POLARIS
SYSTEMS OPTIMIZATION

Getting the Tails into Economic Planning: Do Traditional Tools Work with the Changing Resource Mix?

Russ Philbrick
ESIG Spring Meeting
March 16, 2021

Why do the tails matter?

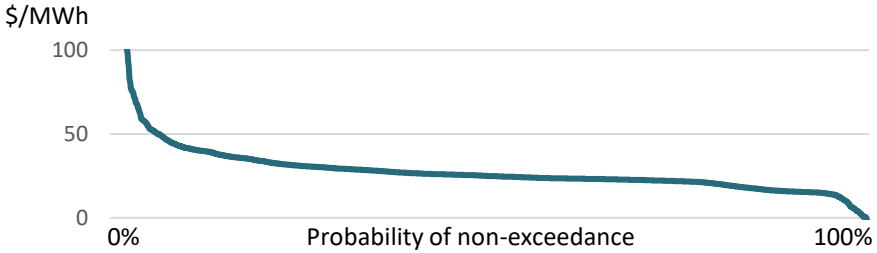
- Tails identify the most-costly extreme events (economics and reliability)
- Impact of tails depend on operations
- System conditions are changing: past simplifications not valid
- Need appropriate models, otherwise answers are wrong!!

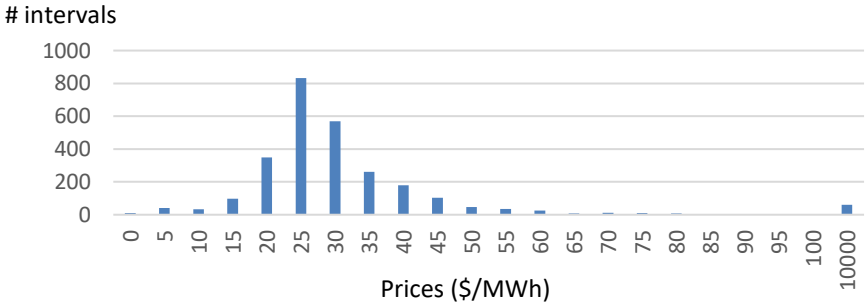
Using a range of different project results, we will review each of these topics to identify the planning problems.

What are the tails?

Extremes in size or rate of change in load or generating capacity. In markets, these may result in high or low prices.

Example: ERCOT Real Time prices, February 2011





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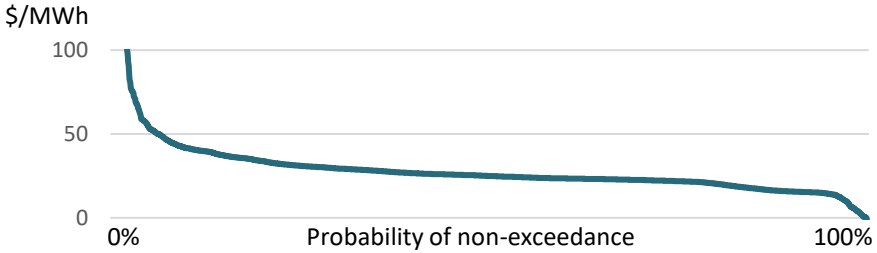
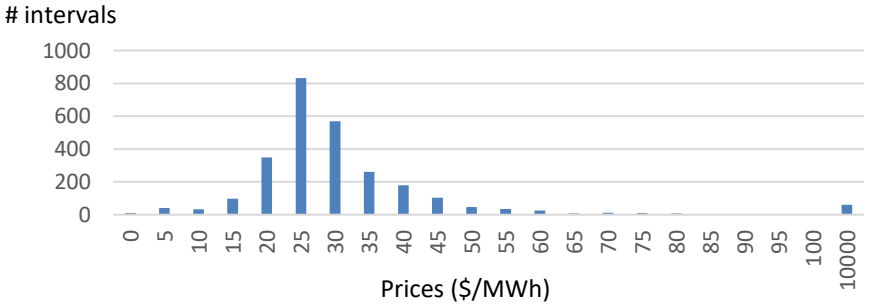
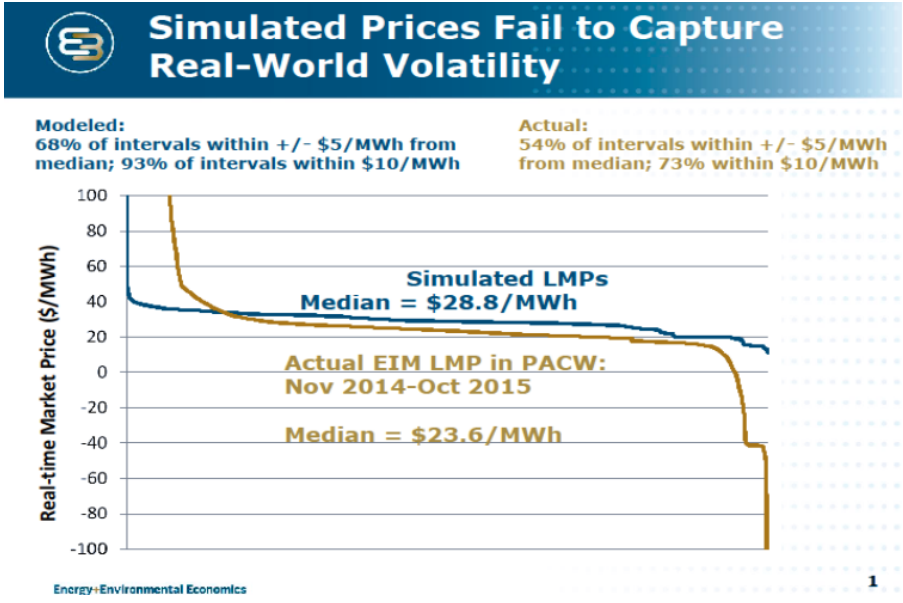


