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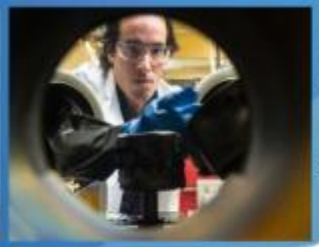
1977 – 2017



# 2017 Standard Scenarios Report: A U.S. Electricity Sector Outlook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October 17, 2017


W. Cole et al., "2017 Standard Scenarios Report: A U.S. Electricity Sector Outlook," NREL/TP-6A20-68548, 62 pp. (October 2017).

NREL/PR-6A20-70328



NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

# What is the “Standard Scenarios?”

- Suite of 26 forward-looking scenarios (projections) of the U.S. power sector
- NREL report that identifies themes from the scenarios
  - Uses the 26 scenarios to provide an outlook of the power sector
- Companion product of the Annual Technology Baseline

# Why do we do the Standard Scenarios?

- Internal Value
  - Consistency across analyses
  - Improved efficiency
- External Value
  - Share our input assumptions and model results
  - Provide an additional perspective on power sector evolution
  - Inform stakeholder decision-making

# Changes from last year

- More scenarios
  - Additional nuclear retirement sensitivities
  - Low/high battery storage cost
  - Low PV and Low Wind cost
- Clean Power Plan included only as a sensitivity
- Default nuclear retirements updated (mix of 60 and 80 years)
- State policy updates
- Various model improvements

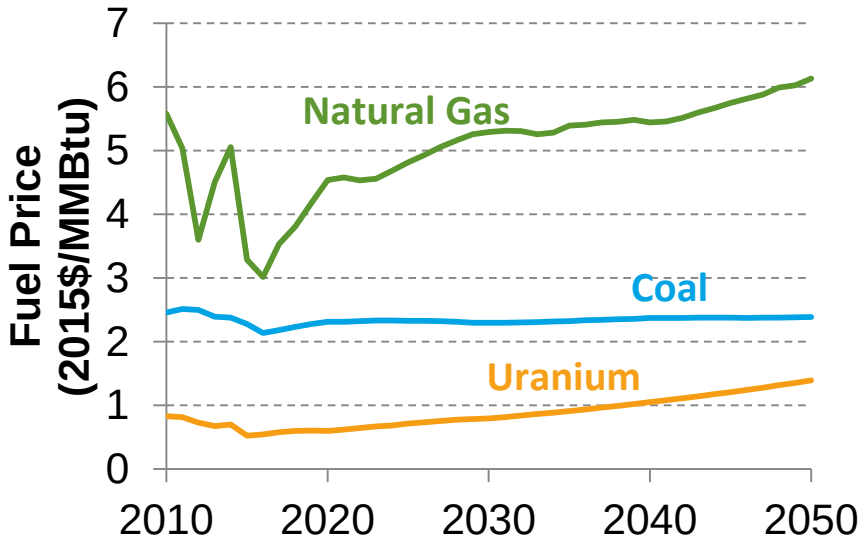
# Webinar Outline

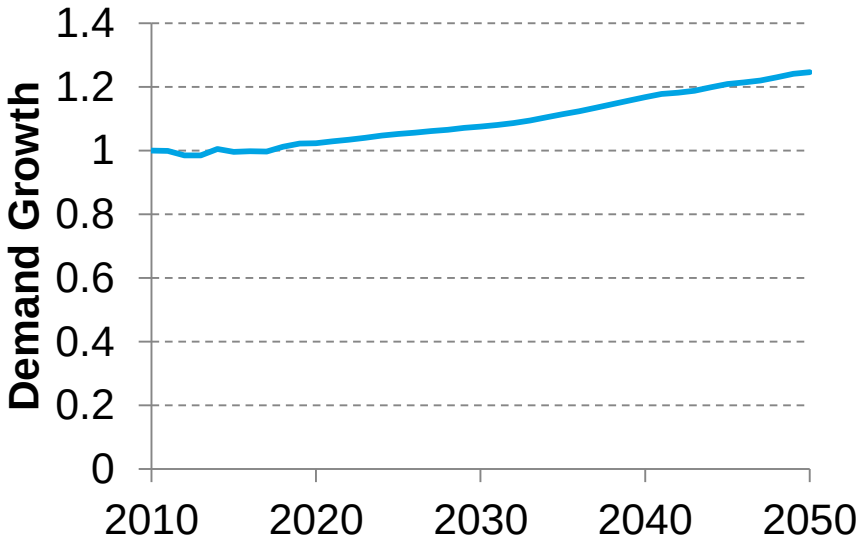
- Summary of the Standard Scenarios
- Insights and perspectives from the 2017 Standard Scenarios (i.e., what is in the report)
- How to access the scenario data

# The Standard Scenarios

# The Mid-case Scenario

- Fuel prices: EIA Annual Energy Outlook (AEO) 2017
- Demand growth: AEO 2017
- Technology cost and performance: 2017 Annual Technology Baseline (ATB)
- Current policies (no Clean Power Plan)
- Current fleet characteristics: ABB Velocity Suite



# Summary of the Standard Scenarios

## Non-Policy Scenarios

### Fuel Cost

- High Oil & Gas Resource (AEO 2017)
- Low Oil & Gas Resource (AEO 2017)

### Demand

- Low Demand
- High Demand
- Vehicle Electrification

### Other

- Low Cost Financing
- Climate Change Impacts
- Reduced RE Resource
- Transmission Expansion Barriers
- Restricted Cooling Water

### Technology Cost

- Low RE Cost
- High RE Cost
- Low Wind Cost
- Low PV Cost
- Nuclear Breakthrough
- Low Battery Cost
- High Battery Cost

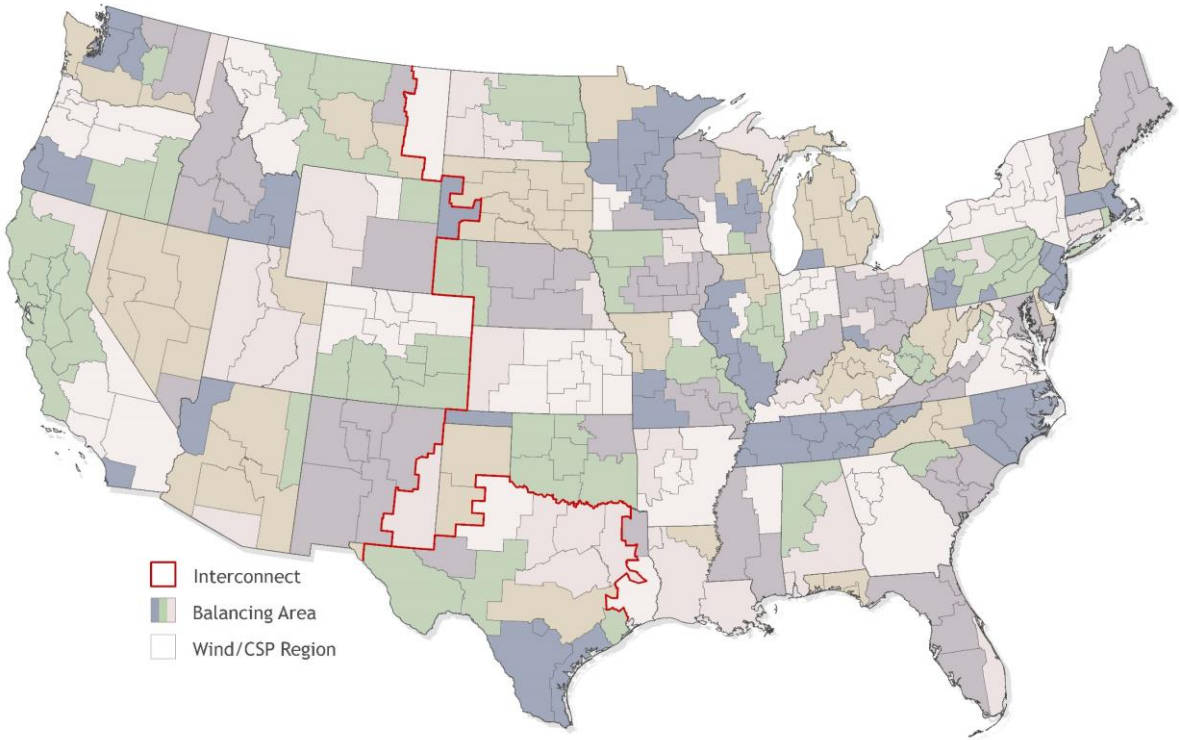
### Retirements

- 80 Year Nuclear
- 60 Year Nuclear
- Accelerated Nuclear Retirement
- Accelerated Coal Retirement

### Policy

- Clean Power Plan (as finalized in 2015)
- National 80% RPS by 2050
- 83% $CO_2$ Reduction by 2050
- ITC & PTC Extension to 2030

# Modeling Tools

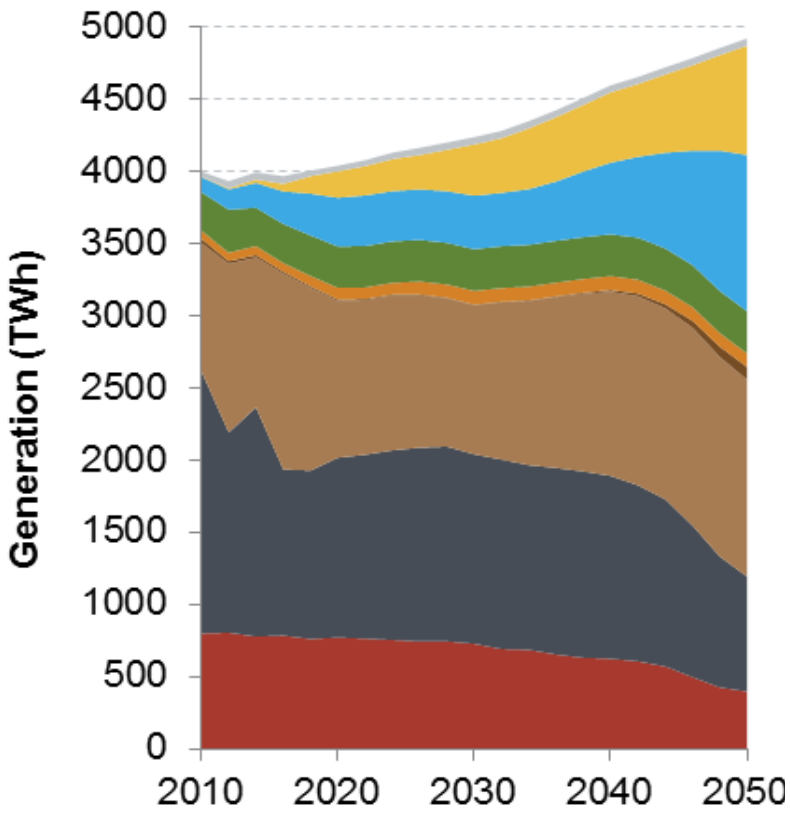


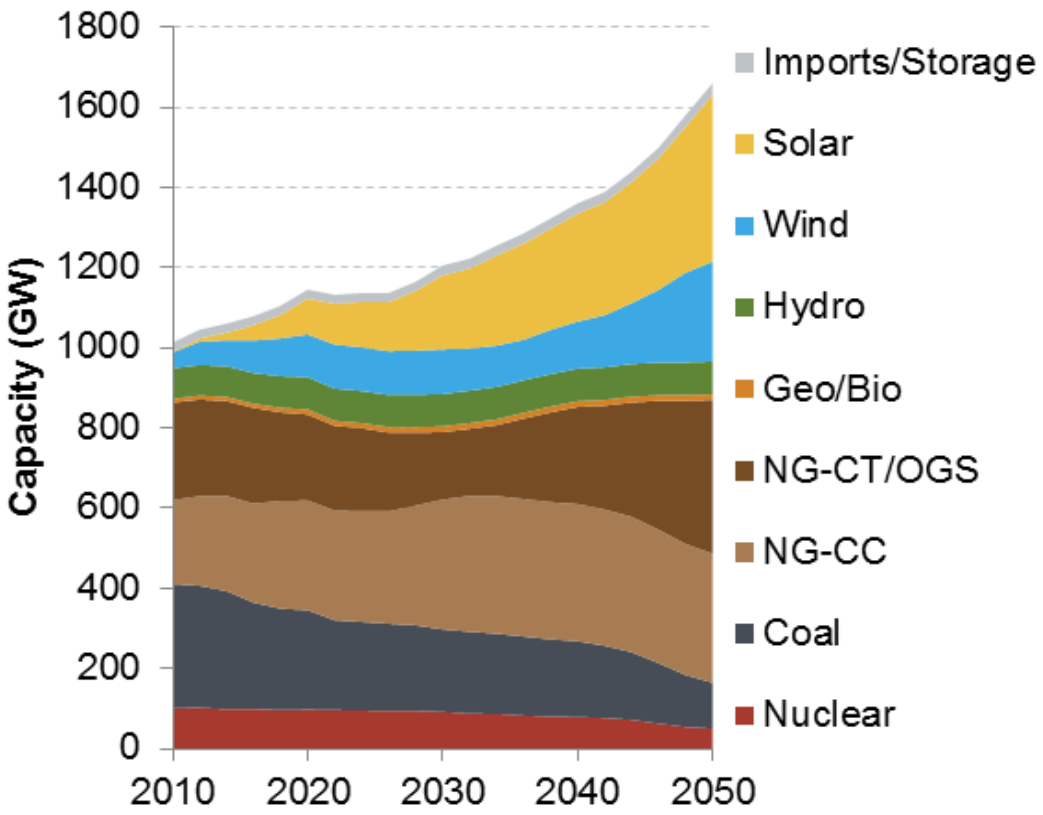

- **ReEDS**: Central-planning optimization model of U.S. Electricity Sector
  - 134 Balancing Areas
  - Explicit consideration of RE integration issues
  - Represents transmission
- **dGen**: Consumer adoption model of distributed PV
  - Solar PV
  - County-level resolution
  - Incorporates state and local incentives and rate structures
  - Residential and C&I included

# Electricity Sector Trends and Outlook

# *The Mid-case Scenario*

# Mid-case Power Sector Evolution




Most new energy growth is met by wind and solar.

