

# Transportation, Electrification and the Path to Net-zero



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PRINCETON UNIVERSITY

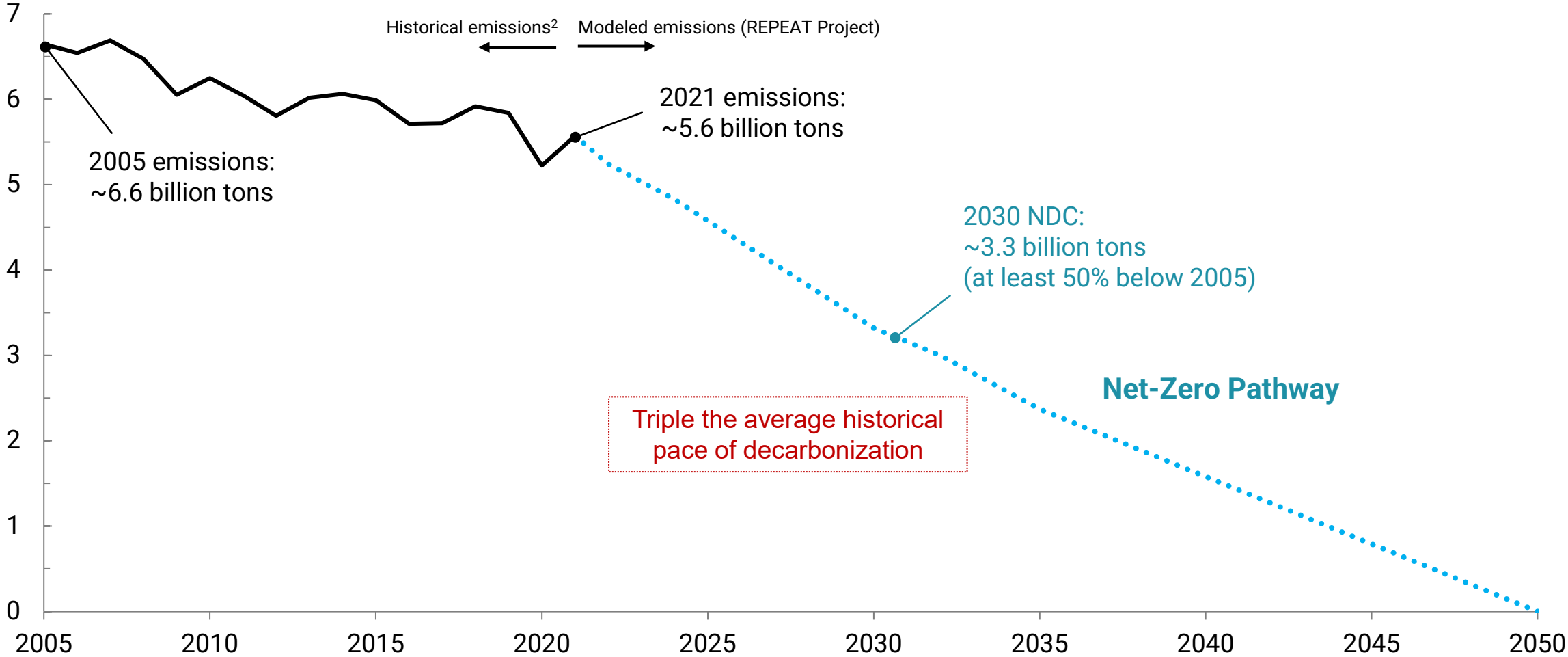
**ZERO LAB**

Zero-carbon Energy Systems Research and Optimization Laboratory

# Net-Zero America

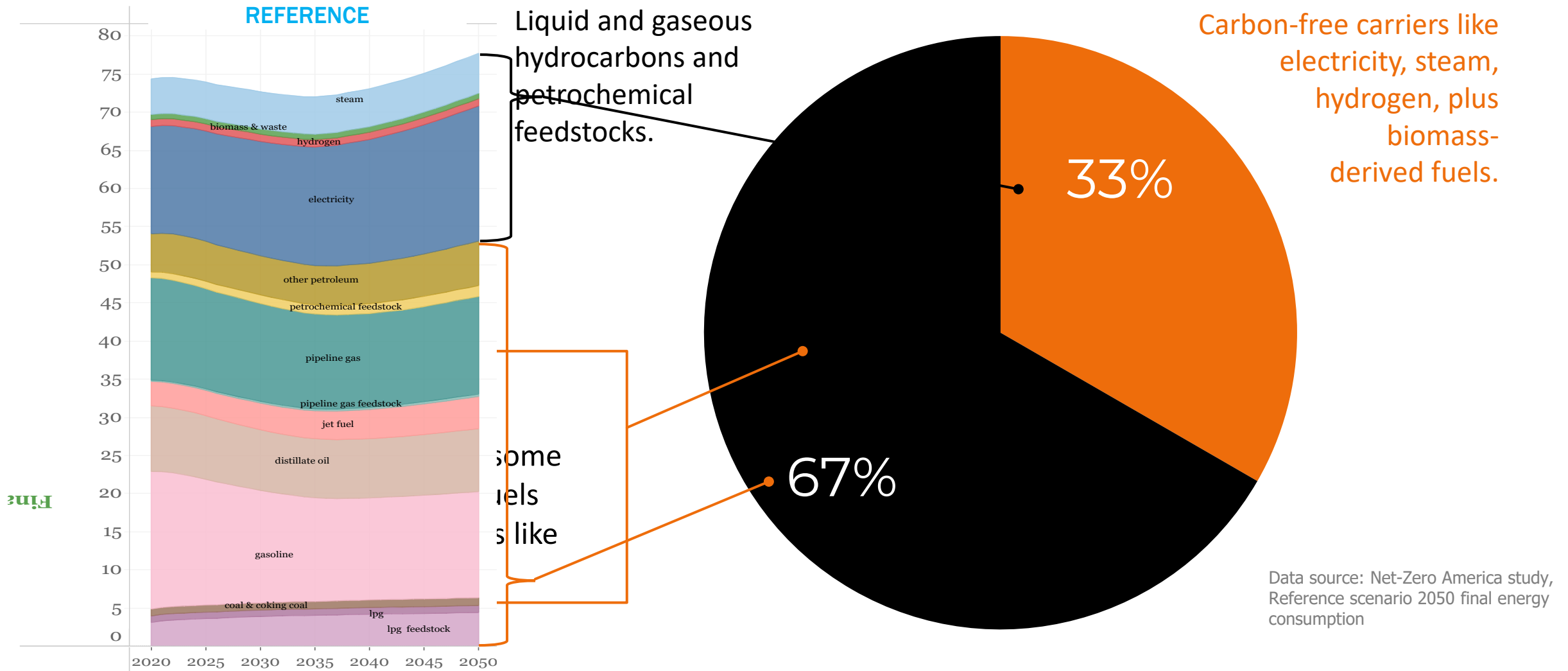
## Historical and Modeled Net U.S. Greenhouse Gas Emissions (Including Land Carbon Sinks)

billion metric tons CO<sub>2</sub>-equivalent (Gt CO<sub>2</sub>-e)<sup>1</sup>



1 - CO<sub>2</sub>-equivalent emissions calculations use IPCC AR4 100 year global warming potential as per [EPA Inventory of Greenhouse Gas Emissions and Sinks](#).  
2 - Historical data from [US EPA Inventory](#) for 2005-2030; 2021 preliminary emissions estimate assumes total net emissions change in proportion to 6.7% year-on-year change in CO<sub>2</sub> emissions from energy and industrial processes estimated by [Global Carbon Monitor](#).

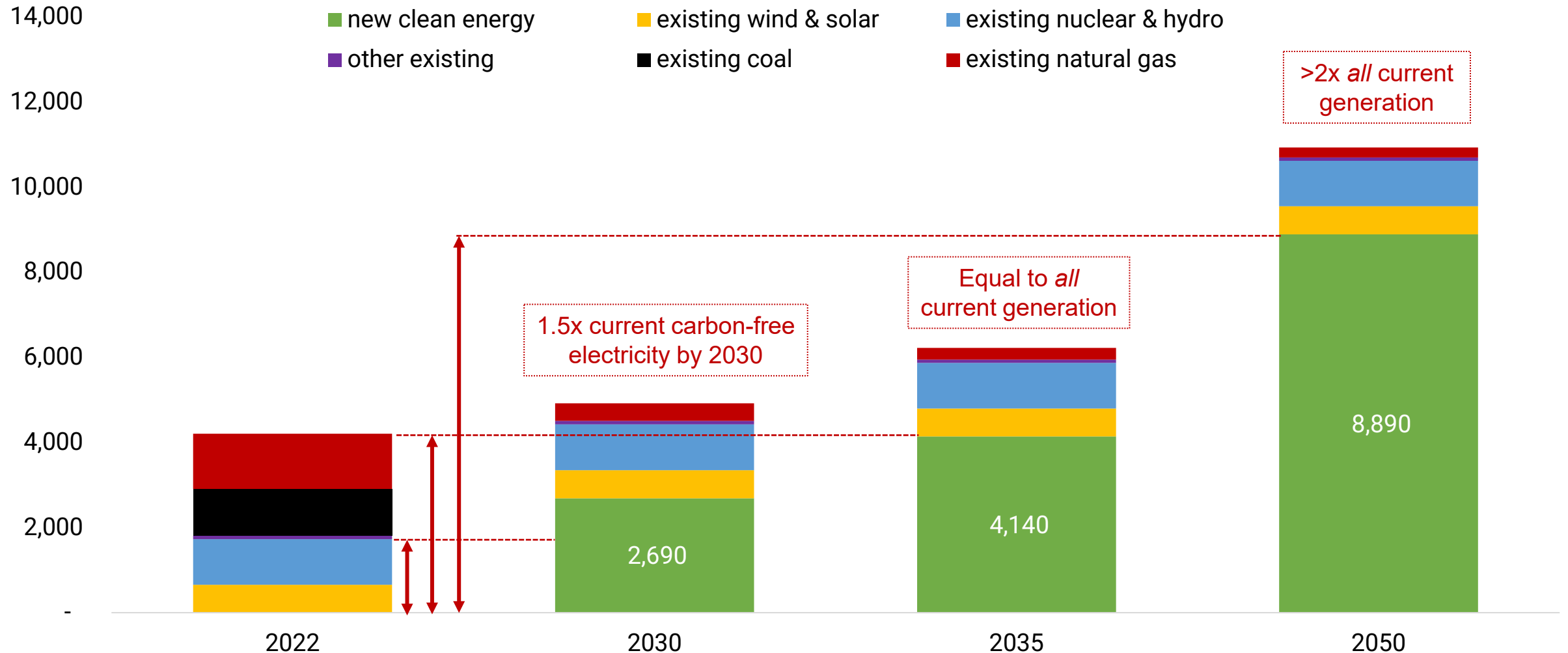
# Sizing up the challenge



# Clean electricity: the linchpin

## Total annual U.S. electricity generation by resource

Billion kilowatt-hours (or terawatt-hours)

