UPDATED INFLATION REDUCTION ACT MODELING USING THE ENERGY POLICY SIMULATOR

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This research note was updated on August 23, 2022 after final passage of the IRA to incorporate modeling updates, add new outputs and data, and add new appendices on our methodologies.

EXECUTIVE SUMMARY

On August 16, 2022, President Biden signed the Inflation Reduction Act (IRA) into law. The IRA's $369 billion in funding for emissions-reducing climate and clean energy provisions run the gamut from clean energy and electric vehicle (EV) tax credits to large-scale investments in domestic clean technology manufacturing to advancing environmental justice. The IRA also requires auctions for oil and gas on federal lands and waters prior to auctions for renewable energy projects and requires completion of several 2022 lease auctions that were previously canceled.

Energy Innovation Policy & Technology LLC® modeled the IRA's impact on emissions reductions, job creation, and public health, using our free and open-source U.S. Energy Policy Simulator (EPS).[1]

Our updated modeling finds that **the IRA is the most significant federal climate and clean energy legislation in U.S. history, and its provisions could cut greenhouse gas (GHG) emissions 37 to 43 percent below 2005 levels.** With additional executive and state actions, the U.S. can realistically achieve its nationally determined commitments (NDCs) under the Paris Agreement.

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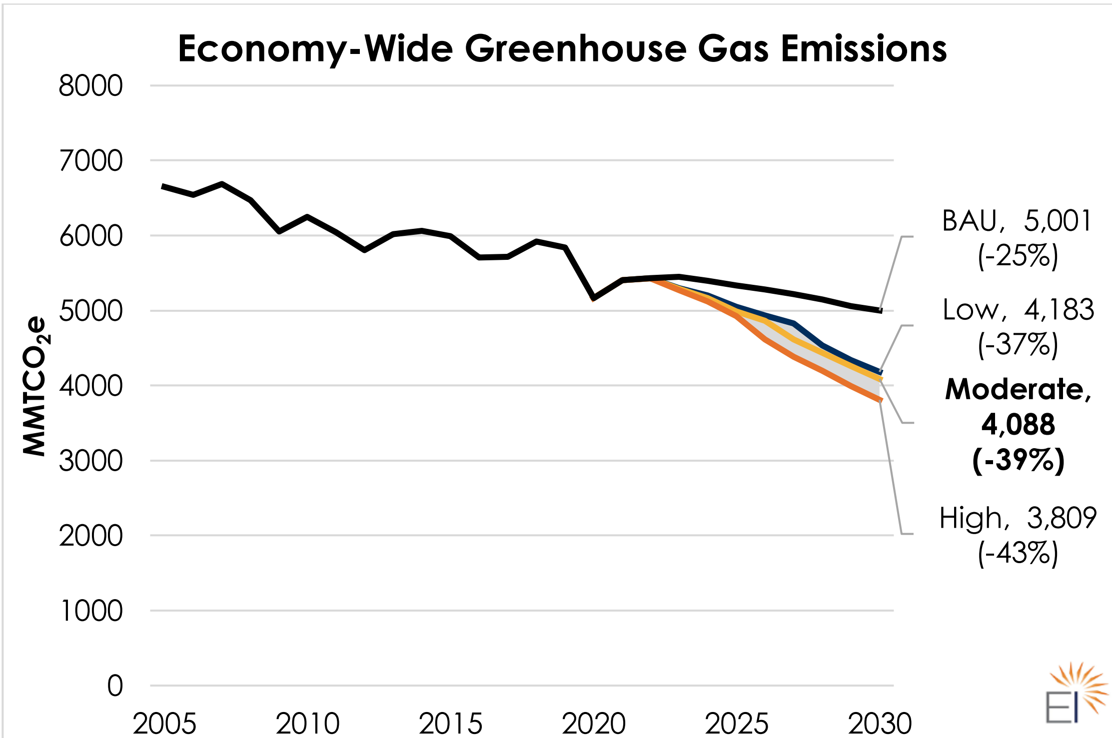
Further, for every ton of emissions generated by IRA oil and gas provisions, at least 28 tons of emissions are avoided by the other provisions.[i]

Under a business-as-usual (BAU) scenario (i.e., including all enacted federal and state policies to date) our modeling forecasts the U.S. would reduce emissions 25 percent compared to 2005 levels by 2030.



In other words, the IRA would enable the U.S. to close 49 to 71 percent of the emissions gap between BAU and the NDC in 2030.

In absolute terms, U.S. emissions in 2030 are projected to be **2,500 million metric tons (MMT) to 2,800 million metric tons** lower than 2005 levels. The IRA provisions could also generate enormous public health and jobs benefits, preventing up to 4,500 premature deaths from air pollution in 2030 and creating up to 1.3 million jobs in 2030. Finally, the IRA could increase U.S. gross domestic product (GDP) by 0.65 to 0.77 percent in 2030.

INTRODUCTION

The final IRA legislative text includes $369 billion in funding for climate and clean energy provisions. These emissions-reducing provisions include clean energy and EV tax credits, large-scale domestic clean technology manufacturing investments, and environmental justice measures. The IRA also requires several auctions for oil and gas on federal lands and waters prior to auctions for renewable energy projects and requires completion of several 2022 lease auctions that were previously canceled.

To help understand its net effect, Energy Innovation® modeled climate and energy provisions of the IRA using the U.S. EPS, an open-source and peer-reviewed climate policy model that estimates climate and energy policy impacts using publicly available data.

Our findings confirm that passing the IRA will reduce GHG emissions an estimated 820 to 1,200 MMTs of carbon dioxide equivalent (CO_2e) in 2030 despite the oil and gas leasing requirements. Those reductions would reduce U.S. emissions 37 to 43 percent below 2005 levels and make significant progress towards achieving the 2030 U.S. NDC of 50 to 52 percent below 2005 GHG emissions.

The IRA could create up to 1.3 million new jobs in 2030 concentrated in the manufacturing, construction, and service industries. Through greater clean energy deployment, the bill could avoid up to 4,500 premature deaths and up to 119,000 asthma attacks annually by 2030.

While this analysis covers the vast majority of the IRA's climate and energy provisions, including all those that could significantly affect GHG emissions, it is not entirely comprehensive. Some provisions or funding mechanisms were excluded from the modeling due to difficulty translating certain spending categories or incentives into emissions reductions. These programs could likely yield small additional GHG reductions beyond what we have modeled. They may also yield important public health benefits that are not captured here.

RESULTS AND KEY FINDINGS

The results in this updated research note include policy scenarios updates reflecting final text of the IRA, along with improvements to the methodologies and assumptions used in our earlier research note.[ii]

Our modeling includes four core scenarios: A Business-as-Usual (BAU) Scenario that holds current policy constant, along with Low, Moderate, and High Scenarios that make different assumptions about the efficacy of certain provisions within the IRA, such as the share of projects or sales that

[ii] The earlier version of the IRA modeling can be found here: https://energyinnovation.org/wp-content/uploads/2022/08/Modeling-the-Inflation-Reduction-Act-with-the-US-Energy-Policy-Simulator_August.pdf

qualify for bonus credits, leverage ratios for private sector dollars, and the evolution of supply chains throughout the decade.

