Rhodium Group

Taking Stock 2024: US Energy and Emissions Outlook

Energy & Climate

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Contents

Executive Summary

Every year, Rhodium Group provides an independent projection of future US greenhouse gas (GHG) emissions under current policy and expectations for economic growth, future fossil fuel prices, and clean energy cost and performance trends. In the ten years since we released our first Taking Stock report, the US has made progress on a path to decarbonization. In 2023, US GHG emissions were 18% lower than they were in 2005. In addition, policies enacted at all levels of government have never been stronger for achieving even deeper cuts to emissions, including the passage of the Inflation Reduction Act (IRA) and Infrastructure Investment and Jobs Act (IIJA), adoption of a suite of federal regulations aimed at driving down emissions, and ambitious state action.

With all federal and state policies on the books as of June 2024, we estimate the US is on track to reduce its GHG emissions by 38-56% below 2005 levels in 2035, representing at least a doubling—and potentially as much as a four-times increase—from the pace of annual emissions abatement from 2005 to 2023. On the way to 2035, we find the US could reduce its emissions by 32-43% below 2005 levels in 2030. These emissions reductions under current policy are a measurable acceleration in mitigation even compared to our Taking Stock 2022 edition from just before the passage of the IRA, in which we found the US on track for a 24-35% reduction below 2005 levels in 2030. But they are not enough for the US to achieve its 2030 climate commitment under the Paris Agreement of a 50-52% reduction by 2030, or deep decarbonization by mid-century.

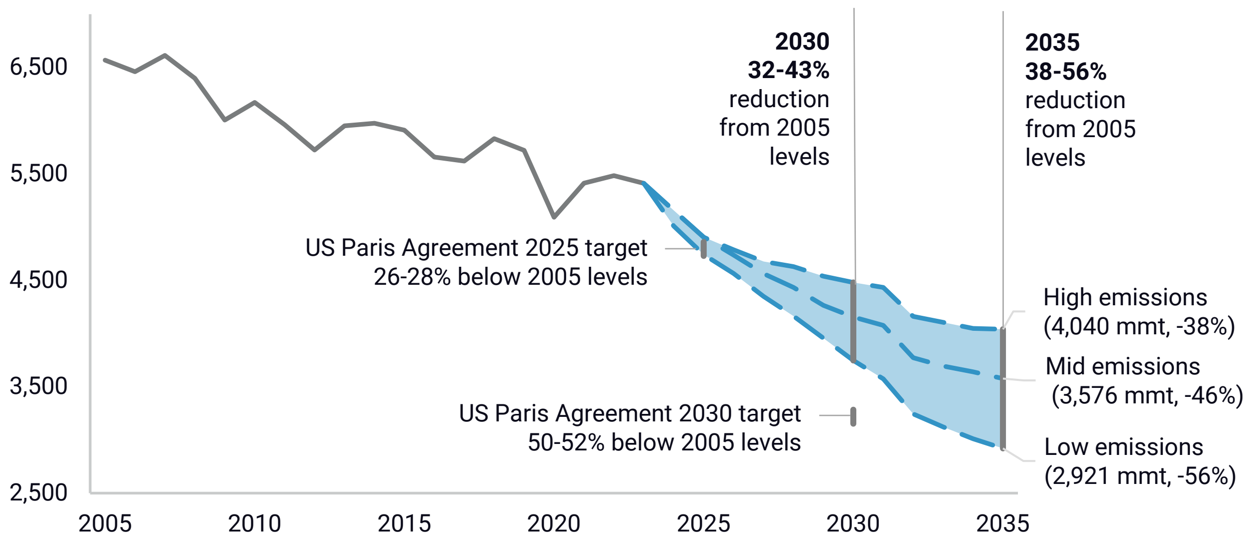
> “We estimate the US is on track to reduce its GHG emissions by 38-56% below 2005 levels in 2035, representing at least a doubling—and potentially as much as a four-times increase—in average annual emissions abatement over the pace from 2005 to last year.

This range of emissions outcomes represents the impacts of current policy under three potential economic and technological scenarios: a low emissions case in which cheap clean energy technologies and relatively more expensive fossil fuels continue to drive a rush of investment into decarbonization technologies which face little friction in deploying to their economic maximum in an economy growing slightly slower than Congressional Budget Office expectations; a high emissions case in which more expensive clean energy technologies and rock-bottom prices for fossil fuels combined with more headwinds like interconnection queue delays and supply chain constraints battering clean energy deployment, plus economic growth consistent with the latest Congressional Budget Office projections; and a mid emissions case which splits the difference between these two extremes.

FIGURE ES1

US greenhouse gas emissions under current policy

Net million metric tons (mmt) of CO_2-equivalent (CO_2-e)



Source: Rhodium Group

Note: The high, mid, and low ranges reflect uncertainty around future fossil fuel prices, economic growth, clean energy technology costs and supply constraints, and data center growth.

This level of decarbonization results from several key trends:

- Emissions from the power sector decline by 42-83% below 2023 levels in 2035. Despite persistently accelerating demand for electricity, we estimate that generation from zero-emitting sources like wind, solar, and nuclear could account for 62-88% of total generation in 2035, with unabated coal generation falling to near zero that year, driven both by the IRA's subsidies and EPA's newly finalized GHG emissions limits for power plants.
- Transportation sector emissions decline by 22-34% below 2023 levels in 2035, enabled in large part by the EPA's GHG emissions standards for light (LDV), medium (MDV), and heavy-duty vehicles (HDV), resulting in 64-74% of LDV sales being electric in 2032 and zero-emitting vehicles comprising 30-45% of all MDV and HDV sales in 2035.
- Emissions from oil and gas operations drop by 12-28% below 2023 levels in 2035, despite flat to increasing domestic production of both oil and natural gas, as EPA regulations reduce methane emissions from production, processing, and transportation.
- Building emissions drop by 9-12% as congressional action and EPA rules phase out the consumption of hydrofluorocarbons (HFC).

Despite this cause for optimism, sizeable challenges loom for achieving these ambitious results. One area of increasing attention is the impacts of accelerating electricity demand from a range of sources, including accelerating vehicle electrification, new domestic manufacturing facilities for clean energy technologies spurred on by the IRA, and an AI-driven surge in electricity demand from data centers. We examine the impacts of demand growth from data centers as well as limits on the ability to build and interconnect clean electric power generators in this report and find that if data center demand grows by nearly triple by 2035 and developers struggle to install new wind and solar, power sector emissions could be more than 275 million metric tons (or 56%) higher than our mid emissions case.

In addition, a substantial portion of the emission reductions results from regulations, which are drawing the ire of a conservative majority on the Supreme Court highly skeptical of the administrative state. These same regulations are also susceptible to rollbacks by the next presidential administration should they be more hostile to climate action. And, in the same vein of elections having consequences, and if past is prologue, a Republican trifecta controlling the White House, Senate, and House could potentially try to weaken or remove key aspects of the Inflation Reduction Act. On the other hand, Democratic control of the White House or a Democratic trifecta could potentially usher in another round of ambitious climate action, but the US will still have a long way to go, with a lot of policy action required, to advance to even deeper levels of decarbonization.

CHAPTER 1

Where is the US on the Path to Decarbonization?

When we released our first Taking Stock report ten years ago, we estimated that the US was on track for a 12-18% reduction in greenhouse gas emissions from 2005 levels in 2020. Emissions in 2020 were actually 22% below 2005 levels, driven by the COVID-19 pandemic and associated recession, but have roughly stabilized at around 17-18% below 2005 levels for the past couple of years. Though how we got to that outcome is a bit different than we anticipated—the Clean Power Plan never came into force, the shale revolution drove down oil and gas prices and drove up oil and gas production, and renewables continued dramatic cost declines—the view from 2014 was one of *upward*-trending emission expectations into the future.

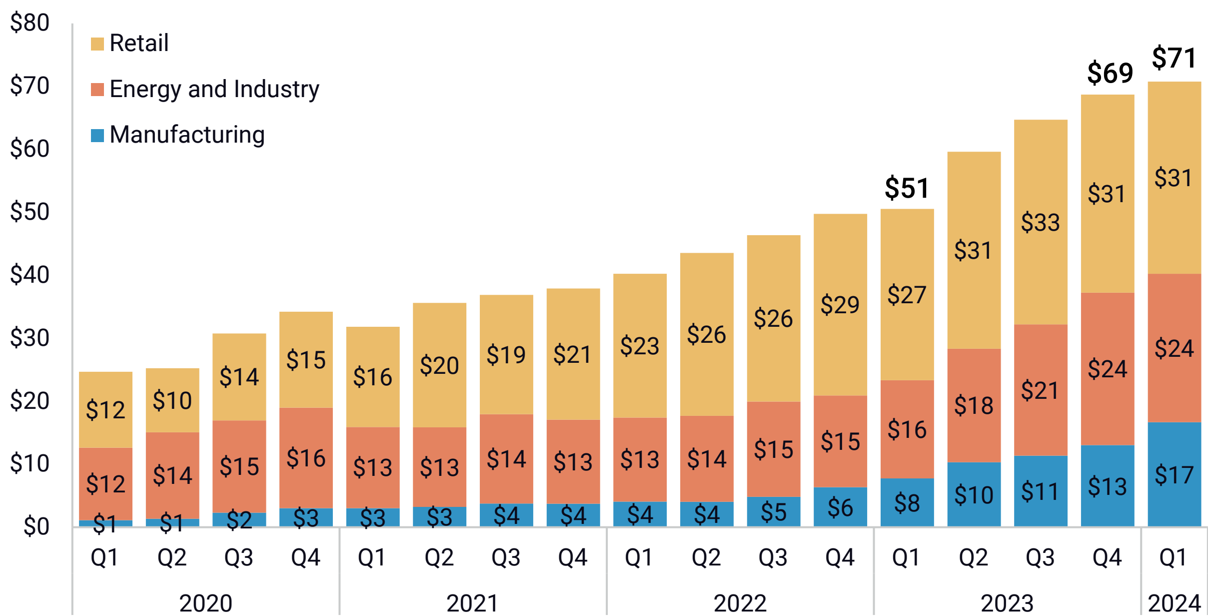
The US is in a meaningfully different place on its path to decarbonization today. US economic growth and emissions growth have largely decoupled: in all but two years since 2014, the economy has grown faster than emissions, and in four of the last 10 years, emissions shrank while the economy grew. Moreover, we concur with a wide range of projections that expect this trend to continue, and even accelerate, into the future.

Recent policy is accelerating a clean energy boom

Chief among the drivers of recent emissions declines and expectations of future, more significant declines is the passage of the Inflation Reduction Act (IRA) and Infrastructure Investment and Jobs Act (IIJA). Together, these laws represent the most substantial action the federal government has ever taken on climate change. And though we're approaching the two-year anniversary of the passage of the IRA (and have already passed that mark for the IIJA), the onerous but critical work of implementing the law continues. Over the past year, Treasury and IRS have proposed (and, in some cases, finalized) guidance for a wide array of tax credits, including those for clean vehicles, clean manufacturing, clean hydrogen, and the new technology-neutral clean electricity tax credits—which we've found may yield the single-largest emissions impact of the IRA. EPA, the Department of Energy, the Department of Agriculture, and other parts of the federal enterprise have likewise been awarding funding and putting in place critical programs that will reduce GHG emissions, improve air quality, and build new domestic manufacturing capabilities.

