# Providing Uncertainty Information to End Users in the Electric Sector

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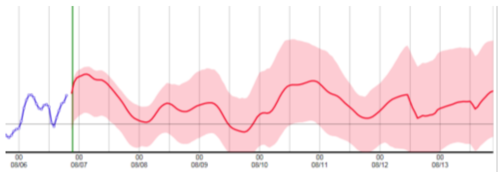
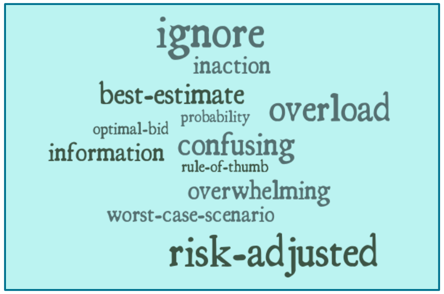
Tutorial on Integration of Uncertainty Forecasts into Power System Operations

# Talk Overview

1

Probability Forecasts





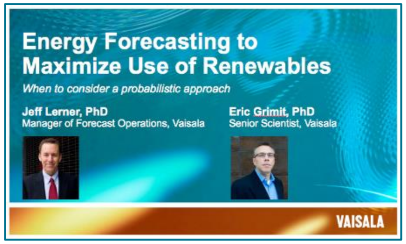

Not Used!

2

Barriers to Adoption

Community effort needed with a 3-pronged strategy

- Policy
- Technology Demonstration
- **Education**

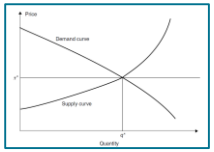


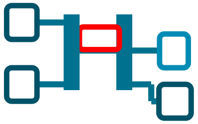

Excerpt from Vaisala Webinar (Jan 2015)

3

Our Efforts

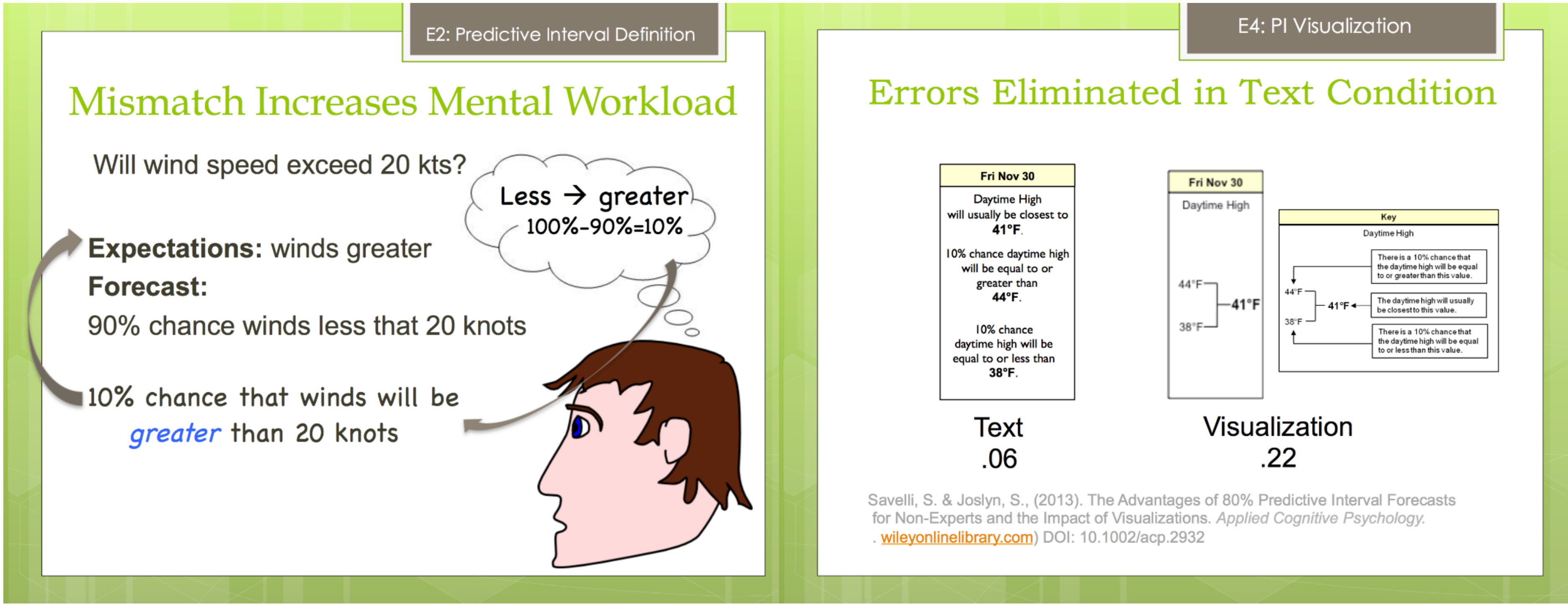
Three examples from private sector use cases





Complex Decision Process

# Human Factors Education




Source: Susan Joslyn, Decision Making Psychology, University of Washington

- Predictive intervals can lead to better decisions and greater trust
- Misinterpretation (reversal errors) quite common
- Cognitive psychology research shows that framing of language and mode of communication are critically important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# Example 1: To Power Marketers

# Submitting Offers into the Day-Ahead Electricity Market

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# Common Energy Scheduling Practices

- Passing through a deterministic forecast (from ISO or forecast provider)
- “Haircutting” (aka scaling) the deterministic
- Scheduling only what you can cover during high uncertainty periods (e.g., known reserve capacity)