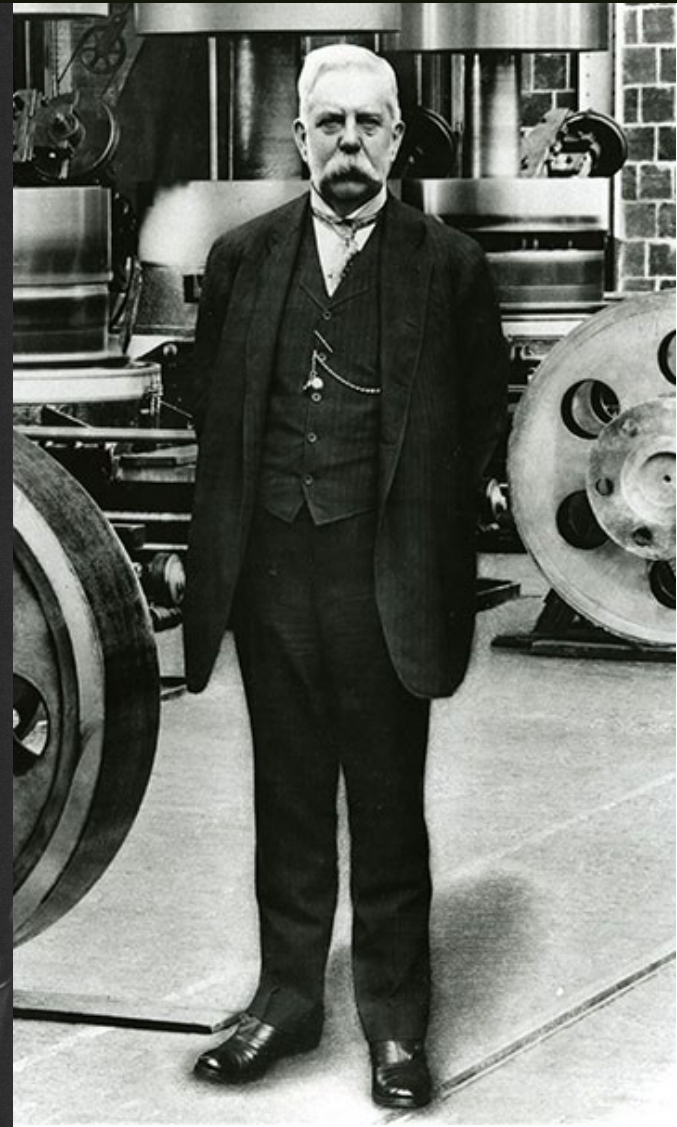
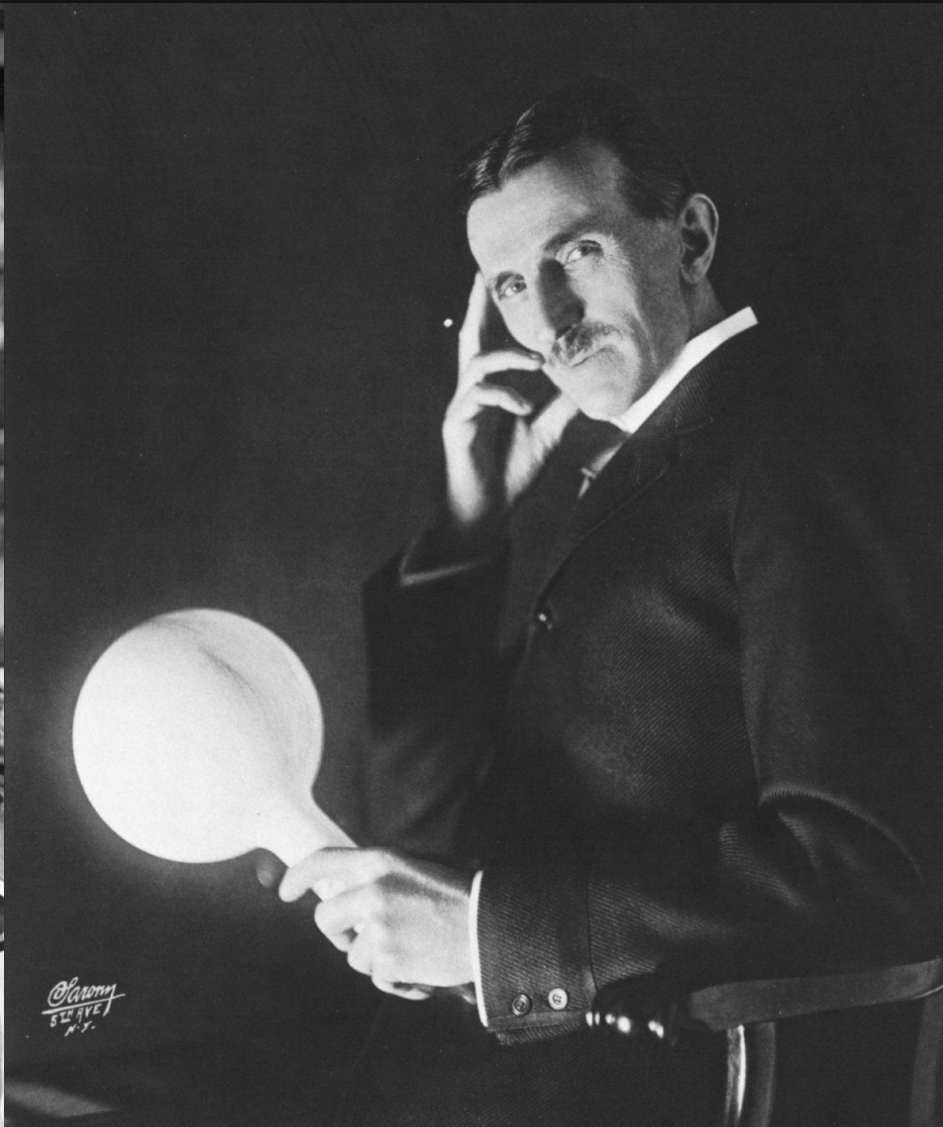
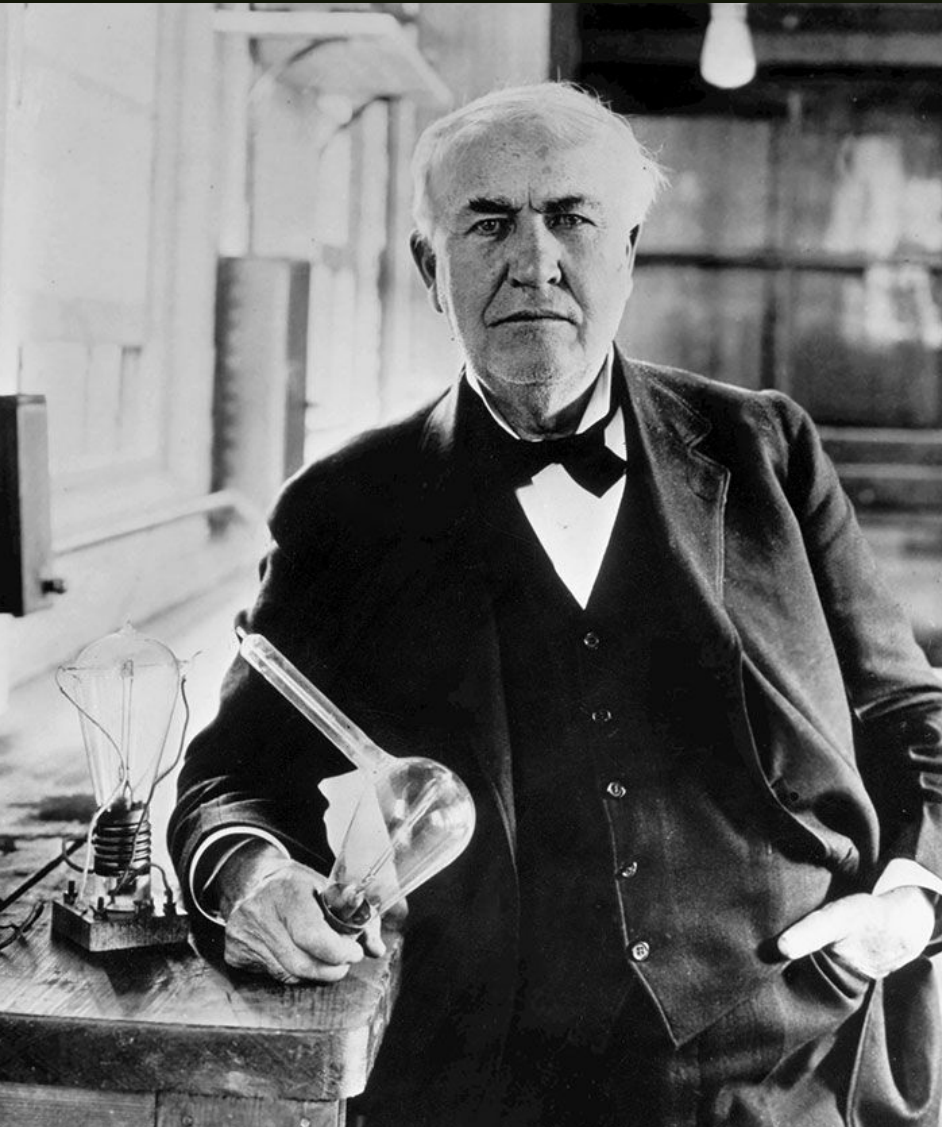


