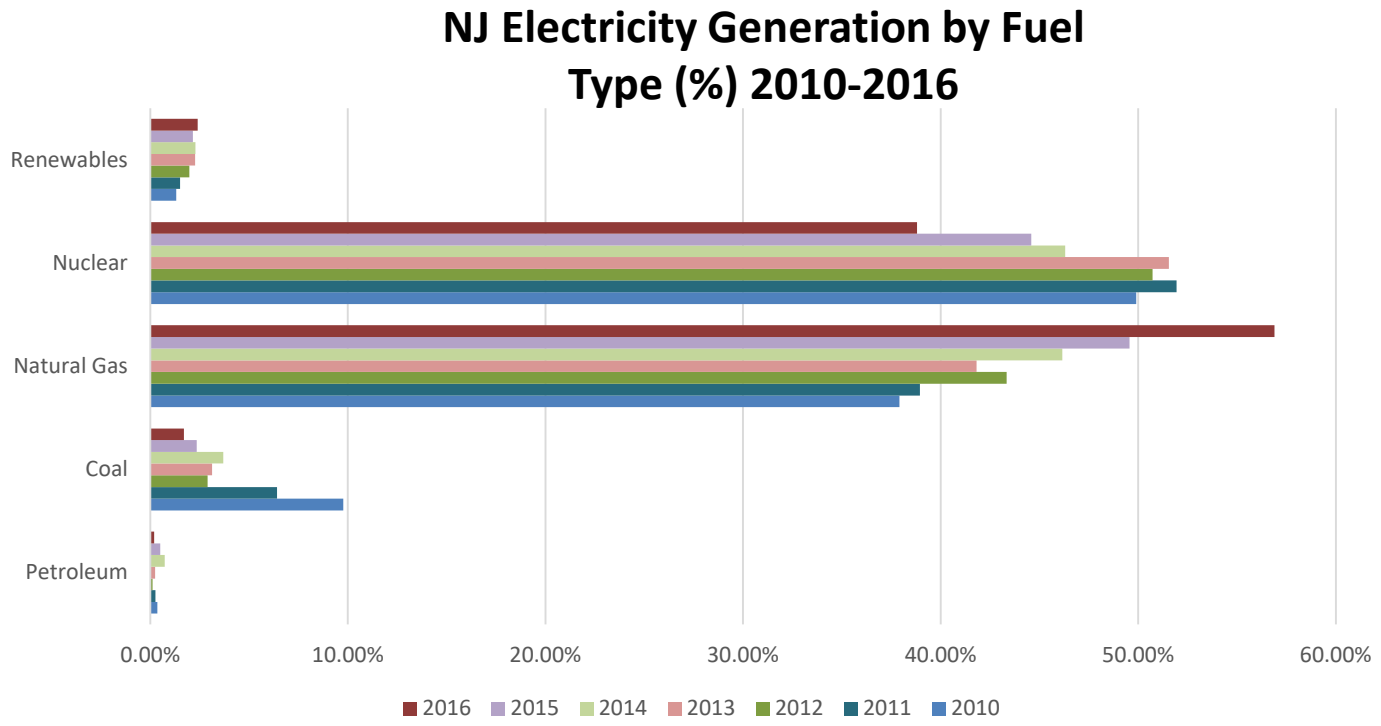
Perspectives on Policy & Economic Considerations of Deep Decarbonization

Abe Silverman

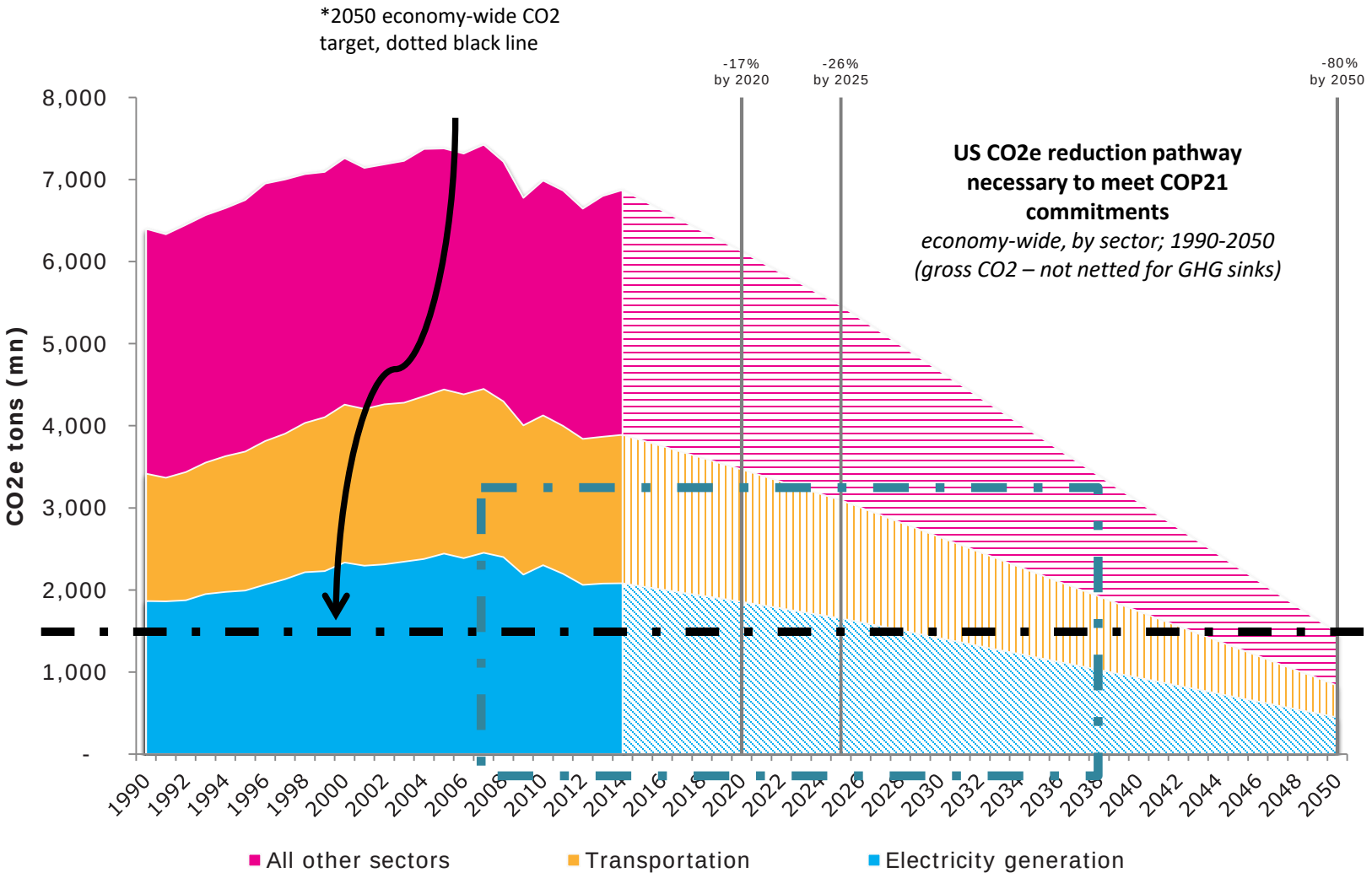
Consider the Source:

