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Bulk System Forecast Uses

Focus of this discussion

FORECAST

Met: Climatological Forecast, Hindcasts
Renewables: Grid Connections + Adoption forecast

Met: Forecast Providers

YEARS AHEAD → YEAR AHEAD → SEASON AHEAD → WEEK / DAY AHEAD → REAL TIME

DECISION

- Nuclear Fuel Cycle
- Production Cost Modeling

- Transmission & Generation Connection
- Fuel Hedging

- Asset Maintenance
- Fuels Optimization
- Ancillary Service Procurement

- Generation Scheduling
- Congestion Management

Similar time frames for distribution

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Forecast Classification


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                          Renewable Power Forecast
        ┌──────────────┬──────────────┬──────────────┬──────────────┐
   Time Scale    Spatial Range   Input Data   Forecast Model   Forecast Form

 Minute-hours     Turbine/        Historical     Persistence      Deterministic
 (intra day)      panel           only

 Day ahead        Wind or PV      NWP model      Physical         Probabilistic
 (short term)     plant           and historical

 Days to          Cluster of                     Statistical/     Event Based
 weeks ahead      plants                          Learning

                  Distributed                    Multivariate
                  PV                             combination
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Adopted from IEC TR 63043 "Renewable energy power forecasting technology", 2020

Any renewable forecast will be combination of these

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Terminology across different functions
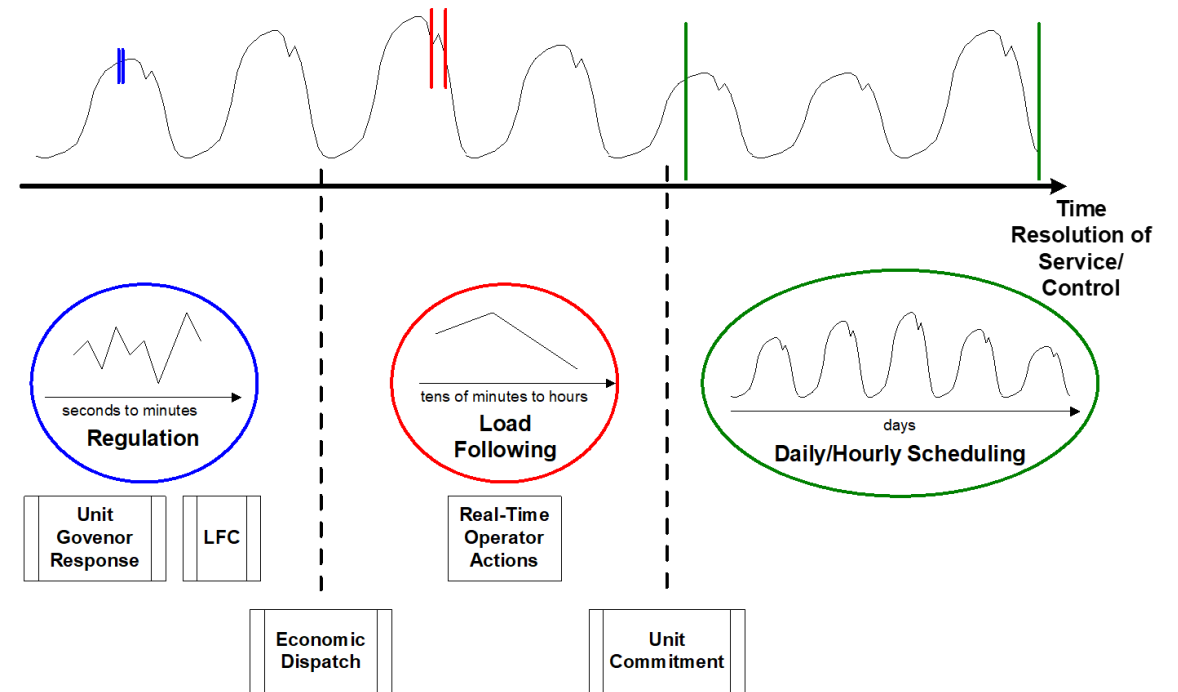
Forecasting