Through the Clean Investment Monitor, a partnership with MIT's Center for Energy and Environmental Policy Research, we regularly track how investors, developers, utilities, consumers, and other market actors have responded to the broad suite of incentives provided by this legislation, as well as other economic drivers. In the first quarter of 2024 (the latest data available at the time of writing), there was a record $71 billion in investment in clean energy and technology in the US—a 40% increase in investment from the first quarter of 2023 and a continuation of sustained quarter-on-quarter growth that began in the first quarter of 2021 (Figure 1).

FIGURE 1
Actual clean investment by segment
Billion 2023 USD



Source: Rhodium Group/MIT-CEEPR Clean Investment Monitor

EPA IS TAKING ACTION

Since we released Taking Stock last year, EPA has finalized three substantial rules that take aim at GHG emissions in major parts of the economy: regulations on methane emissions from oil and gas operations in December 2023, emissions standards for light, medium, and heavy-duty vehicles in March 2023, and emissions limits on existing coal power plants and new natural gas power plants in April 2024. We unpack these rules in more detail later in this report, but in general they help amplify the economic incentives provided by the IRA and provide important guardrails for emissions outcomes.

Challenges lie ahead

The US is making progress on decarbonization and, with a supportive policy environment providing wind in the sails, could even be on track to achieve its 2025 Paris Agreement commitment of a 26-28% emissions reduction below 2005 levels in the best-case scenario. Unfortunately, as we've said in the past, the progress to date and expectations for future emissions levels do not put the US on track to achieve its 2030 Paris Agreement commitment of a 50-52% emissions reduction below 2005 levels by 2030. Nor does current policy drive the US to sustain a pace of emission reductions that would enable the country to achieve deeper levels of decarbonization by mid-century. Moreover, even the outcomes that we and others have modeled in the past are not guaranteed, as decarbonization progress is buffeted by headwinds from several sources: quickening electricity demand growth, difficulties building clean electricity resources, and judicial and political uncertainty.

RECENT EXPECTATIONS FOR RAPID ELECTRICITY DEMAND GROWTH

It's hard to read the energy trade press or even mainstream outlets without encountering stories describing the latest utility bracing for higher-than-expected growth in electricity demand in the coming years, which some utilities and grid operators are using as justification to keep fossil power plants on the grid. The current fever-pitched conversation largely centers on demand coming from AI and other data center uses, as well as new manufacturing facilities for products like lithium-ion batteries and electric vehicles. This unanticipated increase in demand layers on top of more predictable sources of growth like electrification of the transportation fleet and building stock. Taken as a whole, these growth expectations are causing some utilities to raise reliability concerns and reconsider fossil generator retirements as they seek to match supply with demand on the grid.

CONTINUED CHALLENGES BUILDING AND CONNECTING CLEAN ELECTRICITY RESOURCES

The US added 19 GW of utility-scale solar and 6.6 GW of utility-scale storage to the grid in 2023—setting records for both resources as well as another annual record for total clean capacity additions, despite onshore wind additions of a relatively meager 6.4 GW, which is less than half its 2020 record installation year. Plant Vogtle Unit 3 also came online, adding another 1.1 GW of nuclear power to the grid. Yet, as we'll discuss later on, this level of clean capacity addition is well below what's required to achieve the deepest levels of GHG emissions reductions we estimate. Moreover, even sustaining this level of growth may be a struggle as developers face challenges with long interconnection queues, increasing local opposition to installations, onerous siting and permitting processes, lack of sufficient transmission capacity, continued supply chain constraints, and inflation.

JUDICIAL AND POLITICAL UNCERTAINTY

In the final two weeks of its term, the US Supreme Court handed down several decisions that together put the future of federal environmental and energy regulations, including federal regulations in our current policy scenarios, at risk. In *Loper Bright Enterprises et al. v. Raimondo, Secretary of Commerce, et al.*, the Court overturned the Chevron doctrine, the decades-old principle that granted federal agencies the ability to reasonably interpret ambiguous congressional statutes according to their unique expertise. Rather than deferring to agencies' expert views in questions concerning highly technical and specialized matters, the Supreme Court has transferred this power to the judiciary. The decision in *Corner Post, Inc v. Board of Governors of the Federal Reserve System* and *Securities and Exchange Commission v. Jarkesy et al.* also limits the reach of the administrative state by eliminating the time limit in which regulations can be challenged and curtailing the use of in-house tribunals. These decisions build on the Supreme Court's 2022 decision in *West Virginia v. EPA*, which drew a boundary around how EPA could implement GHG emissions limits on power plants and which directly influenced the design of the newly final EPA regulations on power plants.

Recent final regulations on GHGs already faced legal challenges before these recent decisions. The consequences of these decisions remain highly uncertain, depending on which legal battles plaintiffs choose to wage and how courts choose to interpret both these decisions and the specific cases before them. However, legal experts anticipate that the combination of these decisions will result in an explosion of legal challenges to existing regulations, more intense scrutiny of future regulations that effectively hamstrings agencies in charge of drafting them, weaker enforcement of existing and future regulations due to inadequate resources, and significant delays to the implementation of regulations. If this future comes to pass, the 2030 Paris Agreement target will be even harder to achieve without new legislative action.

Furthermore, it may not require an act of the court to reverse these regulations. The person who wins the White House in November will have the chance to leave their mark on GHG regulations, either defending them in court and pursuing additional action or revoking them wholesale. Some components of the IRA may also be susceptible to revision or reversal if there's a Republican trifecta in control of the White House, Senate, and House of Representatives.

Making sense of it all

Given recent history, the economic and policy environment, and these headwinds, we use the rest of this report to unpack where we estimate US GHG emissions to be headed through 2035 under current policies on the books. In Chapter 2, we describe our approach to modeling the US economy, including inputs and key policies. In Chapter 3, we unpack the results of our low, mid, and high emissions scenarios, which we'll refer to throughout as our baseline scenarios. In Chapter 4, we take a deeper dive into two of the major non-cost barriers to decarbonizing the power sector and isolate the effects of increases in electricity demand and limitations on how much clean electricity supply can come online. Finally, in Chapter 5, we offer some thoughts on the uncertainties we mention above, as well as where the US needs to go from here to achieve deeper levels of decarbonization.

CHAPTER 2

Bounding Uncertainty in Projections

We project the energy system and emissions impacts of the suite of current policies under a range of future energy markets, technology, and economic futures. New this year, we also incorporate uncertainty in the power sector around clean technology supply constraints and increased electricity demand: considering the recent increase in electricity demand from machine learning and artificial intelligence, we include three potential trajectories for data center demand growth in our scenarios as well as demand from new clean energy technology manufacturing facilities. Critically, we do not produce probabilistic forecasts but rather determine a range of possible outcomes using a combination of testing and modeler judgment. As such, the ranges we report represent distinct emissions pathways rather than confidence intervals on a central estimate.

We provide emissions and energy system projections for three main scenarios:

> Our **high emissions pathway** provides our sense of a reasonable upper bound on US emissions through 2035, combining the most conservative cost declines for a suite of clean technologies (including clean power, industrial decarbonization technologies, electric vehicle prices, direct air capture costs, and beyond) with our lowest projected oil and gas prices and economic growth consistent with the latest Congressional Budget Office (CBO) projections through the early 2030s. Our high emissions pathway also includes our highest data center growth projections. Also new this year, we limit the ability of wind and solar to deploy meaningfully beyond historic maximum capacity additions in a single year as a way to represent the supply-side barriers we discuss above.
>
> Our **low emissions pathway** provides a lower bound on US emissions through 2035 and is effectively the opposite scenario to our high emissions scenario. It pairs aggressive cost declines and performance improvements for clean technology with our highest projected oil and gas prices and slightly slower-than-expected economic growth. This pathway also includes our lowest data center growth assumptions and no exogenously imposed limit on wind and solar deployment.
>
> Our **mid emissions pathway** assumes more moderate trajectories for many of these factors, with continued cost declines for clean technologies, but not as aggressive as in the low emissions scenario, with no exogenous limit on wind and solar deployment; fossil fuel prices roughly consistent with recent historical averages; economic growth consistent with CBO's projections; and our central data center growth trajectory.

We provide more details on the policies, constituent inputs of these scenarios, and our modeling environment in the rest of this chapter, and we go into much greater detail in the Technical Appendix to this report.

Federal and state policy progress

The year since we released Taking Stock 2023 has been a busy one in the federal executive branch, and we represent all federal and state policies on the books as of June 2024.[1] The Department of Treasury and Internal Revenue Service have proposed two landmark interpretations of IRA provisions, one governing the technology-neutral tax credits in the power sector, the other the production tax credit for clean hydrogen. Though these rules are not yet final, we adopt IRS and Treasury's interpretation of these credits as proposed into our modeling. They have also produced a trove of other implementing regulations, particularly those relating to the clean vehicle credits, bonus crediting for energy communities, and the transfer of select tax credits. Though it doesn't meaningfully impact results within the time frame we examine in this report, we phase out the tech-neutral power sector credits in the low emissions scenario based on achievement of a 75% reduction in power sector emissions over 2022 levels per statute, which we find is met in 2032.

EPA has likewise been productive, and we incorporate four new, final EPA regulations into Taking Stock this year:

- Greenhouse gas standards and emissions guidelines for new gas and existing coal plants
- Emissions standards for model year 2027 and later LDVs, MDVs, and HDVs
- Emissions standards for new and existing oil and gas operations
- Updates to the Mercury and Air Toxics Standards (MATS) for power plants

At the state level, seven states pledged to join California in following Advanced Clean Cars II, requiring 100% light-duty ZEV sales by 2035. Virginia is the only state that backtracked its previous choice to adopt these higher regulations. Ten states joined California in following the Advanced Clean Trucks regulation. Our modeling reflects these adjustments, recognizing both successful policies and the barriers inhibiting others from meaningful implementation. Contract cancellations driven by inflation and supply chain shortages are one of several issues driving uncertainty in state achievement of their offshore wind mandates, and we revise planned offshore wind builds downward accordingly.

The Technical Appendix provides a complete list of all state and federal policies that make up this year's current policy baseline.

Economic projections

We reviewed a range of macroeconomic projections from government institutions, non-governmental organizations, and the financial sector for key metrics, including economic growth, inflation, and federal funds rates. Based on these forecasts, we selected two forecasts to bound economic expectations in our emissions scenarios.

[1] Just as this report was going to press, the Supreme Court stayed enforcement of EPA's "Good Neighbor" plan governing criteria pollutants under the Cross-State Air Pollution rule, so that rule remains in force in this modeling. Similarly, we implement a one-year pause on new liquified natural gas terminal approvals to reflect the Department of Energy's recent actions despite a district court stay.

Under baseline economic conditions, used in our mid and high emissions scenarios, GDP growth stabilizes in the near term around 2.0% on an average annual basis following the economic turbulence of both the pandemic and the associated recovery. Growth reaches 2.2% in the late 2020s and then falls slightly to 2.1% in the early 2030s. The latest CBO projections align closely with our baseline economic conditions, forecasting 2.1% growth on average through the end of this decade. However, CBO expects lower growth than our baseline from 2031-2034 (the final year of its forecast), with growth rates settling at 1.9%—close to their 1.8% historical average since 2008.

