



RFF Policy Boot Camp: A Policymaker's Toolkit for a Low Carbon Future

Kevin Rennert, Fellow and Director, Social Cost of Carbon Initiative

JANUARY 17, 2020



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*“to improve
environmental, energy, and
natural resource decisions
through impartial
economic research and
policy engagement”*

OUR VISION

*“committed to being the
most widely trusted source
of research insights and
policy solutions leading to a
healthy environment and a
thriving economy”*

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Motivation: The Need for “Deep Decarbonization”

Global total net CO₂ emissions

Billion tonnes of CO₂/yr

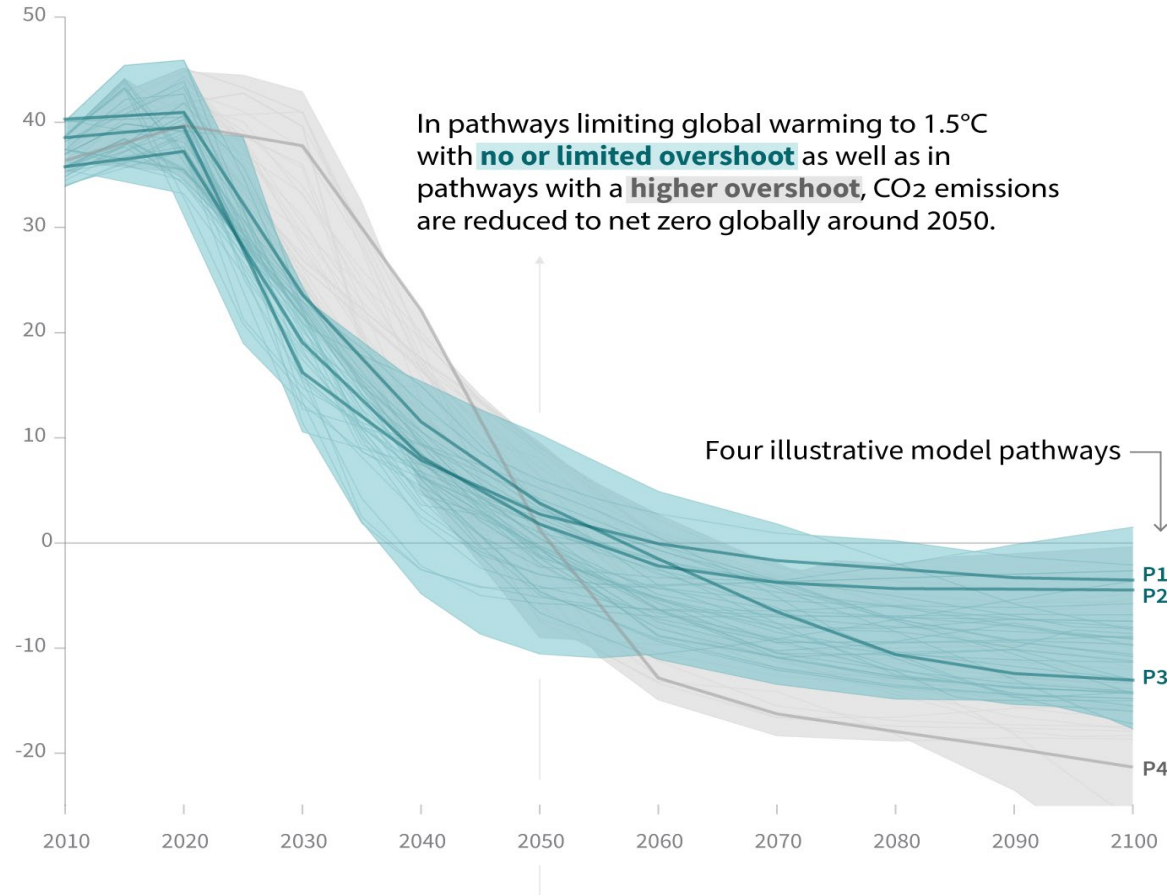


Figure 1: Pathways to limit global temperature to the Paris Agreement target of no more than 1.5 degree warming (Source: IPCC, Special Report: Global warming of 1.5 degrees C, 2018).



Motivation: Trends in Global & Domestic Emissions

Global Carbon Emissions increased by 2 percent in 2017.

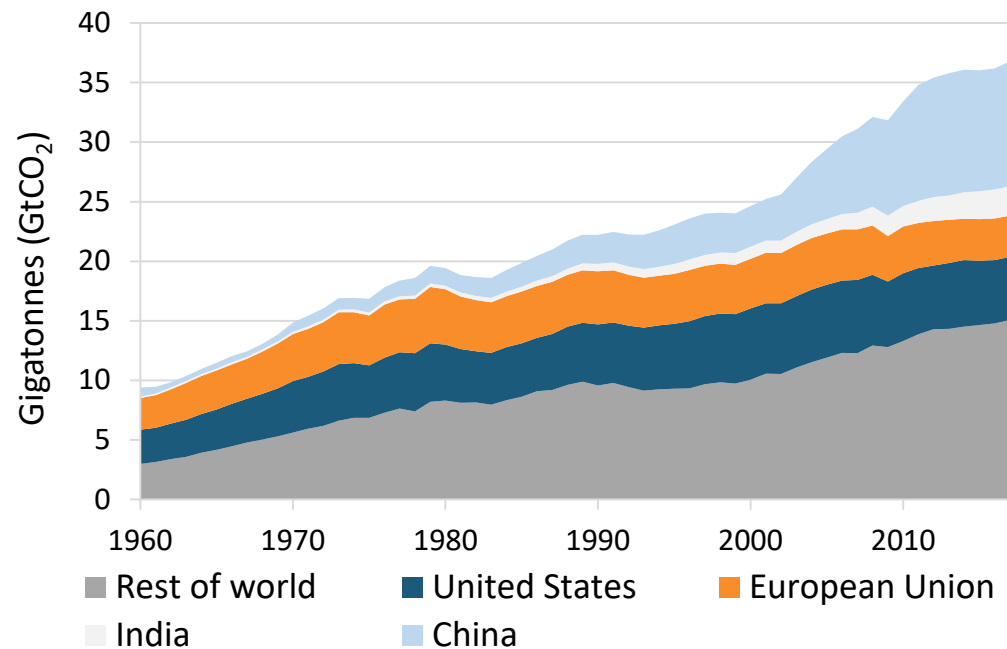


Figure 1. Annual CO₂ emissions from fossil fuels and industry by country.

U.S. Carbon Emissions declined by 14 percent since 2005.

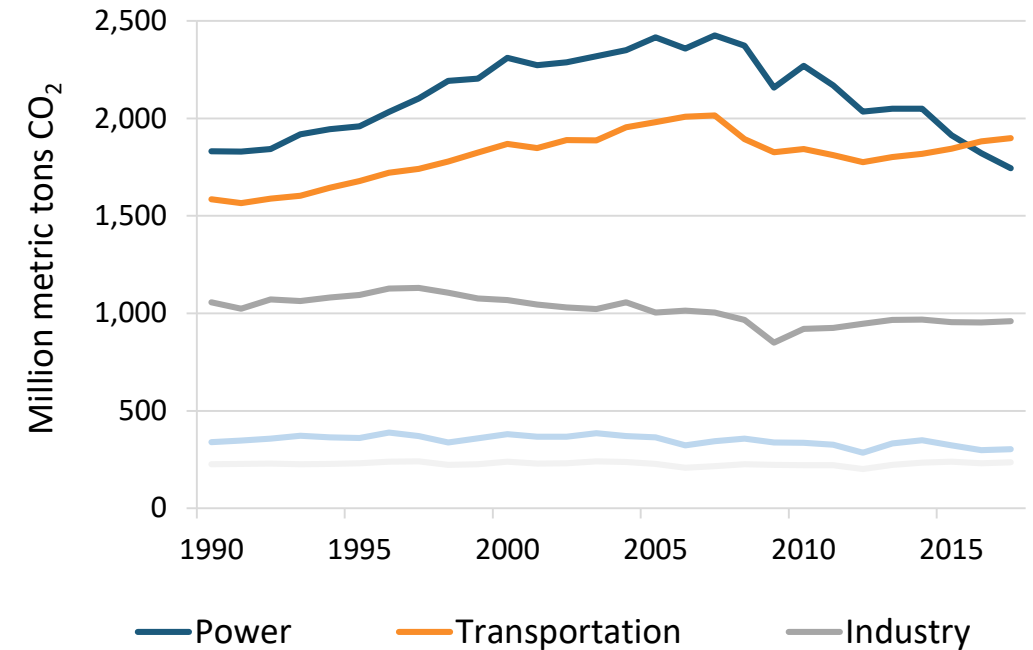


Figure 2. U.S. Energy Carbon Emissions by Sector

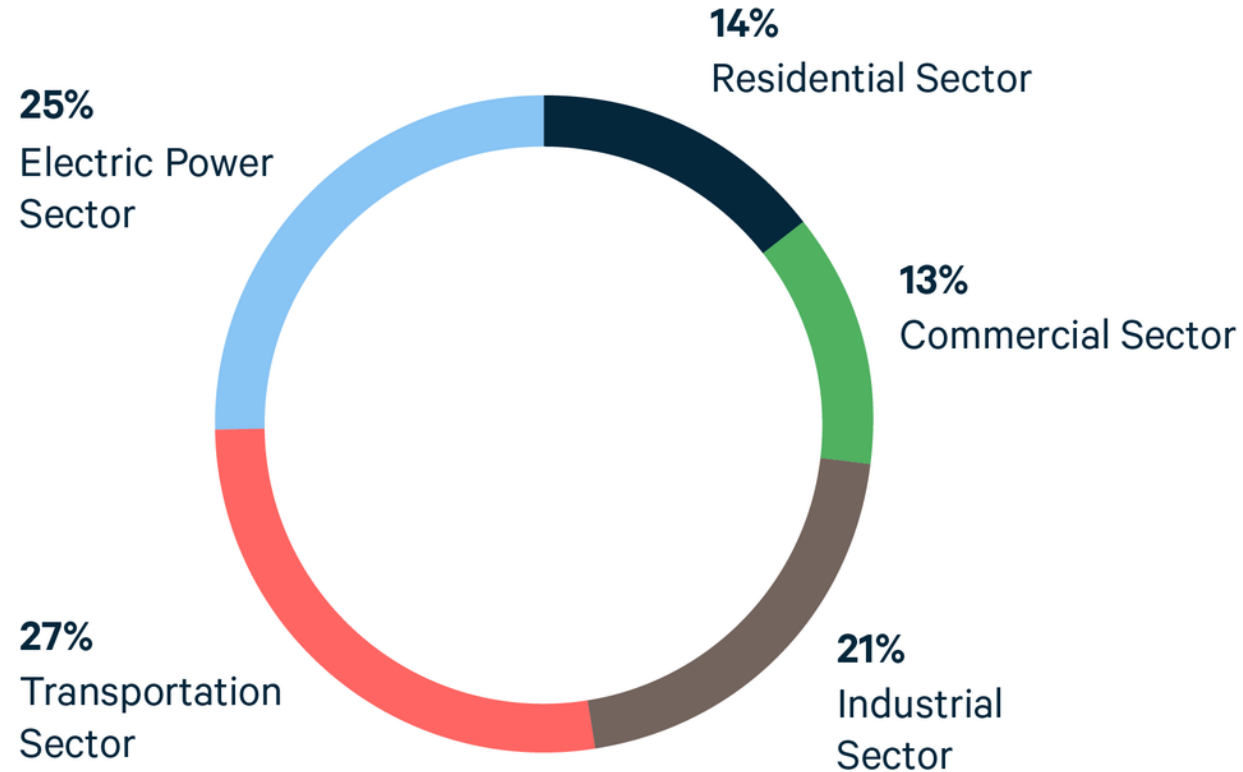


Motivation: Current activities on climate policy in 116th Congress

- Carbon pricing: 7 carbon tax bills, 1 cap and trade
- 2 Clean Energy Standards
- Tax credits (extension and reform)
- Innovation
- Geoengineering
- Backdrop of extensive Executive Branch activity and significant state action



Sources of Greenhouse Gas Emissions from the US Economy



*Source: US Energy Information Administration,
May 2019 Monthly Energy Review*



Evaluation of Climate Policy: Five Crucial Measures

1. Emissions Reductions
2. Cost
3. Equity
4. International Concerns
5. Technological Innovation



Policy approaches to Reduce Emissions from US Economy

Economy-Wide

- Carbon pricing: Implement economy-wide or sectoral **carbon tax** or **cap and trade**
- Comprehensive sector approach (Green New Deal, CLEAN Future Act)
- Clean Air Act: Emissions, vehicle standards

Sector-Specific

- Renewable or Clean Energy Standard
- Low Carbon Fuel Standard
- Intensity standards for industrial emissions

Technology Focus

- Increased funding for technology research in hard-to-decarbonize sectors
- Programs to address market barriers to private sector development and deployment of new clean energy technologies at scale



Schedule

- **9:00 a.m.–9:20 a.m., Morning Session 1**

Setting the Stage for a Low-Carbon Economy: What Policy Options Exist, and What Criteria Should Policymakers Consider?

Kevin Rennert, RFF Fellow

- **9:20 a.m.–10:00 a.m., Morning Session 2**

Economy-Wide Policies: Carbon Pricing, A Green New Deal, and More

Marc Hafstead, RFF Fellow

- **10:00 a.m.–10:40 a.m., Morning Session 3**

Power Sector Policies: Clean Energy Standards, Renewable Portfolio Standards, Grid Reforms

Karen Palmer, RFF Senior Fellow

- **10:40 a.m.–10:55 a.m., Break**



Schedule

- **10:55 a.m.–11:35 a.m., Morning Session 4**

Transportation Sector Policies: Tailpipe Standards, Fleet Electrification, Other Alternative Fuels and Travel Modes

Joshua Linn, RFF Senior Fellow

- **11:35 a.m.–12:15 p.m., Morning Session 5**

Spurring Innovation: Policy Options to Drive New Low-Carbon Technology Development and Deployment

David Hart, Information Technology and Innovation Foundation

- **12:15 p.m.–12:30 p.m., Lunch Served**

- **12:30 p.m.–1:30 p.m., Lunch Session**

Policies to Decarbonize Other Sectors of the US Economy: Reflections Across All Sectors

Leslie Jones, College of the Atlantic Research Fellow; Dallas Burtraw, RFF Senior Fellow;



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Economy-Wide Options for Reducing Greenhouse Gas Emissions

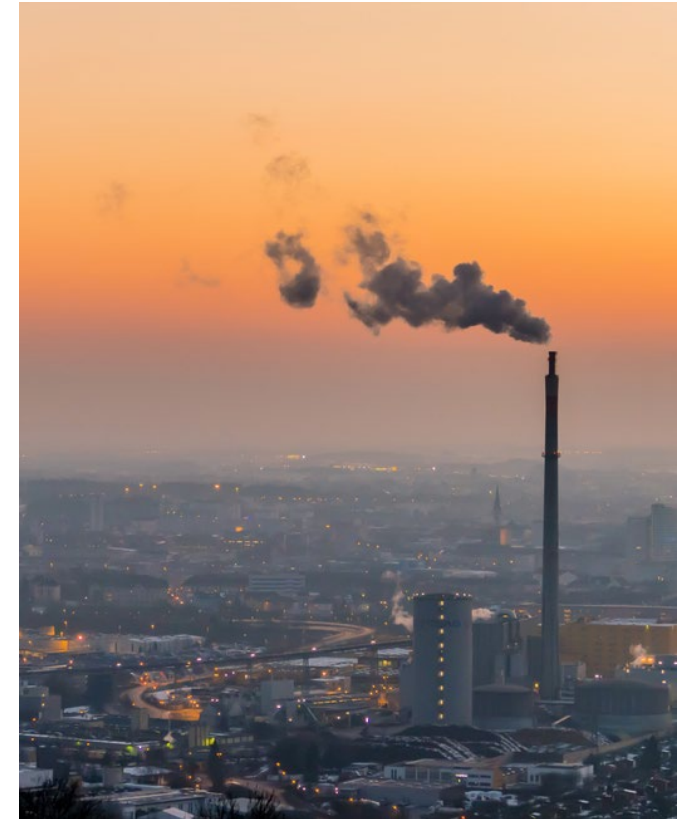
Marc Hafstead

JANUARY 17, 2020



Economy-Wide Options to Reduce GHG Emissions

- Carbon Pricing
 - Carbon Tax
 - Cap and Trade
- Comprehensive Sector-by-Sector Approach
 - Green New Deal
 - Energy and Commerce Committee framework: the Climate Leadership and Environmental Action for our Nation's (CLEAN) Future Act



Carbon Pricing Options

- Carbon Tax
 - A tax imposed on fossil fuels based on their carbon content
 - CO₂ emissions from combustion are proportional to carbon content
- Cap-and-Trade Programs
 - A limit (“cap”) on the total amount of CO₂ that can be emitted by covered facilities
 - Government issues allowances: “the right to emit one ton of CO₂”
 - Sales and purchases of allowances yields a **market price** for a ton of CO₂ emissions



Carbon Tax vs. Cap and Trade

Traditional view:

- A carbon tax provides **price certainty**
- A cap-and-trade program provides **quantity certainty**

Modern view includes hybrid approaches:

- Tax adjustment mechanisms can **automatically adjust tax rates if emissions miss projections**
- Cap-and-trade **price floors** and **price ceilings** restrict price volatility



Benefits of Carbon Pricing as a Tool for Climate Policy

- Flexibility
- Equal Marginal Costs of Abatement Across Sectors
- Encourages Conservation
- Creates Revenues



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2019 – The Year of the Carbon Pricing Proposal

- **Carbon Tax Proposals**

- Energy Innovation and Carbon Dividend Act (Ted Deutch and 58 cosponsors)
- American Opportunity Carbon Fee Act of 2019 (Sheldon Whitehouse, Brian Schatz, Martin Heinrich, Kirsten Gillibrand)
- Stemming Warming and Augmenting Pay Act (Francis Rooney, Dan Lipinski)
- Raise Wages, Cut Carbon Act (Dan Lipinski, Francis Rooney)
- Climate Action Rebate Act (Chris Coons)
- America Wins Act (John Larson)
- MARKET CHOICE Act (Brian Fitzpatrick, Salud Carbajal, Scott Peters, Francis Rooney)

- **Cap-and-Trade Proposals**

- Healthy Climate and Family Security Act (Chris Van Hollen)



RFF's Carbon Pricing Calculator

RFF employs sophisticated models of the economy to evaluate the effects of these bills in detail.