- General Counsel, New Jersey Board of Public Utilities
- Formerly Deputy General Counsel & VP of Regulatory Affairs for NRG Energy, Inc.
  - A large competitive power company owning generation and retail energy

The views expressed here are mine along and do not represent the view of the Board of Public Utilities or of Board Staff

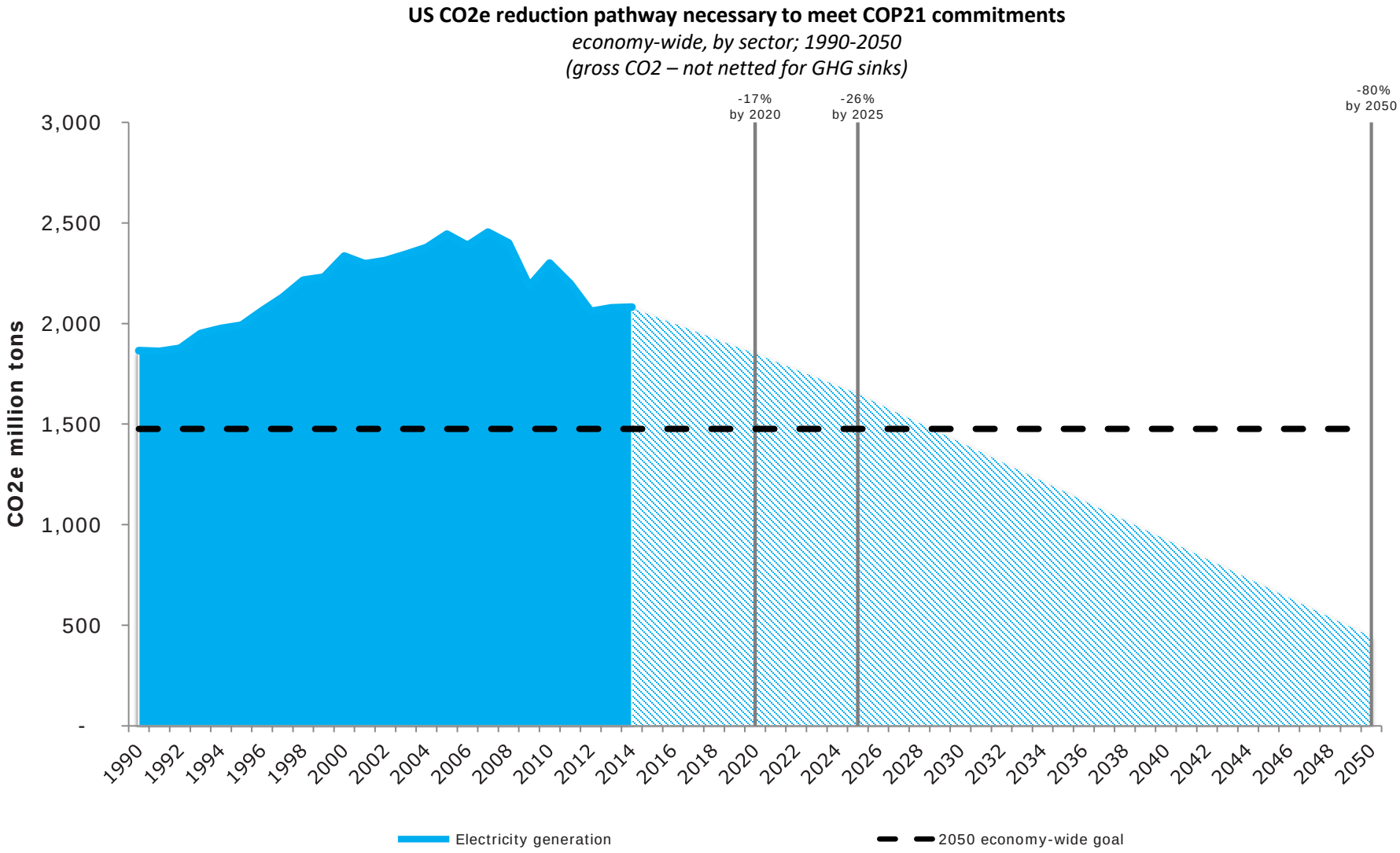


National CO2 Emissions Trajectory



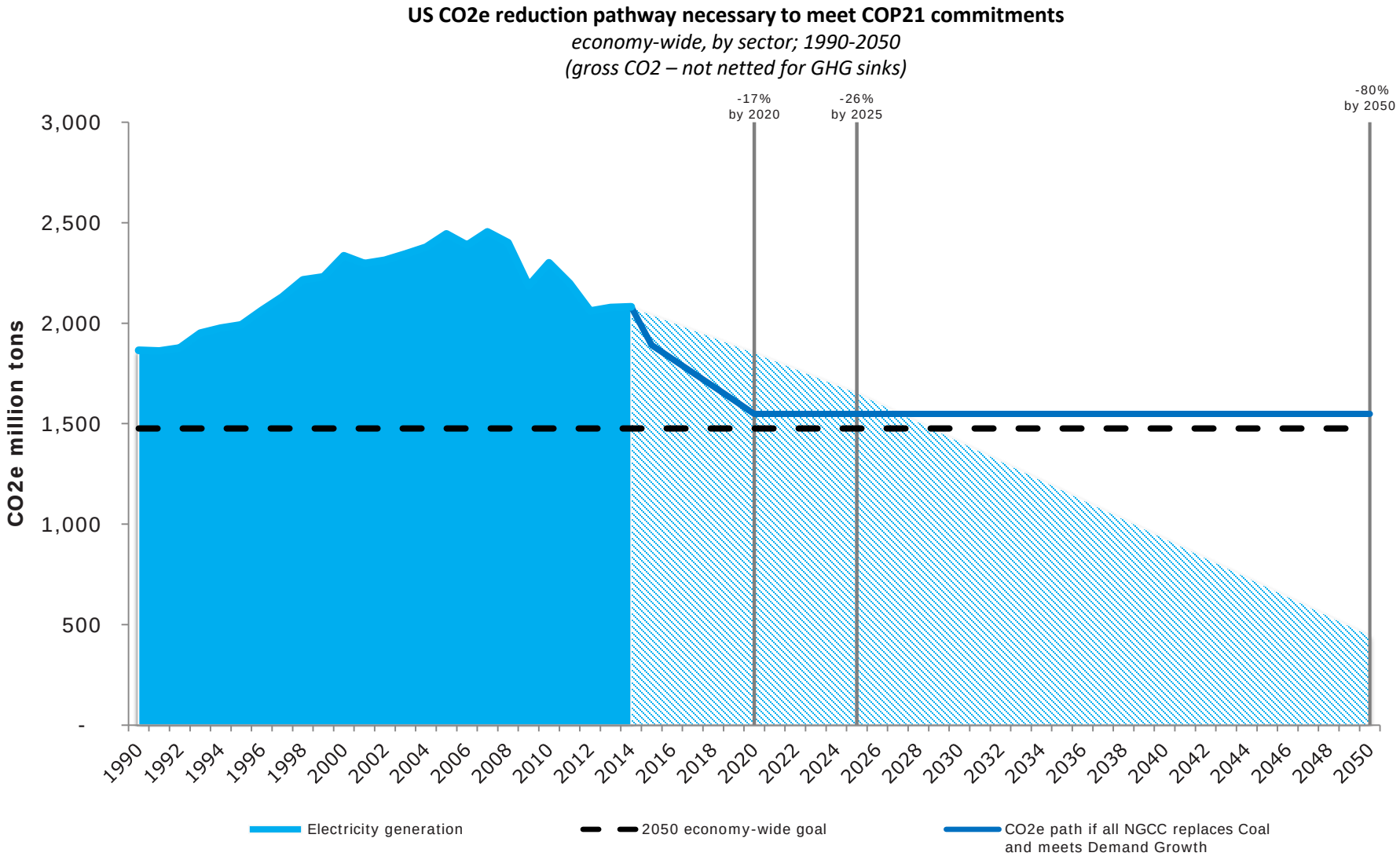
Source: Data from US EPA