Our slower growth economic assumptions, used in our low emissions scenario, fall below CBO expectations primarily in the short term but align with CBO projections by the 2030s. Under these low assumptions, growth is slower to recover following the pandemic and the dramatic interest rate hikes of the last couple of years, averaging 0.8% through 2025. Growth becomes steadier at 1.9% from 2026-2030 and then grows further to 2.0% in the 2030s. The total size of the US economy as measured by GDP is 4.9% larger under baseline economic growth relative to this slower growth scenario. In both economic scenarios, we boost interest rates through 2026 to reflect expectations that interest rates remain elevated for the next couple of years.

Economic conditions alone play an important role in future emissions pathways. GDP drives emissions growth through a number of factors, including the availability of household disposable income, which in turn drives factors like vehicle purchasing decisions, vehicle miles traveled, and home energy consumption. For households experiencing energy poverty and insecurity, higher disposable income can enable safer conditions within a home by allowing occupants to run the air conditioning or space heating earlier in the season and increasing its dial setting. Industrial output, a key component of GDP, is also positively correlated with emissions. In our testing, we found that a shift from baseline to low economic growth while holding all other inputs constant yields an emissions increase of at least 230 million metric tons in 2035. On the other hand, any surprise shocks that push GDP down can also decrease emissions, and such shocks are not captured in this framework.

Energy markets

In addition to the two economic scenarios outlined above, we use three sets of energy market conditions to build our three emissions scenarios. In all three scenarios, natural gas prices take two to three years to recover from the 2022 price spike driven by the war in Ukraine. In the lowest price projection, natural gas prices at Henry Hub average $3.80/MMBtu through 2025 and decline to an average of $2.90/MMBtu in the late 2020s, continuing some of the lowest annual average prices in recent history. Prices rebound to $3.30/MMBtu in the early 2030s. Brent crude prices likewise remain slightly elevated through 2025, averaging $90/barrel, before settling just above historical averages at $80/barrel in the late 2020s and $80/barrel in the early 2030s. These prices represent robust growth of US oil and gas production through 2035.

The mid and high fossil price projections represent higher prices than in recent history, which corresponds with many external forecasts for these prices. In the mid price scenario, natural gas averages $4.40/MMBtu for the next couple years, $3.30/MMBtu in the late 2020s, and $3.90/MMBtu in the early 2030s. In the high price scenario, gas prices take even longer to return from recent peaks, averaging $5.10/MMBtu through 2025, before settling around $4.15/MMBtu in the late 2020s and $4.85/MMBtu in the early 2030s. In oil markets, Brent crude averages $95 and $115/barrel in the mid and high price scenarios through 2025, $90 and $125/barrel in the late 2020s, and finally, $95 and $125/barrel through 2035.

While our high gas prices are meaningfully higher than recent average annual prices, they are also considerably lower than the highest annual average prices over the last 15 years and lower than the assumptions we used for Taking Stock 2023. Natural gas has been persistently cheap over the past several years—except for the price shock in 2022—in large part because US oil and gas production has been steadily climbing. Today, US fossil fuel production sits at record levels with no indication of a slowdown in the near- to medium-term. Current gas production far exceeds domestic demand. In light of these dynamics and consistent with external projections of natural gas prices, we have revised our high price assumptions downwards by about $0.80 through 2035 relative to the high prices in Taking Stock 2023. Additionally, these prices reflect relatively flat oil and gas production at current levels through 2035, where we previously reflected declining production.

Clean technology cost and performance

We use the latest technology cost projections from the National Renewable Energy Laboratory's 2024 Annual Technology Baseline (ATB) for most of our utility-scale and distributed clean technology costs. Where appropriate, we adjust costs to reflect important differences between the technologies that ATB assumes and the technology included in our model, but we remain well-aligned with the overall cost trajectories. ATB projects higher expected capital costs for both onshore wind and offshore wind than last year's vintage of the ATB through our study window. This year, NREL adopted a new methodology for estimating costs for advanced and small nuclear reactors, which we've included in our inputs for the first time.

We use low, reference, and high battery storage costs from Annual Energy Outlook (AEO) 2023 in the power sector. We use Rhodium Group's estimates for central, low, and high costs for carbon capture technologies in the power sector. We generally rely on AEO2023 reference case projections for unabated fossil generator costs.

In the transportation sector, we align our battery cost assumptions with those underlying EPA's analysis of its latest GHG standards for light-duty and medium-duty vehicles. In industry, we recently completed a substantial update to our Industrial Carbon Abatement Platform (ICAP), including updated carbon capture retrofit costs and replacing existing steam methane reformers with electrolyzers for hydrogen production.

Using RHG-NEMS

We use RHG-NEMS to quantify energy sector and emissions outcomes. RHG-NEMS is Rhodium Group's modified version of the National Energy Modeling System (NEMS), a model developed by the US Energy Information Administration (EIA) to produce their Annual Energy Outlooks (AEOs). Rhodium Group maintains a version of NEMS that we modify from the EIA base version. EIA did not release an AEO in 2024, because they are implementing substantial updates to the model. This year, we continue to use the base

NEMS model from AEO 2023. As we do each year with base NEMS, in addition to changing many key inputs (as described above) and bringing the current policy representation up to date as of June 2024, we also vary key assumptions and algorithms in the model based on research and recent real-world observations.

We further augment this version of NEMS by integrating results from RHG-ICAP, our industrial sector decarbonization tool, to estimate deployment of carbon capture and electrolyzer installation at existing industrial end uses. We also integrate results from EPA's Optimization Model for reducing Emissions of Greenhouse Gases from Automobiles (OMEGA) to project the composition of the light-duty fleet under EPA's new tailpipe rules.

We expand this version of NEMS to include all sectors of the US economy and coverage for all six greenhouse gases targeted for reduction under the Kyoto Protocol. We continue to use the latest land use, land use change, and forestry (LULUCF) projections from the US Fifth Biennial Report. Consistent with EPA's annual Inventory of Greenhouse Gas Emissions and Sinks and United Nations Framework Convention on Climate Change (UNFCCC) requirements, we use 100-year global warming potential (GWP) values from the IPCC Fifth Assessment Report (AR5). Finally, we downscale this data to provide state-level results for key metrics.

Incorporating new demand for electricity

RHG-NEMS endogenously derives future demand for electricity from a number of end uses, including electric vehicles and building electrification, which flows through to the model's power sector decisions. However, it does not incorporate unanticipated surges in electricity demand, the likes of which have been attracting meaningful recent attention. As such, we increase electricity demand from a couple of new sources to reflect what's playing out on the ground: data centers and new domestic clean energy manufacturing.

First, we increase electricity demand from data centers driven by AI and other major new sources of computing demand. We reviewed a range of analyst projections for where demand could be heading from data centers and developed three growth pathways, which we incorporated into our three baseline scenarios (Table 1). NEMS includes modest endogenous demand growth from data centers, representing 4-8% of the absolute levels of demand we project in the scenarios in Table 1; we remove this growth before adding our own projections.

TABLE 1
Growth in demand from data centers from 2023
Percent increase from 2023 levels

Data center case	Taking Stock scenario	Growth in 2030	Growth in 2035
Low growth	Low emissions	85%	140%
Mid growth	Mid emissions	110%	180%
High growth	High emissions	160%	260%

Source: Rhodium Group

Second, we incorporate electricity demand from two major new areas of clean energy manufacturing: batteries and electric vehicles. To do so, we review manufacturing facility announcements on the Clean Investment Monitor and add additional demand for electricity scaled to the size of the facility in the appropriate regions. We incorporate this demand consistently across all three baseline scenarios. Though total demand from these sources is meaningfully smaller than our data center demand increase, they can have important regional consequences.

CHAPTER 3

Emissions Outlook and Key Sectoral Trends

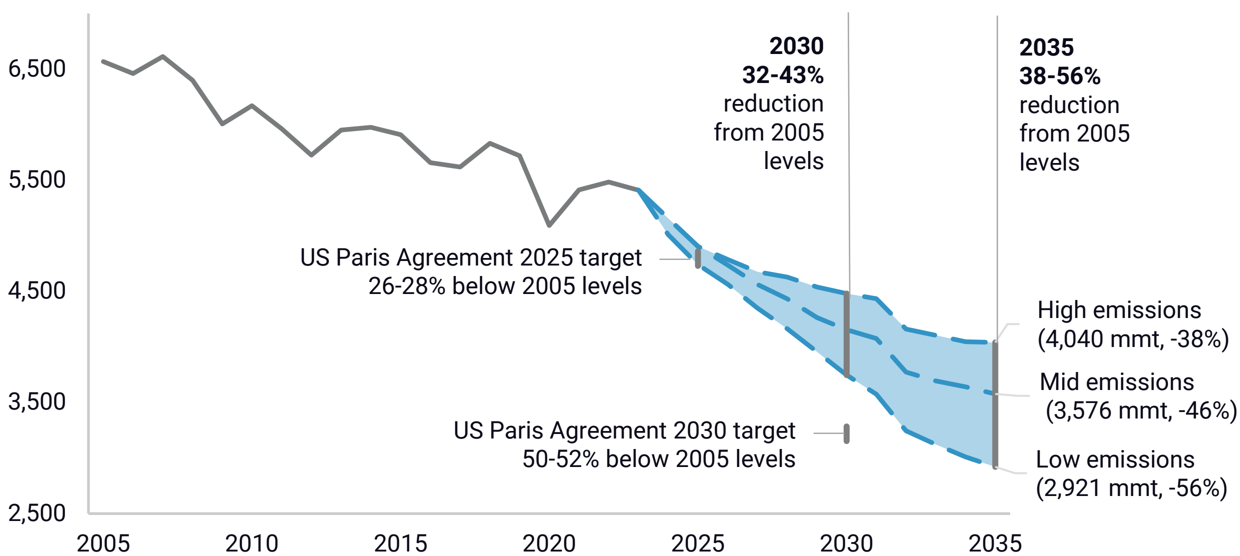
We estimate that US GHG emissions will decline to 2.9 to 4.1 gigatons of CO_2-e in 2035, a 38-56% reduction in emissions levels below 2005 levels (Figure 2). This represents an average annual decrease of 2.2-4.8% annually from 2024 through 2035, roughly two to four times more annual decrease than the US experienced from 2005 through 2023. As we'll explore below, federal policy drives emissions reductions beyond the economics of the IRA. Even the high emissions scenario sees a steep decline in emissions in the 2030s as clean technologies replace incumbent fossil technologies to meet new EPA regulations on vehicles and power plants.

Along the way, we estimate emissions decline to 3.5 to 4.5 gigatons in 2030, or a 32-43% decrease from 2005 levels. In these scenarios, the US does not reach its 2030 commitment under the Paris Agreement of a 50-52% reduction below 2005 levels, though it does achieve that target by 2035 in the low case. In our modeling, the US could still meet its 2025 Paris target of a 26-28% emissions reduction below 2005 levels, but we only find that in the low emissions case—our most ambitious decarbonization scenario—though it's relatively close in our mid and high cases as well.

FIGURE 2

US greenhouse gas emissions under current policy

Net million metric tons (mmt) of CO_2-equivalent (CO_2-e)



Source: Rhodium Group

Note: The high, mid, and low ranges reflect uncertainty around future fossil fuel prices, economic growth, clean energy technology costs and supply constraints, and data center growth.