No dramatic changes until post-2040.

# The U.S. power system evolves to a system primarily powered by natural gas and renewable energy

## Upper figure: 2016

Renewable Energy Generation: 15%

Natural Gas Generation: 34%

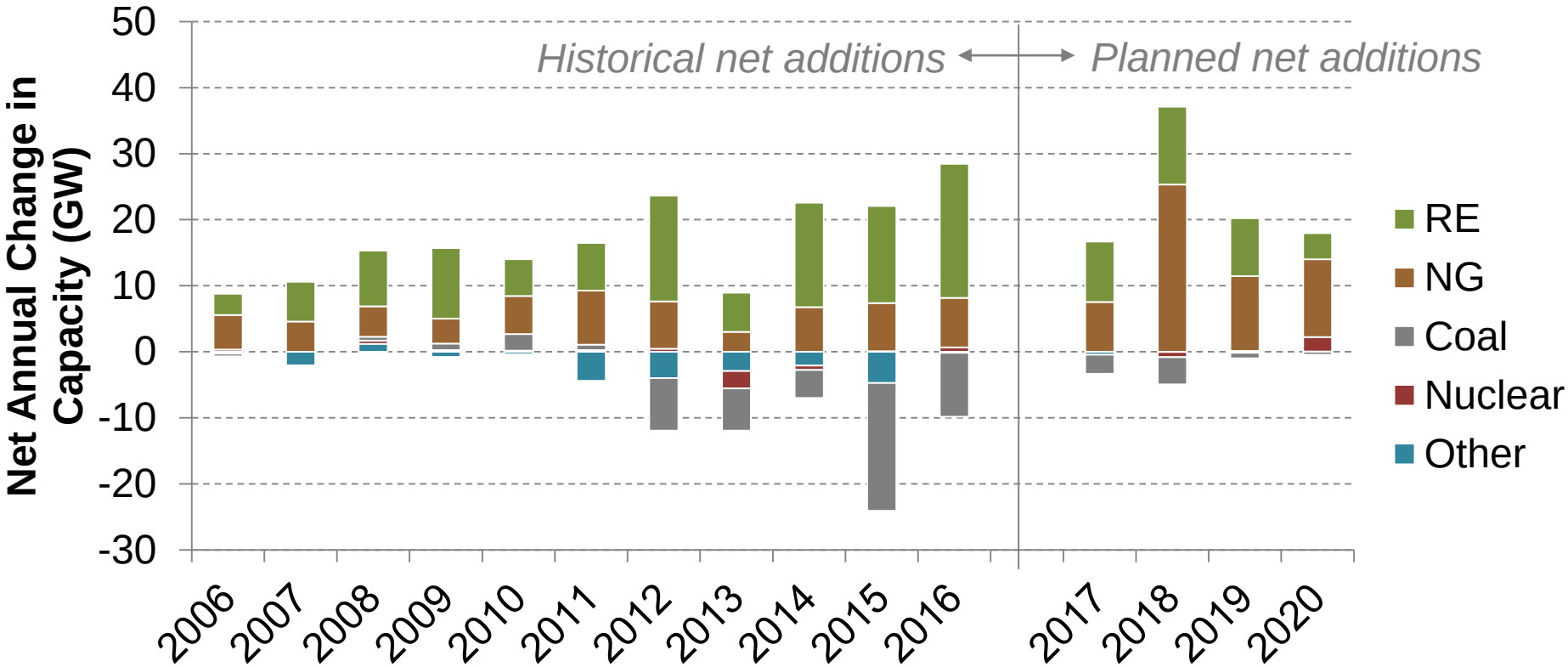
## Lower figure: 2050

Renewable Energy Generation: 45%

Natural Gas Generation: 30%

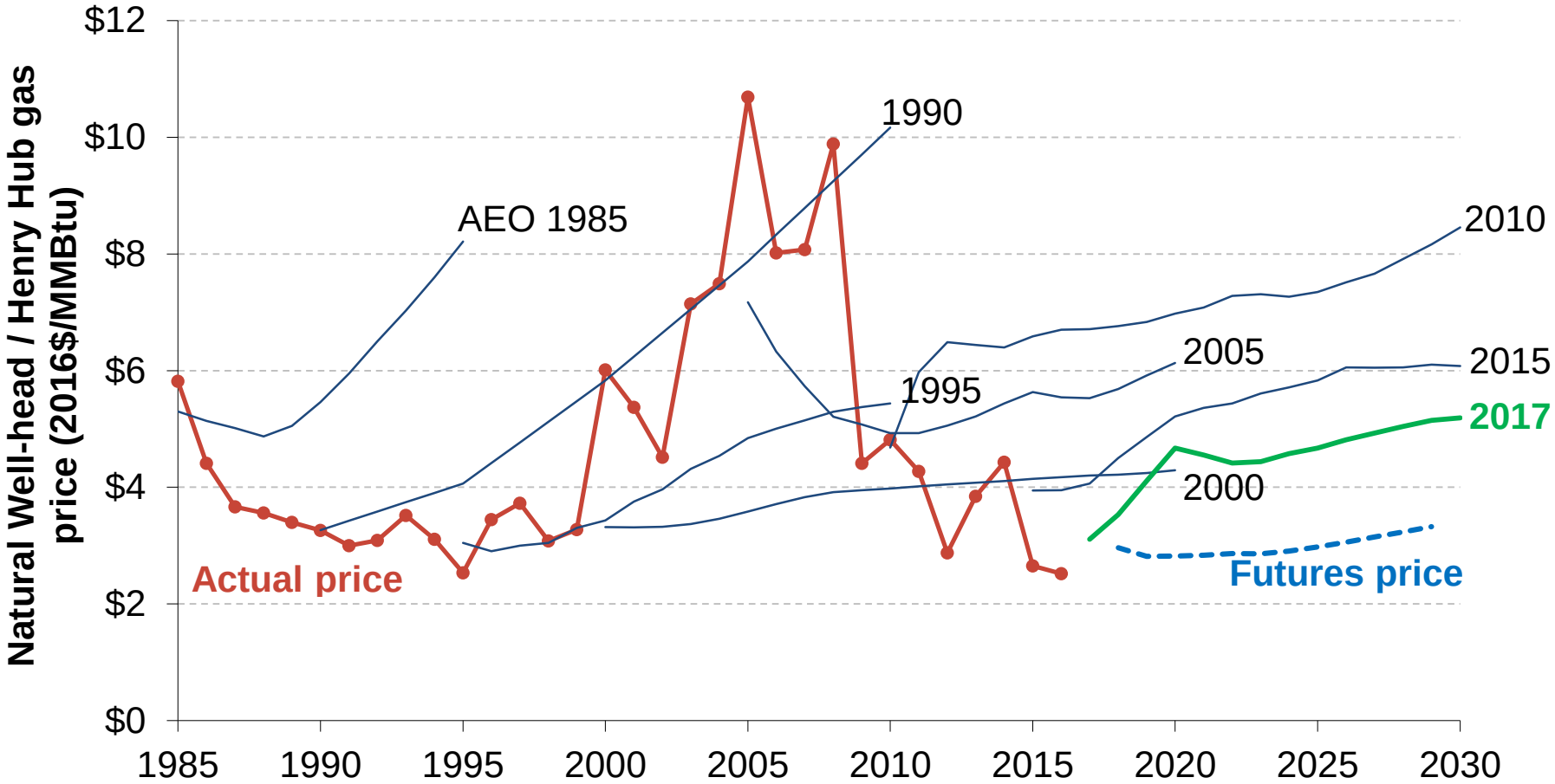
# *Theme #1: A promising future for natural gas and renewable energy*

# Recent historical and planned capacity additions are predominantly natural gas and renewable energy technologies



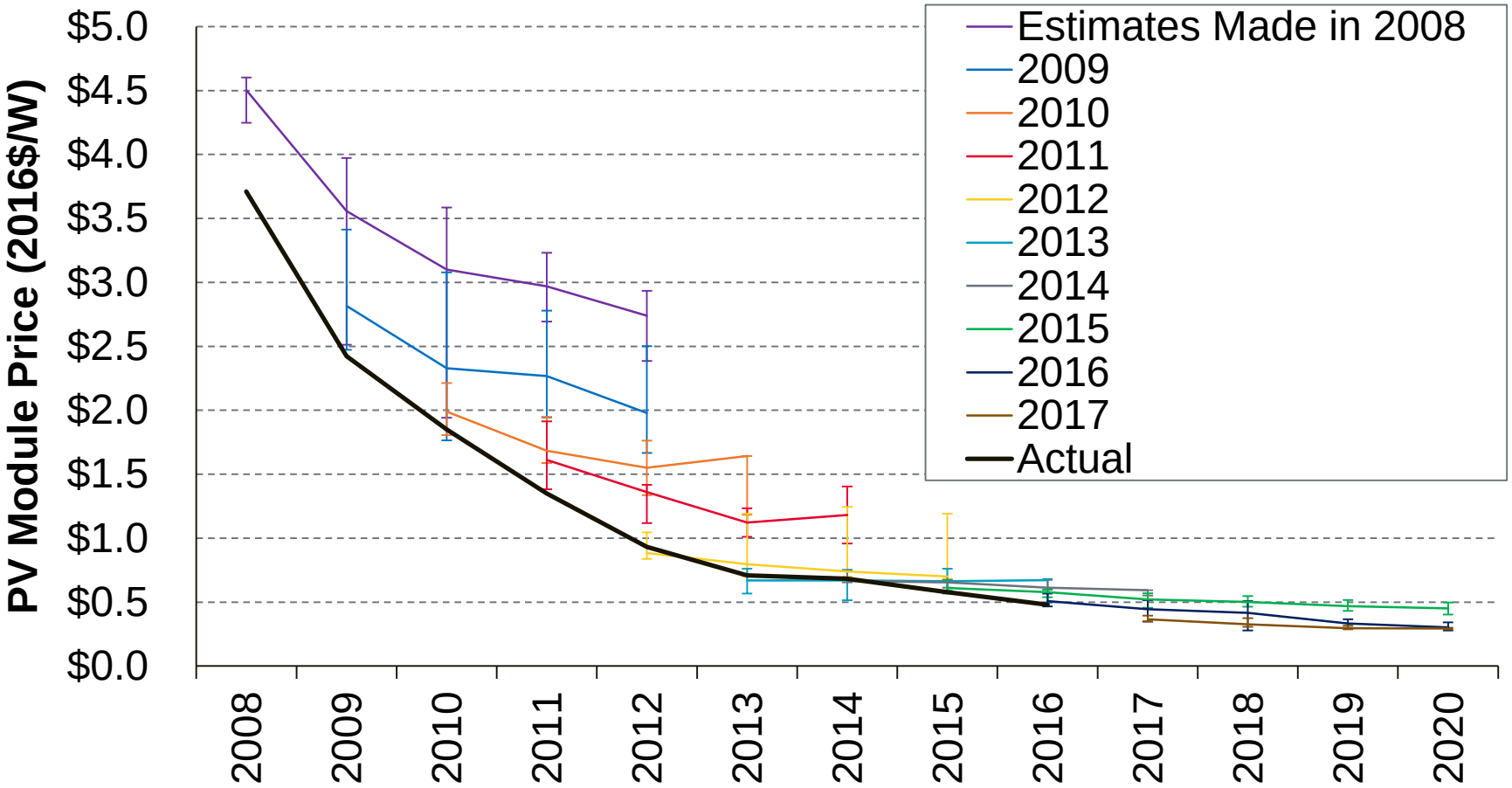

*Historical* net additions are defined as the differences in installed net summer capacity at the end of the year shown from the end of the prior year. *Planned* net additions are defined as planned capacity minus planned retirements. Planned additions differ from forecasted additions and can understate the amount of renewable capacity under consideration, as renewable technologies can have short siting and construction periods.
Data sources: EIA Electric Power Annual and Electric Power Monthly