Figure 1-1 Illustration of a forecast issued at 5:00am with a horizon of 1-hour, run length of 1 hour and four 15-minute intervals.
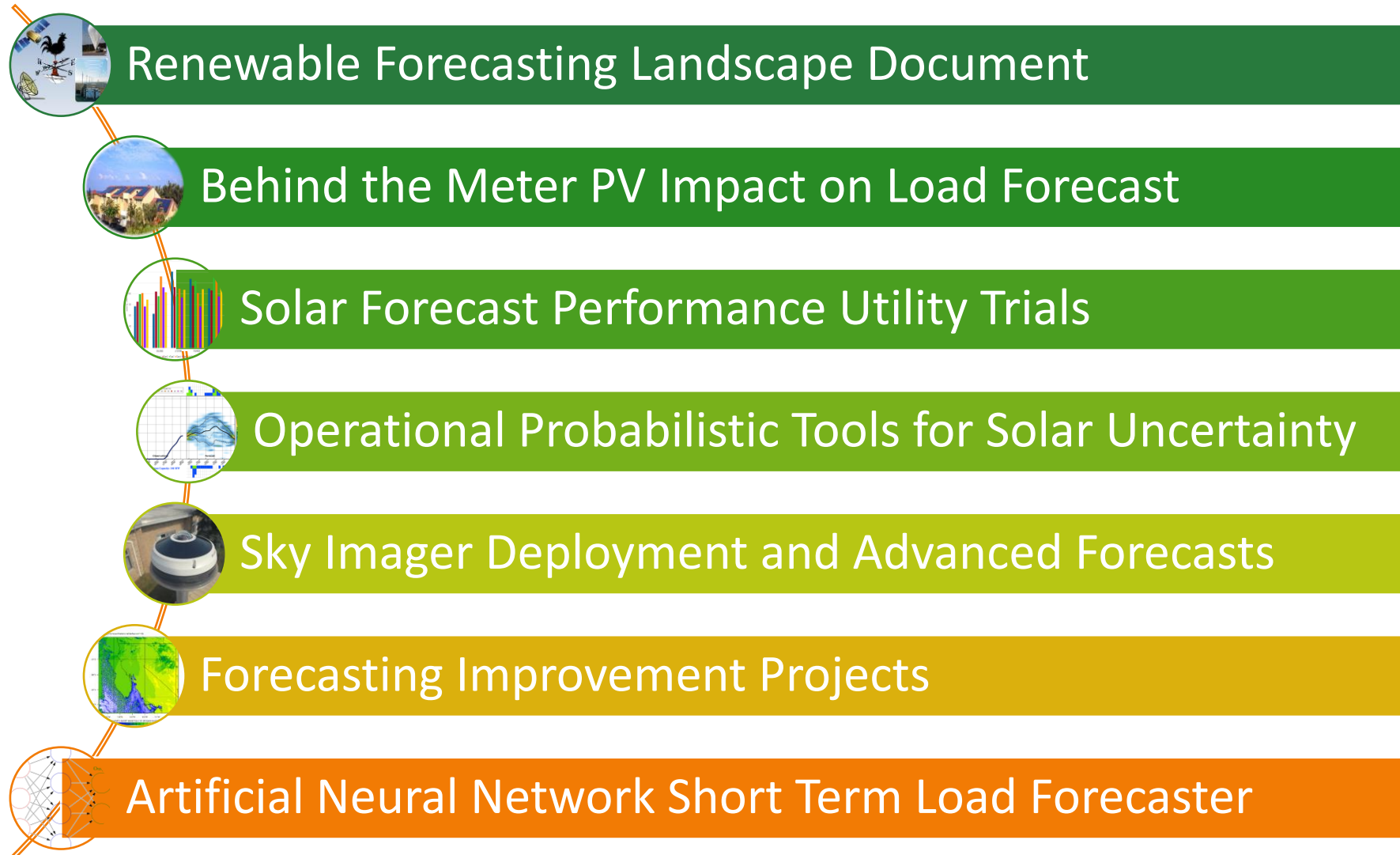
System Operations
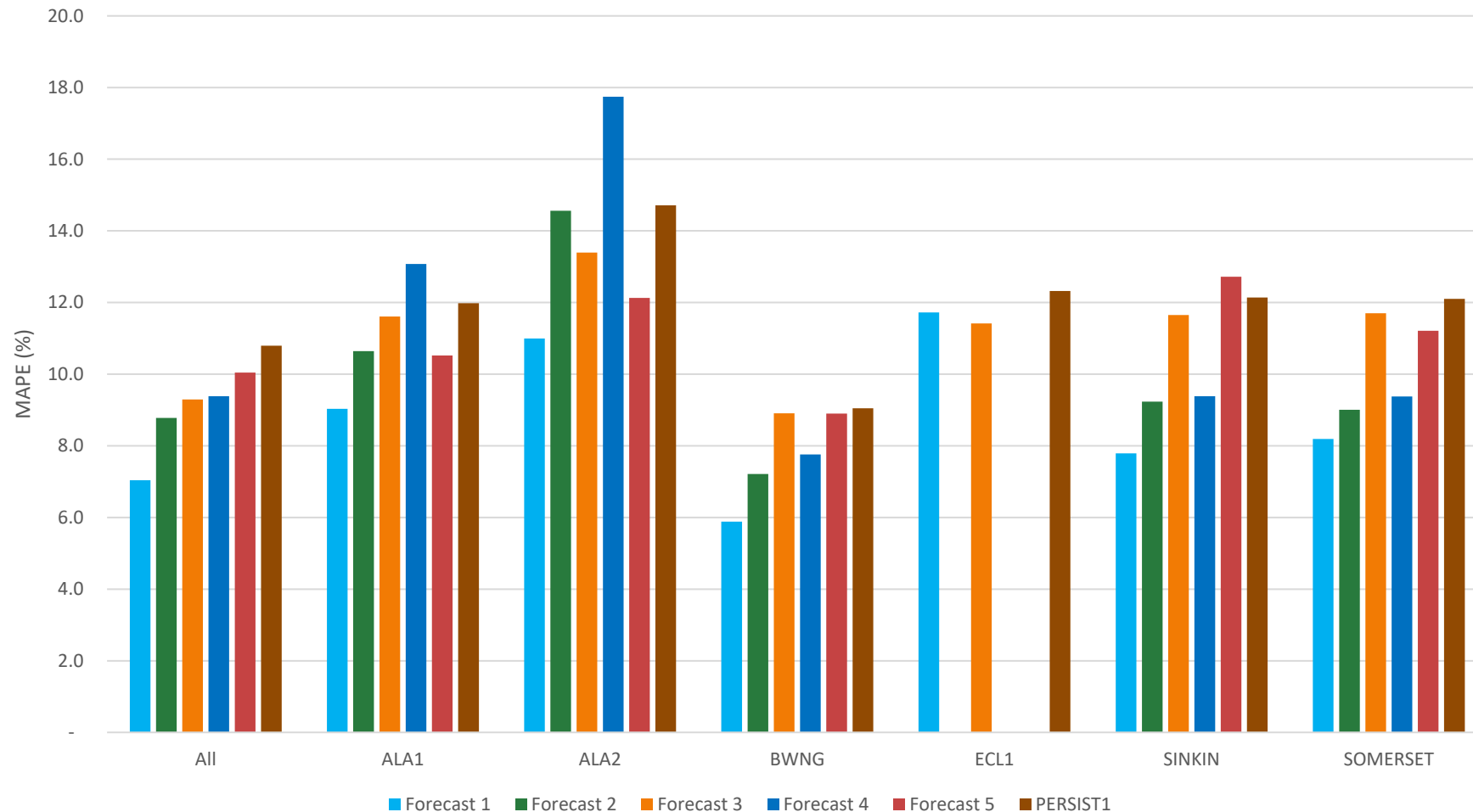
Questions for the audience