RFF's Carbon Pricing Calculator provides a web interface for easy exploration of the results and alternate policy options.

www.rff.org/CPC

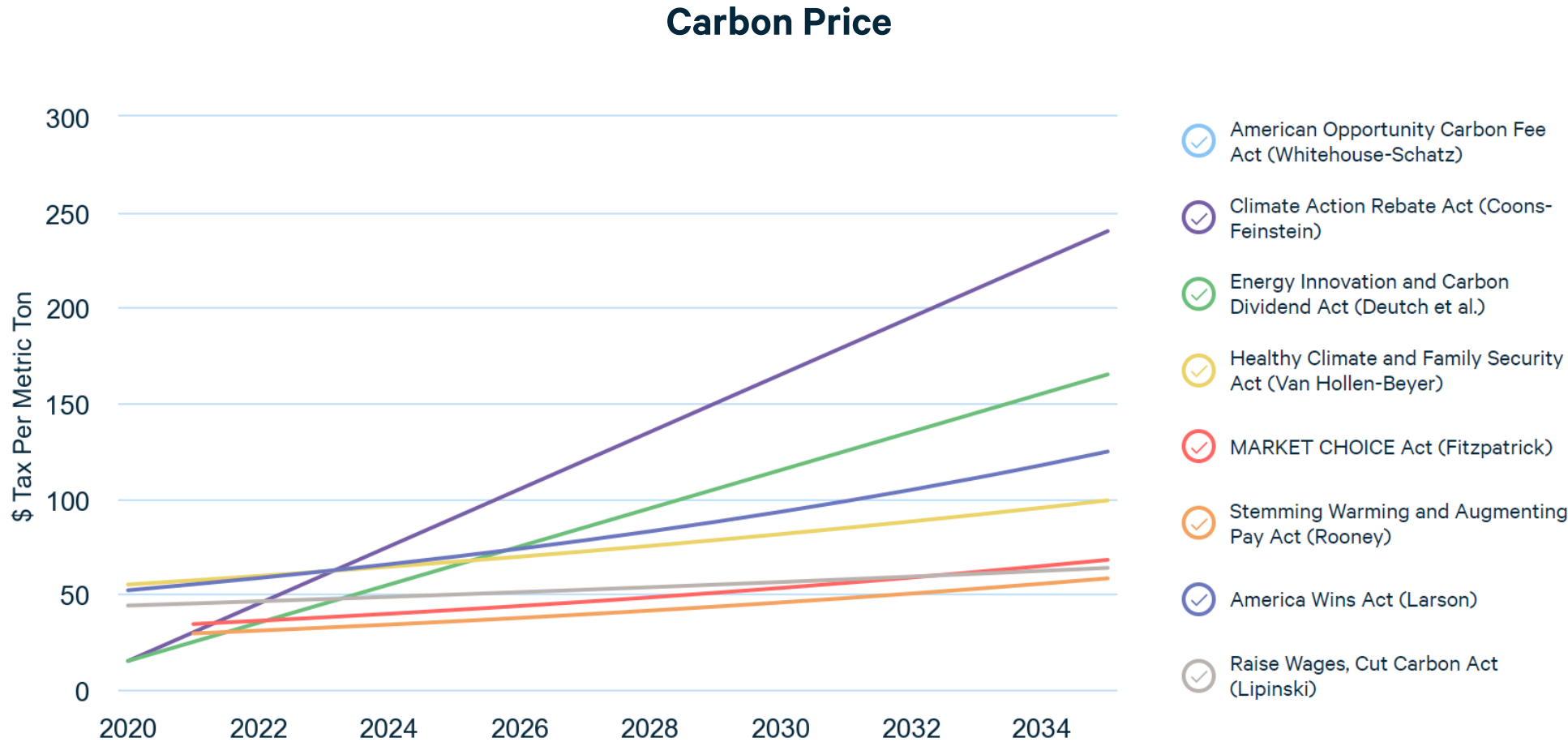


Critical Carbon Pricing Design Decisions

- Stringency
 - Initial price or level of emissions cap and changes in price/cap over time



Stringency depends on how the price changes over time

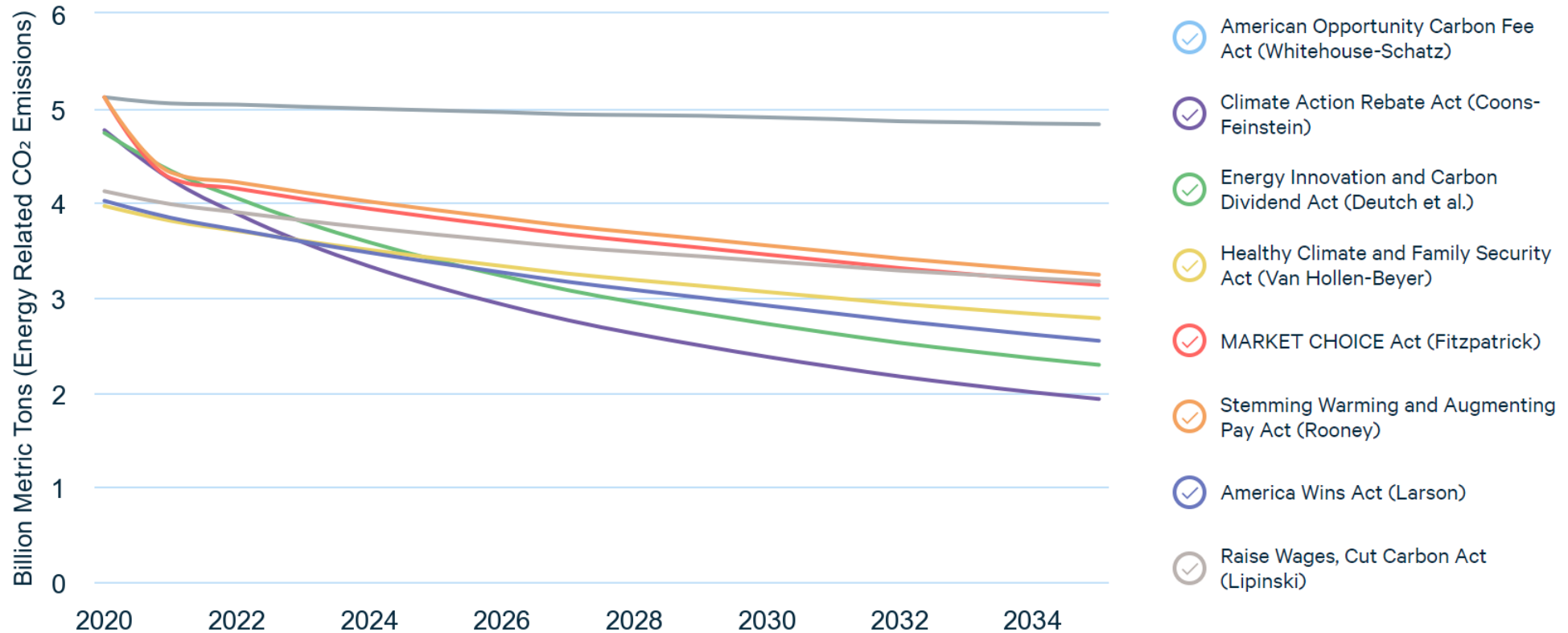


Source: Goulder-Hafstead E3 model



All else equal, higher prices lead to lower emissions

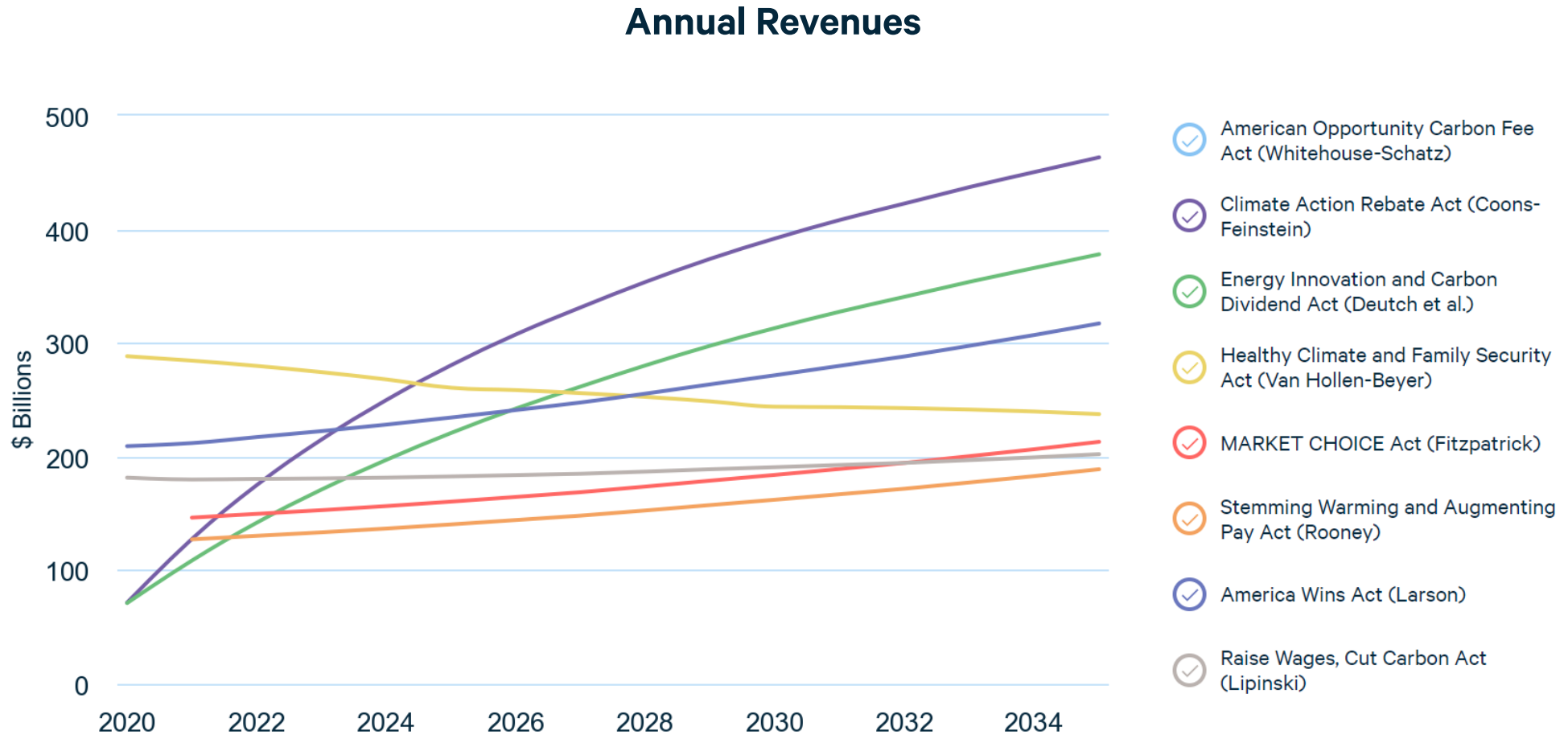
Energy-Related CO₂ Emissions



Source: Goulder-Hafstead E3 model



And higher prices lead to higher revenues



Source: Goulder-Hafstead E3 model

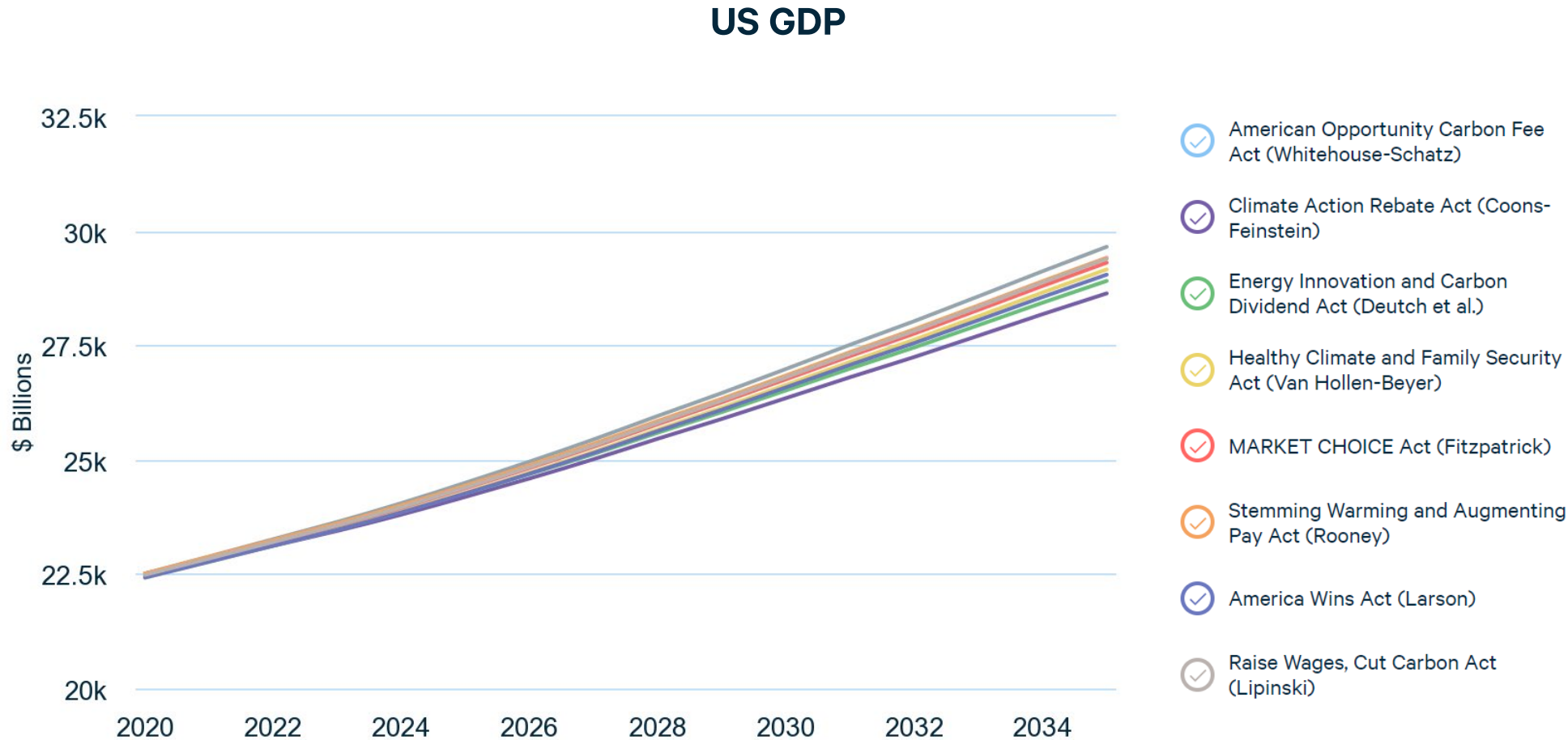


Critical Carbon Pricing Design Decisions

- Stringency
 - Initial price or level of emissions cap and changes in price/cap over time
- Revenue Use
 - Per-capita rebate
 - Tax swaps (payroll, personal or corporate income)
 - Deficit reduction / debt service



Projected effects on US economy as a whole are modest...