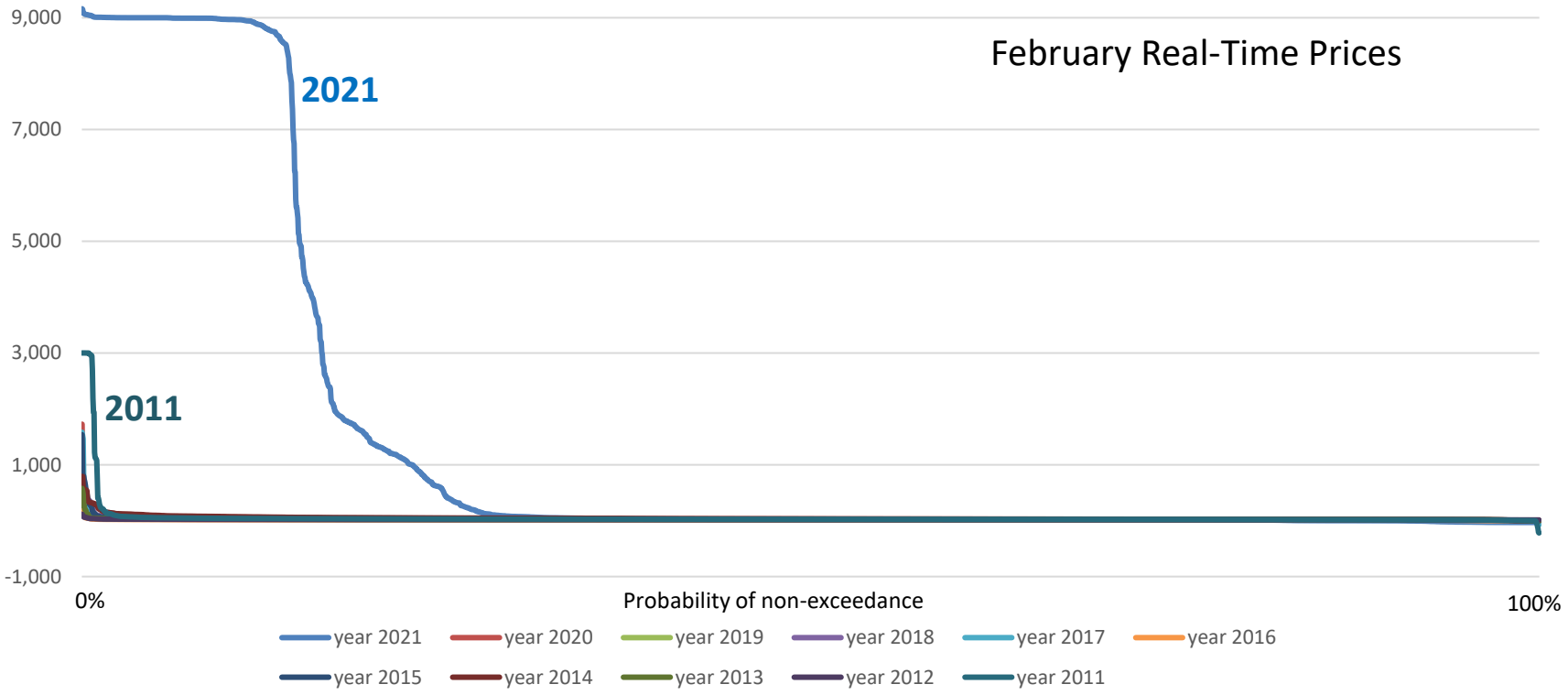


Simulating the impact of tails can be difficult.

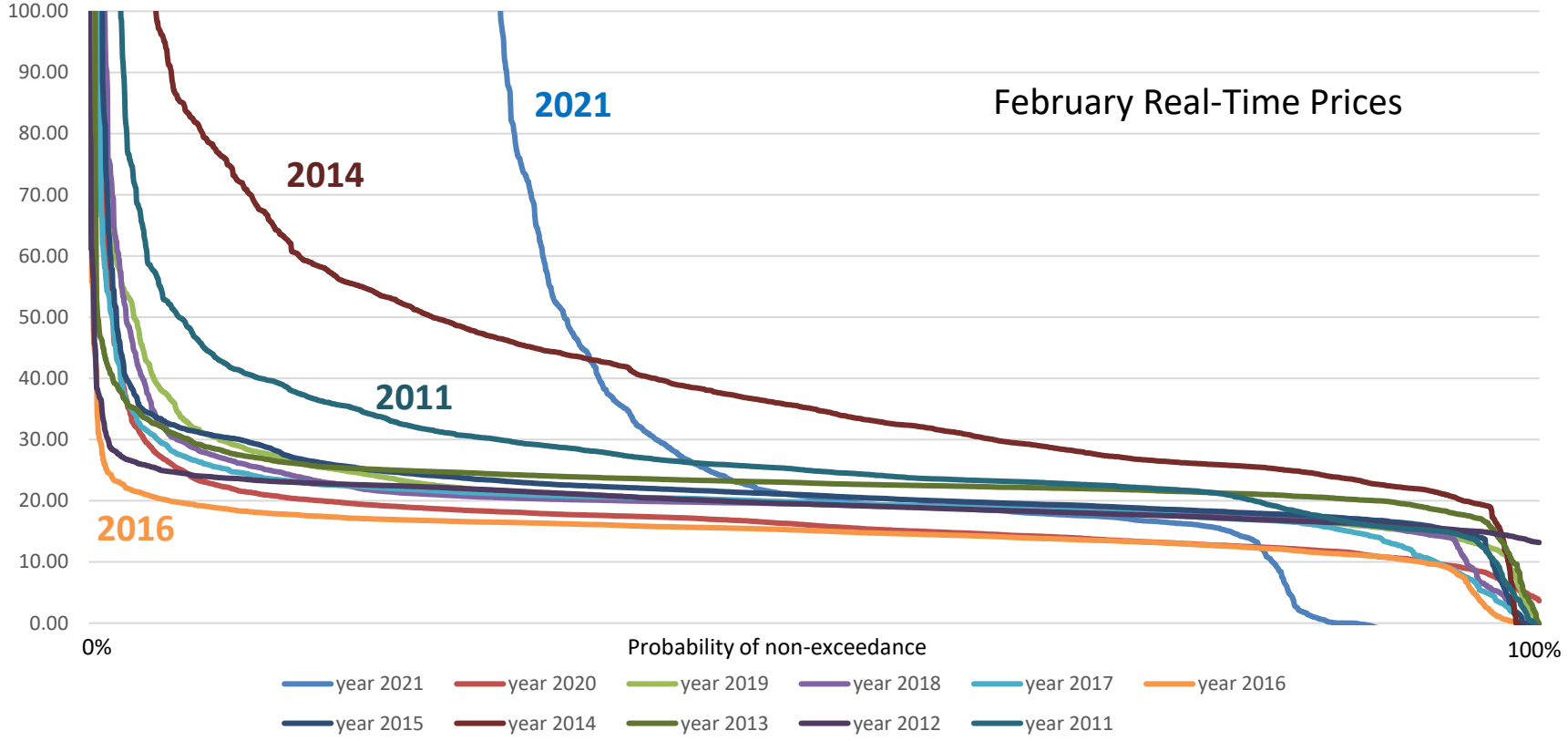


Nick Schlag, E3, ESIG Spring Workshop, April 26, 2016, Sacramento, CA.