National CO2 Emissions Trajectory: *Focus on Electricity Sector*



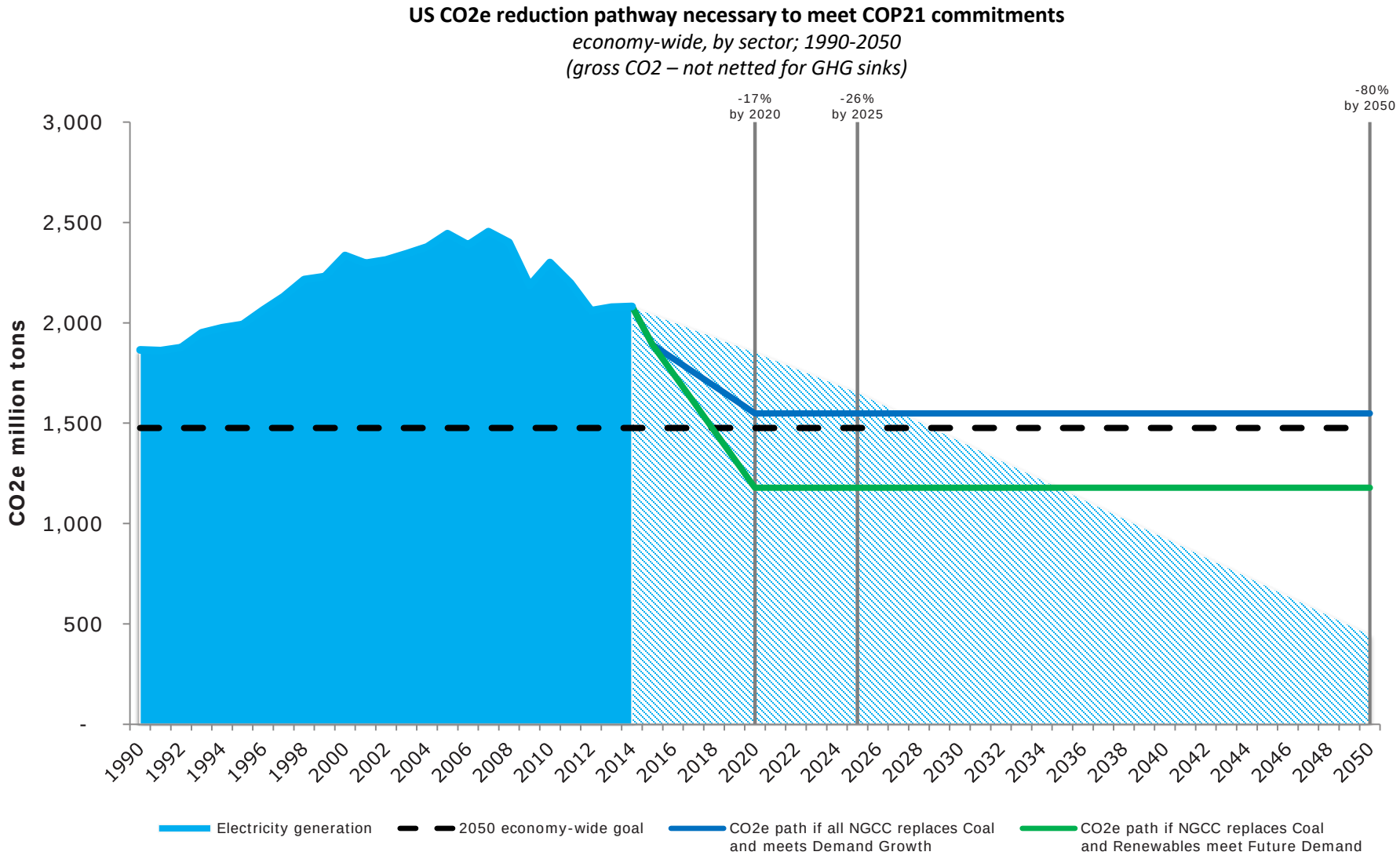
Source: Data from US EPA

National CO2 Emissions Trajectory: *Gas Replaces Coal & Meets Load Growth*



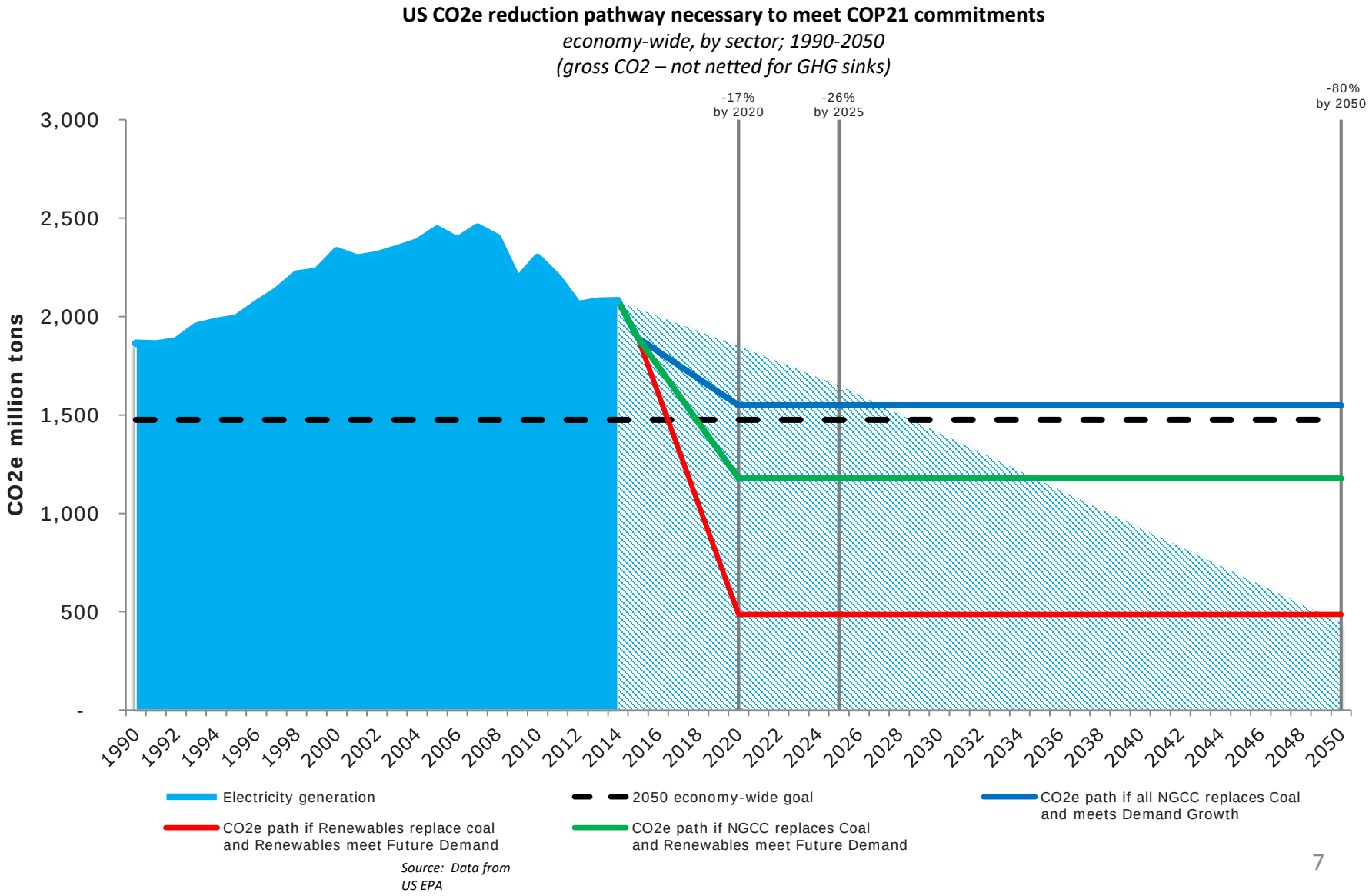
Source: Data from US EPA

National CO2 Emissions Trajectory:
Gas Replaces Coal & Renewables Meet Growth



Source: Data from US EPA

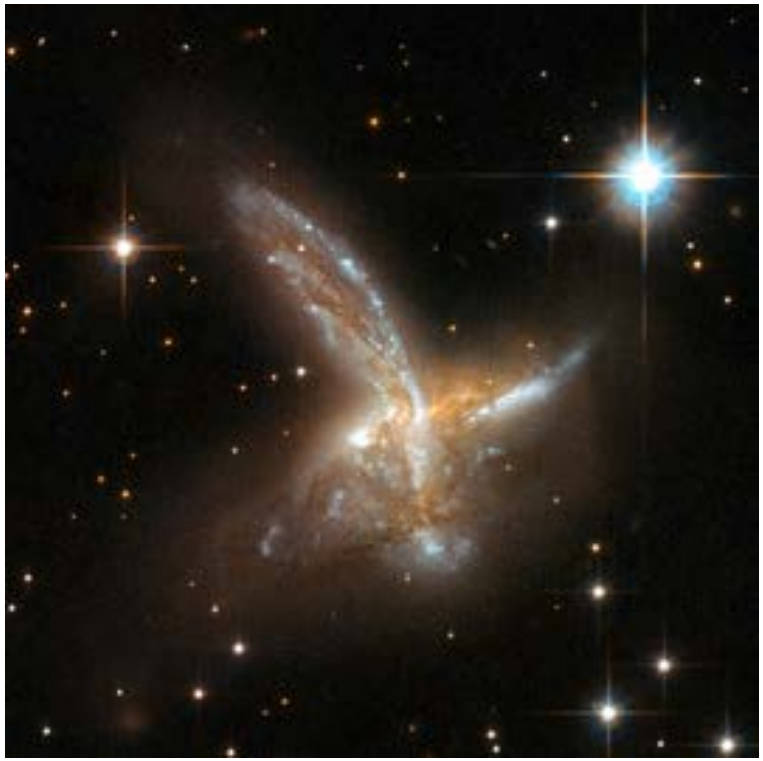