Source: Goulder-Hafstead E3 model



...but significantly depend on revenue use

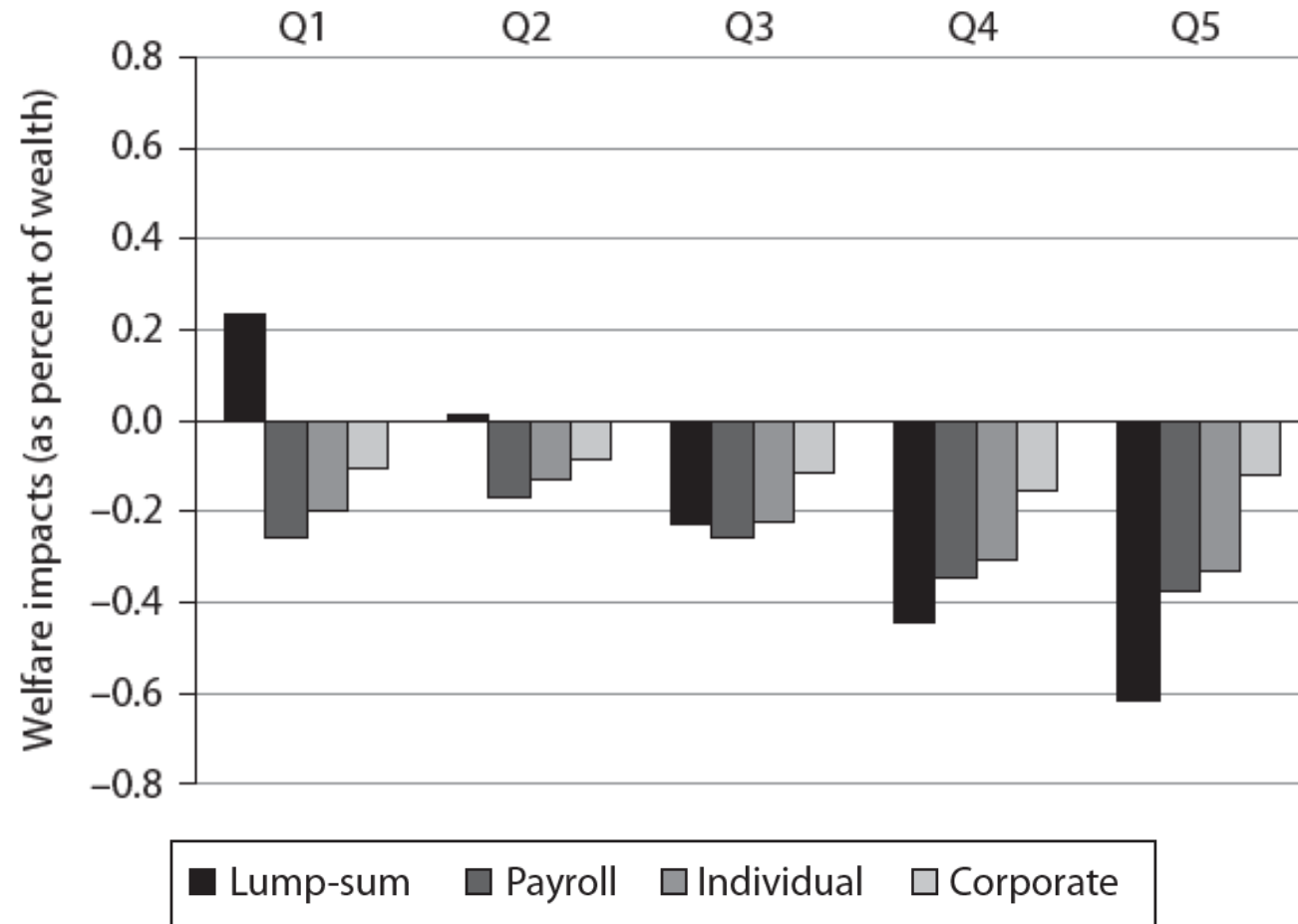
	Recycling Method			
	Lump-Sum Rebates	Cuts in Employee Payroll Taxes	Cuts in Individual Income Taxes	Cuts in Corporate Income Taxes
Welfare Costs	\$3,356.47 -0.41%	\$2,844.71 -0.35%	\$2,479.64 -0.30%	\$1,068.60 -0.13%
Climate Benefits				
• Average, 3% Discount Rate	\$5,678.74	\$5,663.85	\$5,646.42	\$5,453.86
Co-Benefit Estimates				
• Energy Security Premium	\$79.31	\$78.60	\$79.53	\$104.76
• Local Pollution Benefits	\$8,454.59	\$8,240.89	\$8,091.67	\$7,032.97
Total Benefits	\$14,212.65	\$13,983.34	\$13,817.62	\$12,591.59

Source: *Confronting the Climate Challenge: US Policy Options*; Table 5.10



Impacts across households also depend on revenue use

Overall Welfare Impacts of Carbon Tax by Quintile



Critical Carbon Pricing Design Decisions

- Stringency
 - Initial price or level of emissions cap and changes in price/cap over time
- Revenue Use
- Coverage
- Point of Regulation
- Other
 - Options to mitigate price/quantity uncertainty
 - Border tax adjustments



Carbon Pricing: Key Takeaways

- Carbon pricing is favored by economists for its cost-efficiency among other key attributes.
- Appropriately designed federal-level climate policies produce significant net benefits.
 - Costs depend on nature of revenue-recycling
 - Non-climate benefits may exceed climate benefits
- Costs are not evenly distributed across industries, household, and states
 - Adverse impacts on industry and households can be addressed through revenue use, with little additional aggregate economic costs.



Comprehensive, sector-by-sector approach:

Green New Deal Resolution

- Introduced by Rep. Ocasio-Cortez and Sen. Markey
- Sets goals for net-zero US economy
- Envisions 10-year mobilization to (among other activities) reduce emissions across all sectors and build climate resilience
- Does not prescribe specific policy approaches, but emphasizes role of federal investment.



Comprehensive, sector-by-sector approach:

CLEAN Future Act

- Outline released by House Energy and Commerce Majority
- Sets national goal for net-zero US economy by 2050
- Multiple policy approaches taken to address sector-specific emissions
 - Agencies directed to put US on path to net-zero target
 - Sector specific policies (e.g. Clean Energy Standard, GHG emissions standards for transportation, programs to promote industrial decarbonization)
 - States required to submit plans to reach net zero by 2050



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Climate and Electricity

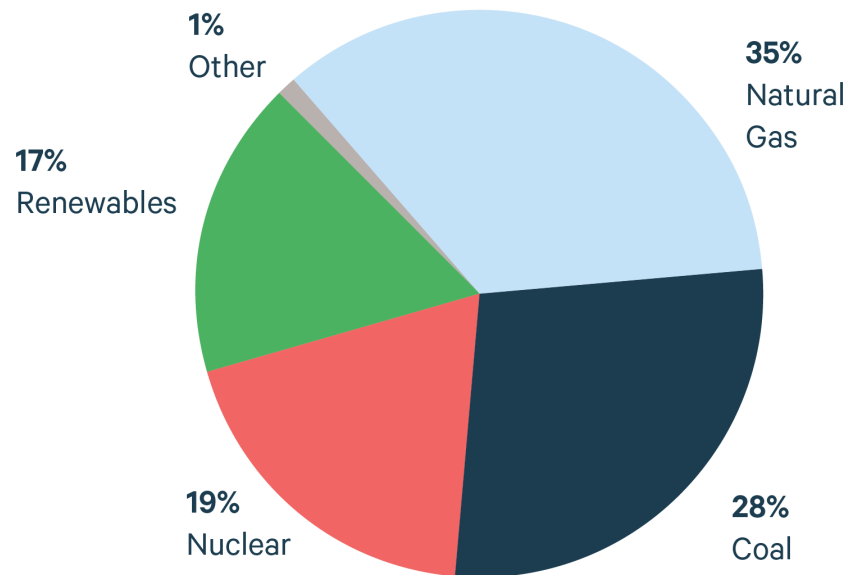
Karen Palmer, Senior Fellow

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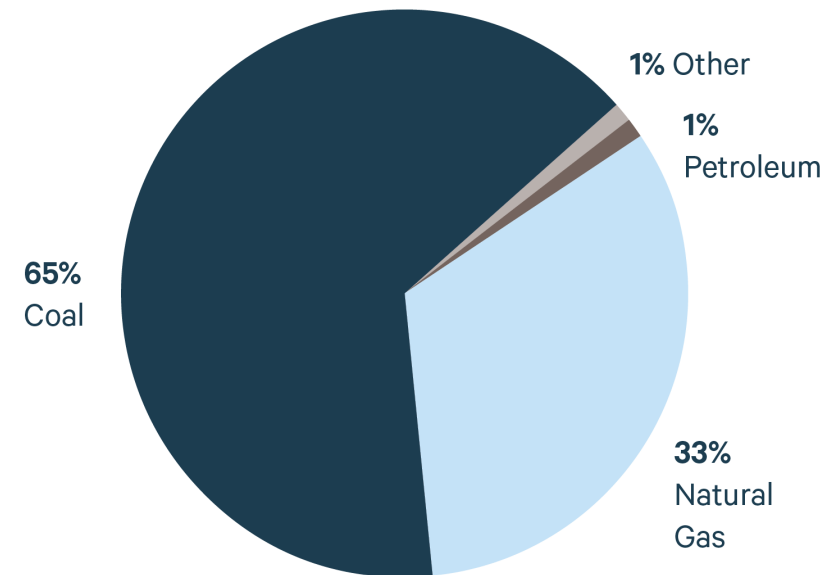


Current State: Electricity Generation and Emissions by Fuel Type

US Electricity Generation (billion kWh)
Breakdown by Fuel (2018)



US Carbon Dioxide Emissions (million
metric tons) from Electricity (2018)

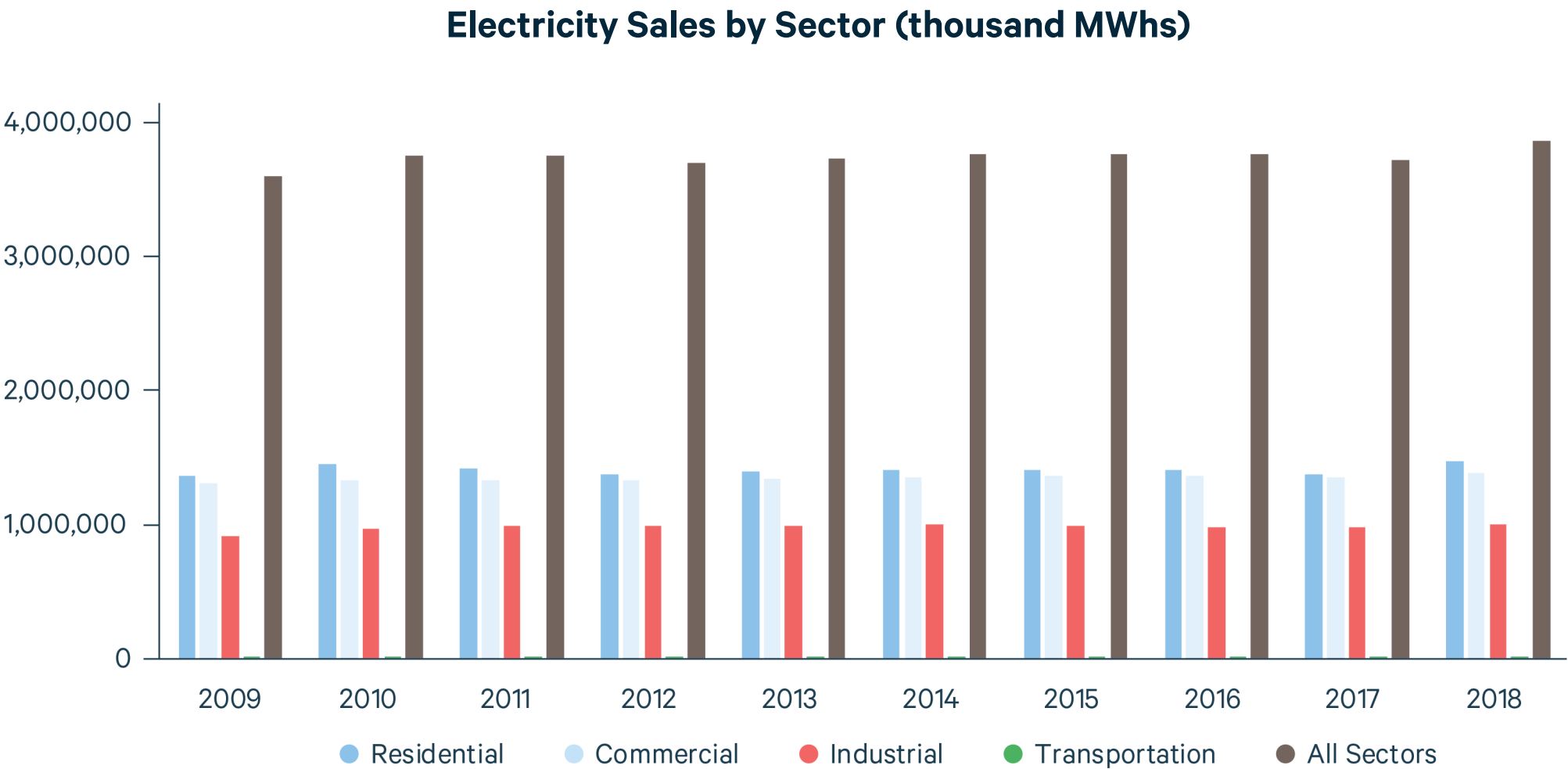


Source: EIA (2018)

Electricity Generation Accounts for **28%** of total US Greenhouse Gas Emissions

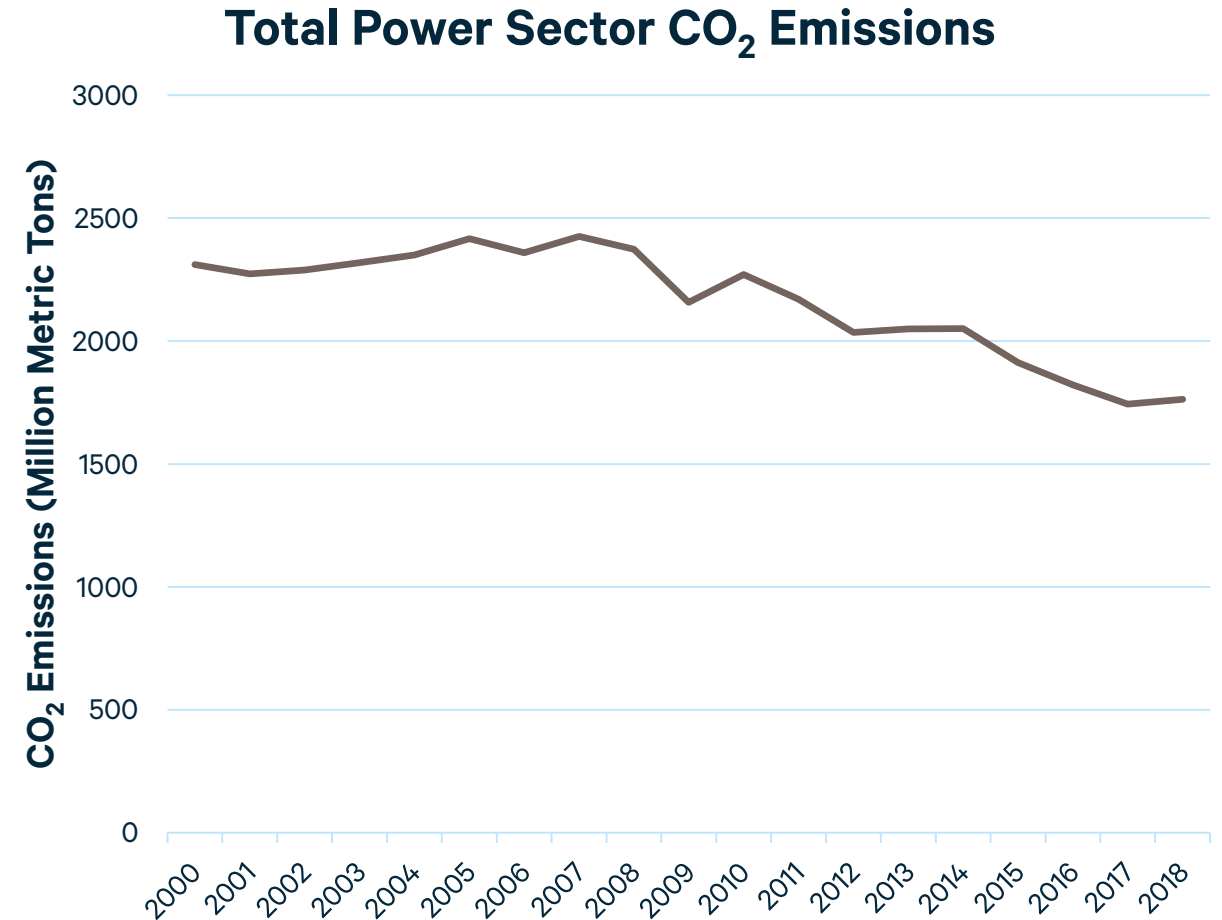


Current State: Electricity Sales Have Been Relatively Constant over Time



Current State: Emissions from Electricity Generation are Falling

- Contributing factors:
 - Cleaner, cheaper-natural gas driving out coal
 - State and federal policies (cap and trade, renewable requirements, and tax incentives)
 - Falling costs for renewables
- Additional policies are necessary to achieve carbon neutrality by 2050



Options for Reducing Emissions from Electricity

Use cleaner fuels

- Build more renewables (solar, wind, etc)
- Prevent existing nuclear plants from retiring (or build more)
- Fuel switch from coal to lower-emitting natural gas

Improve energy efficiency

- **Demand-Side:** Improve the energy efficiency of end-use technologies (lighting, appliances, etc.)
- **Supply-Side:** Improve fossil generator efficiency (as assumed in EPA's ACE rule)

Capture carbon directly

- Retrofit fossil plants with carbon capture and storage (CCS) or require new builds to have CCS



Policy Options for Reducing Emissions from Electricity:

Change relative prices of energy based on emissions

Carbon Pricing

- Implement economy-wide or sectoral **carbon tax** or **cap and trade**
(Increases cost of energy from emitting sources.)

Clean Energy Standard

- Require increasing amounts of “clean” electricity using a tradeable credit mechanism
(Decreases cost of lower-emitting sources)

Federal Tax Incentives

- Extend or expand existing clean energy tax credits (PTC, ITC)
(Decreases cost of lower-emitting sources)
- Repeal tax incentives for fossil fuels
(Increases cost of emitting sources)



What is a Clean Energy Standard (CES)?