***These approaches may help to avoid over-promising generation, but they lose sight of the “upside potential”***


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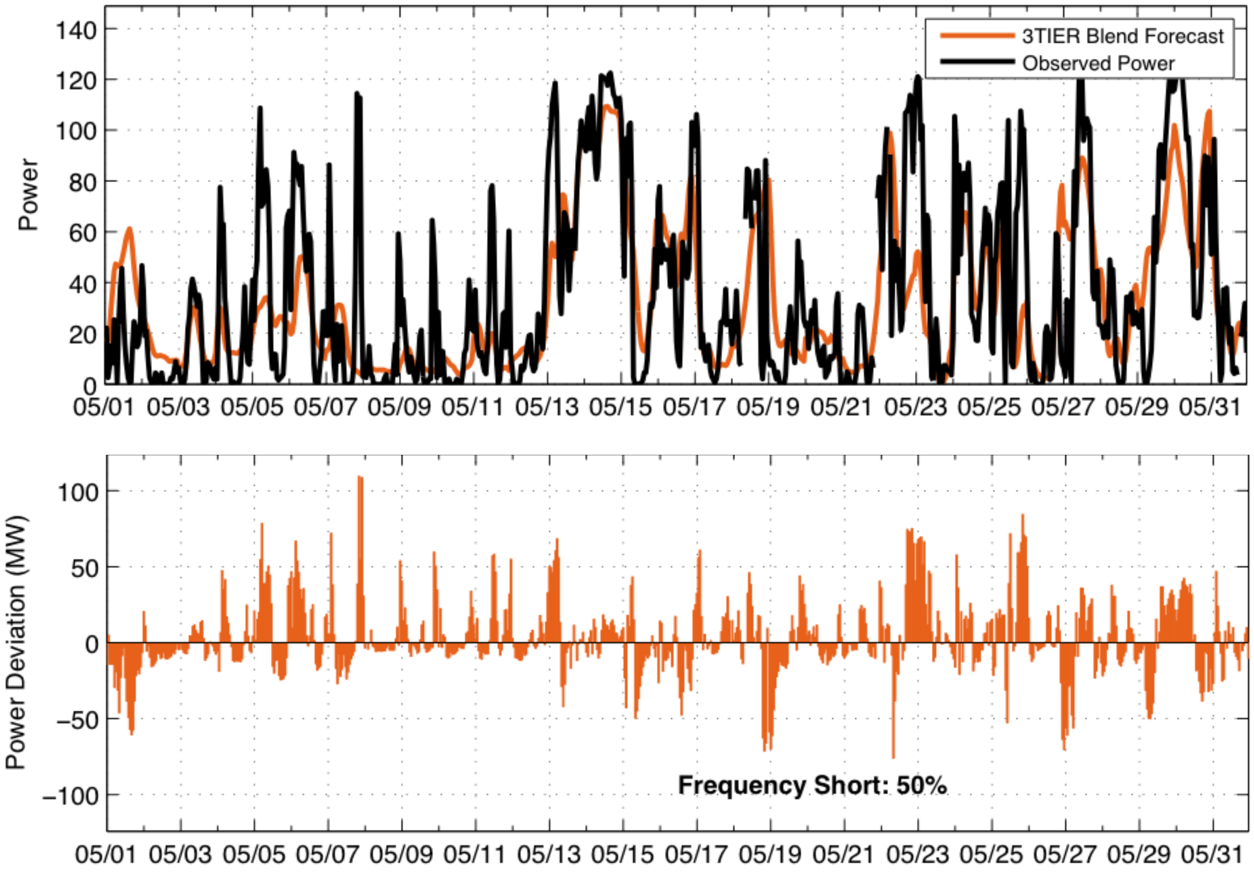
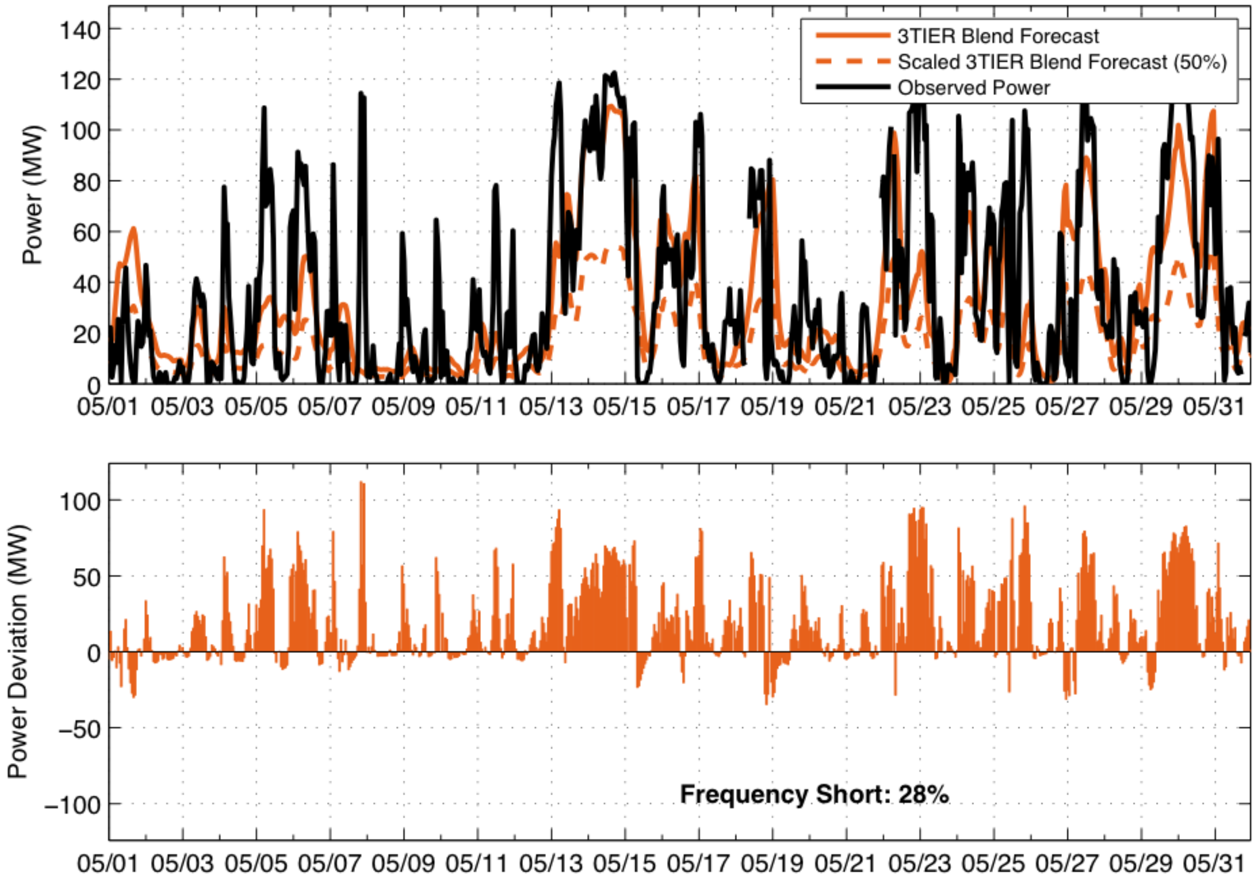
# The Problem: *Downside Risk Exposure*



