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The effect of Trump's climate policies on U.S. energy-related CO_2 emissions and the discontinuity with the Inflation Reduction Act

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Executive Summary

This report evaluates the emissions implications of contrasting U.S. federal climate policy trajectories over the period 2024 to 2035. It focuses on two of the country's largest sources of greenhouse gas emissions: the electricity generation sector and the light-duty transportation sector. Together, these sectors represent more than half of national CO_2-equivalent (CO_2e) emissions and are highly responsive to policy incentives, regulatory frameworks, and investment signals. The central objective is to assess how the dismantling of the Inflation Reduction Act (IRA), combined with potential fossil fuel expansion under a second Trump administration, may alter U.S. emissions trajectories compared to alternative policy futures.

To this end, we construct and analyze three policy scenarios: (1) a Business-as-Usual case without the IRA and without additional fossil fuel expansion, (2) full IRA implementation under a hypothetical Democratic continuation, and (3) a Trump rollback scenario involving aggressive deregulation and fossil fuel support. An IPAT-based decomposition framework is applied to quantify the underlying drivers of emissions, including economic scale, electricity intensity, technology stock and flow, and direct emission factors. In the transport sector, we apply a similar approach, decomposing emissions into fleet composition, energy efficiency, energy source carbon intensity, and behavioral factors such as ownership and distance traveled.

Under Scenario 2 (IRA continuation), emissions from the electricity sector decline by more than 65% by 2035, falling from approximately 1.4 to 0.45 billion metric tons (Bt). This outcome is driven by accelerated renewable deployment, early fossil retirements, and improved emissions intensity. In parallel, light-duty vehicle (LDV) emissions decline by around 45%, reflecting robust electric vehicle (EV) adoption, stronger fuel economy standards, and upstream grid decarbonization. This trajectory represents the most coordinated federal climate strategy, supported by durable incentives, administrative alignment, and substantial public investment.

Scenario 1 (No IRA) leads to only marginal emissions reductions. Electricity sector emissions fall slightly to 1.3 Bt by 2035, while LDV emissions remain largely flat. This reflects limited federal support, with market trends and state-level efforts insufficient to drive systemic decarbonization. Fossil fuel generation remains persistent, and EV adoption progresses slowly due to weaker financial and regulatory signals.

Under Scenario 3 (Trump rollback), emissions rise in both sectors. Electricity sector CO_2 increases to 1.8 Bt by 2035, a more than 25% increase from current levels, driven by fossil fuel expansion, slowed renewable deployment, and weakened regulatory oversight. In the LDV sector, emissions grow by 25%, as fuel efficiency standards stagnate and gasoline vehicles retain fleet dominance. This scenario reflects a broad reversal of climate-oriented policies, resulting in rising emissions across the energy system.

The decomposition analysis reveals that emissions pathways are shaped not just by available technologies, but by the policy frameworks that govern their diffusion, integration, and competitiveness. Policy continuity and coherence are shown to be essential for sustained decarbonization. In contrast, political reversals and regulatory uncertainty introduce delays, reduce investor confidence, and risk locking in high-carbon infrastructure.

While our analysis is based on stylized projections rather than detailed optimization modeling, it offers strong directional insight. The contrast between scenarios highlights a widening gap in cumulative emissions outcomes, suggesting that decisions made in the current and upcoming presidential term will be pivotal in determining whether the United States remains aligned with its long-term decarbonization targets.

Contents

1 Introduction

1.1 Motivations

U.S. energy-related CO_2 emissions significantly influence global climate efforts due to the nation's substantial economic weight and high levels of energy consumption. Consequently, domestic policy shifts often have profound implications for international climate strategies (Pickering et al., 2018; Sanderson et al., 2017; Khadka, 2025).

The Inflation Reduction Act (IRA), implemented during the Biden administration, represents the largest historical U.S. investment aimed at promoting clean energy and reducing emissions (U.S. Department of Energy, Loan Programs Office, 2022). Conversely, the Trump administration's return indicates a marked policy reversal, focusing on the expansion of fossil fuel usage and the rollback of environmental regulations. Notably, President Trump announced withdrawal from the Paris Agreement and other United Nations Framework Convention on Climate Change ("UNFCCC")-related international environmental agreements, with the effective withdrawal period commencing one year following notification (The White House, 2025c). This stance echoes actions during Trump's first term, subsequently reversed by President Biden.

Further, the Trump administration is aggressively dismantling environmental protections and IRA-established funding initiatives, emphasizing increased fossil fuel and mineral extraction. It does so mainly through deregulation with the stated aim of enhancing consumer choice by lowering energy costs and boosting economic competitiveness and national security through increased energy exports. (The White House, 2025a).

Although substantial obstacles exist, ranging from energy market dynamics to legal limitations that hinder the immediate effectiveness of executive orders without Congressional approval, there are numerous deregulation actions and policy initiatives that have already been implemented. This significantly hinders progress towards energy transition goals (World Economic Forum, 2025; Sabin Center for Climate Change Law, 2025a).

Certain IRA provisions may persist due to their economic advantages in Republican-leaning states; nonetheless, Trump's policies are expected to notably decelerate the energy transition by prioritizing fossil fuel production and limiting electric vehicle (EV) adoption. This is particularly critical, given transportation and electricity generation together constituted over half of total U.S. CO_2-equivalent (CO_2e) emissions in 2022 (U.S. Environmental Protection Agency, 2024d).

1.2 Research Question

The context above defines our research question as follows:

How will the dismantling of specific Inflation Reduction Act provisions, combined with additional climate policy reversals announced by the Trump administration, impact U.S. energy and transport related CO_2 equivalent emissions relative to the policy trajectory under the Biden administration?

Our analysis distinctly evaluates two interconnected areas:

- **Electricity Generation Sector**: Investigating how eliminating IRA-driven renewable energy incentives and Trump's planned fossil fuel expansion and deregulation could reshape the national energy mix, potentially increasing reliance on fossil fuels and elevating emissions.
- **Transportation Sector**: Assessing how discontinuing IRA incentives (particularly EV subsidies) and additional policy rollbacks will alter vehicle electrification trajectories and transportation-related emissions.

The research specifically targets electricity generation, as net electricity imports represent approximately 1% of total generation, with even lower proportions over the past three years (U.S. Energy Information Administration, 2025b).

Similarly, in the transportation sector, the analysis is limited to light-duty vehicles (LDVs), primarily used for personal transportation, which comprise passenger cars (20%) and light-duty trucks such as SUVs, pickups, and minivans (37%). Together, these account for approximately 57% of U.S. transportation-related CO_2e emissions (U.S. Environmental Protection Agency, 2024d).

1.3 Work Methodology

This paper begins by reviewing climate policies implemented during President Trump's first term, analyzing historical outcomes to contextualize current policy proposals. It then evaluates the emission reduction benefits of the Inflation Reduction Act (IRA), along with other climate-focused initiatives enacted during President Biden's administration. Finally, the analysis turns to the current Trump 2025–2028 mandate, examining the implications of recent policy reversals and fossil fuel expansion efforts on future U.S. emissions trajectories.

The following sections present detailed decomposition analyses for the two identified sectors under three projected scenarios:

- *Scenario 1:* A business-as-usual pathway with neither IRA nor Trump-era fossil fuel expansion.
- *Scenario 2:* IRA implementation and the continuation of sustainable policy trajectories, consistent with a hypothetical Democratic administration (e.g., under President Kamala Harris).
- *Scenario 3:* A rollback of IRA provisions and a reintroduction of fossil fuel-centric policies under President Trump, reflecting the current political trajectory.

Leveraging existing quantitative studies on IRA's impacts, we project the evolution of each decomposition factor, emphasizing anticipated future trajectories.

To accurately isolate impacts of specific policy-driven changes (e.g., IRA subsidy cessation, deregulation) from broader influences (economic shifts, geopolitical pressures, market-driven sustainability trends), we adopt decomposition methodologies and scenario-based modeling established in academic and specialized literature. Nevertheless, we explicitly acknowledge methodological limitations, particularly the complex interactions between policy, market, and behavioral factors that complicate efforts to isolate the impact of specific interventions. Addressing these limitations transparently is essential, especially given the significant gaps between stated policy goals and actual outcomes observed during Trump's previous administration.

The final section critically examines our findings, outlines research limitations, and proposes areas for future inquiry to enhance analytical rigor.

2 Literature review

2.1 First Trump's Presidency (2017-2020)

During his first term, President Trump issued multiple executive orders that broke decisively with the *Mid-Century Strategy for Deep Decarbonization* (MCS), the Obama-era roadmap targeting an 80% cut in GHG emissions by 2050 (The White House, 2016). Consistent with his current rhetoric, Trump's earlier actions promoted domestic fossil-fuel production, revoked prior climate-related directives, and elevated skeptics of climate science to key climate related Federal Institutions (Sabin Center for Climate Change Law, 2025b).

Although these actions might have spread anxiety and fear about a drastic impact to American emissions, scholars caution against overstating the federal impact of Trump-era rollbacks because constitutional checks, congressional opposition, and agency procedures constrained policy change. For example, attempts to dismantle Obama's *Clean Power Plan* (CPP), designed to cut power-sector CO_2 by 30% from 2005 levels by 2030, faltered amid legal and regulatory push-back, including rejection by the Federal Energy Regulatory Commission (Selby, 2019; Galik et al., 2017).

Moreover, Trump's deregulatory agenda also failed to drive up coal production. According to the U.S. Energy Information Administration, annual coal output declined from 728 million short tons in 2016 (the year before Trump took office), to 539 million short tons by 2020, despite explicit efforts to revive the industry through regulatory rollback and leasing expansion (U.S. Energy Information Administration, 2022a). This sharp decline occurred largely independent of federal rule-making: even without Obama's Clean Power Plan (CPP), the introduction of cheap shale gas fracking techniques was the main driver behind 80% of coal's decline, and by 2018 the national generation mix had already reached one of the CPP's 2030 targets (33% gas, 27% coal) (U.S. Energy Information Administration, 2019). Trump's subsequent deregulation reinforced this market dynamic by further lowering gas prices, thereby marginalizing coal and reducing the average CO_2 intensity per kWh; however, methane leakage from increased gas production remains a significant concern. The overarching lesson is that price signals and technology costs, rather than federal (de)regulation alone, have been the dominant forces reshaping the U.S. power sector (MacNeil et al., 2019).

It would be incorrect to assume that President Trump's first term had no impact on climate change mitigation. In the electricity generation sector, while natural gas displaced coal and contributed to a short-term decline in emissions, the concurrent abundance of cheap gas and oil suppressed renewable energy investments. This dynamic led to the construction of long-lived natural gas infrastructure, potentially locking the sector into higher emissions for decades (see Sec. 4 for a thorough treatment of this topic). Natural gas combined-cycle (NGCC) plants, for instance, are typically designed for a technical lifetime of around 30 years, including two years of construction and 28 years of operation (Mann et al., 2000). Plants commissioned during or shortly after this period may thus remain operational into the 2050s, complicating efforts to achieve net-zero emissions by mid-century. While retrofitting coal and natural gas plants with **carbon capture and storage (CCS)** could theoretically mitigate long-term emissions, current deployment remains limited due to high capital costs, low project maturity, and policy uncertainty (International Energy Agency, 2023).

Furthermore, as Selby (2019) argues, the administration's rollback of international climate finance and weakening of domestic mitigation targets increased both political and economic barriers to future climate action. These shifts undermined the credibility of U.S. commitments and amplified the risk of a disorderly, contested energy transition.

2.2 Biden's Term and IRA Impact (2021–2024)

President Biden strongly promoted a comprehensive climate agenda aimed at reversing climate-adverse policies established by the previous administration. His strategy relied on aligning federal and state-level initiatives through a distributed framework referred to as a "whole-of-government" approach (South et al., 2021; Cha et al., 2022). This approach emphasized direct engagement with the international community, such as rejoining the Paris Agreement, enforcing G20 commitments, and fostering joint efforts in innovation and technological advancement to address climate change. This while simultaneously strengthening internal climate policy through federal agencies and coordination with state governments. This distributed method sought to amplify the effectiveness of implementation and enhance its resilience against potential future rollbacks (Popovich et al., 2021), learning from the experience of the Obama-to-Trump transition, where climate efforts were vulnerable due to their reliance on centralized regulatory authority, particularly through the EPA.

Among the policies advanced by the Biden administration, the most significant in terms of federal climate-related economic commitment was the Inflation Reduction Act (IRA) (Bistline et al., 2023), alongside the Infrastructure Investment and Jobs Act (IIJA)-also know as the Bipartisan Infrastructure Law (BIL)- which allocated \$1.2 trillion to modernize national infrastructure, providing complementary investments in clean energy projects and upgrades to the electric grid to support the green transition (U.S. Environmental Protection Agency, 2023). Notably, these major initiatives were passed through congressional legislation rather than executive orders, marking a significant shift from prior practices and underscoring a broader and more durable institutional commitment to addressing climate change.

Specifically, the IRA, signed into law in 2022, allocated approximately \$369 billion over the subsequent decade to energy security and climate change programs, with the explicit objective of reducing U.S. greenhouse gas emissions by roughly 40% below 2005 levels by 2030 (U.S. Senate Democrats, 2022; Congressional Budget Office, 2022).

Several analyses suggest that public incentives could crowd in substantial additional private capital. According to projections by Goldman Sachs, total investment stimulated by the IRA could reach as high as \$3 trillion under favorable market conditions (Goldman Sachs Research, 2023).

The IRA provides robust incentives across key sectors of the U.S. economy (electricity, transportation, buildings, and industry) to address technical, informational, administrative, and cost barriers hindering the widespread adoption of emission-reducing technologies. Key provisions include tax incentives for renewable energy projects, investments in clean manufacturing, substantial support for electric vehicle (EV) adoption, and the establishment of clean hydrogen hubs. According to the Rhodium Group's "Taking Stock 2024" report, maintaining IRA provisions could enable renewable energy to supply over 50% of U.S. electricity generation by 2035 and accelerate EV market share to 45% of new light-duty vehicle sales by the early 2030s. Concurrently, the carbon intensity of electricity is projected to decline significantly, enhancing the emissions reduction benefits of transportation electrification (Rhodium Group, 2024).

Empirical data indicates early impacts: between 2022 and 2024, renewable energy capacity additions reached record highs, with utility-scale solar and wind installations accounting for nearly 90% of all new capacity additions in the first nine months of 2024, driven in part by IRA incentives (Deloitte Insights, 2025). EV sales also rose sharply, with 1.2 million new electric vehicles sold in 2023, representing 7.6% of total new vehicle sales, up from 2% in 2020 (Cox Automotive, 2024; U.S. Energy Information Administration, 2024l).

2.3 Trump's Second Term and the Dismantling of Climate Policy (2025–2028)

Upon returning to office in January 2025, President Donald Trump initiated a comprehensive rollback of climate policies implemented during the Biden administration. Central to this agenda was the effective repeal of the Inflation Reduction Act. This reversal brought most climate-focused programs to a halt and signaled a broader departure from federal climate ambition (Sabin Center for Climate Change Law, 2025a).

One of the administration's first moves was the declaration of a "national energy emergency," aimed at accelerating the development of domestic fossil fuel infrastructure. In parallel, the White House announced the immediate withdrawal of the United States from the Paris Agreement, its second such exit, under Executive Order 14162, titled *Putting America First in International Environmental Agreements* (The White House, 2025c). This directive emphasized prioritizing domestic energy expansion over international climate cooperation.

The Department of the Interior soon followed with plans to fast-track permitting for fossil fuel and mining projects. Under the revised framework, the environmental review process was shortened to a maximum of 28 days, replacing what previously took years. The administration argued this would enhance energy security and economic competitiveness, particularly under the declared energy emergency (The Guardian, 2025).

Simultaneously, the administration launched efforts to suppress climate-related policy initiatives at the state level. A new executive order authorized the Department of Justice to challenge state regulations on climate change, ESG criteria, and environmental justice, citing federal preemption concerns and potential economic burdens (Reuters, 2025).

Taken together, these actions constitute a substantial pivot in U.S. environmental governance. Rather than focusing on mitigation, they signal a reorientation toward maximizing fossil fuel production and deregulation. In light of the electricity generation sector's outsized contribution to national CO_2 emissions, and its responsiveness to federal policy signals, a quantitative decomposition analysis is essential to assess the long-term climate implications of this political shift. The following section introduces an IPAT-based decomposition framework to assess how recent policy reversals under the Trump administration may alter future CO_2e emissions trajectories under contrasting scenarios.