More information on data sources is available online at https://us.energypolicy.solutions/docs/. A full description of our provision-by-provision methodology is included in Appendix A, including how our assumptions varied across scenarios. A full description of our methodology for the oil and gas leasing calculations is included in Appendix B.

Our model results are discussed below, including emissions projections, changes in clean electricity and zero-emission vehicle (ZEV) deployment, and oil and gas supply changes, along with impacts on public health, jobs, and the economy.

Greenhouse Gas Emissions

Our modeling shows the IRA could help reduce 2030 U.S. GHG emissions 37 to 43 percent below 2005 levels, while emissions would fall only 25 percent below 2005 levels under a BAU Scenario. This means the IRA will enable the U.S. to close 49 to 71 percent of the emissions gap between BAU and the U.S. NDC to reduce emissions 50 to 52 percent in 2030—representing a major down payment on our Paris commitment.

Scenario	2030 GHG Emissions (AR4 GWP-100 CO_2e)	Percent Below 2005 Emissions in 2030
Business-as-usual	5,001	-25%
Low	4,183	-37%
Moderate	4,088	-39%
High	3,809	-43%

Table 1: GHG Emissions Reductions

Figure 1 below presents emissions trajectories for each of the scenarios we modeled and highlights the range between our Low and High scenarios.

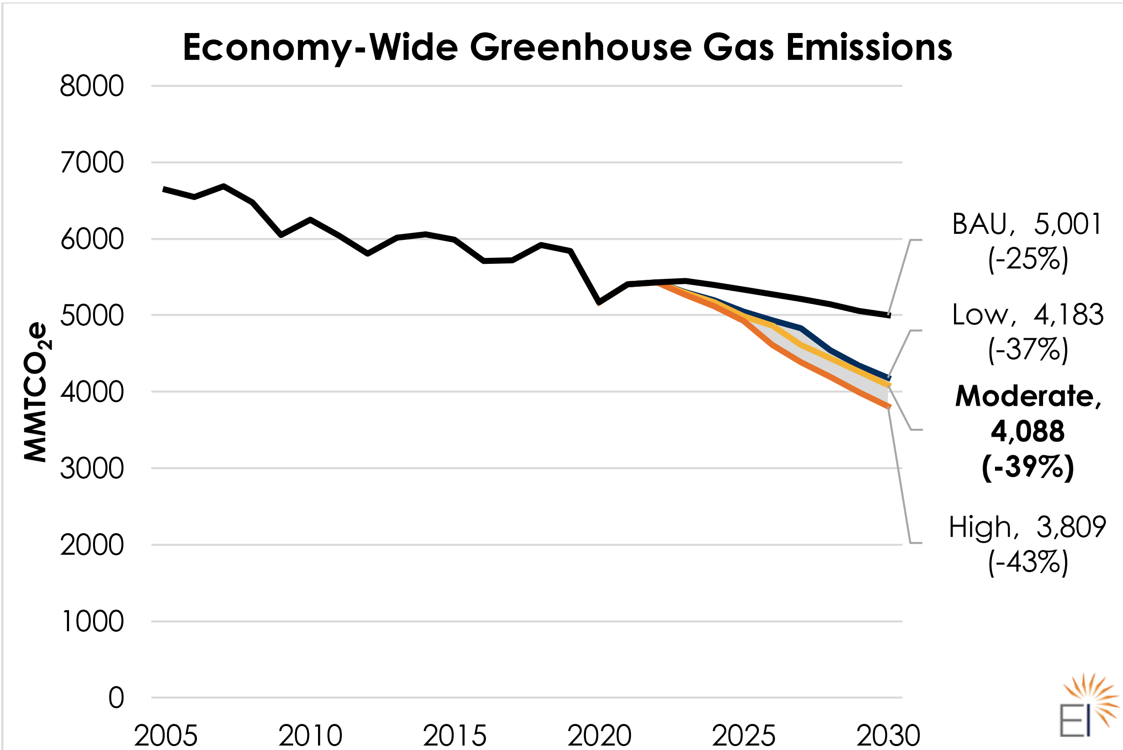


Figure 1: 2005-2030 GHG Emissions Trends by Scenario

Figure 2 and Figure 3 include projected sectoral GHG emissions and reductions by scenario in 2030. As Figure 3 highlights, emissions reductions are most concentrated in the power sector, with smaller contributions from other sectors. Transportation and building sector reductions are limited because of the nature of the incentives and funding programs, along with the stock turnover dynamics of those sectors, i.e., even with growth in the sales share of clean technology significant emissions reductions take years to accrue.