# Natural gas prices are hard to predict



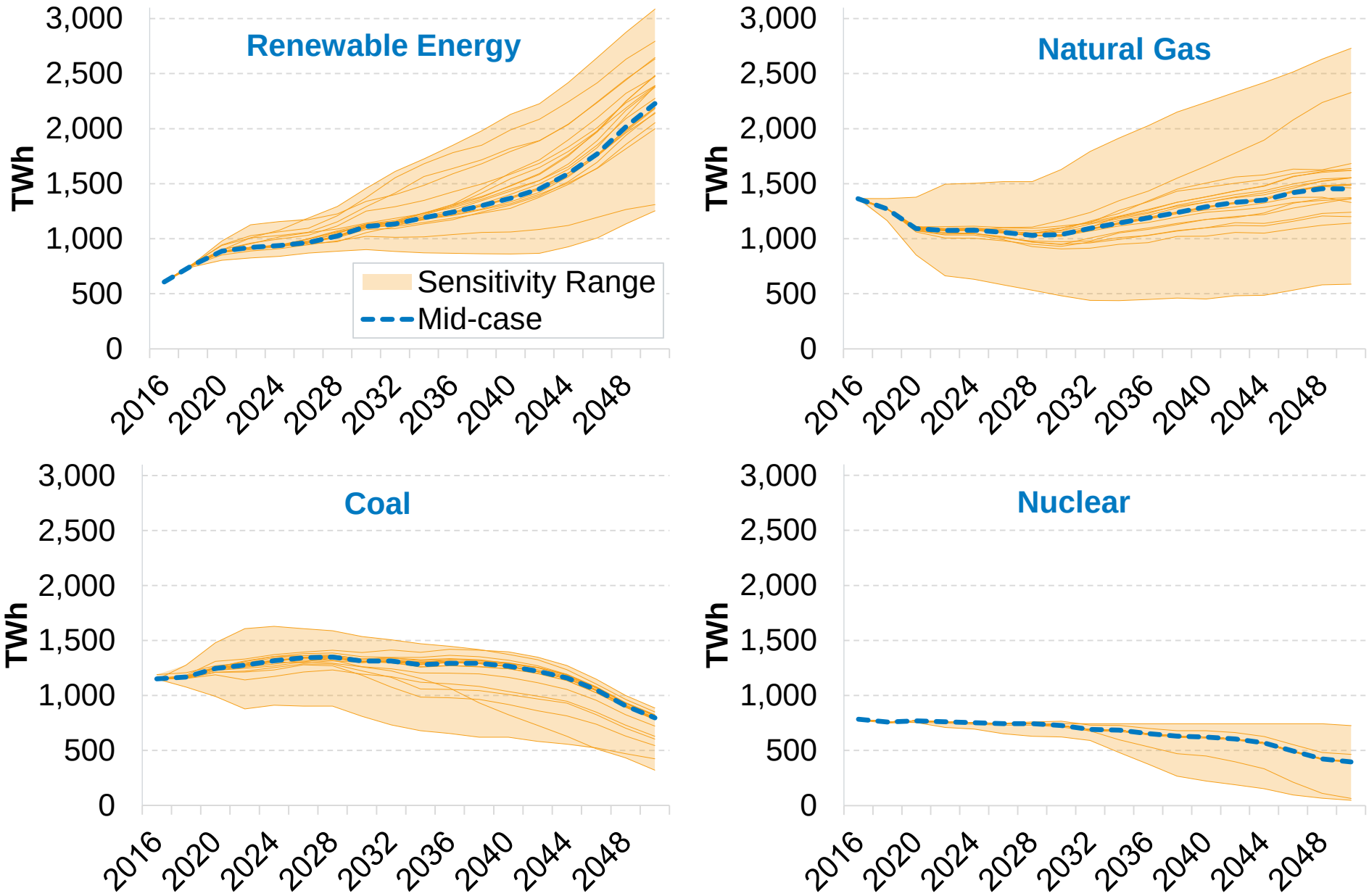

Actual natural gas prices reflect average—for the lower 48 states—well-head prices from 1985 to 1996 and Henry Hub prices from 1997 to 2016, as reported by EIA. Projected gas prices are from select AEO editions (reference cases), and they reflect Henry Hub prices for 2015 and 2017 projections and average well-head prices for earlier AEOs. The AEO often also includes high/low cases, which are not shown in the figure. Futures prices are NYMEX prices accessed July 26, 2017.

# So are renewable energy costs

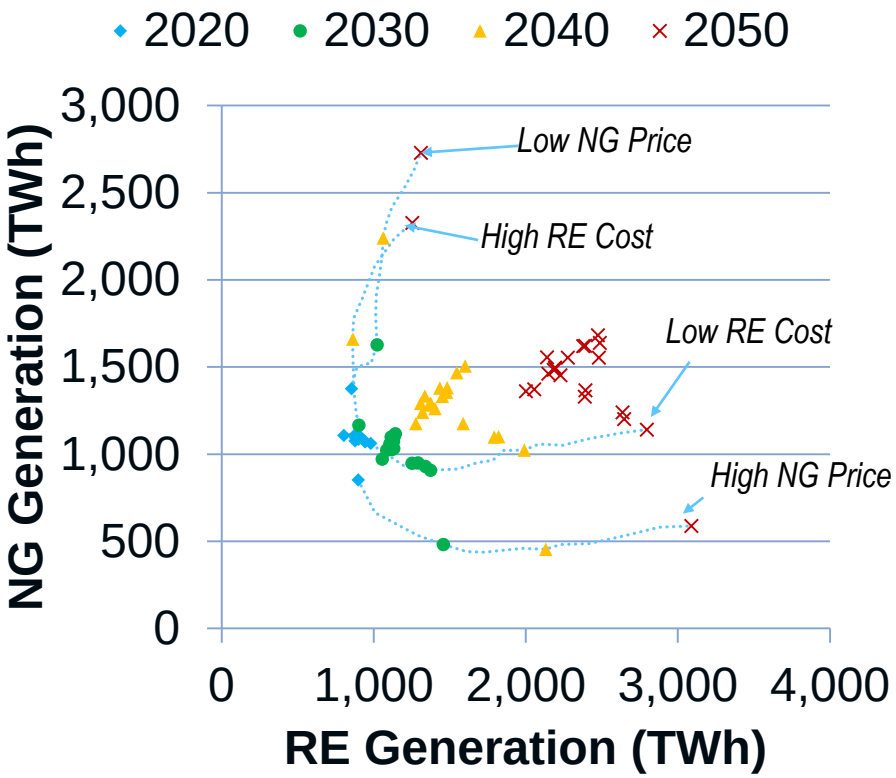


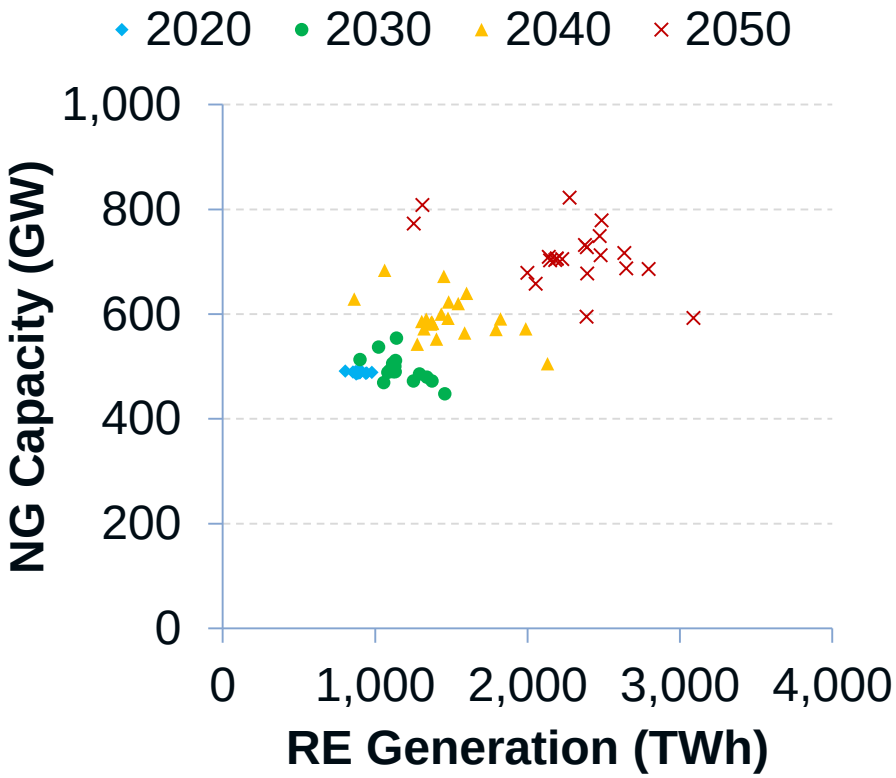

The figure is a modified version of one from Margolis, Feldman, and Boff (2017).

# Uncertainties in future technology and market conditions drive uncertainties in projected generation across many technologies



# Interaction of Natural Gas and Renewable Energy




Although future competition for RE and NG exists, there is also complementary generation and capacity growth