3 Electricity Generation Sector

3.1 Decomposition for Total U.S. Electricity Generation Production-Related CO_2 Equivalent Emissions

$$
\begin{aligned}
\mathrm{CO}_{2\mathrm{eq},t}^{\mathrm{total}} = \sum_j \underbrace{\mathrm{GDP}_{US,t}}_{\text{scale}} \times \underbrace{\frac{\mathrm{El.Demand}_t}{\mathrm{GDP}_{US,t}}}_{\text{elec. intensity}} \times \Bigg[& \underbrace{\frac{\mathrm{El.Demand}_{t-1}}{\mathrm{El.Demand}_t} \times \frac{\mathrm{El.Prod}_{j,t-1}}{\mathrm{El.Demand}_{t-1}} \times \frac{\mathrm{Cap}_{j,t-1}}{\mathrm{El.Prod}_{j,t-1}}}_{\text{stock: existing capacity \& utilisation}} + \\
+ \underbrace{\frac{\Delta \mathrm{El.Prod}_{j,t}}{\mathrm{El.Demand}_t} \times \frac{\Delta \mathrm{Cap}_{j,t}}{\Delta \mathrm{El.Prod}_{j,t}}}_{\text{flow: capacity additions \& retirements}} \Bigg] & \times \underbrace{\left(\frac{\mathrm{Cap}_{j,t}^{\mathrm{act}}}{\mathrm{Cap}_{j,t}} \times \frac{\mathrm{El.Prod}_{j,t}}{\mathrm{Cap}_{j,t}^{\mathrm{act}}} \right)}_{\substack{\text{utilisation factor:} \\ \text{generation per unit} \\ \text{of available/installed MW}}} \times \underbrace{\frac{\mathrm{CO}_{2\mathrm{eq},j,t}^{\mathrm{direct}}}{\mathrm{El.Prod}_{j,t}}}_{\substack{\text{electricity-emission} \\ \text{efficiency (kg CO}_2\text{/MWh)}}}
\end{aligned}
$$

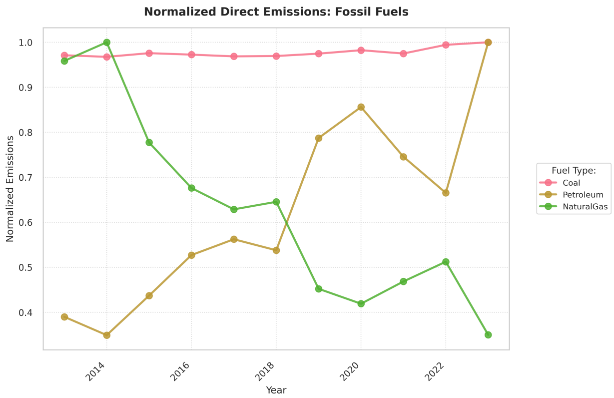
Explanation of terms:

- $\frac{\text{El.Demand}_t}{\text{GDP}_{US,t}}$: Reflects the electricity intensity of economic production. GDP was retrieved from the World Bank (2024). [MWh/$]
- $\frac{\text{El.Demand}_{t-1}}{\text{El.Demand}_t}$: Captures changes in electricity demand year-over-year. Electricity demand was retrieved from U.S. Energy Information Administration (2024d). [dimensionless]
- $\frac{\text{El.Prod}_{j,t-1}}{\text{El.Demand}_{t-1}}$: Share of total electricity demand in year $(t-1)$ fulfilled by technology j. Indicates the established contribution of technology j in meeting electricity demand. Electricity Production was retrieved from U.S. Energy Information Administration (2024j). [dimensionless]
- $\frac{\text{Cap}_{j,t-1}}{\text{El.Prod}_{j,t-1}}$: Inverse of full-load hours, installed capacity per unit of electricity produced by technology j in year $(t-1)$. Represents capacity utilisation efficiency at $(t-1)$. Capacity was retrieved at U.S. Energy Information Administration (2024c). [MW/MWh]
- $\frac{\Delta\text{El.Prod}_{j,t}}{\text{El.Demand}_t}$: Incremental[1] change in electricity production by technology j relative to total electricity demand in year t. Reflects how changes in demand are met by technology-specific production changes. [dimensionless]
- $\frac{\Delta\text{Cap}_{j,t}}{\Delta\text{El.Prod}_{j,t}}$: Incremental change in installed capacity per unit of incremental electricity production for technology j. Indicates the capital intensity of changes in electricity supply. [MW/MWh]
- $\frac{\text{Cap}^{\text{act}}_{j,t}}{\text{Cap}_{j,t}}$: Fraction of nameplate capacity that is actively used to generate electricity for technology j in year t. Reflects actual utilisation of installed capacity. Capacity Factor was retrieved at U.S. Energy Information Administration (2024c). [dimensionless]
- $\frac{\text{El.Prod}_{j,t}}{\text{Cap}^{\text{act}}_{j,t}}$: Annual electricity produced per unit of actively used capacity, representing the actual operational utilisation (full-load hours) of technology j. [MWh/MW]
- $\frac{\text{CO}^{\text{direct}}_{2\text{eq},j,t}}{\text{El.Prod}_{j,t}}$: Direct CO_{2eq} emissions per unit of electricity generated by technology j. Quantifies the direct carbon intensity of electricity production. CO_{2eq} emissions were retrieved from U.S. Energy Information Administration (2024k). [Thousand Metric Tons of CO_2/MWh]

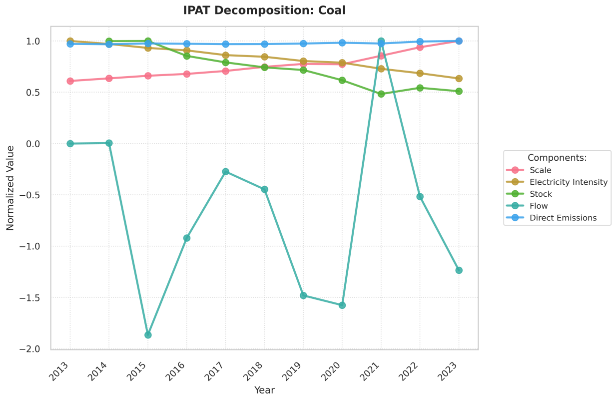
Sources of data

GDP data is taken from (World Bank, 2024), electricity demand from (U.S. Energy Information Administration, 2024e), and generation and emissions from (U.S. Energy Information Administration, 2024h; U.S. Energy Information Administration, 2024i). Capacity values are based on technology-specific factors from (U.S. Energy Information Administration, 2024a).

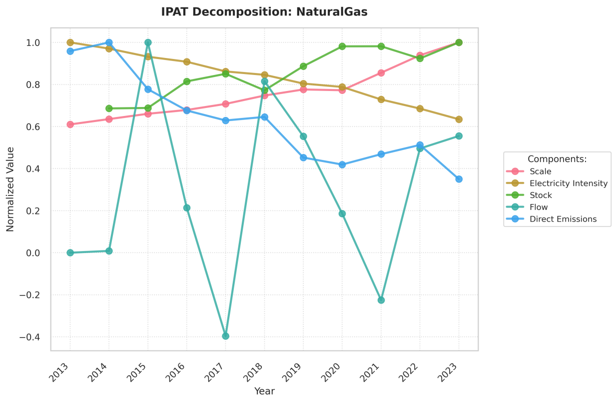
[1] A positive (negative) Δ denotes capacity addition (retirement) from year $(t-1)$ to (t).



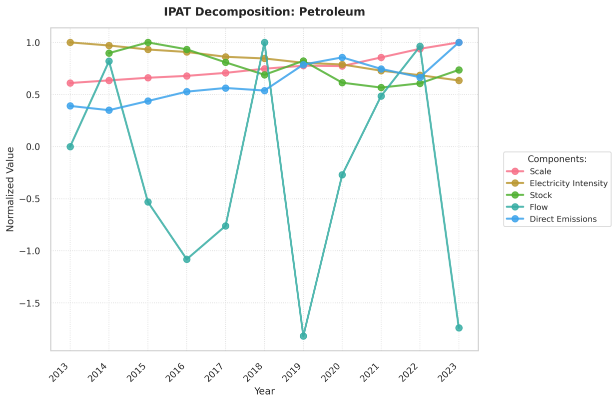
(a) Direct Emissions Trend for Fossil Fuels



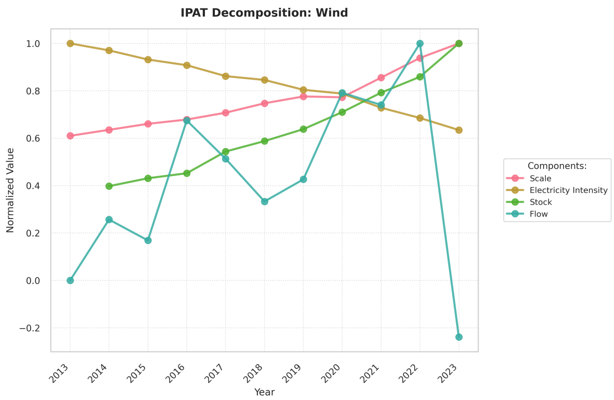
(b) Coal Decomposition



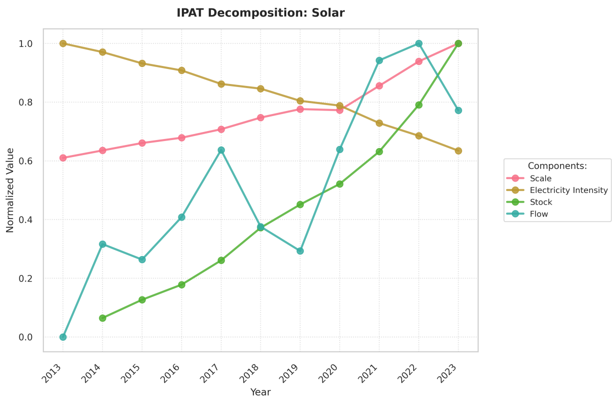
(c) Natural Gas Decomposition



(d) Petroleum Decomposition

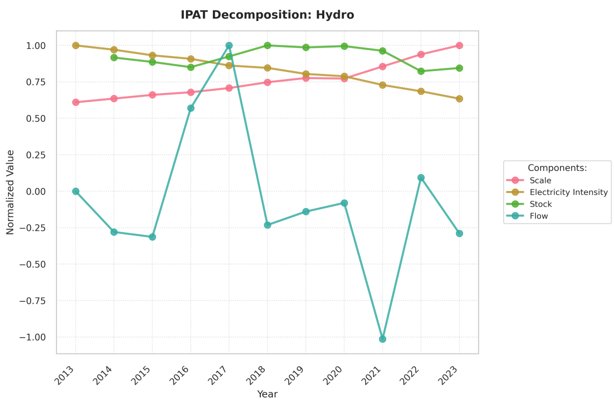


(e) Wind Decomposition

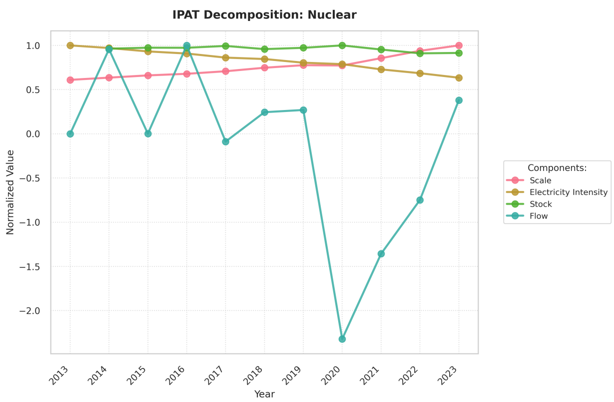


(f) Solar Decomposition

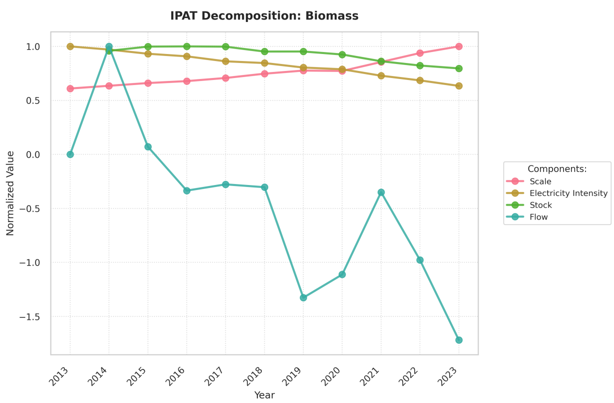
Figure 1: IPAT Decomposition Analysis - Part 1: Fossil Fuels and Major Renewables



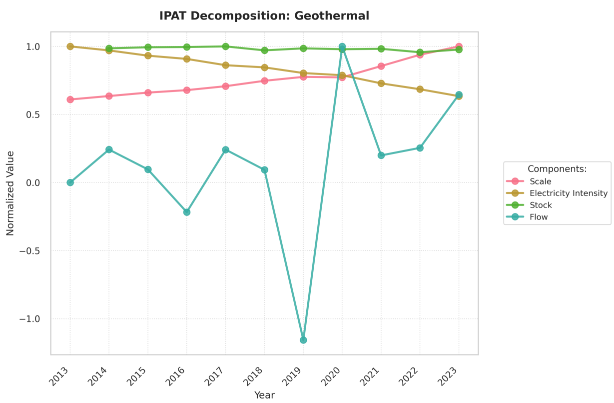
(a) Hydro Decomposition



(b) Nuclear Decomposition



(c) Biomass Decomposition



(d) Geothermal Decomposition

Figure 2: IPAT Decomposition Analysis - Part 2: Other Energy Sources

3.2 Kaya-Decomposition Assumptions

- Direct emissions from electricity generation using clean technologies (e.g., wind, solar, hydro, nuclear) are assumed to be zero.
- Only direct CO_2 emissions and emissions of other greenhouse gases with well-established CO_2 equivalent conversion factors have been considered. Pollutants lacking standardized CO_2 equivalent conversions, such as nitrogen oxide (NO) and sulfur hexafluoride (SF_6), have been excluded from this analysis. This exclusion does not significantly affect the overall results, as these gases constitute only about 2% of emissions by mass and contribute less than 1% to CO_2-equivalent emissions in the electricity sector, even after accounting for their high Global Warming Potentials (U.S. Environmental Protection Agency, 2024c).
- Official data from the Energy Information Administration (EIA) and the Environmental Protection Agency (EPA) on greenhouse gas emissions from other generation sources included in this analysis were either unavailable or reported as negligible (U.S. Environmental Protection Agency, 2024c). As a result, the decomposition focuses exclusively on direct emissions from fossil fuel-based electricity generation.

3.3 Policies Likely to Influence Decomposition Outcomes

A range of recent U.S. energy policies directly affect the factors captured in the decomposition framework. In particular, actions taken under the Trump administration demonstrate a coordinated institutional alignment with fossil fuel expansion. Federal agencies such as the Department of Energy (DOE), Environmental Protection Agency (EPA), and Office of Management and Budget (OMB) have actively advanced the President's energy agenda through regulatory rollbacks, implementation memoranda, and enforcement decisions. These actions confirm that climate policy changes are not confined to executive orders but extend deeply into the administrative apparatus. For a comprehensive inventory of such developments, see the *Climate Backtracker* maintained by Columbia Law School's Sabin Center (Sabin Center for Climate Change Law, 2025a).

However, the scope of the following analysis focuses primarily on estimating how the discontinuation of IRA subsidies is likely to slow the rate of capacity expansion for renewable electricity sources. This is considered alongside the potential effect of deregulation in boosting natural gas extraction, which may further increase the share of electricity generated from fossil fuels.

An executive order titled "Unleashing American Energy" directed the immediate halt in disbursing Inflation Reduction Act funds (The White House, 2025c). While this order signals a major shift in federal priorities, it is important to acknowledge that legal and institutional constraints may limit its full implementation. Nonetheless, even partial rollbacks and the resulting regulatory uncertainty can significantly dampen investor confidence and slow capital flows into clean technologies (Shah, 2025).

3.4 Scenario-Based Emissions Analysis

This section compares the projected impacts of three energy policy scenarios on the U.S. electricity sector's CO_2e emissions trajectory, based on the annual capacity growth assumptions summarized in Table 1. The analysis combines growth-rate inputs with an IPAT decomposition framework to isolate how shifts in generation mix, capacity utilization, and emissions intensity affect overall sectoral emissions.

Table 1: Assumed Annual Capacity Growth Rates by Energy Source (2023–2035)

Energy Source	IRA Scenario	No IRA Scenario	Trump Rollback
Coal	-12 %	-7 %	+2 %
Natural Gas	-5 %	+3 %	+6 %
Petroleum	-15 %	-8 %	+1 %
Solar	+18 %	+10 %	+2 %
Wind	+12 %	+8 %	+1 %
Nuclear	+2 %	-1 %	-3 %

The scenario values for IRA, No-IRA, and Trump Rollback are aligned with projections and expert analysis. The IRA scenario reflects a strong policy push, including over $500 billion in climate and energy investments, leading to rapid deployment of renewables and emissions reductions up to 40% by 2030 (Jenkins et al., 2022). The No-IRA scenario assumes a policy-neutral baseline with slower clean energy adoption, as seen in pre-IRA modeling (Rhodium Group, 2021). The Trump Rollback scenario models a reversal of federal climate policies seen during 2016–2020, including regulatory rollbacks and weakened climate commitments (Brookings Institution, 2020).