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Data source: REPEAT Project, Net-Zero Pathway

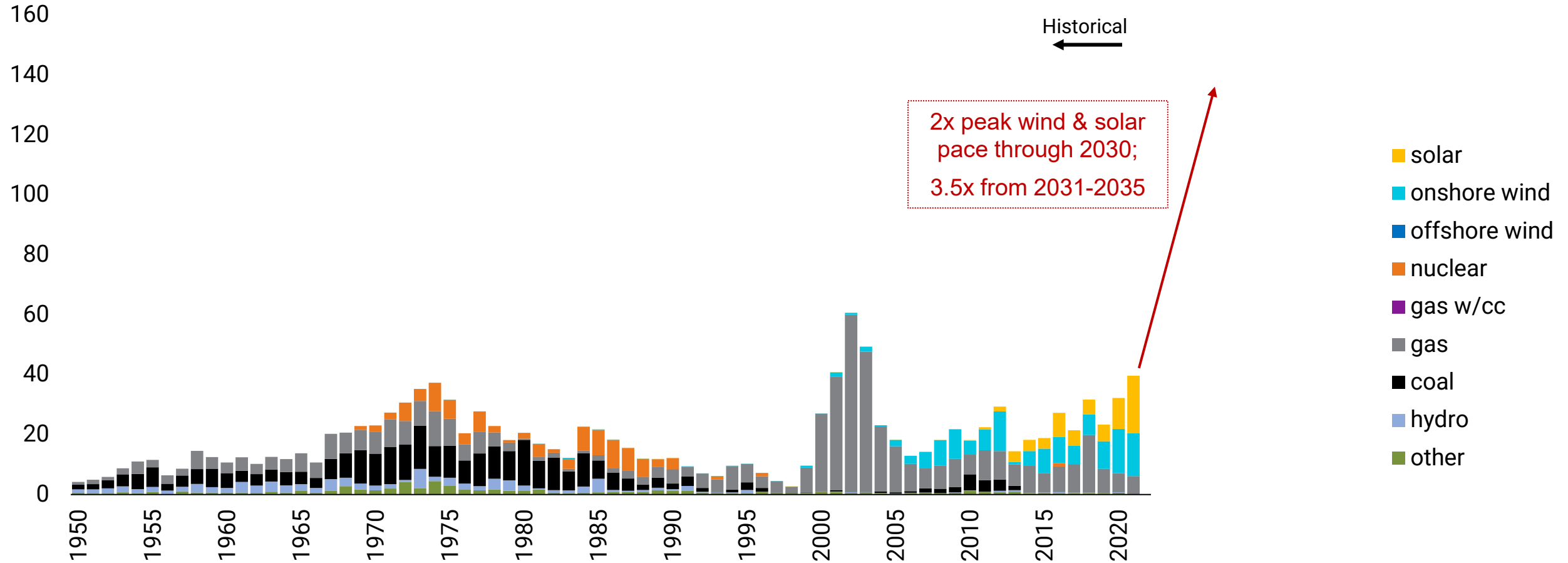
# 140 years since the days of Edison, Tesla, and Westinghouse...