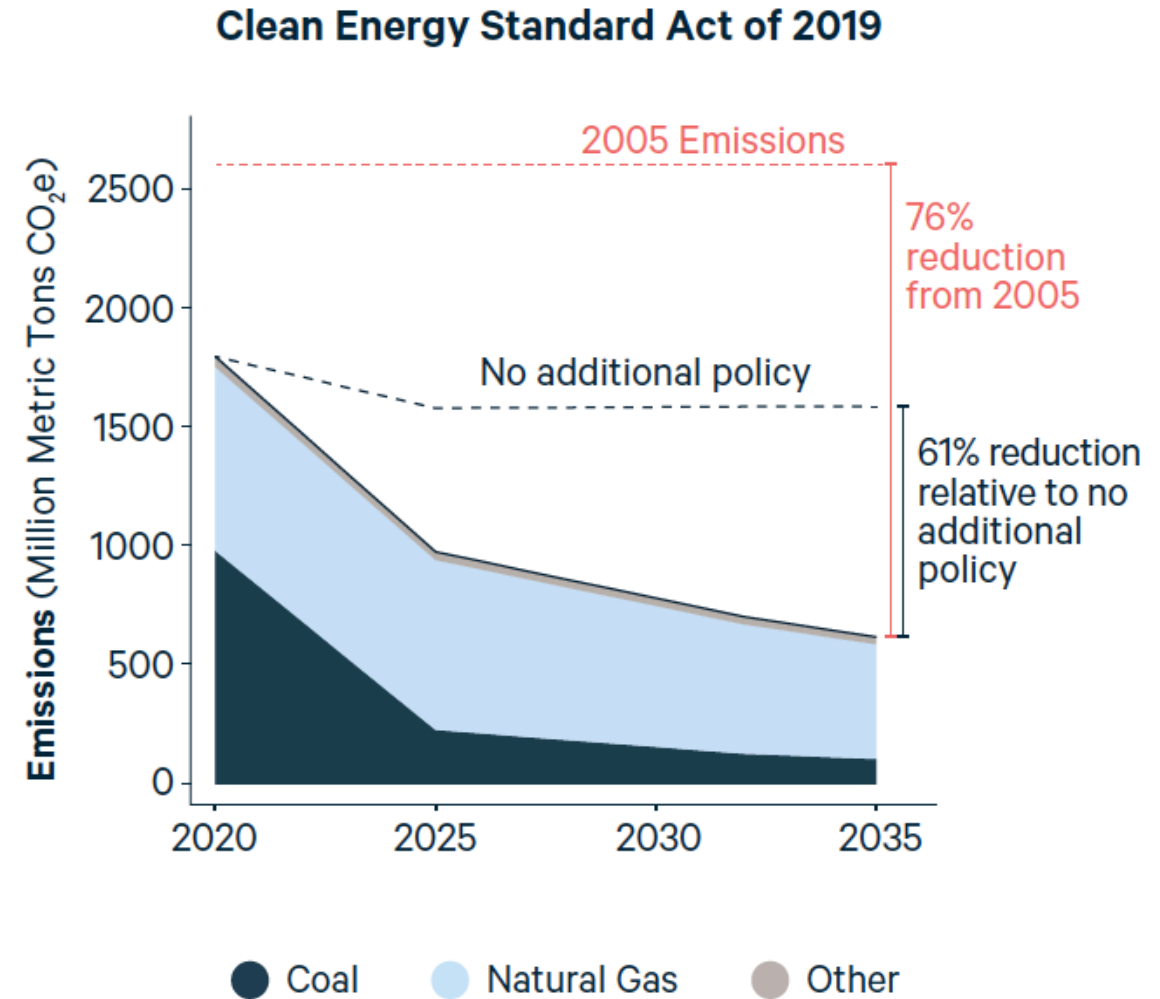
- A power sector-only policy like a traditional renewable portfolio standard (RPS)
- A percentage of electricity sales must come from “clean” energy sources (accounted for with “clean energy credits”)
- Clean energy credits awarded to qualifying generators for electricity they produce
- Clean energy credits are tradable in a national market
- Requirement grows over time, encouraging a transition to cleaner generation

CES policies have drawn support from a broad array of stakeholders, including labor, utilities, and environmental advocates.



A CES could yield large emissions reductions at low cost

- A CES can yield significant emissions reductions.
- The broader set of technologies included in a CES allows for greater flexibility, lower costs than a similarly decarbonizing RPS.
- Depending on its design, the economic efficiency of certain CESs can approach that of carbon pricing.
- *CESA 2019* is projected to reduce emissions 61%, increase nationally averaged retail electricity costs by 4% in 2035.



Federal Tax Incentives

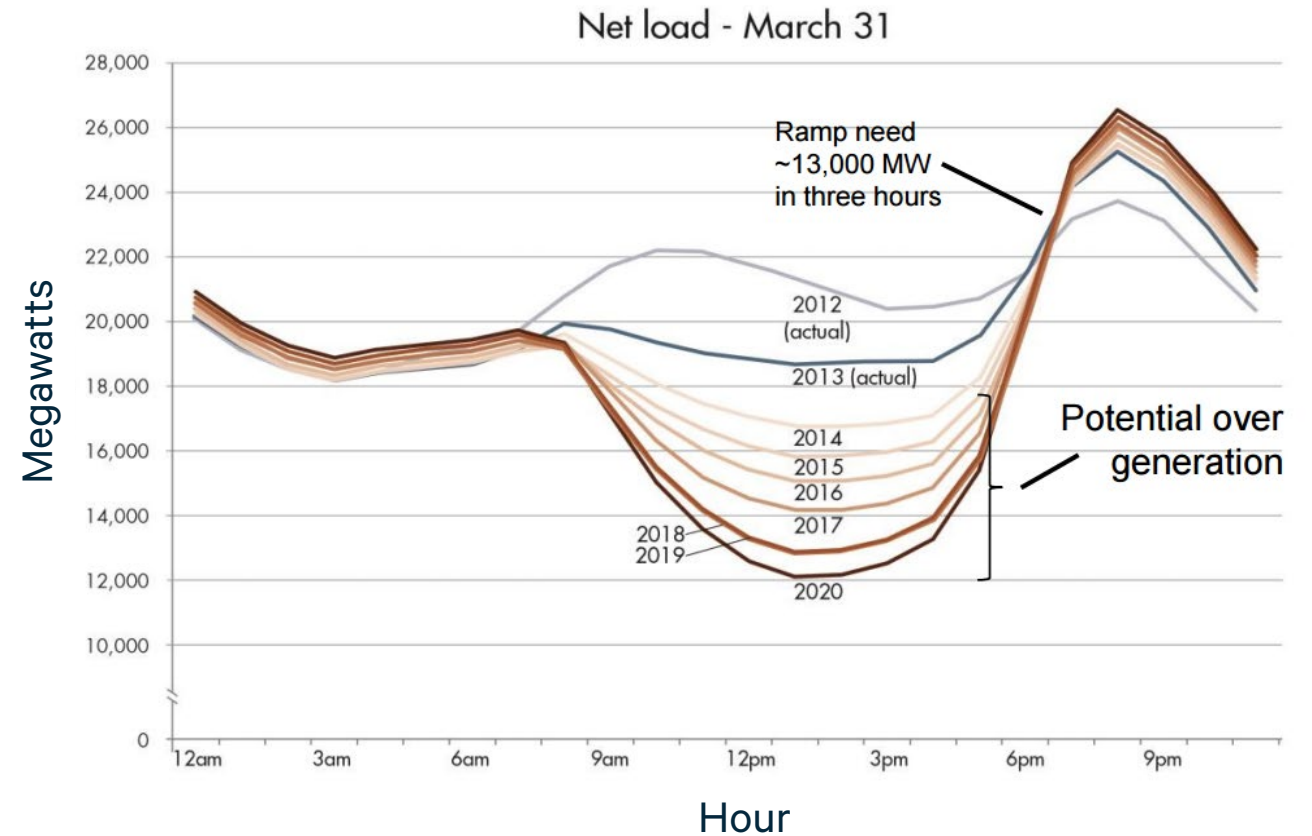
- Currently >40 different energy tax incentives, many of them technology specific and temporary, requiring periodic renewal.
- Examples for clean electricity:
 - Production Tax Credit (PTC) for producing renewable electricity (Section 45)
 - Investment Tax Credit (ITC) for building renewable facilities (Section 48)
 - Tax credit for sequestering CO₂ (Section 45Q)
- Tax incentives have been effective but far less efficient at driving emission reductions than carbon pricing or a CES.
- Proposals have been offered to replace the suite of tax incentives with a technology-neutral, emissions-based set of incentives.



Challenges and Solutions for Integrating Renewables

- Renewables are **intermittent**
- Energy storage can help accommodate fluctuations in renewable energy production and smooth out the “duck curve”
- Energy storage can also reduce curtailment of renewables and overall emissions of the electricity sector if paired with clean energy
- Storing energy long-term faces technical challenges

Demand in Excess of Solar Generation



Other Solutions for Integrating Renewables

More ways to address intermittency:

- Building or expanding transmission lines to connect regions with diverse renewable resources
- Bringing electricity demand to meet supply by shifting load **in time**

Market solutions:

- **Retail time-varying prices** to shift demand to periods of abundant renewables and low prices
- **Wholesale market design** that rewards demand-side resources, energy storage, and resources that can respond quickly to fluctuation in production



Electrification as a Solution

- Electrification of transportation and buildings can reduce emissions in these sectors
- Resulting electricity demand is **flexible** and can be shifted (through incentives, software, or both) to periods of high renewables generation
 - Example: Charging EVs during the sunniest parts of the day
- As the grid gets cleaner, electrification reduces emissions further and benefits the grid more
- While electrification could increase demand for electricity significantly (as much as 40% by 2050), it can also be a grid solution



Conclusions

- New policies are needed to decarbonize electricity generation to meet 2050 economy-wide goals
- Policies that change relative prices of energy based on emissions are low-cost approaches
 - These include carbon pricing, clean energy standards and tax incentives
- Renewables will play a big role in the clean energy transition, and their integration will require additional policy support.
- Electrification can help with renewables integration and can reduce emissions from fossil fuel use in transport, buildings and industry.



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Challenges and Policy Opportunities in the Transportation Sector

Joshua Linn, Senior Fellow

JANUARY 17, 2020



Overview

The US transportation sector accounts for more greenhouse gas (GHG) emissions than any other sector.

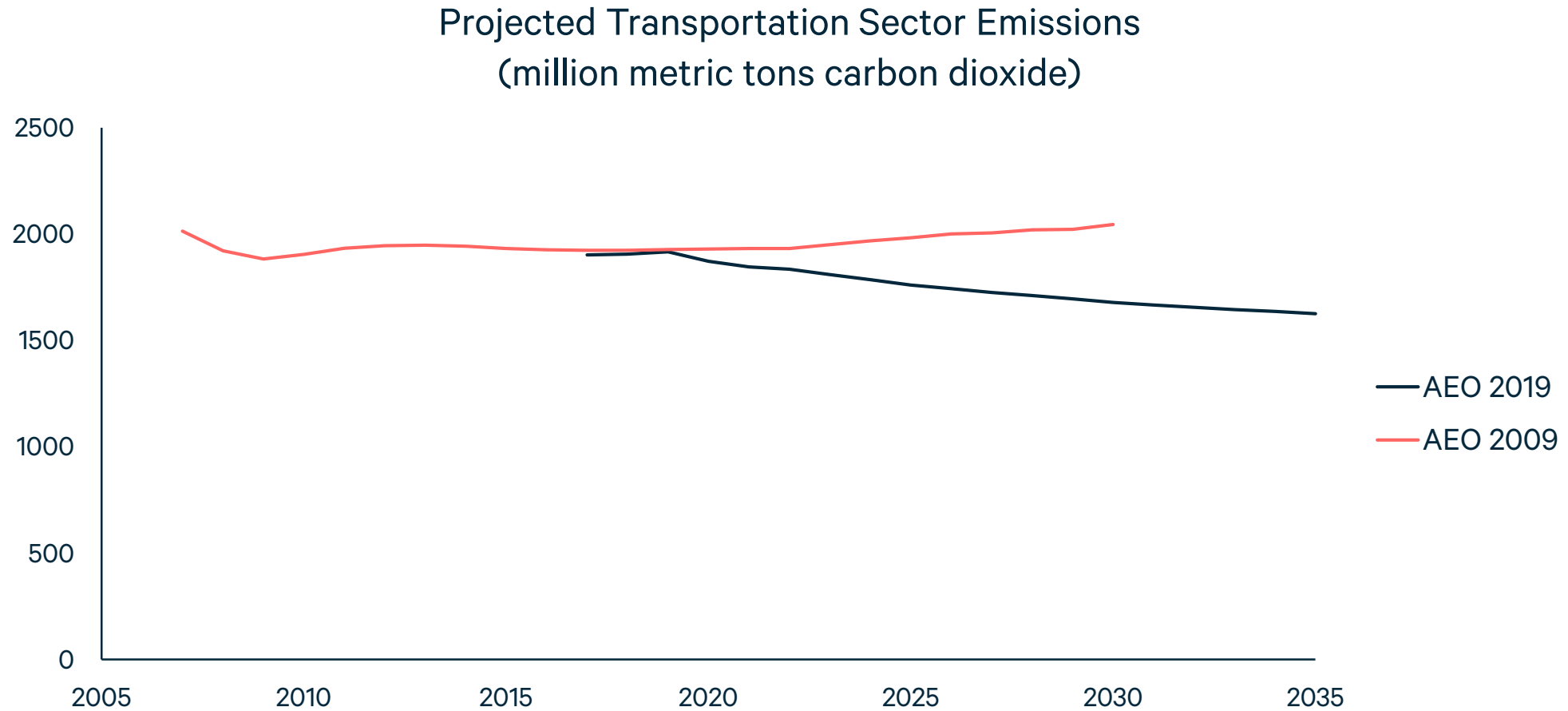
Cleaner passenger vehicles and **curbing growth of miles traveled** are the keys to achieving climate objectives.

Positive roles for federal policy:

- Price greenhouse gas (GHG) emissions and incentivize cleaner vehicles
- Promote research and development
- Support state and regional climate efforts



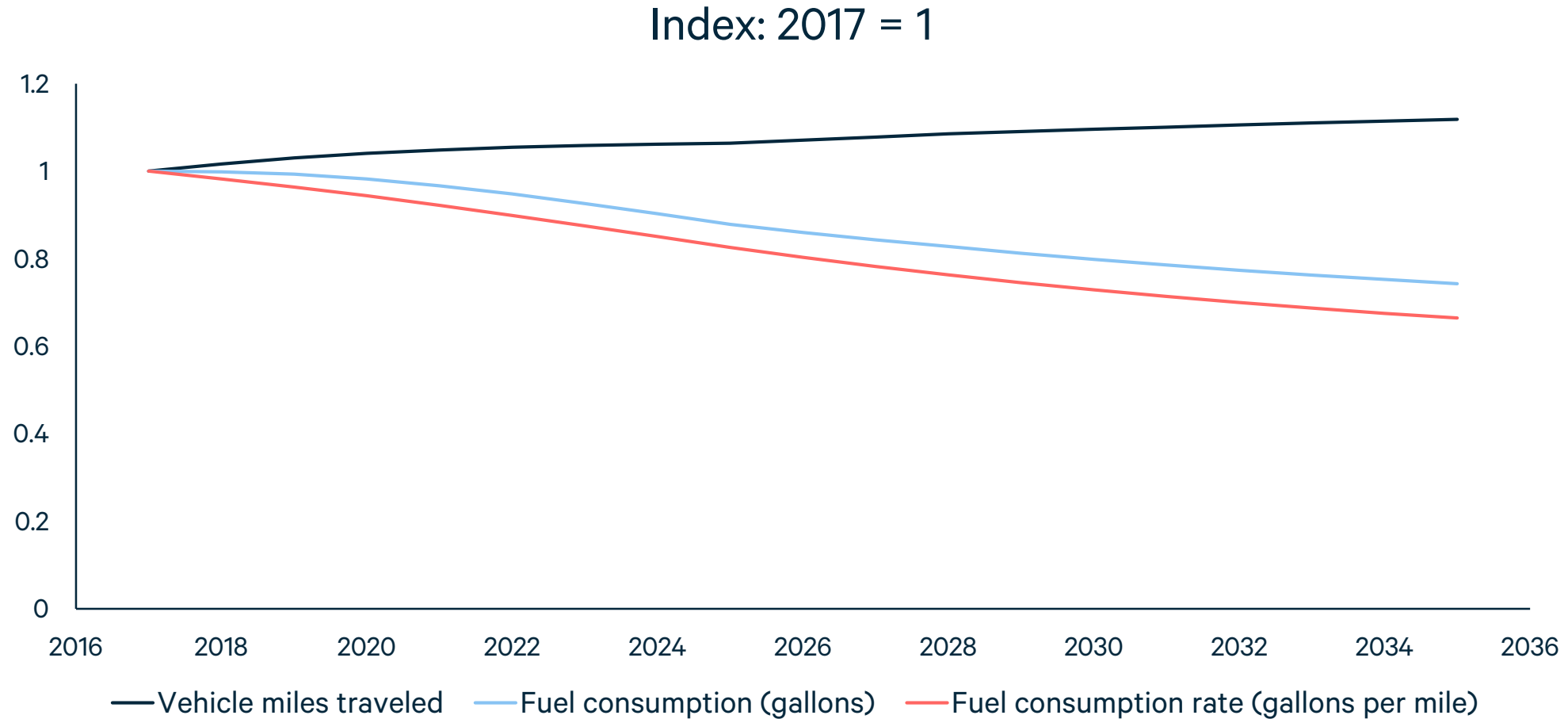
Overall, Transportation Sector Emissions Were Flat in the 2010s, but Emissions Are Expected to Decrease 20 Percent through 2035