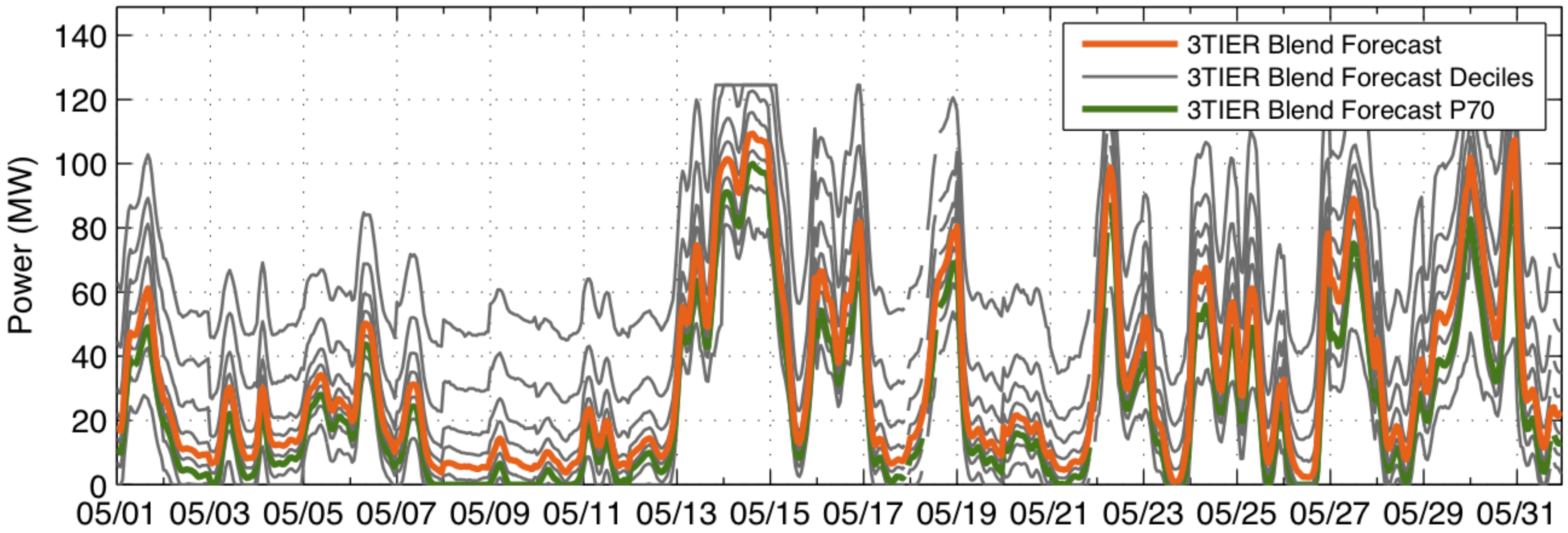

***3TIER Blend minimizes bias and MAE; 50% downside risk***

# **One Strategy:** ***Scaling the Forecast***



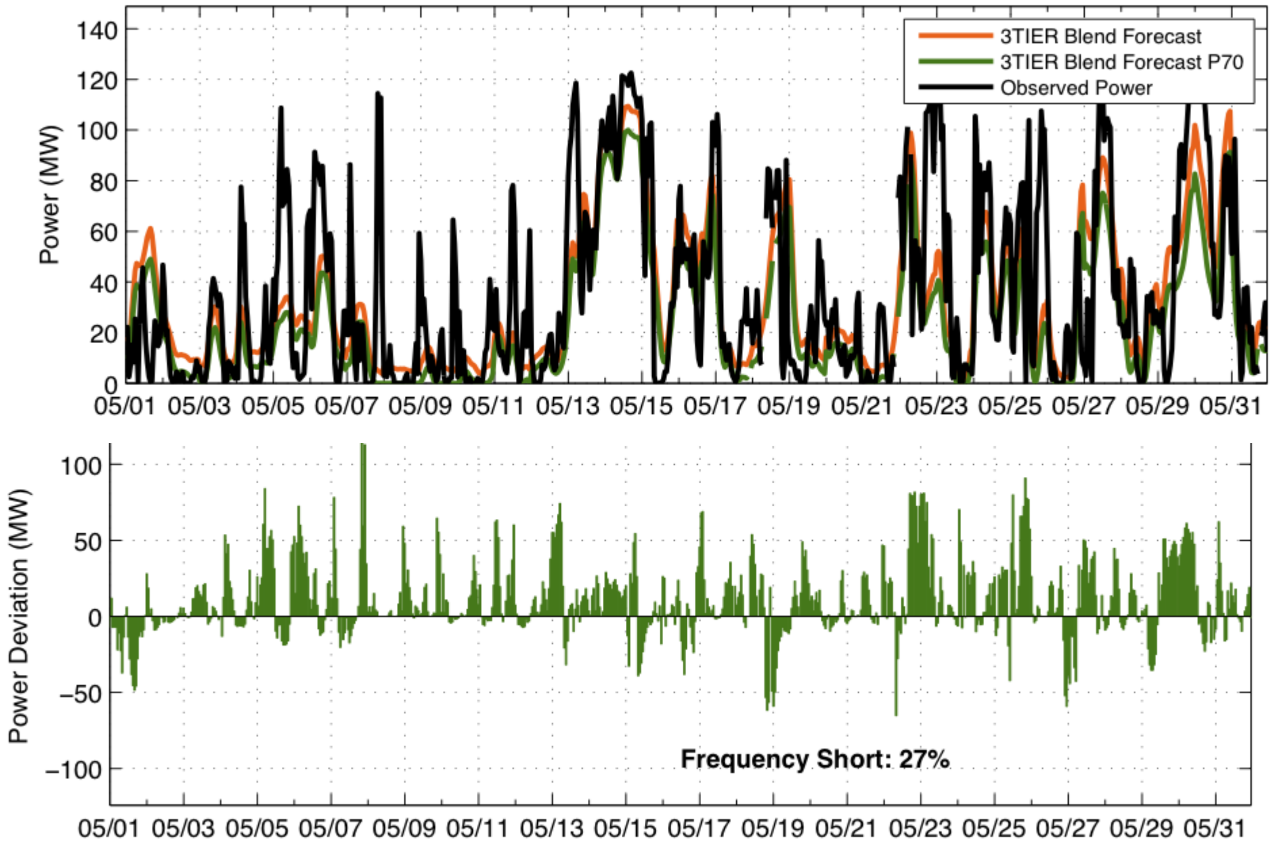

***50% scaled 3TIER Blend biased low; 28% downside risk***

# Another Strategy: *Choosing Risk Tolerance*



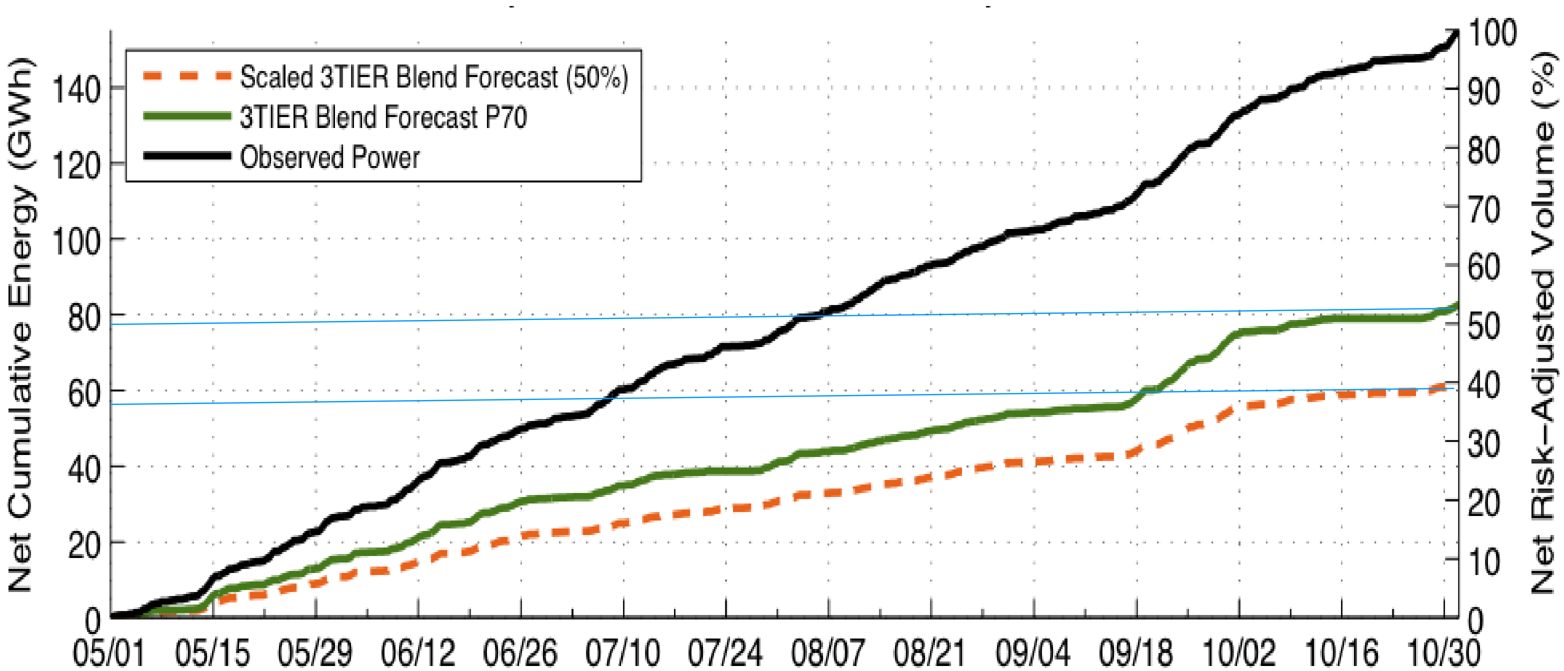

***P70 forecast estimates level with 30% downside risk***

# Checking the Risk Exposure




***P70 forecast has 27% downside risk, very close to the scaled forecast risk***

# Comparing the Two Strategies Over Time




**Net 20.5 GWh more over a 6-month period!**

***With similar downside risk exposure, the P70 forecast netted 20.5 GWh more energy scheduled into the day-ahead market over 6 months***