Relative to our estimates using roughly similar scenarios in Taking Stock 2023, we expect about the same level of emissions reductions in 2030 in the low and mid emissions cases. In the high emissions case, EPA's oil and gas methane regulations help put downward pressure on emissions from those sources, leading to lower emissions in this year's report (compared to a 29% reduction in Taking Stock 2023). By 2035, emissions outcomes are uniformly lower, owing mostly to the combination of power, transport, and oil and gas regulations from EPA. We discuss each of these sectors in further detail below.

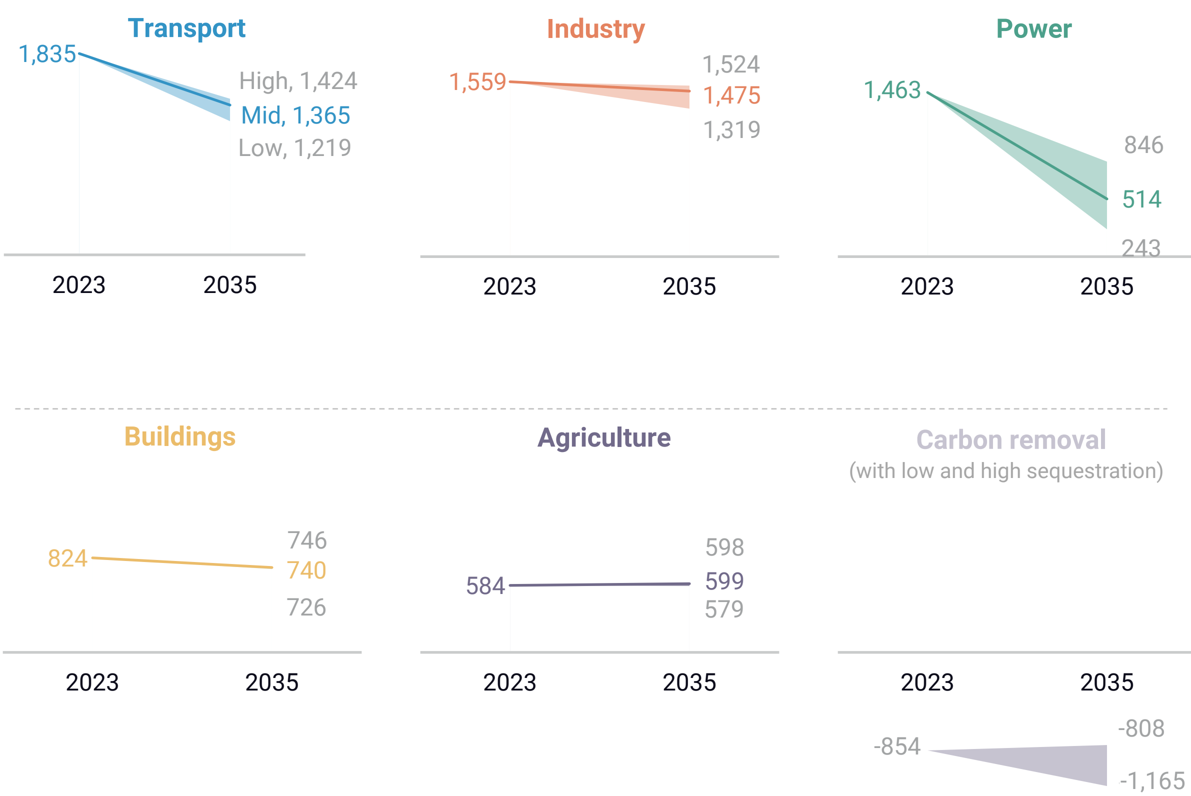
Emissions decline meaningfully in power and transport

As we've found in the past, there's a reshuffling of the order of the largest emitting sectors in the US. The power sector, which until 2016 was the largest emitting sector in the economy, sees the sharpest declines in emissions and reaches 42-83% below 2023 levels in 2035 (Figure 3). The transportation sector—currently the largest emitter—also sees meaningful declines of 22-34% below 2023 levels in 2035 and falls behind industry as the second-highest emitting sector. Industry, inclusive of emissions from oil and gas operations, sees far more modest declines (2-15% below 2023 levels) and becomes the biggest emitter in the US in 2033. In fact, in the mid and high cases, all of the emissions decline in industry comes from oil and gas emissions, while non-oil and gas industrial emissions increase further.

FIGURE 3

US greenhouse gas emissions under current policy

Net million metric tons of CO_2-e



Source: Rhodium Group

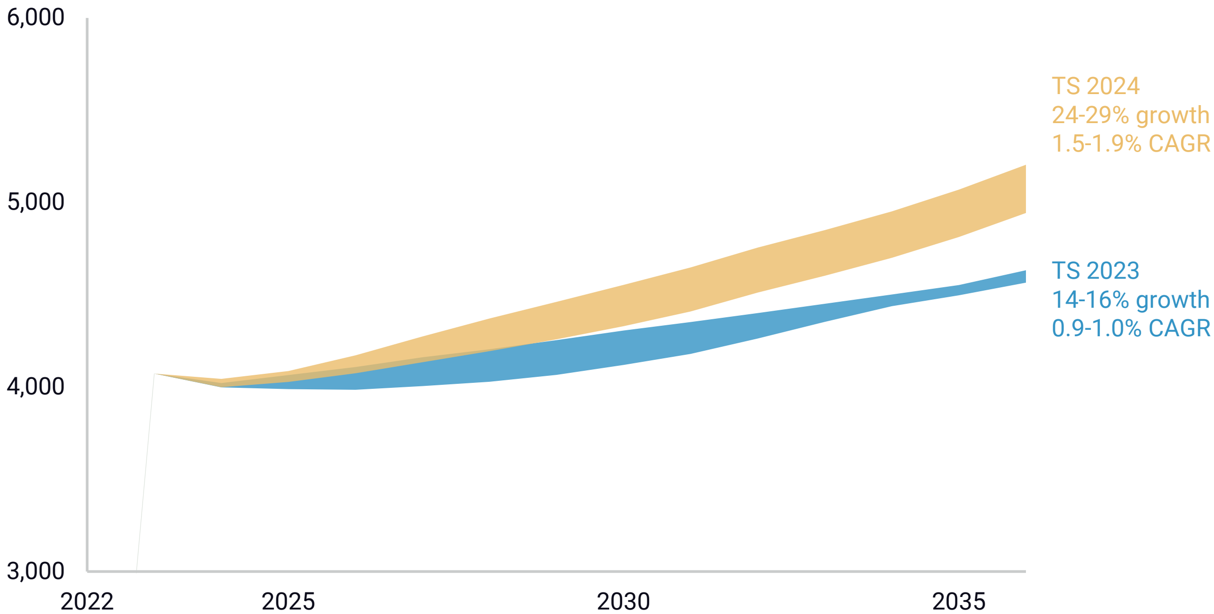
Note: The high, mid, and low ranges reflect uncertainty around future fossil fuel prices, economic growth, clean energy technology costs and supply constraints, and data center growth.

Other sectors generally see less change. Building sector emissions decline by 9-12% over 2023 levels in 2035, driven largely by decreases in emissions associated with the consumption of hydrofluorocarbon (HFC) and emissions from municipal landfills attributed to waste from homes and businesses. Agricultural soil emissions, methane from cattle, and other agricultural emissions remain effectively flat.

The power sector is an increasing nexus for decarbonization

We take a deeper dive into the power sector in Chapter 4, but at a high level, the significant decline in power sector emissions represents an interplay between a number of individual factors. First, as we introduced in Chapter 1, we expect electricity demand to grow faster than in the recent past, at up to nearly twice the rate this year as we did in last year's Taking Stock (Figure 4). As a result, demand for electricity is 24-29% higher than today in 2035. This is a function of both long-term structural electrification of transportation and buildings, faster overall economic growth, and more immediate growth from sources like data centers and manufacturing of clean energy technologies.

FIGURE 4
Electricity demand
Billion kilowatt hours (BkWh)

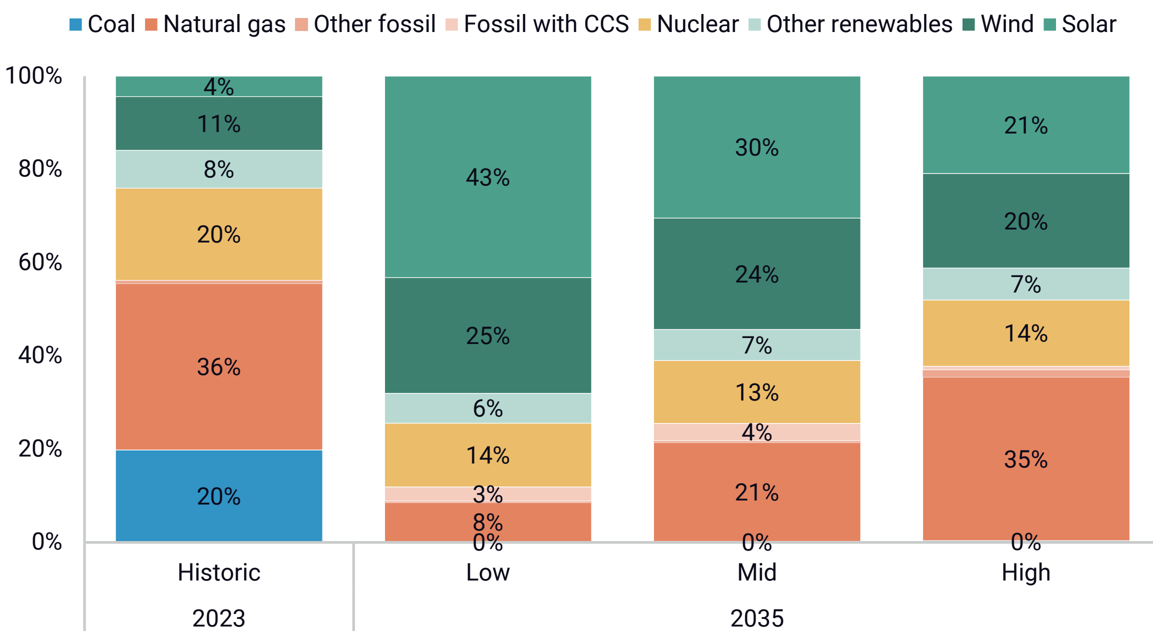


Source: Rhodium Group

Despite this growth in demand, the grid continues to shift to cleaner generating resources. By 2035, zero-emitting generation accounts for 62-88% of total generation, with 41-68% coming from wind and solar alone (Figure 5). This outcome is a result of a few forces pulling in the same direction. Continued capital cost declines for variable renewables and batteries, combined with IRA subsidies for zero-emitting technologies, allow these resources to outcompete fossil fuels for new capacity and, in many cases, displace existing fossil generation.

In addition, the newly adopted GHG limits on power plants reduce generation from uncontrolled coal plants (i.e., those without carbon capture) to nearly zero by 2035. Though we've estimated a decline in coal generation due to unfavorable economics for years now, these 111 regulations accelerate this trend. Online coal capacity in 2035 is down 85-90% from 2023 levels. Moreover, the little bit of uncontrolled coal that does remain on the grid in 2035 effectively disappears once the final requirements for meeting emissions levels consistent with the application of carbon capture are fully in place beginning in 2039.

