NREL
Transforming ENERGY

The Evolving Nature of Grid Energy

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Content credits to Wesley Cole and Pieter Gagnon

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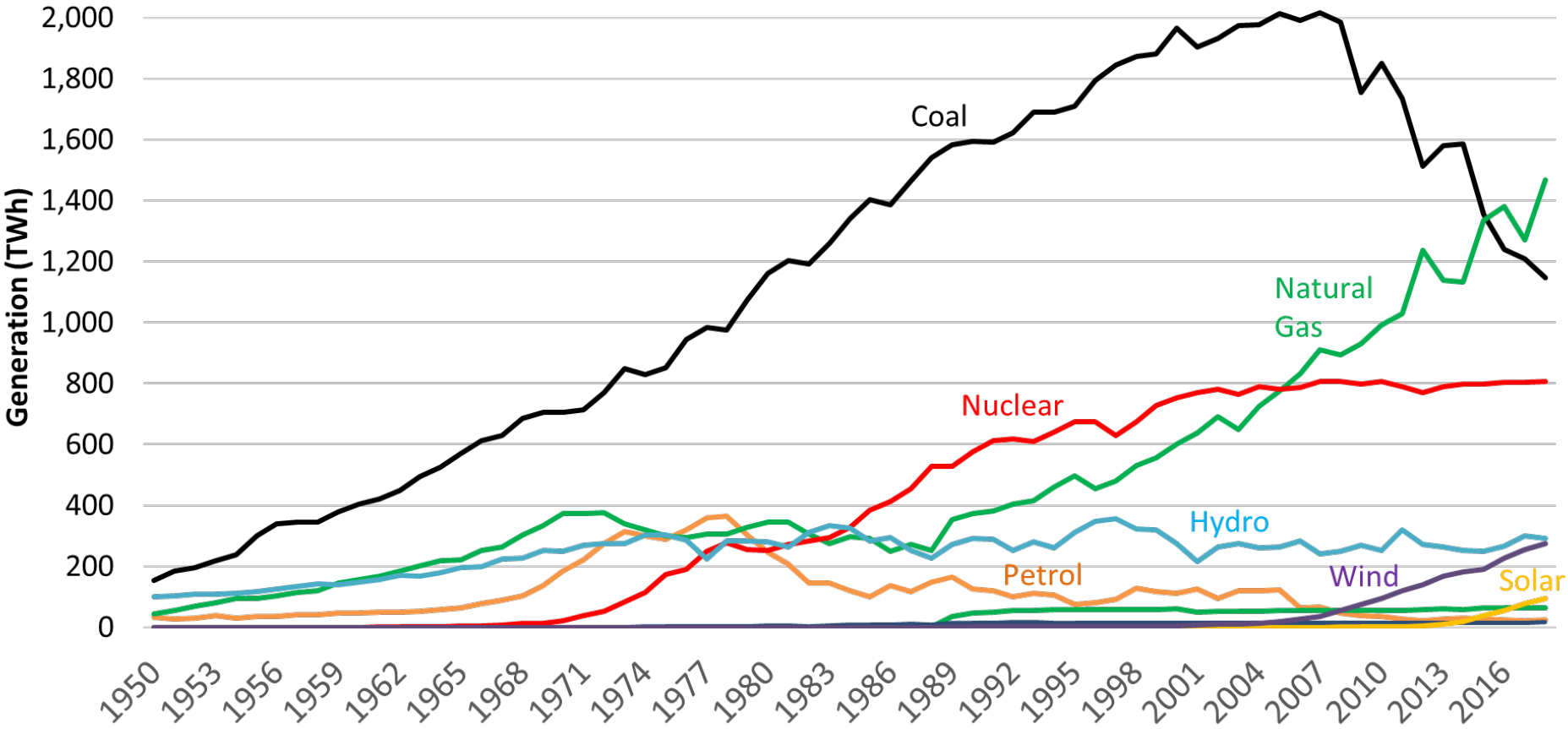