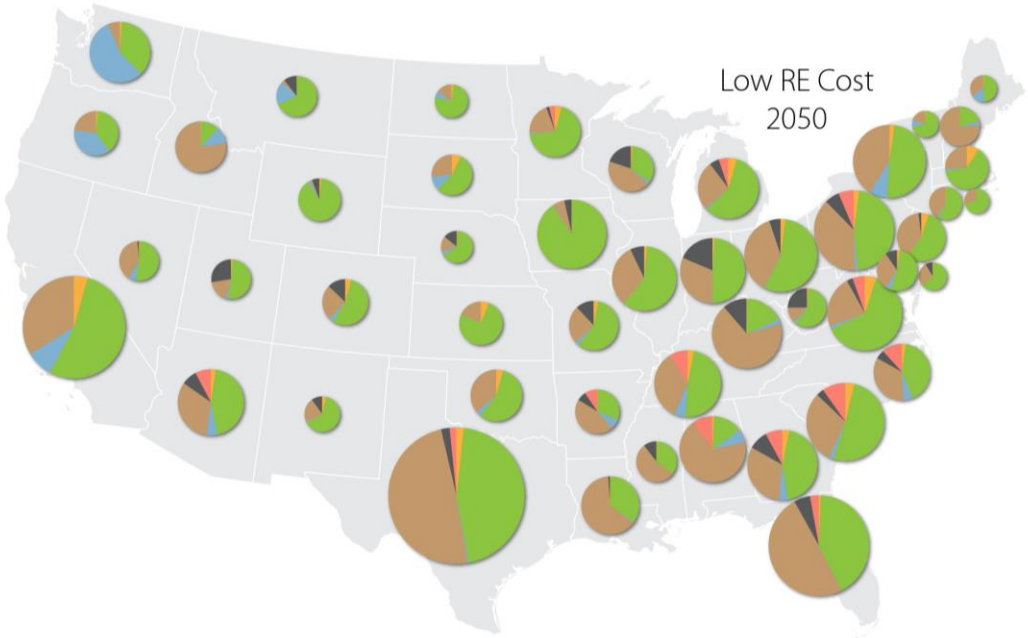
# 2050 Capacity Mix

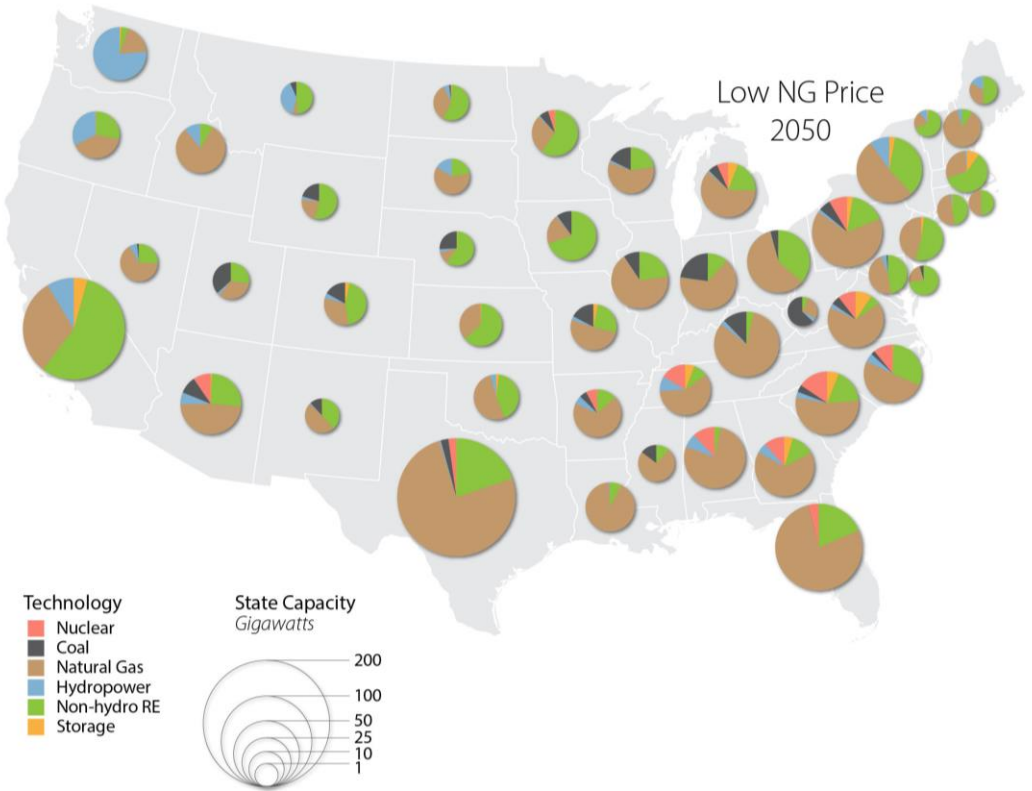
## Top: Low RE Cost

Renewable Energy Generation: 57%
Natural Gas Generation: 23%

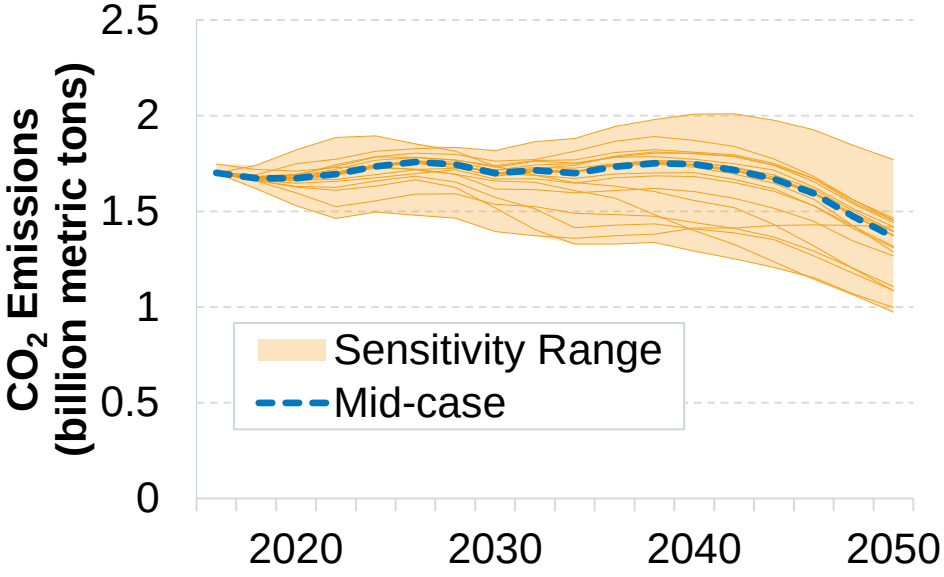
## Bottom: Low NG Price

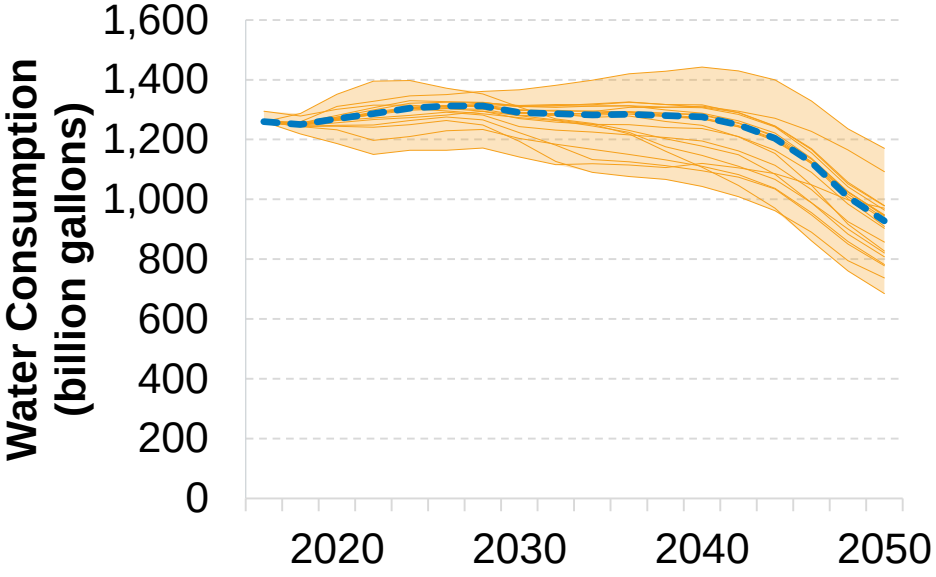
Renewable Energy Generation: 27%
Natural Gas Generation: 56%