FIGURE 5
Power sector generation by technology
Percent of total generation



Source: Rhodium Group
Note: The high, mid, and low ranges reflect uncertainty around future fossil fuel prices, economic growth, clean energy technology costs and supply constraints, and data center growth.

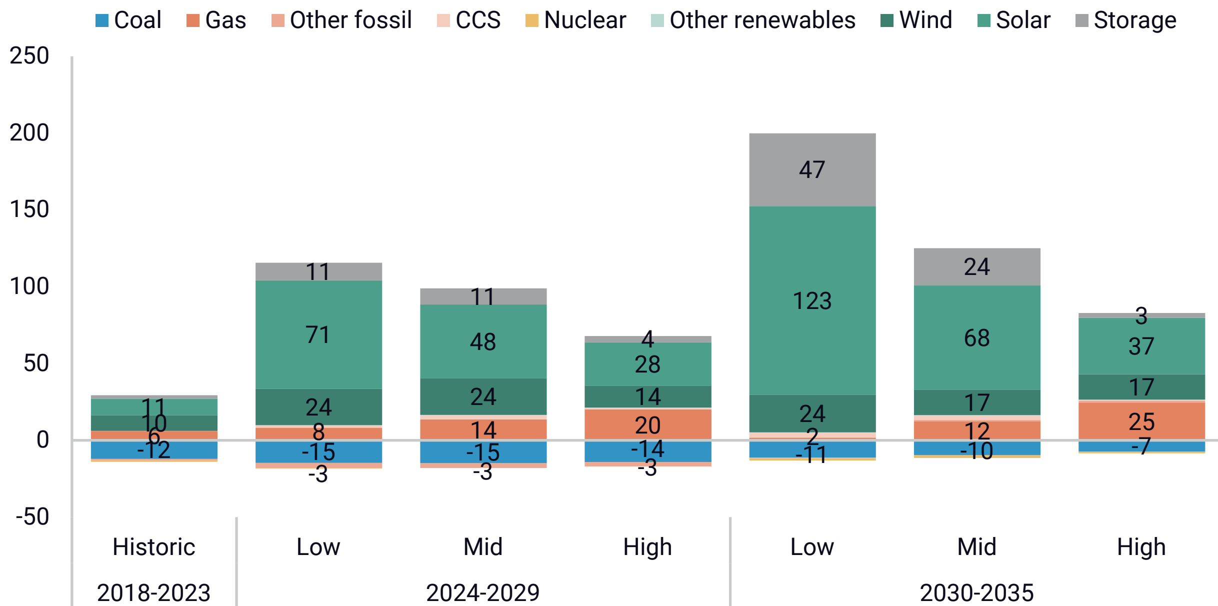
Given the retirement of this coal capacity plus anticipated faster growth in electricity demand than we've seen in the recent past, what the grid mix looks like in 2035 is heavily dependent on assumptions around the cost and availability of other types of generators. In the low emissions case, at the high end of the range of zero-emitting generation, wind, solar, and storage expand rapidly, averaging 145 GW of generator capacity additions in the early 2030s and another 47 GW of storage additions (Figure 6)—just under seven times recent historical averages. Though this level of growth is the most economically optimal given rock-bottom renewable prices and relatively more expensive natural gas, it will not happen without additional policy action to overcome the non-cost barriers facing clean electricity deployment today, such as siting and permitting, interconnection, and supply chain challenges that we discuss in Chapter 4.

In the high emissions case, in which gas hovers at or below $3/MMBtu for most of the time we consider, renewables cost more, and we constrain the ability of renewables to build substantially faster than their historical maximum. In that case, wind and solar only comprise 39% of generation on the grid in 2035, and gas generation remains effectively at today's levels. That said, gas plays a meaningfully different role, with lower capacity factors across the entire gas fleet and a higher reliance on peaker capacity.

FIGURE 6

Average annual net capacity change (additions less retirements)

Gigawatts



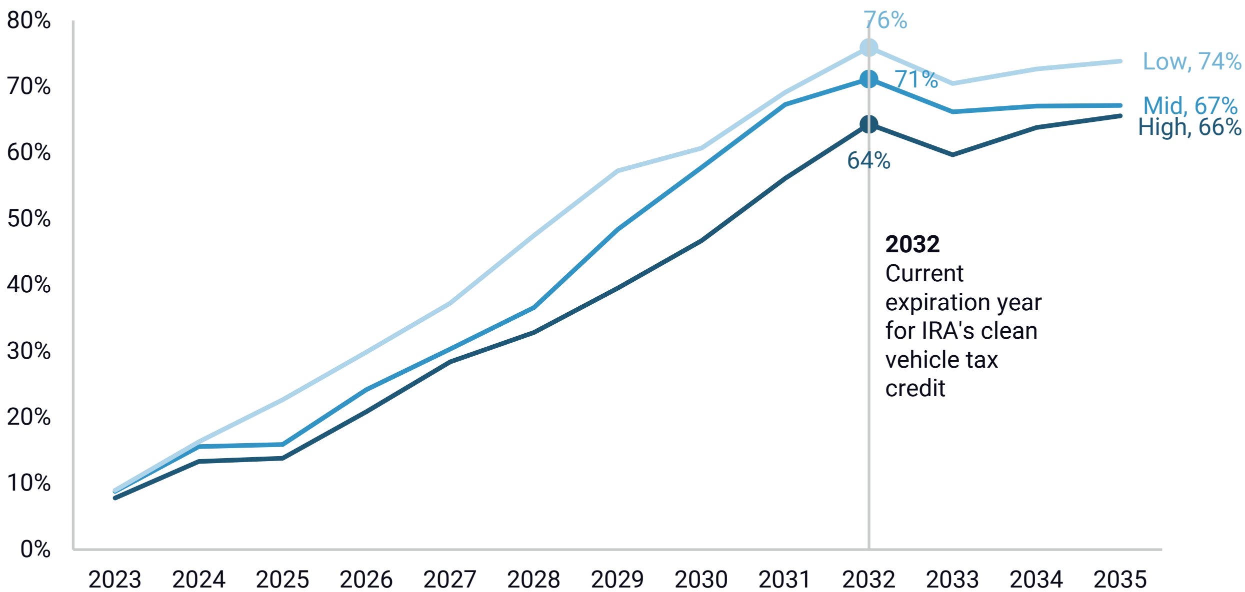
Source: Rhodium Group

Note: The high, mid, and low ranges reflect uncertainty around future fossil fuel prices, economic growth, clean energy technology costs and supply constraints, and data center growth.

Cleaner transportation across the board

EPA's newly adopted regulations governing emissions from the light, medium, and heavy-duty on-road fleets, combined with tax incentives provided through the IRA, rapidly accelerate the uptake of zero-emitting vehicles. In the light-duty vehicle (LDV) fleet, we estimate electric vehicles (including both pure battery electric as well as plug-in hybrid electric vehicles) reach 64-76% of all LDV sales in 2032, the current expiration year for the IRA's clean vehicle tax credit, and then sustain at those levels thereafter (Figure 7). This marks a significant upward revision in EV sales projections from Taking Stock 2023, in which we expected 33-66% of LDV sales to be electric in 2035, demonstrating the role of EPA regulations in moving the needle on consumer uptake and, particularly in the high case, putting an aggressive floor under EV sales. EPA projects that the new LDV standards will result in an 85 grams/mile industry-wide average target for the light-duty fleet in MY2032. This is nearly 50% lower than target emissions in MY2026.

FIGURE 7
Light-duty vehicle electric sales shares
Percent of total light-duty vehicle sales



Source: Rhodium Group
Note: Electric vehicles include battery electric and plug-in hybrid vehicles. The high, mid, and low ranges reflect uncertainty around future fossil fuel prices, economic growth, clean energy technology costs and supply constraints, and data center growth.

Medium and heavy-duty fleet zero-emitting vehicle (ZEV) sales shares continue to rise through 2035, reaching 30-45% of total sales. The EPA medium and heavy-duty emission standards finalized in the past year markedly raise the floor of heavy-duty electrification, reaching 30% versus only 15% in Taking Stock 2023. Heavy-duty EV sales shares lag behind their LDV counterparts by roughly 30%, reflecting continued challenges facing the electrification of the freight transportation sector.

Production increases, emissions decline in the oil and gas sector

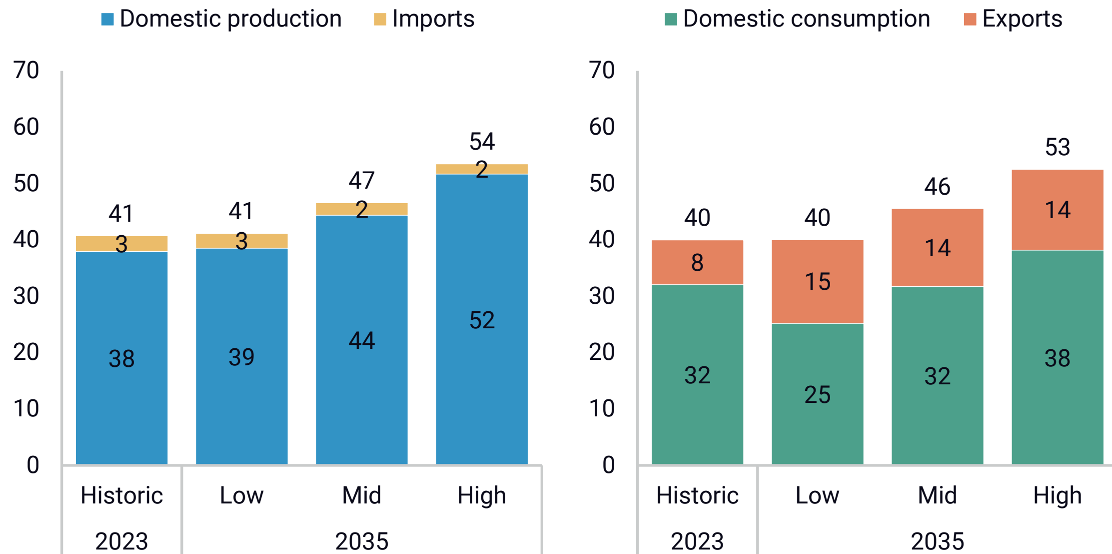
With current policy on the books, we project production of oil and gas to remain roughly flat from today's levels in the low emissions case. Gas production increases by 16-34% in the mid and high cases, and oil production increases by 11-50% in the mid and high cases (Figures 8 and 9). Of the increase in gas production, 13-29% comes from associated gas with the remainder coming from non-associated gas.

This increase in production comes despite shrinking or flat demand for gas in all but the high emissions scenario and shrinking demand for oil across the board. Excess production expands exports in the case of natural gas (nearly all in the form of liquified natural gas), while it reduces imports in the case of crude oil.