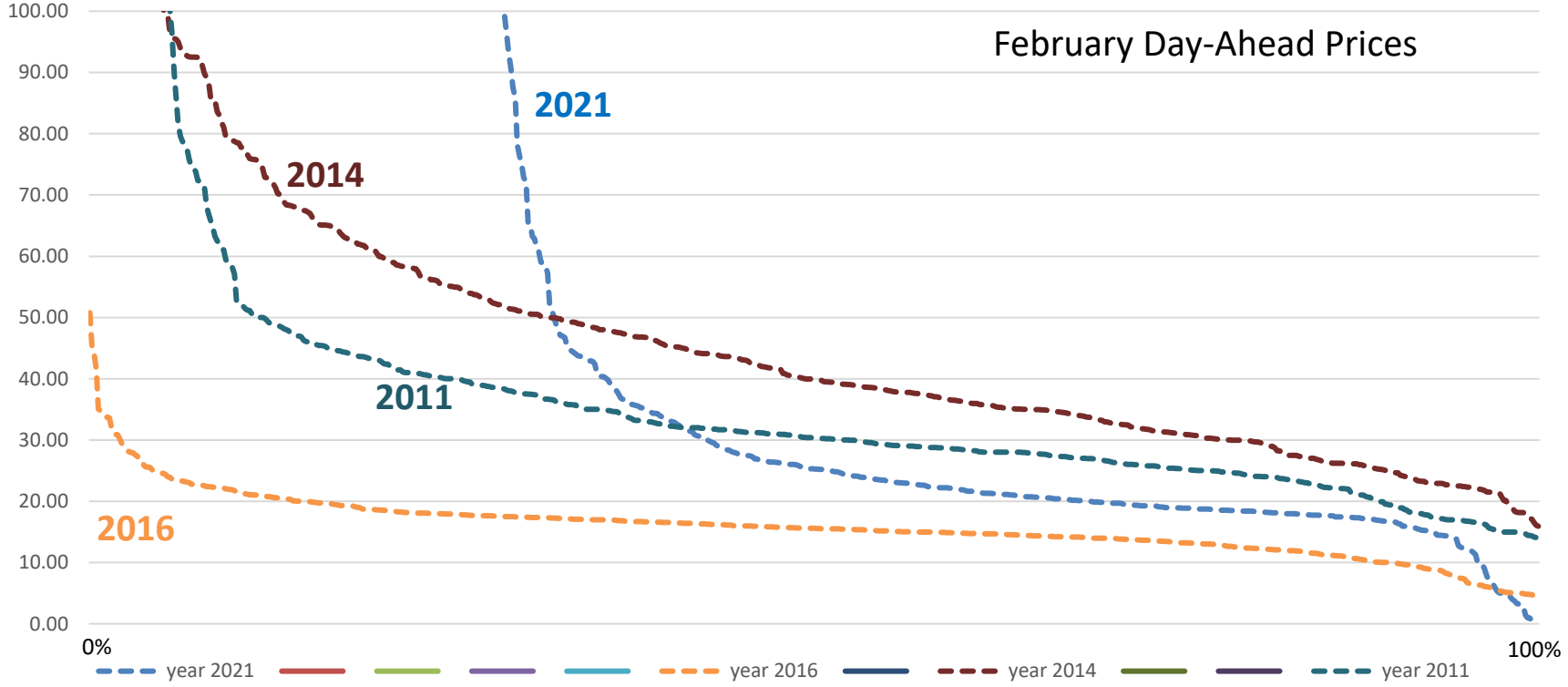
ERCOT Real Time Prices 2010 to 2021



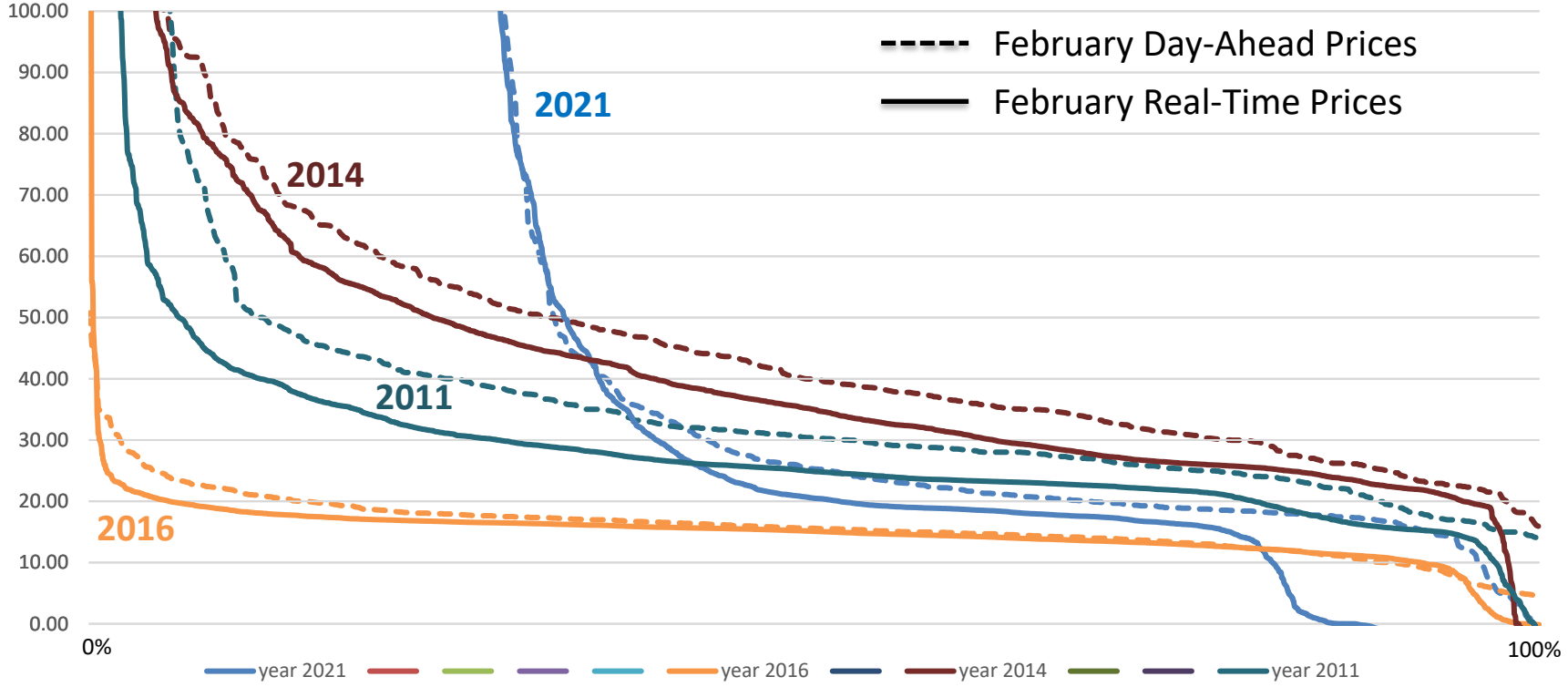
ERCOT Real Time Prices: A Closer Look



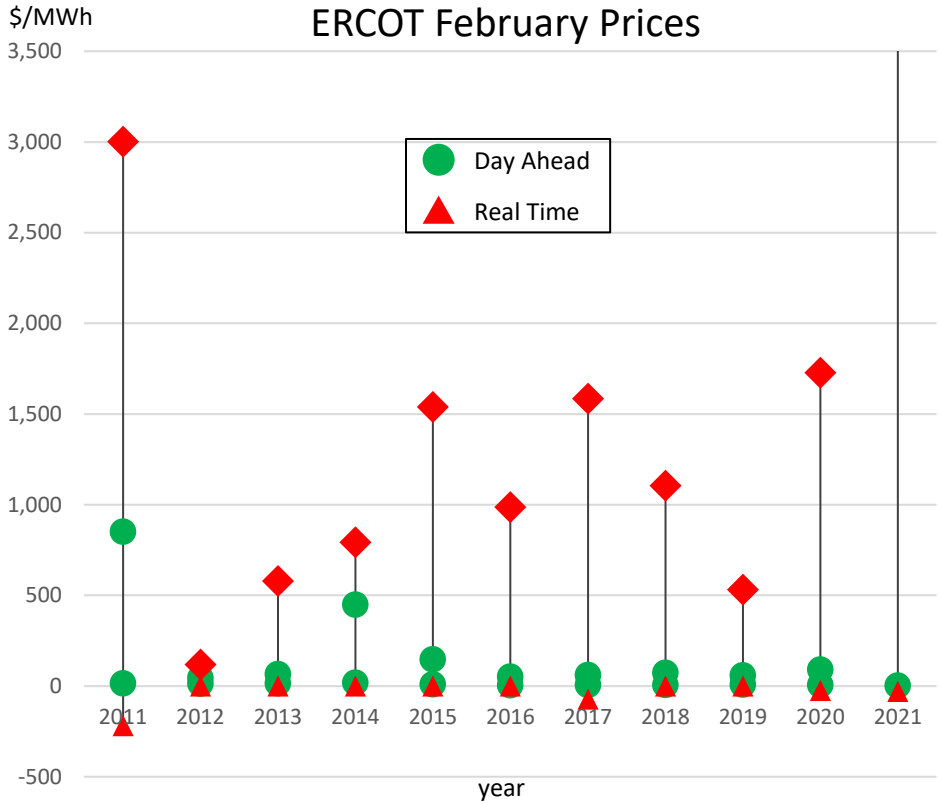
Day-Ahead prices are similar



… but different: Why?