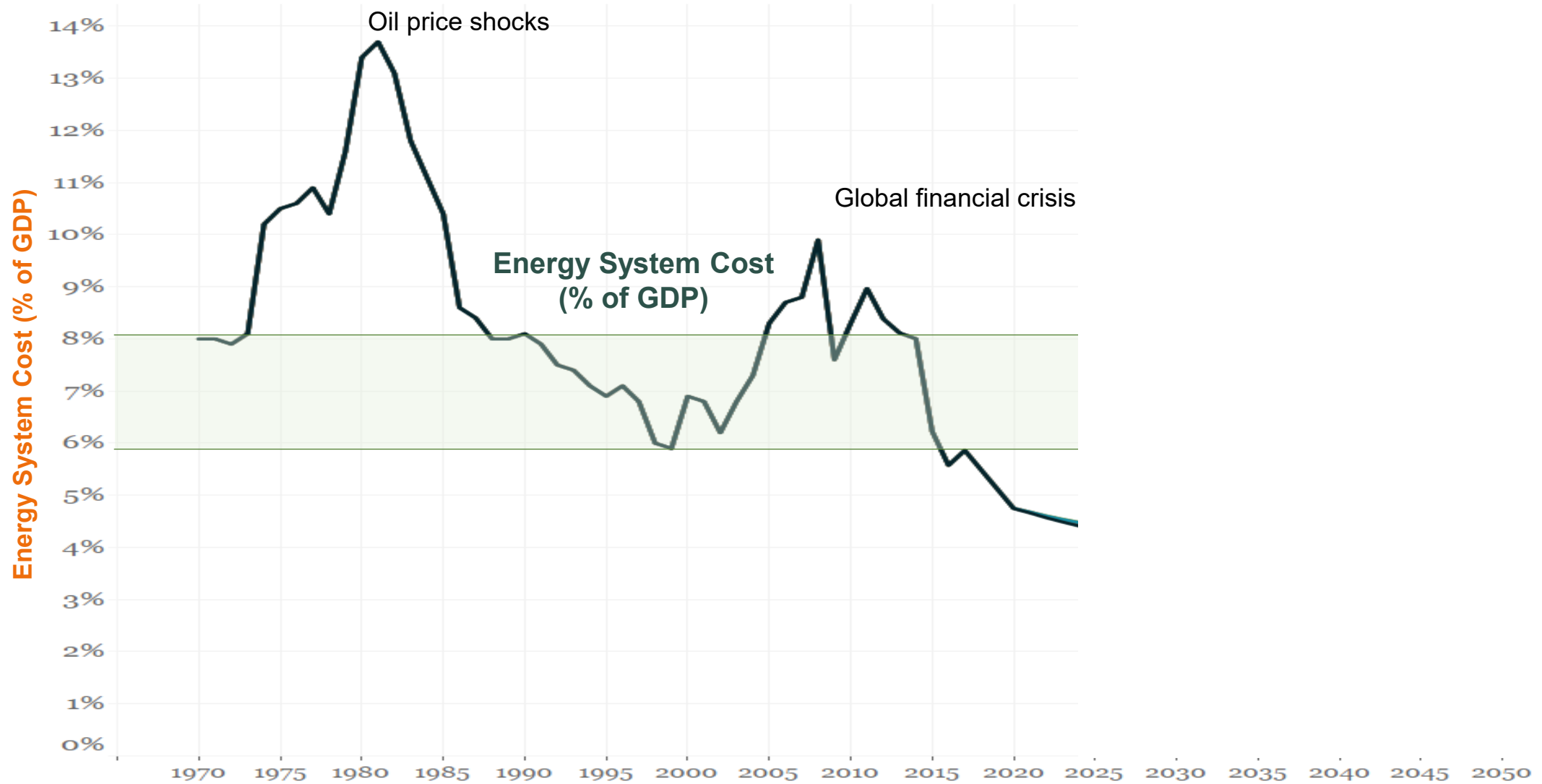
# Smashing new records

## Historical power generation capacity additions vs modeled Net-Zero Pathway

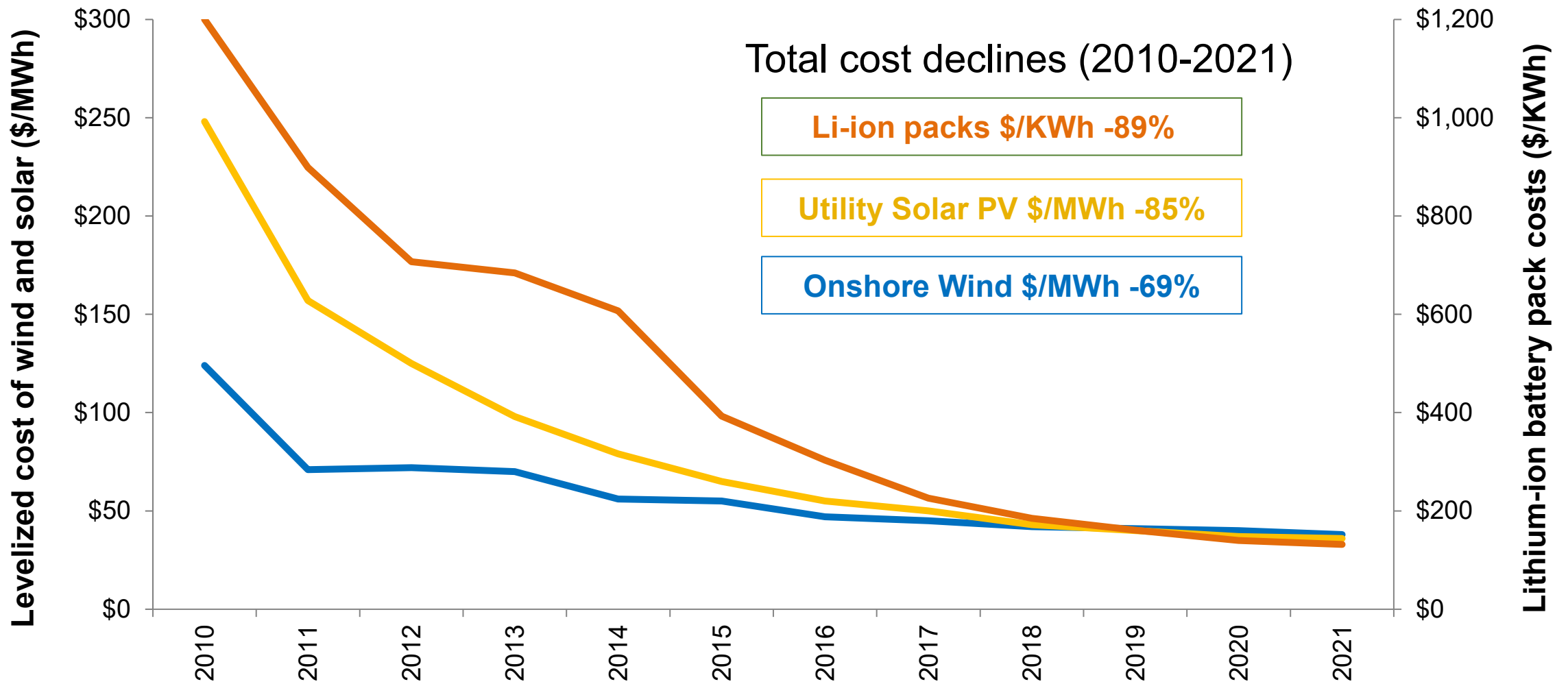
gigawatts per year

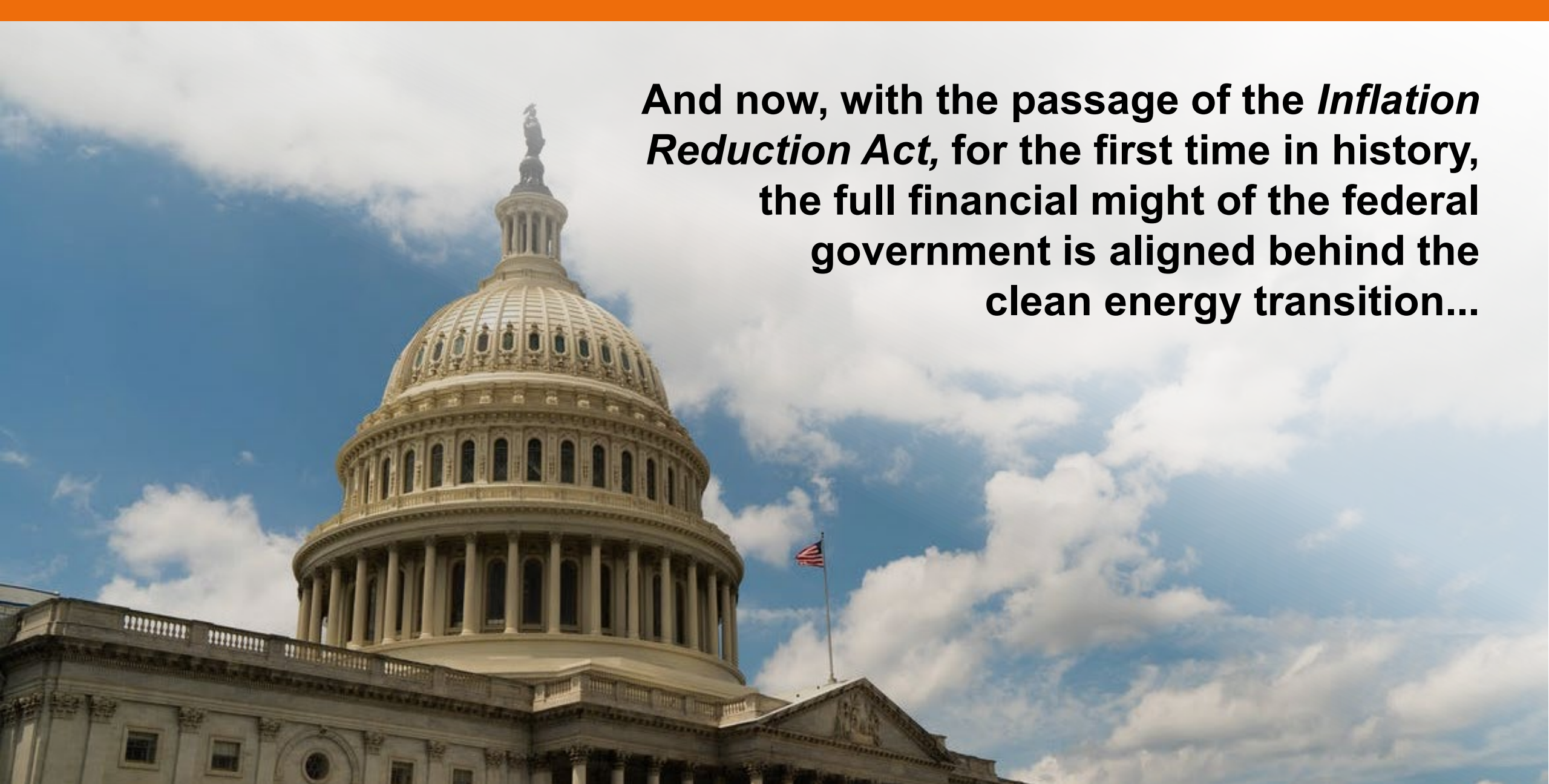


# Transformative, but affordable



# Wind, solar, and battery costs have plummeted...





**And now, with the passage of the *Inflation Reduction Act*, for the first time in history, the full financial might of the federal government is aligned behind the clean energy transition...**

# The Infrastructure Law and *Inflation Reduction Act* focus on making clean energy\* cheap

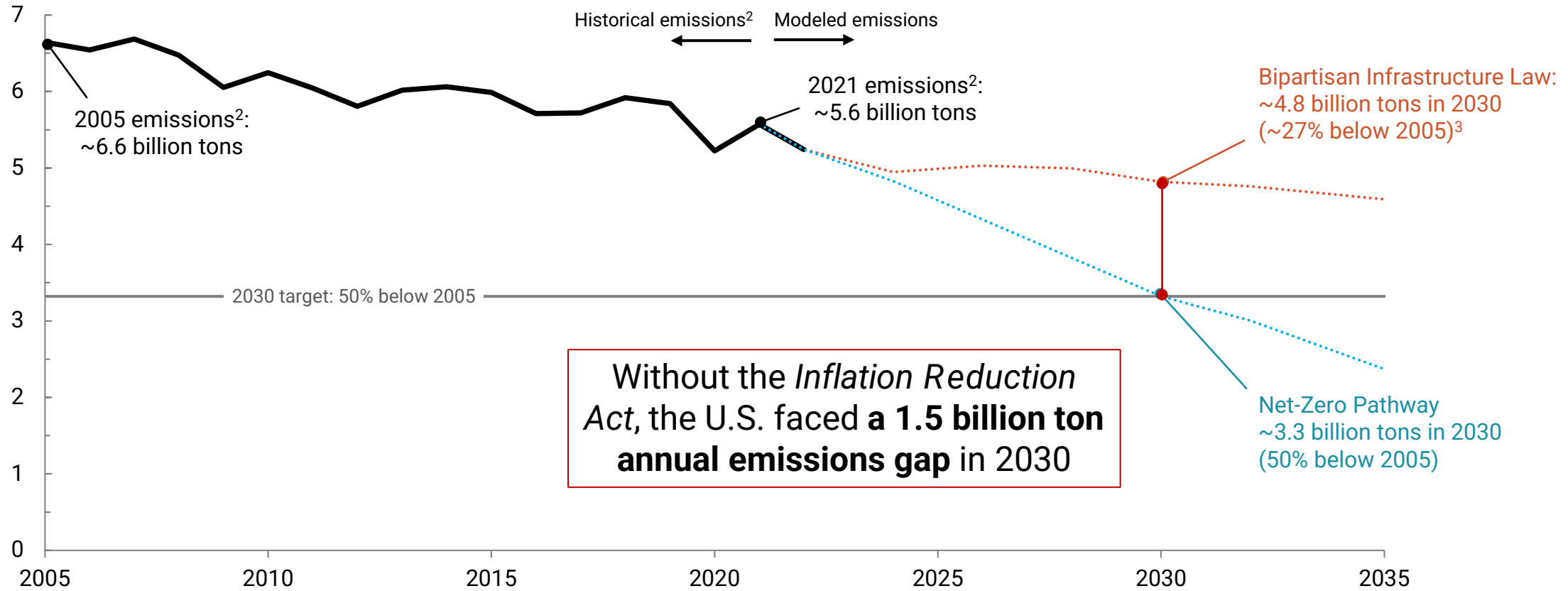
\* (and other climate solutions)

Well over \$500 billion in tax credits, grants, rebates, and loan guarantees for:

- clean electricity
- hydrogen and clean fuels
- carbon capture & storage
- electric vehicles
- energy efficiency & electrification
- technology demonstration, hubs, and network infrastructure

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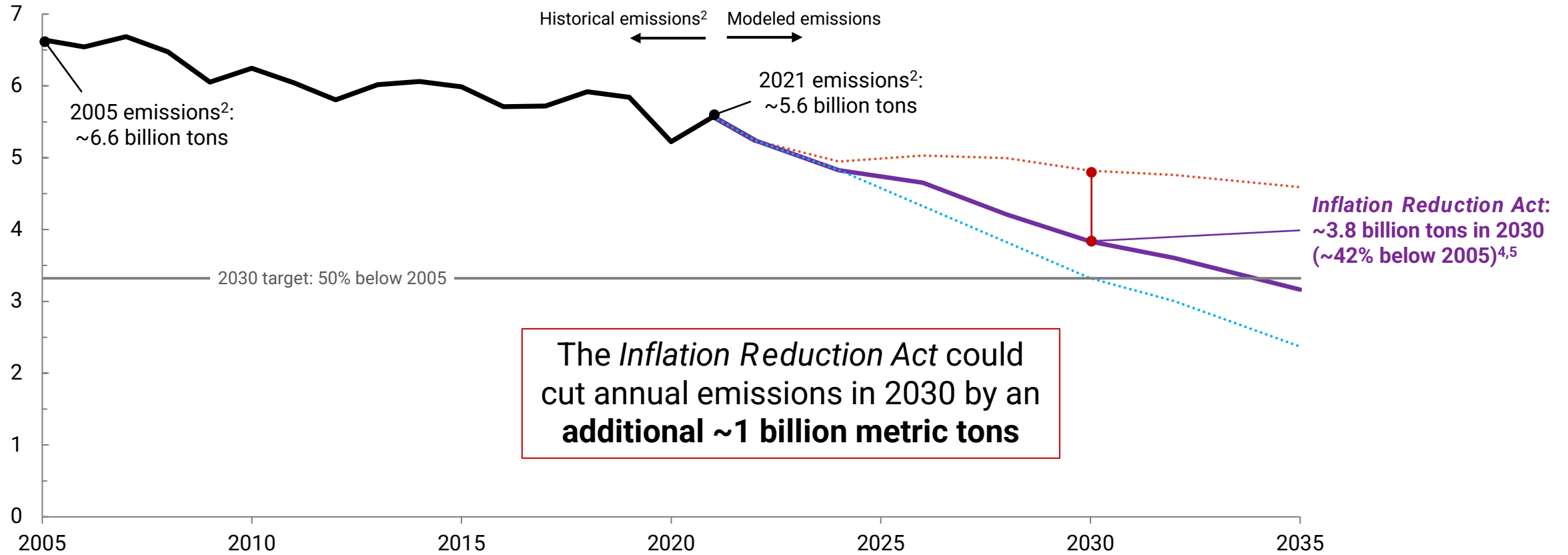
3 - Modeled emissions exclude any changes in passenger and freight miles traveled due to surface transportation, rail, and transit investments in IJJA. [According to the Georgetown Climate Center](#), emissions impact of these changes depend heavily on state implementation of funding from IJJA, which could result in anywhere from -14 Mt to +25 Mt change in CO<sub>2</sub> emissions from transportation in 2030.