- Is your expertise on forecasting, market operations, both or none?

- Do you already have a good idea of how forecasts are used in operations or do you want to know more in that area?

- Do you interact with forecasts often in your day job?

- Do you interact with market operations often in your day job?

- For emerging resources such as storage, DER, hybrids, how important do you think forecasting is? More/less/about the same as for how we think about VRE

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EPRI Short Term Forecast Integration Efforts

Renewable Forecasting Landscape Document

Behind the Meter PV Impact on Load Forecast

Solar Forecast Performance Utility Trials

Operational Probabilistic Tools for Solar Uncertainty

Sky Imager Deployment and Advanced Forecasts

Forecasting Improvement Projects

Artificial Neural Network Short Term Load Forecaster

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Solar forecast performance across vendors and locations

Performance varies widely for different forecasters and across solar farms, due to data availability and technology

More uncertainty in performance than summary metrics show

More Information:

Solar Power Forecasting for Grid Operations: Evaluation of Commercial Providers, EPRI, 3002012135

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Forecast Arbiter: https://solarforecastarbiter.org/

impartial, repeatable & auditable forecast evaluation tool

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Forecasting Trends

Solar	Wind	Load
• Satellite imagery for intra-day (<6h) • Deep learning interest (research and vendors) • Models not relying on measured power data • Sub-hourly resolution • Probabilistic forecasts	• Probabilistic forecasts • Offshore wind forecast emphasis • Deep learning interest (research and vendors)	• Increase spatial and dist level forecast • Accounting for behind-the-meter solar • Accounting for batteries/DER • Changing demand profile (COVID-19, remote work) • Extreme events

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Days Out Forecasts Help Develop Scenarios to Improve Reliability

High-risk Scenarios Often Not Peak Cases
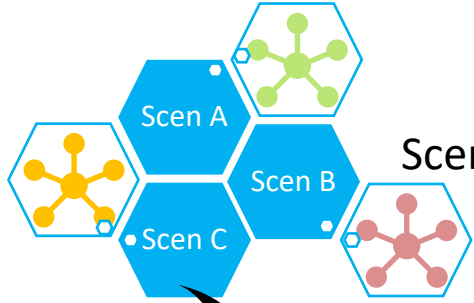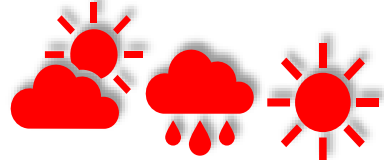Thus, Missing in Operations Planning Studies

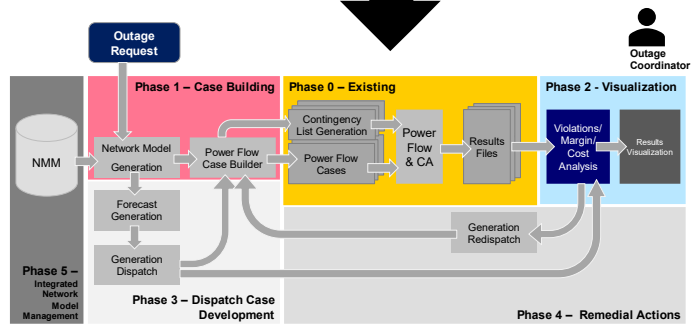

Load, VER, DER Distributions

Expected Topology

Weather Event Likelihood

Scenario Development

Days-Weeks Out Outage Studies

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History

- Continuous 1–7 day region-level load
- 20+ years of R&D
  - First NN-based load forecaster
- Used by many operators & traders
  - Ongoing supp 12+ members
- Competitive performance
  - 3% MAPE or less
- Data required
  - Single point actuals & forecasts
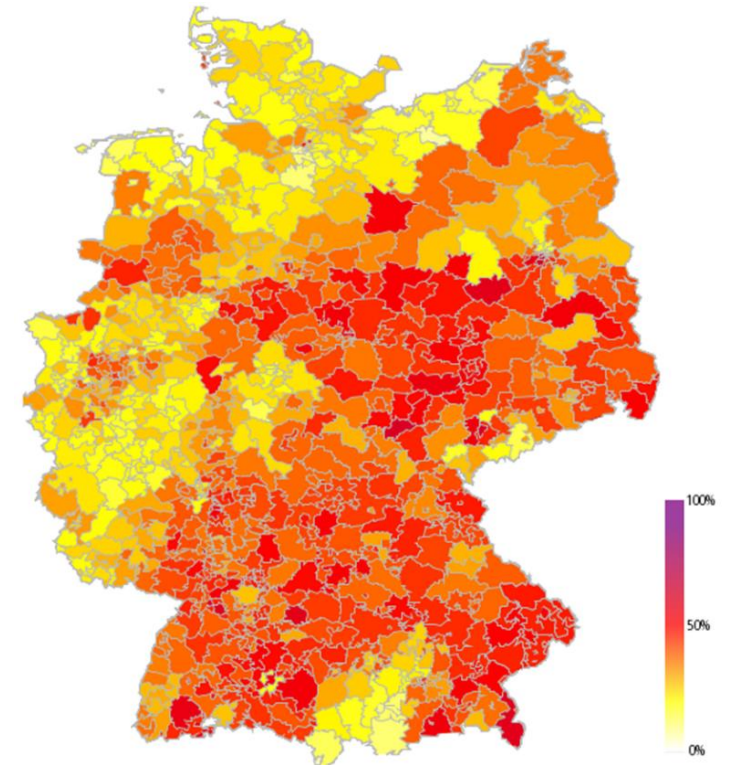   - Temp, Humidity
  - Holidays, half-holidays