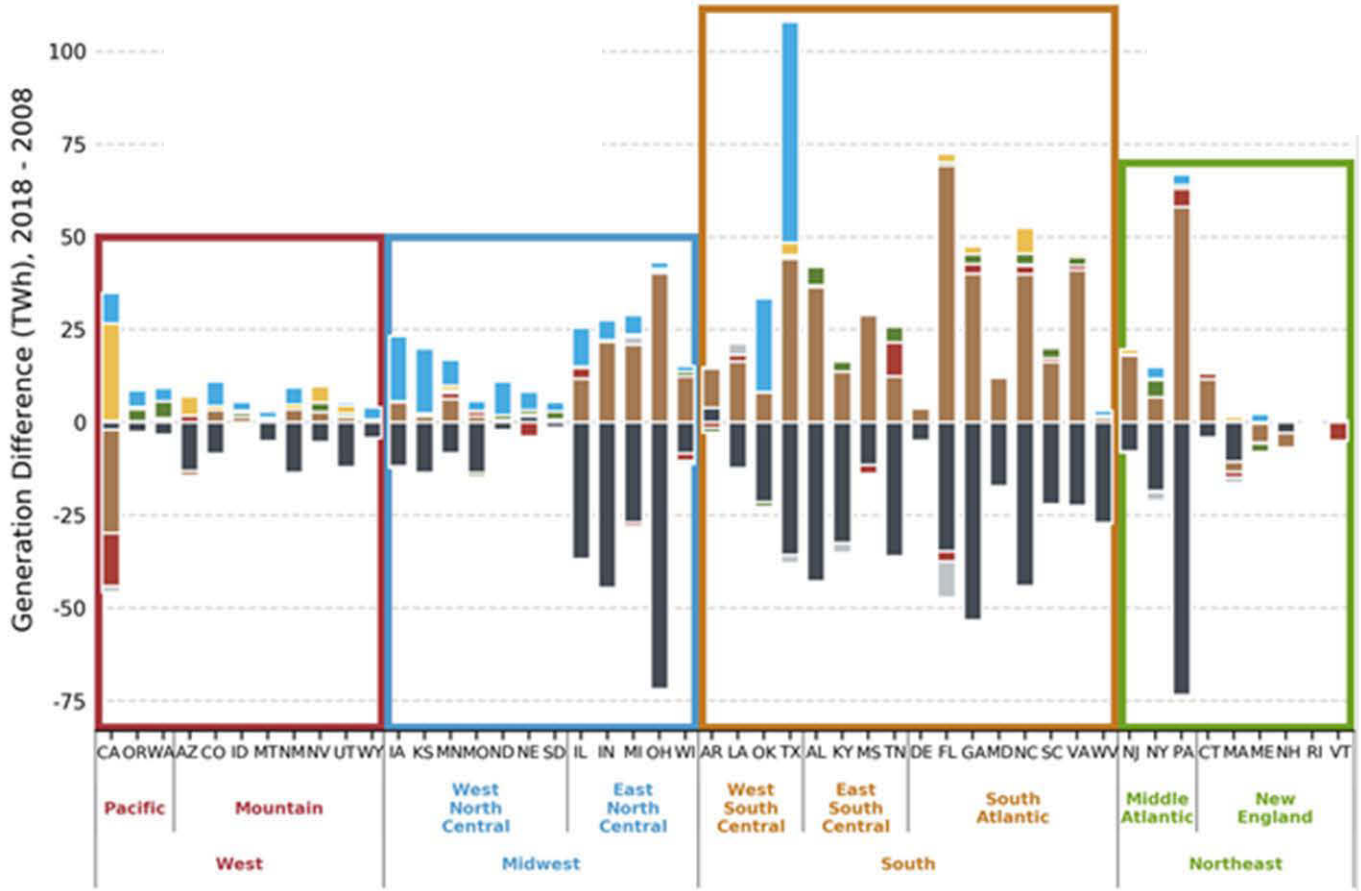
Education Session E11
Efficiency, Grid Harmonization, Storage and Renewables: Integration of Distributed Energy Resources to Achieve Decarbonization in LEED v4.1