4 - Results reflect preliminary modeling based on the [July 27, 2022 draft legislation](#).

5 - Results reflect average of estimated high and low oil & gas production scenarios, which span +/- 20 Mt CO<sub>2</sub>-e in 2030 (see p. 13-14). Impact on land carbon sinks based on analysis by [Energy Innovation](#).

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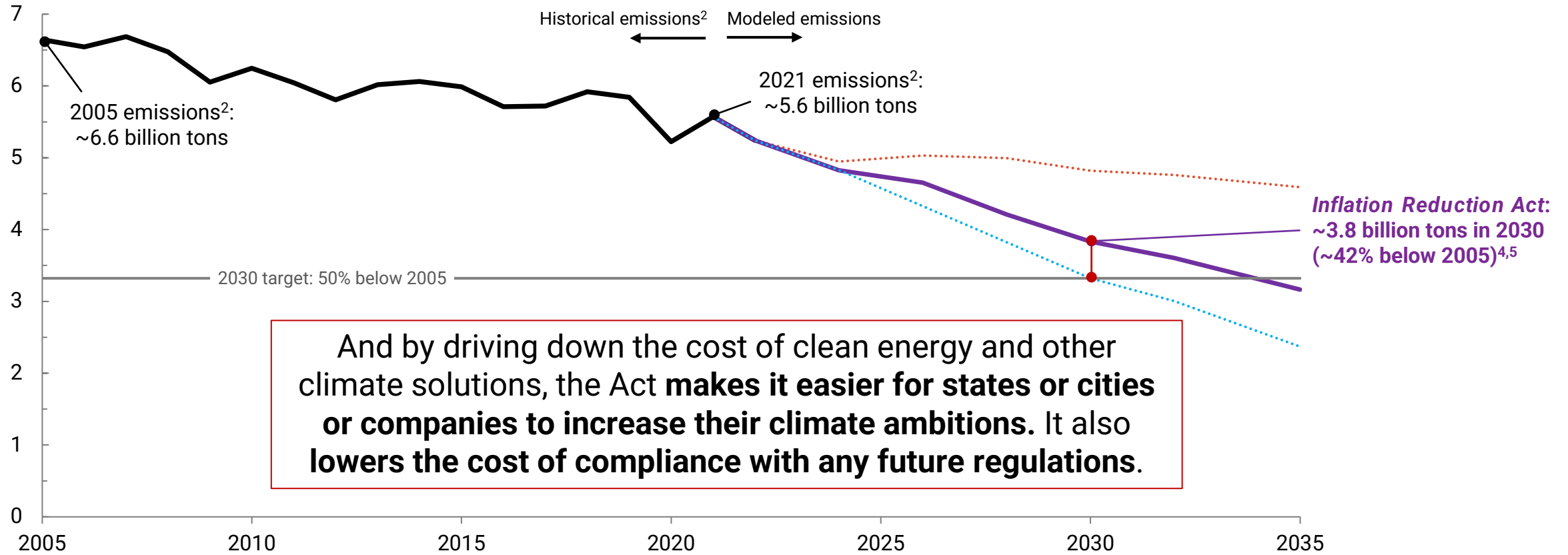


The *Inflation Reduction Act* could cut annual emissions in 2030 by an additional ~1 billion metric tons

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And by driving down the cost of clean energy and other climate solutions, the Act **makes it easier for states or cities or companies to increase their climate ambitions.** It also **lowers the cost of compliance with any future regulations.**

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# Governor Murphy Announces Comprehensive Set of Initiatives to Combat Climate Change and Power the “Next New Jersey”

02/15/2023

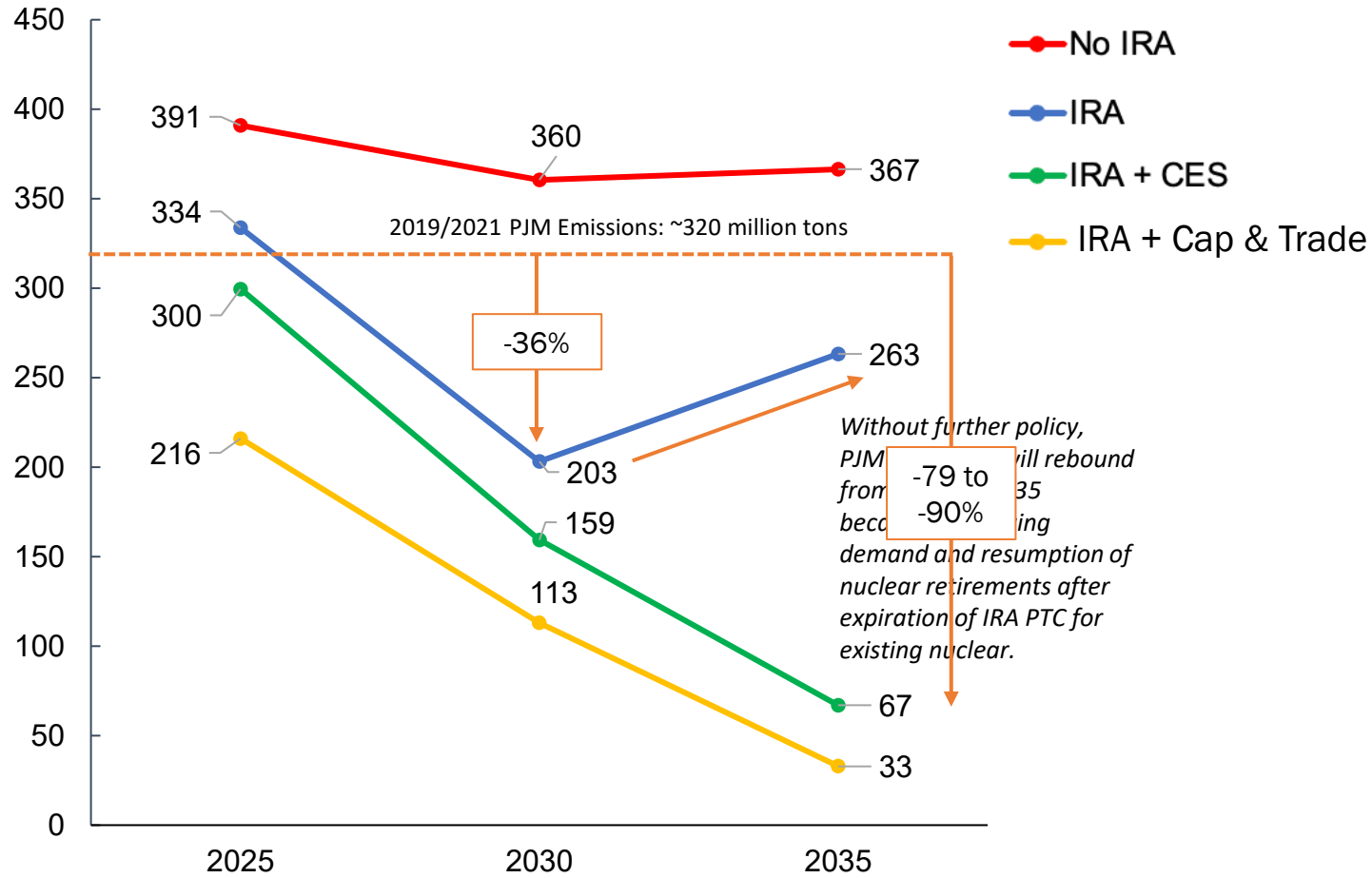
## Murphy Administration Sets Accelerated Target of 100% Clean Energy by 2035

The Governor outlined six pillars that will serve as the foundation for a cleaner, greener, and more resilient New Jersey.