# Emissions and Water

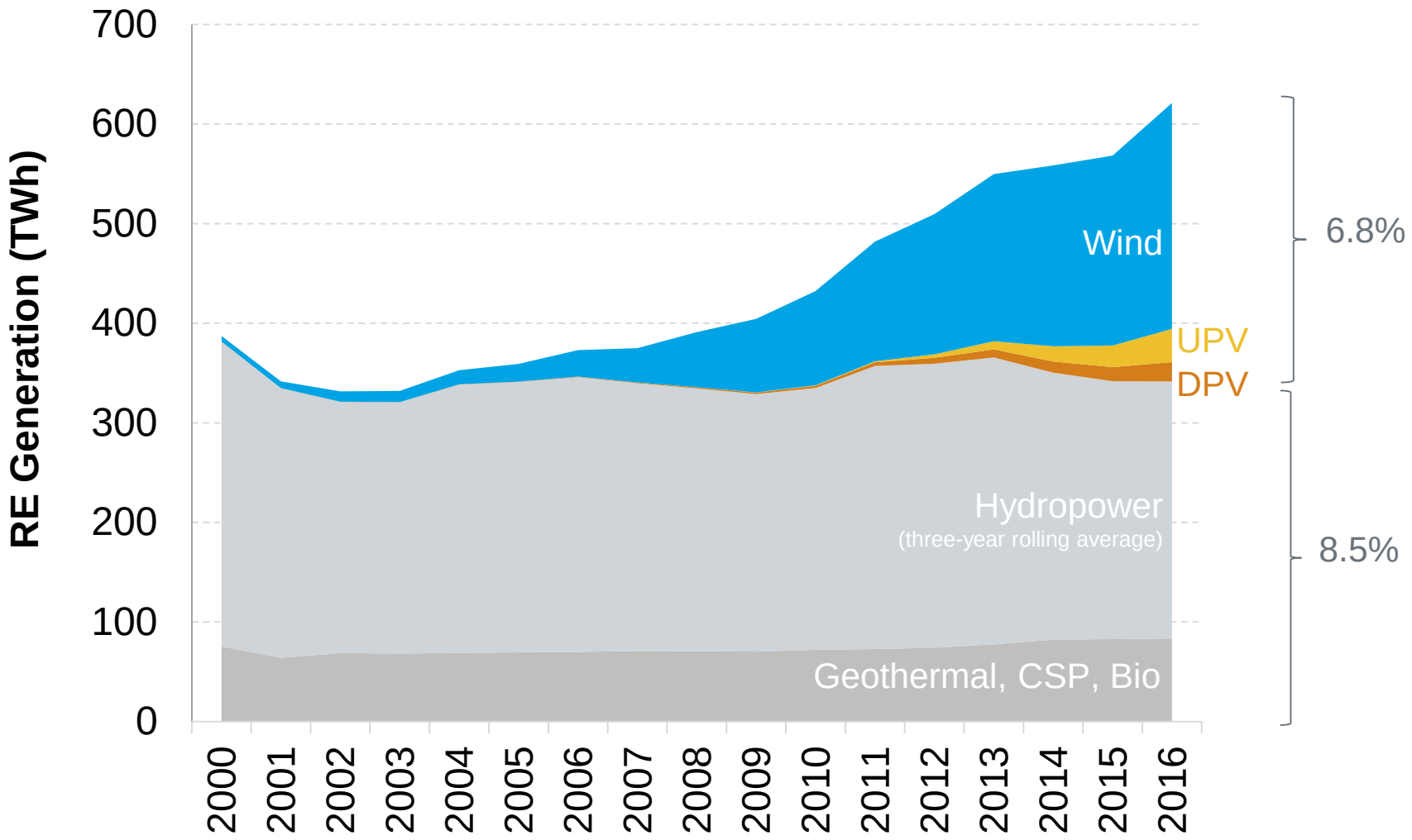


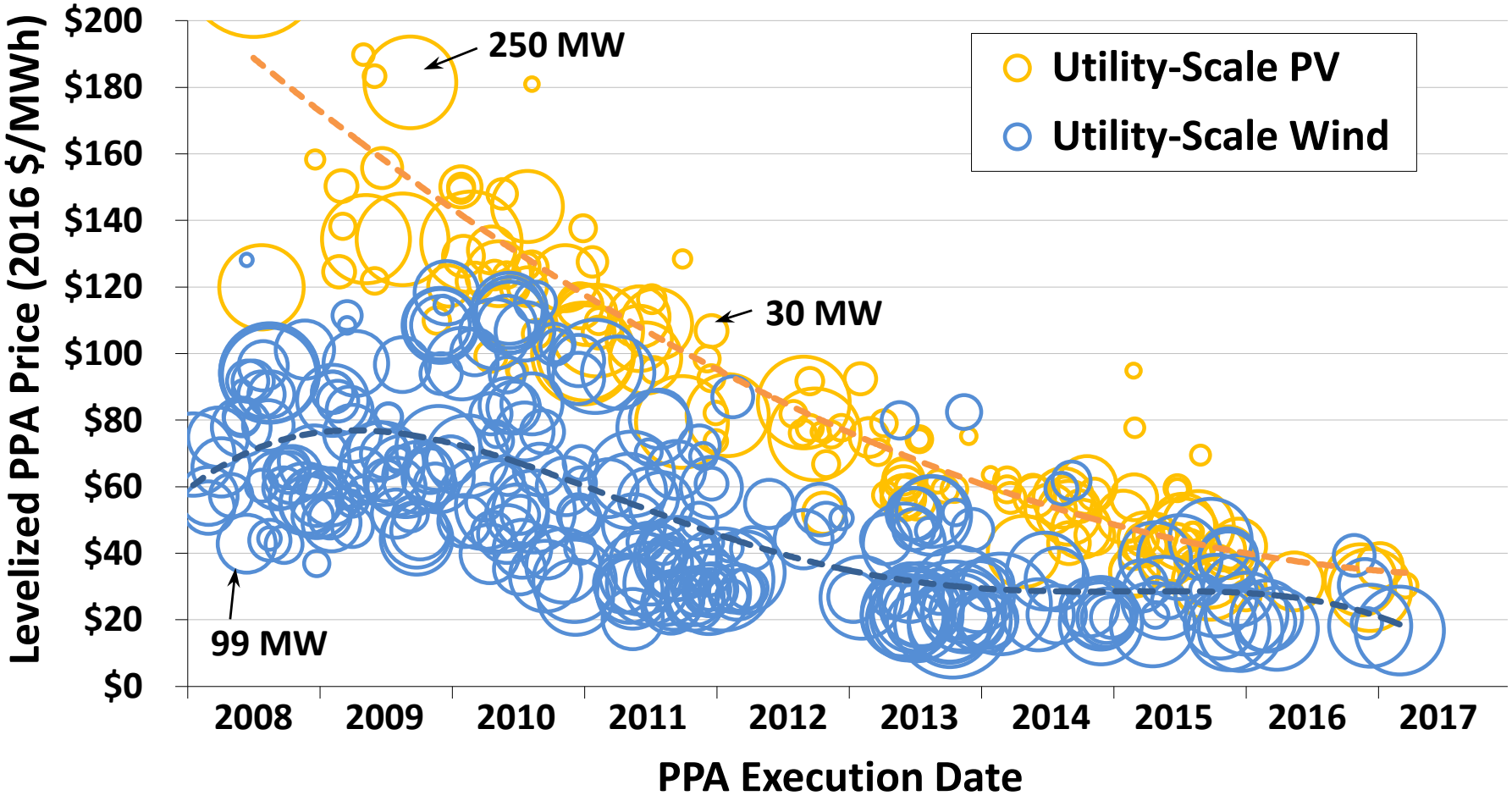

Power sector emissions and water use are mostly flat in all non-policy scenarios

# Theme #2: Wind and Solar Competition

# Recent growth in RE generation is primarily from wind and from PV



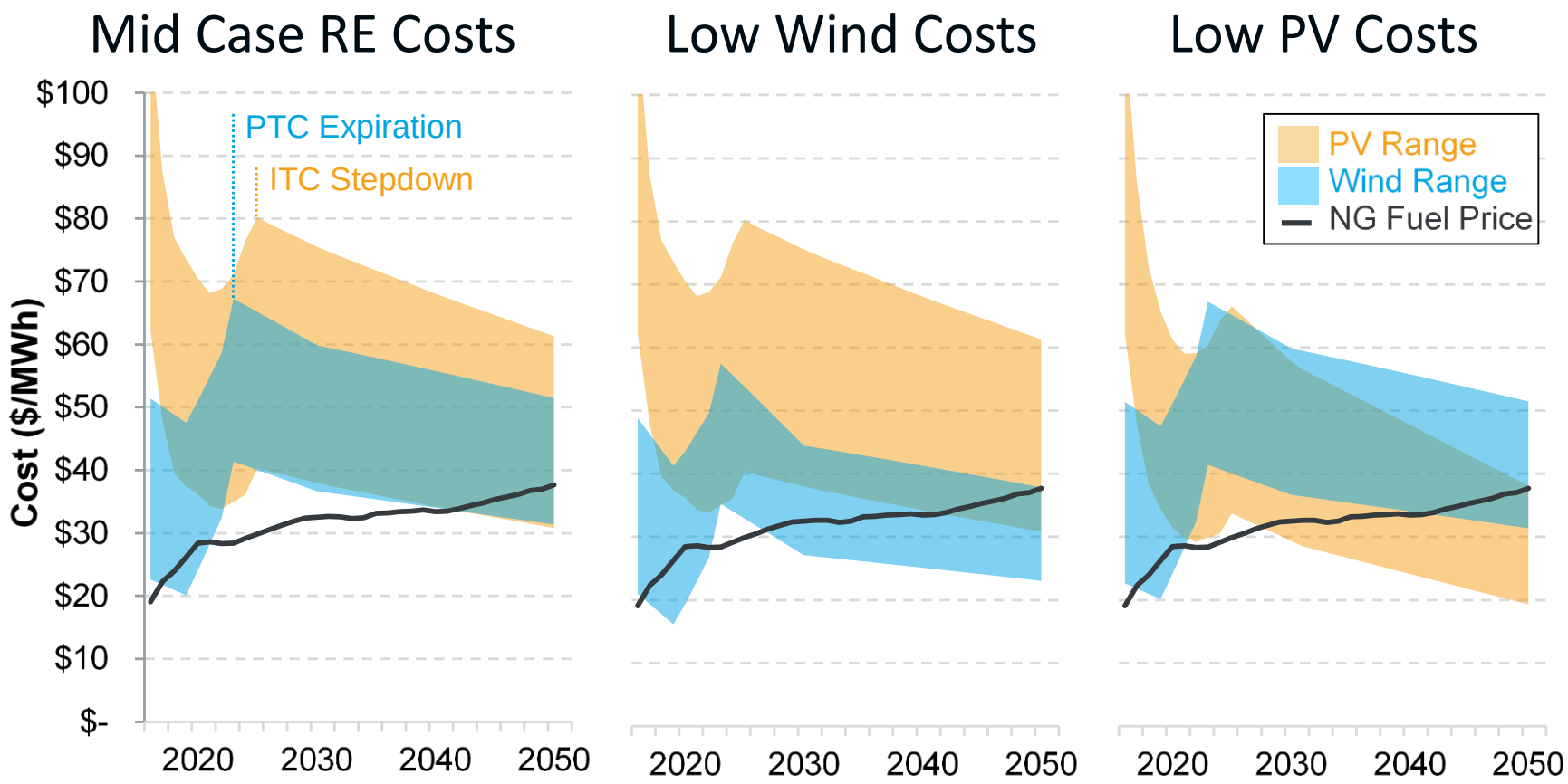
# Wind and PV PPA prices show noticeable decline and convergence over the past decade




Note that PPAs are market values that reflect the impact of tax credits and other incentives.

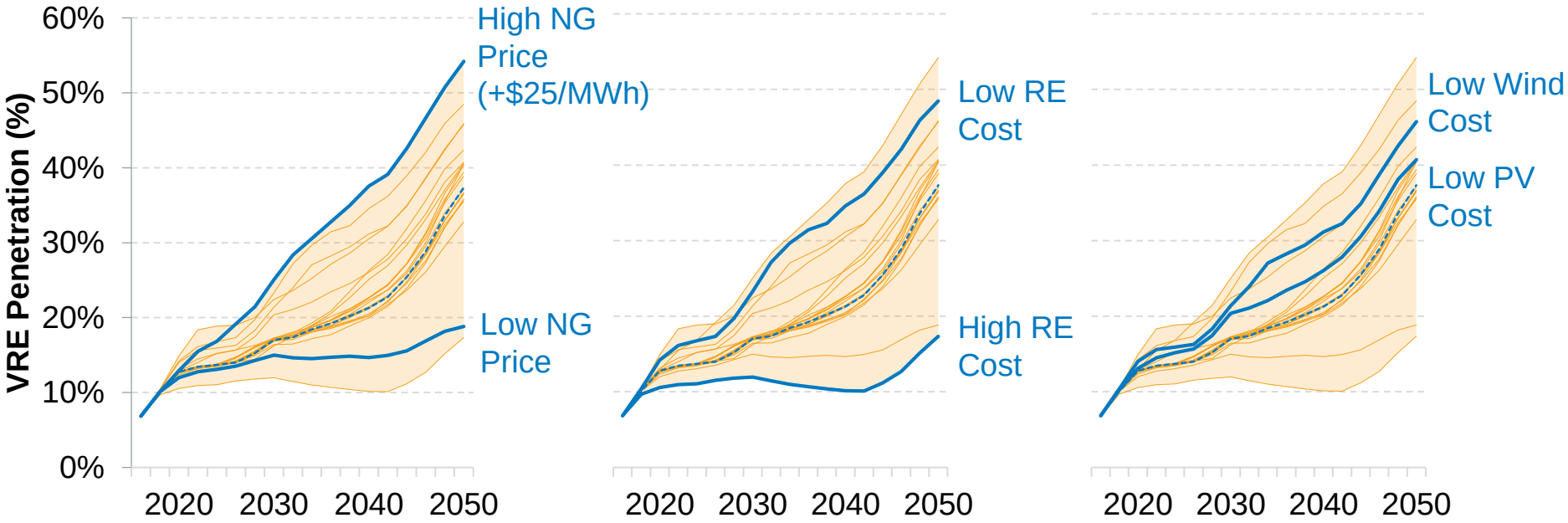
Figure from Wiser, Bolinger, and Seel (2017).

# NG, Wind, and PV Are Increasingly Competitive

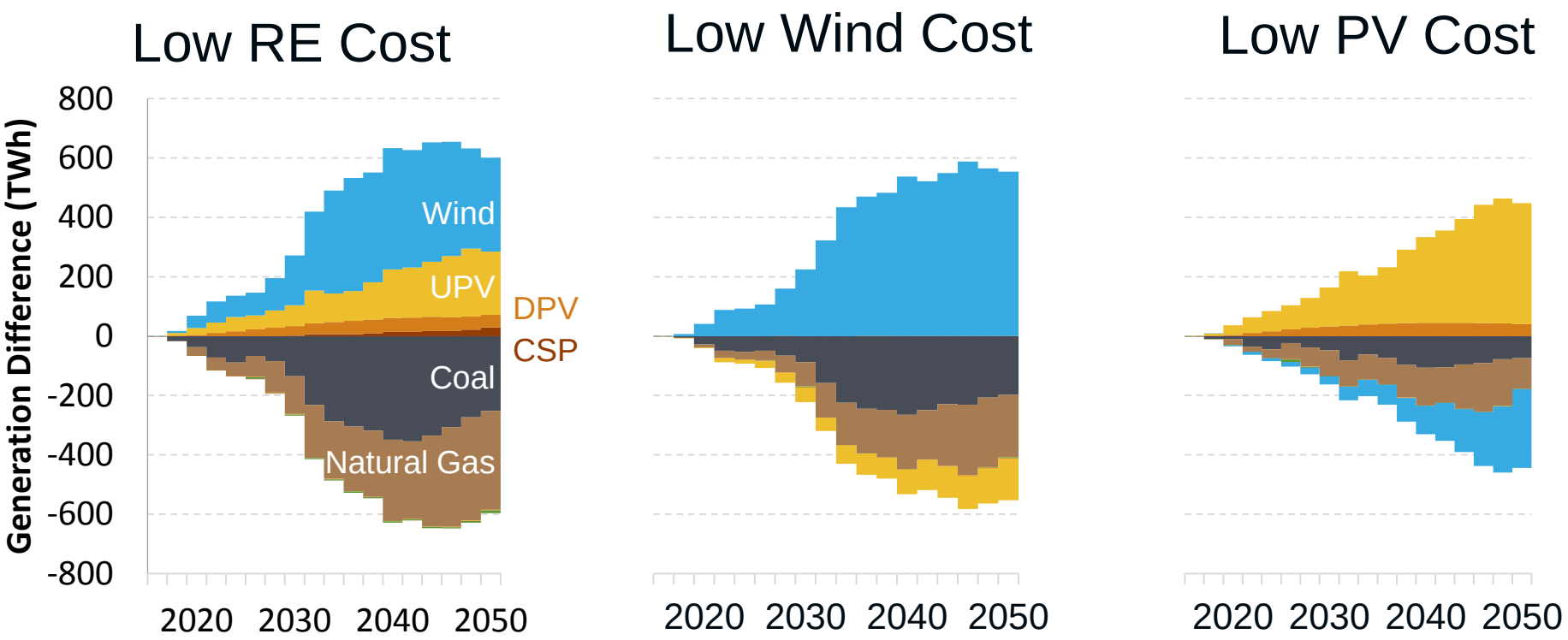



Costs include effects of tax credits but exclude the highest cost, lowest resource quality wind resources (techno-resource groups [TRGs] 8–10) for ease of comparison. These ranges also exclude geographic capital cost factors, and only account for costs within the plant boundary. Fuel price assumes combined-cycle heat rate. For details, see Eurek et al. (2016) and the 2017 Annual Technology Baseline (ATB) (NREL 2017)