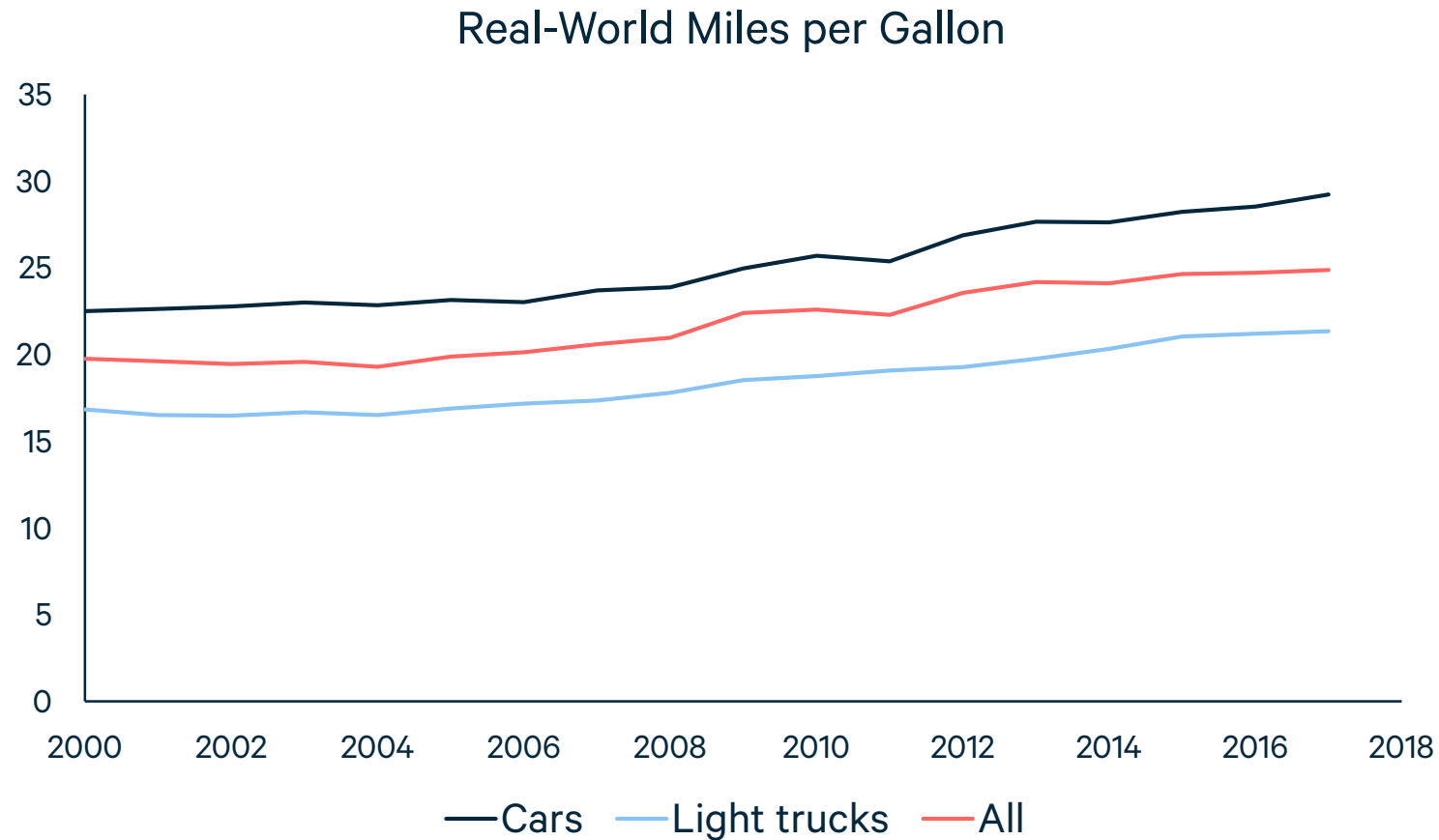
Sources: Energy Information Administration (EIA)
Annual Energy Outlook (AEO) 2009 and 2019



What's behind These Trends? Declining Fuel Consumption Rate Outweighs Increasing Travel



Largely Because of Fuel Economy and GHG Standards, New Vehicle Fuel Economy Has Increased 25 Percent

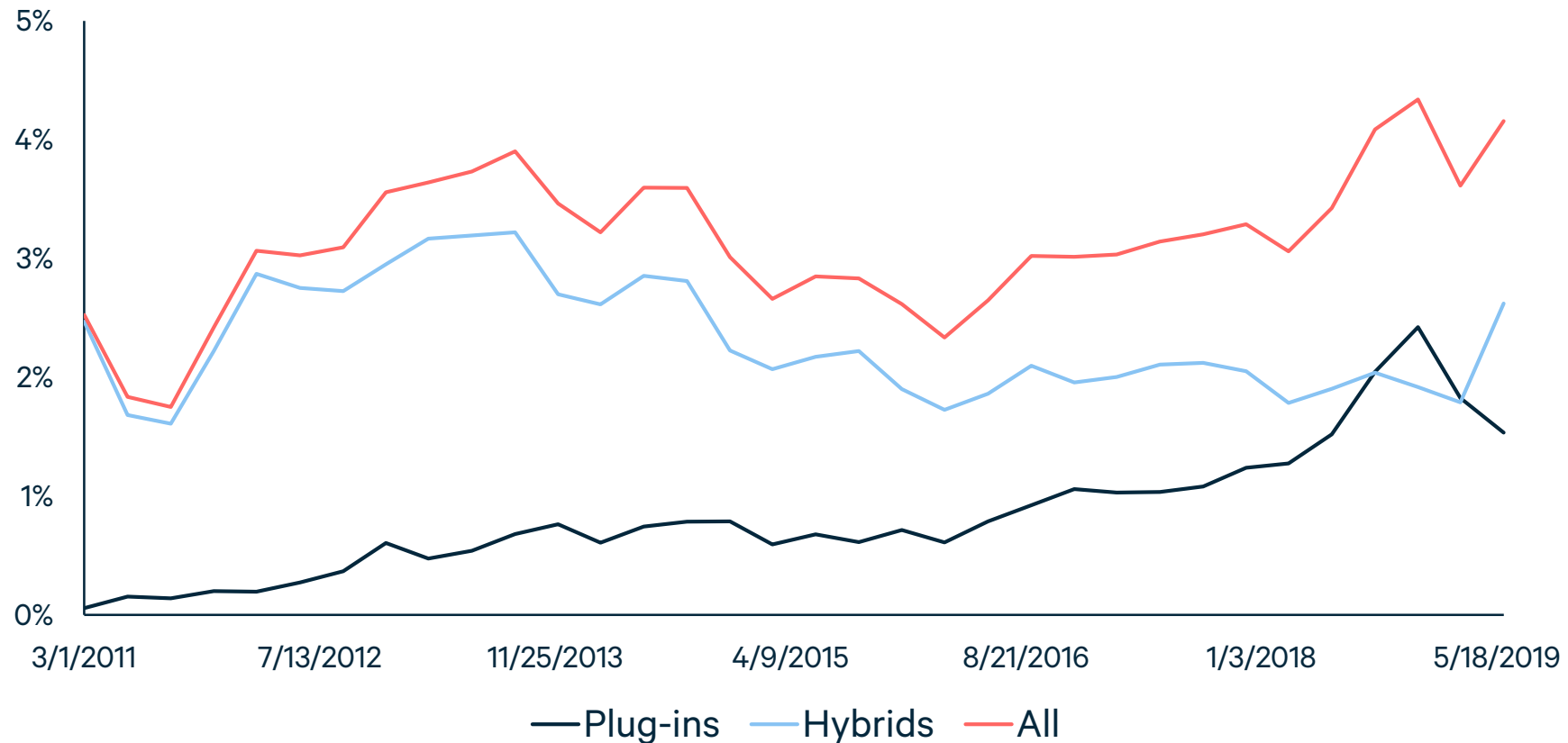


Source: 2018 Environmental Protection Agency
Automotive Trends Report



Plug-In Vehicle Sales Have Increased Rapidly, Partly at the Expense of Hybrids

Hybrids and Plug-Ins: Percentage of Total Vehicle Sales, 2011-2019



The Time Frame for Reducing GHG Emissions

Passenger vehicles produced today will last a long time

- Many passenger vehicles will be on the road for 20+ years
- New vehicles account for about 10 percent of total driving in any particular year

Implication: fuel economy/GHG standards have long-lasting effects

- Example: freezing the standards at 2020 levels raises passenger vehicle emissions by 5 percent in 2025 and more than 10 percent in 2030
- Encouraging vehicle retirements can accelerate the turnover of the fleet, but adverse selection makes this costly



Three Pathways to Lower Emissions



Increase fuel
economy of gasoline
and diesel fuel
vehicle



Reduce emissions
content of the fuels
(biofuels and
electricity)



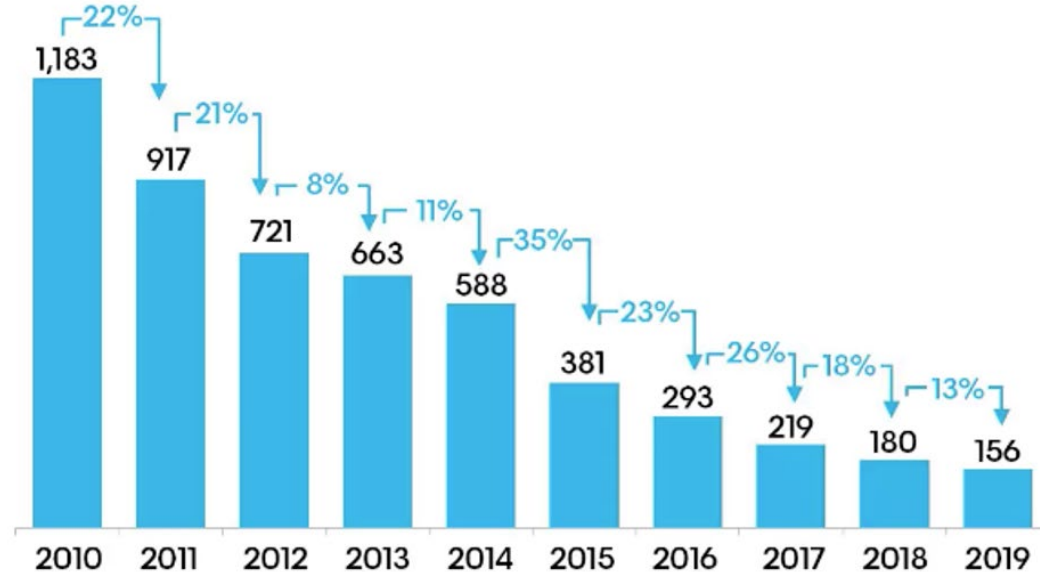
Drive less



Electric Vehicle Battery Costs Have Fallen Dramatically

Lithium-ion battery price survey results: Volume-weighted average

Battery pack price (real 2019 \$/kWh)



Source: BloombergNEF

At a cost of \$100/kWh, an electric vehicle could cost the same as a similar gasoline vehicle

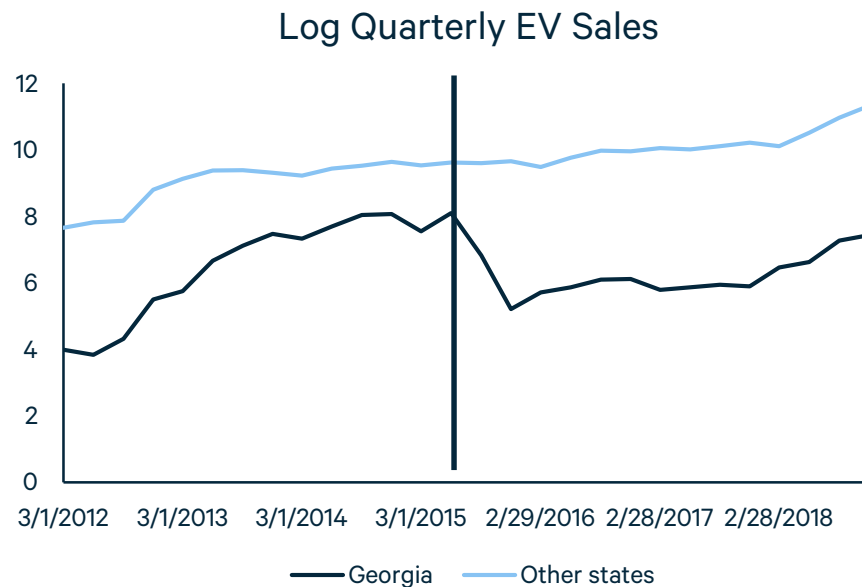
Why the interest in “parity”?

- In DC, average fuel costs for a hybrid sedan are roughly \$0.06 per mile
- Fuel costs for an all-electric are roughly \$0.04 per mile



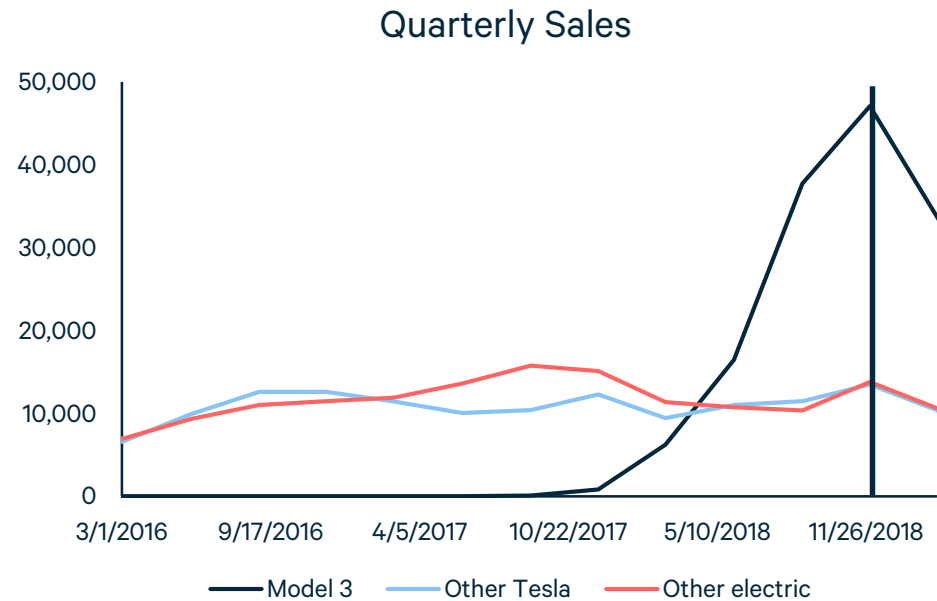
Federal and State Subsidies Appear to Have Big Effects on Sales

Example #1: Georgia eliminates a \$5,000 vehicle subsidy in July 2015



Source: IHS

Example #2: Tesla's federal tax credit starts phasing out in 2019



Source: Wards



Key Uncertainties about Vehicle Technologies



How much will fuel economy continue to improve?

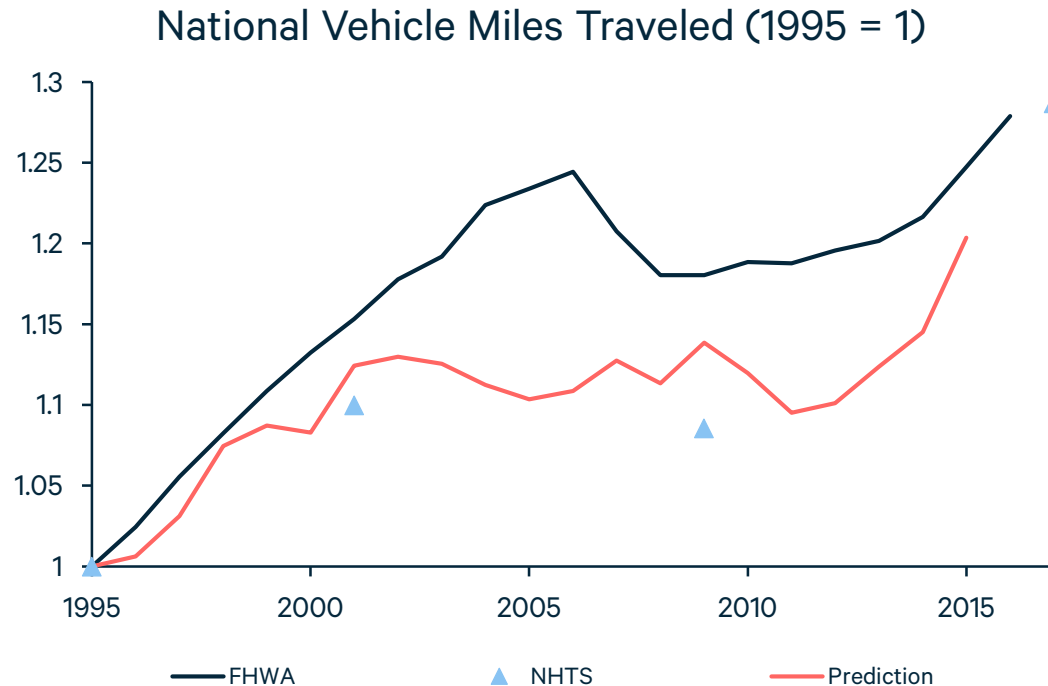


How far and how quickly will battery costs fall?