Figure 3 illustrates how these differing capacity growth assumptions reshape the U.S. electricity generation mix. Under the IRA scenario, renewables rapidly expand, displacing coal and reducing natural gas reliance. In contrast, the Trump rollback scenario shows an accelerated buildout of natural gas and a stagnation or decline in renewables, with coal experiencing a slight resurgence. The No IRA pathway lies in between, reflecting a policy vacuum where existing market dynamics remain the dominant force.

The observed variations between scenarios result from different policy-driven dynamics, even though one may anticipate that overall electricity generation would converge by 2035 under comparable macroeconomic assumptions. Strong federal subsidies dramatically speed up the electrification of industry, buildings, and transportation in the IRA scenario, raising the demand for power. On the

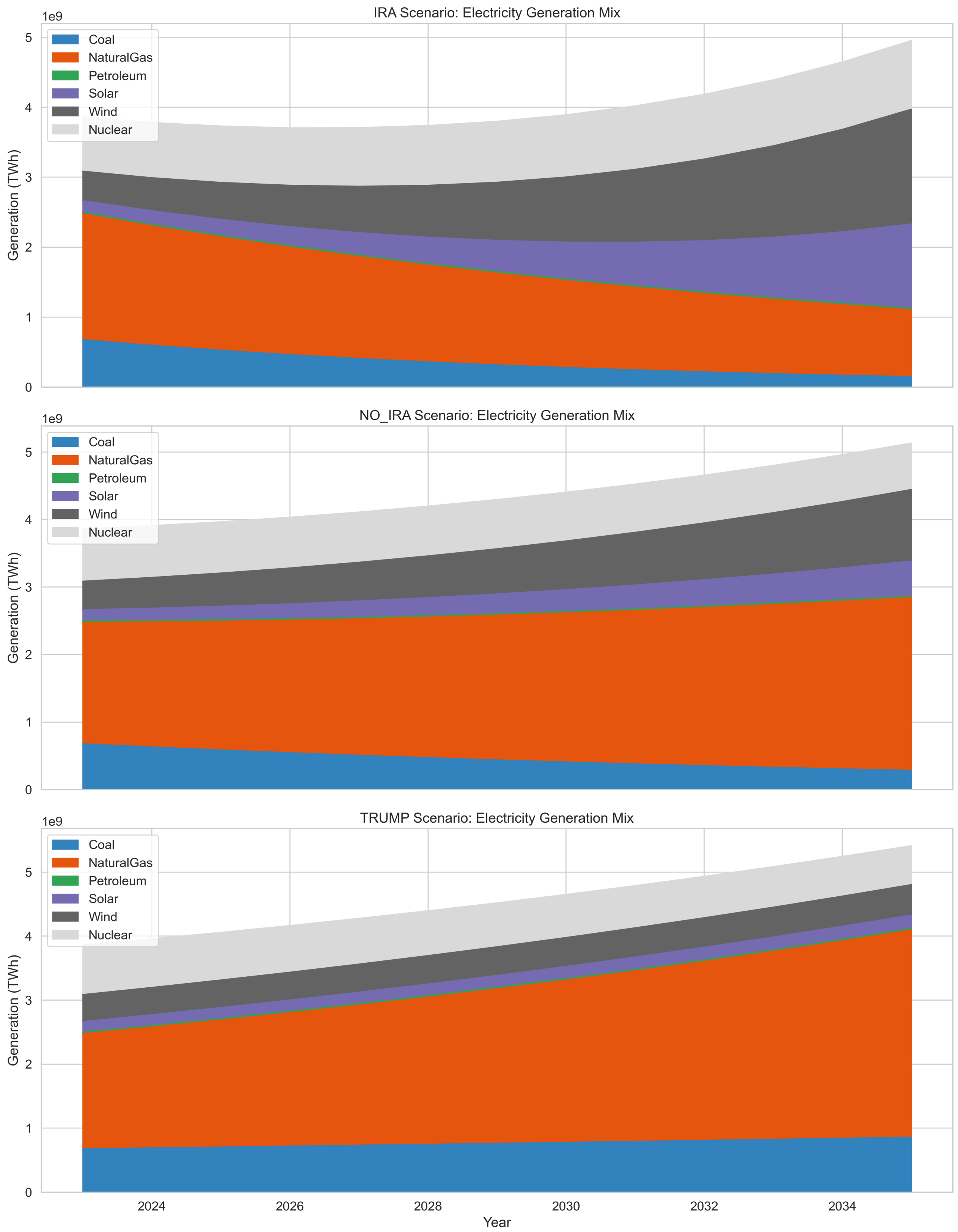


Figure 3: Projected electricity generation mix (TWh) under three policy scenarios: IRA continuation, No IRA, and Trump rollback (2024–2035). The IRA scenario sees a substantial rise in wind and solar; fossil generation declines. Under Trump, natural gas and coal grow sharply.

other hand, slower electrification and lower electricity requirements are the outcomes of the Trump Rollback and No-IRA scenarios. The total generation needed to meet demand also varies depending on the technology mix due to variations in curtailment levels, system losses, and generation efficiency.

These shifts in generation mix translate directly into diverging emissions pathways, as shown in Figure 4. Under the IRA scenario, sector-wide CO_2e emissions decline by approximately 65%, falling from 1.4 billion metric tons (Bt) in 2024 to just under 0.5 Bt by 2035. In contrast, emissions rise steadily under the Trump rollback scenario, reaching nearly 1.8 Bt by 2035, a 30% increase over the same period. The No IRA scenario exhibits modest reductions, with emissions stabilizing around 1.25 Bt, representing a decline of roughly 10% compared to 2024 levels.

These projections underscore the profound role that federal policy direction plays in shaping long-term emissions trajectories. The next subsection decomposes these trends through an IPAT-based framework, quantifying the contribution of each factor, scale, intensity, technology mix, and emissions efficiency, to the observed differences.

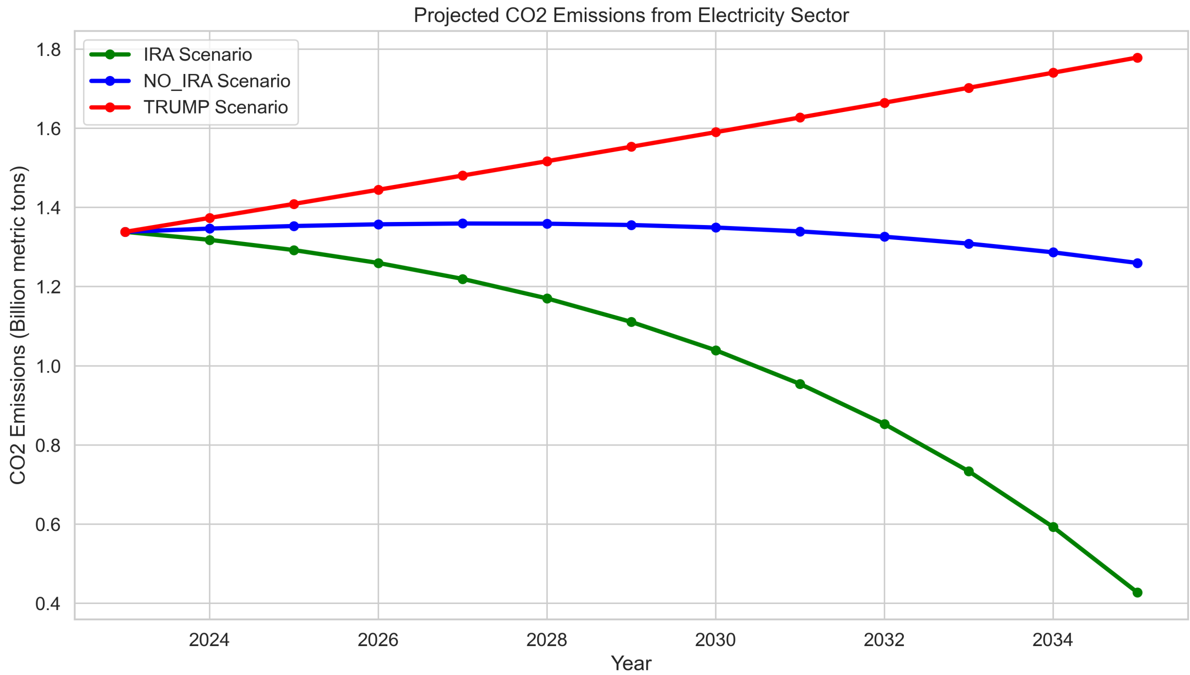


Figure 4: Projected CO_2e emissions from the electricity sector (in billion metric tons, Bt) across three scenarios. IRA policies drive steep decarbonization, while emissions rise steadily under the Trump rollback scenario.

3.4.1 IRA Scenario

In the IRA scenario, total CO_2e emissions from electricity generation decline from approximately 1.4 Bt in 2024 to 0.5 Bt in 2035, representing a reduction of over 65%. This outcome is driven by targeted policy support for renewable energy deployment and fossil fuel phaseout.

The decomposition introduced in Section 3.1 helps quantify the drivers of this decline:

- **Flow Term:** The strong growth in renewable capacity (with annual additions of +18% for solar and +12% for wind) increases $\Delta\text{Cap}_{j,t}$ and $\Delta\text{El.Prod}_{j,t}$, resulting in a dominant negative contribution from the flow component $\left(\frac{\Delta\text{El.Prod}_{j,t}}{\text{El.Demand}_t} \times \frac{\Delta\text{Cap}_{j,t}}{\Delta\text{El.Prod}_{j,t}}\right)$.

- **Electricity-Emission Efficiency:** The average emissions per unit of electricity, $\left(\frac{\text{CO}_{2\text{eq},j,t}^{\text{direct}}}{\text{El.Prod}_{j,t}}\right)$, decrease substantially due to the declining share of coal and gas in the generation mix and increasing contributions from zero-emissions sources.
- **Stock Term:** The existing generation base contributes less to emissions over time as older coal units are retired, reducing the term $\left(\frac{\text{Cap}_{j,t-1}}{\text{El.Prod}_{j,t-1}}\right)$.
- **Electricity Intensity:** The ratio $\left(\frac{\text{El.Demand}_t}{\text{GDP}_{US,t}}\right)$ declines modestly, reflecting improved energy efficiency and structural decoupling of electricity use from economic growth. This trend is driven by a shift toward less energy-intensive service sectors, increased efficiency standards in buildings and appliances, and advances in industrial and digital technologies that lower electricity intensity per unit of output (International Energy Agency, 2022).

Together, these trends demonstrate the compound effect of IRA-aligned policies: accelerating clean energy deployment, retiring high-emission infrastructure, and improving both energy and emissions intensity. The decomposition confirms that decarbonization under the IRA scenario is primarily flow-driven but supported by favorable shifts across all other dimensions of the IPAT identity.

3.4.2 No IRA Scenario

In the No IRA scenario, electricity-sector CO_2e emissions remain relatively stable, decreasing only marginally. This stagnation reflects the absence of strong federal policy signals: IRA subsidies are not implemented, but neither is there an active rollback or expansion of fossil fuels as seen under the Trump rollback case below.

The decomposition introduced in Section 3.1 helps identify the structural drivers behind this trend:

- **Flow Term:** Moderate growth in renewables (+10% for solar, +8% for wind) contributes to some emissions reduction, but the effect is limited in scale and significantly weaker than under the IRA scenario. The incremental term $\left(\frac{\Delta\text{El.Prod}_{j,t}}{\text{El.Demand}_t} \times \frac{\Delta\text{Cap}_{j,t}}{\Delta\text{El.Prod}_{j,t}}\right)$ plays only a minor role in shifting the generation mix.
- **Electricity-Emission Efficiency:** The ratio $\left(\frac{\text{CO}_{2\text{eq},j,t}^{\text{direct}}}{\text{El.Prod}_{j,t}}\right)$ decreases only slightly, as coal and natural gas continue to account for a large share of generation through 2035.
- **Stock Term:** The contribution of legacy infrastructure remains significant. Retirements proceed slowly, with gas capacity continuing to rise and coal declining only moderately, limiting reductions in $\left(\frac{\text{Cap}_{j,t-1}}{\text{El.Prod}_{j,t-1}}\right)$.
- **Electricity Intensity:** The term $\left(\frac{\text{El.Demand}_t}{\text{GDP}_{US,t}}\right)$ shows little improvement, reflecting limited gains in end-use energy efficiency and stagnant demand-side policies.

This scenario highlights the consequences of policy inertia: without strong incentives or mandates, structural change occurs only incrementally. While market forces continue to support slow renewable growth, the pace is insufficient to significantly bend the emissions trajectory.

3.4.3 Trump Rollback Scenario

In the Trump rollback scenario, emissions from the electricity sector rise sharply, from 1.4 Bt in 2024 to nearly 1.8 Bt by 2035, marking a 30% increase over the period. This outcome reflects an aggressive policy shift favoring fossil fuels: IRA subsidies are repealed, environmental regulations weakened, and permitting for coal and gas projects fast-tracked.

Using the decomposition introduced in Section 3.1, the key drivers of this increase can be identified:

- **Flow Term:** The incremental capacity term $\left(\frac{\Delta \text{El.Prod}_{j,t}}{\text{El.Demand}_t} \times \frac{\Delta \text{Cap}_{j,t}}{\Delta \text{El.Prod}_{j,t}}\right)$ contributes positively to emissions, as new generation is dominated by high-carbon sources. Coal and gas both see net capacity increases (+2% and +6% annually, respectively), while renewable growth nearly stalls.
- **Electricity-Emission Efficiency:** The emissions intensity term $\left(\frac{\text{CO}_{2\text{eq},j,t}^{\text{direct}}}{\text{El.Prod}_{j,t}}\right)$ deteriorates, as the generation mix shifts back toward higher-emitting fossil sources, particularly coal, which emits over twice as much CO_2 per MWh as gas.
- **Stock Term:** Legacy fossil infrastructure, including older coal plants reactivated or kept online longer than scheduled, maintains a high baseline of emissions. As a result, the stock term $\left(\frac{\text{Cap}_{j,t-1}}{\text{El.Prod}_{j,t-1}}\right)$ contributes strongly to the emissions rise.
- **Electricity Intensity:** Electricity demand grows in line with GDP, with no significant policy measures to improve efficiency or manage load. Consequently, the ratio $\left(\frac{\text{El.Demand}_t}{\text{GDP}_{US,t}}\right)$ remains flat or increases slightly, reinforcing the emissions trajectory.

This scenario illustrates the emissions impact of reversing climate-oriented policies and re-expanding fossil fuel use. The decomposition confirms that both stock and flow dynamics are aligned toward higher emissions, with minimal counterbalancing from efficiency or technology improvements.

3.5 Summary of Decomposition Drivers Across Scenarios

Table 2: Qualitative contribution of IPAT decomposition terms across scenarios. "Negative" indicates a reduction in emissions; "Positive" indicates an increase.

Decomposition Term	IRA	No IRA	Trump Rollback
Flow (New Capacity)	Strong Negative	Moderate Negative	Strong Positive
Electricity-Emission Efficiency	Decreasing	Slightly Decreasing	Increasing
Stock (Legacy Infrastructure)	Mild Negative	Flat	Strong Positive
Electricity Intensity	Declining	Stable	Slight Increase

From Power to Mobility: Linking Electricity and Transport Emissions

While electricity generation remains the largest contributor to U.S. energy-related CO_2e emissions, the transportation sector follows closely, and the two are increasingly interconnected through the electrification of vehicles. As such, the decarbonization of the power sector directly amplifies the climate benefits of electric vehicle (EV) adoption.

The following section applies a sector-specific IPAT decomposition to transportation emissions from light-duty vehicles (LDVs), assessing how contrasting policy trajectories are likely to shape vehicle fleet composition, energy efficiency, and the carbon intensity of electricity used for EVs.

4 Political and Institutional Lock-in Effects in the Electricity Generation Sector

Beyond our decomposition analysis—which highlights possible *specifically* IRA-driven scenarios—in this section we examine how political change shapes short- and medium-run power generation by conditioning the **degree of lock-in** across different technologies.

4.1 Lock-In Effects: Carbon and Renewable Lock-In

Carbon lock-in in the power sector has been extensively examined since the early 2000s, when (Unruh, 2000; Unruh, 2002) described a self-reinforcing configuration of technological, institutional, and social forces which—while rooted in CO_2-emitting infrastructures—entails environmental as well as health and economic externalities (Bertrand, 2021), thereby creating path-dependent inertia that impedes the deployment of zero-emission generation.