# Relative wind and solar costs along with natural gas prices are major factors driving VRE generation



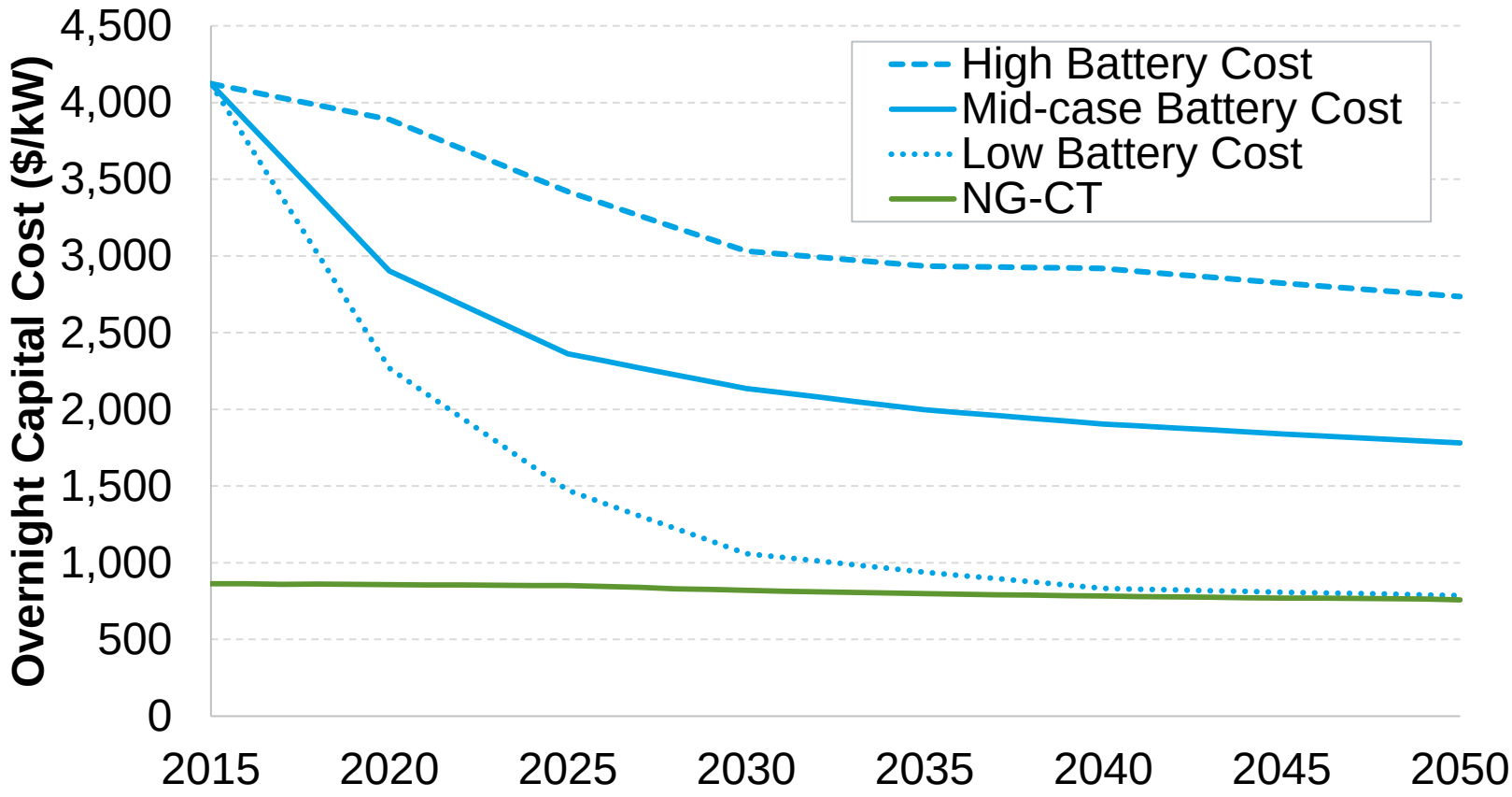
# Trade-off of wind and solar is not 1:1




Differences are relative to the Mid-case

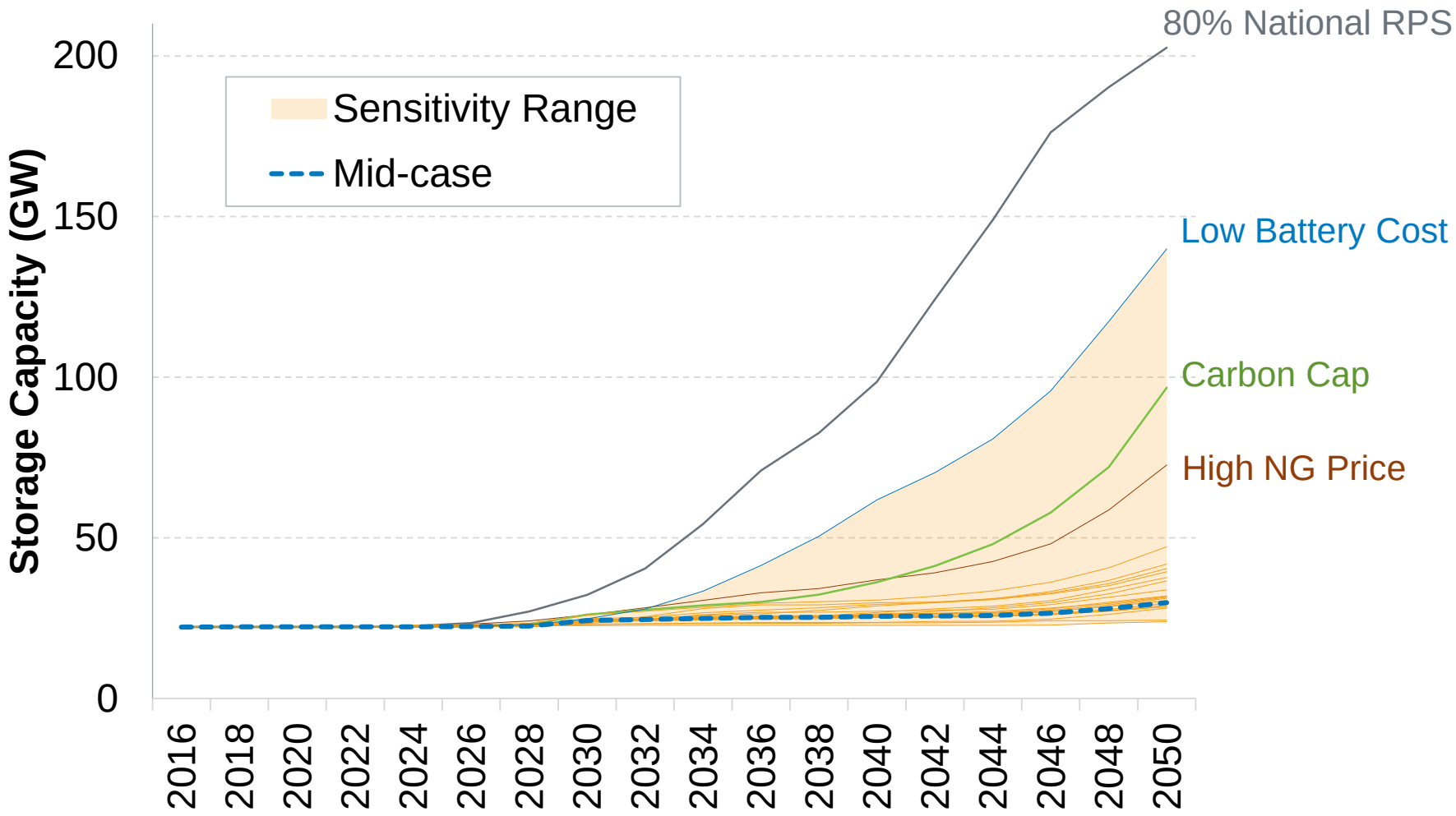
# *Theme #3: There is a lot of potential for low-cost battery storage*

# 8-hour battery: low-cost projection approaches NG-CT

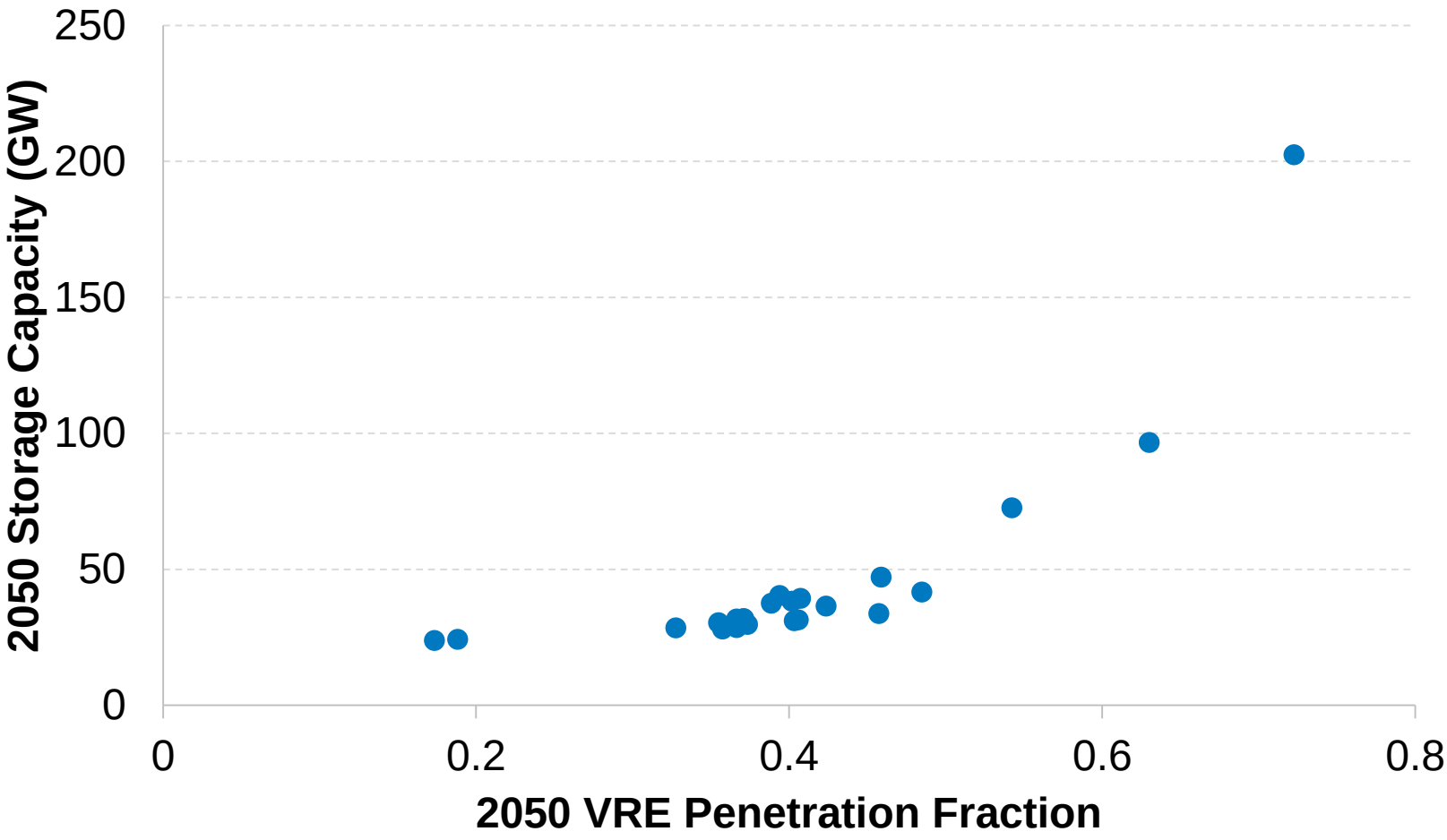



Battery costs are from Cole, Marcy, et al. (2016) and NG-CT costs are from the 2017 Annual Technology Baseline (NREL 2017).