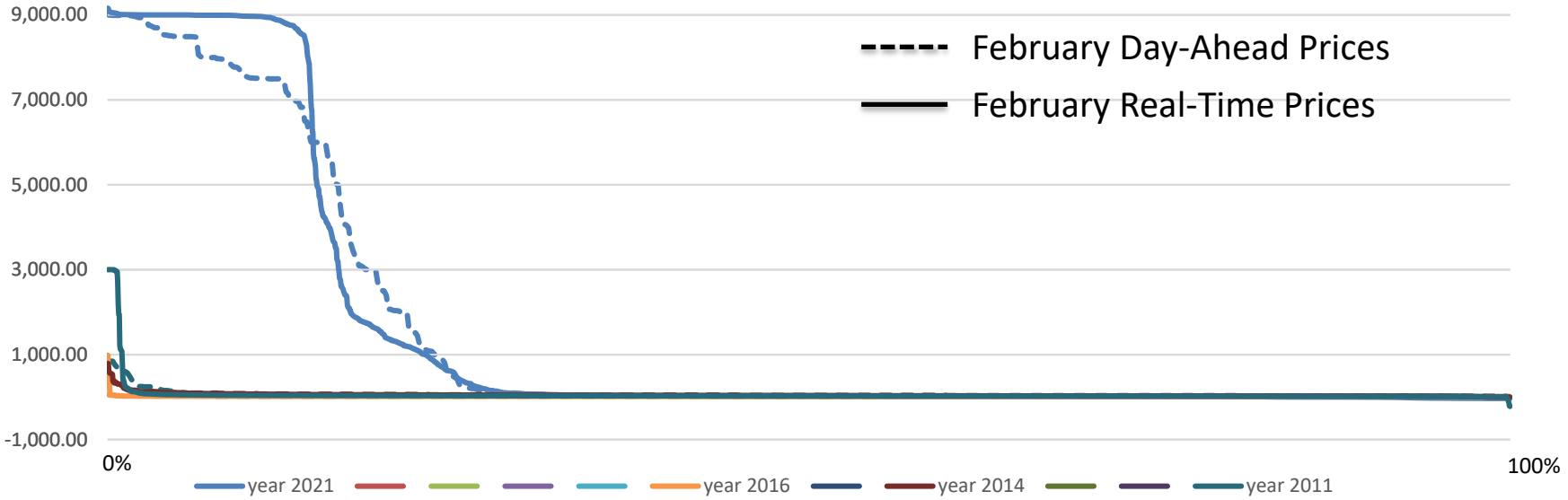


DA and RT Minimum and Maximum Prices

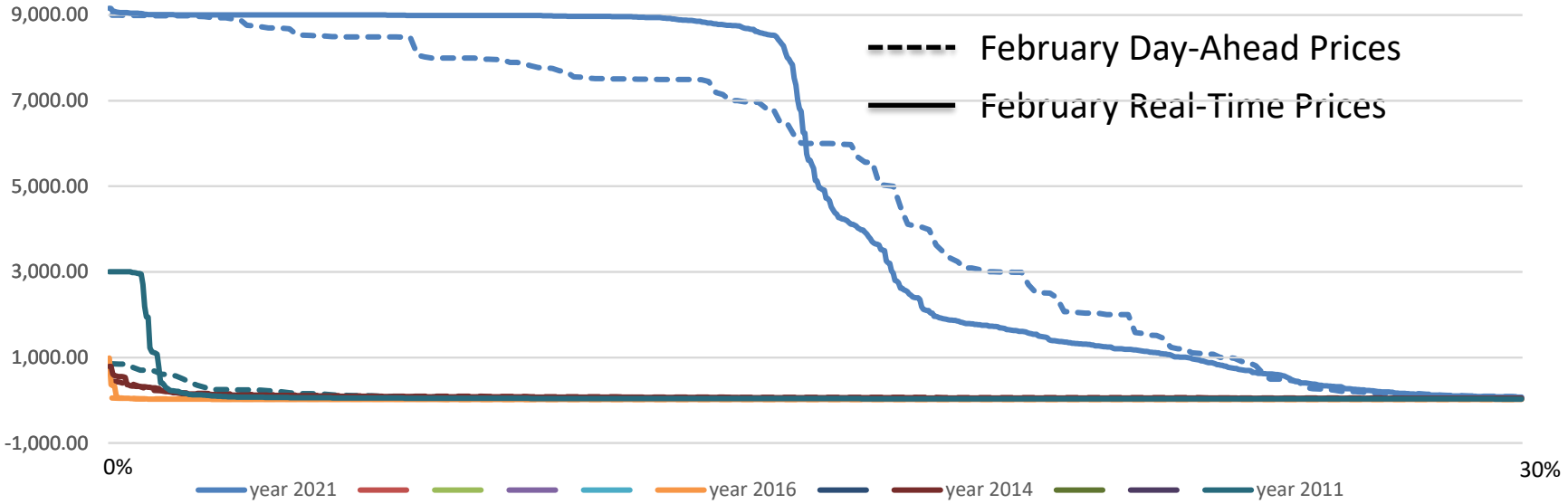


- Median prices higher in DA
- More extreme prices in RT
- Total revenues roughly similar (due to virtual trading)