This lock-in dynamic is often caused by **path-dependent** mechanisms: past choices and sunk investments generate self-reinforcing dynamics that impede large-scale shifts (Cecere et al., 2014; Seto et al., 2016). The literature identifies several mechanisms that *initiate* path dependence—namely (i) economies of scale; (ii) learning-by-doing; (iii) network externalities and complementarities; and (iv) coordination requirements, standards, and switching costs. These mechanisms in turn create **a self reinforcing positive feedback**: scale and learning reduce costs, network effects raise the value of the incumbent system, and institutional arrangements reinforce compatibility—together amplifying adoption and entrenching the prevailing trajectory (Fisch-Romito et al., 2021; Pierson, 2000).
Nevertheless, some **negative feedbacks** push in the opposite direction—namely, growing social-acceptance constraints and community pushback as the footprint of carbon-intensive generation expands; fuel-price competition, where sustained low natural-gas prices displaced coal as the main source of electricity generation in U.S.; and diminishing returns in mature carbon technologies, where capacity-factor erosion and slower learning raise unit costs for incumbents (Selby, 2019; Zhang et al., 2022).

Lock-ins should not be viewed as static or permanent; they can emerge, persist, and dissolve or transform as technologies, policies, information, and markets evolve. Therefore they should be analyzed as system-embedded processes shaped by multiple factors evolving over time and occurring at niche, system and landscape levels (Bessi et al., 2021). This shift has enabled more effective strategies for addressing lock-ins and advancing transitions to more sustainable, adaptable systems (Seto et al., 2016).

Recent work extends this lens to renewables, showing that historical, technological, economic, and regulatory factors can also affect clean technologies (Eitan et al., 2023). While carbon lock-in has unambiguously adverse environmental implications that must be addressed (Unruh, 2002), **renewable-energy lock-in** has a dual nature: on one side it provides investment certainty, lowers transaction costs, and facilitates capital formation; on the other, it can constrain flexibility and hinder subsequent transitions to superior options or system designs (Eitan et al., 2023).

We now turn to **institutional lock-in**, defined as *"the lock-in associated with governance, institutions, and decision-making that affect energy-related production and consumption, thereby shaping energy supply and demand"* (Seto et al., 2016, p. 427), and we focus specifically on government influence in the U.S. electricity generation sector. Here, "institutional" is interpreted narrowly as political–administrative mechanisms at the federal level together with their extension into agencies via leadership appointments and management directives. Importantly, institutional, technological, and social lock-ins are **interdependent and mutually reinforcing**; progress in one domain typically requires complementary changes in the others, because inertia in the remaining spheres can dampen or reverse gains (Seto et al., 2016). Namely, a policy that subsidizes construction of a coal-fired power plant not only embeds an **institutional** lock-in often through dedicated policies (authorizations, long-term contracting, fiscal support) but also creates a **technological** one through long-lived physical infrastructure. By design, these assets have multidecade lifetimes (Fisch-Romito et al., 2021). For example, coal and gas plants typically operate for roughly 50 and 40 years, respectively, entrenching technology choices for decades (see Secs. 4.3.1 and 4.3.2).

4.2 Assessing the Degree of Political Lock-in in the U.S.

In line with our analysis, we assess politically induced lock-in by comparing the last two federal terms, along with the current one. A core insight in the literature is that analysts often *overestimate* how much federal action alone determines power-sector outcomes. This applies especially to Trump's pro-fossil fuel stance, given multiple veto points–understood as institutional decision nodes and empowered actors capable of blocking, diluting, delaying, or reversing President's initiatives (Selby, 2019; MacNeil et al., 2019)–but in part also to the limitations that even Biden had encountered to promote the transition (Cha et al., 2022). We organize the discussion around these constraints and draw implications for lock-in.

Why federal initiatives encounter veto points.

- **Congress.** Because executive orders are issued—and revoked—by the president alone, they can bypass Congress but lack the durability and stability of statutes (Bomberg, 2021). They are frequently undone by a subsequent administration of the opposite party, as seen across the recent Trump–Biden–Trump transitions (Sabin Center for Climate Change Law, 2025a; Sabin Center for Climate Change Law, 2025b; Sabin Center for Climate Change Law, 2025c). By contrast, President Biden advanced several major initiatives through legislation—most notably the BIL and the IRA—making them harder to reverse, since repeal would require new congressional action (Climate Action Tracker, 2024). Nonetheless, even during Biden's term, Congress constrained efforts to scale up federal support for the transition (Cha et al., 2022).
- **Courts.** Although Trump's first term saw eighty-four reversal actions –executed through what has been defined by Thompson et al. (2020) "*search-and-destroy*" strategy targeting prior rules and funding streams viewed as burdensome to fossil interests – 48% triggered litigation (Yozwiak et al., 2021). This litigation—often led by state attorneys general—frequently *delayed or blocked* high-profile actions, including the solar panel tariffs and the rollback of the Obama-era GHG emissions measure (Yozwiak et al., 2021). As a result, many Trump-era reversals were halted before Biden's election, with similar dynamics in the current term (Guarna et al., 2025).
- **Administrative resilience.** Agency procedures, scientific norms, and appropriations oversight limited attempts to redirect EPA and other environmental institutions through the appointment of climate skeptics to his cabinet (Bomberg, 2021).
- **State policy.** South et al. (2021) highlight the importance of state-level programs that establish explicit GHG targets, often pursued through investments in cleaner power technologies. Subnational initiatives—such as California's cap-and-trade program designed to reduce GHG emissions through investments in clean technologies (California Air Resources Board, 2025), state renewable portfolio standards (RPSs) requiring utilities to source a fixed share of electricity from renewables (National Conference of State Legislatures, 2025), or the U.S. Climate Alliance (USCA)—a coalition of 17 states pledging to ignore Trump's first withdrawal from the Paris Agreement—have frequently compensated for federal inaction. As early movers invest time, money, and administrative capacity to design and pilot thousands of programs, they generate practical knowledge and implementation know-how that lowers costs and barriers for other jurisdictions—including Washington—to adopt similar climate policies in the future, thus enabling the so-called **"policy learning"** (MacNeil et al., 2019, p. 13).
  Even so, state leadership did not preclude consequential federal interventions. The Trump

administration advanced measures that set a national floor and asserted *preemption* over stricter state rules, narrowing state discretion (Yozwiak et al., 2021). Moreover, the states taking a proactive stance on climate action largely exclude laggards with different political sensibilities toward climate policy (see Fig. 5); in the absence of federal requirements, these states fail to adopt structured climate measures, hindering the transition (Bomberg, 2021).

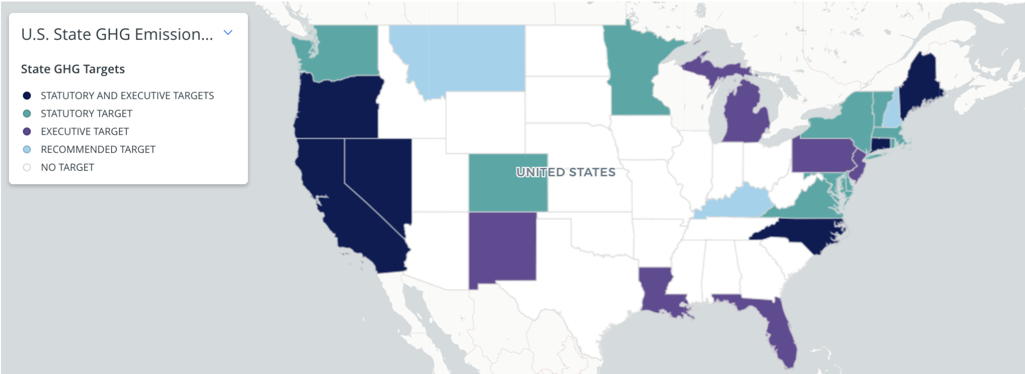


Figure 5: U.S. State greenhouse gas (GHG) emissions targets (statutory and executive targets, statutory-only, executive-only, recommended, or no target). Source: Center for Climate and Energy Solutions (C2ES), 2024, U.S. State Greenhouse Gas Emissions Targets.

- **Markets.** Fuel and technology cost trends—especially cheap natural gas and falling renewable capex—shift dispatch and retirement economics independent of federal swings, reinforcing coal exit and limiting the effect of attempted reversals (see Section 4.3 for a detailed analysis) (U.S. Energy Information Administration, 2018; Galik et al., 2017).

Despite these veto points, it would be wrong to conclude that federal action has no effect on climate policy. **Both presidencies influenced the transition through lock-in**, though in opposite directions. As Bomberg (2021, p. 636) argues, Trump's most enduring impact is an "ideational legacy", intended as the use of narrative devices that vilify opponents and distort the core ideas, values, norms, and principles underpinning U.S. environmental and climate policy. The power of such discursive framing to shape energy pathways has been widely emphasized also as a lever to shift away from carbon lock-in (Buschmann et al., 2019). Climate-change denialism, embedded in broader culture-war identity politics, turns climate policy into a proxy for anti-regulatory, anti-expert, and nationalist grievances rather than an evidence-based debate, leading to a twofold negative effect (Bomberg, 2021). On the one hand, it dampens investment in green power projects and slows the shift of generation capacity toward renewables—affecting both the *flow* (additions and retirements) and the *stock* term of the decomposition discussed in Sec. 3.1. On the other hand, it weakens consumer shifts toward sufficiency, shaping the carbon intensity of lifestyles—salient given that households account for 38% of U.S. electricity consumption—and thus influences the energy-intensity component in Sec. 3.1. (Selby, 2019; Seto et al., 2016; International Energy Agency, 2025).

Although power-sector emissions fell during Trump's first term (see Fig. 6), the decline was insufficient to meet long-term requirements (Climate Action Tracker, 2024). Even a relative pause in an otherwise steeper downward trajectory shifts the burden to later years and heightens risk amid uncertain climate impacts. In the **short term**, some institutional **lock-ins are less visible**—though certain actions (e.g., replacing the Clean Power Plan (CPP)—which defined the best system of emission reduction (BSER) across three building blocks: improving plant carbon intensity, shifting generation from coal to natural gas, and expanding renewables—with the Affordable Clean Energy (ACE) rule that confined BSER to heat-rate improvements at individual existing coal plants and also increasing GHG emission limits for new power plants) likely increased emissions relative to the counterfactual—while the more consequential effects accumulate over the long run (Yozwiak et al., 2021; Galik et al., 2017). On the contrary, meeting net-zero by 2050 and limiting warming to 1.5°C require greater, immediate federal effort; absent such action, lock-in steepens the future abatement path and forces more dramatic effort later (Bomberg, 2021; Galik et al., 2017; Climate Action Tracker, 2024).

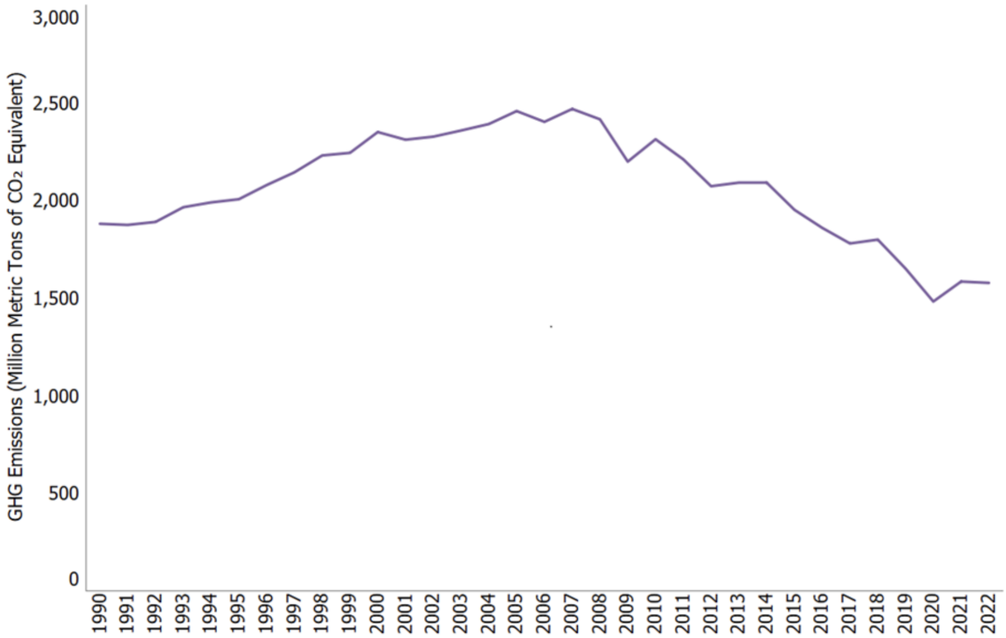


Figure 6: Greenhouse Gas Emissions from Electric Power, 1990-2022. Source: EPA Electric Power Sector Emissions *(U.S. Environmental Protection Agency, 2024b).*

Moreover, policy feedbacks tied to **interest groups** reinforced these outcomes (Lockwood, 2022). Under Trump, deliberate **protection** and **subsidization** of **fossil interests** preserved an advantage over increasingly cost-competitive renewables—an ecologically and socially suboptimal result that institutional arrangements amplified and then locked in through self-reinforcing feedbacks (Chen et al., 2021; Skovgaard et al., 2019). The interdependence of actors, interests, and institutions thus contributes to the stickiness and penetration of federal policies (Bomberg, 2021; Cha et al., 2022).

By contrast, Biden's term followed a two-part strategy. First, it sought to remove existing institutional lock-ins that impede decarbonization. Second, it aimed to cultivate new institutional lock-ins that stabilize a cleaner trajectory once momentum builds (Seto et al., 2016). The administration adopted a "*Whole-of-Government*" approach in which agencies coordinated under White House direction, while broad consensus-building sought to secure legitimacy across sectors and stakeholders (Cha et al., 2022; South et al., 2021). Policy design combined regulatory measures, such as technology mandates and **performance standards**, with technology policies that expand research and development (Fisch-Romito et al., 2021). In addition, the Inflation Reduction Act attracted large volumes of **private investment**, creating policy and subsidy feedbacks that strengthen a lock-in around renewables (see Sec. 2.2) (Goldman Sachs Research, 2023; Lockwood, 2022).

With the reelection of Trump and the recent reversal of some renewables incentives granted by IRA (Simpson Thacher & Bartlett LLP, 2025), a climate of uncertainty has risen (Britton et al., 2025). This uncertainty itself becomes a driver of lock-in (Seto et al., 2016): faced with policy instability, some actors will stick to familiar investments (like natural gas plants) deemed safer under lenient regimes, potentially over-building fossil capacity that later becomes **stranded**–i.e., unable to recover sunk capital or operate economically as policy tightens, fuel prices shift, or cheaper competitors diffuse (see Sec. 4.4). Others may hesitate to invest in innovative clean technologies without assurance that supportive policies will endure long enough to recoup costs (MacNeil et al., 2019).

However, important **limits** of inference remain. Federal policy often evolves beyond initial commitments and must contend with implementation realities. A central limitation of this analysis is the difficulty of **isolating the effect of any single policy** or decision—such as withdrawal from the Paris Agreement—from concurrent influences and trends (Pickering et al., 2018). **Long lags** between announcement and implementation, and the multiyear timelines for adding or retiring electricity capacity, mean that the effects of executive orders and rollbacks may surface only after the presidency in which they were initiated (see Fig. 7). **External shocks** can also reroute priorities, as illustrated by the invasion of Ukraine and the COVID-19 pandemic (Selby, 2019). The resulting shifts are evident in the push to expand U.S. LNG production and exports to meet European demand after the curtailment of Russian gas—an adjustment that began under the Biden administration and continued under Trump (Cha et al., 2022; Mathiesen et al., 2025).

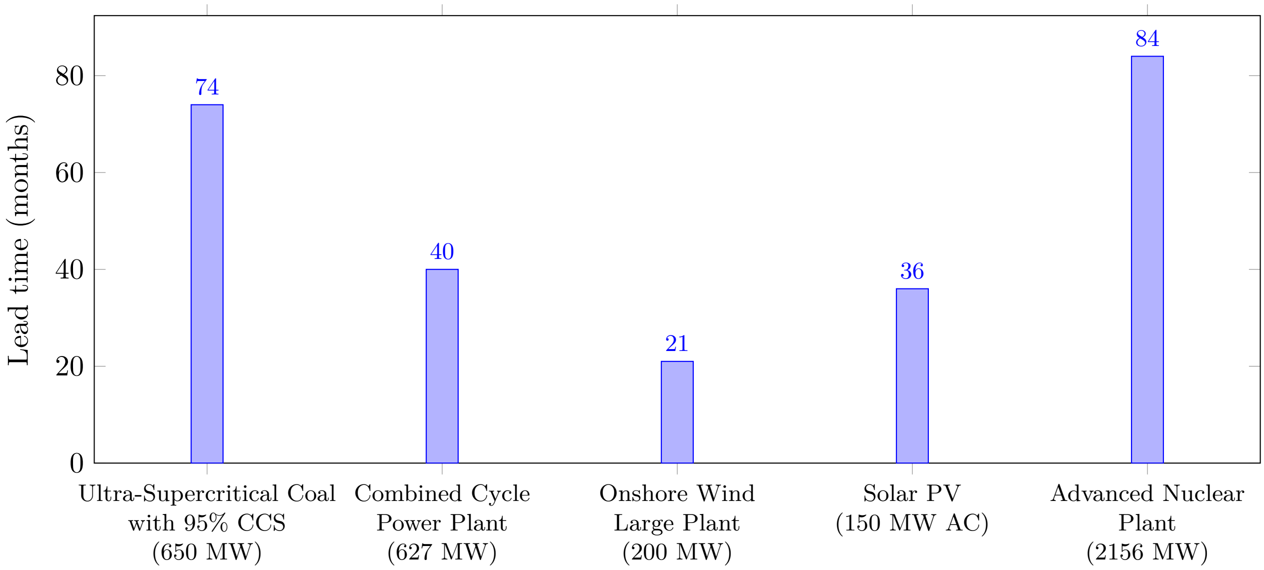


Figure 7: Estimated total lead time before commercial operation date (COD) for utility-scale projects by technology (months). Source: Graph derived from Capital Cost and Performance Characteristic Estimates for Utility-Scale Electric Power Generating Technologies (U.S. Energy Information Administration, 2024b).