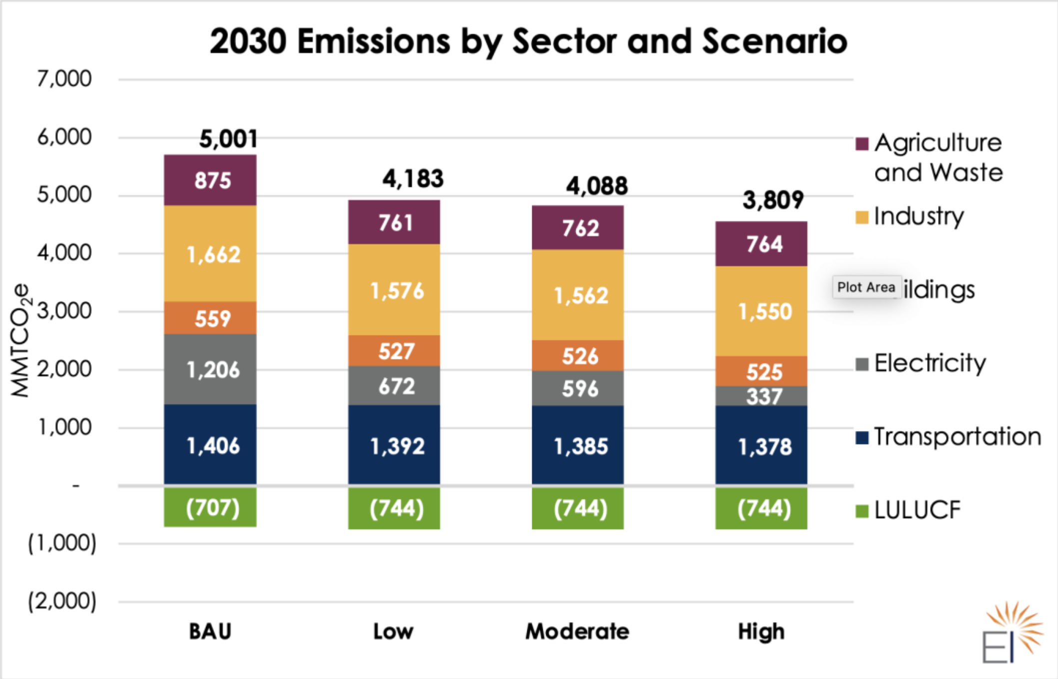


Figure 2: 2030 GHG Emissions by Sector

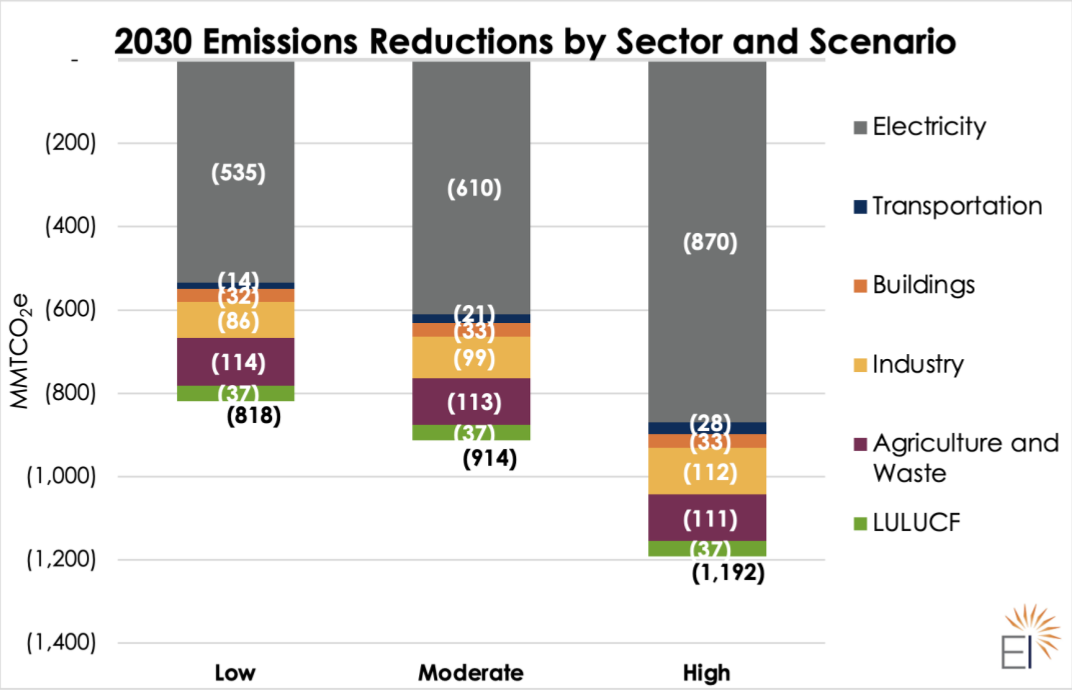


Figure 3: 2030 GHG Emissions Reductions by Sector and Scenario

Clean Electricity

The IRA includes many incentives and significant funding to deploy clean power and reduce emissions. Provisions include investment and production tax credits (which become technology neutral in later years), a tax credit for existing nuclear power points, a new U.S. Department of Energy (DOE) loan program (section 1706), and funding for rural utilities, among others. The tax credits also have bonus provisions that increase their value if certain project conditions are met, such as using unionized labor, meeting minimum domestic content requirements, and siting within certain communities.

To model the impacts of the clean energy tax credit provisions for clean electricity, we partnered with Energy Transitions AI, an external consultant group running the ReEDS capacity-expansion model. We coupled the results of these modeling runs with estimated impacts of funding programs to estimate the combined impact of the programs on clean electricity deployment. Table below highlights our findings. In our BAU Scenario, clean electricity represents 49 percent of electricity generation in 2030, corresponding to 413 gigawatts (GW) of cumulative renewable capacity. In our IRA scenarios, the share of clean electricity ranges from 72 to 85 percent, corresponding to a range of cumulative solar and wind capacity of 795 GW to 1,053 GW.

Scenario	Share of Clean Electricity Generation (2030)	Solar + Wind GWs (2030)
Business As Usual	49%	413
Low	72%	795
Moderate	75%	877
High	85%	1053

Table 2: 2030 Clean Electricity Shares and Cumulative Renewable Capacity

It is important to note these findings do not account for important barriers that could limit clean electricity deployment. In particular, the modeling assumes that necessary transmission will be built, interconnection delays are addressed, supply chains provide the necessary materials to deploy these levels of clean electricity, and a sufficient workforce can supply the labor.

Each of these represents a potential barrier to scaling electricity deployment at the rates our modeling envisions. However, each barrier is being actively addressed by federal and state policymakers. The Federal Energy Regulatory Commission (FERC) is addressing transmission planning and interconnection processes through several current rulemaking proceedings, likely to be concluded in late 2022 or early 2023. Infrastructure Investment and Jobs Act (IIJA) of 2021 provisions could strengthen DOE authority to site and financially support transmission lines, and could bolster manufacturing facilities and supply chains to support new transmission. President

Biden has also invoked the Defense Production Act to ramp up domestic production of critical materials and clean energy manufacturing to address supply chain concerns.

More work is needed to understand how much each barrier might constrain deployment as well as the impact of current and future policy actions to address them.

Zero-Emission Vehicles

The IRA also includes new tax credits for personal and commercial clean vehicles. The commercial clean vehicle tax credit provides an incentive of up to $7,500 for vehicles under 14,000 pounds, and up to $40,000 for vehicles 14,000 pounds and over, depending on the vehicle cost and comparative cost of a similar internal combustion engine vehicle.

The vehicle tax credit is much more complicated for personal vehicles, and includes the following elements:

- The credit is split into two pieces: a $3,750 credit for meeting increasingly stringent domestic battery assembly requirements and a $3,750 credit for meeting increasingly stringent critical minerals requirements.
- The credit contains a manufacturer's suggested retail price (MSRP) cap of $55,000 for cars and $80,000 for all other vehicles, and all cars must be assembled in North America to qualify for the credit.
- An additional adjusted gross income (AGI) cap limits the tax credit to individuals earning less than $150,000 a year or households earning less than $300,000.
- Restrictions on which vehicles qualify as clean begin in 2024, notably removing vehicles that use materials from "entities of concern," which includes Chinese companies, in the battery and for any of the mineral sourcing or processing starting in 2025. It remains to be seen how restrictive this language will be on limiting the ability of vehicle manufacturers, but it could significantly limit qualifying vehicles, at least until the industry has time to find alternative sources of materials and establish the relevant supply chains. However, IRA manufacturing incentives, especially when coupled with incentives in the IIJA and the Chips and Science Act, create a very strong incentive to grow the necessary minerals processing, battery, and semiconductor industries in the U.S.

Given the complexity of each requirement, our modeling of the personal vehicles evaluated a range of possibilities. In our Low Scenario, we assume no manufacturers qualify for the credits once new restrictions on the "entities of concern" kicks in. In our High Scenario, we assume a gradually increasing share of new vehicles qualify, such that by 2030 all new vehicles would qualify. Our Moderate Scenario falls between the Low and High Scenarios. We also account for the MSRP cap, AGI cap, the made in North America requirement, the ability of manufacturers to use batteries assembled in North America, and their ability to source the critical minerals from qualifying regions.