DA and RT Prices: It's all about the tails



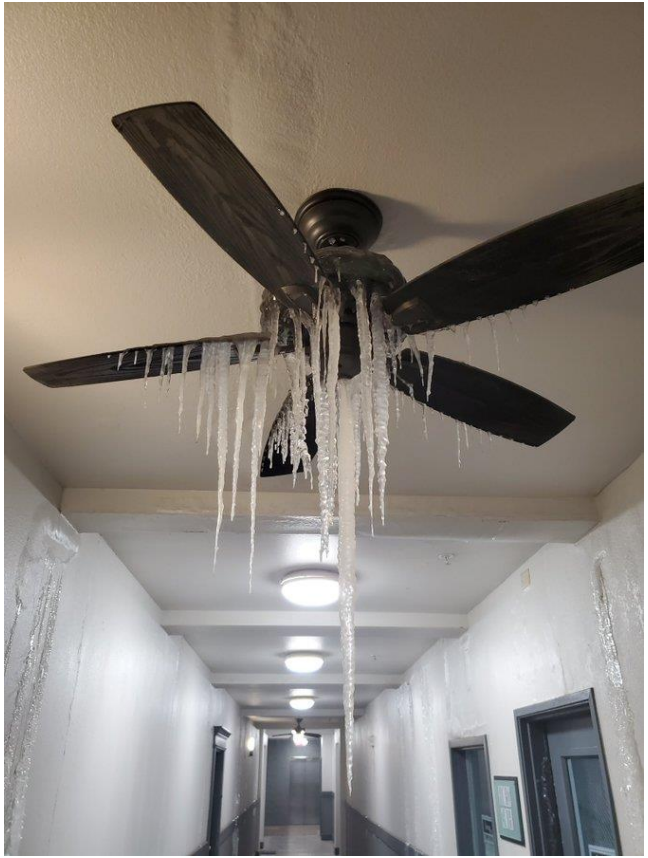
DA and RT Price Duration Curves



Observations:

- Median prices higher in DA
- More extreme prices in RT
- Total revenues roughly similar (due to virtual trading)

Who manages the tails?



The largest and oldest *power* cooperative in *Texas* is filing for *bankruptcy* protection, citing last month's winter storm that left millions without ...

Who manages the tails?

In short … EVERYONE!

- Tails are a result of the collective impact of all parties: loads, generators, operators, planners, traders, regulators, states, federal agencies, …
- … and everyone has a role in managing the tails

However, NOT everyone has an equal role

- Risk management is difficult. There is a reason we buy insurance
- Those who can manage risk should be allowed to, but we should not insist on this
    - "buyer beware" not sufficient when folks do not have information and bandwidth
- Impacts of failures depend on planning and operations

"It's the **process**, not the people"

Managing tails begins with planning

… **outcomes** depend on **operations**

… **operations** depend on **planning**

… **planning** depends on simulations of future **outcomes**

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… **outcomes** depend on **operations**

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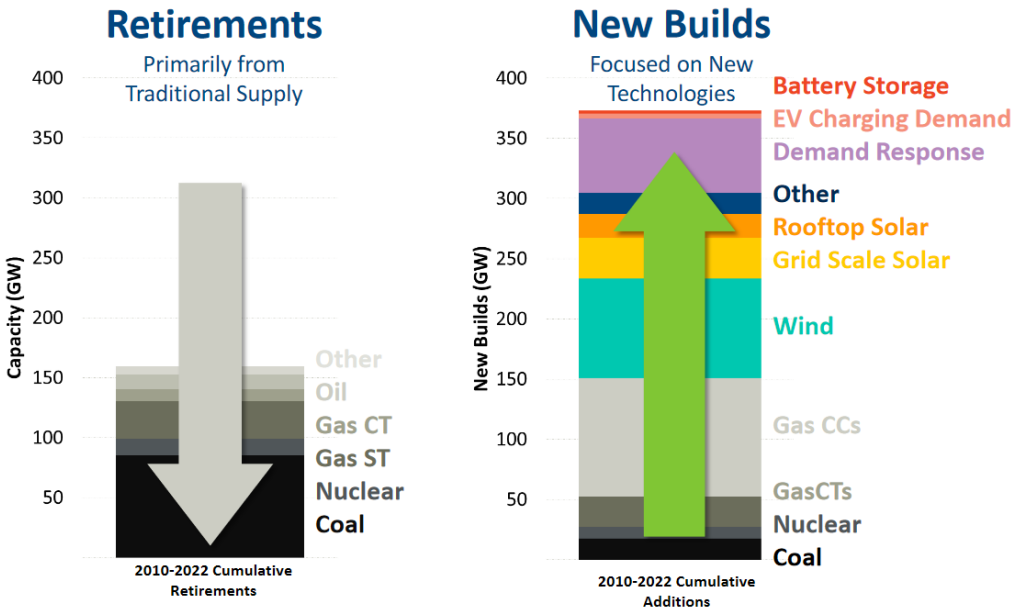
This impacts all planning processes

- **Transmission expansion**
- **Generation expansion**
- **Asset valuation**
- **Resource adequacy**
- **Maintenance scheduling**
- **Production-cost modeling**
- **Market Design**
- **“Week-ahead” scheduling**
- **Day-ahead scheduling**
- **Reliability scheduling**
- **Real-time scheduling**

Traditional planning assumptions are no longer valid

New Technologies & Engaged Customers Are Rapidly Overtaking Traditional Supply



Data Source: Energy Velocity Suite (US and Canadian generation) and Brattle research (US-only distributed resource and storage).