National CO2 Emissions Trajectory: *Renewables Replace Coal & Meet Load Growth*



Source: Data from US EPA

Thoughts

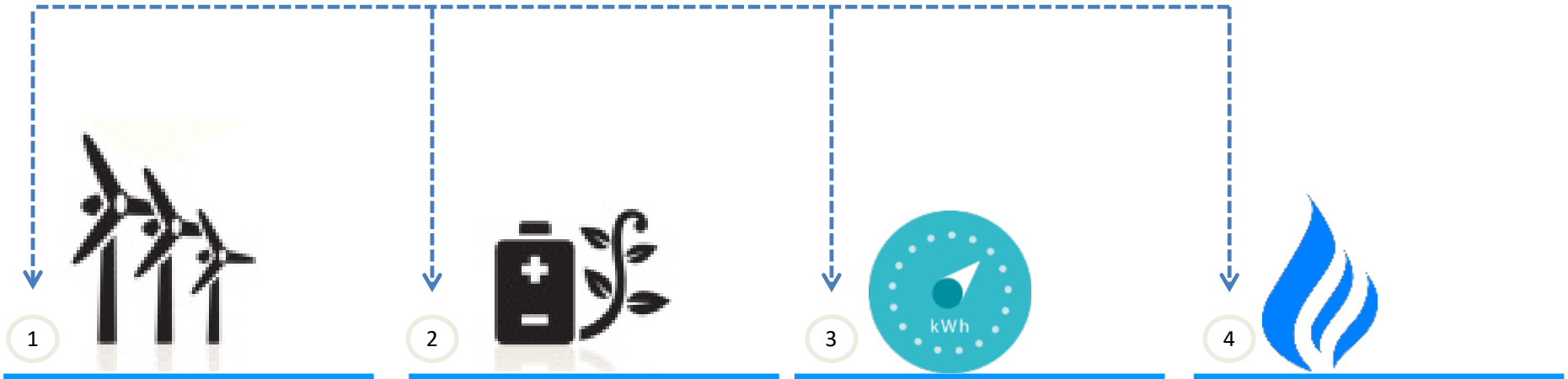
1. We must decarbonize at a price consumers can afford.
2. 100% green is largely an economics problem, not an engineering challenge.
3. 2030 is the easy part.
4. Competitive markets that co-optimize reliability, cost and carbon are least-cost.
5. Many state regulators no longer trust the federal government (or markets) to deliver outcomes.