Scenario	Passenger Vehicle BEV Sales Share in 2030	Passenger Vehicle PHEV Sales Share in 2030	Light/Medium Truck BEV Sales Share in 2030	Light/Medium Truck PHEV Sales Share in 2030	Bus BEV Sales Share in 2030	Heavy Truck BEV Sales Share in 2030
Business as Usual	21%	8%	17%	4%	15%	10%
Low	22%	8%	36%	3%	20%	24%
Moderate	25%	9%	37%	3%	21%	25%
High	29%	10%	38%	3%	21%	27%

Table 3: Sales Shares of BEV and PHEVs in 2030 by Scenario

Scenario	Passenger Vehicle BEV Stock Share in 2030	Passenger Vehicle PHEV Stock Share in 2030	Light/Medium Truck BEV Stock Share in 2030	Light/Medium Truck PHEV Stock Share in 2030	Bus BEV Stock Share in 2030	Heavy Truck BEV Stock Share in 2030
Business as Usual	9%	5%	7%	3%	5%	2%
Low	9%	4%	16%	3%	6%	5%
Moderate	10%	5%	16%	3%	6%	5%
High	11%	5%	16%	3%	6%	6%

Table 4: Stock Shares of BEV and PHEV in 2030 by Scenario

Our findings in Table 3 and Table 4 show changes in sales and stock in 2030 resulting from tax credits and other provisions affecting vehicle sales, and highlight the large range of uncertainty for the personal vehicle tax credits.

As is reflected in these tables, even higher sales shares drive a smaller change in the vehicle stock by 2030, which reflects limitations related to transportation sector stock turnover. Put another way, because only a fraction of the total stock of vehicles is replaced each year, it can take many years to realize deep sectoral reductions, even with high shares of clean vehicle deployment. This highlights the importance of strong ZEV incentives in the next decade, as waiting runs the risk of missing climate goals due to slow stock turnover. It is also worth noting that transportation emissions reductions in 2035 or 2040 will be significantly greater than in 2030 given the stock turnover dynamic.

Oil and Natural Gas Supply and Emissions

Oil and Natural Gas Leasing Provisions

In oil and natural gas markets, demand drives prices, which in turn drive supply. Therefore, we expect changes in demand for oil and natural gas to be the primary driver of U.S. production changes. Considering significant natural gas demand reductions from the IRA and moderate decreases in petroleum product consumption, we would most likely see a decrease in production of oil and gas, as is suggested by modeling from the Rhodium Group, not an increase.[2]

Nevertheless, we choose a potential worst-case scenario because oil and gas infrastructure has a long life, and any production that might result from the IRA could continue to operate beyond 2030. We modeled upstream and downstream U.S., as well as rest-of-world emissions from the additional oil and gas production on federal lands and waters which could result from the IRA provisions, assuming those lands go into production.

Our methodology is as follows (see Appendix B for a full discussion of our methodology):

1) We developed two baseline cases of oil and gas lease auctions in the absence of the IRA. In our Low Case, we assume a leasing ban through the end of the decade without the IRA. In our High Case, we assume lease auctions continue based on the actions of the Biden administration to date.
2) Next, we develop our IRA Case. This reinstates the cancelled 2022 lease auctions as required under the IRA and assumes 60 million acres of offshore land and 2 million acres of onshore land offered at auction every year to the end of the decade.
3) To determine how much land is leased at auction, we used historical data covering multiple administrations. The share of land that is leased at offshore auctions is very low on average, around 2 percent. For onshore auctions, approximately 30 percent of acreage offered is leased.
4) From there, we then developed production profiles using historical data:
    a. For offshore, we used Bureau of Ocean Energy Management data on the timeline of well completions for a given area of development. On average, an increasing number of wells are drilled for the first 15 to 20 years, followed by a decreasing number through years 30 to 35, resulting in a production profile of about 50 years.
    b. For onshore, this data was not available, and we simply assumed land goes into production at average production to area values once the land is leased at auction.
5) For offshore, we then applied production profiles to the wells that reflect the varying amount of product produced over the lifetime of the well. For example, around 50 percent of a well’s total product is produced in the first year after it is drilled, with diminishing output after.

6) We then assumed that 30 percent of the new production on federal lands was offset by decreases on private lands, based on data from Brian Prest at Resources for the Future.[3]
7) Next, we developed price elasticities of supply using data from the U.S. Energy Information Administration (EIA) and we estimated the percent change in the U.S. price of natural gas, crude, and petroleum products using these values.
8) We fed the increased production and the changes in prices into the EPS, which captures the emissions associated with production, processing, transmission, and distribution and the subsequent change in downstream consumption and emissions from the price impacts.[iii]
9) Finally, we estimated the leakage of emissions internationally using values from Brian Prest's paper.

Our estimates assume that decreases in natural gas consumption as well as incremental supply can be exported via liquified natural gas export terminals and international pipelines. Between our Low and High Scenarios, U.S. natural gas demand decreases by roughly 18 to 27 percent relative to the BAU Scenario, equivalent to 6.2 to 9.3 trillion cubic feet (TCF) of natural gas. Incremental natural gas domestic consumption from the oil and gas leasing provisions in 2030 totals 0.10 to 0.23 TCF. In our BAU Scenario, based on EIA data, the U.S. exports about 9 TCF of natural gas, 5.4 TCF of which is liquefied natural gas (LNG), in 2030. Based on the latest FERC data, under construction, approved, and proposed LNG terminals total 19.4 TCF of capacity, though many of these projects do not have an estimated completion date.[4]

Nevertheless, if a significant share of the under construction, approved, and proposed terminals are completed by 2030, they could create sufficient capacity to export gas from reduced domestic demand and incremental production. It is unclear whether sufficient demand for U.S. exported gas exists to support this much export capacity, as well as the likelihood that all these facilities will be completed by 2030, or completed at all.

Our revised approach to estimating lease auction impacts has several notable improvements on our prior approach and related estimates. First, it correctly accounts for switching between federal and non-federal lands, which was ignored in our earlier estimates. Second, it better estimates the time profile of when extraction occurs from a given piece of land by looking at empirical data rather than assuming all production starts in a single year. Finally, it correctly accounts for changes in U.S. prices and consumption relative to international consumption and allows us to distinguish between the two. For these reasons, the revised approach generates more accurate results.

[iii] See the Method section below for a discussion of methane global warming potential (GWP) used in the EPS and how it affects our estimates.

The findings are still conservative, as they do not account for potential decreases in domestic demand for oil and gas resulting from the IRA that would likely reduce total U.S. production. The approach also assumes that developers are able to obtain necessary drilling permits.

The updated approach generates estimates that are lower than, but of the same magnitude as, our earlier estimates. As shown in Figure 4, we estimate the oil and gas lease provisions could add 17 to 29 MMT CO_2e to global emissions, represented by the orange dots, the vast majority of which occurs outside the U.S. In our Moderate Scenario, we actually find emissions decreases domestically from changes in energy prices, which is why that scenario is lower than either the Low or High Scenarios.