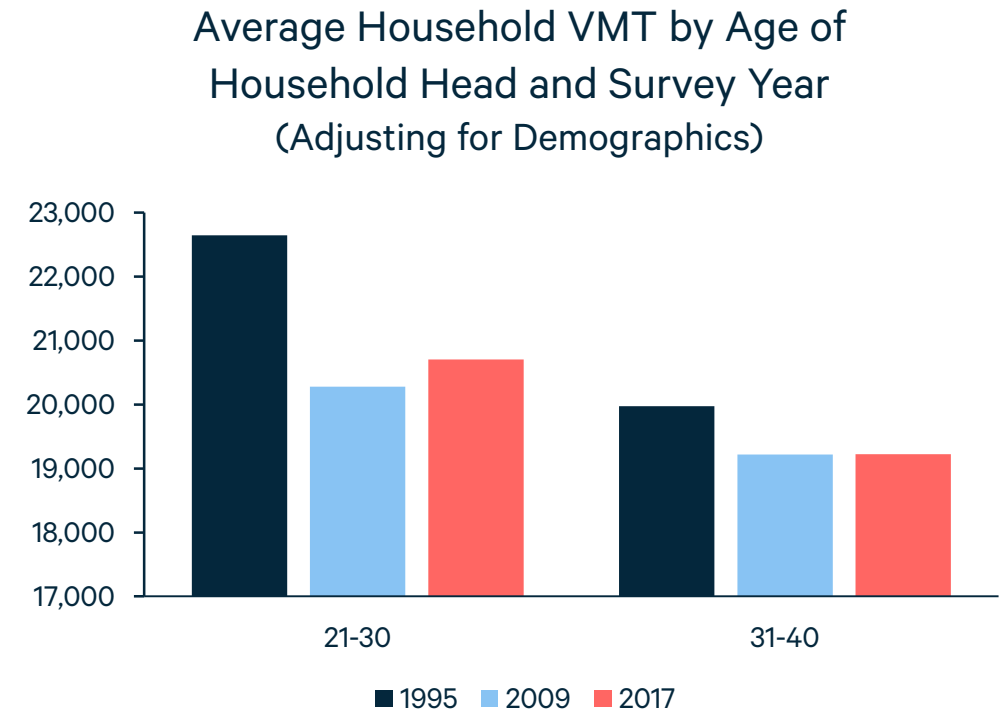


Is “parity” sufficient for electric vehicles to take off?

Challenge to State and Local Efforts to Reduce Miles Traveled: Driving Habits Are Highly Persistent



Sources: Federal Highway Administration, National Household Travel Survey, and Leard et al. (2018)



Source: National Household Travel Survey



Roles for Federal Policy (Besides Pricing Emissions)

Clean vehicles and fuels

- Incentivize low-emissions technologies, such as setting emissions standards
- Address market failures for new technologies, such as funding research and development

Driving

- Make large-scale infrastructure investments that would reduce driving (for example, inter-city rail)
- Use pilot programs to help state and local governments identify promising policies



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Clean Energy and Climate Innovation Policy

David M. Hart

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Professor, Schar School, George Mason University

@ProfDavidHart

About ITIF

- Independent, nonpartisan research and education institute focusing on intersection of technological innovation and public policy, including:
 - Innovation and competitiveness
 - IT and data
 - Telecommunications
 - Trade and globalization
 - Life sciences, agricultural biotech, and energy
- Formulates and promotes policy solutions that accelerate innovation and boost productivity to spur growth, opportunity, and progress
- World's top think tank for science and technology policy, according to the University of Pennsylvania's authoritative *Global Go To Think Tank* Index

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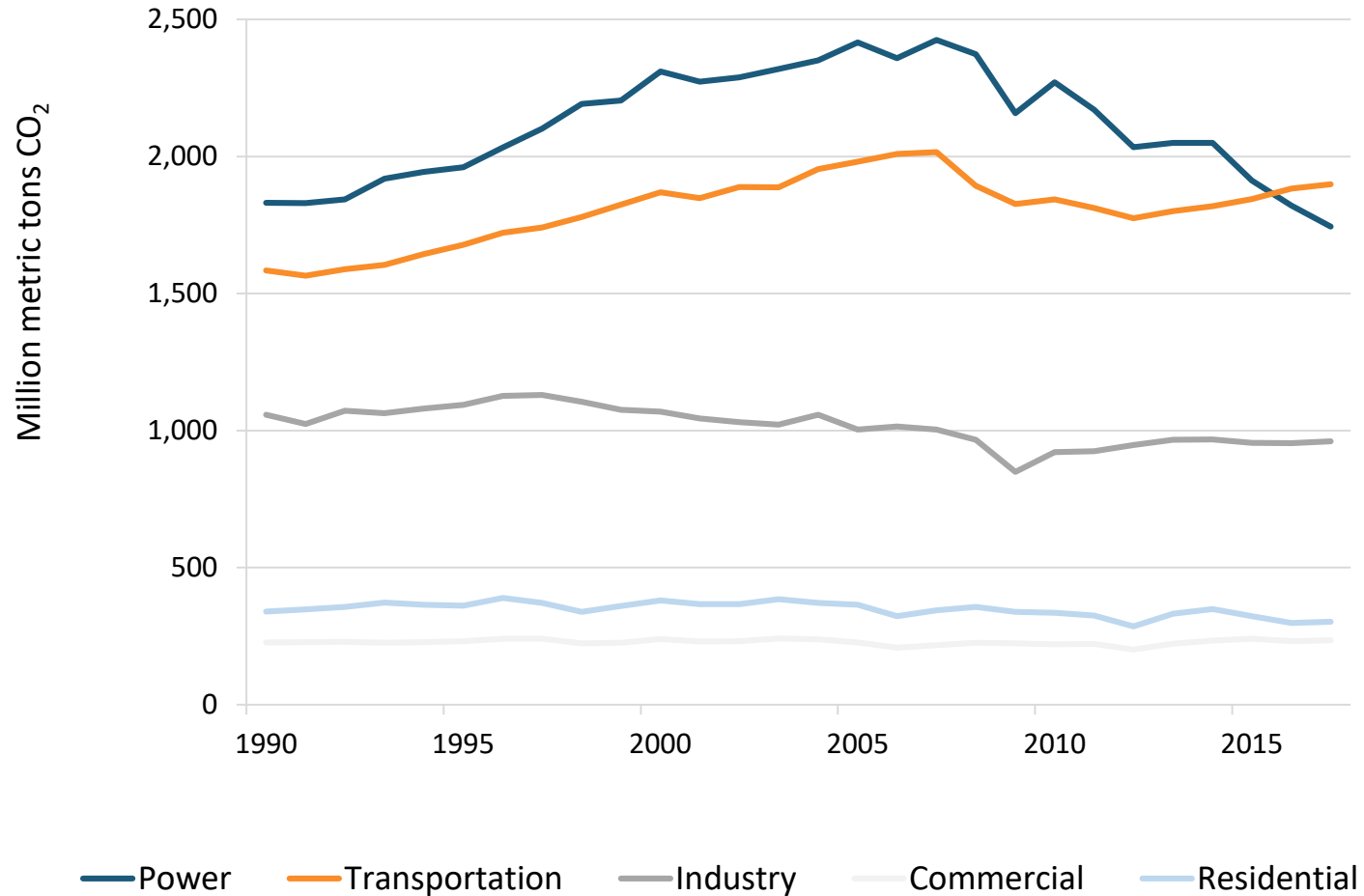
1 Emissions Reductions: Hard and Harder

2 Harder-to-Eliminate Emissions

3 Climate Policy to Accelerate Innovation

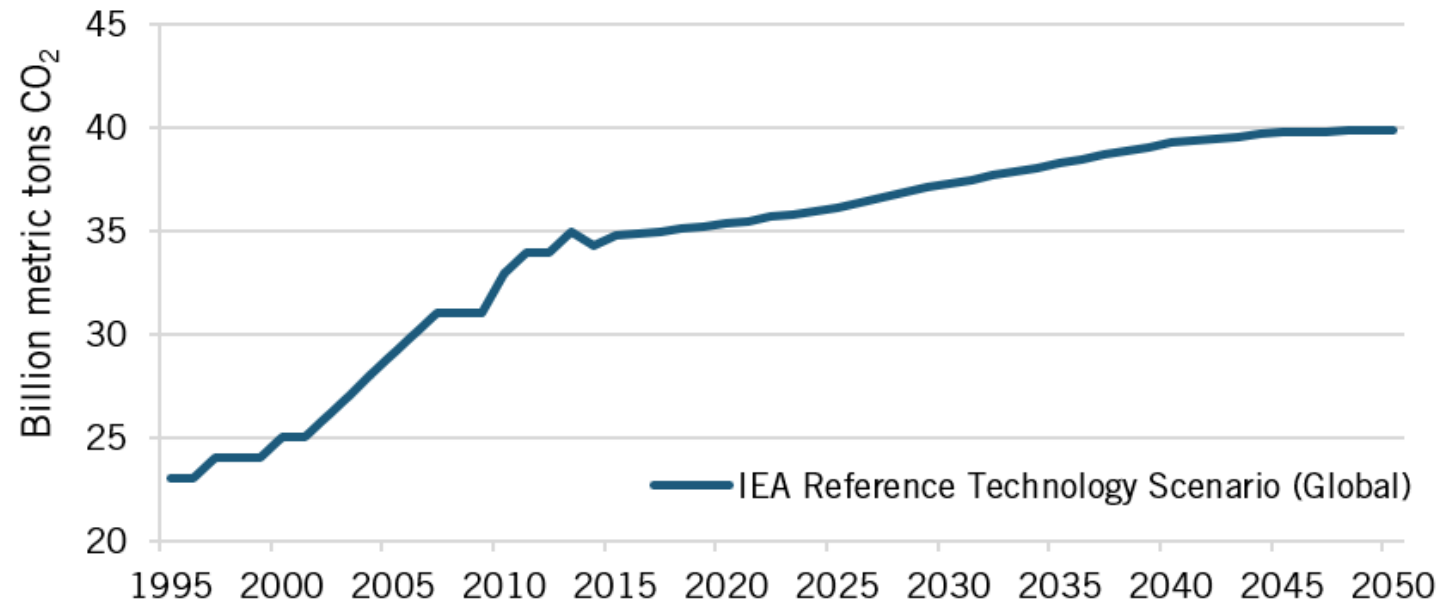
Even “Easy” Is Hard

U.S.
Emissions
Since 1990



Even More So When Considered Globally

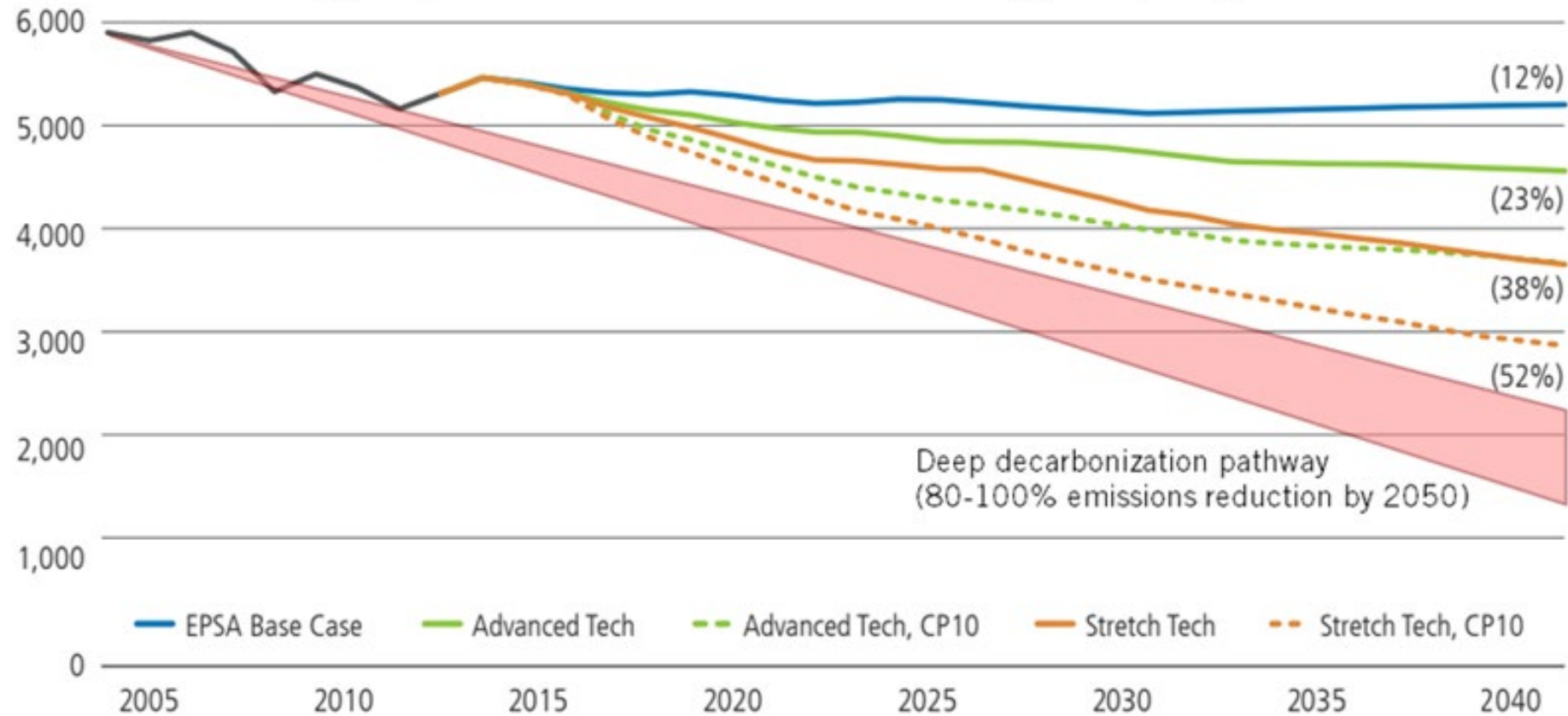
Figure 5. Projections of Global and Domestic Carbon Emissions Under a Reference Technology Scenario.³⁶



- Includes Paris commitments and future cost reductions for renewables and other clean energy technologies.

More “Push” and More “Pull” Will Be Needed

Figure 6. U.S. energy CO₂ emissions under different technology and policy scenarios



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1 Emissions Reductions: Hard and Harder

2 Harder-to-Eliminate Emissions

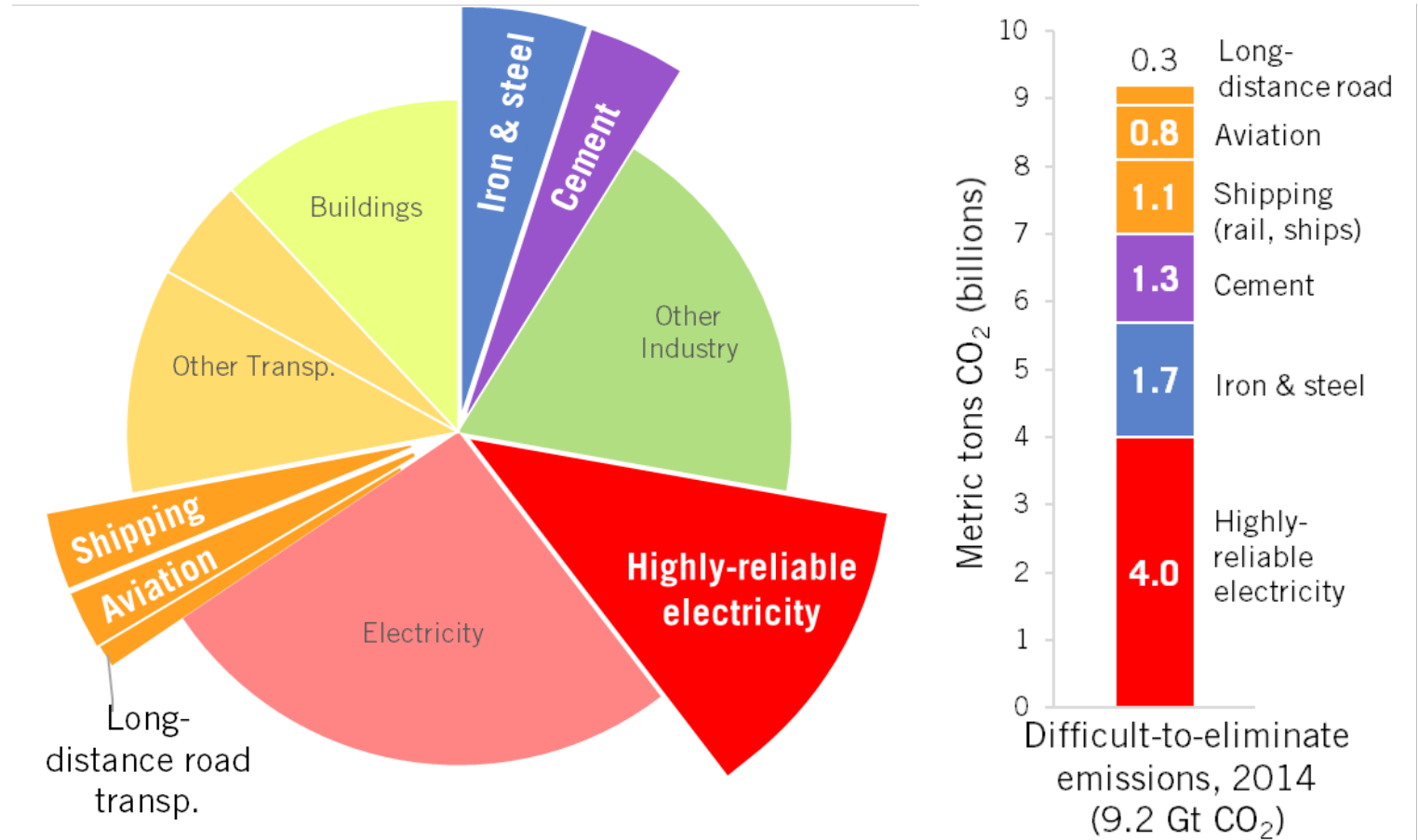
3 Climate Policy to Accelerate Innovation

“Harder” Emissions Reductions at the Global Scale

1. Electricity

2. Transportation

3. Industry



Source: Davis, et al., *Science* (2018) 1419.