The United States power sector has evolved and continues to evolve through time



Source: Data from EIA (Monthly Energy Review 2019), Plotted by Jeff Logan (NREL)

State level differences in generation for 2018 as compared to 2008 show increasing natural gas, wind and solar; less coal (EIA Form 860 2019)



Every year, the National Renewable Energy Laboratory (NREL) produces Standard Scenarios. The Standard Scenarios are a suite of forward-looking scenarios of the U.S. power sector

- An NREL report identifies themes from the scenarios (https://www.nrel.gov/analysis/standard-scenarios.html)
- Companion product of the Annual Technology Baseline (https://atb.nrel.gov)

Standard Scenarios for 2018

Non-Policy Scenarios

Fuel Cost
- High Oil & Gas Resource (AEO 2018)
- Low Oil & Gas Resource (AEO 2018)

Demand
- Low Demand
- High Demand
- Vehicle Electrification

Other
- Extended Cost Recovery
- Climate Change Impacts
- Reduced RE Resource
- Transmission Expansion Barriers
- Restricted Cooling Water

Mid-case
- Reference or Mid-level Assumptions

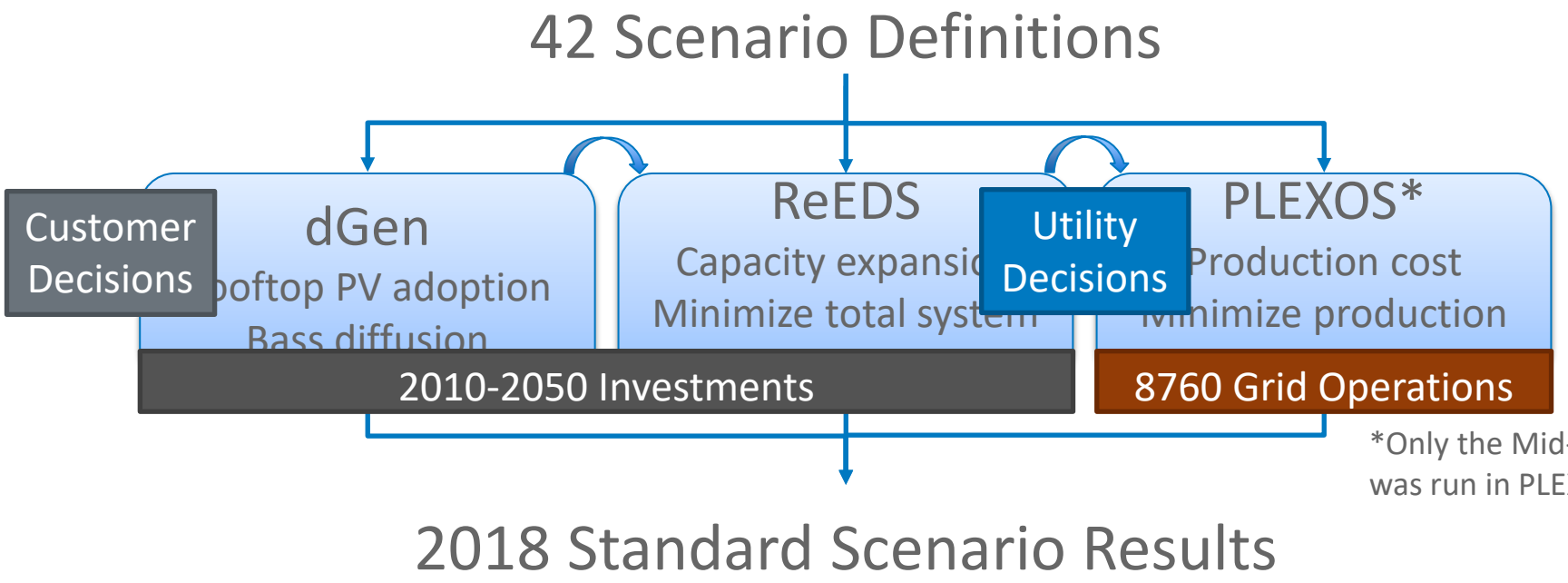
Technology Cost
- Low RE Cost
- High RE Cost
- Low Wind Cost
- Low PV Cost
- Low Geo Cost
- Low CSP Cost
- Low Hydro Cost
- Low Offshore Wind Cost
- Nuclear Breakthrough
- Low Battery Cost
- High Battery Cost