Example Annual Performance for 3 Regions

Load Region	ANNSTLF MAPE		Combined ANNSTLF & HbH-ANNSTLF MAPE	
	Peak Load	All Hours	Peak Load	All Hours
APS	2.3	2.4	2.1	2.2
ISONE	2.4	2.0	2.1	1.7
ALTW	2.8	2.5	2.3	2.1

Operational load forecaster benefiting members for over 20 years

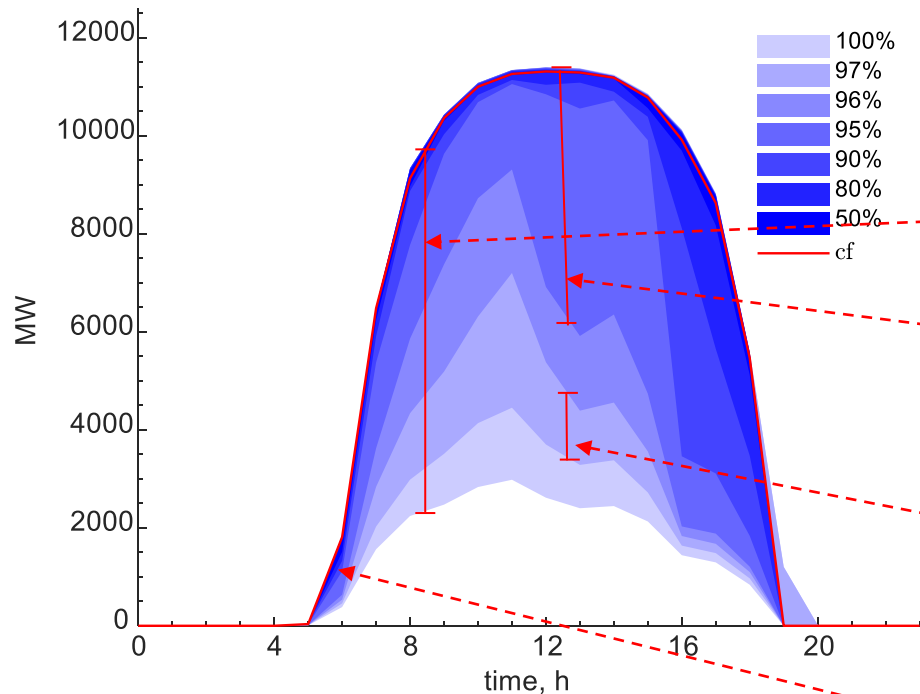# Understanding Impacts of Distributed PV on Load Forecasting

- Continued growth of distributed PV (DPV) is changing loads at all levels (customer, utility, ISO/RTO)
- Forecasting approaches for traditional loads are mature, but not designed for high levels of DPV
- Need to study effects now to plan for future:
  - Data sources
  - Infrastructure
  - Forecast methodologies

Real Time estimation of solar power in Germany (provided by energy & meteo)
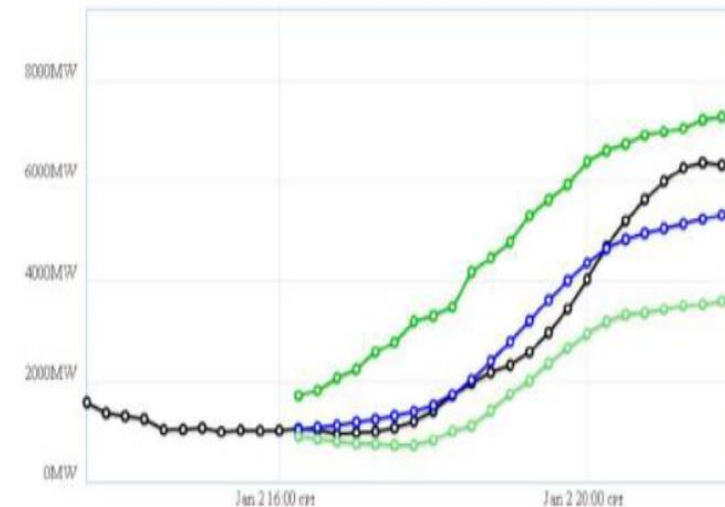
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Probabilistic Forecasts