Challenge: Highly-Reliable “Firm” Low-Carbon Electricity

Power sector emissions are declining in the United States.

But:

- Natural gas not emissions free
- Renewables not dispatchable
- Progress slow in much of the world

Gap: Zero-carbon “firm” electricity



Challenge: Harder-to-Electrify Transportation

Electric cars + low-carbon grid = great start!

But some transportation is hard to electrify:

- Aviation
- Shipping
- Long-distance road haulage

Gap: Energy-dense carbon-neutral fuels



Challenge: Harder-to-Electrify Industrial Sources

Industry sensitive to energy costs

But:

- Heat $>750^{\circ}\text{F}$ hard to electrify
- Process emissions not energy-dependent

Gap: clean heat, new processes



Challenge: Atmospheric Carbon Dioxide Removal (CDR)

Growing awareness of harms caused by greenhouse gas emissions

But emissions reductions may not:

- occur quickly enough
- be large enough

Gap: CDR technologies



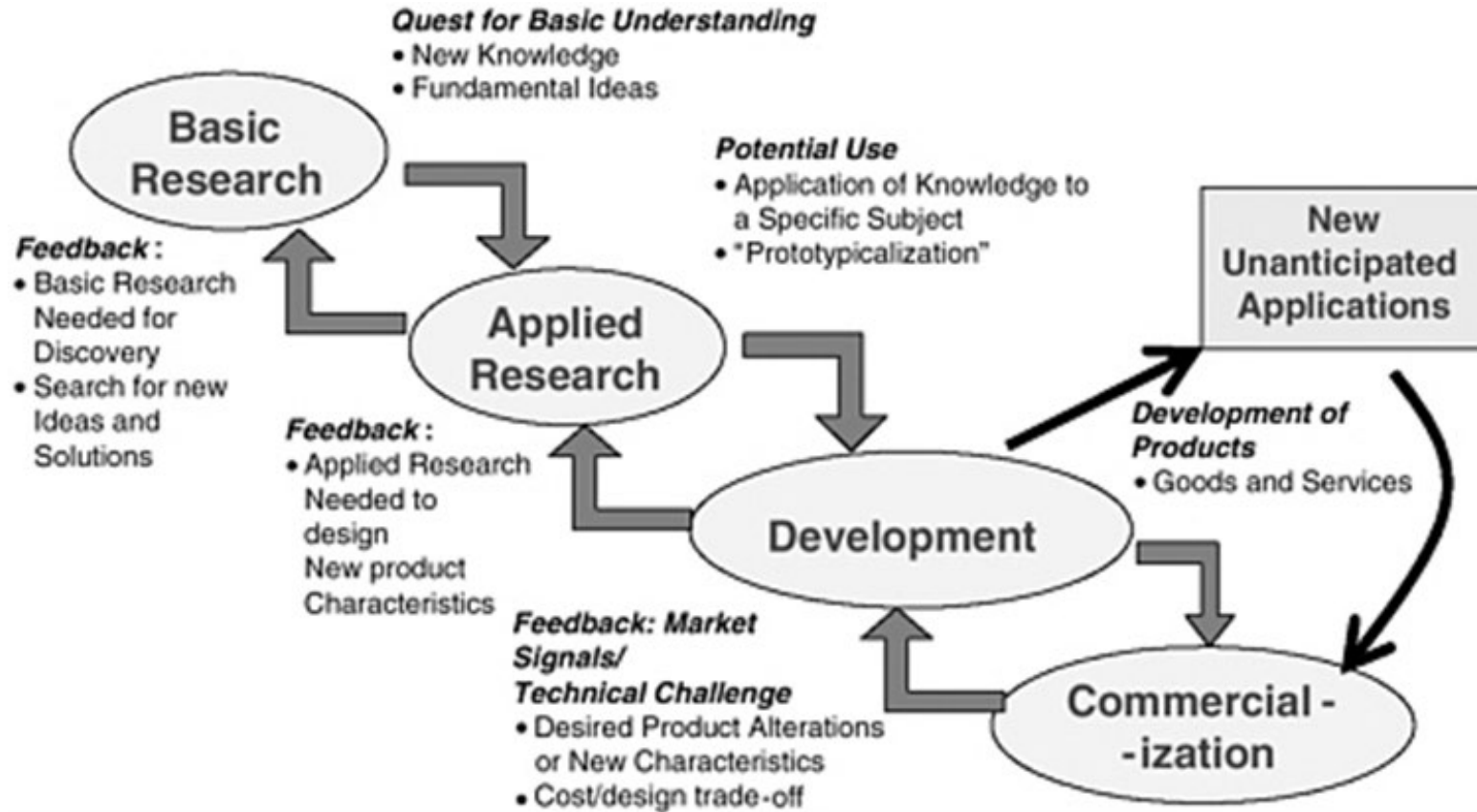
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2 Harder-to-Eliminate Emissions

3 Climate Policy to Accelerate Innovation

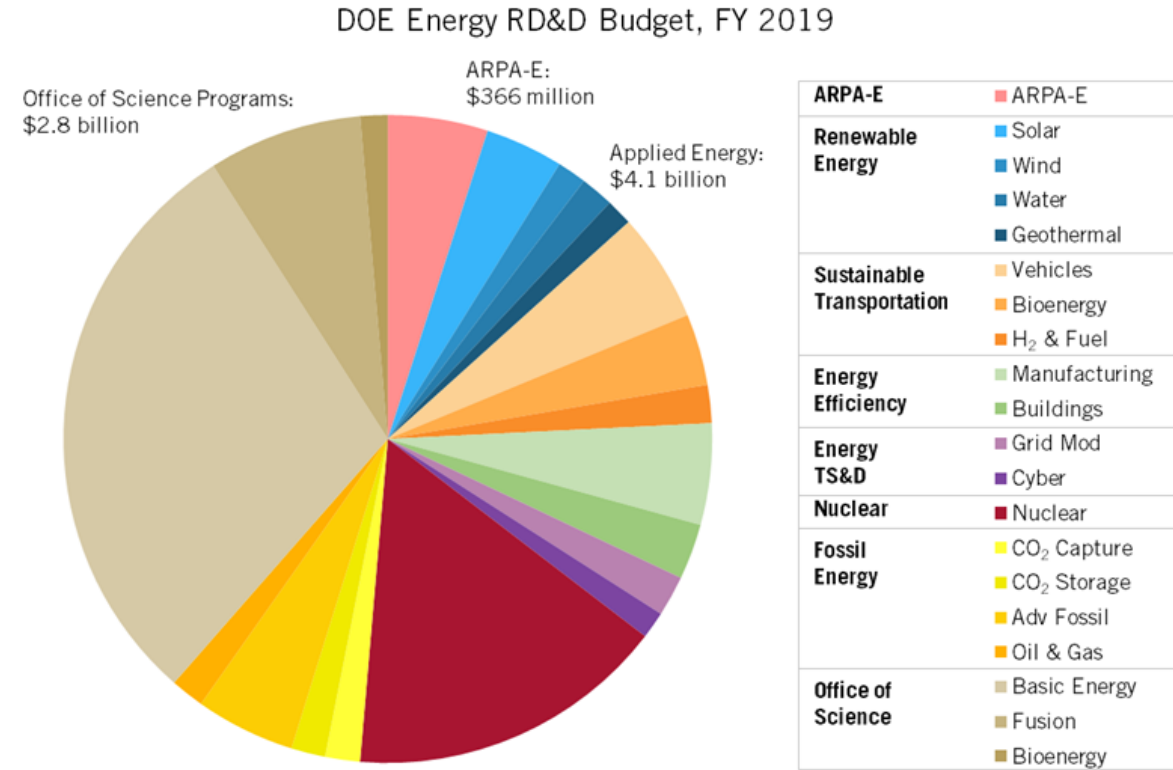
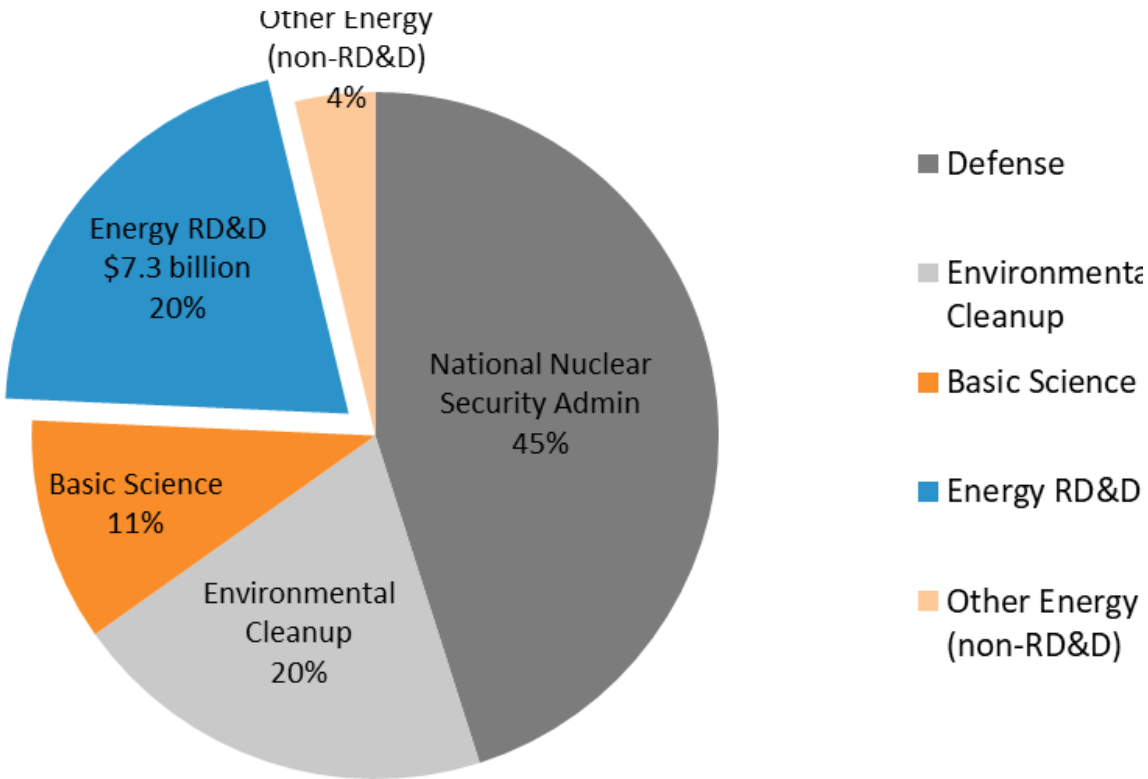
Energy Innovation: It's Complicated!



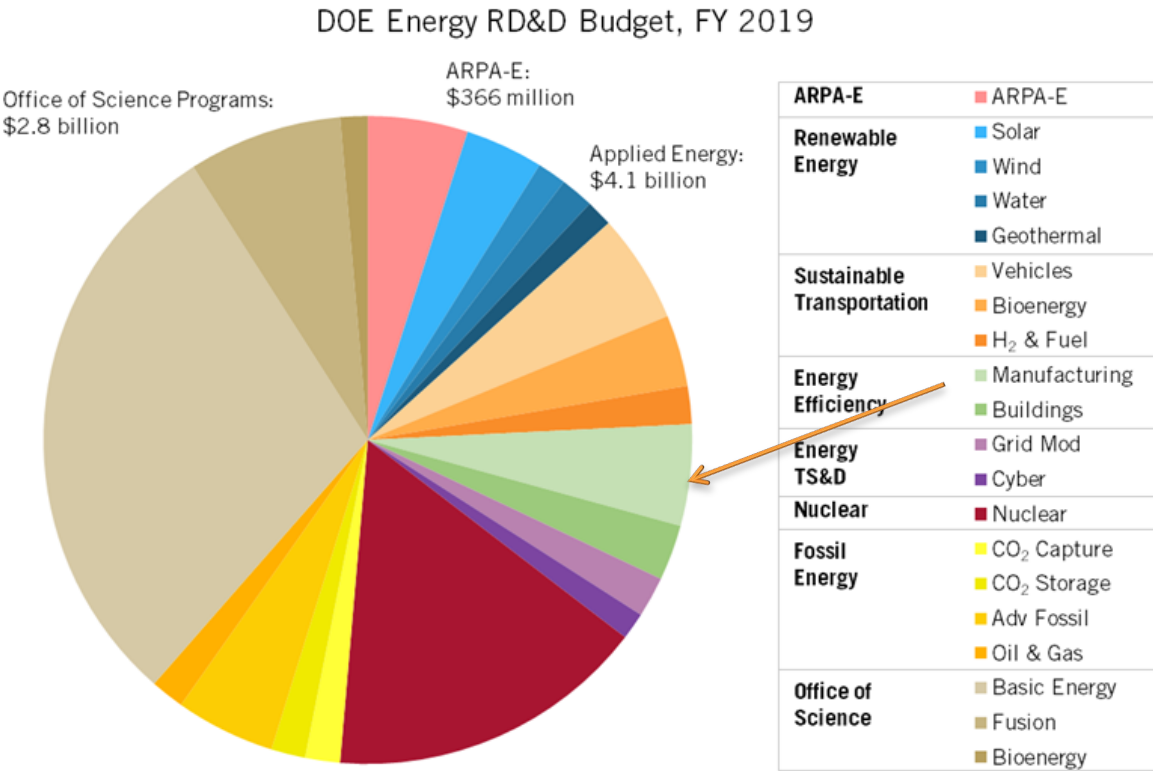
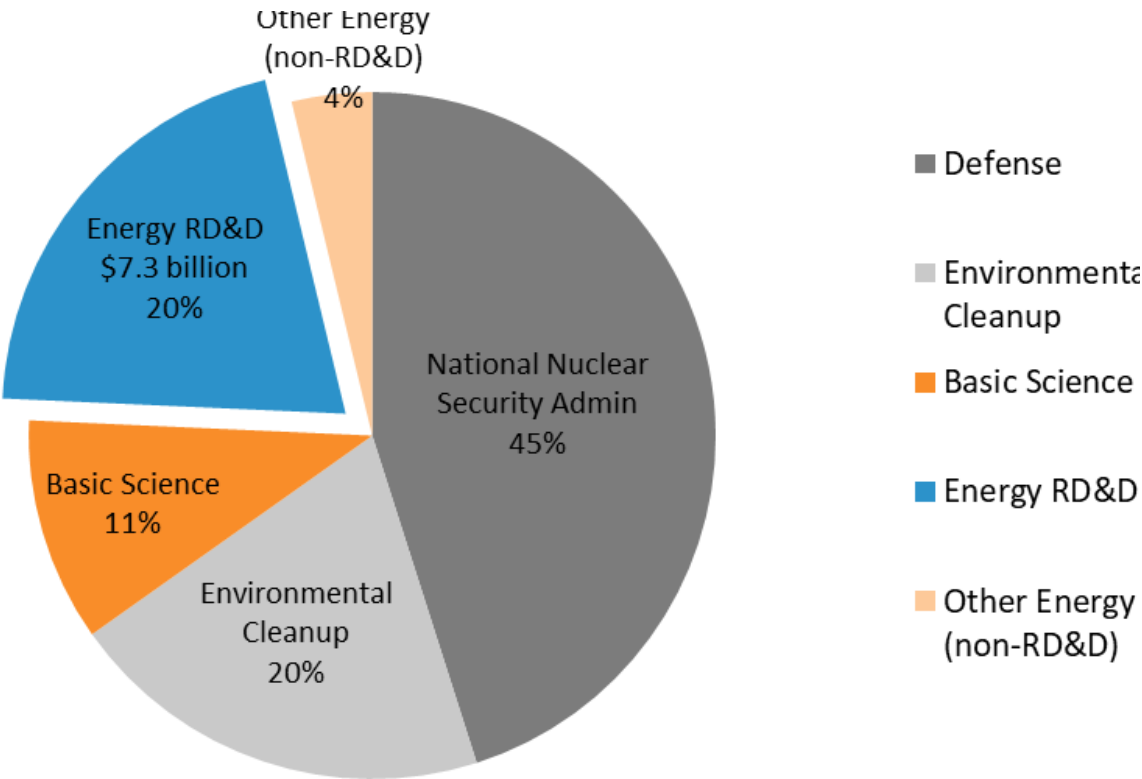
An Aggressive, Smart Federal Energy Innovation Policy Agenda

- Generous, stable use-inspired research funding.
- Dramatically expanded federal co-investment in applied research, demonstration, and infrastructural technology development.
- Enhanced connectivity and user pull along the energy-innovation chain.
- Stronger regional collaboration, including linkages with DOE national labs.
- Energy tax incentive reform.
- Strategic use of federal procurement to build clean energy technology markets.
- Encouragement of business-model and regulatory innovation.
- Steady, predictable tightening of energy efficiency and carbon regulations (or pricing).