Building on this framework, the next subsection assesses technology-specific lock-in risks across the major sources that together generated about 93% of U.S. electricity in 2023 (U.S. Energy Information Administration, 2023d).

4.3 Different Energy Sources Lock-in Effects Degree

4.3.1 Coal

After petroleum—which accounts for only 0.4% of total electricity generation in 2023—coal-fired power plants are the **most carbon-intensive** major source of electricity (see the *electricity-emission efficiency* term in Sec. 3.1) (U.S. Energy Information Administration, 2023d). Thus, tracking capacity trends over time is essential to understand the degree of coal lock-in.

U.S. coal units typically operate for about 50 years, and as of 2021 the average operating unit was 45 years old. The **long lifetime** creates technological lock-in (Seto et al., 2016), yet much of the fleet was built in the 1970s–1980s with only modest additions in the early 2000s, so a large share is nearing end of life (U.S. Energy Information Administration, 2021a).

This trajectory reflects both **market** and **regulatory** forces (Selby, 2019). Cheap natural gas and renewables, together with environmental rules, rendered much of the coal fleet uneconomic or non-compliant. Over 100 GW of coal capacity retired between 2002 and 2021, and no new coal capacity has been added since 2013 (Climate Action Tracker, 2024).

Trump's ACE rule could have fostered coal lock-in by focusing on efficiency upgrades at existing plants rather than shifting generation toward lower-carbon sources. In practice, it did not alter underlying economics: renewable costs continued to fall and natural gas retained a cost advantage; strong state policies kept pushing GHG reductions; and legal uncertainty led many operators to plan for CPP-consistent targets in case ACE was struck down (Yozwiak et al., 2021). Coal retirements therefore continued, although with minor timing delays at the margins (Galik et al., 2017). The same pattern holds in the current term: 2025 analyses find Trump-era interventions produced only small extensions to some retirement dates—a modest slowdown in coal's decline, not a reversal (Gearino, 2025). For example, the 1.56 GW Campbell plant received a 90-day extension under a U.S. Secretary of Energy emergency order issued pursuant to Trump's *Declaring a National Energy Emergency*, to keep regional capacity from dipping below 2024 levels (Leach, 2025). Additional DOE emergency orders similarly kept other plants online beyond planned shutdowns, prioritizing short-term adequacy over environmental concerns—an unprecedented frequency of such orders (Lavelle et al., 2025). These actions likely postpone, rather than prevent, exit; they underscore that coal's near-term viability hinges on policy preference more than on competitiveness.

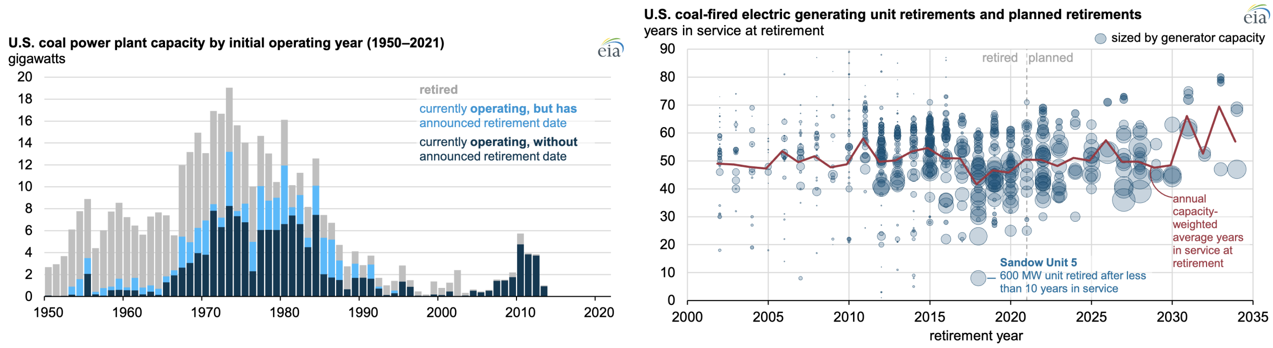


Figure 8: U.S. coal fleet age profile and retirements. Source: U.S. Energy Information Administration, Preliminary Monthly Electric Generator Inventory, September 2021. (U.S. Energy Information Administration, 2021b)

Coal-directed subsidies are another lock-in channel (Seto et al., 2016). Even if direct subsidies constitute a smaller share, coal in the U.S. still benefits from support; when externalities are considered, such support lowers effective prices through tax breaks and production incentives and disadvantages lower-carbon options, thereby raising emissions (Robertson, 2022; Skovgaard et al., 2019; Vernon et al., 2021). However, fuel prices alone have not reversed the trend. U.S. coal for power fell from about $2.11/MMBtu in 2016 to $1.92/MMBtu in 2020, but total generation costs are driven by *O&M*, capital, and aging-related expenses that keep coal relatively expensive versus alternatives (U.S. Energy Information Administration, 2023b; U.S. Environmental Protection Agency, 2025). Furthermore, the Biden administration pledged to identify and suspend these subsidies (Climate Action Tracker, 2024). Namely, with the expiration of the refined coal production tax credit in 2022, the production as well as the consumption of coal plummeted, thus resulting in a fall in the share of electricity generated using refined coal (U.S. Energy Information Administration, 2022d).

As far as new capacity additions are concerned, EIA reports that supercritical coal—despite higher efficiency—has among the **highest** Levelized Cost of Electricity (**LCOE**) of major technologies amounting at $82.61. According to definition given by U.S. Energy Information Administration, 2022b, p. 1, this indicator represents the *"average revenue per unit of electricity generated that would be required to recover the costs of building and operating a generating plant and a battery storage facility, respectively, during an assumed financial life of the plant"*. For reference, coal came just after biomass, at about $90.17/MWh, and offshore wind at $105.38/MWh (U.S. Energy Information Administration, 2022b). Interestingly, in EIA's newer LCOE projections, supercritical coal no longer appears among the candidate technologies, signaling a continued shift away from this form of generation (U.S. Energy Information Administration, 2025a).

Policy moves to expand drilling areas and ease permitting also added abundant, cheap natural gas supply, further eroding coal's competitiveness (MacNeil et al., 2019). Capacity-factor (CF) trends-which are evidenced as a way to move away from carbon lock-in (Seto et al., 2016)- tell the same story: coal's **average CF fell** from roughly 53% in 2017 to 40.5% in 2021, consistent with a shift toward a residual or backup role (see Sec. 3.1) (U.S. Energy Information Administration, 2023d).

Looking ahead, coal's generation share is expected to keep declining regardless of partisan control, as efficient gas capacity enters and the costs of renewables and storage continue to fall; retirements will also be driven by age, with the average retiring unit around 54 years old (U.S. Energy Information Administration, 2024g; Loomis, Sayles & Company, L.P., 2020).

4.3.2 Natural Gas

Natural **gas–fired generation expanded rapidly in the 2000s–2010s** as hydraulic fracturing and horizontal drilling lowered fuel costs (from roughly $8/MMBtu on average in the 2000s to about $4/MMBtu in the 2010s) and largely displaced coal as a form of electricity generation (Galik et al., 2017; Selby, 2019). Gas plants now supply the largest share of U.S. electricity, amounting at 43.1% in 2023 (U.S. Energy Information Administration, 2023d). This prominence creates **technological lock-in**: the grid depends on gas for reliability, and an extensive supporting infrastructure—pipelines, storage, and LNG facilities—has been built around steady or growing demand (Seto et al., 2016). Pipeline and plant investments are mutually reinforcing: new pipelines enable additional plants, while new plants justify pipeline expansions, and once built, there is pressure to keep those assets utilized to recover sunk costs.

Gas plants typically have **shorter lifetimes than coal units** (on the order of 40 years), and many combined-cycle installations from the 2010s will remain in service into the 2040s. Utilities and merchant generators therefore have significant capital at stake and anticipate cost recovery over decades, which strengthens constituencies favoring continued gas use (Selby, 2019).

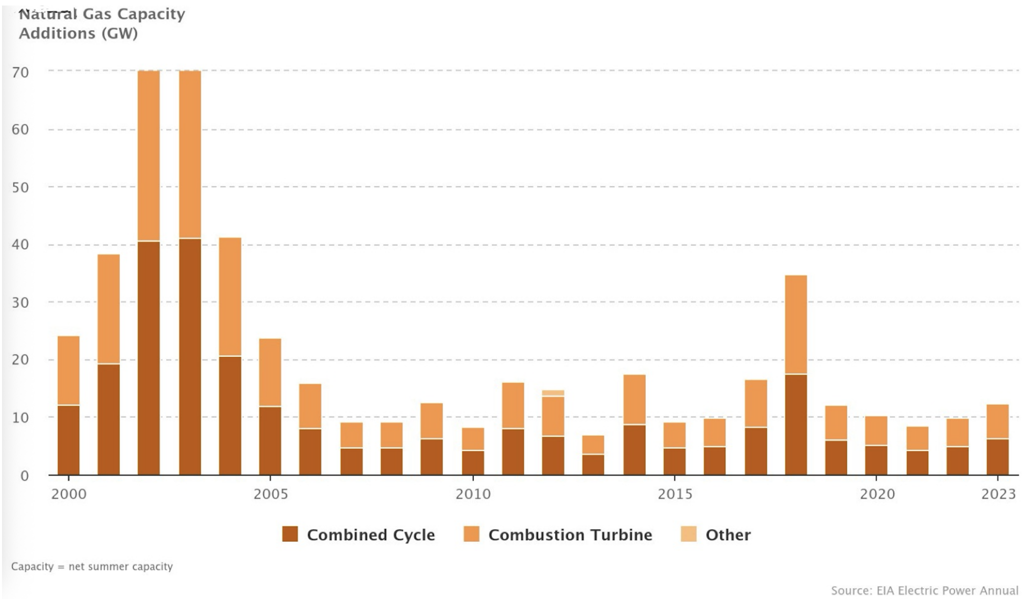


Figure 9: After a large build-out in the early 2000s, natural gas construction remains steady: annual U.S. natural gas capacity additions (GW) by technology. Source: EIA Electric Power Annual *(U.S. Environmental Protection Agency, 2025).*

Policy signals have generally **supported this trajectory**. Under Trump, the federal government expanded drilling access on public lands and sought to streamline environmental reviews for fracking, creating a favorable regulatory environment for gas even though a number of actions were blocked or modified (Yozwiak et al., 2021; MacNeil et al., 2019; World Economic Forum, 2025). While the Biden administration reinstated methane rules to curb the potent warming effects of methane, it also advanced fossil development—approving drilling in Alaska, issuing leases in Wyoming, allowing the Dakota Access Pipeline and Line 3 to continue operating, and in 2021 presiding over one of the largest oil-and-gas lease sales in U.S. history (Sabin Center for Climate Change Law, 2025c; Martin, 2021; Cha et al., 2022). These decisions, alongside market fundamentals, help explain gas's continuing role as the **system's flexible backstop** while IRA-driven incentives direct most *new* capacity additions toward renewables. Combined-cycle gas plants commonly serve both base and peak loads due to high efficiency and suitability for extended operation (U.S. Energy Information Administration, 2023c). By 2024, EPA had proposed CO_2 standards that would pressure new gas plants to adopt carbon capture in the 2030s, although these rules were not yet in effect (Climate Action Tracker, 2024).

On the technology mix, natural-gas combined-cycle (NGCC) units have replaced much of the older simple-cycle fleet; by 2023, NGCC comprised about 59% of total gas capacity, improving average emissions intensity relative to older configurations (see Sec. 3.1) (U.S. Environmental Protection Agency, 2025). Utilization has also risen: the **average capacity factor increased** from roughly 34% in 2016 to 40.7% in 2023, reinforcing operational lock-in (see Sec. 3.1).

In cost terms, EIA estimates a federal average LCOE of about $64.55/MWh for new NGCC, while NGCC equipped with carbon capture technology can be lower (about $48.78/MWh) when enhanced IRA tax credits are included; these levels keep gas **broadly competitive with onshore wind and utility-scale solar**, depending on local conditions (U.S. Energy Information Administration, 2025a; U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, 2023).

Overall, as with coal's decline being driven chiefly by market forces, the growth of gas has been led by economics and then reinforced by policy and regulatory choices that, across administrations, have tended to preserve its role as a large, dispatchable share of supply—often providing quasi-baseload service via NGCC fleets (Yozwiak et al., 2021; U.S. Environmental Protection Agency, 2025).

This feeds a wider debate on whether **gas serves as a bridge in the power transition** (Gürsan et al., 2021). Cross-country evidence often shows an inverted-U trajectory for gas in power—growth followed by a peak and decline—whereas in the United States that plateau has not yet been reached (Bessi et al., 2021).
Compared with renewables growth, U.S. natural gas has maintained a dominant role; moreover, renewables expansion often co-evolves with gas in a *collaborativ*e relationship, meaning that rising RE output reinforces gas's system role (e.g., firming and flexibility) (Bessi et al., 2021). As a result, the expected bridge phase—when gas peaks and then declines as renewables and storage scale—has not yet clearly begun in the United States, with gas still on the rise (Gürsan et al., 2021).

4.3.3 Nuclear

The United States hosts the world's largest commercial nuclear fleet—about 97 GW of installed capacity. In 2023, those reactors generated nearly 19% of U.S. electricity, making nuclear the second-largest source after natural gas (U.S. Energy Information Administration, 2023d).

Nuclear has long **enjoyed bipartisan rhetorical support**, though the strength and form of practical backing have varied across administrations (Behr et al., 2024). During President Trump's first term, ideas to subsidize at-risk nuclear units circulated, but no broad federal bailout for nuclear materialized and policy attention tilted more toward coal (Selby, 2019; Yozwiak et al., 2021). In his current term, the White House signaled a stronger push for nuclear expansion through directives to accelerate licensing, demonstration, and testing, setting an aspirational target of 400 GW of installed capacity by 2050 (The White House, 2025b; U.S. Department of Energy, Office of Nuclear Energy, 2025).

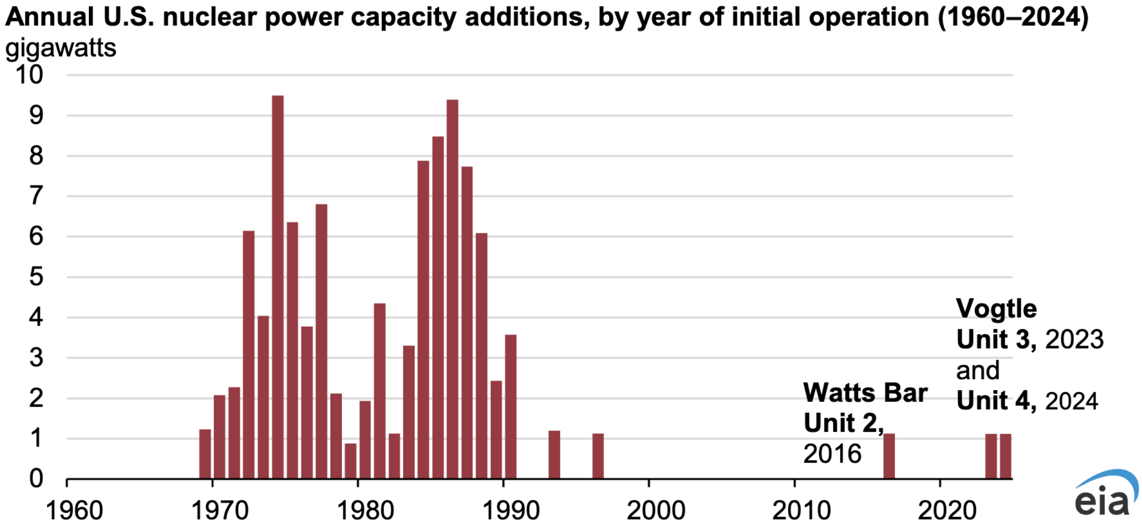


Figure 10: Source: U.S. Energy Information Administration, Annual Electric Generator Report. (U.S. Energy Information Administration, 2024f)

This favorable regulatory framework induces a form of institutional lock-in that lies in continuation with the measures adopted under President Biden that seek to stabilize existing plants and de-risk new investment. Namely, the Bipartisan Infrastructure Law allocated \$6 billion to prevent premature retirements at NRC-certified safe facilities (U.S. Energy Information Administration, 2022c). Furthermore, the Inflation Reduction Act added a zero-emission Nuclear Production Tax Credit for existing units and expanded loan and credit support that can finance new nuclear alongside renewables and carbon-capture projects (U.S. Environmental Protection Agency, 2023).