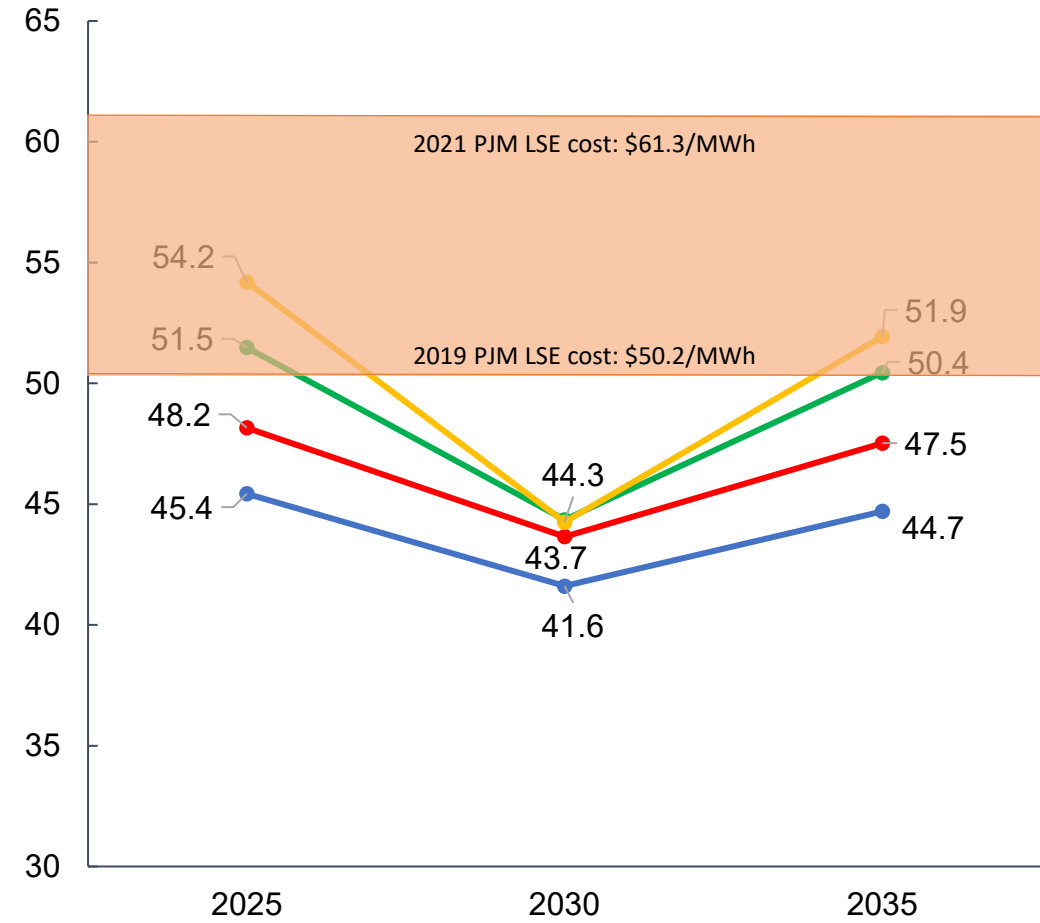
1. Adoption through Executive Order No. 315 of an **accelerated target of 100% clean energy by 2035...**
2. Adoption through Executive Order No. 316 of a **target to install zero-carbon-emission space heating and cooling systems in 400,000 homes and 20,000 commercial properties ...**
3. Initiation through Executive Order No. 317 of a process ... to plan for the Future of the Natural Gas Utility in New Jersey
4. Allocation of \$70 million ... toward **lowering consumer upfront costs for medium- and heavy-duty EV adoption**
5. Initiation of the stakeholdering process to **adopt Advanced Clean Cars II in New Jersey, which would require all new cars and light-duty truck sales to be zero-emission vehicles (ZEV) by 2035**
6. ... provide enhanced flood protection for homeowners, businesses, and infrastructure against increased flooding in riverine and coastal areas

# Thanks to the *Inflation Reduction Act*, the PJM region can now cut PJM CO<sub>2</sub> emissions 80-90% by 2035 while keeping electricity supply costs comparable to or lower than recent years

**PJM CO<sub>2</sub> emissions** (medium fuel cost, medium RE cost case)  
Million metric tons per year



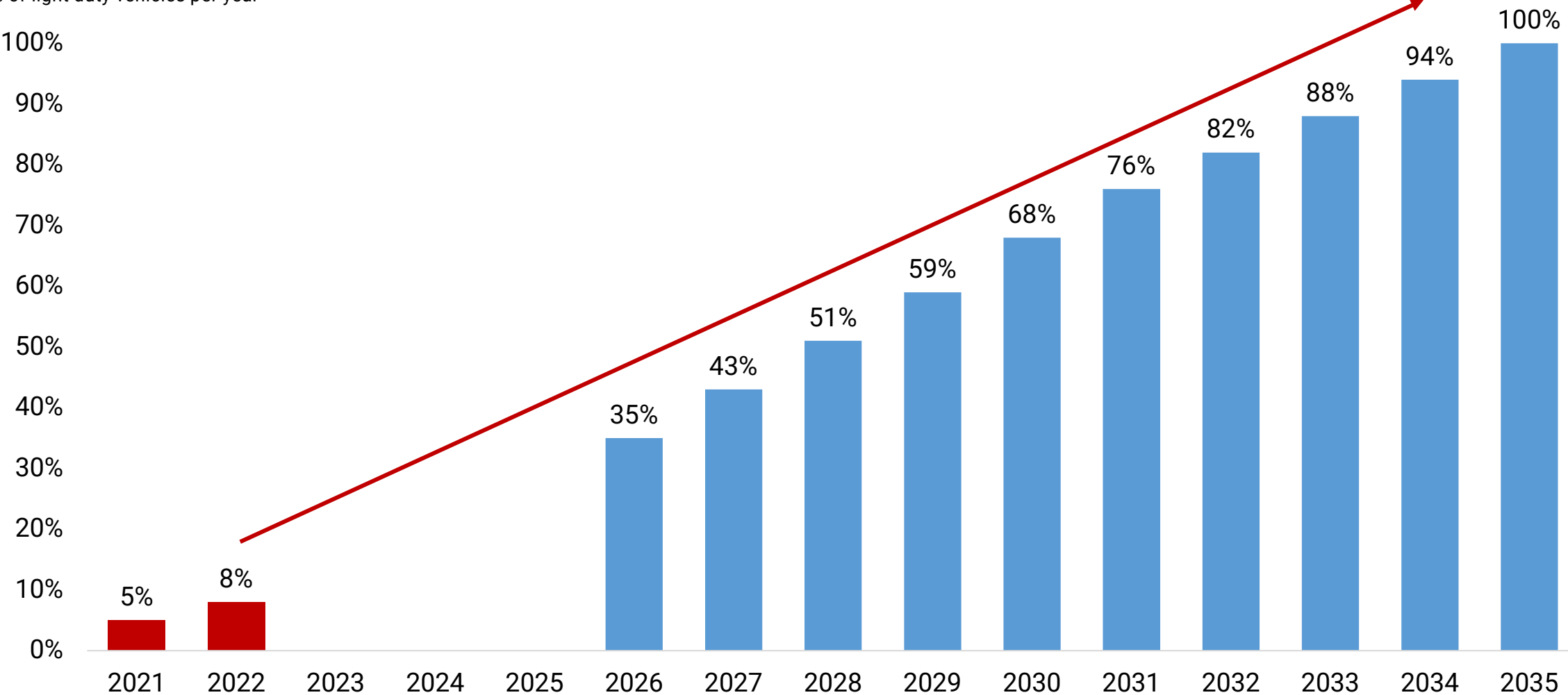
**PJM load-serving entity bulk supply cost** (medium fuel cost, medium RE cost case)  
2020 USD per MWh