- Probabilistic forecasts provide users with valuable information on uncertainty
- They are composed of probabilistic thresholds in which the variables are expected to materialize:
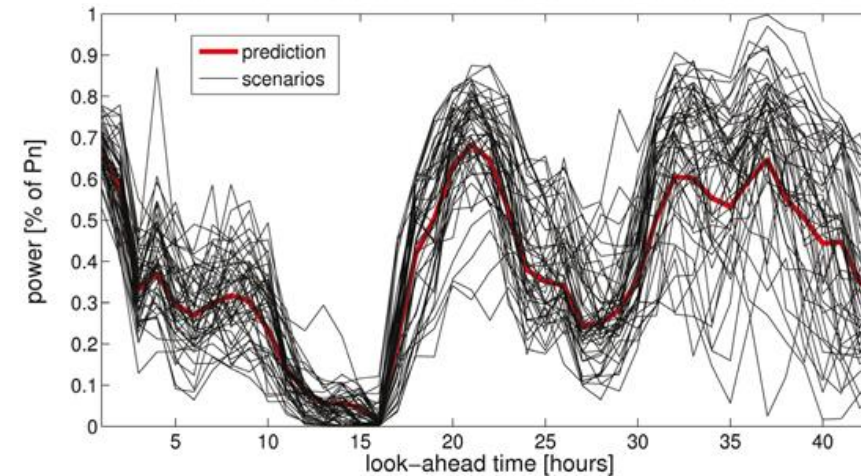 - A 100% threshold indicates total certainty of the variable being within the band
  - Lower probability thresholds indicate that the likelihood of the variable being within a narrower band (e.g., 95%)
  - Area between thresholds represent the probability of the variable materializing only in that space (e.g., (97-96)/2 = 0.5%)
  - The redline represents the central expected forecast

Why use probabilistic forecasts?

- Takes advantage of risk-based methods such as stochastic programming

- Captures outliers (assuming data is representative)

- Should be more economically efficient while can also be more reliable than traditional methods

- May give us better rationale for responding to some extreme events, e.g. extreme cold

Source: David Maggio, Using probabilistic information in real life, 2011 UWIG Forecasting Workshop
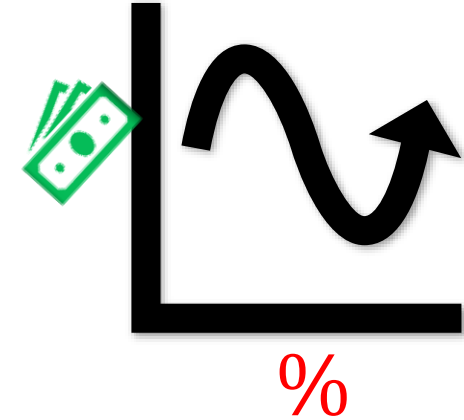
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Quantifying Forecast Value

What is the value of improving MAPE by 0.1%?

One forecast vendor has a lower MAPE but another better forecasts the peak, which is better?

%

Group 1
Analytical Formula

- Value as a function of forecast error
- E.g., $ per 1% MAPE reduction
- Usually based on historical values or expert estimates

Group 2
Production-cost Simulations

- Simulate market operation ED/UC
- Feed forecast scenarios into simulations
- Compare resulting economic impacts

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Key Takeaways

- Forecasting is widely used across all operations practices
  - While scheduling is most obvious, other applications also relevant
  - Increasing value for forecasting
- Linking the decision making process with forecasts is important
  - Keeping decision until later can help get a better forecast
  - Needs to be traded off with operating decision process on system side
- Increasingly complex data and different decision makers
  - Behind the meter solar, distributed storage, hybrid plants all bring their own complexities
  - Probabilistic information becomes more important for decision makers

As the system changes, forecasting applications need to keep up
Focus today on storage, DER, hybrids and other newer issues in forecasting

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