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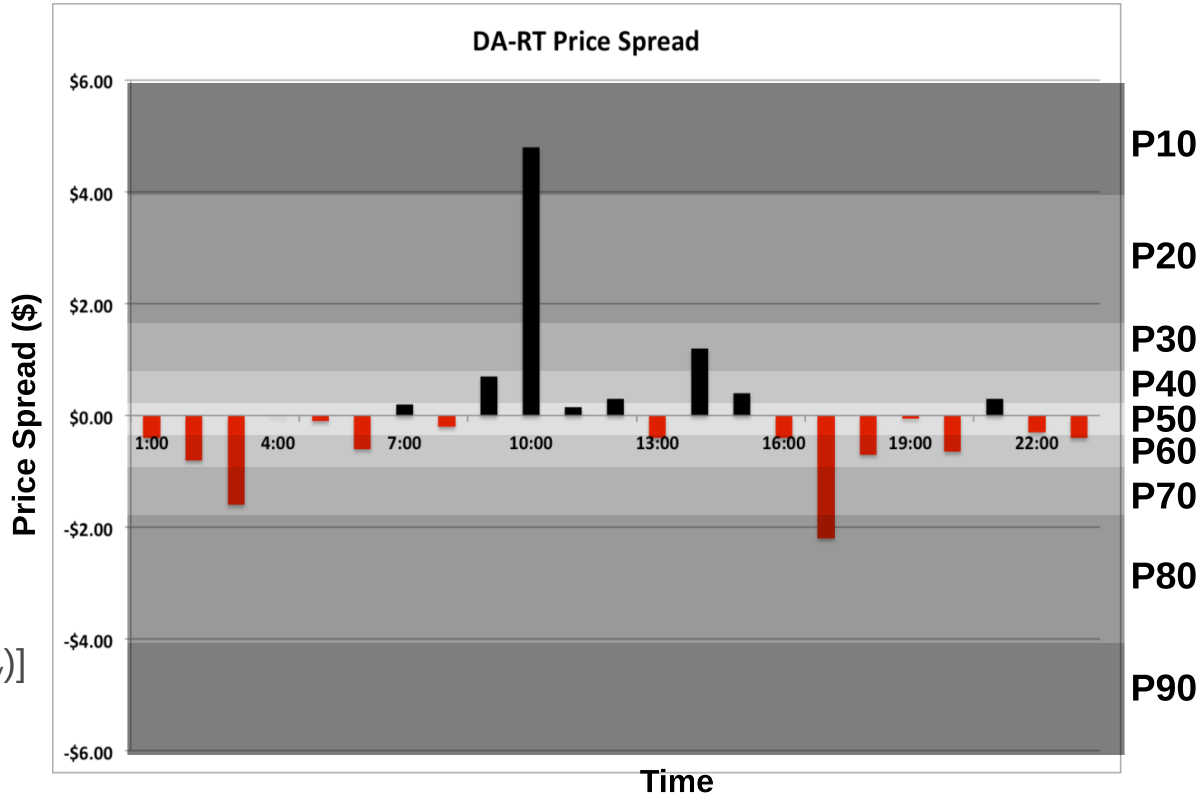
# Advanced Offering Strategies

- Accounting for risk that varies with time
  - Energy price expectations
  - Load forecast uncertainty
  - Transmission congestion
- Developing rules or an algorithm customized to detailed risk profile
  - Choose optimal quantile:

$q = 0.5 + 0.5 \cdot \tanh[(\pi_{DA} - \pi_{RT})/(r \cdot \pi_{DEV})]$

r = Pratt coefficient of risk aversion




***Additional gains can be made with a customized approach***



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# Example 2: To Balancing Authorities

# Scheduling Firm Capacity Hour-Ahead and Protecting Against Down Ramp Events

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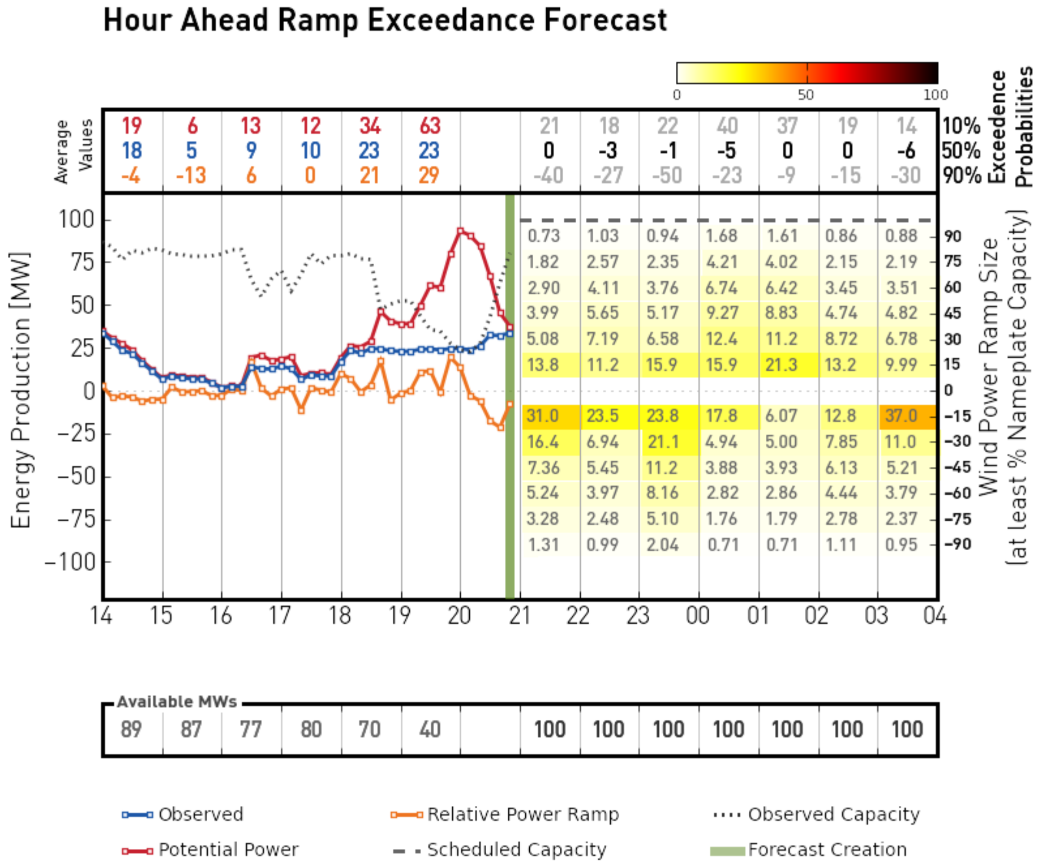
# Taking a Risk-Based Approach