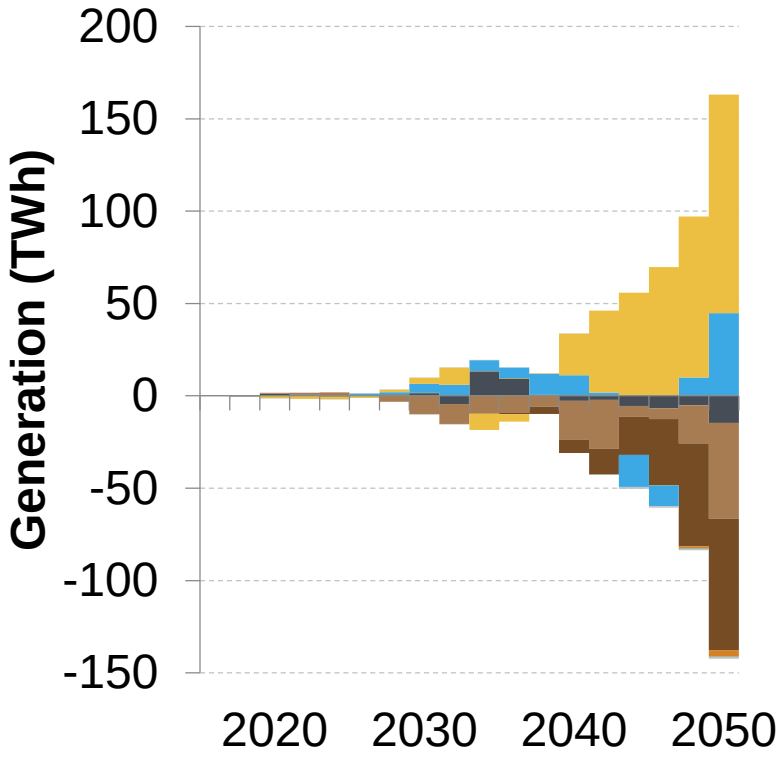
# Cumulative storage capacity over time

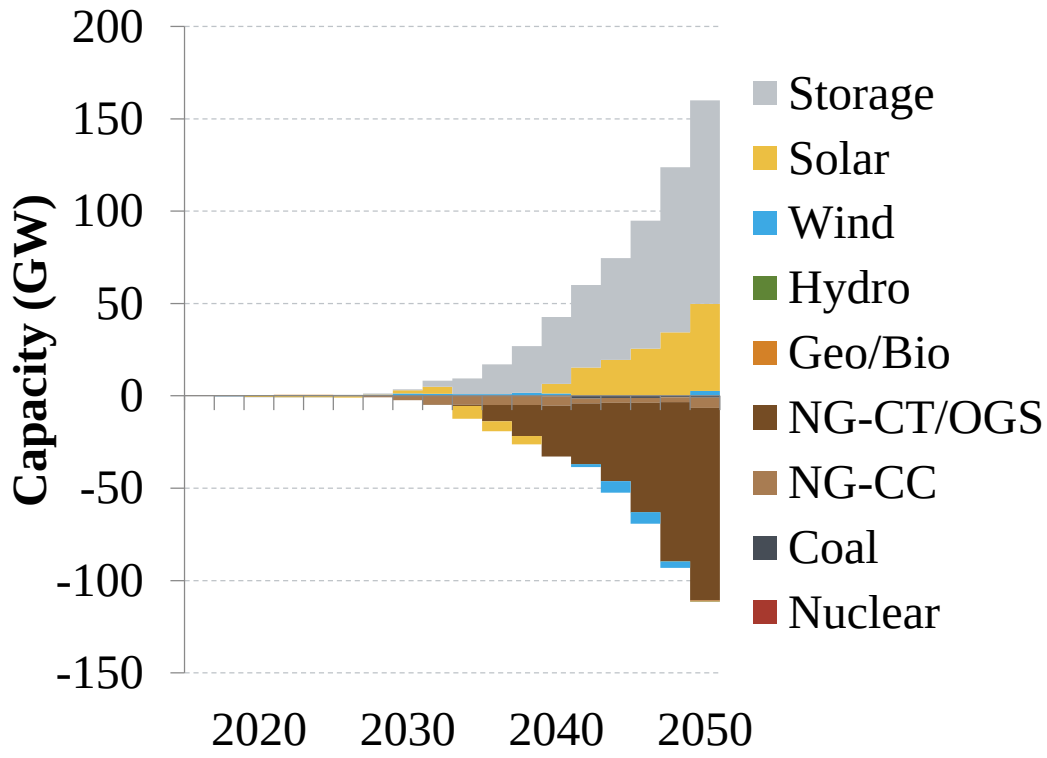


# Storage vs. VRE penetration



# Low-cost storage enables higher RE penetration

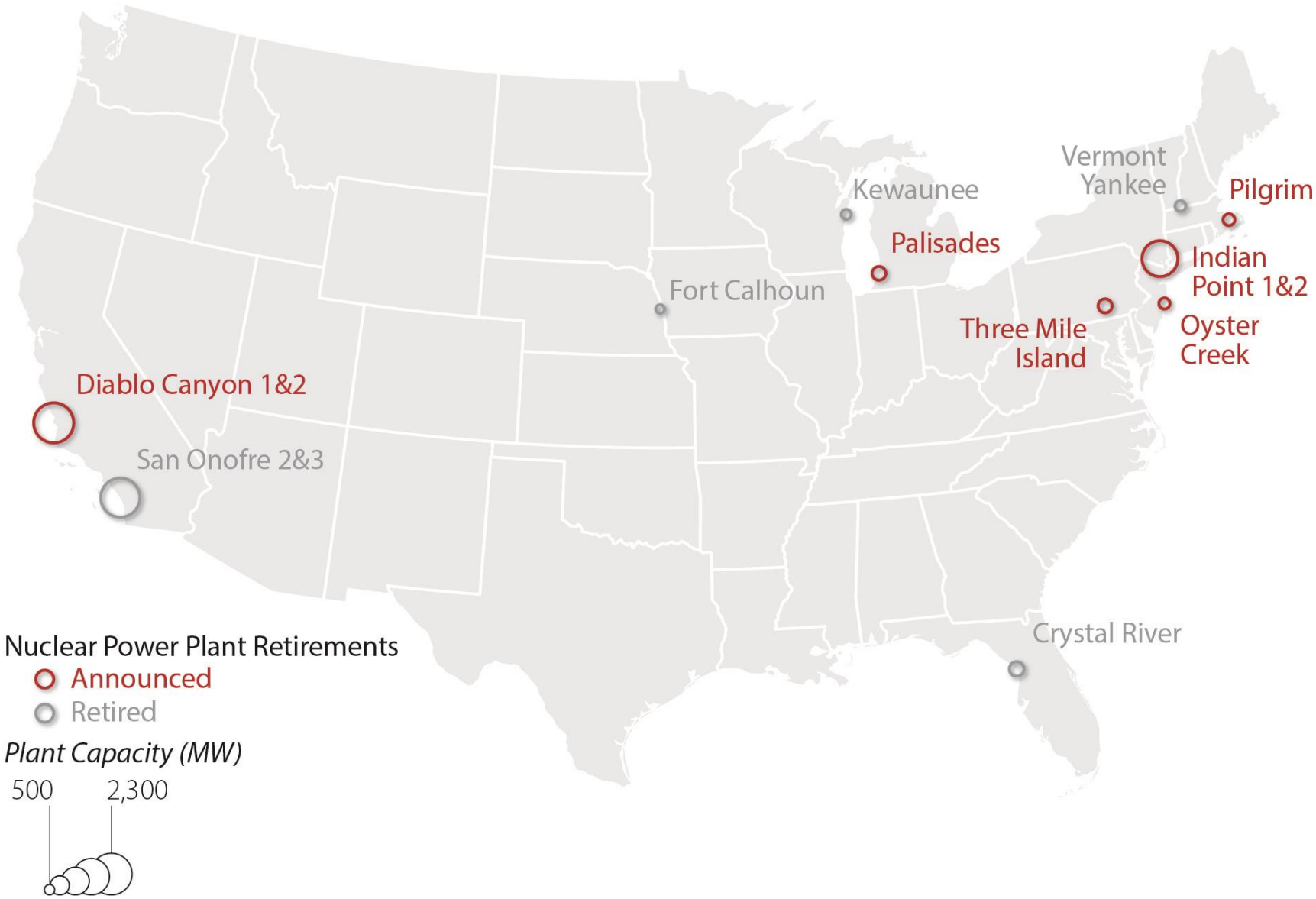


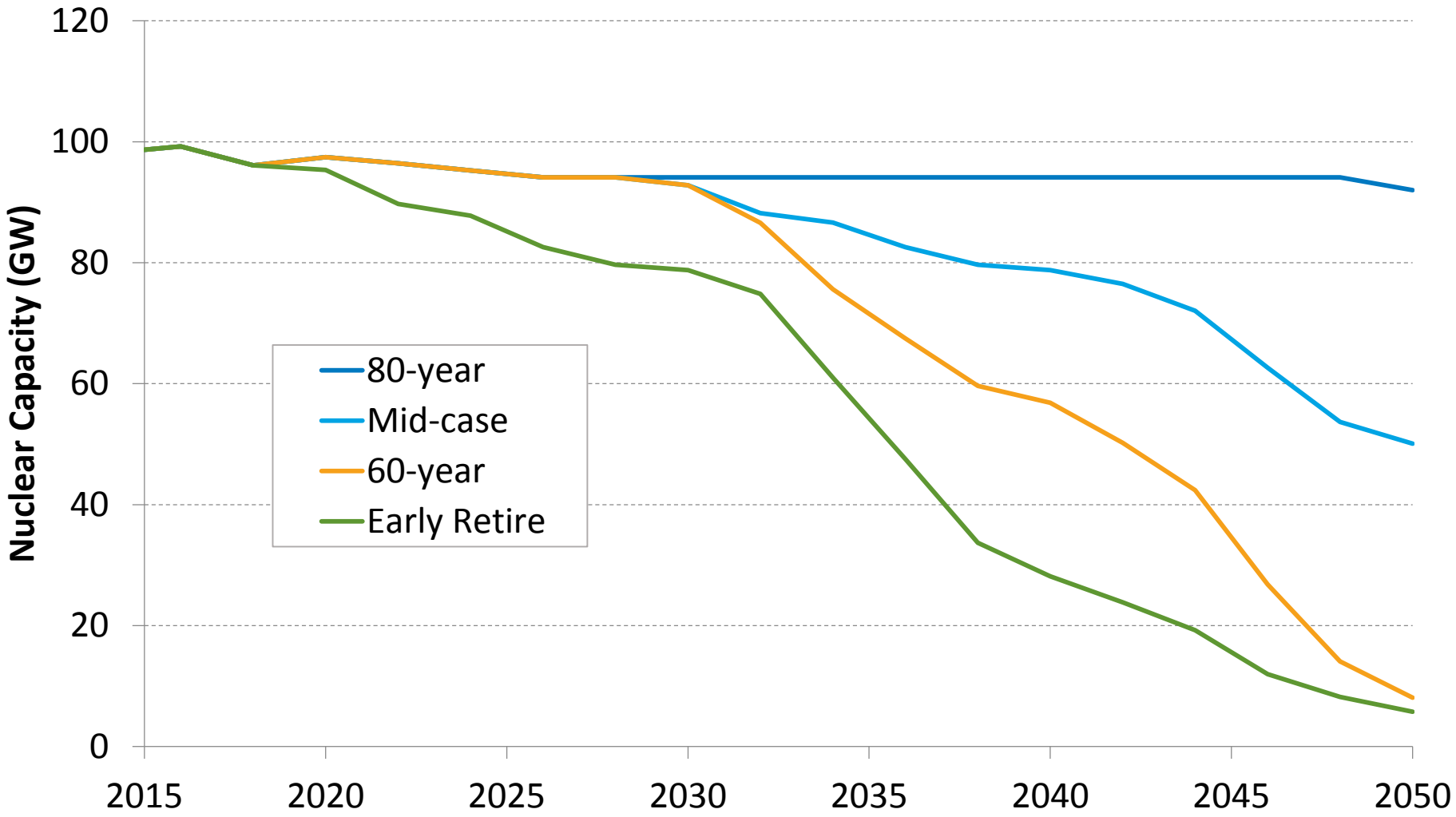

Differences relative to the Mid-case

# *Theme #4: Uncertainty in nuclear retirements lead to uncertainty in future capacity and generation needs*

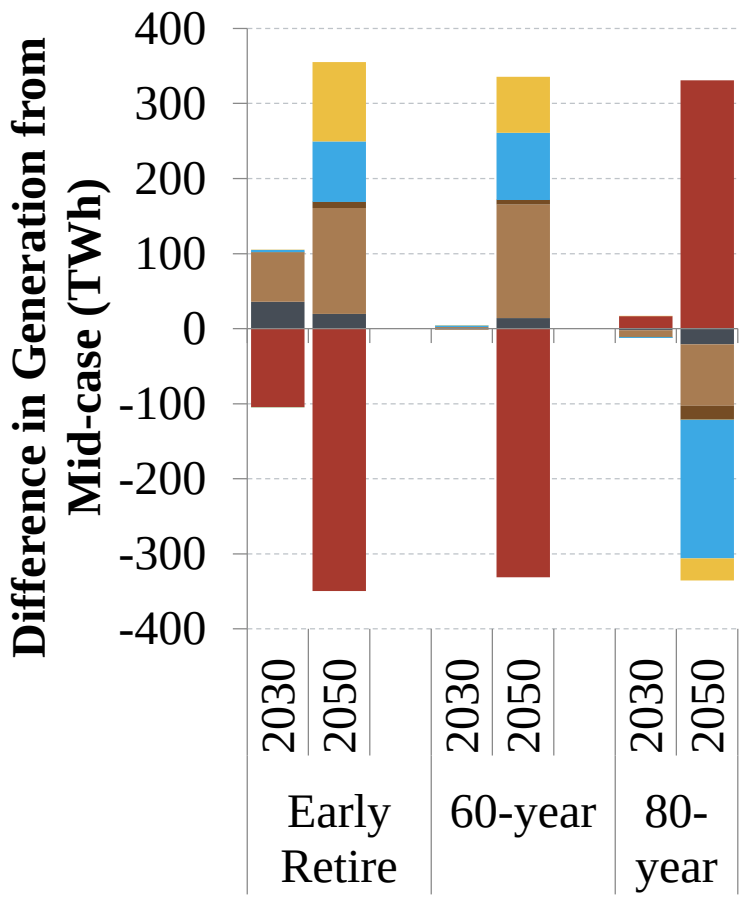
# Recent and announced nuclear retirements