*Hubble Space Telescope image of galaxies getting ripped apart as they collide.

Four Products Comprise the Grid of the Future

The Four Product Future:



Renewables

- ✓ Renewables will provide the vast majority of energy needed by consumers. Utility-scale renewables growth will track strongly along existing (and expanding) state RPS targets. Distributed renewables will also grow, enabled by rate design, state policies, consumer demand and improving economics.

Storage

- ✓ Utility-scale or commercially-sited energy storage can balance variable renewables generation and manage peak demands while providing critical grid support products (e.g. ancillaries).

Controllable demand

- ✓ Smart, controllable loads, e.g. connected water heaters, will become pervasive in end-use devices and can address capacity / demand-shift challenges imposed by high penetrations of weather-dependent renewables. This will provide value to customers and the grid.

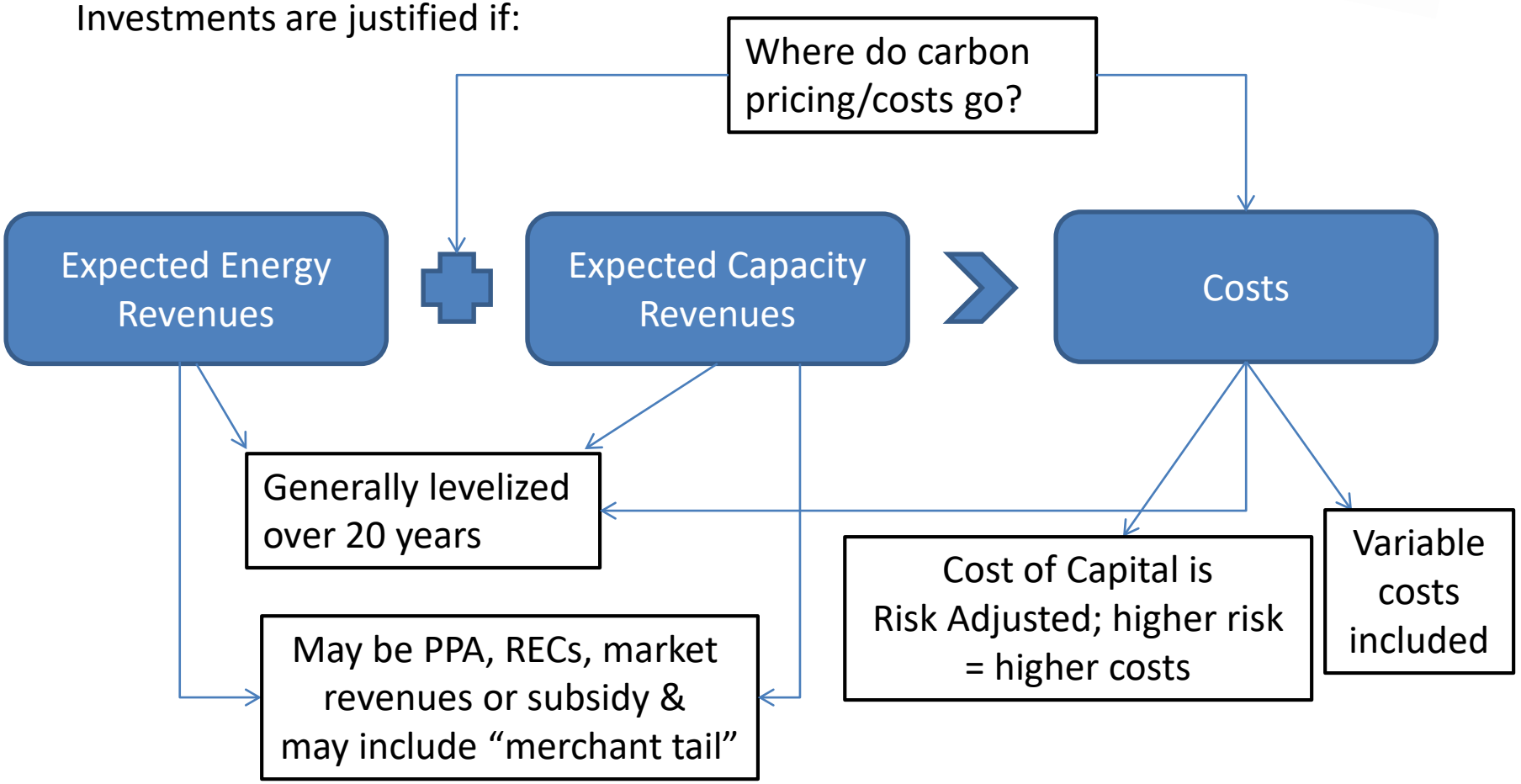
Fast-ramping gas

- ✓ Fast-start gas capacity can provide flexible, dispatchable capacity to ramp as needed to balance renewables.

Source: https://www.nrg.com/insights/energy-education/the-four-product-future-transforming-the-energy-industry-today.html

Power Plant Finance

Investments are justified if:



1. Carbon Price or Carbon Tax

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0.04 Miles

California & the RGGI States (CT, DE, MA, MD, NY, ME, NH, RI and VT)

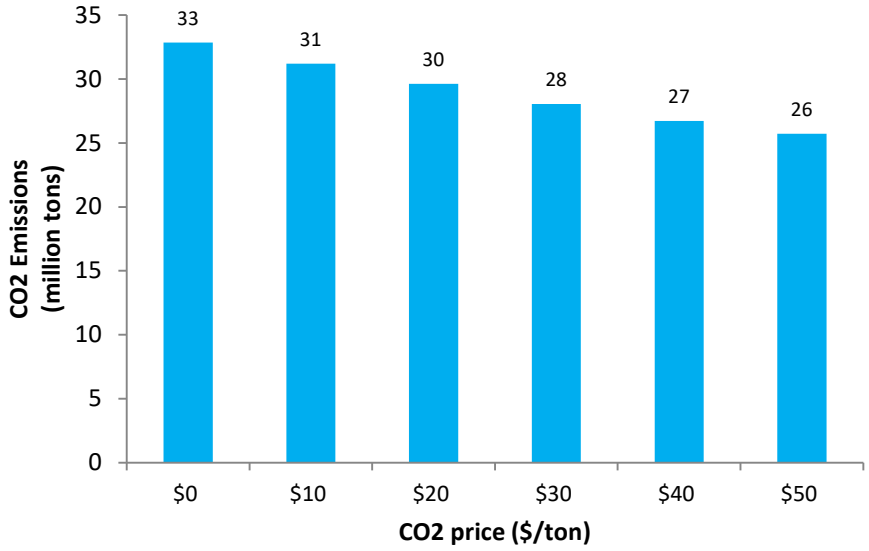
Favorite of economists everywhere. Great for coal-to-gas switching....
But can it drive renewables investment at an acceptable price? read more