Despite supportive policy signals, **large-scale deployment is constrained by timelines and cost**. The *total lead time* to commercial operation is roughly 7 years for new advanced large reactors and about 5.5 years for small modular reactors, before accounting for project-specific delays (U.S. Energy Information Administration, 2024b). The Vogtle 3 and 4 experience illustrates these risks: construction began in 2009 with initial in-service dates planned for 2016–2017 and a \$14 billion budget, but completion slipped by years and total costs more than doubled to over \$30 billion (U.S. Energy Information Administration, 2024f).

Economically, nuclear remains capital intensive. Even with incentives, EIA estimates an LCOE of about \$81.45/MWh for for new Generation III+ utility-scale plants (e.g., AP1000), which is among the highest major technologies and second only to offshore wind in recent comparisons (U.S. Energy Information Administration, 2025a).
Moreover, nuclear faces the competition from renewables that generally provide lower utilization and operating risks and benefit from stronger learning effects typical of granular technologies, whereas large, complex builds such as nuclear exhibit lower or even negligible learning rates (Fisch-Romito et al., 2021).

Operationally, the existing fleet runs at **high and stable utilization**—about a 93% capacity factor—which helps anchor system reliability even as renewables and gas output grow (see Sec. 3.1). Financial pressures in competitive wholesale markets remain the primary driver of retirements, and it is too early to judge how far recent institutional support will offset those pressures and translate into durable capacity growth (U.S. Energy Information Administration, 2024f).

4.3.4 Renewables — Solar & Wind

As of 2023, renewables supplied 21.4% of U.S. electricity, with wind, hydropower, and solar contributing 10.2%, 5.7%, and 3.9%, respectively (U.S. Energy Information Administration, 2023d). Since at least 2019, most newly installed capacity has been wind, solar, and—more recently—storage, a pattern evident in Fig. 11.

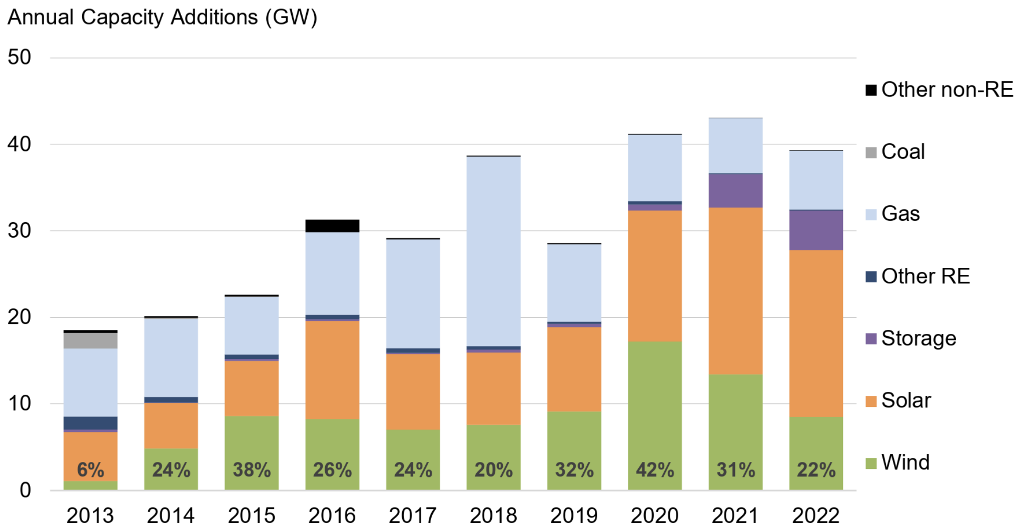


Figure 11: Relative contribution of generation types and storage to U.S. annual capacity additions. Source: Adapted from Land-Based Wind Market Report: 2023 Edition. (U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, 2023, p. 5)

This **buildout is expected to continue** and strengthen because sustained declines in capital and O&M costs have improved the competitiveness of both technologies (U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, 2023; Bolinger et al., 2023). With current incentives, many regions show wind and solar exceeding the breakeven threshold against alternatives, and in several cases even outcompeting new NGCC on expected revenues (Fig. 12). Consistent with that, utility-scale solar additions are projected to dominate near-term builds, and **solar remains broadly competitive even without the full value of tax credits**—helping explain why forecasts assign it a rising share of new capacity (Bolinger et al., 2023).
Still, policy reversals can slow deployment, as discussed in Sec. 4.2.

From a political-economy perspective, the contrast between administrations matters for institutional lock-in. Trump-era actions increased carbon lock-in, whereas Biden sought to seed a durable, decarbonizing trajectory (South et al., 2021). Transition *windows of opportunity* arise when coherent regulatory and financial measures align to shift expectations and investment (Seto et al., 2016; Buschmann et al., 2019). The Bipartisan Infrastructure Law and the IRA operationalize this via long-lived, technology-neutral tax credits—principally the Investment Tax Credit (ITC) and the Clean Electricity Production Tax Credit (PTC)—that respectively reduce up-front costs and reward output over a project's first ten years, with inflation adjustment (U.S. Environmental Protection Agency, 2023; U.S. Energy Information Administration, 2024b). By design, these credits promote a *long-term* lock-in of clean investment and learning.

Biden also aimed to broaden participation—important for technologies like PV that diffuse through distributed as well as utility-scale projects—through the Whole-of-Government approach and targeted support for community and low-income solar (South et al., 2021; U.S. Environmental Protection

[2]The LACE (value) provides a proxy measure for potential revenues (or avoided costs) from the sales of electricity or other ancillary services produced from a candidate project displacing another marginal asset.

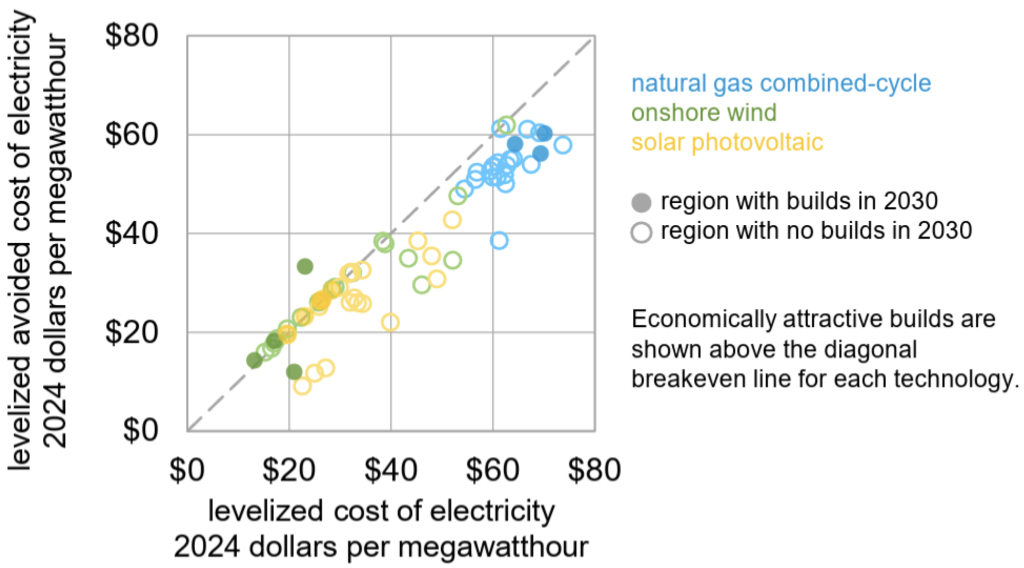


Figure 12: Levelized cost of electricity and levelized avoided cost of electricity (LACE[2]) by region for online year 2030, AEO2025 Reference case. Data source: U.S. Energy Information Administration, Annual Energy Outlook 2025. (U.S. Energy Information Administration, 2025a, p. 7)

Agency, 2024a). Such measures enlist diverse public and private actors, strengthening constituency feedbacks that stabilize the clean-energy path (Eitan et al., 2023).

By contrast, under current Trump administration, Congress adopted a phaseout of ITC/PTC eligibility for new wind and solar projects that begin construction more than 12 months after enactment (after July 4, 2026) and are not placed in service by December 31, 2027 (Simpson Thacher & Bartlett LLP, 2025). This shortened runway threatens the pipeline of projects and undermines the stabilizing effect of long-horizon credits—exactly the kind of policy uncertainty that weakens institutional lock-in and risks slowing the transition (Seto et al., 2016; U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, 2023).

In sum, wind and solar now meet the economic test for widespread adoption (Seto et al., 2016)—an essential precondition for technological diffusion—and their share of total capacity continues to climb (U.S. Environmental Protection Agency, 2025). That market strength, together with broadening stakeholder involvement, can counteract efforts to re-entrench fossil lock-in, though sustained policy certainty remains critical to keep the buildout on track.

4.4 The problem of stranded assets

Limiting global warming to 1.5°C under the Paris Agreement requires not only building large volumes of new renewable capacity, but also accelerating the retirement of older fossil-fuel plants—i.e., phasing units out before their expected end of operations (Climate Action Tracker, 2024; Fisch-Romito et al., 2021). Decisions to retire typically reflect a holistic economic assessment that weighs escalating maintenance and retrofit costs (and any incentives), the cost of available alternatives, and the prevailing and expected social–policy context (Seto et al., 2016). When retirement occurs before the plant's economic life has been recovered and the owner must write down value due to external circumstances, the outcome is a **stranded asset** (Kefford et al., 2018).

It is useful to distinguish *stranded investment* from *stranded profit*. The former arises when a plant is retired before the end of its *physical* lifetime (the period it could technically operate), while the latter occurs when the plant remains operable but its *economic* lifetime ends earlier—i.e., expected cash flows are insufficient to recover the initial capital outlay (Kefford et al., 2018). Policies can shift the balance toward low-carbon options by altering market conditions (for example, a carbon tax that renders fossil generation uneconomic) or by imposing regulations that force premature shutdowns (Firdaus et al., 2023). Accordingly, evaluating the potential of different policies to create stranded generating assets has become a rapidly developing field in the literature (Fisch-Romito et al., 2021).

Stranding can also be **driven purely by economics**. A salient example is the Oak Creek facility in Wisconsin: commissioned in 2011, it is slated to retire 17 years early in 2025, leaving roughly $645 million in unrecovered investment because cheaper power from natural gas and renewables outcompeted the plant (Fong et al., 2025). Even absent new federal policy, renewable energy paired with storage is increasingly undercutting coal on cost and reliability, raising the risk of market-driven stranding (U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, 2023).

Quantitative studies estimate stranded capacity under alternative transition pathways—e.g., a two-degree scenario (2DS) consistent with the Paris Agreement upper bound, or the IEA's Sustainable Development scenario—relative to trajectories in which plants operate until their economic lifetimes are reached (Kefford et al., 2018; Dulong, 2023; Saygin et al., 2019).
In the United States, where much coal and oil capacity is already old, **estimated stranded volumes are generally lower** than in countries with younger fleets; early retirements cluster near end-of-life rather than far below it (Fisch-Romito et al., 2021). For example, Kefford et al., 2018 estimate about 27 GW of oil-fired capacity would retire early under a 2DS—non-trivial, but close to ages already implied by the current steam-cycle fleet's average of more than 45 years. Regarding early coal retirements, the U.S. is well positioned to bring units offline early: required capacity reductions are modest, and average retirement ages remain close to economic lifetimes (Kefford et al., 2018). This reflects an ongoing phaseout—no new coal capacity has been added since 2013—so the remaining fleet is progressively older (see Sec. 4.3.1).

Gas-fired assets rarely retire well before their technical lifetimes, reflecting their lower carbon intensity relative to coal and their operational complementarity with variable renewables (Firdaus et al., 2023). U.S. modeling shows early gas retirements in a 2DS concentrated largely in the last five years of the horizon, totaling about 90 GW over a decade which, although it represents a significant capacity to retire in that time window, it only slightly precede nominal physical lifetimes (Kefford et al., 2018). Consequently, near-term early-retirement risk for gas appears limited—also because gas plants are less capital-intensive and have shorter lifetimes, allowing faster depreciation than coal. (Firdaus et al., 2023) The challenge, however, is that substantial gas capacity has been added in recent years; despite higher efficiencies, it still emits directly and complicates the path to a zero-carbon power sector by 2035 (see Sec. 3.1).

Compliance pathways to limit outright stranding include retrofitting with carbon capture or repowering coal units with natural gas (Kefford et al., 2018). Carbon-capture retrofits are generally uneconomic without a high carbon price and can impose efficiency penalties and rebound effects that slow the transition (Firdaus et al., 2023). Repowering typically entails converting a coal-steam boiler and related balance-of-plant to burn natural gas, or replacing the coal unit with a gas plant at the same site (U.S. Energy Information Administration, 2020). However, such conversions or replacements are often costly and, especially for plants with substantial remaining life, frequently fail to clear an economic test—as illustrated by the Wisconsin case and broader empirical evidence (Bos et al., 2019; Fong et al., 2025).

Although the U.S. is well position to tackle the problem of stranded assets, **delaying policy action increases** these **risks**: compressed cost recovery windows push up consumer prices, complicate orderly divestment, and heighten firms' exposure to stranded assets (Kefford et al., 2018). The legal and regulatory backdrop further shapes outcomes: following the cost-recovery precedents established during wholesale market restructuring—for example, recovery mechanisms associated with FERC Order 88811—litigation and rulemaking continue to determine how, and to what extent, stranded costs may be socialized (Altemus Cullen, 2025). Anticipating such exposures, incumbent utilities often lobby to preserve the status quo or secure recovery of losses (Firdaus et al., 2023).

Finally, **stranded-asset impacts extend well beyond the plant** gate. Early retirements strand capital at coal- and gas-fired units and cascade upstream to mining, fuel logistics, and equipment suppliers; downstream, they affect local public finances via decommissioning liabilities, compensation, and land and natural-capital remediation (Firdaus et al., 2023). Losses are distributed across owners, suppliers, and sub-national governments, with magnitudes shaped by ownership concentration and local economic dependence; once these factors and mitigation channels are accounted for, headline estimates of stranded value may overstate net losses (Loomis, Sayles & Company, L.P., 2020).

The overarching policy challenge, therefore, is to manage the transition in a way that internalizes stranded-asset risks while keeping the power system affordable, secure, resilient, and dependable—recognizing that some level of stranding is inevitable in a competitive, rapidly decarbonizing market (Wright, 2020).

5 Transportation Sector

5.1 IPAT Decomposition of CO_2e Emissions from Light-Duty Vehicles

$$\mathrm{CO}_{2\mathrm{eq}} = \text{Population} \cdot \frac{\text{Cars}}{\text{Population}} \cdot \left[\sum_j \left(\text{Share of GVs}_j \cdot \frac{\text{Fuel}_j}{\text{km}_j} \cdot \frac{\mathrm{CO}_{2,j}}{\text{Fuel}_j}\right) + \text{Share of EVs} \cdot \frac{\text{Electricity}}{\text{km}} \cdot \frac{\mathrm{CO}_{2,\text{elec}}}{\text{Electricity}}\right] \cdot \frac{\text{km}}{\text{Cars}}$$

Explanation of terms:

- Population: Total number of U.S. inhabitants. Captures the scale of the transportation demand base. [dimensionless]
- $\frac{\text{Cars}}{\text{Population}}$: Vehicle ownership rate, number of light-duty vehicles per capita. [vehicles/person]
- Share of GVs_j and Share of EVs: Fraction of total kilometers traveled by gasoline vehicles (GVs) and electric vehicles (EVs), respectively. These shares sum to 1. [dimensionless]
- $\frac{\text{Fuel}_j}{\text{km}_j}$ and $\frac{\text{Electricity}}{\text{km}}$: Energy consumption per kilometer for GVs and EVs, respectively. Reflects vehicle energy efficiency. [L/km or kWh/km]
- $\frac{\mathrm{CO}_{2,j}}{\text{Fuel}_j}$ and $\frac{\mathrm{CO}_{2,\text{elec}}}{\text{Electricity}}$: Carbon intensity of gasoline and electricity, CO_2 emitted per unit of energy used. [kg CO_2/L or kg CO_2/kWh]
- $\frac{\text{km}}{\text{Cars}}$: Annual average distance traveled per vehicle. Reflects travel demand intensity. [km/vehicle/year]

5.2 Decomposition Assumptions

The following assumptions are made to operationalize the decomposition of CO_2 emissions from light-duty vehicles:

- We assume that individuals drive the same average number of kilometers per year regardless of whether the vehicle is gasoline-powered or electric.
- Consequently, the number of kilometers traveled using electric vehicles is calculated as the total kilometers driven by the population multiplied by the EV share in the fleet. The same applies to gasoline vehicles.