Combinations
- Low/High NG Price with
  - Low/High RE Cost
  - Low/High Geo Cost
  - Low/High CSP Cost
  - Low/High Hydro Cost
  - Low/High Offshore Wind Cost

Retirements
- 80 Year Nuclear
- 60 Year Nuclear
- Accelerated Nuclear Retirement
- Accelerated Retirements
- Extended Lifetimes

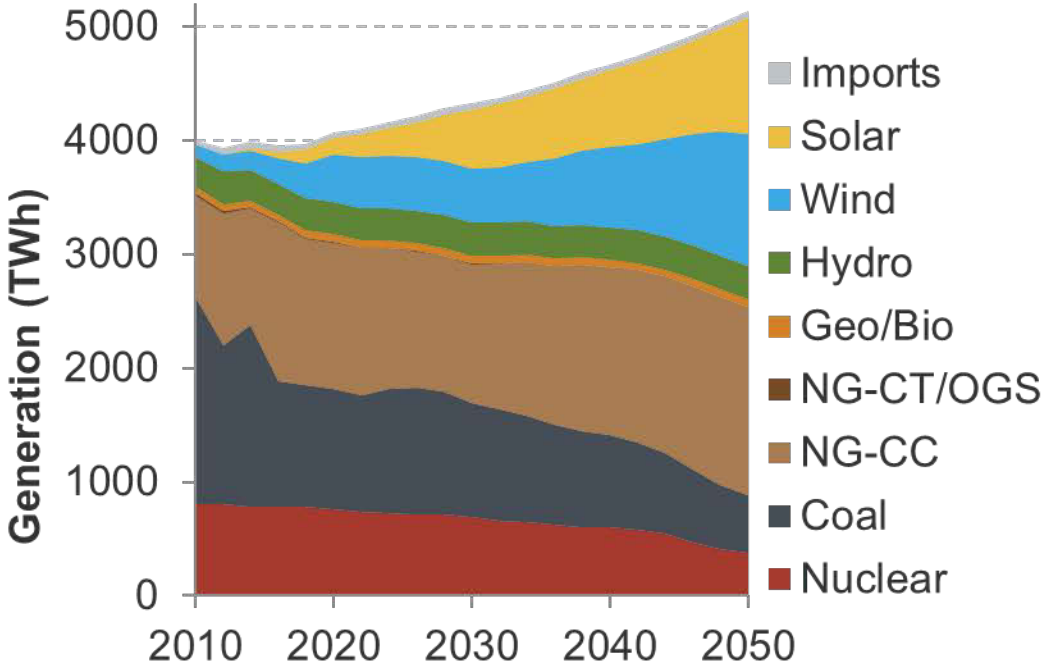
Policy
- National 80% RPS by 2050
- 83% CO_2 Reduction by 2050
- ITC & PTC Extension to 2030

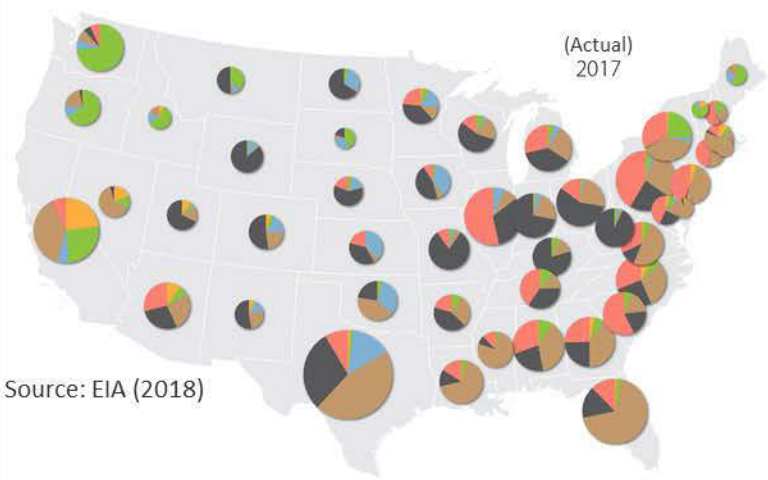
The tools and methods are reused and refined each year