- Current operating practice is to <u>protect against ramp events at all times</u>, even when the risk is very low.
- Although current ramp forecast guidance has low to moderate skill and large uncertainty, it is not worthless.  There is value.
- Value can be extracted by considering the uncertainty of each forecast situation directly, thereby minimizing missed ramp events over the long term, while maximizing the scheduling, transmission, and use of VG when it is produced.
- Guidance on ramp events is needed in probabilistic form to facilitate the user to take action only when the estimated risk is above the user's tolerance for it.

# Ramp Event-Based Forecasts




- Is the risk of a significant down ramp event next hour larger than your tolerance for it?
  - 31% for -15 MW or more
  - 16% for -30 MW or more
  - 5% for -60 MW or more
  - 1% for -90 MW or more
- Answer depends on the user or situation:
  - cost of missed event
  - tolerance for false alarms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# Comparing Risk Tolerances

**Examples of User-Specificity:** ***Which kind of user are you?***

» Consider hypothetical forecast users A, B, and C.

» Each aims to schedule maximal firm wind energy capacity 1 hour ahead and must protect against missed down ramp events.

» They can tolerate any number of false alarms.

> User A accepts a 5% risk of being caught short and can afford to schedule 66% of the total realized energy.

> User B is more risk averse, accepting a 2% chance of being short, and schedules 42%.

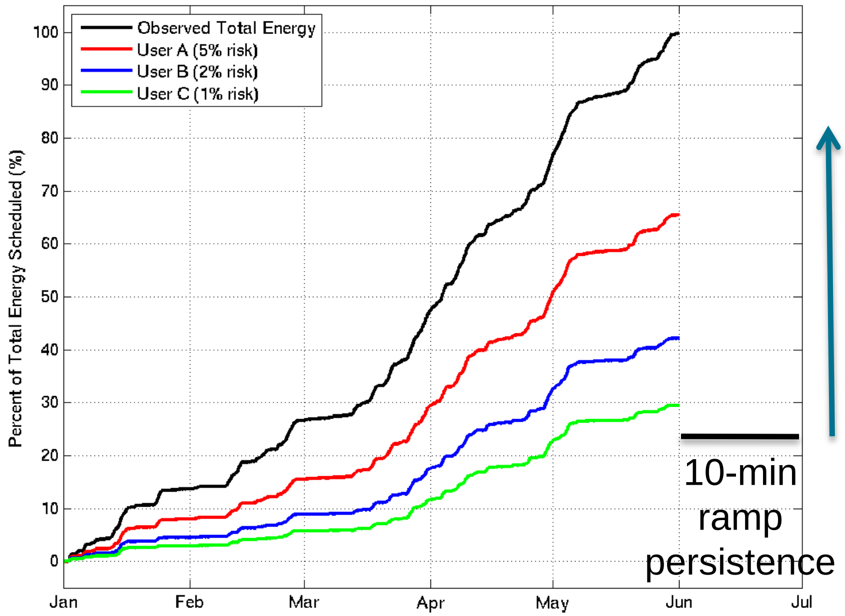
> User C is the most risk averse, accepting only a 1% risk, and is able to schedule 30%.

Risk Adjusted Volume (MWh)

=

Forecast Value

($$$)




6% Increase

=

$65K / month *

*for a 100MW wind facility with a 30% capacity factor and $50/MWh energy price



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# Example 3: To Owner/Operators