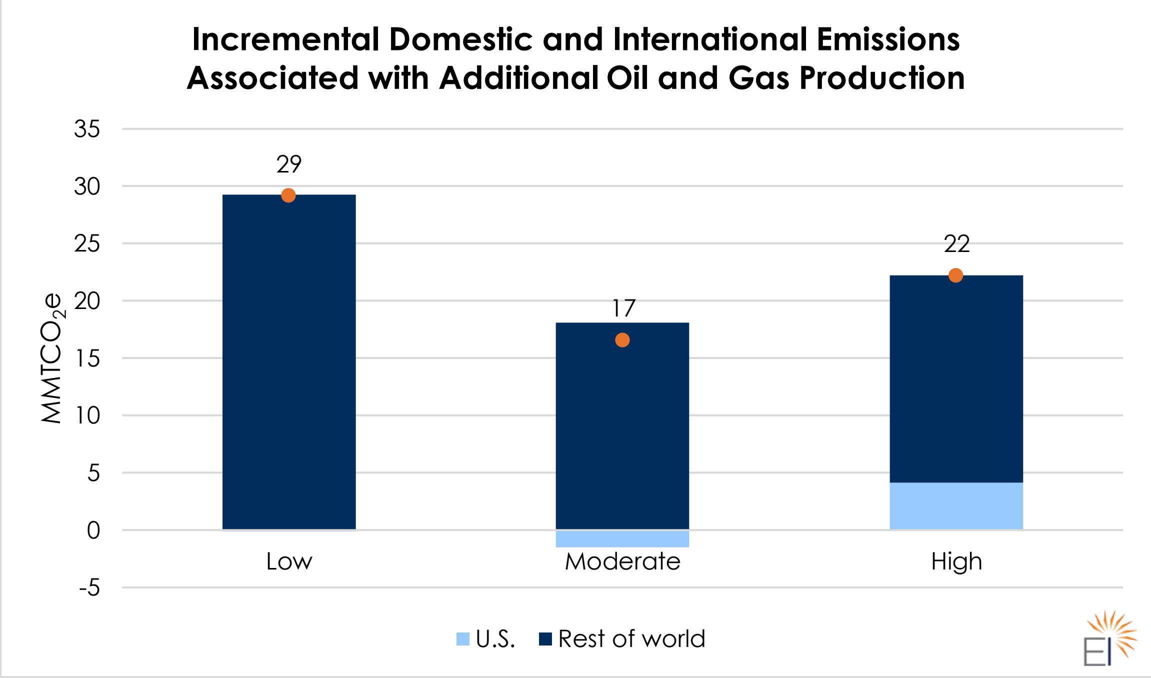


Figure 4: Potential Changes in Global GHG Emissions from Oil and Gas Leasing Provisions

The global increase in 2030 is relative to U.S. reductions of 820 to 1,200 MMT reductions in 2030. In other words, based on the updated methodology, for every one ton of global emissions increases caused by oil and gas leasing provisions, at least 28 tons of emissions are avoided by other IRA provisions in the U.S. Thus, despite the potential for increased oil and gas extraction, the IRA overwhelmingly reduces emissions.

While increased extraction could occur on public lands, the vast majority of it would occur offshore, and would be associated with decreases in production on private lands, it is important to note that increased extraction could lead to an increased pollution burden in communities where oil and gas is processed and transported.

Methane Emissions Reduction Program

The Methane Emissions Reduction Program (MERP) imposes a fee on oil and gas sector methane emissions that rises to \$60/ton CO_2e for companies with facilities that exceed certain emissions leakage rates. In the final legislation, the reporting threshold for facilities is 25,000 tons per year and aligns with facilities required to report to the U.S. Environmental Protection Agency's (EPA) Greenhouse Gas Reporting Program (GHGRP). Similarly, emitting companies are allowed to aggregate emissions across their sites as opposed to having site-specific leakage requirements.

The combination of these requirements significantly reduces the program's coverage relative to earlier iterations and the sector's total methane emissions. For example, the latest U.S. GHG inventory showed 212 MMT CO_2e of methane emissions from the natural gas and oil supply sectors in 2020,[5] but only 82 MMT CO_2e of methane emissions were reported to the GHGRP,[6] meaning only 39 percent of emitters are covered by the program. From there, the aggregation rules further shrink the market size. Using data from M.J. Bradley and Associates, roughly 78 percent of emissions that report to GHGRP are above the leakage thresholds. Finally, only a share of those emissions are abatable for under \$60/ton CO_2e. Putting each of these together, we find the MERP would reduce emissions by 29 MMT CO_2e by 2030.

Improvements to this program could significantly increase its scope and emissions reductions. Lowering the reporting threshold could increase the share of emissions covered by GHGRP and therefore by the MERP. The IRA includes funding to assist the EPA and emitters with better leak monitoring, which could also help improve the program because empirical measurements have typically shown leakage rates significantly higher than what companies self-report, meaning more companies would fall under the program's scope. Finally, the EPA is working towards final rules for existing oil and gas producers, which could help cover facilities not covered by the IRA.

Carbon Capture, Utilization, and Storage

The IRA includes an expansion of the 45Q tax credit for carbon capture, utilization, and storage (CCUS) on top of the existing credit. Given the value of other IRA clean energy tax credits, our modeling does not find any power sector CCUS is deployed by 2030. However, is it possible that certain utilities will opt to install CCUS on existing plants, particularly if they are able to rate-base the costs of doing so. However, even with this possibility, it is unlikely we will see significant deployment of power sector CCUS by 2030.

To model industrial CCUS applications that result from 45Q we rely on Rhodium Group's projected carbon capture capacity under various IRA scenarios and assign the CCUS growth to sectors in the EPS.[7] By 2030, our modeling finds an additional 17 to 19 MMT of capture potential in the industrial sector, relative to 77 MMT of capture under the BAU Scenario. However, the Rhodium modeling finds significant growth in carbon capture after 2030, and by 2035 the total installed industrial carbon capture is significantly higher. Additionally, while the Rhodium modeling finds up to 7 MMT of direct air capture deployed by 2030, we do not see a market by 2030 for direct air capture (DAC) given its costs (even with 45Q), and therefore do not include deployment of DAC.

Figure 5 shows estimated carbon capture in the manufacturing sector by industry. Based on the data from Rhodium, growth in carbon capture is primarily concentrated in the chemicals and refining industries (including hydrogen production) and natural gas processing.