# Going electric

## Historical New Jersey EV and PHEV light vehicle sales sales and Advanced Clean Cars II targets

% of light duty vehicles per year



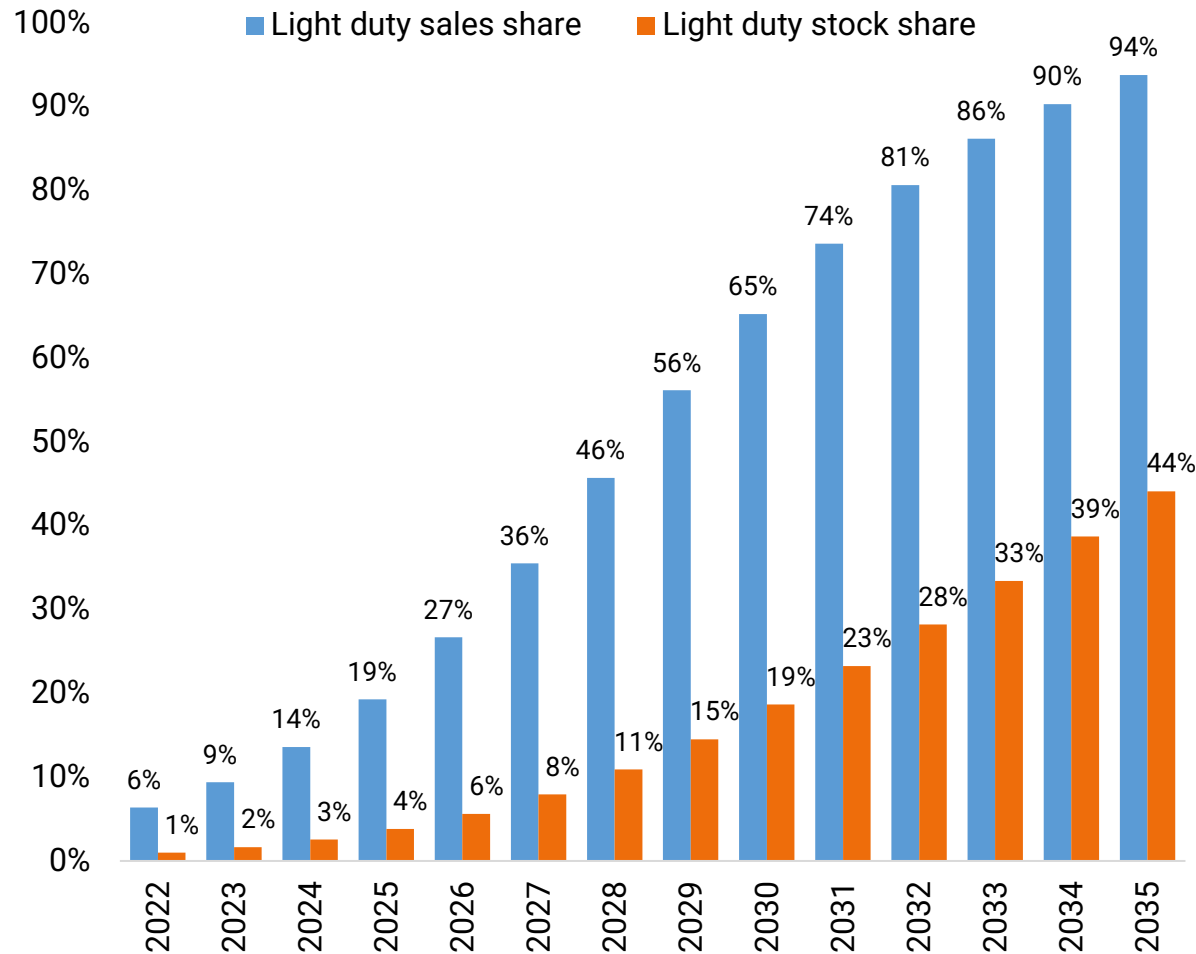
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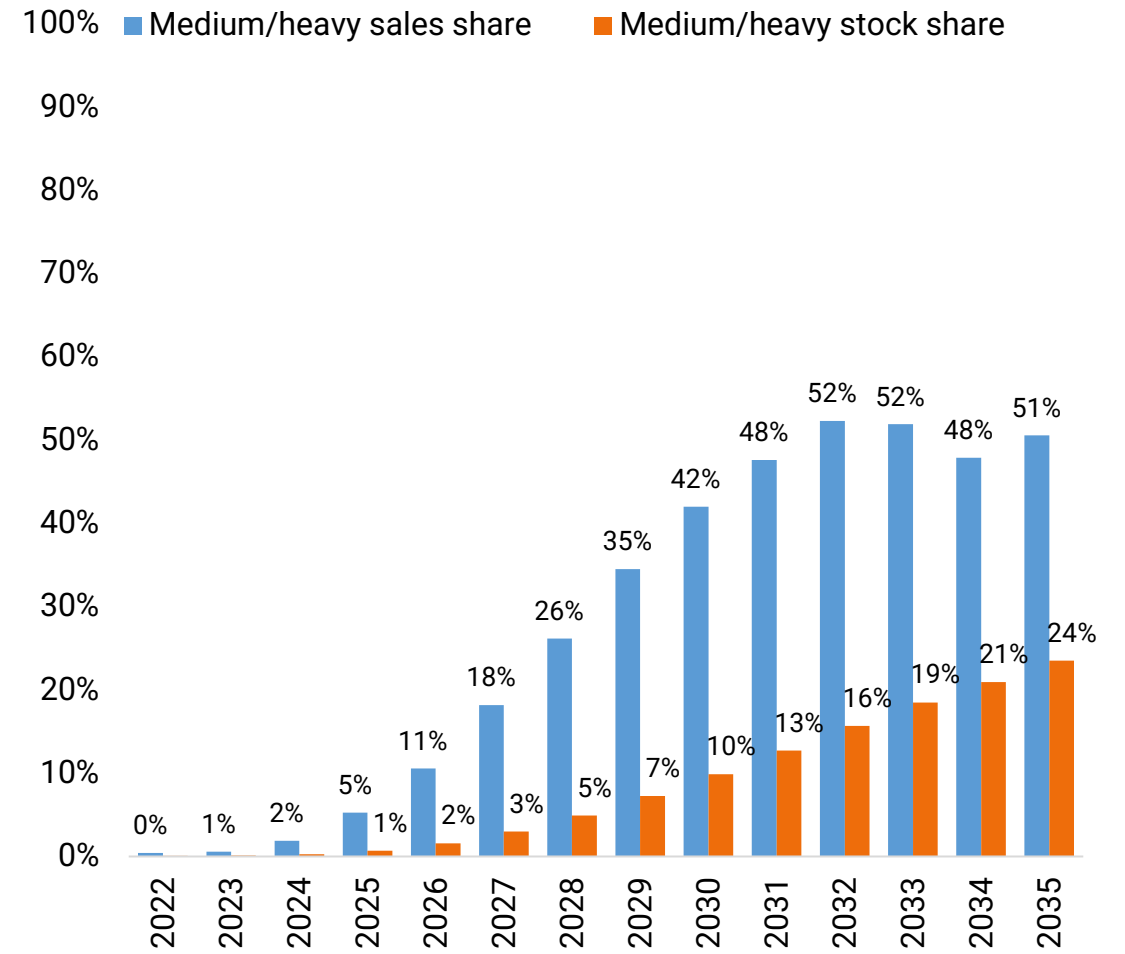
# We have time to prepare

## Modeled US EV and PHEV sales and stock shares

### Light duty vehicles



### Medium & heavy duty vehicles



# Unlocking charging flexibility

**US electric cars sold in 2022 averaged 291 miles range**

**That's 7 days of the average American's daily commute**

**An EV battery offers enormous flexibility to shift charging patterns to avoid stressing the grid...**

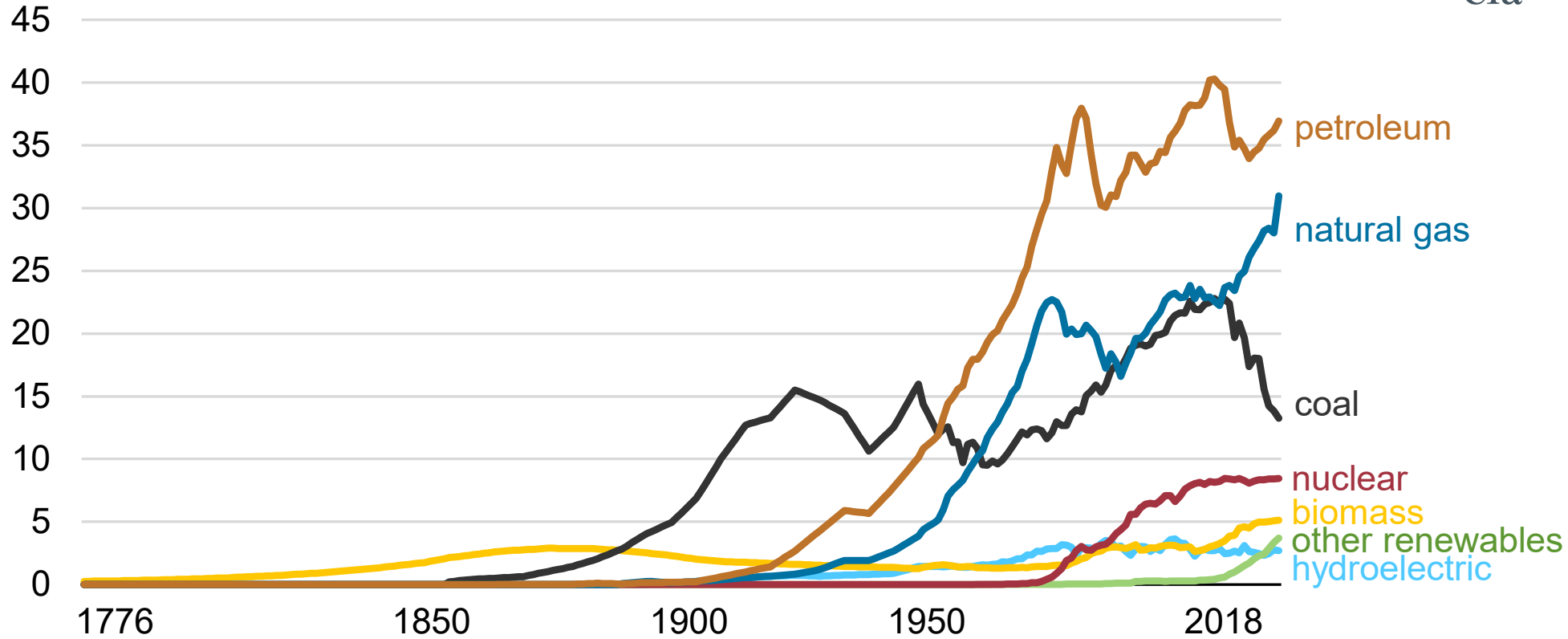
***...if properly incentivized.***

**Unlocking flexible EV charging and water heating could reduce NJ peak demand by 16% in 2040.**

# For all of U.S. history, petroleum and natural gas consumption has steadily risen (outside of recessions)...

Energy consumption in the United States (1776-2018)

quadrillion British thermal units

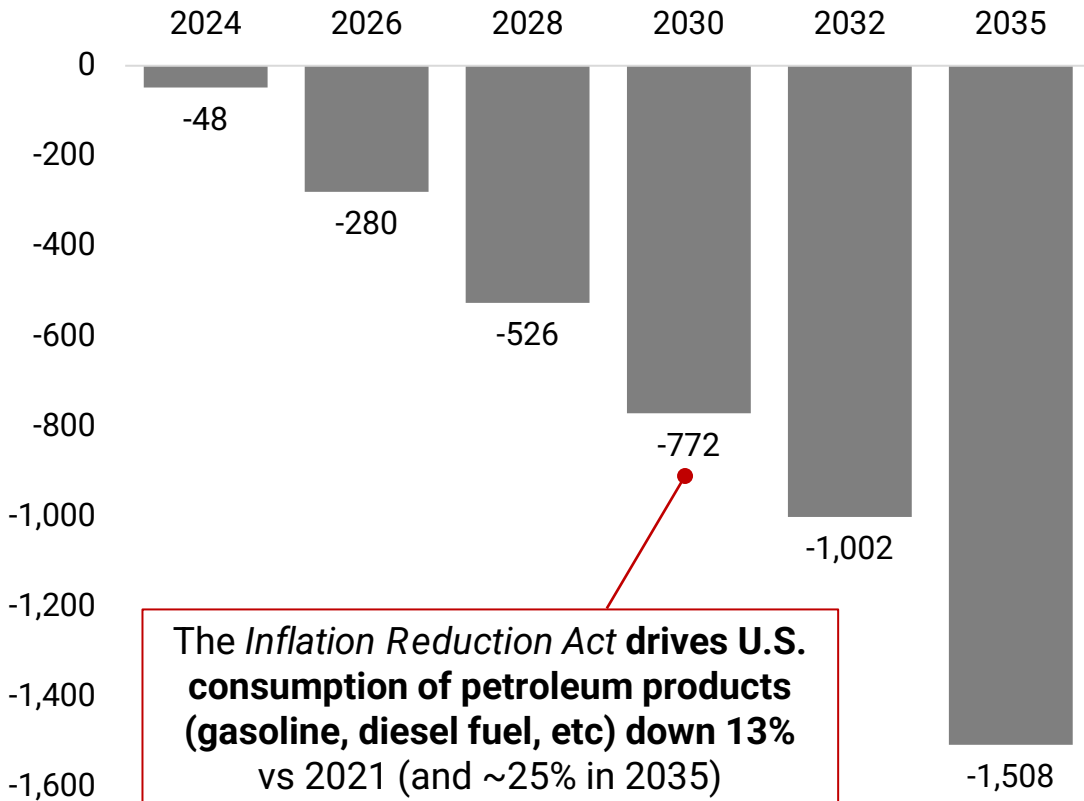


**Changes in Annual U.S. Petroleum Product and Natural Gas Consumption vs No IRA Case (Including Bipartisan Infrastructure Law)**