Carbon pricing in New England:

- ✓ With virtually no coal left in the region's fuel mix, increased carbon pricing has a limited ability to alter the relative cost of fuels in the dispatch stack.
- ✓ NRG dispatch modeling shows that progressively higher carbon prices result in, at best, only moderately lower CO2 emissions from the power sector in New England.
- ✓ In a gas-defined generation mix, there are limited marginal benefits to progressively higher carbon prices – even at 10x current RGGI prices.

Est. Annual New England Power Sector CO2 Emissions

Assuming various carbon prices



Source: NRG Analysis

New Jersey conducting its own detailed modeling exercise due in December as part of its Energy Master Plan and as we re-join RGGI

https://nj.gov/emp/

2. **Long-Term Contracts for Renewables**

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0.04 Miles

California, with MA, NY and CT following right behind!

Politicians love it! Long-term contracts allow E-Z financing.... But should consumers wear market & development risk, or shareholders? read more

- Record low renewable energy and battery storage prices were observed in the recent Colorado clean energy RFP.
- Wind-plus-storage and solar-plus-storage shows a eye-popping price of $21-36/MWh.

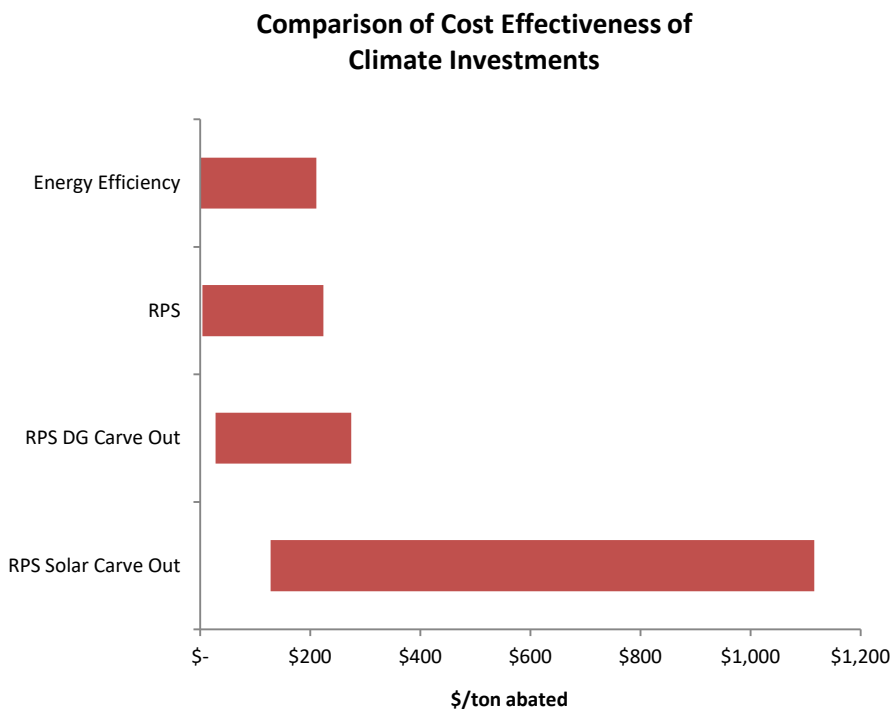
2017 Xcel Colorado All-Resource Solicitation Results

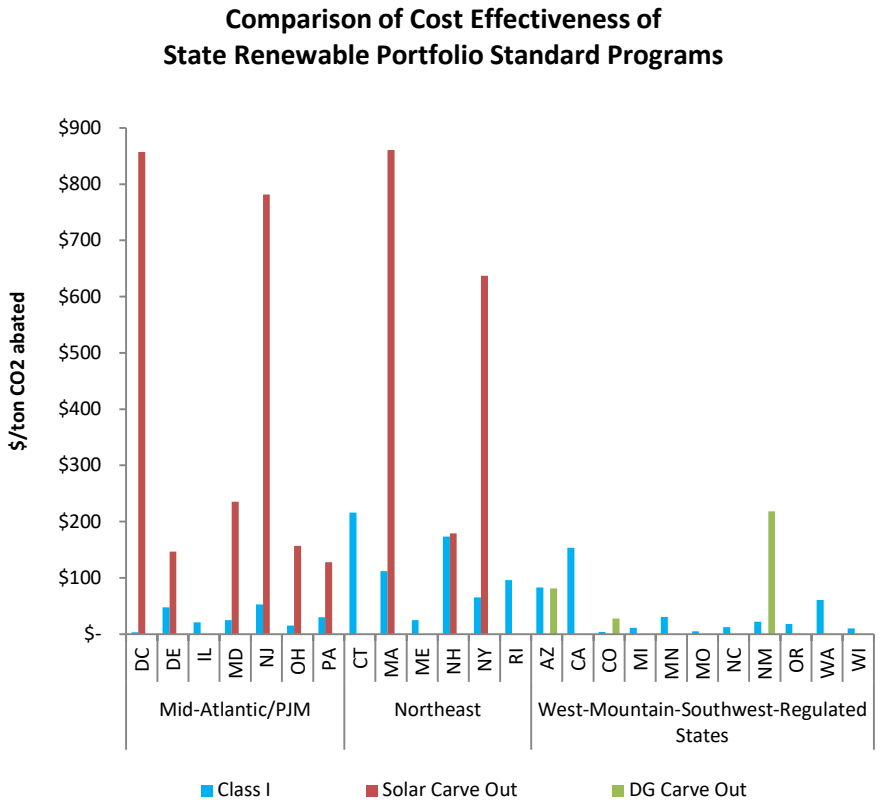
Delivery Year 2023

Generation Technology	# of Bids	Bid MW	# of Projects	Project MW	Median Bid Price or Equivalent	Pricing Units
Combustion Turbine/IC Engines	30	7,141	13	2,466	$ 4.80	$/kW-mo
Combustion Turbine with Battery Storage	7	804	3	476	6.20	$/kW-mo
Gas-Fired Combined Cycles	2	451	2	451		$/kW-mo
Stand-alone Battery Storage	28	2,143	21	1,614	11.30	$/kW-mo
Compressed Air Energy Storage	1	317	1	317		$/kW-mo
Wind	96	42,278	42	17,380	$ 18.10	$/MWh
Wind and Solar	5	2,612	4	2,162	19.90	$/MWh
Wind with Battery Storage	11	5,700	8	5,097	21.00	$/MWh
Solar (PV)	152	29,710	75	13,435	29.50	$/MWh
Wind and Solar and Battery Storage	7	4,048	7	4,048	30.60	$/MWh
Solar (PV) with Battery Storage	87	16,725	59	10,813	36.00	$/MWh
IC Engine with Solar	1	5	1	5		$/MWh
Waste Heat	2	21	1	11		$/MWh
Biomass	1	9	1	9		$/MWh
Total	430	111,963	238	58,283		

PPAs in renewable-rich integrated service territories are already at cost-parity. What about market regions without low-cost renewable options?