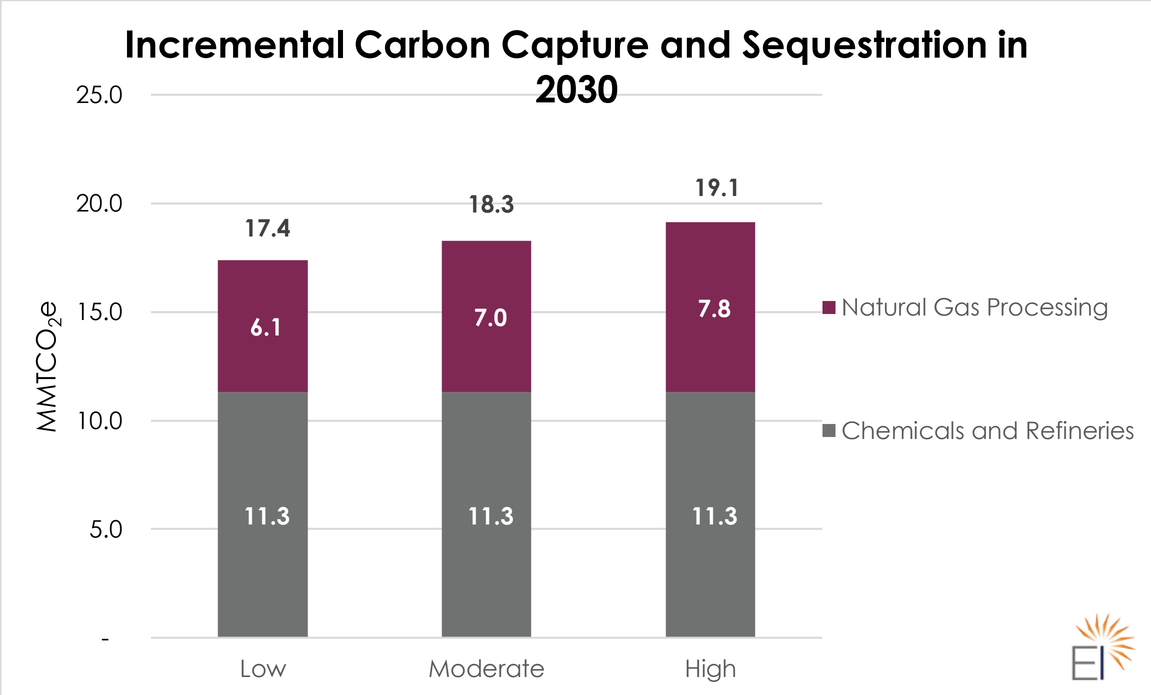


Figure 5: 2030 Carbon Capture Amounts

Public Health and Climate Impacts

In addition to significantly reducing GHG emissions, the IRA could cut emissions that lead to negative health outcomes, including particulates and precursor emissions like SOx and NOx. We find that reduced air pollution in the modeled scenarios could avoid between 2,900 and 4,500 premature deaths in 2030, in addition to preventing 76,000 to 119,000 asthma attacks and 312,000 to 484,000 lost workdays.

Scenario	Avoided Premature Mortalities	Percent Change in Deaths by Race - White	Percent Change in Deaths by Race - Black	Percent Change in Deaths by Race - Asian	Percent Change in Deaths by Race – Other Race or Multiple Races
Low	2,900	-0.09%	-0.11%	-0.12%	-0.17%
Moderate	3,200	-0.10%	-0.12%	-0.13%	-0.19%
High	4,500	-0.13%	-0.17%	-0.18%	-0.27%

Table 5: Annual Avoided Premature Deaths in 2030 by Scenario

As a percentage decrease, avoided deaths are concentrated in communities of color, which have historically experienced the most harm from air pollution. Disadvantaged communities are often located in close proximity to polluting infrastructure and, on average, the bill's provisions reduce more negative health impacts in communities of color.

Scenario	Avoided Asthma Attacks	Avoided Lost Work Days	Avoided Respiratory Symptoms and Bronchitis	Avoided Nonfatal Heart Attacks	Avoided Hospital Admissions	Avoided Respiratory ER Visits	Avoided Minor Restricted Activity Days
Low	76,300	312,200	115,100	3,300	1,500	1,400	1,821,700
Moderate	85,900	350,700	129,200	3,700	1,700	1,600	2,046,300
High	118,600	484,600	178,900	5,100	2,300	2,200	2,825,900

Table 6: Avoided Health (Morbidity) Outcomes in 2030 by Scenario

Using the EPA's Value of a Statistical Life, the monetized avoided health damages are $27 to $42 billion alone in 2030. Using the White House's social cost of carbon estimates, the economic value of avoided GHGs is valued at $51 to $74 billion in 2030.

Scenario	Annual Monetized Benefit from Avoided Climate Damages in 2030	Annual Monetized Benefit from Avoided Premature Mortality in Year 2030	Cumulative Monetized Benefit from Avoided Climate Damages by 2030	Cumulative Monetized Benefit from Avoided Premature Mortality by 2030
Low	$51.1 billion	$27.2 billion	$211.3 billion	$118.4 billion
Moderate	$57.0 billion	$30.5 billion	$250.3 billion	$138.9 billion
High	$74.4 billion	$42.4 billion	$335.1 billion	$199.8 billion

Table 7: Monetized Avoided Climate and Health Damages by Scenario

Cumulatively, the IRA results in climate benefits of $211 to $335 billion by 2030 and monetized avoided health damages of $118 to $200 billion by 2030, for a total of $329 to $535 billion.

Jobs and GDP

The IRA earmarks billions in funding for climate and energy provisions, which could generate significant domestic job growth. Our modeling finds the provisions could create 1.2 million to 1.3 million net new jobs in 2030 relative to BAU. These new jobs are spread across the economy, but focused in the service, manufacturing, trade, and construction sectors as shown in Figure 6.

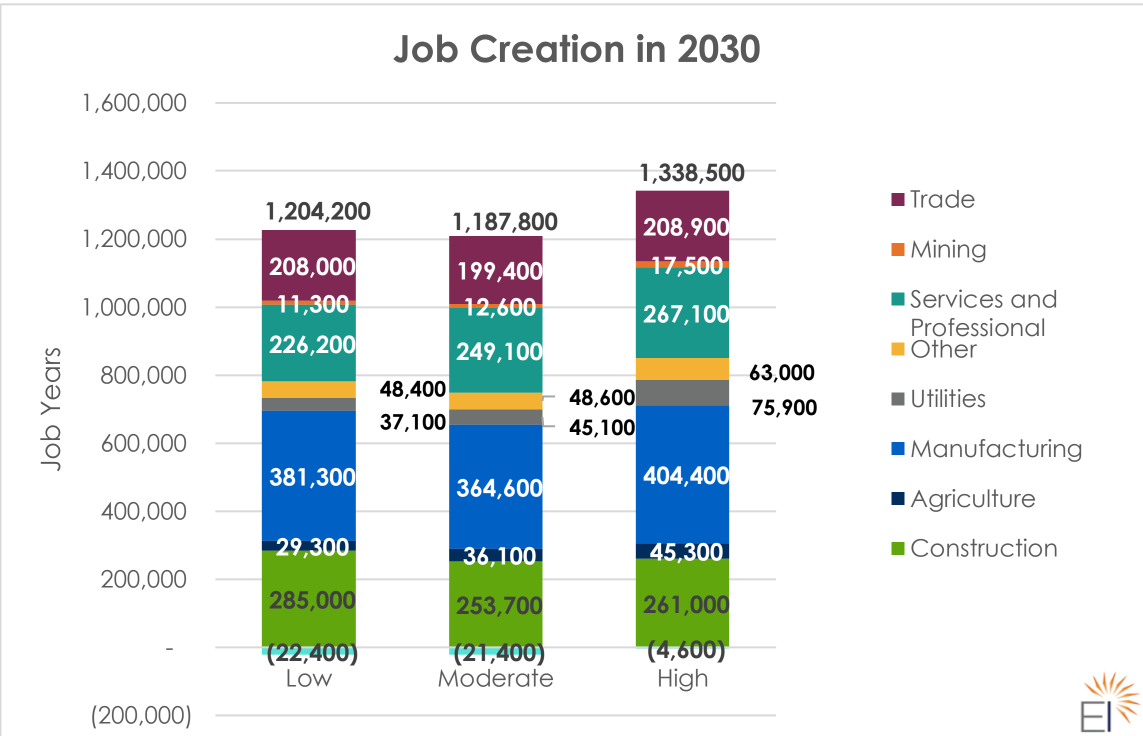


Figure 6: Net Annual Change in Jobs in 2030 by Scenario and Sector

These estimates are conservative because while they include impacts from the advanced manufacturing tax credits and Defense Production Act funding, they do not include estimated impacts from the domestic content bonus credits for clean technology deployment. These bonus credits are very likely to create significant demand for U.S. commodities and equipment that would likely further increase job growth in manufacturing.