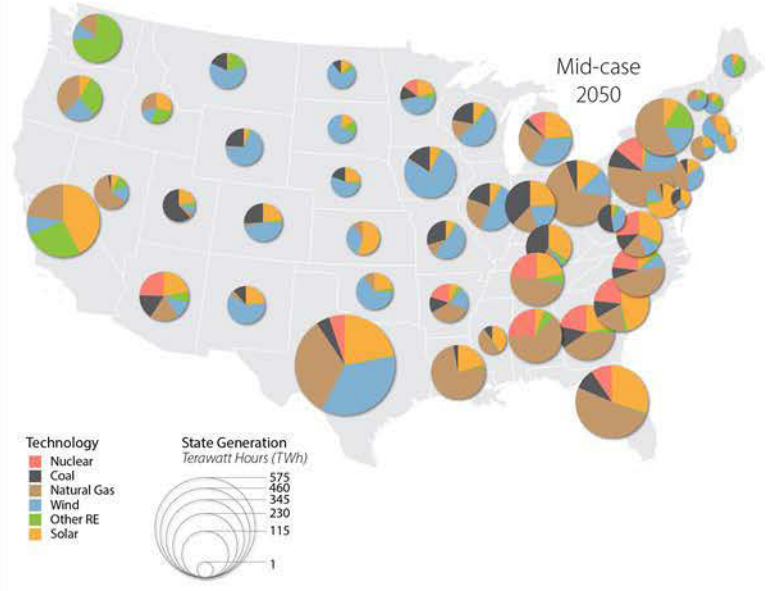
*Only the Mid-case was run in PLEXOS

2018 Mid-case: Growth in Renewable Energy and Natural Gas

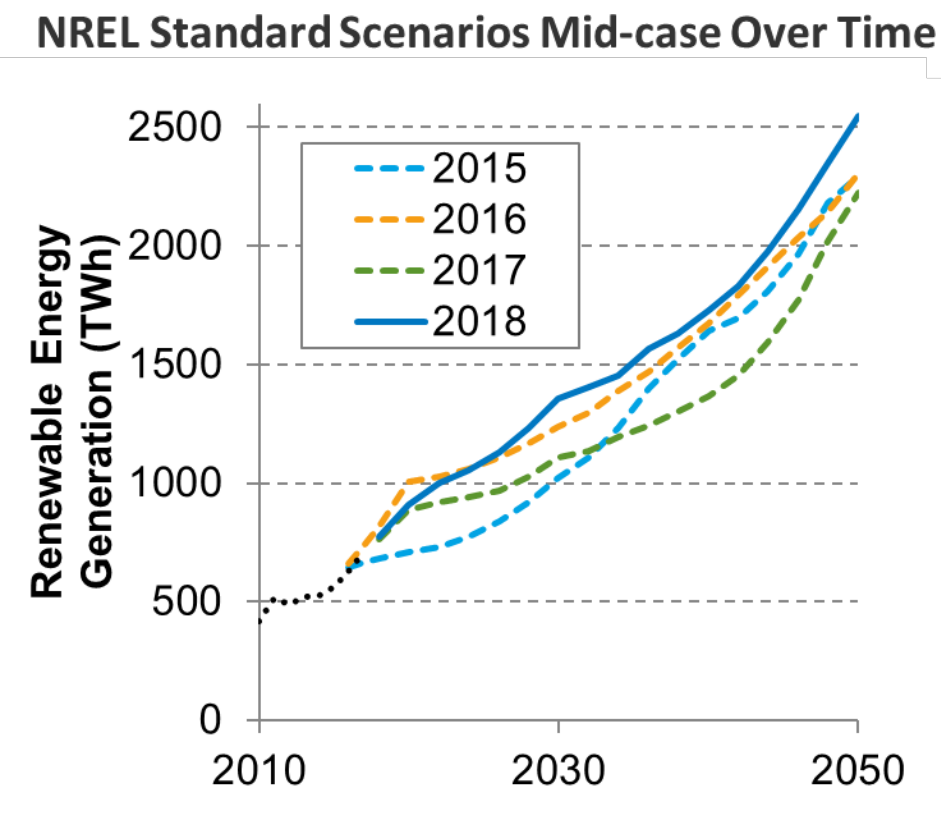


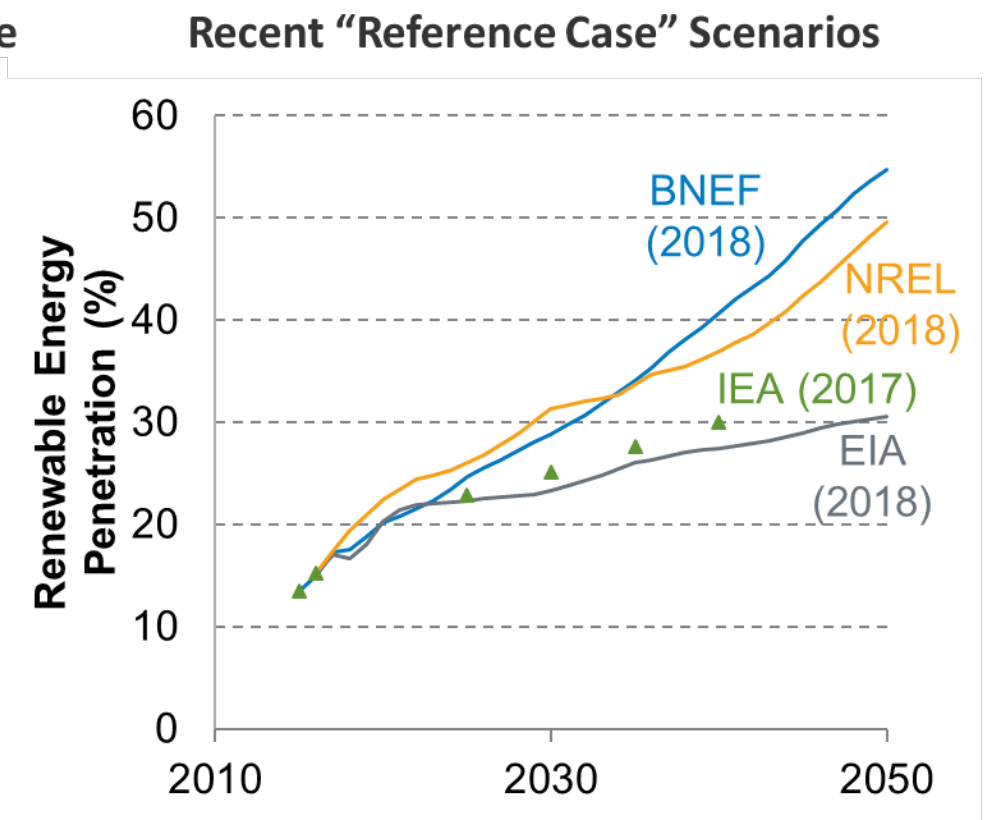


Source: EIA (2018)