# Hedging Seasonal Anomalies from Budgeted Renewable Generation

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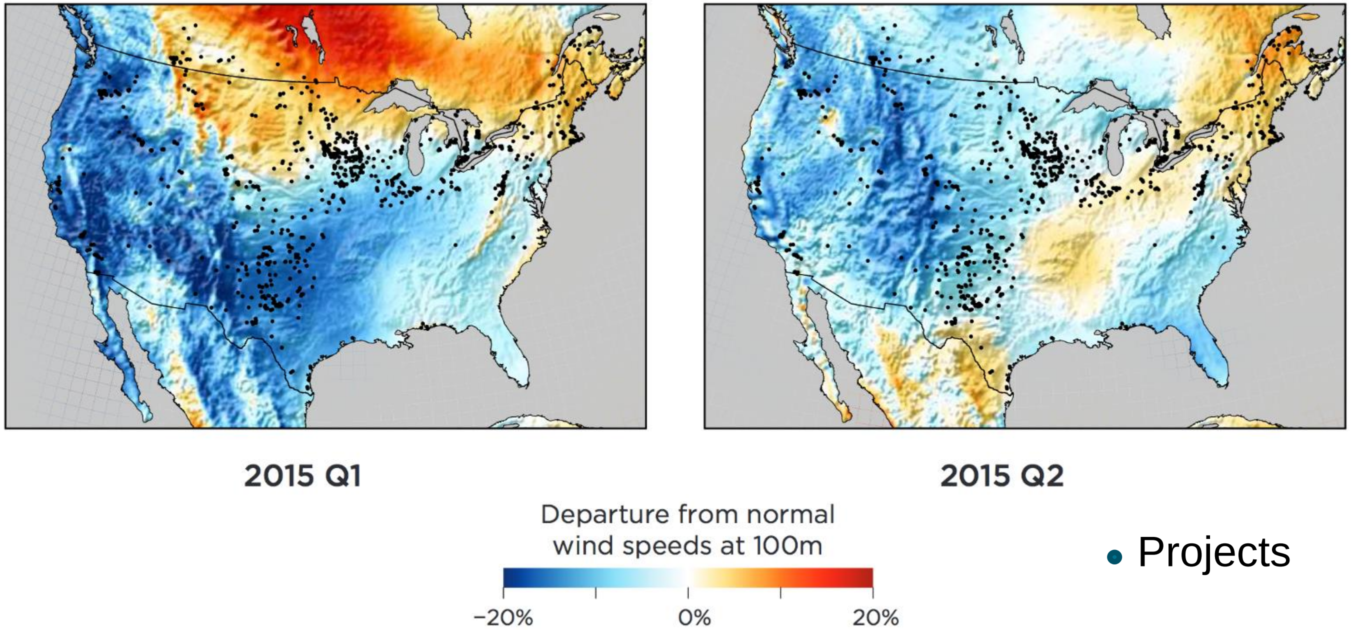
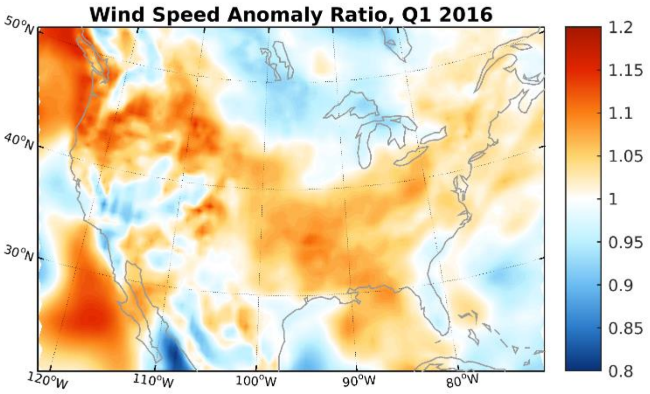
# Recent Large Anomalies in Wind