The IRA includes bonus credits and other incentives aimed at increasing deployment of clean energy technologies in energy communities, which includes communities with fossil fuel extraction, processing, and burning. The goal of these incentives is to promote job creation in communities that have been are likely to be hardest hit by a transition away from fossil fuels. It is important to note, however, that changes in total jobs ignores important regional and field specific considerations. For example, a coal mining job is not the same as a job installing solar panels, both from a technical perspective but also considering differences in pay or benefits.

The growth in production and construction from the IRA is also associated with a significant increase in GDP. We find the IRA could increase GDP by 0.65 to 0.77 percent in 2030.

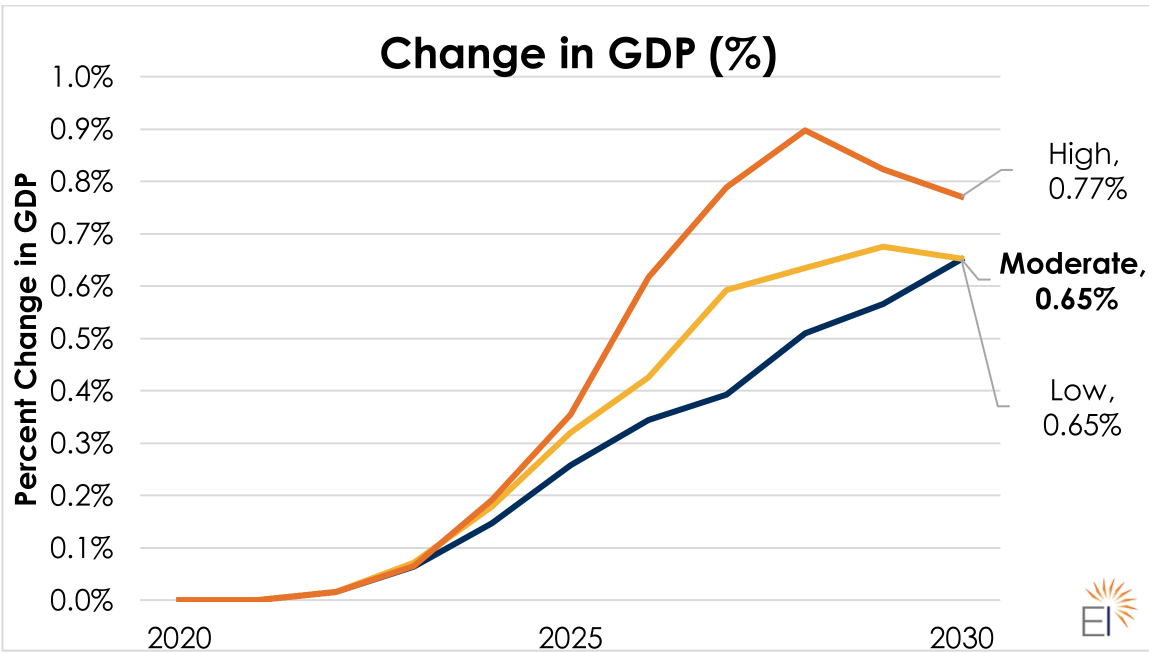


Figure 7: Percent Change in Annual GDP by Scenario through 2030

Deployment of Capital and Spending on Energy

The IRA would significantly increase clean energy technology deployment and associated capital outlays. Our modeling finds the IRA could result in up to $180 billion a year in additional capital equipment investment through 2030, as shown in Figure 8.

The shift to clean electricity, electrified technologies, and more efficient equipment results in large savings on energy expenditures, which grow over time. By 2030, our modeling finds reductions in annual spending on energy of $79 to $85 billion. These savings persist even after capital equipment spending returns to normal levels.