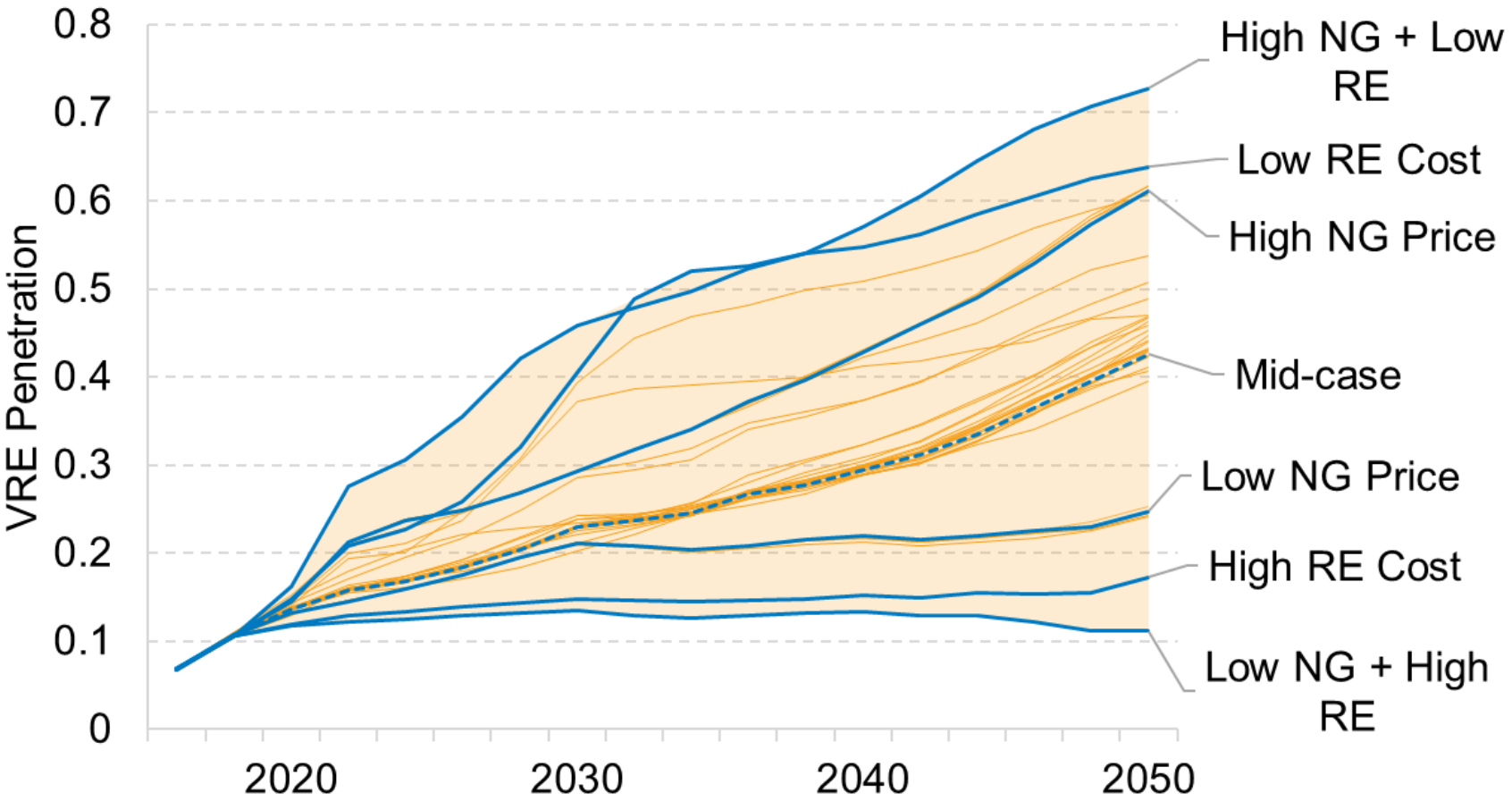


NREL Mid-case in Context

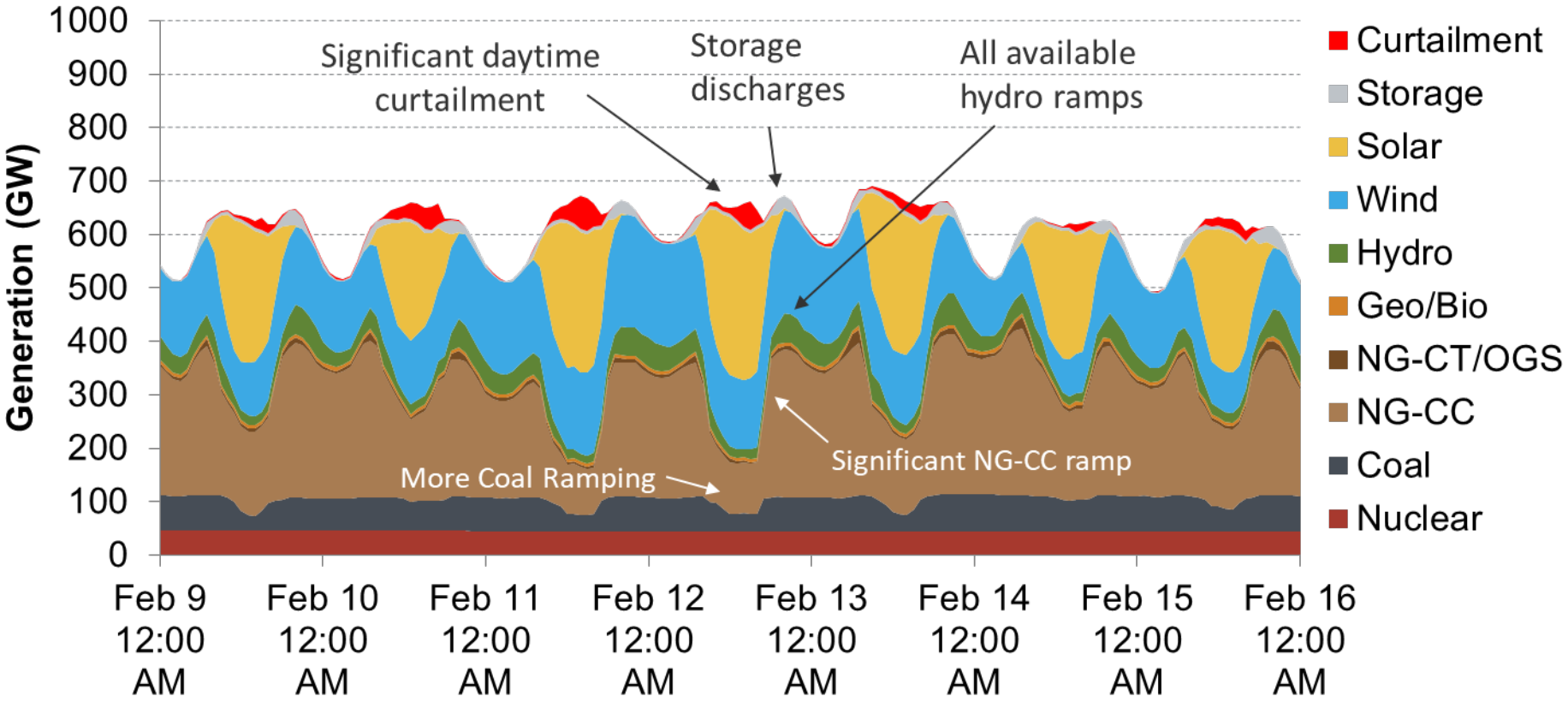




Variable Renewable (VRE) Growth Across Scenarios



Hourly Operation – High Ramp Day (in 2050)