*Inflation Reduction Act*

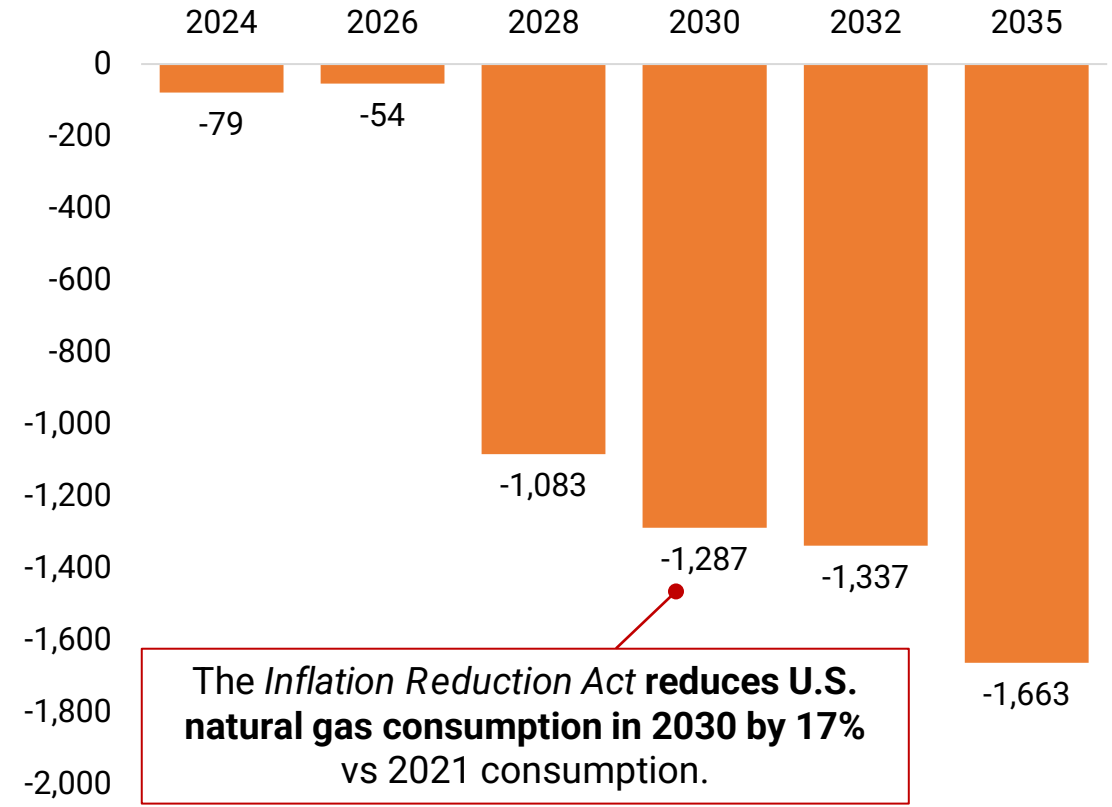
**Petroleum Products**

million barrels per year (mmbbl/y)



**Natural Gas**

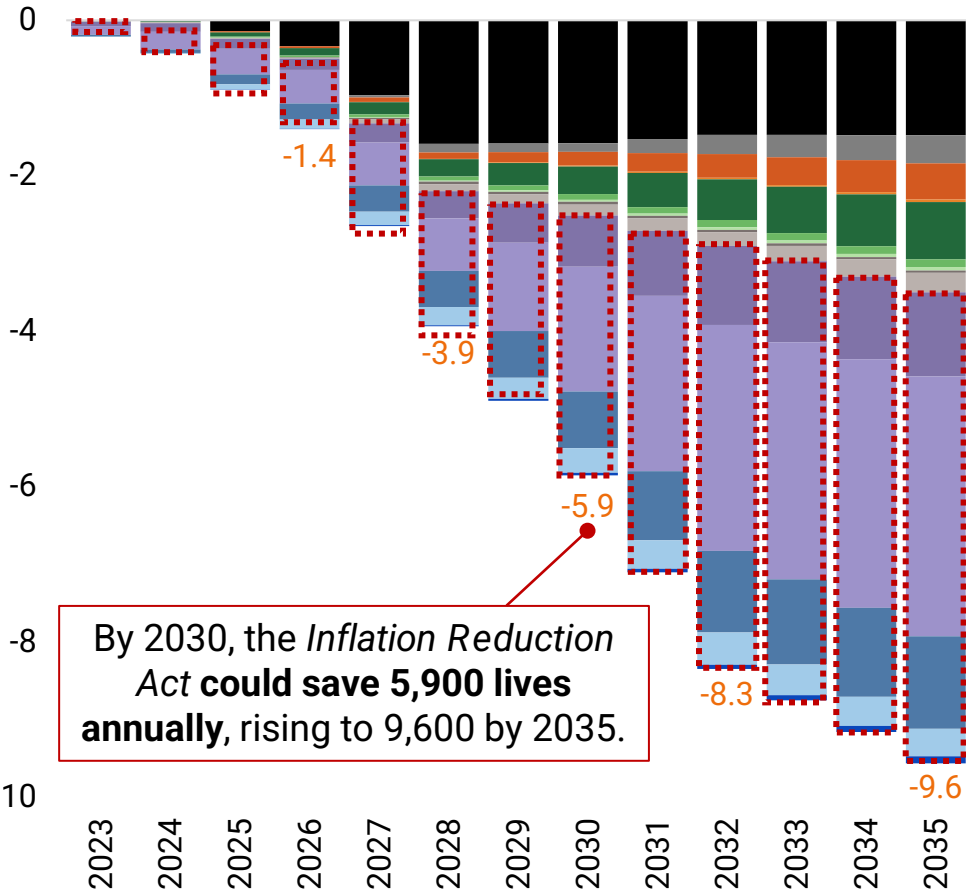
billion cubic feet per year (bcf/y)



### Annual Avoided Premature Deaths From Exposure to Fine Particulate Matter From Energy Activities vs No IRA Case (Including Bipartisan Infrastructure Law)

Thousands

*Inflation Reduction Act*

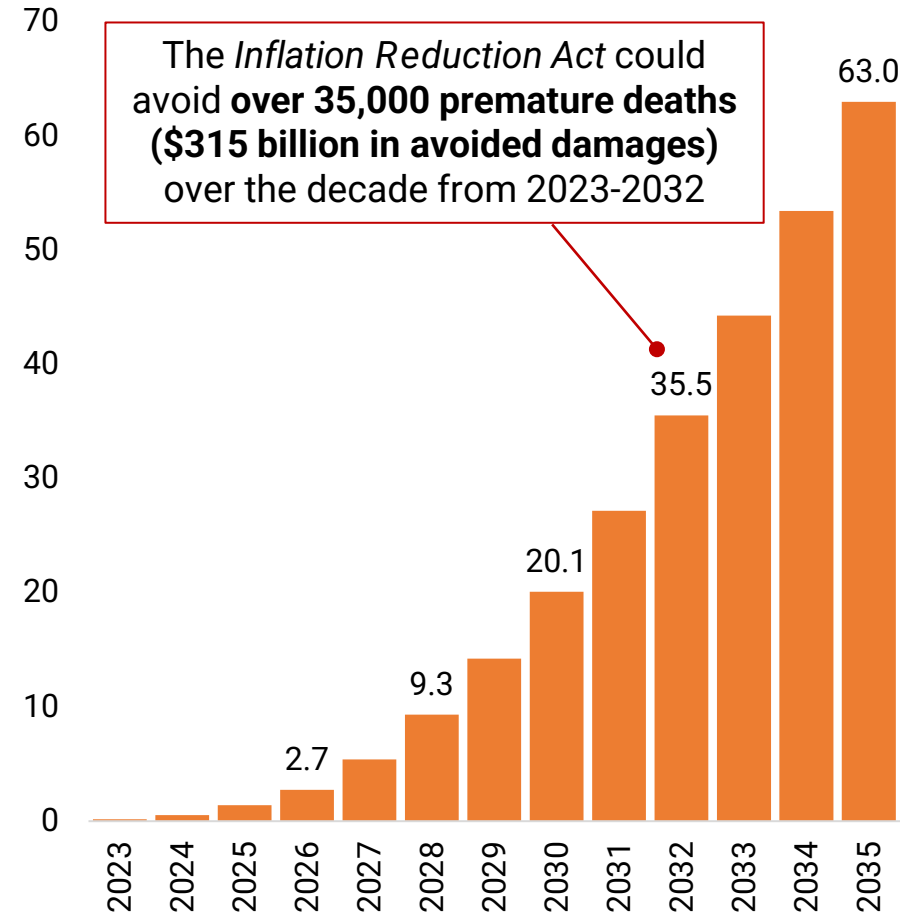


- electric generation - coal
- electric generation - gas
- commercial & institutional - coal
- commercial & institutional - gas
- commercial & institutional - oil
- commercial & institutional - other
- residential - gas
- residential - oil
- residential - other
- coal mining
- oil and gas production<sup>1</sup>
- light duty autos
- light duty trucks
- medium duty trucks
- heavy duty trucks
- buses

<sup>1</sup> – Mortalities from exposure to PM 2.5 pollution from oil and gas production is estimated based on the average of production under the High and Low Oil & Gas Production scenarios (see p. 13).

### Cumulative Avoided Premature Deaths vs No IRA Case (Including Bipartisan Infrastructure Law)

Thousands



The *Inflation Reduction Act* could avoid over 35,000 premature deaths (\$315 billion in avoided damages) over the decade from 2023-2032



The new challenge: how *fast* can we scale??





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EVOLVED  
ENERGY  
RESEARCH

[repeatproject.org](https://repeatproject.org)