Renewable Costs Vary Across State Programs





Source: Assessing the Cost and Benefits of US Renewable Portfolio Standards,2017,NREL
Energy efficiency data are based on PSEG, NY CES and RGGI programs annual reports.

4. **Use Markets to Achieve Renewable Goals**

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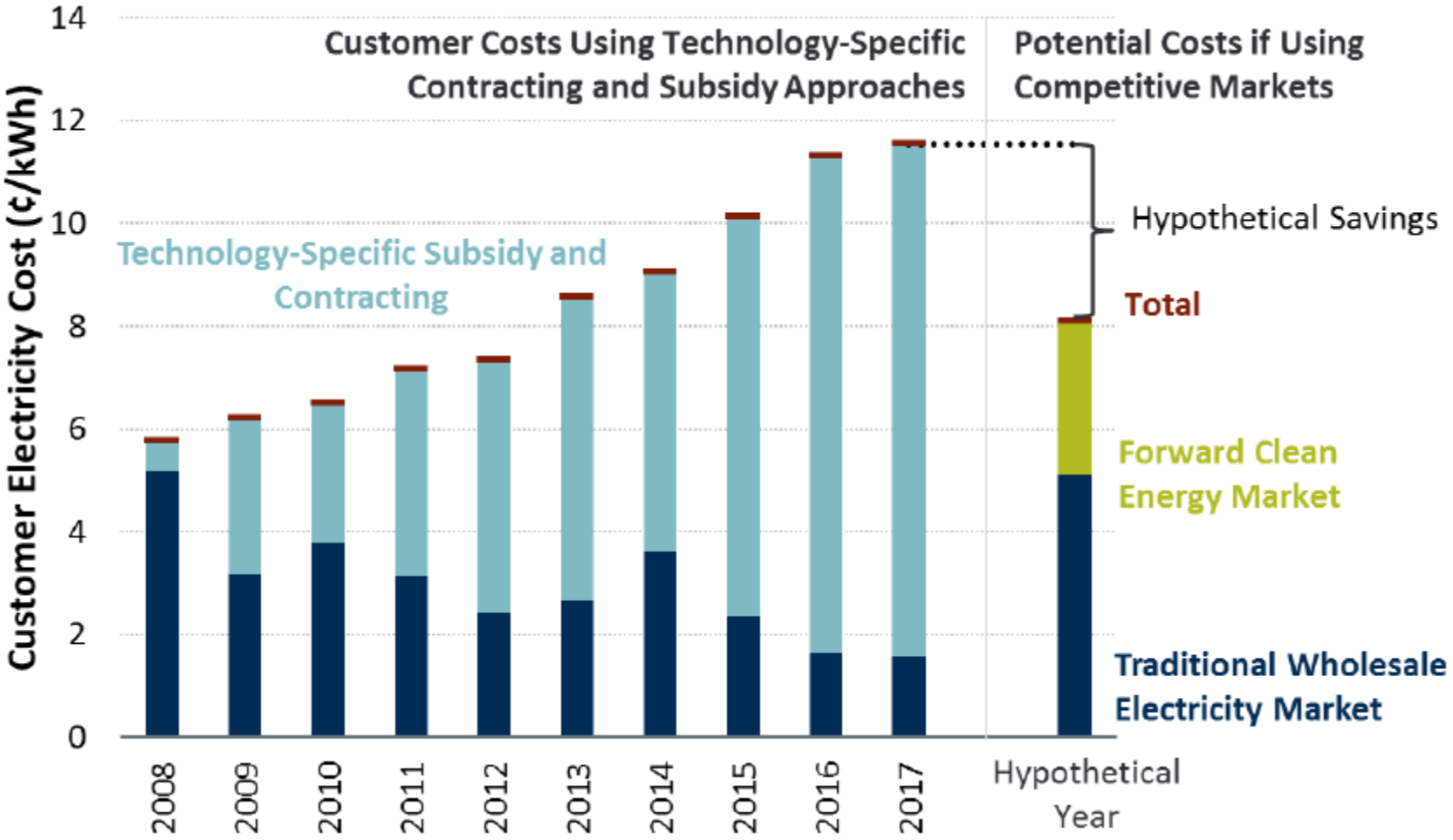
Opened 2 months ago

Conceptual - maybe NY or NE States?

More carbon abatement at a lower price -- but requires state regulators to give up control over handing out contracts (and work with the Feds)! read more