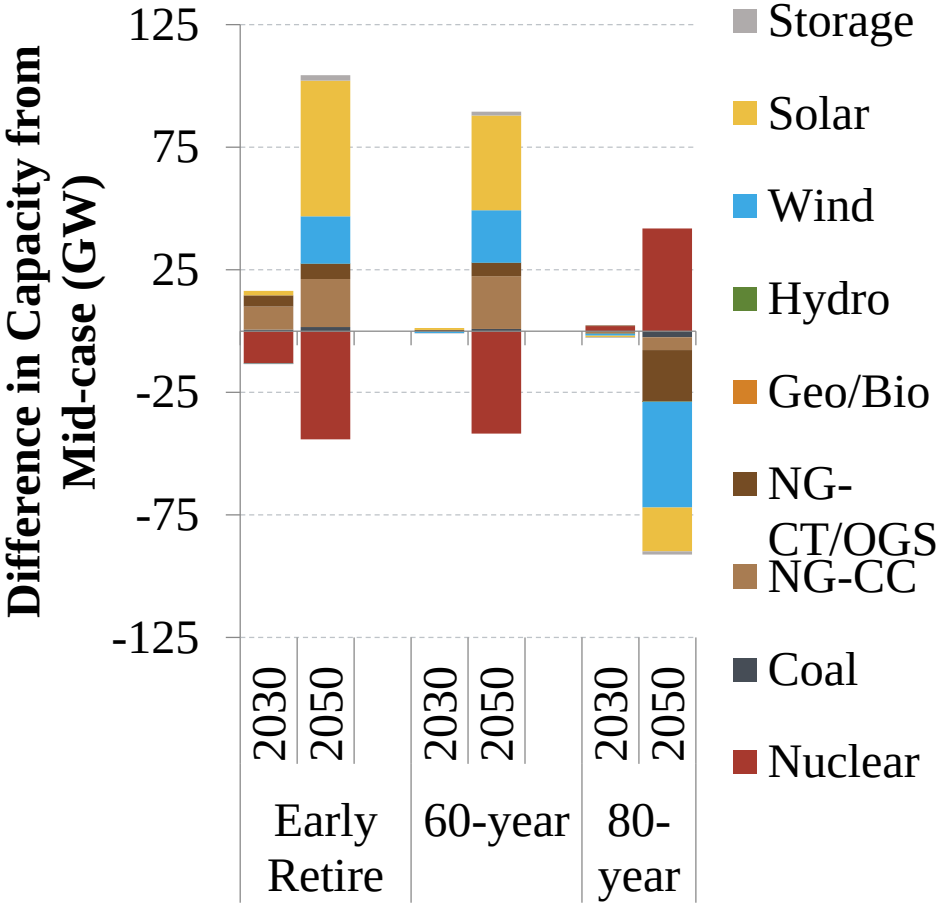


# Nuclear capacity over time across the four retirement scenarios



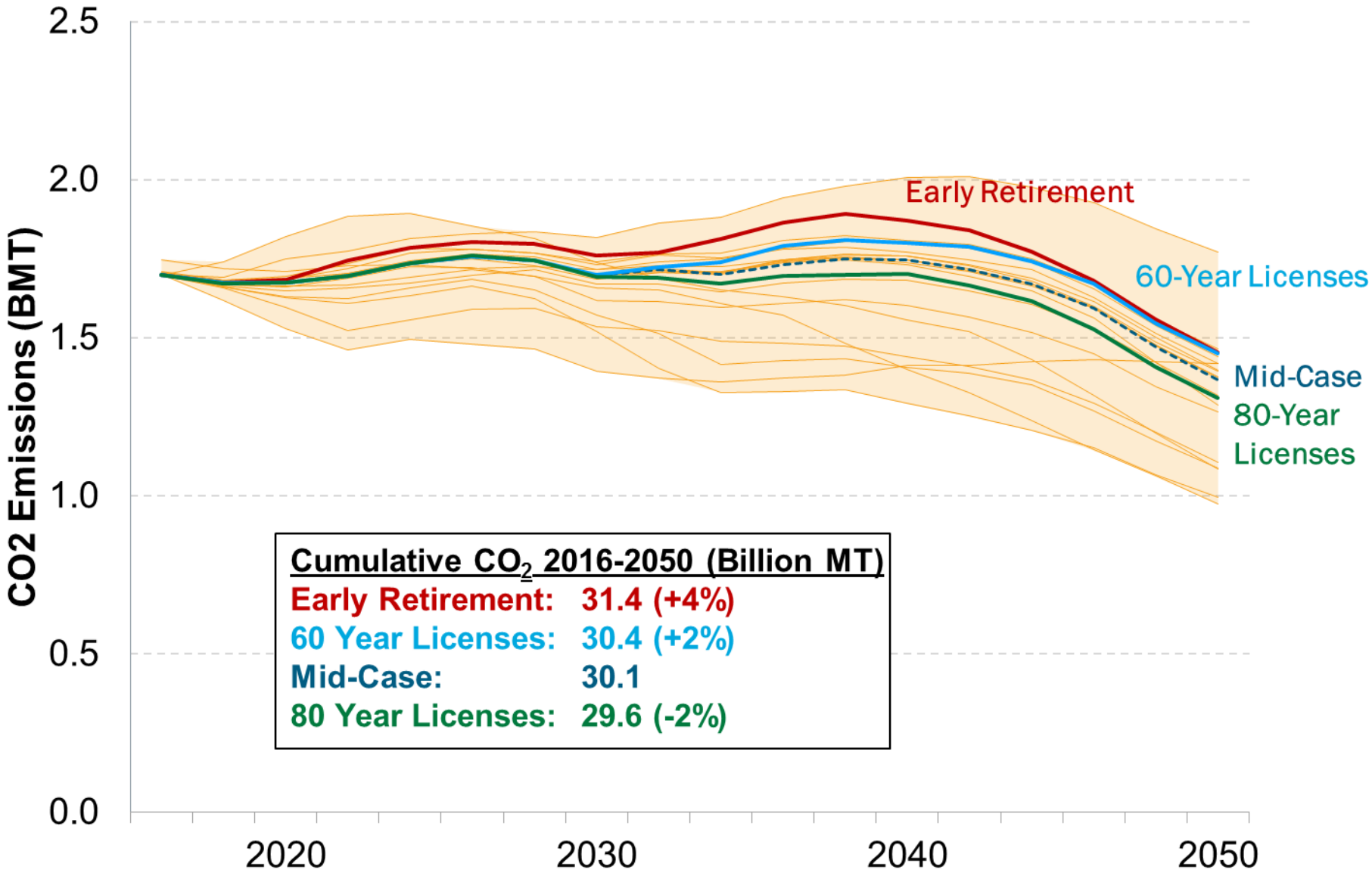
# Generation and capacity differences by technology relative to the Mid-case scenario for 2030 and 2050



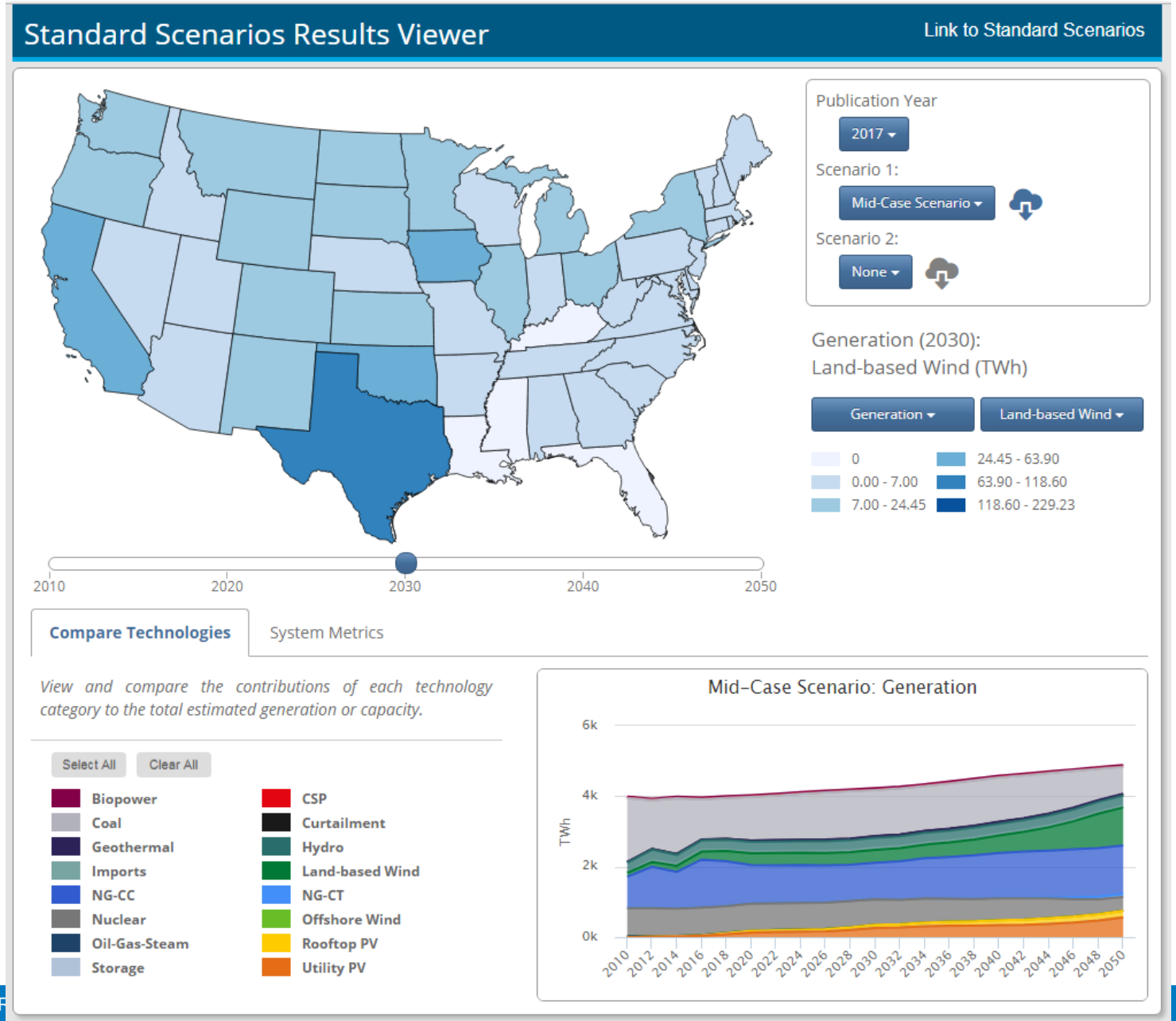

NG-CC is natural gas combined cycle, NG-CT is natural gas combustion turbine, OGS is oil-gas-steam, and Geo/Bio is geothermal and biopower.

# Impact of nuclear retirements on $CO_2$ emissions



# How to Access Scenario Data

# Scenario data available online



# Summary

- Standard Scenarios provides a framework to
  - Improve analysis and modeling work
  - Provide a perspective on the U.S. electricity sector evolution
  - Get access to state-level projections
- Themes from 2017:
  - Growth in natural gas and renewables
  - Competition between wind and PV
  - The large potential for battery storage
  - Nuclear lifetimes

# Questions or Comments?

The Standard Scenarios Report is available at

http://www.nrel.gov/analysis/data-tech-baseline.html

Viewer: https://openei.org/apps/reeds/

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