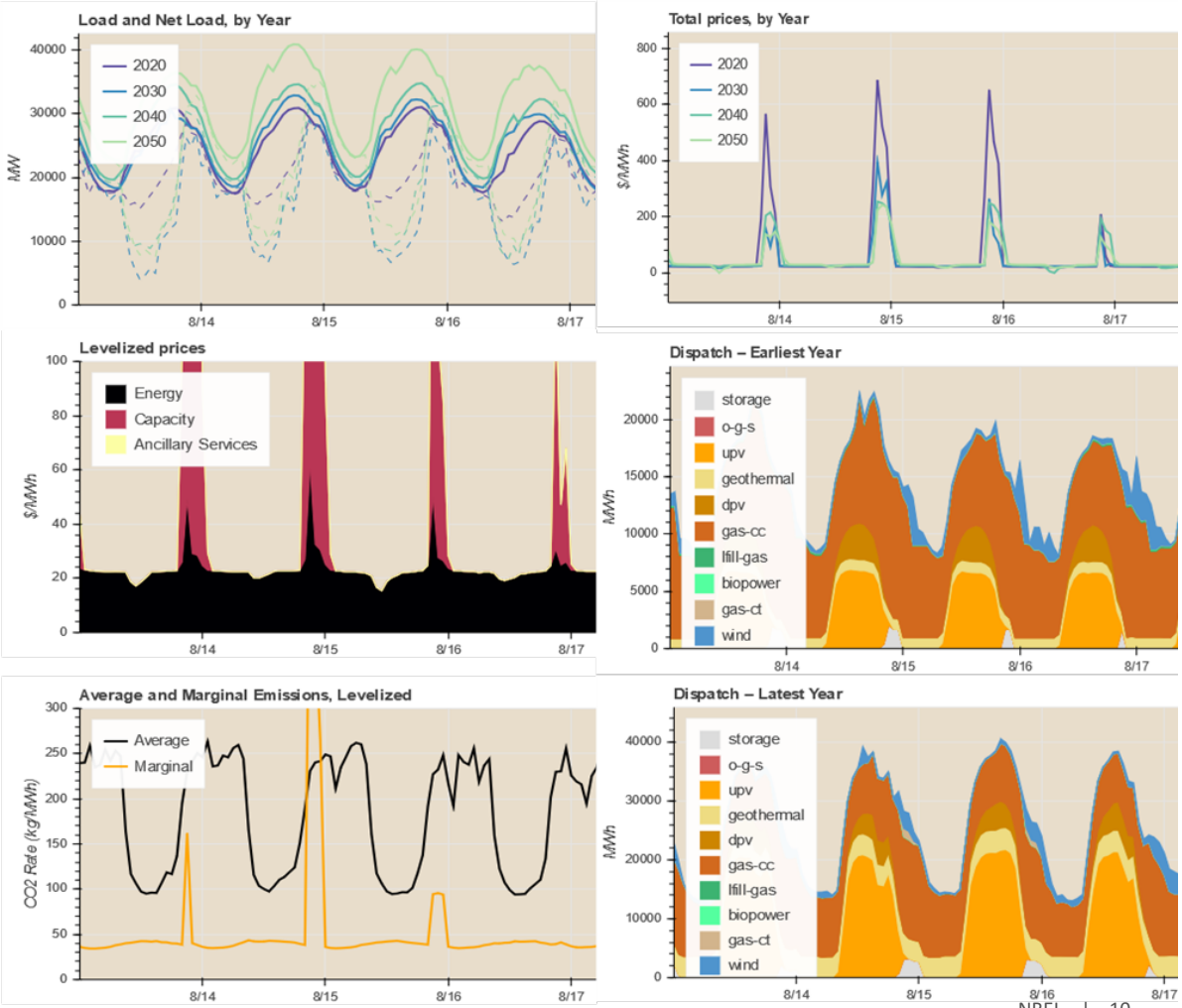
What is Cambium?

Hourly data for the future grid scenarios modeled in NREL's Standard Scenarios

- Marginal costs (separated into energy, capacity, ancillary services, etc.)
- Emission rates (marginal and average)
- Load and net load
- Dispatch stacks

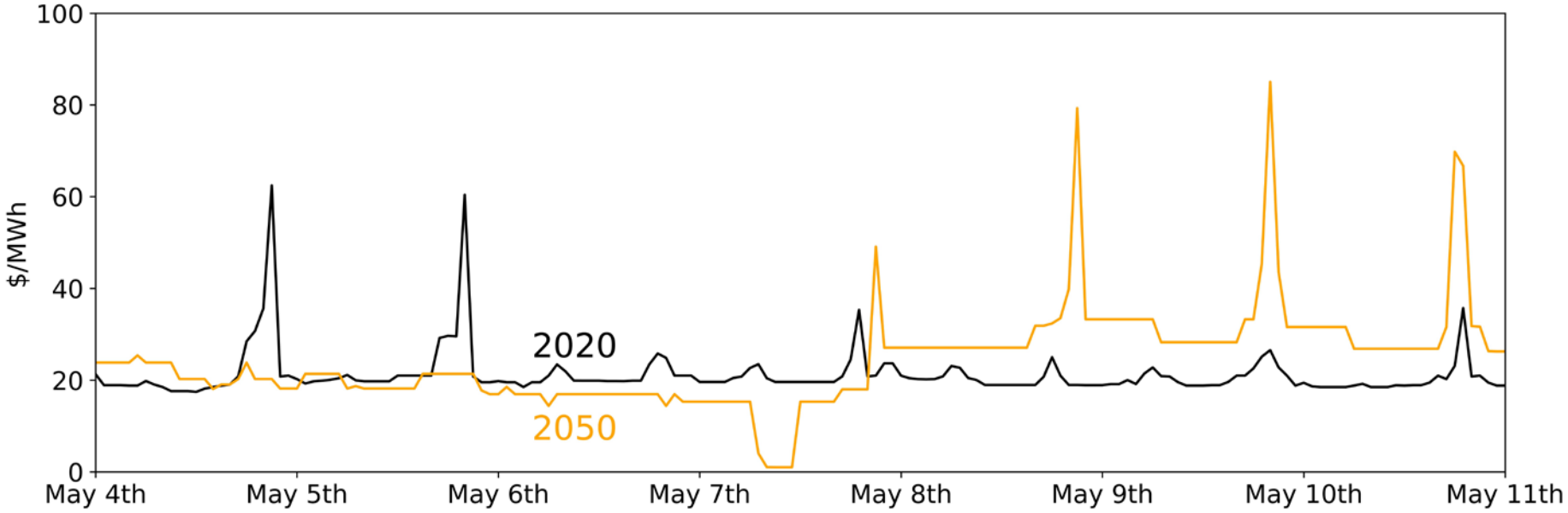
An interface for users to query the data