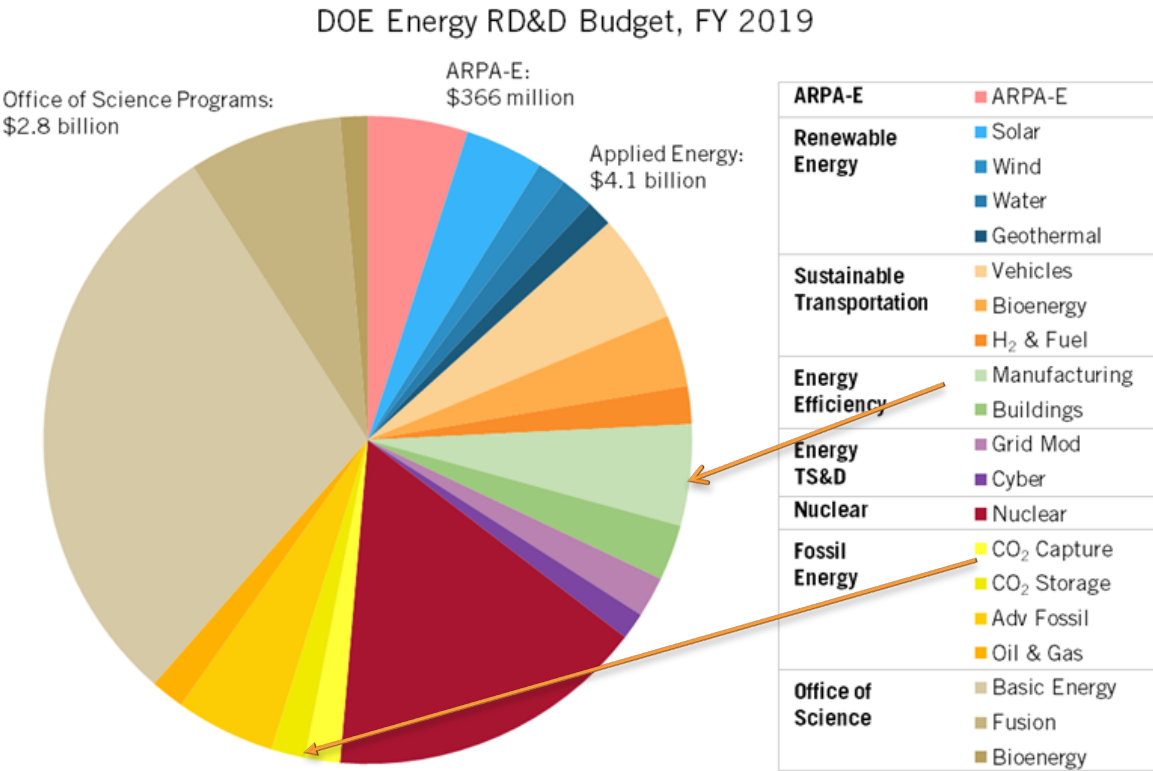
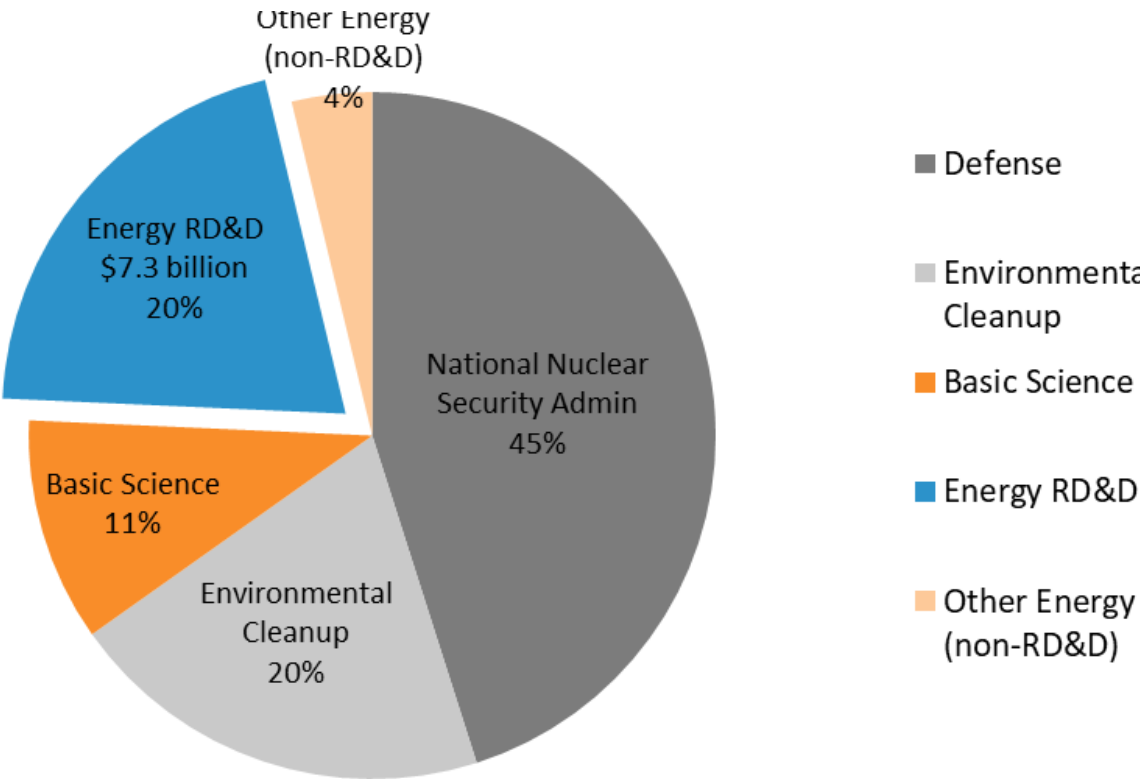
DOE Energy RD&D Budget



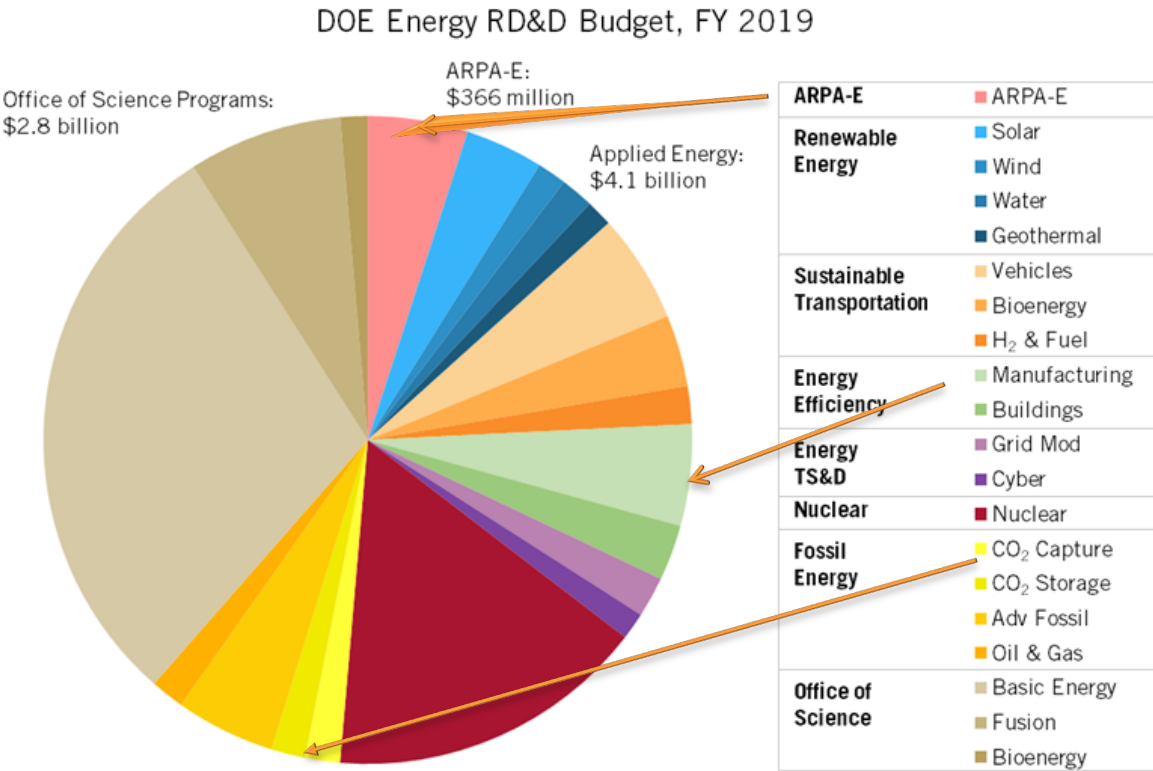
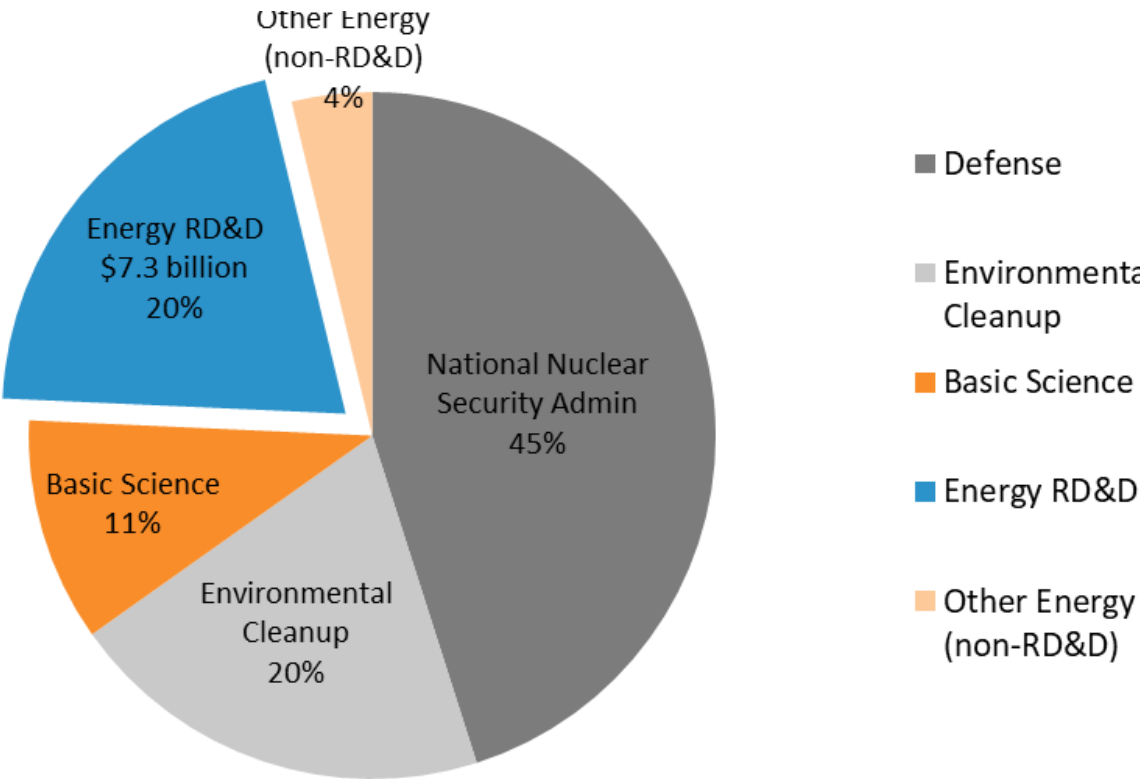
DOE Energy RD&D Budget



DOE's Energy RD&D Budget



DOE's Energy RD&D Budget



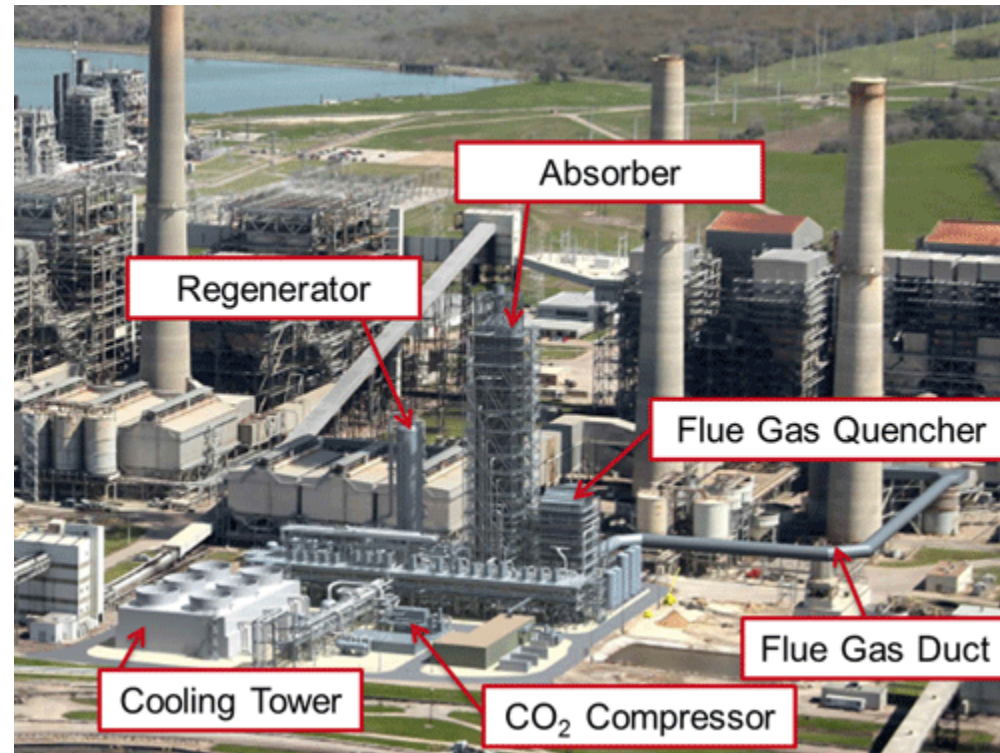
Regional Collaboration via DOE's Manufacturing USA Innovation Institutes

- High opportunity technologies
- Competitive selection
- Diverse members & structures
- 5 year cooperative agreement
- Min. 1:1 non-federal cost share



Public-Private Demonstration Partnerships

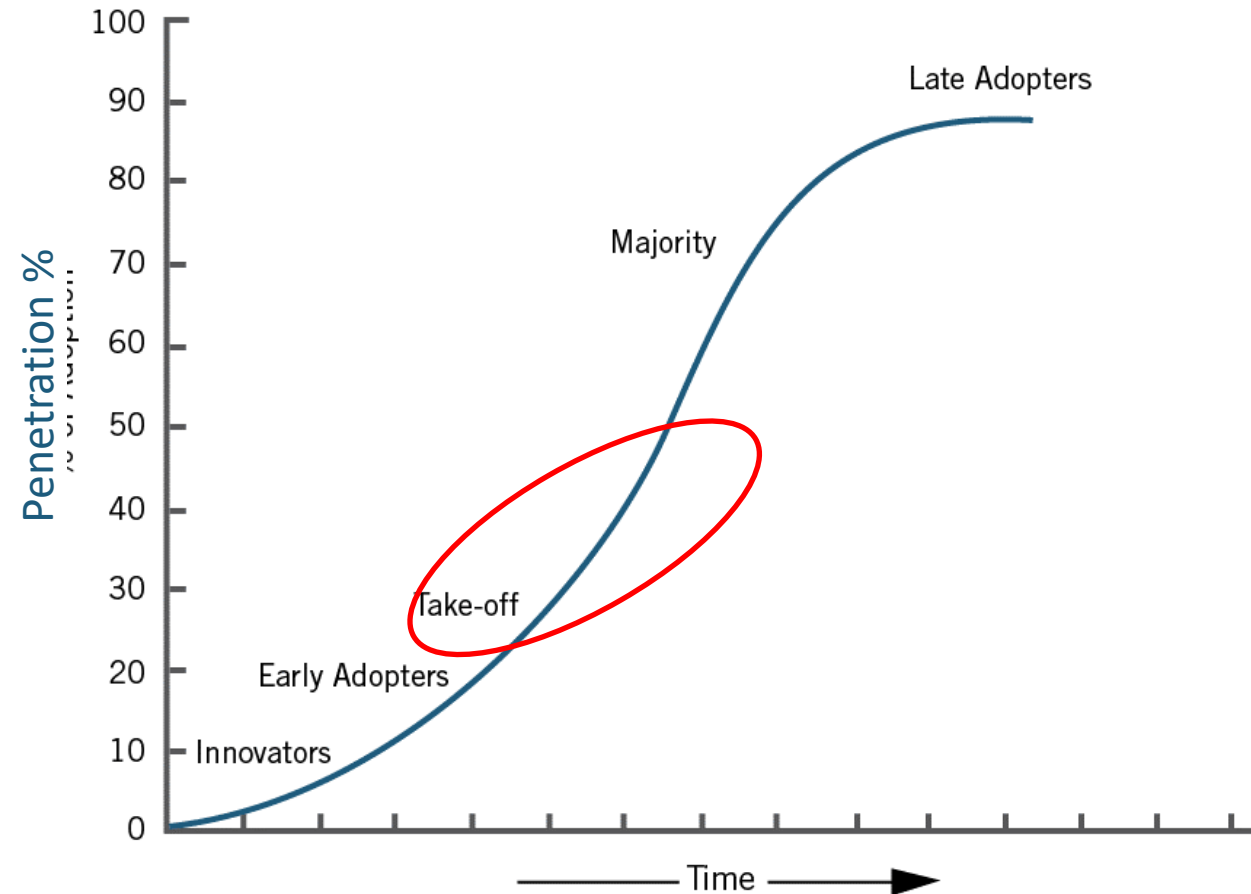
- First of a kind projects are often expensive and risky
- But if you don't build the first one, you'll never build the second one



Petra Nova Carbon Capture Facility
(Source: [Mitsubishi](#))

Tax Incentives: Timing Matters

- Policy sequence
 - R&D funding
 - Demonstration/validation
 - Tax incentives – take-off phase
 - Carbon price
- Policy mistakes
 - Too early
 - Too late



ITIF Clean Energy Innovation Policy Program Reports

- Colin Cunliff, “An Innovation Agenda for Deep Decarbonization: Bridging Gaps in the Federal Energy RD&D Portfolio.”
- Colin Cunliff, “FY 2020 Energy Innovation Funding: Congress Should Push the Pedal to the Metal”
- Elizabeth Noll and David Hart, “Less Certain than Death: Using Energy Technology Tax Incentives to Drive Innovation”
- Full text: itif.org/issues/energy-climate.



Thank You!

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