2015




2016

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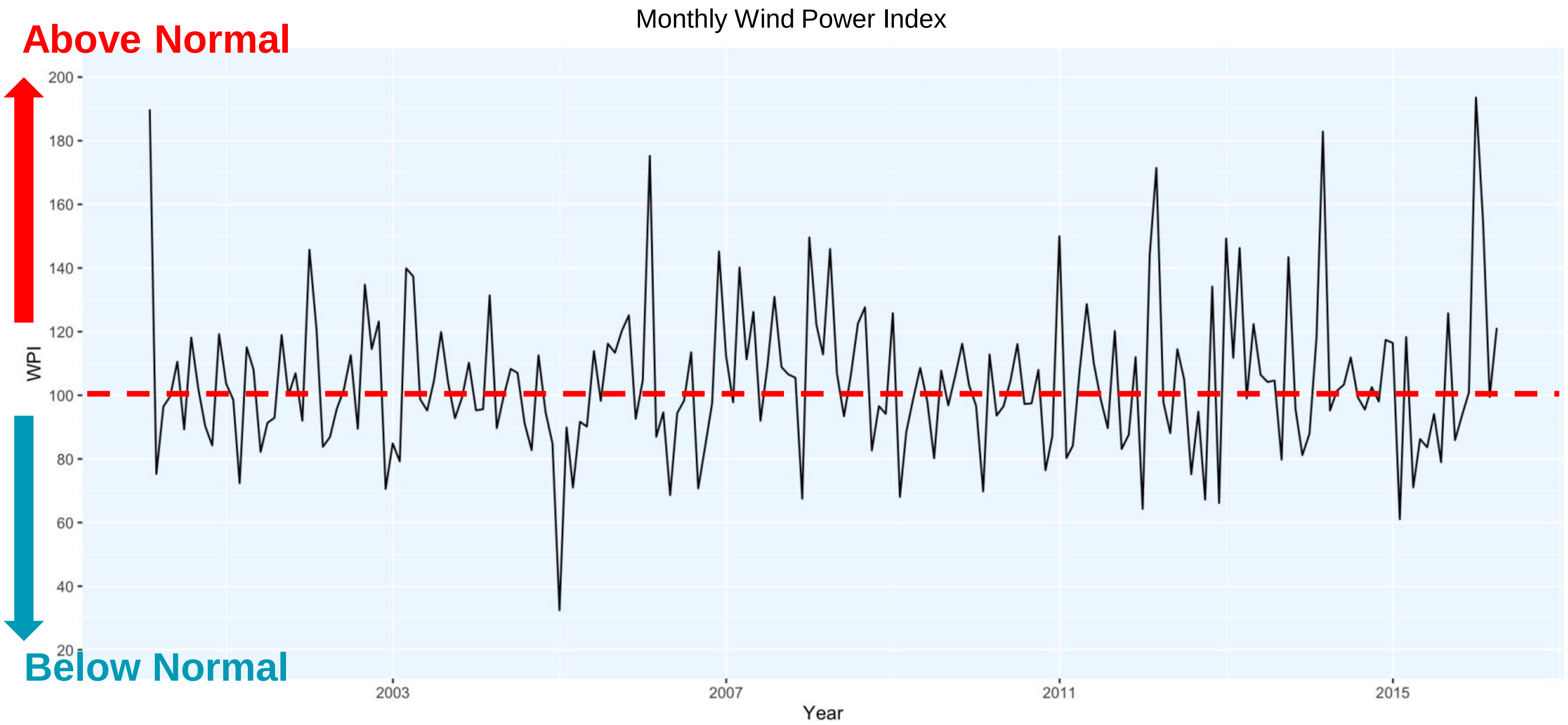
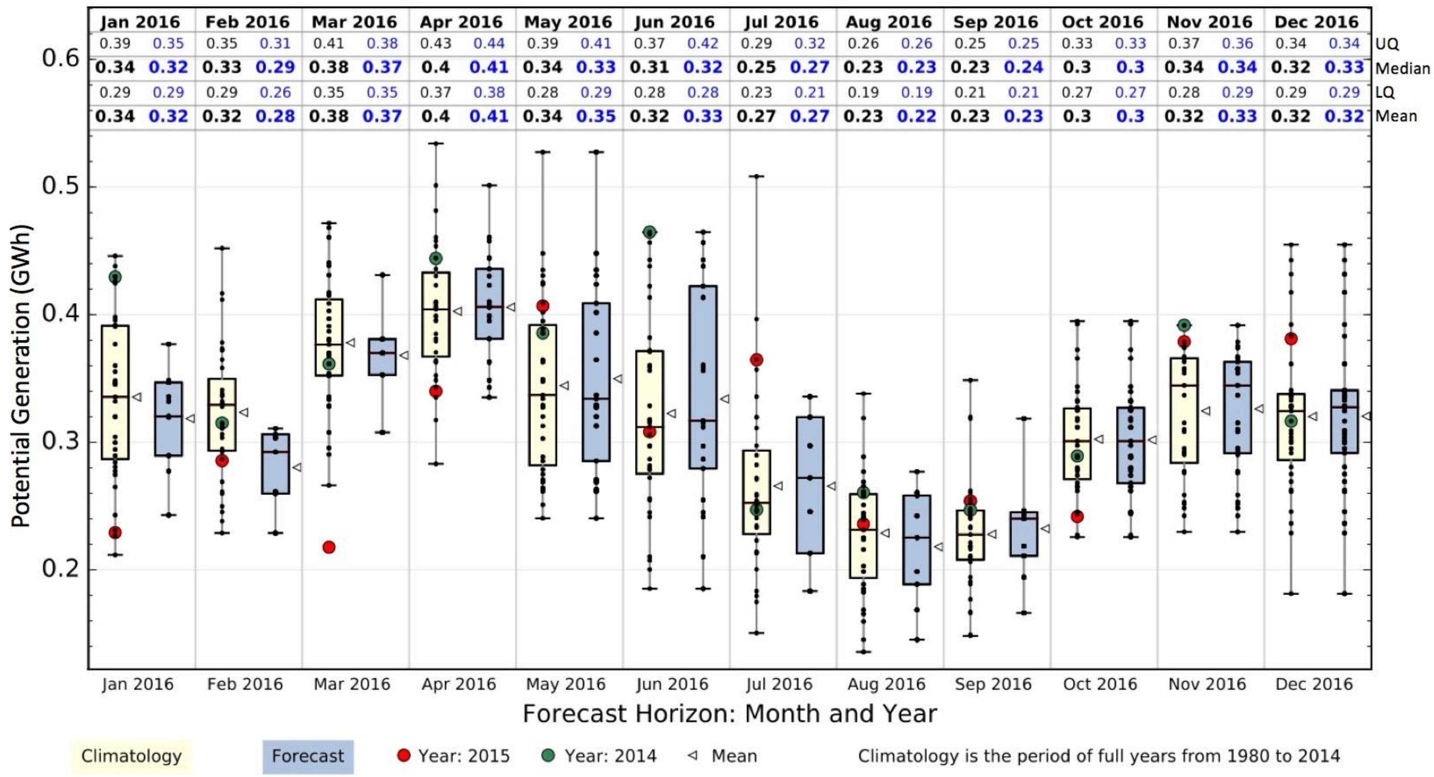
# Monthly Anomalies At One Project




***Some projects can deviate wildly from normal on a monthly basis.***

# Probabilistic Budget Setting Guidance




An example figure from our seasonal forecasting product that includes an operational reforecast to set climatology or "normal" for each month and the expected variation around normal based on the historic record (yellow bars) and the future climate state (blue bars).

***Boxplots used to convey summary statistics and possible extremes.***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# Take Home Messages

- Probabilistic forecasts widely available, not widely used
- Requires community efforts to promote adoption
  - Policy
    - Market Rules & Transparency
    - Regulatory Mandates & Independent System Operator Practices
  - Technology Demonstrations
    - Dynamic Reserve Allocation & Stochastic Unit Commitment
  - Education
    - Conferences & Workshops
    - Industry Journals & Magazines
    - Webinars & Interactive Customer Engagements
- Usage may prove advantageous to bottom line (3 examples)
  - Power Marketers: Day-Ahead Market Offers
  - Balancing Authorities: Hour-Ahead Firm Capacity
  - Owner/Operators: Monthly Budget Setting Guidance

# Thank You…

Further Reading:

- Scheduling More Wind:  Exploiting Probabilistic Forecasts
  - Grimit and Lerner, 2016:  6.8, 7ENERGY, 96th AMS Annual Meeting, New Orleans
  - Grimit et al. 2015:  Article, North American Clean Energy, Jan/Feb 2015, pp. 16-17
  - http://www.nacleanenergy.com/magazine/janfeb_2015/index.html#p=16
- Making Energy Balancing Decisions Based on Very Uncertain Wind Power Ramp Forecasts
  - Grimit et al., 2011:  Poster 753, 2ENERGY, 91st AMS Annual Meeting, Seattle
- Benchmarking the Accuracy of Seasonal Forecasting for Renewable Energy Resource Anomalies
  - Grimit et al., 2017:  J7.6, 8ENERGY/15AI, 97th AMS Annual Meeting, Seattle

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