FIGURE 8

Natural gas supply and utilization in 2035

Quadrillion BTU



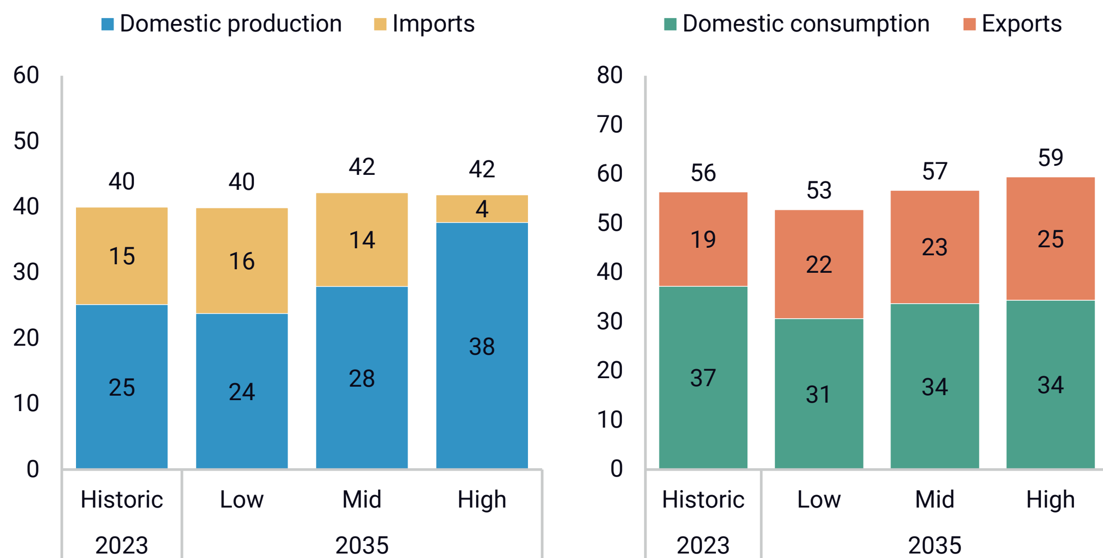
Source: Rhodium Group

Note: The high, mid, and low ranges reflect uncertainty around future fossil fuel prices, economic growth, clean energy technology costs and supply constraints, and data center growth.

FIGURE 9

Crude oil supply and petroleum utilization in 2035

Quadrillion BTU



Source: Rhodium Group

Note: The high, mid, and low ranges reflect uncertainty around future fossil fuel prices, economic growth, clean energy technology costs and supply constraints, and data center growth.

Despite increases in production, emissions from oil and gas operations drop uniformly owing to EPA's finalized methane regulations. Emissions drop 12-28% in 2035 below 2023 levels, counteracting otherwise rising industrial emissions in the mid and high emissions scenarios and amplifying a modest drop in non-oil and gas industrial emissions in the low case.

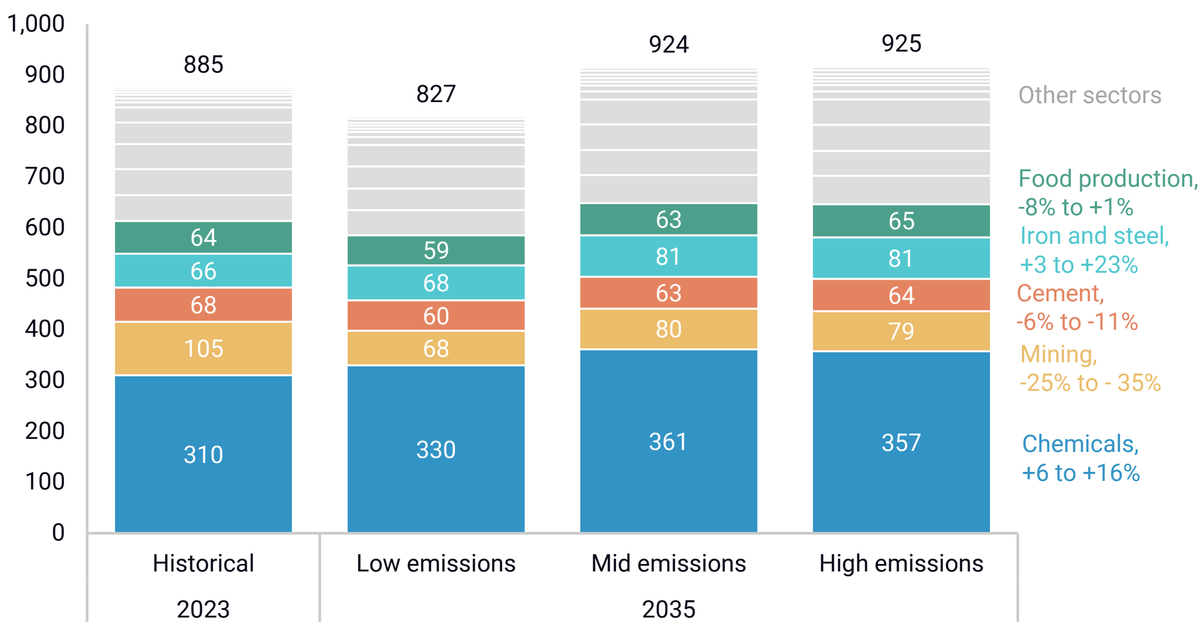
Manufacturing and other non-oil and gas industrial emissions change little

The drop in emissions from oil and gas leads to a 2-15% total drop in industrial emissions in 2035 from 2023 levels, but we see little change in the other sub-sectors of industry. Industrial sector emissions in 2035 from all industries except oil and gas operations fall by 7% in the low emissions scenario and increase by 4% and 5% in the mid and high emissions scenarios, respectively, compared to 2023 levels. Five major industries—chemical production, mining, cement manufacturing, iron and steel production, and food production—are responsible for around 70% of total non-oil and gas industrial emissions both in 2023 and in future scenarios. Among these, the chemical industry shows the highest absolute growth in emissions across all three scenarios and expands by as much as 16% in 2035 (Figure 10).

FIGURE 10

Industrial sector emissions from non-oil and gas sources

Million metric tons of CO_2-e



Source: Rhodium Group

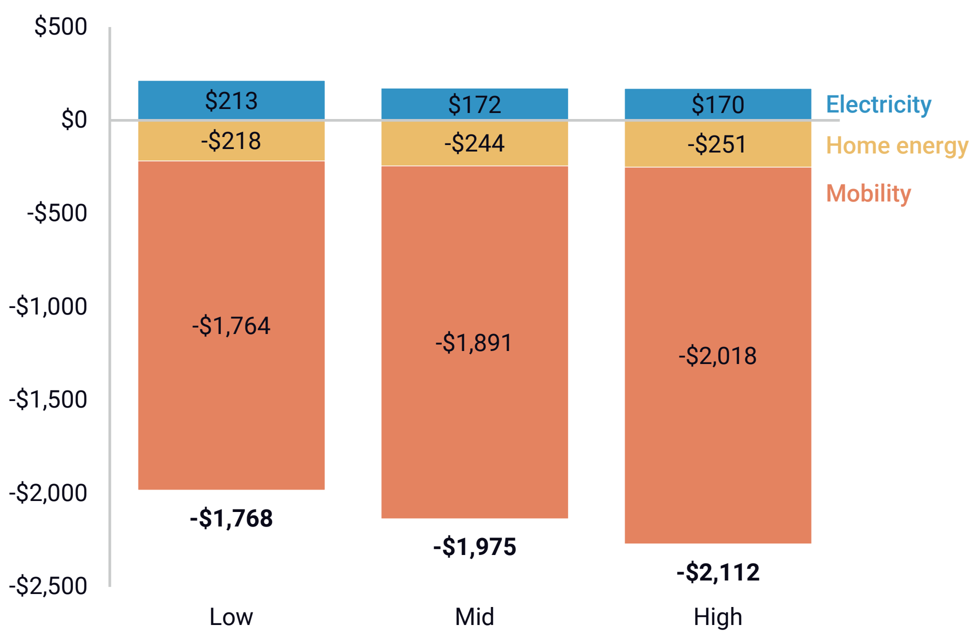
Note: These figures include combustion and process emissions but not emissions from electricity use in these industries. The high, mid, and low ranges reflect uncertainty around future fossil fuel prices, economic growth, clean energy technology costs and supply constraints, and data center growth.

The biggest differences between scenarios come from different projections for industrial output linked to the two economic growth cases we use, leading to higher emissions in the mid and high scenarios. In the low scenario, point-source carbon capture retrofits on key sources of industrial emissions and deployment of electrolyzers to produce green hydrogen substituting for current demand for grey hydrogen are more affordable, and so we find higher uptake of these decarbonization technologies in this scenario, spurred on by tax credits consistent with our recent findings.

Household energy bills decline from today

In line with the past two years of Taking Stock, household energy bill expenditures continue to show declines through 2035. We estimate total household energy bills drop by $1,768-$2,112 in 2035 (Figure 11). The vast majority of this decline comes from lower average bills for gasoline and diesel. EV adoption, fuel economy standards, and overall lower fuel demand push down gasoline and diesel spending. Costs, in turn, fall for all consumers. Electricity bills are slightly higher as a result of increased home charging of these EVs, but lower overall electric rates help mitigate the total bill increase. Home energy bills see modest decreases as various household appliances electrify and increase in efficiency.

FIGURE 11
Change in household energy costs from 2023 to 2035
2023 dollars



Source: Rhodium Group
Note: The high, mid, and low ranges reflect uncertainty around future fossil fuel prices, economic growth, clean energy technology costs and supply constraints, and data center growth.

CHAPTER 4

Barriers to Powering Through

As we've referenced throughout the report, the power sector has an instrumental role to play in decarbonization: electrification of a wide range of end uses is a major strategy in any deep decarbonization roadmap, enabling a transition away from the direct use of fossil fuels and benefitting from generally higher energy efficiency of electrified end uses relative to fossil combustion alternatives. To contribute to decarbonization, the electricity powering these new electric vehicles, heat pumps, and electric industrial boilers needs to come from clean generators. If all goes to plan, growing electricity demand will be met by growing clean generation, reducing GHG emissions across the economy.

Of course, all rarely goes to plan. We've touched on some of the headwinds that have started blowing more strongly recently, particularly faster demand growth for power and challenges building clean resources. In this chapter, we unpack those demand and supply-side challenges and quantify the impacts that they might have—individually and jointly—on the trajectory of power sector emissions through 2035. To do so, we ran three sensitivities varying electricity demand growth from data centers and headwinds to the buildout of renewable resources, starting from our mid emissions baseline.

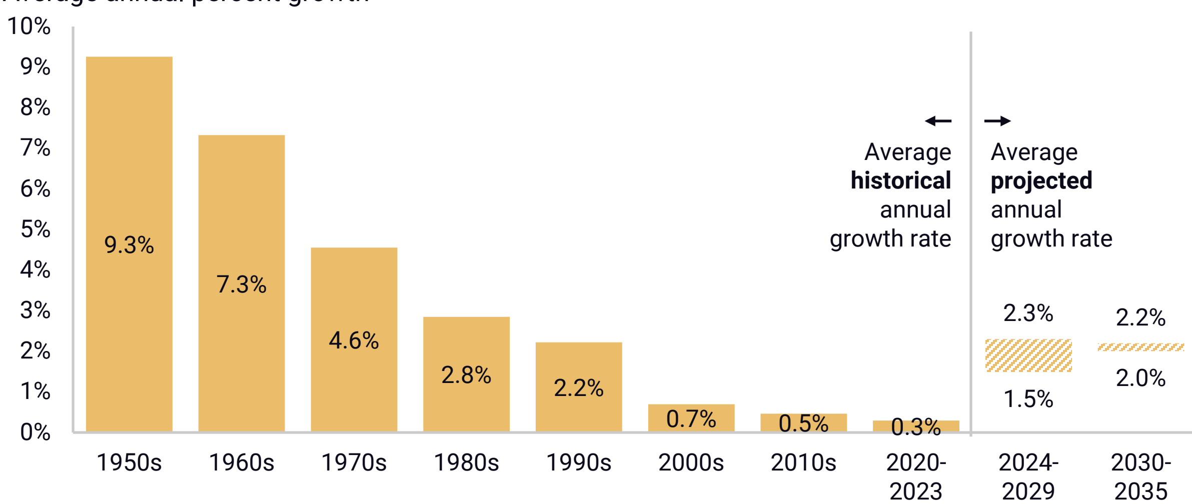
Faster electricity demand growth

We project demand for electricity to increase by 24-29% over 2023 levels in 2035, at least 50% faster and, in the high case, nearly double the pace of growth we projected in Taking Stock 2023. This translates into an average annual growth rate of 1.5-2.3% this decade and 2.0-2.2% in the early 2030s (Figure 12). Though this level of growth is not unprecedented for the US, we haven't seen annual averages approaching that level since at least the 1990s.