These simplifying assumptions allow us to isolate the impact of fleet composition and energy source on total transportation emissions, independent of behavioral changes in driving demand.

5.3 Policies Likely to Influence Decomposition Outcomes

Each component of the transportation IPAT decomposition is strongly shaped by federal climate policy, particularly through incentives, regulations, and infrastructure investments introduced under the Inflation Reduction Act or proposed for repeal under a Trump administration.

- **Fleet Composition (Share of EVs vs. GVs):** The IRA provides up to $7,500 in tax credits for qualifying electric vehicles, combined with production and battery sourcing incentives under the Advanced Manufacturing Production Credit (Section 45X). These measures significantly reduce the total cost of ownership and are projected to potentially increase the EV share of new vehicle sales beyond 50% by 2030 (Larsen et al., 2022). In contrast, a rollback of these incentives would slow EV adoption, particularly among cost-sensitive consumers.
- **Vehicle Energy Efficiency:** IRA-era policies reinforce Corporate Average Fuel Economy (CAFE) standards, which target 50.4 miles per gallon (MPG, a measure of fuel efficiency) by 2031. DOE investments in battery R&D and drivetrain efficiency further reduce electricity consumption per kilometer. Under a Trump rollback, CAFE standards are likely to be weakened or rescinded, leading to stagnation in fuel economy improvements (National Highway Traffic Safety Administration, 2024).
- **Carbon Intensity of Electricity:** Because EV emissions are tied to grid emissions, the benefits of electrification depend heavily on the upstream electricity mix. The IRA accelerates grid decarbonization, thereby improving $\left(\frac{CO_{2,\text{elec}}}{\text{Electricity}}\right)$ over time. In contrast, Trump's energy agenda prioritizes fossil fuel expansion and repeals climate-focused utility subsidies, potentially raising average grid intensity.
- **Ownership and Travel Demand:** IRA provisions also include indirect mobility interventions, investments in public transportation, urban density, and charging infrastructure, designed to moderate car ownership and total kilometers traveled. Under a Trump rollback, these measures are likely to be defunded, which may lead to modest increases in vehicle ownership or usage.

In sum, transportation emissions are not only a function of vehicle technology, but also of the broader energy and urban policy context. The following subsections apply the decomposition framework to each policy scenario.

5.4 Scenario-Based Emissions Analysis

The following subsections apply the IPAT-based decomposition to light-duty vehicle emissions under three policy scenarios: continuation of the Inflation Reduction Act, a No IRA counterfactual, and a Trump rollback scenario. These narratives quantify how differences in policy direction affect the evolution of key decomposition terms (fleet composition, energy efficiency, carbon intensity of electricity) and ultimately shape transportation-sector CO_2e emissions through 2035.

5.4.1 IRA Scenario

In the IRA scenario, transportation-sector CO_2 emissions from light-duty vehicles decline substantially between 2024 and 2035. This trajectory is driven by a coordinated policy framework that accelerates the adoption of electric vehicles (EVs), improves vehicle energy efficiency, and decarbonizes the electricity grid, each targeting a specific component of the decomposition framework introduced in Section 4.1.

- **Fleet Composition (Share of EVs):** The share of kilometers traveled by EVs rises significantly, supported by federal tax credits up to $7,500, domestic manufacturing incentives, and investments in nationwide charging infrastructure. As EVs displace gasoline vehicles, the emissions intensity per kilometer decreases accordingly.

- **Electricity-Emission Efficiency ($\frac{\mathbf{CO_{2,elec}}}{\mathbf{Electricity}}$):** Grid decarbonization under the IRA reduces the carbon intensity of electricity used by EVs, further enhancing the emissions benefit of vehicle electrification.
- **Vehicle Efficiency ($\frac{\mathbf{Fuel}}{\mathbf{km}}$, $\frac{\mathbf{Electricity}}{\mathbf{km}}$):** Fuel economy improves under strengthened CAFE standards, while DOE-supported advancements in battery and drivetrain technology increase EV efficiency.
- **Ownership and Distance ($\frac{\mathbf{Cars}}{\mathbf{Population}}$, $\frac{\mathbf{km}}{\mathbf{Cars}}$):** These terms remain relatively stable. While EV affordability may slightly increase ownership, IRA investments in public transit and urban mobility are expected to moderate overall travel demand.

Together, these policy-driven improvements across multiple dimensions result in a structurally lower-emissions pathway for LDVs. The IRA scenario demonstrates how integrated incentives across energy and transportation can accelerate decarbonization in a high-impact sector.

5.4.2 No IRA Scenario

In the absence of the Inflation Reduction Act, transportation-sector CO_2 emissions from light-duty vehicles exhibit only modest declines between 2024 and 2035. This scenario reflects a policy landscape where IRA provisions were never enacted, but no additional fossil fuel expansion takes place either. As a result, technology adoption and energy efficiency improve only incrementally, driven primarily by market trends rather than federal mandates.

- **Fleet Composition (Share of EVs):** Without IRA subsidies and infrastructure incentives, the EV share of kilometers traveled grows at a slower rate. EV adoption continues in high-income and urban markets, but cost barriers and limited charging infrastructure hinder mass-market penetration.
- **Electricity-Emission Efficiency ($\frac{\mathbf{CO_{2,elec}}}{\mathbf{Electricity}}$):** Grid decarbonization proceeds at a moderate pace due to state-level initiatives and market forces, but lacks federal coordination. As a result, the emissions advantage of EVs improves only gradually.
- **Vehicle Efficiency ($\frac{\mathbf{Fuel}}{\mathbf{km}}$, $\frac{\mathbf{Electricity}}{\mathbf{km}}$):** Fuel economy and EV efficiency see slow improvements in the absence of strengthened CAFE standards or large-scale Department of Energy R&D investments. Automakers make incremental gains but face weak regulatory pressure.
- **Ownership and Distance ($\frac{\mathbf{Cars}}{\mathbf{Population}}$, $\frac{\mathbf{km}}{\mathbf{Cars}}$):** Vehicle ownership and usage patterns remain largely unchanged, as public transit and urban mobility initiatives lack the funding boost they would have received under IRA provisions.

This scenario highlights the limitations of relying solely on market dynamics to drive emissions reductions. Without federal policy support, the transition to low-emission transportation is likely to occur slowly and unevenly, resulting in higher cumulative emissions over time.

5.4.3 Trump Rollback Scenario

In the Trump rollback scenario, transportation-sector CO_2 emissions from light-duty vehicles stagnate or rise slightly through 2035. This outcome reflects a deliberate reversal of IRA provisions, including the elimination of EV subsidies, the weakening of fuel economy standards, and an aggressive re-expansion of fossil fuel production. These changes affect nearly every component of the decomposition framework introduced in Section 4.1.

- **Fleet Composition (Share of EVs):** The removal of federal EV tax credits and delays in infrastructure rollout slow EV adoption significantly. As a result, gasoline vehicles continue to dominate the share of kilometers traveled, and total electrification lags behind global peers.
- **Electricity-Emission Efficiency ($\frac{\mathbf{CO_{2,elec}}}{\mathbf{Electricity}}$):** Grid decarbonization slows or reverses as IRA investments are halted and fossil fuels regain policy favor. The carbon intensity of electricity remains high, reducing the relative climate advantage of EVs.
- **Vehicle Efficiency ($\frac{\mathbf{Fuel}}{\mathbf{km}}$, $\frac{\mathbf{Electricity}}{\mathbf{km}}$):** The weakening or repeal of Corporate Average Fuel Economy (CAFE) standards leads to stagnation in vehicle efficiency. Automakers face fewer incentives or regulatory requirements to improve fuel economy or innovate on drivetrain efficiency.
- **Ownership and Distance ($\frac{\mathbf{Cars}}{\mathbf{Population}}$, $\frac{\mathbf{km}}{\mathbf{Cars}}$):** Without federal investment in public transit and smart urban design, private vehicle dependence may increase slightly. Modest growth in car ownership and vehicle kilometers traveled adds to total emissions.

The Trump rollback scenario highlights how federal disengagement from clean transport policy can reinforce existing dependencies on gasoline vehicles and high-carbon infrastructure. In contrast to the IRA pathway, which bends the emissions curve downward, this scenario risks locking in decades of elevated transportation-sector emissions.

5.5 Decomposition Drivers Across Scenarios

5.5.1 EV adoption

The IRA's policies are projected to dramatically accelerate EV adoption in new car sales, whereas without the IRA or under a rollback scenario the growth is slower. By 2030, roughly half of new U.S. light-duty vehicles could be electric in an IRA scenario (48–50 % EV share), compared to only about one-third without the IRA (34%). In an extreme rollback scenario (repealing EV credits, canceling state ZEV mandates, etc.), the EV share in 2030 would drop to roughly 32% (Buckberg et al., 2025). These gaps widen slightly by 2035: with IRA incentives and supportive policies, around 60–75% of new cars sold could be EVs, versus ∼48% with no IRA, and on the order of 55–60% in a "Trump rollback" case (where federal support and state mandates are removed) (Buckberg et al., 2025). Figure 13 illustrates these trajectories, based on published scenario analyses. The IRA pushes EV uptake faster in the 2020s, whereas removing incentives causes a persistently lower EV sales fraction through the mid-2030s. Notably, even the rollback case still shows continued EV growth (driven by ongoing technology cost declines), but with a 2–3 year lag in adoption relative to the IRA scenario. This aligns with findings that eliminating all EV credits and support would cut the 2030 EV sales share by ∼16 percentage points (from ∼48% down to ∼32%) (Buckberg et al., 2025).

5.5.2 Vehicle Energy Efficiency (Fuel Economy)

Strengthening or weakening of fuel-efficiency and greenhouse gas standards has a major impact on the average energy efficiency of new light-duty vehicles. Under policies in place (and assuming future standards tighten in line with climate goals), the IRA scenario sees steady efficiency improvements. The new vehicle fuel economy (combining cars and light trucks) is projected to increase from about 25 mpg in 2020 to approximately 35-40 mpg in 2030, and approximately 40 + mpg in 2035 (EPA-rated real-world MPG) in an IRA scenario (which also includes the growing share of EV). By contrast, a

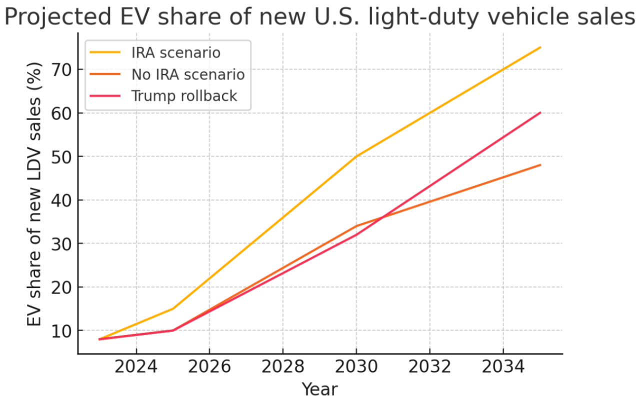


Figure 13: Projected electric vehicle share of new U.S. light-duty vehicle sales under three scenarios. The IRA scenario (with federal incentives and state EV mandates) significantly accelerates EV market share through 2030, whereas removing the IRA (No IRA) or rolling back policies further (Trump rollback) leads to a lower EV uptake (Buckberg et al., 2025).

Trump rollback scenario – reflecting the SAFE rule that relaxed standards – would significantly flatten this efficiency trend. The Trump administration's final rule required only ∼1.5% annual efficiency gains (versus ∼5% prior), yielding an average of 40.4 mpg (CAFE standard) in 2026 instead of 46.7 mpg under the original Obama-era plan (Reuters, 2020). This translates to new vehicles achieving only about 26–27 mpg real-world in the mid-2020s under the rollback, compared to ∼30 mpg if previous standards held. Over 2027–2035, if no further tightening occurs, the rollback scenario might see new vehicle efficiency stagnate around the high-20s mpg. The No IRA (baseline) scenario in our comparison assumes current 2025–2026 standards remain in force (so new vehicles reach ∼28–30 mpg by 2026), but without additional IRA-driven momentum, post-2026 improvements might stall or modestly continue due to market forces. Figure 14 illustrates these trends. By 2035, new LDVs in the IRA scenario are ∼10–12 mpg more efficient on average than under a prolonged Trump-era rollback (e.g. ∼40 mpg vs ∼28–30 mpg) – a gap which translates to significantly lower fuel use per mile. In short, maintaining and strengthening efficiency standards (as enabled by the current policy environment) yields a much higher-performing vehicle fleet than a rollback scenario.

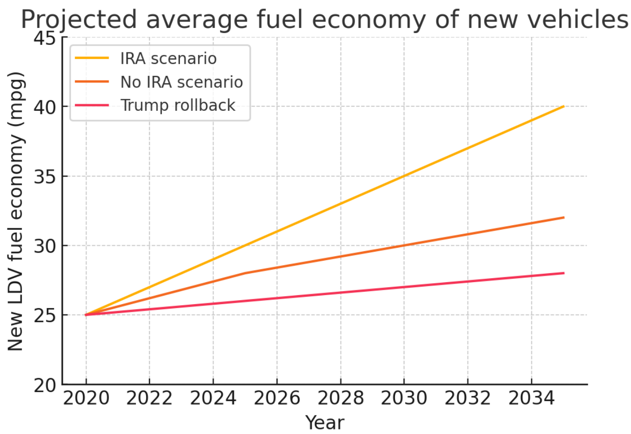


Figure 14: Projected average fuel economy of new light-duty vehicles (mpg, EPA real-world). The IRA scenario assumes continued stringent GHG standards (approaching ∼40 mpg by 2035), whereas a rollback of standards after 2020 leads to stagnant efficiency (∼28–30 mpg). Even the No-IRA case (with Obama/Biden-era standards through 2026 but no further improvements) falls behind the IRA case.

5.5.3 Carbon Intensity of Fuels (Gasoline vs. Electricity)

The carbon intensity of gasoline (and diesel) fuel itself is essentially constant across our scenarios, since it depends on chemical properties and refining. Burning one gallon of gasoline emits about 8.89 kg CO_2 (approximately 19.6 pounds CO_2) per gallon (Hausfather, 2020), a value which is not expected to change appreciably by 2035. (Minor variations could occur with different ethanol blends or refinery inputs, but these are small). Thus, in Figure 15 (left), the gasoline CI is a flat line. All scenarios assume gasoline remains around 8.89 kg CO_2/gal. There is no policy in the IRA or the rollback specifically altering gasoline's carbon content – the IRA focuses on replacing gasoline with electricity, rather than lowering carbon per gallon. In a rollback scenario, one might even see slightly higher gasoline carbon intensity if renewable fuel programs are weakened, but the effect is marginal.

By contrast, the carbon intensity of electricity (CO_2 per kWh) is highly sensitive to policy. The power sector's transition to renewables under the IRA markedly lowers the CO_2 per kWh associated with EV charging. In the IRA scenario, huge investments in clean power drive down generation emissions. The EPA projects U.S. grid emissions in 2030 to be 69–80% below 2005 levels in 2030 with the IRA, versus ∼50% below 2005 without it (Larsen et al., 2022). Concretely, U.S. grid CO_2 intensity, which was around 0.45 kg/kWh in 2021, is expected to drop to roughly 0.2 kg CO_2/kWh by 2035 under the IRA (due to ∼60–80% clean electricity) (Carbon Brief, 2023). Without the IRA, decarbonization is slower – 2035 grid intensity might be on the order of 0.3 kg/kWh (Synapse Energy Economics, 2023). A Trump rollback scenario (e.g. repealing the Clean Power Plan, supporting coal) could further impede clean energy, yielding perhaps ∼0.35–0.4 kg/kWh in 2030–2035 (essentially flat vs. today). Figure 15 (right) shows this divergence: IRA policies bend the electricity CI sharply down, whereas in a no-IRA case the decline is shallower. Notably, the IRA's clean power provisions are a major reason EVs reduce emissions: by 2035 an EV's electricity may emit less than half the CO_2 per mile of what it would on a 2020 grid. In the rollback case, however, an EV in 2030s might be charging on a higher-carbon grid, diminishing its emissions benefit (and increasing overall LDV sector emissions). According to Rhodium Group, the IRA's power sector impacts are critical – it "may have its greatest effect in the power sector", driving far deeper CO_2 cuts by 2030 than would occur otherwise (Rhodium Group, 2022).