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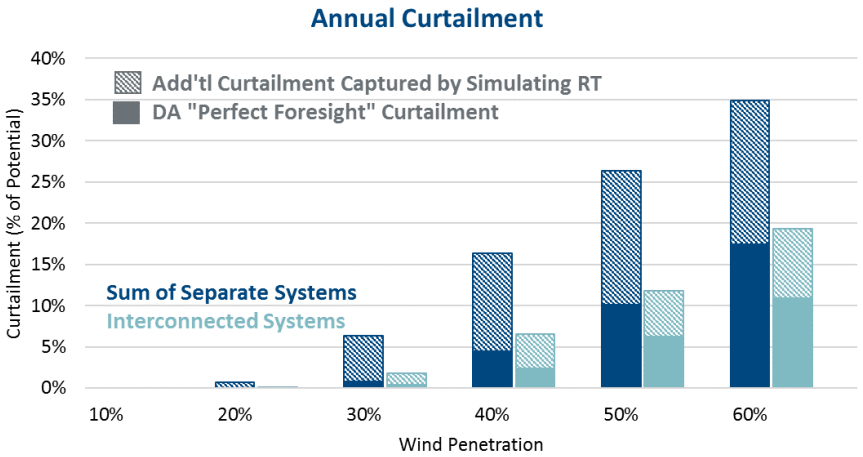
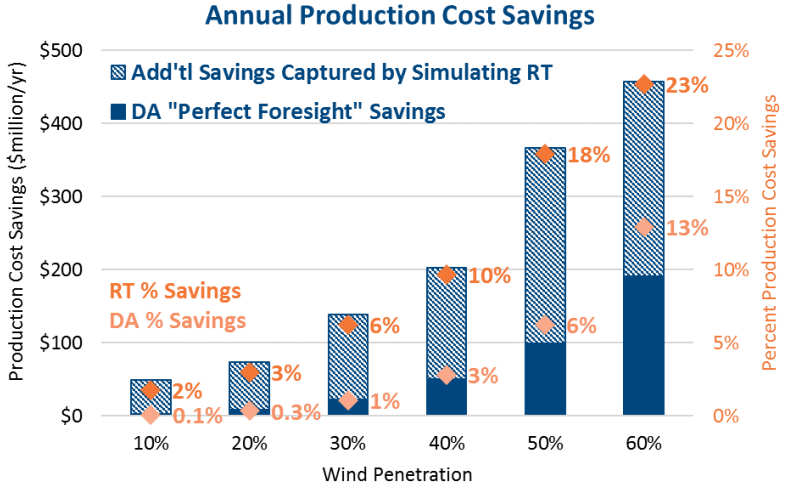
Kathleen Spees, The Brattle Group, The Cutting Edge in Resource Planning, Solar Energy Industries Association, November 12, 2018

Traditional planning misses operational impacts

Impact on value of new transmission

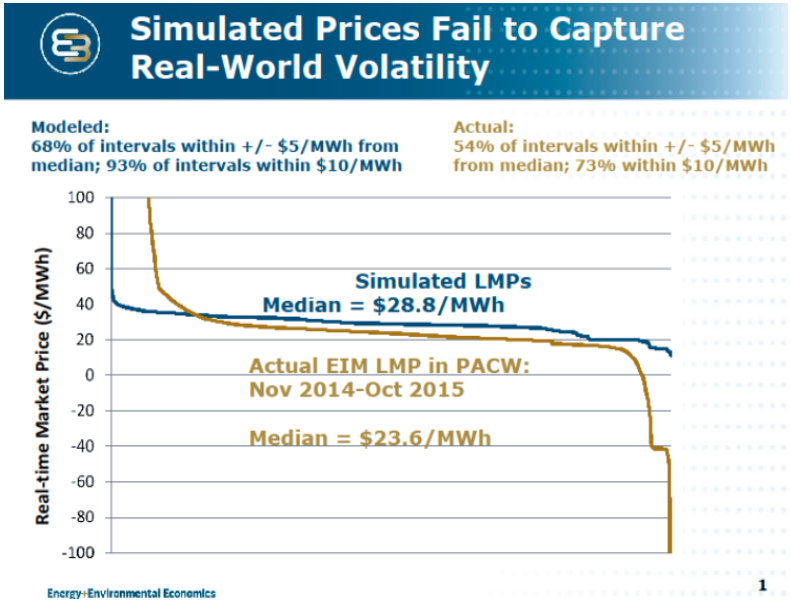
"When real-time uncertainties of renewable generation are taken into consideration, the benefit of geographic diversification through the transmission grid are 2 to 20 times higher than benefits quantified only based on "perfect forecasts" under day-ahead market conditions."





K. Van Horn, J. Pfeifenberger and P. Ruiz, *The Value of Diversifying Uncertain Renewable Generation through the Transmission System*, Boston University Institute for Sustainable Energy, September 2020.

How do operations impact tail events?



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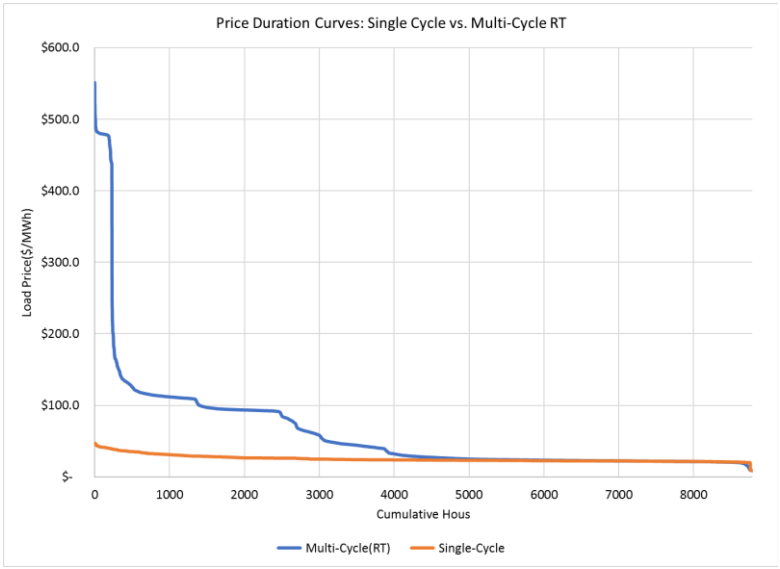

Results courtesy of EPRI and TCR

- Missing simulation of operational process
- Missing impacts of uncertainty on operations

- Extreme prices ("tails") seen in real-time prices of a multi-cycle simulation are not seen in a single-cycle simulation
- RT sees ramping of units responding to DA forecast errors (e.g., loads, wind, solar, outages)
- RT sees deployments and violations of reserves

Planning Problem: "Operations Not Included"

Control-room decisions have evolved but planning has not kept up

- Range of decision processes: week-ahead, day-ahead, real-time, intra-day, …
- Procurement and deployment of reserves
- Recourse and non-recourse decisions (i.e., provisional and final decision)

Traditional planning often does not simulate **operational impacts**

- Zonal vs nodal (e.g., missing transmission "security constraints")
- Simplified metrics (e.g., peak capacity)

"Multi-Cycle" Modeling is one of the critical elements needed to model operational impacts (see results presented earlier).