FIGURE 12

Evolution of electricity demand since the 1950s

Average annual percent growth



Source: EIA Monthly Energy Review, Rhodium Group. Note: Ranges for future projections correspond to low and high emissions scenarios.

Rapid growth in data center electricity demand spurred by energy-intensive processes like AI model training, cryptocurrency mining, and cloud computing has become a hot topic in the last several months, with some concerned that utilities won't be able to scale up electricity supply quickly enough to meet unprecedented demand. Unlike growth in electricity demand from new electric vehicles or heat pumps, demand from data centers represents *new* energy service demand not previously being met by other forms of energy.

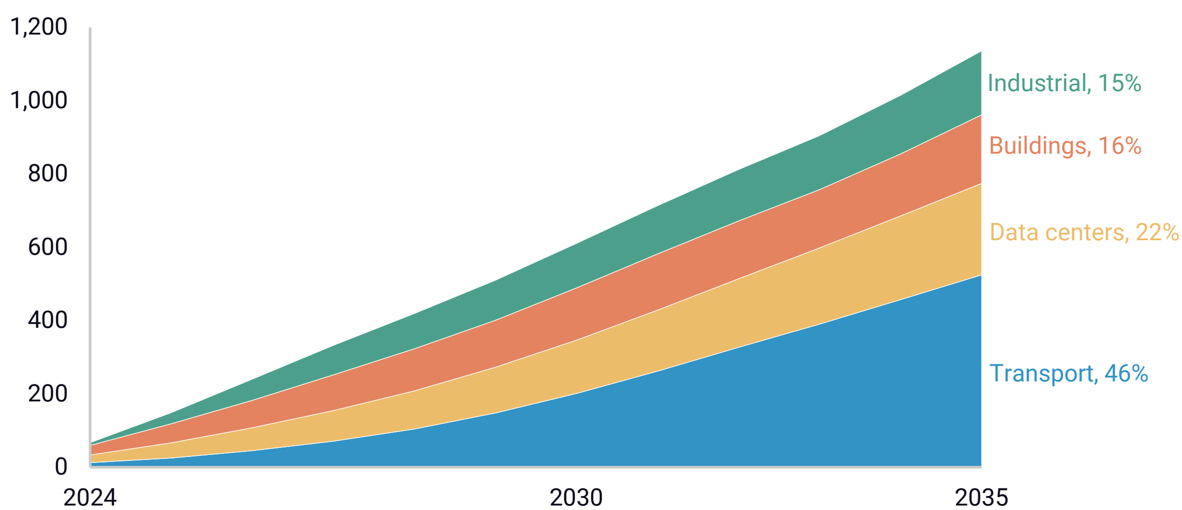
We reviewed a collection of data center growth projections from various governmental and non-governmental organizations and found that, while projections generally agree that data center demand will increase in the coming decade, there's a wide range in growth expectations reflective of uncertainties like efficiency gains, capacity utilization, the degree to which on-device processing takes off, and the general pace of AI expansion and demand for services provided by AI. We designed three data center demand growth pathways that are informed by these external projections.

By 2035, in our mid emissions scenario, nearly half of the overall growth we see in electricity demand comes from the electrification of transportation, and another 16% comes from new electricity demand from buildings (Figure 13). In industry, which makes up 15% of total load growth, about 5% of the growth comes from new battery and electric vehicle factories, while the remaining 95% from longer-term trends toward electrification. Growing electricity demand from data centers makes up 22% of the total increase in demand in 2035.

FIGURE 13

Sources of electricity demand growth from 2023 levels in the mid emissions scenario

Billion kilowatt hours



Source: Rhodium Group

Taken together, about three-quarters of all new electricity demand is coming from predictable, structural trends toward electrification rather than urgent demands for interconnection, like from data centers and new clean manufacturing facilities. This is important, as utilities and grid planners have sufficient time to anticipate this coming demand and make sensible choices to meet it. Indeed, many are already doing so. In an industry facing a supposed "death spiral" less than a decade ago, these increases should breathe new life into the power sector and allow them to become important players on the path to economywide decarbonization.

In these sensitivities, we only vary demand from data centers and hold the rest of electricity growth constant from the mid baseline levels. Increased demand from data centers has an impact on the grid mix and, therefore, on power sector emissions, as we'll unpack further below. On the national level, while spikes in demand from data centers may be less of an immediate threat, there will likely be important regional implications in areas with concentrated growth, like Northern Virginia. We apply data center growth at the regional level in RHG-NEMS, but we lack sufficiently granular grid topology to comment on the specific circumstances of any individual data center. There are important ways that data centers can mitigate their greenhouse gas emissions impacts.

Supply-side headwinds

If a new focus on demand is a recent development, there has been a longer-term emphasis on addressing a number of supply-side headwinds facing deployment of clean electricity generators. Though a full review of all the challenges facing new generation is beyond the scope of this report, we'll highlight a few of the most limiting factors.

Ever since the IRA passed, there have been start-and-stop attempts at brokering a broad infrastructure deal in Congress, as well as a raft of standalone bills attempting to address some of the most important barriers. Much of this legislation focuses on enabling faster and more efficient transmission buildout, which many groups have found to be critical to reducing emissions, and improving the cost-effectiveness of the grid (as reviewed in the Department of Energy's National Transmission Needs Study, for instance.) The recent Federal Energy Regulatory Commission Order 1920 marks an important step in requiring regional transmission planning with clear cost allocation parameters.

In addition to these longer-distance transmission lines, another commonly cited barrier to clean electricity deployment is the lengthy interconnection process that allows generators to connect to the grid. The number of generators waiting in line to connect and the length of time they're waiting until they ultimately connect have both been increasing in recent years. PJM and MISO, two large grid operators that together represent about 40% of total interconnection requests, have both taken steps to mitigate issues with their queues, but nationally, the process remains an obstacle today and looks likely to remain so into the near future.

Alongside increasing local opposition to the siting of renewable energy facilities, long permitting processes, lack of equipment availability and other supply chain headwinds, and inflation, these barriers are already hampering deployment relative to our and others' expectations of the impacts of IRA subsidies. To consider a future in which these types of barriers persist in the long run, we constructed a "what if" sensitivity case to our mid emissions baseline in which we constrain the ability of solar and onshore wind to build at a meaningfully faster rate than their historical maximum additions. We also consider a "what if" case in which we use the endogenous growth in electricity demand from data centers from NEMS, which results in only 4-8% of the total demand growth we project in our baseline. We then cross the two to get a sense of what could happen if data center demand materializes but headwinds to clean energy deployment remain unaddressed (Table 2).

TABLE 2
Mid emissions scenario sensitivities
Percent increase from 2023 levels

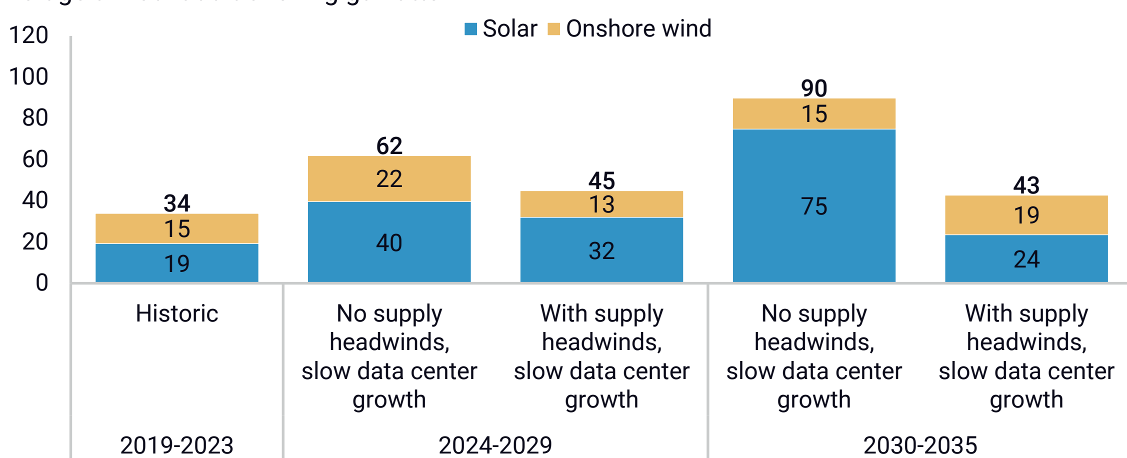
Sensitivity	Data center demand	Supply-side headwinds
Mid emissions baseline	180% growth in demand by 2035	No headwinds
No supply headwinds, slow data center growth	Minimal growth	No headwinds
With supply headwinds, slow data center growth	Minimal growth	Local opposition, interconnection delays, and siting and permitting challenges represented by constraining new onshore wind or solar annual capacity additions to recent historical record levels
With supply headwinds, fast data center growth	180% growth in demand by 2035	Local opposition, interconnection delays, and siting and permitting challenges represented by constraining new onshore wind or solar annual capacity additions to recent historical record levels

Source: Rhodium Group

Electric power sector implications of rising demand and headwinds on new clean supply

First off, if headwinds on new clean supply are not addressed, average annual variable renewable additions are cut by a quarter in the 2020s and in half in the early 2030s, relative to a scenario without these limits (Figure 14). This makes it much more challenging to make sure new demand is served with clean electrons.