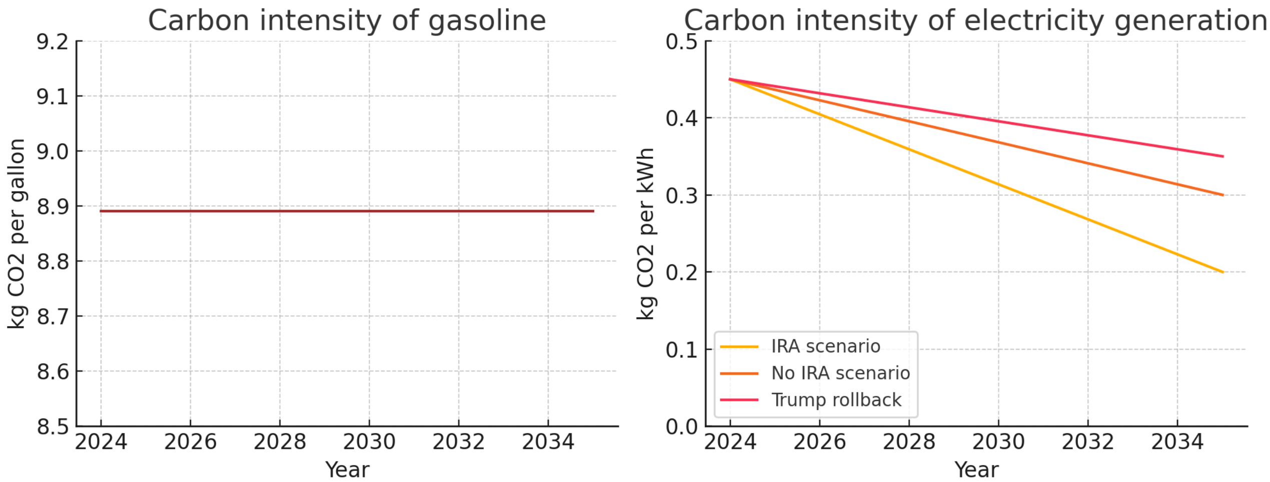


Figure 15: Carbon intensity of fuels. Left: Gasoline CO_2 emissions per unit fuel remains ∼8.9 kg CO_2/gal in all scenarios (Hausfather, 2020). Right: Electricity generation emissions rate (kg CO_2 per kWh) improves significantly under IRA-driven clean energy deployment, versus a slower decline with no IRA, or stagnation under a rollback of power sector regulations (Carbon Brief, 2023). A cleaner grid under the IRA means EVs have much lower upstream emissions.

5.5.4 Distance Traveled per Vehicle

The average distance traveled per vehicle is primarily driven by societal and economic factors (population, incomes, land use) and is not expected to change drastically between these policy scenarios. All scenarios anticipate slowly rising travel demand – Americans will likely drive somewhat more miles per year in the 2020s and 2030s, given population and economic growth. The EIA projects that U.S. passenger vehicle-miles traveled increases steadily through 2050, roughly in proportion to population and GDP (U.S. Energy Information Administration, 2023a), offsetting some efficiency gains. In our scenarios, we assume VMT (Vehicle Miles Traveled)/vehicle rises from about 11,000 miles/year in 2024 to roughly 12,000–12,500 miles/year in 2035 (see Figure 16). The differences between scenarios are minor: there could be a slight rebound effect in the IRA case (lower cost per mile for efficient EVs might encourage a bit more driving), and potentially a small increase in the rollback case if cheaper gasoline spurs more travel. For example, one analysis notes that increasing vehicle efficiency tends to increase miles traveled slightly (rebound effect) (U.S. Energy Information Administration, 2023a). In a rollback scenario, fuel is less efficient but potentially cheaper per gallon; these effects may roughly balance out. Thus, all three scenarios show a similar upward creep in VMT per vehicle (on the order of +0.5% to +1% per year). By 2035, a typical vehicle might be driving ∼12–13k miles annually in any case. Importantly, none of these policies (IRA or rollback) impose direct limits or inducements on driving distance – those are more influenced by infrastructure and behavior. The total fleet VMT will grow substantially (as more vehicles hit the roads), but per-vehicle averages stay in a narrow band across scenarios.

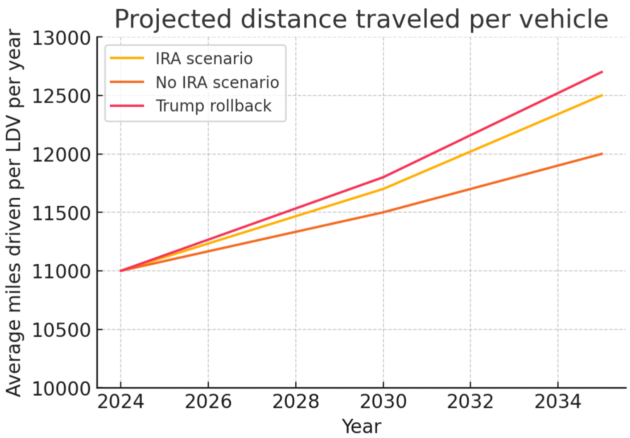


Figure 16: Projected average annual distance driven per light-duty vehicle. VMT per vehicle is expected to rise modestly in all scenarios (U.S. Energy Information Administration, 2023a). Policy has limited impact here – e.g. IRA's effect (slightly lower driving costs for EVs) might increase VMT per vehicle only marginally. All scenarios assume travel grows with population and economic activity.

5.5.5 Vehicule ownership

U.S. vehicle ownership (vehicles per person) is already high (∼0.8 vehicles per capita) and is projected to remain relatively stable or rise slightly through 2035 across all scenarios. Population growth and economic growth lead to a larger total vehicle fleet, but as these factors are essentially the same in IRA vs. no-IRA scenarios, the ownership rate doesn't significantly diverge. Figure 17 shows the projected trend: from about 820 vehicles per 1000 people in 2024, rising to roughly 870–880 per 1000 by 2035 (i.e. not quite one vehicle per person, but 0.87–0.88 per capita). The slight increase reflects saturation approaching but not exceeding 1:1 ownership. Neither the IRA's EV incentives nor a rollback of standards has an obvious direct impact on how many cars Americans own. (One could speculate that cheaper EVs might encourage multi-car households to add an EV, or conversely that higher efficiency could reduce the need for a second car – but such effects are negligible by 2035.) Thus, we show all three scenario lines clustered closely together. In practice, all scenarios assume similar vehicle ownership trajectories, driven by demographics and income. By 2035 the U.S. could have on the order of 360 million people and ∼310–320 million light-duty vehicles, yielding ∼0.88 vehicles per capita, regardless of IRA or not (University of Virginia, Cooper Center for Public Service, 2024). The Trump rollback scenario likewise is not expected to alter vehicle ownership rates (unless extreme economic differences come into play, which are outside this analysis).

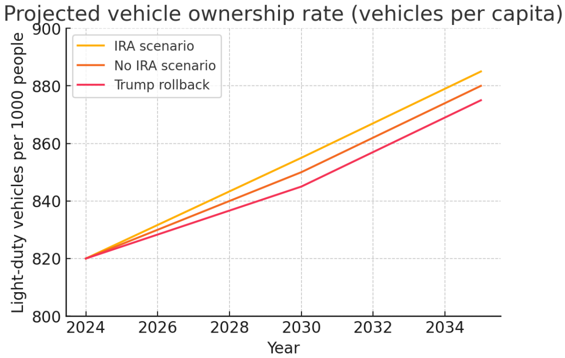


Figure 17: Projected U.S. light-duty vehicle ownership rate (vehicles per 1,000 people). The rate trends slowly upward as population grows and saturates near one vehicle per adult. Policy scenarios show no meaningful divergence in this fundamental metric by 2035 – it is assumed to be ∼0.87–0.88 across the board.

5.5.6 US population trends

Finally, underlying all these factors is U.S. population growth, which is generally treated the same in all scenarios. As seen in Figure 18, by 2035, the U.S. population is expected to reach roughly 360 million (up from about 334 million in 2024) (University of Virginia, Cooper Center for Public Service, 2024). This equates to an average growth of ∼0.5–0.6% per year. Figure 7 shows the population trajectory (which is identical for IRA, No IRA, and rollback scenarios). The population assumption comes from official projections (e.g. Census or CBO) and is not influenced by the policies in question. Thus, all scenario analyses use a common population baseline. Population growth drives proportional increases in total travel, vehicles, and energy demand, but since we apply the same population to each scenario, it doesn't explain the differences between IRA vs. rollback outcomes – those differences stem from technology and policy, not how many people there are. For completeness, we note that by 2035 a larger population contributes to higher absolute emissions in all scenarios (everything else equal), which is the "P" in the IPAT equation. However, the range of population projections for 2035 is narrow across scenarios (unless one imagines drastically different immigration or birth rates policies, which is beyond our scope). In summary, population is a common growth factor across the scenarios and is projected to rise steadily ∼0.5% annually through 2035 (University of Virginia, Cooper Center for Public Service, 2024).

5.6 CO2 emissions

As shown in Figure 19, policy direction dramatically shapes emissions outcomes based on our projected IPAT components. IRA provisions drive a sustained 45% reduction in LDV emissions, while the absence of federal support under the Trump rollback leads to a 25% increase over the same period. The No IRA scenario yields a near-flat trajectory and illustrates the limits of relying solely on market-driven adoption without coordinated policy support.

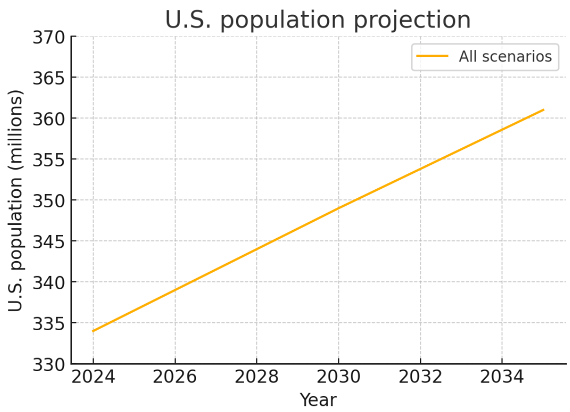


Figure 18: U.S. population projection (all scenarios). The U.S. population is assumed to grow from 334 million in 2024 to 360+ million by 2035 (University of Virginia, Cooper Center for Public Service, 2024). This demographic trend is independent of climate policy scenarios, though it scales overall transportation activity.

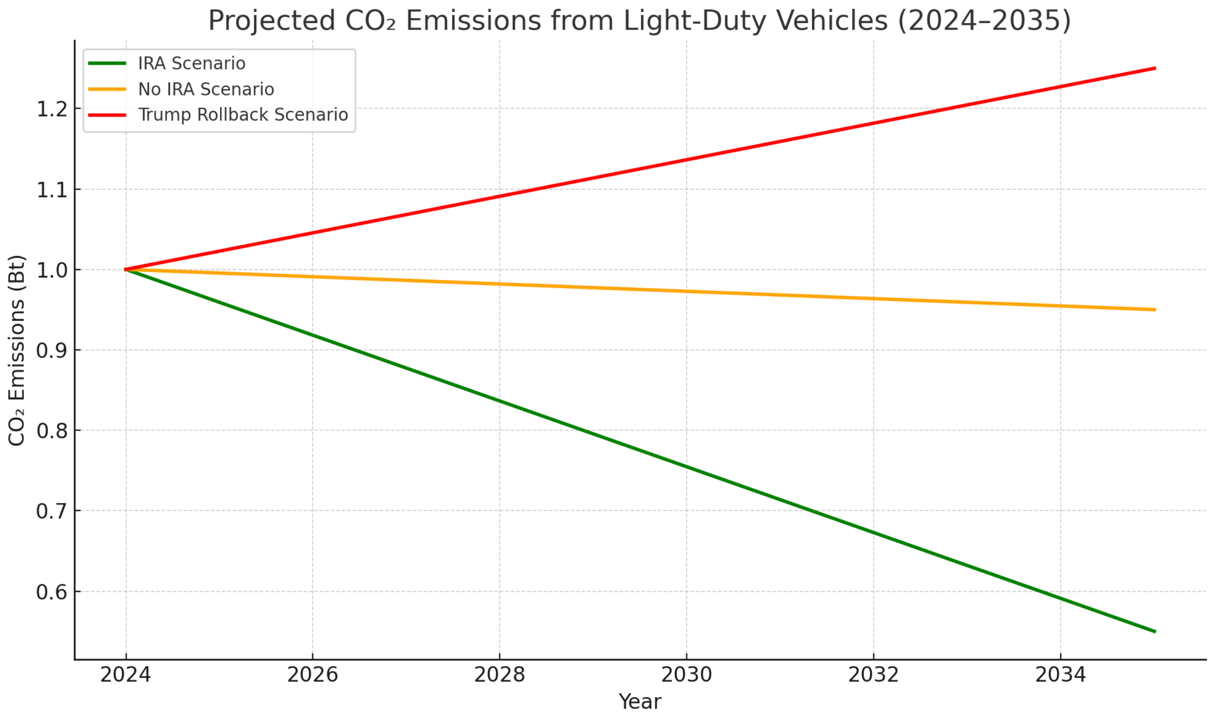


Figure 19: Projected CO_2e emissions from light-duty vehicles under three policy scenarios (2024–2035). The IRA scenario drives sharp reductions, the No IRA path results in marginal decline, and emissions rise under a Trump rollback.

Toward a Policy-Critical Decade

The dual-sector analysis presented in this report highlights the decisive role that federal climate policy plays in shaping long-term emissions trajectories in both electricity and transportation. Whether through capacity expansion, vehicle electrification, or emissions intensity, the presence (or absence) of coordinated policy support alters the structure and pace of decarbonization.

The final section summarizes the main findings and reflects on the implications of divergent federal climate policies, while identifying areas for further research.

6 Conclusion

This report applied an IPAT-based decomposition framework to assess how divergent climate policy trajectories affect U.S. CO_2e emissions from two major sectors: electricity generation and light-duty transportation. By modeling three distinct scenarios, the continuation of the Inflation Reduction Act (IRA), a neutral baseline without IRA implementation, and a Trump rollback emphasizing fossil fuel expansion, we quantified the structural and dynamic drivers of emissions across each pathway.

The results demonstrate that the IRA scenario delivers the steepest and most sustained emissions reductions, driven by accelerated renewable energy deployment, grid decarbonization, and rapid electrification of the vehicle fleet. In contrast, the No IRA scenario reveals the limits of market-driven progress in the absence of coordinated federal policy. Meanwhile, the Trump rollback scenario reinforces fossil fuel dependence and undermines previous gains, producing rising emissions in both sectors through 2035.

Importantly, the decomposition analysis shows that emissions trajectories are not simply a function of technology, but of policy design: whether investment flows target low-carbon infrastructure, whether incentives align across supply and demand, and whether institutional momentum is sustained over time. These findings reinforce the importance of integrated and durable federal climate policy as a precondition for meaningful emissions reductions. Minimizing political lock-in requires making these instruments durable and self-reinforcing: (i) statutory, investment-grade incentives (e.g., transferable/direct-pay credits) that generate finance and supply-chain feedbacks; (ii) predictable, cumulative standards that ratchet without regulatory whiplash; and (iii) market-design reforms that reward flexibility and system integration, crowd in private capital, and reduce stranded-asset risk. The Biden-era package moved on all three levers—legitimacy, regulation, and technology—but its payoff hinges on sustained, coordinated application; taken in isolation, each lever is insufficient. Reversals under Trump—across both terms—underscore the fragility of purely administrative measures and the premium on policies that can withstand political turnover. In short, long-term policy stability is the binding constraint: when expectations are clear and durable, fossil-favoring reversals become economically and politically fragile, while clean-energy momentum becomes increasingly hard to unwind.

Looking ahead, future research should refine these projections with more granular data on state-level dynamics, behavioral responses, and feedback loops between sectors. Nevertheless, the directional insights presented here make one conclusion clear: the emissions gap between policy pathways is widening, and decisions taken in this (and the next) presidential term will be critical in determining whether the United States can stay on track toward its decarbonization goals.

While this analysis captures the directional impact of major federal policy shifts, it is subject to several limitations. The modeling relies on scenario assumptions and stylized growth rates rather than full-scale system optimization. State-level policy heterogeneity, behavioral rebound effects, and the role of global supply chains are not explicitly captured but may significantly shape real-world outcomes. Future work could integrate these dimensions using dynamic modeling tools and subnational data to better assess the resilience and distributional effects of decarbonization pathways under uncertain political conditions.

AI Usage Disclosure

This report was supported by ChatGPT (GPT-5, August 2025 version), accessed via https://chat.openai.com. The tool was used to assist with deep literature exploration, initial structuring of comparative frameworks, refinement of academic language, and LaTeX formatting. While ChatGPT helped identify relevant academic sources, all cited articles, figures, and policy documents were read, interpreted, and verified directly by the authors. No AI-generated content was used to replace core analysis, argumentation, or data interpretation. The authors retain full responsibility for the accuracy, originality, and conclusions of this report.

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