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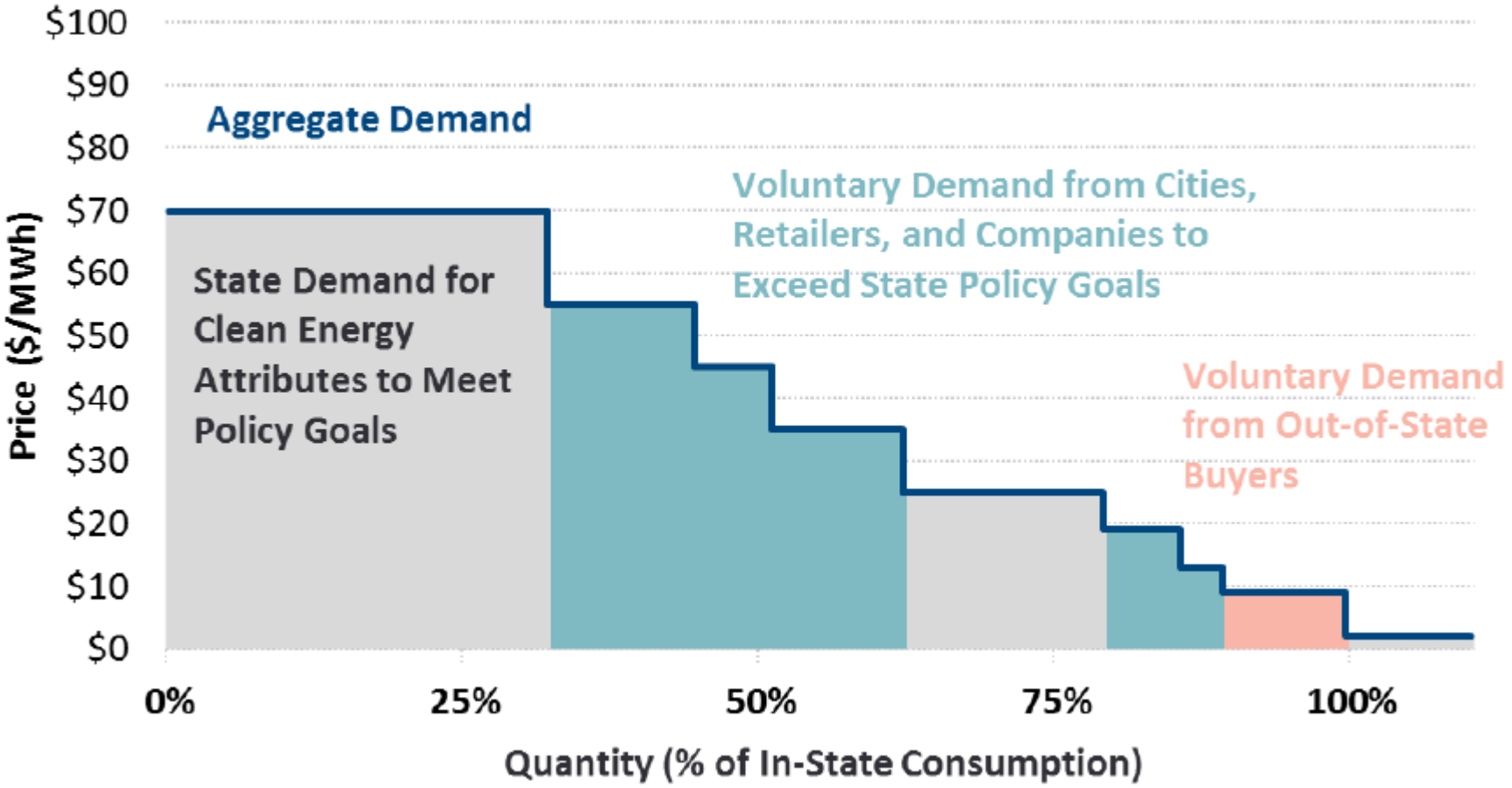
Aggregate Demand for Clean Energy Attribute Credits



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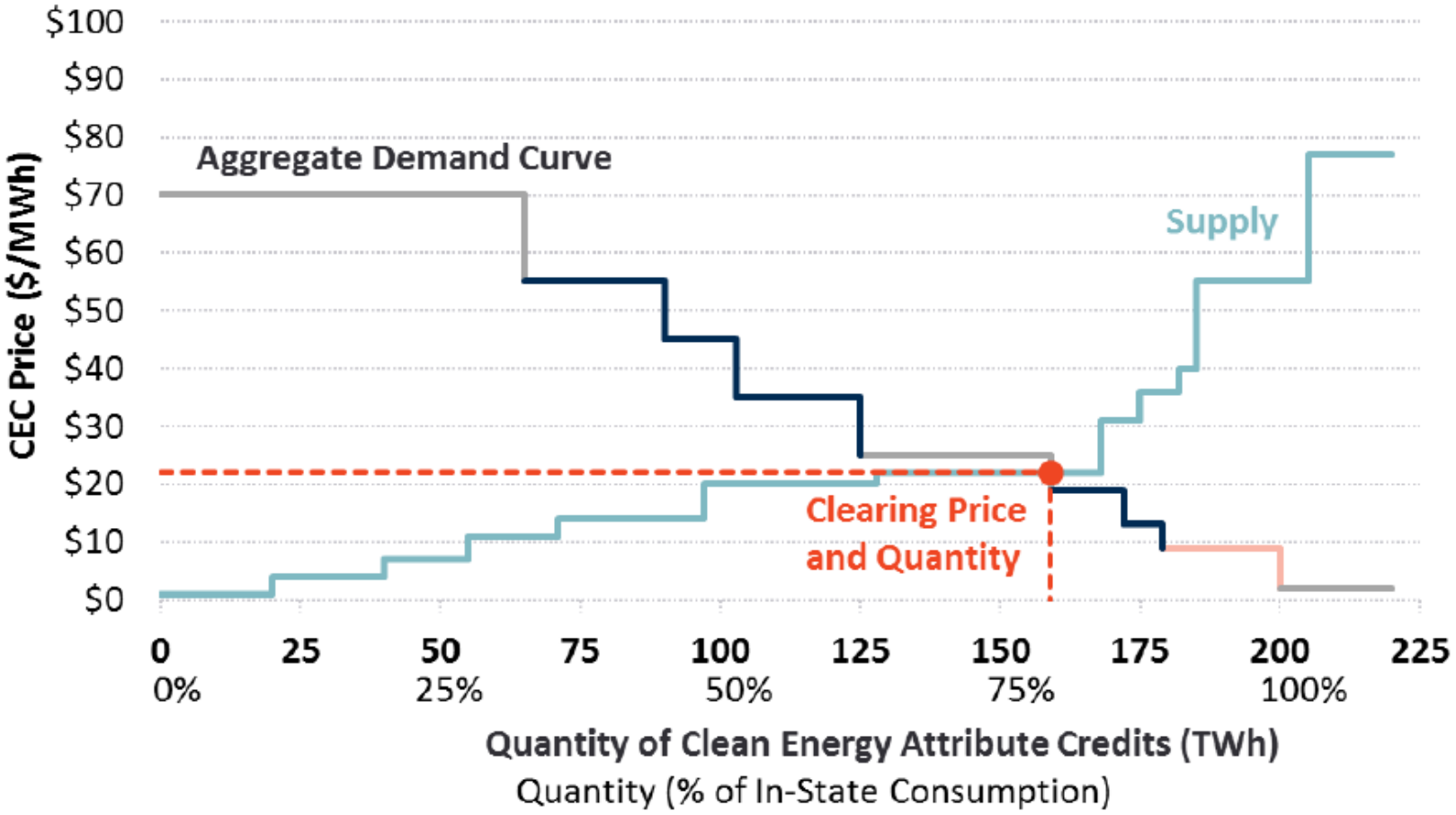
Example: Clearing the Forward Clean Energy Market



Mad Scientists and Economists Wanted!

"The bigger task is to redesign power markets to reflect the new need for flexible supply and demand…. Bills could be structured to be higher or lower depending how strongly a customer wanted guaranteed power all the time—a bit like an insurance policy. ***In short, policymakers should be clear they have a problem and that the cause is not renewable energy, but the out-of-date system of electricity pricing.*** *Then they should fix it."*

-- The Economist, February 25, 2017

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https://nj.gov/bpu/about/employment/