- This is how you simulate cost of caution on planning decisions
- … and the success of those decisions in operations

Challenging Questions

What are benefits of

- Transmission expansion?
- Flexible transmission control? (FACTS, DLR, active switching, …)
- Peaking vs Baseload generation?
- Different types of storage?
- Load response and/or price-responsive load?
- Energy efficiency?
- Better forecasts?
- Changing how we operate the grid ?

If you don't capture impact in planning, answers are wrong!!

You see what you look for …

Transition to a Cleaner Grid: Are We Headed for Blackouts When the Sun Goes Down?

Myths	Realities
Intuition may give us a false sense that the grid won't stay reliable unless we….	**It's not all hype. It will be a big challenge to maintain reliability while going clean…**
• Save baseload plants from retirement (or coal, or nuclear, or gas)	• Many customers and policymakers want to go clean (reliability concerns won't stop them)
• Save a specific "favored" plant	• Intermittent renewables do not provide the same bundle of reliability services as traditional thermal plants
• Stop building renewables	• Grid services we used to get "for free" will need to be defined and paid for
• Build a gas pipeline	• Grid operators must learn to rely on non-traditional resources to provide these grid services
• Impose on-site fuel requirements	• Customers may prefer to save money by allowing some outages

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Kathleen Spees, The Brattle Group, *The Next Generation of Energy Resource Planning*, National Conference of State Legislatures, August 4, 2019

Do Traditional Tools Work?

Questions? Comments?

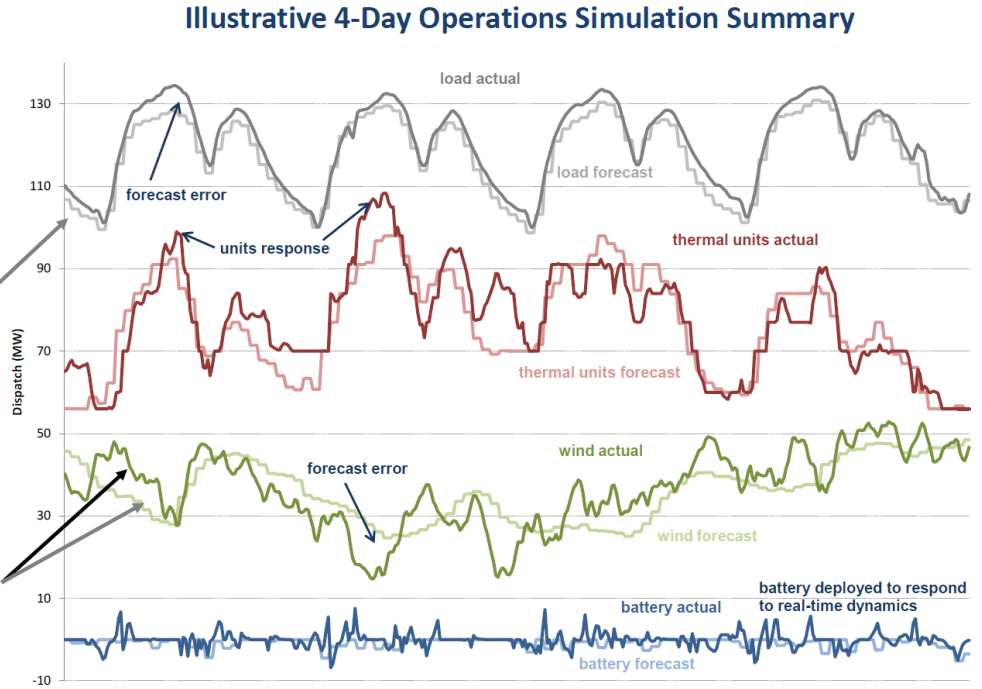
Traditional planning misses operational impacts

Forecast uncertainty is a major driver of dispatch and production costs

Our study starts with the conventional "Perfect Foresight" study approach by simulating multiple scheduling horizons with day-ahead load and renewable generation forecasts

A "Perfect Foresight" simulation typically focuses on just one view, often the day-ahead

We additionally simulate the need to respond to uncertainty in real-time with a more limited set of resources, considering both scheduling and actual operations



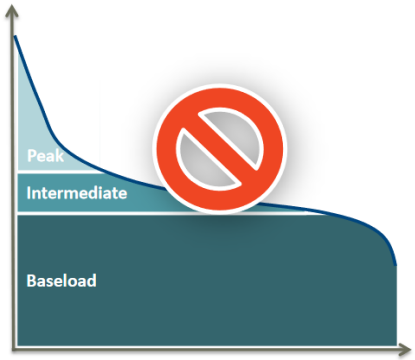
Dark lines are real-time "actual" outcomes

Light lines are day-ahead scheduling outcomes, based on forecasted conditions

K. Van Horn, J. Pfeifenberger and P. Ruiz, *The Value of Diversifying Uncertain Renewable Generation through the Transmission System*, Boston University Institute for Sustainable Energy, September 2020.

The "Old" IRP Model Doesn't Work Anymore

The Traditional IRP



What's Missing?

- New reliability & flexibility needs
- Policy goals
- New technologies
- Corporate sustainability goals
- Customer preferences
- Distributed resources uptake
- Electrification vs. grid defection
- Enabling policies & infrastructure

In other words… Traditional IRP approaches are ill-equipped to address almost every major driver that is reshaping the grid!

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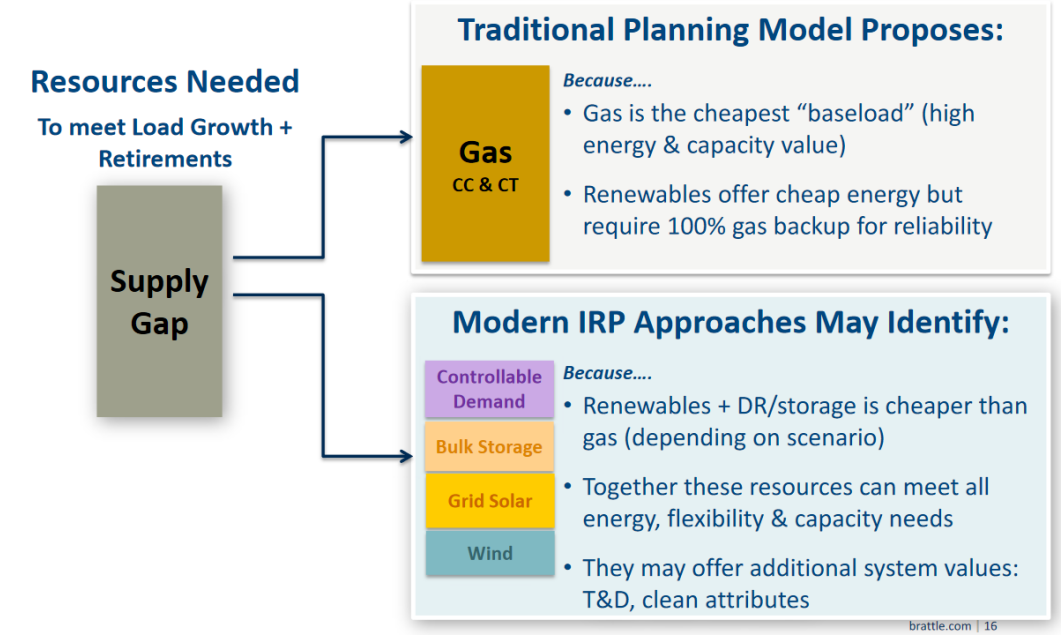
Typical Question: How to Replace a Retiring Coal Plant?