- Users specify region and timeframe (e.g. Colorado for 2020-2050)
- Cambium returns year-over-year, present-values, and annualized values



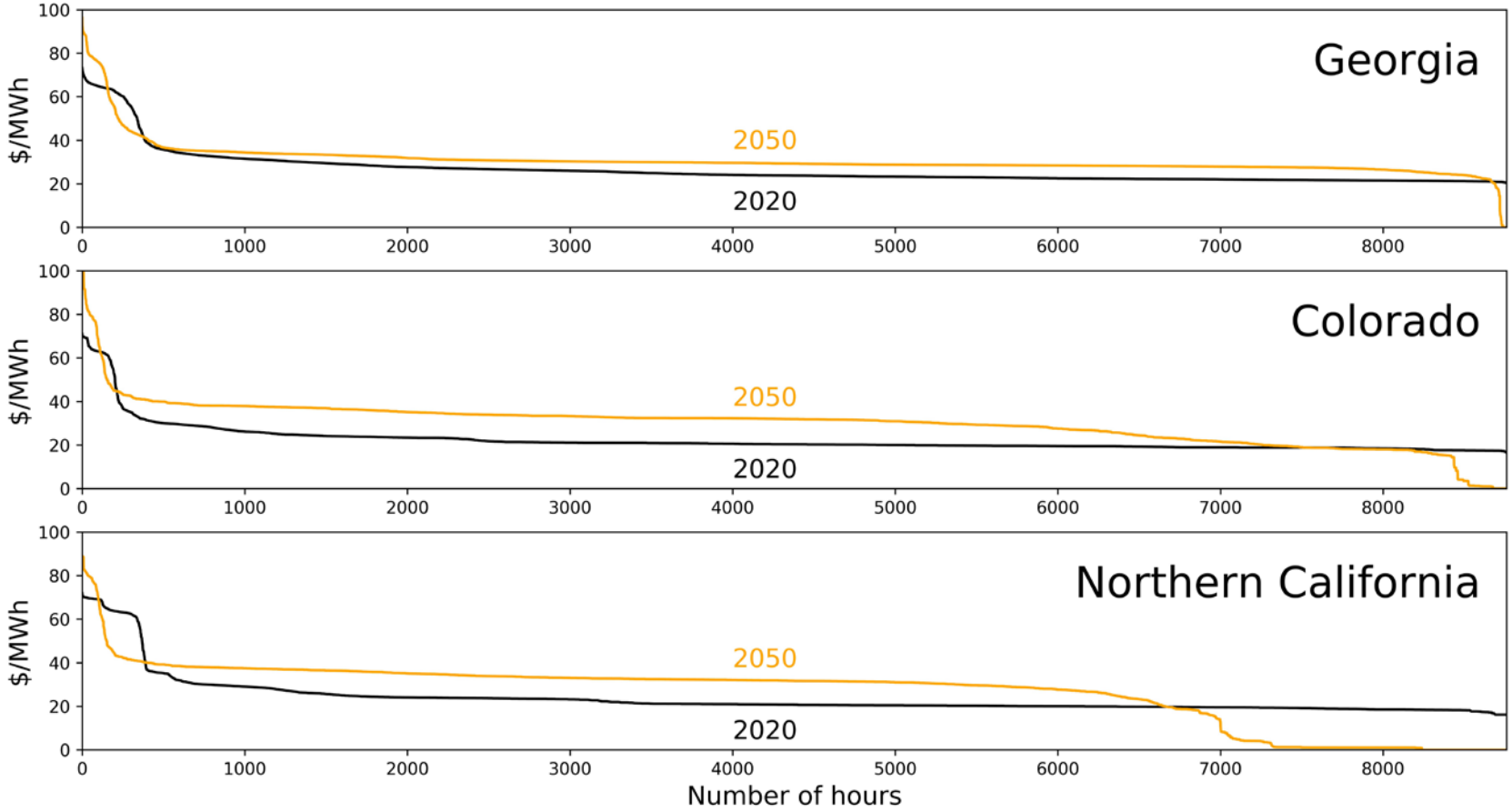
Grid service prices are time-varying; patterns are expected to change as grid resources change

Preliminary Cambium Modeled Energy Prices in Colorado, Mid-Case Scenario, Example Week



Regional differences are also apparent in modeled energy prices

Preliminary Cambium Modeled Energy Price Duration Curves



Key Takeaways

- Grid energy is always changing at all timescales
- Ideally, built environment planning would account for expected changes in grid-provided energy
- The Cambium project is aiming to produce grid price and emissions datasets through 2050 based on the NREL Standard Scenarios
- Historical data contains actual variability seen in markets; Cambium will be lacking in some of that variability, but will capture impacts of expected technological change

Points of Contact (POC)

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Demand-side grid modeling POC: Elaine Hale (Elaine.Hale@nrel.gov)

Thank you

www.nrel.gov

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As a member of the Economics and Forecasting Group in the National Renewable Energy Laboratory's (NREL's) Strategic Energy Analysis Center, Elaine Hale conducts interdisciplinary systems research currently focused on understanding potential roles for flexible and demand-side technologies in future power systems with more variable renewable generation. With a background in control and optimization algorithm development, since joining NREL Elaine has enabled and conducted large-scale analysis of complex engineering systems, including buildings (2008-2014), power systems (2014-2016), and now combining the two (2016+). https://www.nrel.gov/research/elaine-hale.html