FIGURE 14
Solar and onshore wind capacity additions without and with a constraint on growth
Average annual additions in gigawatts



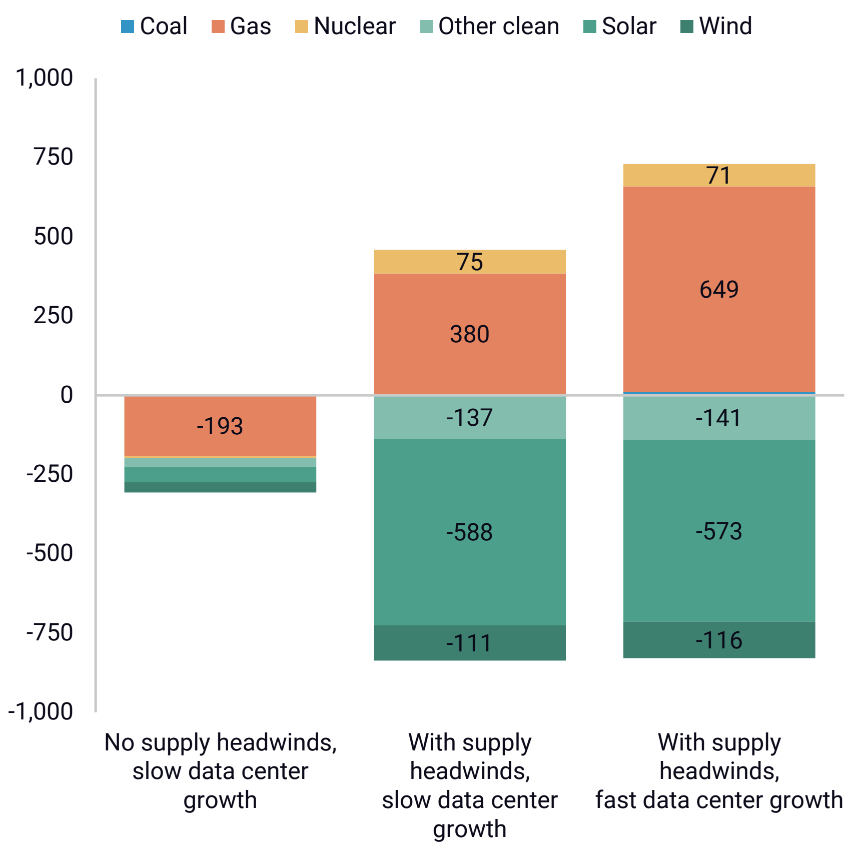
Source: Rhodium Group

Instead, gas is the dominant resource that responds to new electric demand and headwinds on clean energy deployment. When we remove additional demand from data centers, the lion's share of the decrease in generation comes from gas plants running less when compared with the mid emissions baseline (Figure 15). Similarly, when we apply the supply-side headwinds without also adding back in demand from data centers, generation from wind and solar drops substantially as fewer resources are built, and the grid relies on gas (as well as retaining a bit more existing nuclear) to fill in the gap. Finally, gas ramps up even further to meet additional demand for electricity from data centers when combined with headwinds on clean energy. Across the board, coal continues to play effectively no role on the grid as EPA's section 111 regulations come into force.

FIGURE 15

Change in the generation mix from the mid emissions baseline in 2035

Billion kilowatt hours



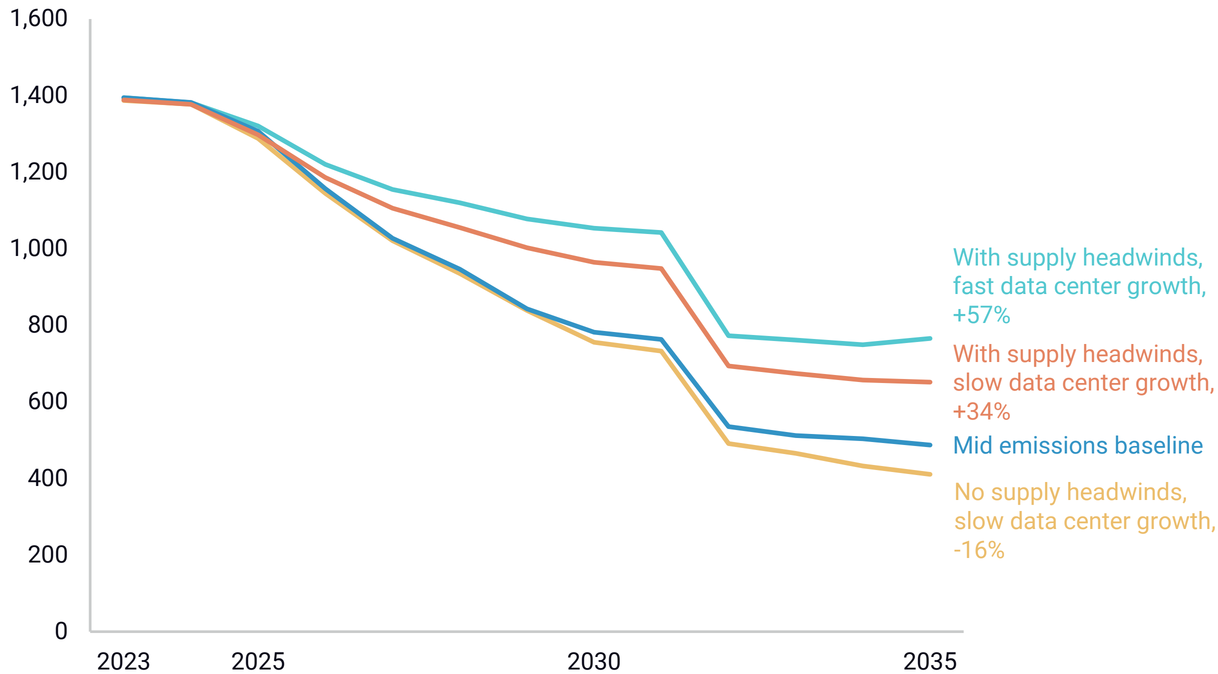
Source: Rhodium Group

The emissions implications of this shift in generation are similarly stark. Without data center demand, we estimate power sector emissions drop by 77 million metric tons (mmt) (-16%) in 2035 relative to our mid emissions baseline (Figure 16). Headwinds on the clean energy supply side alone, without accounting for additional data center demand, increase emissions by 164 mmt (34%) in 2035. Once we layer data center demand growth back on, the effect is greater than the sum of its parts—power sector emissions increase by 278 mmt (56%) in 2035.

FIGURE 16

Power sector emissions in the mid emissions baseline and with sensitivities

Million metric tons of CO_2-e, percent change from baseline



Source: Rhodium Group

Taken together, these results illustrate the importance of resolving supply side headwinds in the face of growing demand, lest the grid not fulfill its potential of contributing to meaningfully lower levels of economy-wide emissions, and they underscore the importance of minimizing the growth of data center demand on the grid through efficiency and other approaches.

CHAPTER 5

An Uncertain Policy Future

The modeling results we've discussed in the preceding pages present a look at where the US is headed with all federal and state policies on the books as of June 2024. The only thing that we can be certain of is that these policies will change by 2035—probably many times over. We can use these results to assess the impact of future policy changes and determine whether they further advance the US on its decarbonization pathway or if they represent a step backward.

The clean energy industry is no longer a cottage industry or niche market: clean investment accounted for 5.1% of total US private investment in structures, equipment, and durable consumer goods in the first quarter of 2024. We expect that private actors will continue making investments in clean manufacturing and clean energy technology deployment to some degree, regardless of electoral or judicial outcomes. But we still expect the market to be highly responsive to policy drivers.

We anticipate two major sources of policy uncertainty: judicial and political. We anticipate a flood of new lawsuits challenging all manner of federal regulations in light of the Supreme Court's recent decisions, discussed in Chapter 1. Given the extent to which much of the ground gained in emissions abatement in this year's Taking Stock is a function of these regulations, we will carefully watch to see which rules hold and which do not.

We'll also be closely watching the outcome of the November elections, which will undoubtedly have important implications on the US emissions trajectory. Continued Democratic control of the White House leaves open the path for further administrative action to reduce emissions—though that path is less clear given judicial uncertainty. Still, a climate-friendly White House will work to protect rules on the books today and explore options for more progress. If past is prologue, a Republican-controlled White House might take the opposite tack, declining to defend regulations finalized during the Biden administration, rolling them back where possible, and enacting weaker alternatives.

Split party control between the White House and one or both chambers of Congress likely signals continued legislative deadlock, though with the potential for at least some progress on areas of bipartisan consensus (like the recently passed ADVANCE Act aimed to smooth the process of building new nuclear plants). Unified Republican control could potentially mean attempts to overturn pieces of landmark climate legislation like the IRA and potentially advance bills that seek to protect incumbent fossil industries. Unified Democratic control could potentially pave the way for another round of legislative climate action as well as efforts to shore up regulatory action by clarifying congressional intent. Regardless of which party is running each chamber of Congress, the expiration of most tax provisions in the Tax Cut and Jobs Act will be a catalyst for revisiting some or all tax credit components of the IRA. This could lead to removal or reductions in incentives or enhancements and expansion, depending on the electoral scenario.

In all cases, but particularly if actors at the federal level take a step backward on climate ambition, there is an important role for states to continue to drive action on decarbonization. With continued federal ambition, states can advance decarbonization further and faster than national policy can, and they can adopt complementary policies that reach into sectors that are more challenging to address at the federal level, like agriculture, and that address supply-side headwinds to clean energy deployment. With federal inaction on climate change, states can serve as a bulwark to substantial emissions backsliding by enacting binding regulatory policies that guarantee outcomes in key sectors like power and transport. But this progress will only occur in states with the political will to achieve it, and as of 2023, around 60% of US emissions occur in states outside of the US Climate Alliance, a coalition of states committed to climate action.

In last year's Taking Stock, we modeled the impacts of an ambitious "joint action" scenario, a set of additional steps beyond what was then current policy that all levels of government need to take to push US emissions to 50% below 2005 levels in 2030. Despite the inclusion of new policies in this year's Taking Stock, we don't find that the US is on that "joint action" pathway for a few reasons. First, though we included versions of several of the recently finalized EPA regulations as part of that scenario, the final versions from EPA generally kick in later than we assumed. Second, not all of the state policies we modeled have been adopted by states. Finally, as we've discussed previously, macroeconomic growth and energy demand are generally higher in this year's Taking Stock.

What's certain is that more policy action is needed for the US to put itself on track for its 2030 commitment under the Paris Agreement and for deep decarbonization by mid-century. As the international climate community approaches the next round of nationally determined contributions (NDCs) due in 2025, a credible US target will help set the tone for global ambition.

Access the data

TABLE 3
US GHG emissions under emissions scenarios
Million metric tons of CO_2-e

Gas	2005	2023	2025	2030	2035
Carbon dioxide	6,119	4,946	4,622 to 4,777	3,794 to 4,466	3,090 to 4,081
Methane	794	756	560 to 577	550 to 588	539 to 590
Nitrous oxide	419	388	378 to 380	365 to 374	356 to 366
HFCs	122	164	115	114	89
Other F-Gases	22	10	11	11	11
Gross GHG emissions	7,476	6.265	5,687 to 5,860	4,834 to 5,553	4,085 to 5,138
Carbon removal*	-908	-854	-946 to -956	-1,073 to -1,087	-1,098 to -1,165
Net GHG emissions	6,568	5,410	4,741 to 4,904	3,746 to 4,480	2,921 to 4,040
Change from 2005	0%	-18%	-25% to -28%	-32% to -43%	-38% to -56%

Source: Rhodium Group. Columns represent the minimum and maximum annual net US emissions given likely energy market, policy, and carbon removal outcomes. *Includes Land Use, Land Use Change, and Forestry (LULUCF) from the high sequestration scenario and carbon capture and sequestration.

We've provided a national look at trends in this report, but RHG-NEMS also produces state-level estimates for GHG emissions and key energy sector outcomes. Direct access to those results for our three main emissions scenarios is available via the ClimateDeck, a partnership between Rhodium Group and Breakthrough Energy. The ClimateDeck equips users with comprehensive datasets, unique and responsive insights, and a robust set of tools for tracking pathways to climate targets and understanding the emissions and economic implications of major international, national, and state developments. All of this is available for exploration and download from our interactive data visualization platform. For access, contact climatedeck@rhg.com.

About Rhodium Group

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Disclosures

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