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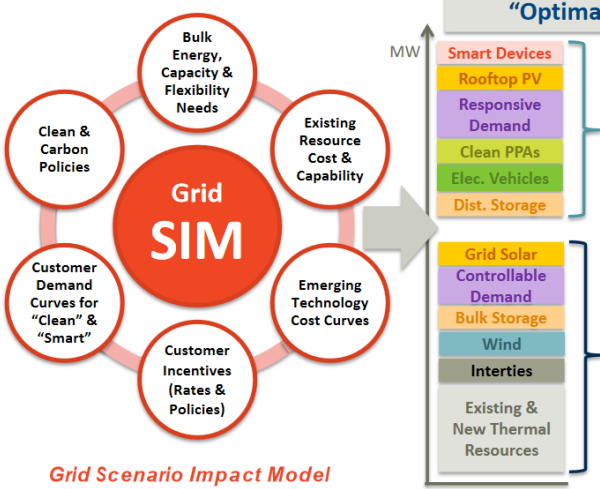
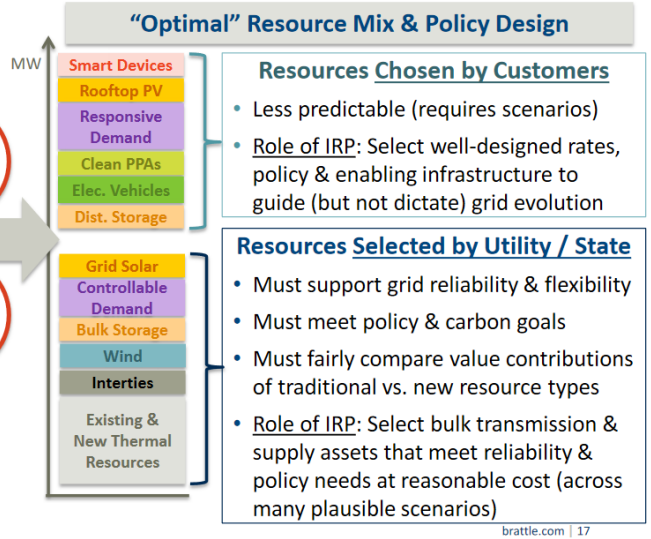
Fairly Evaluate Disparate Technologies?

Planning tools and methods have to fully account for all system needs and all resource types' capabilities on a level playing field





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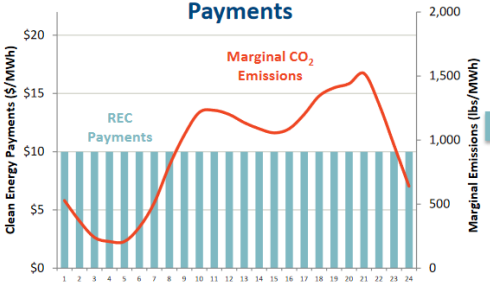
Better Product Definition: Achieves Faster Decarbonization at a Lower Cost

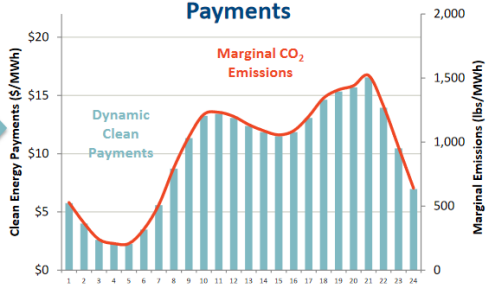
Enhanced "dynamic" clean energy attributes approach would align payments with marginal carbon abatement

Illustrative Traditional REC Payments



- Flat payments over every hour
- Incentive to offer at negative energy prices during excess energy hours

Illustrative "Dynamic" Clean Payments



- Payments scale in proportion to marginal CO_2 emissions (by time and location)
- Incentive to produce clean energy when and where it avoids the most CO_2 emissions
- No incentive to offer at negative prices

Sources and Notes:
See the full design proposal here: http://www.nepool.com/uploads/IMAPP_20170517_LT_Straw_Dynam_Clean_Energy_Market.pdf

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Traditional Production Simulation Tools vs. Needs

TRADITIONAL PRODUCTION SIMULATION MODELS

Strengths

- Decision support tools for developing trading strategies and operating plans
- Detailed modeling of operational characteristics of thermal units with transmission system constraints
- Pre-packaged

Weaknesses

- Unable to model **different decision timeframes**
  - Real time (e.g., 5-minutes ahead)
  - Hour-ahead
  - Day-ahead
- **Deterministic** decision methodologies do not optimize accounting for forecast uncertainty.
  - Uncertainty captured only in additional simulation mode (Monte Carlo approaches)
- Decisions **not strongly linked between different** timeframes lead to operational and trading issues (e.g., real time issues due to lack of appropriate modeling in intermediate time decisions)
- **Preset interval length** modeling

NEEDED MODELS

- Preserve capabilities of traditional models
- Support decisions at various overlapping timeframes (year, month, week, day, hours, minutes)
- Flexible intra-hour modeling with user-defined time intervals and decisions
- Simulate user-defined individual ancillary services and products
- Simulate forecast uncertainties for load and generation
  - User-specified probabilistic parameters to generate forecast and realization time series
  - Direct use historical time series
- Simulate uncertainties (costs, outages, etc.) and obtain results in probabilistic distributions of the variables of interest using a Monte Carlo approach
- Perform stochastic optimization of commitment and dispatch
- Simulate energy storage directly based on efficiency parameters
- View dispatch decisions graphically

Adapted from K. Van Horn, J. Pfeifenberger and P. Ruiz, *The Value of Diversifying Uncertain Renewable Generation through the Transmission System*, Boston University Institute for Sustainable Energy, September 2020.

DA and RT Prices: tails?