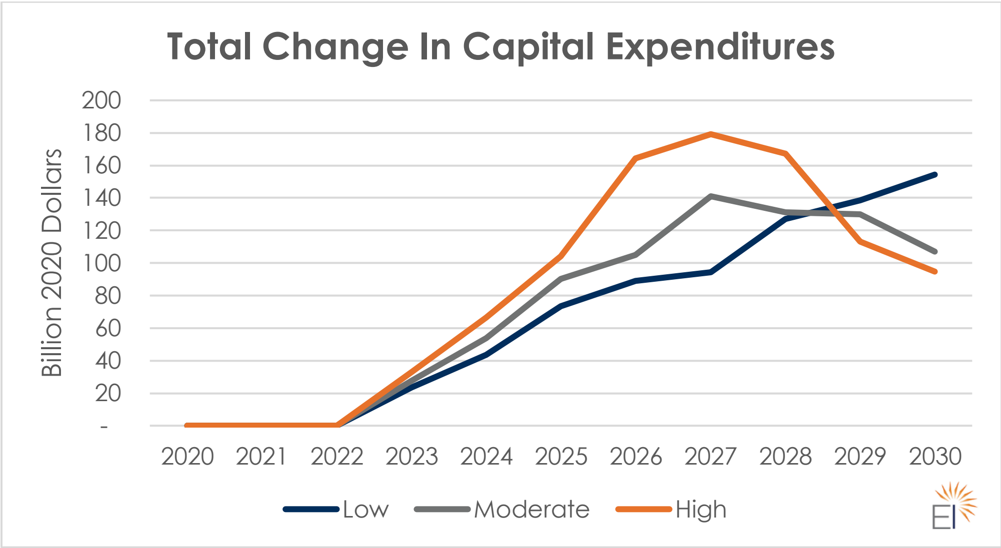


Figure 8: Annual Change in Capital Expenditures by Scenario

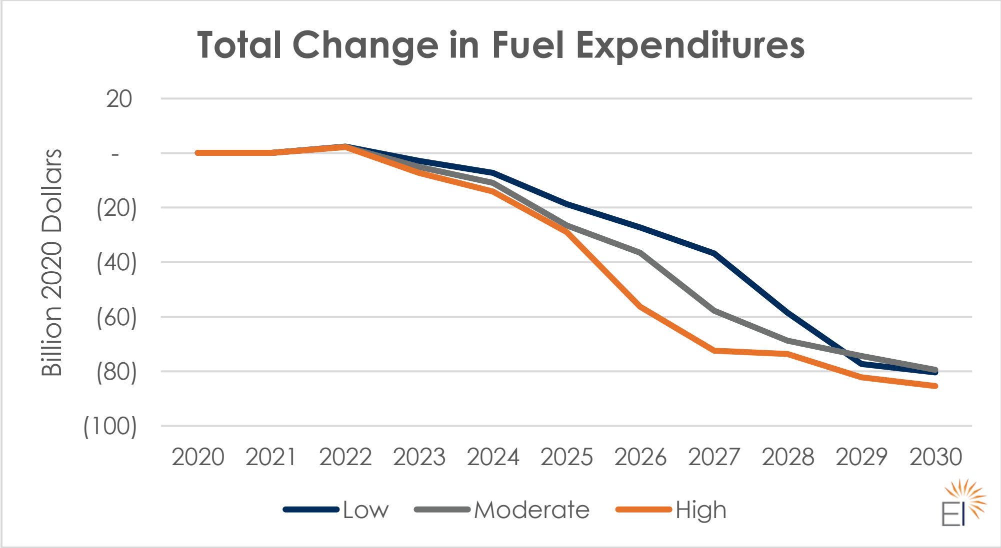


Figure 9: Annual Change in Energy Expenditures by Scenario

These savings affect household energy spending. We find savings of $79 to 80 per household per year by 2030 due to the IRA. These savings would grow in future years as stock turnover of building equipment and vehicles would reduce spending on building fuels and transportation fuels.

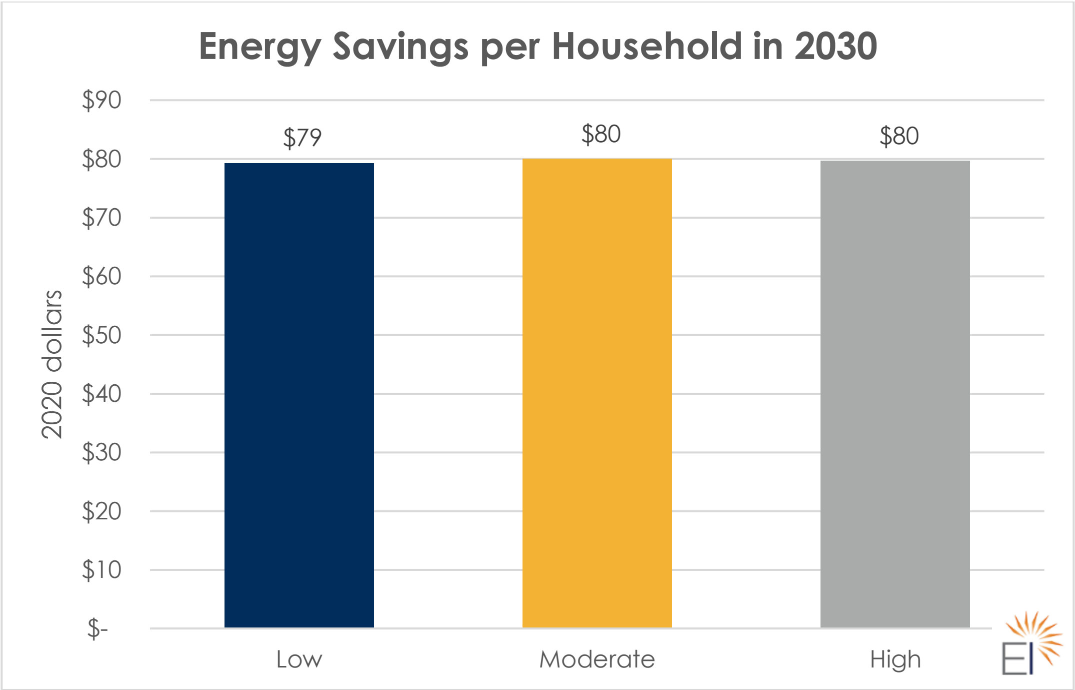


Figure 10: Annual Household Energy Savings in 2030 by Scenario

METHOD

Energy Innovation used the U.S. EPS to estimate the net effects of IRA provisions on U.S. GHG emissions through 2030. For this analysis all emissions are reported in AR4 GWP-100 values. Our methane values are tied to the EPA's inventory.[8]

Many studies have shown the EPA's inventory undercounts methane leakage and associated methane emissions. Methane is a potent GHG that has a 100-year global warming potential using AR4 values 25 times that of CO_2, and a 20-year global warming potential using AR4 values 84 times that of CO_2. These are important considerations when evaluating policy impacts and their importance for limiting global warming. In this instance, we chose to use the same factors as the EPA to ensure comparability to the inventory, to other modeling studies, and to international convention around emissions reporting and tracking. We nevertheless acknowledge that using more updated values or assessing impacts using GWP20 values would change the estimated reductions of emissions in CO_2e.

For this analysis, Energy Innovation used a customized model built on EPS version 3.4.0.1 to accurately model the IRA's provisions, though these scenarios are not yet available online. This version of the model is built on top of version 3.4.0.1, but includes customizations to be able to accurately model the provisions of the IRA. For example, we added multiple components to track the government spending on various provisions.

Our BAU Scenario relies heavily on the EIA's Annual Energy Outlook 2022 Low Economic Growth Scenario for energy demand in buildings and industry, transportation service demand, and fuel prices. It is also adjusted to reflect the current high energy price situation due to the Russian invasion of Ukraine and supply chain constraints. The 2022 Outlook's Low Economic Growth Scenario closely aligns with the latest projected GDP trajectory from the Congressional Budget Office. Because the EPS calculates the impacts of policies relative to a single BAU case, the range of impacts in our Low, Moderate, and High Scenarios reflects uncertainty in policy efficacy and implementation rather than uncertainty about a business-as-usual future (e.g., fuel and technology prices, energy service demand).

To estimate IRA provision impacts, we carefully reviewed each section to develop a set of policy assumptions for each provision. In many cases we developed a range of potential impacts to reflect uncertainty around policy efficacy. For example, we varied the share of clean electricity projects that qualified for bonus credits, with our Low Scenario reflecting more pessimistic assumptions and our High Scenario reflecting more optimistic assumptions.

A full, section-by-section description of our modeling methodology is included in Appendix A.

The list of provisions we modeled is included in Table 8 below:

Title I, Finance

- ***Section 13101***, Extension and Modification of Credit for Electricity Produced from Certain Renewable Resources
- ***Section 13102***, Extension and Modification of Energy Credit
- ***Section 13103***, Increase in Energy Credit for Solar and Wind Facilities Placed in Service Connection with Low Income Communities
- ***Section 13104***, Extension and Modification of Credit for Carbon Oxide Sequestration
- ***Section 13105***, Zero-Emissions Nuclear Power Production Credit
- ***Section 13204***, Clean Hydrogen
- ***Section 13301***, Extensions, Increase, and Modifications of Nonbusiness Energy Property Credit
- ***Section 13302***, Residential Clean Energy Credit
- ***Section 13303***, Energy Efficient Commercial Buildings Deduction
- ***Section 13304***, Extensions, Increase, and Modifications of New Energy Efficient Home Credit
- ***Section 13401***, Clean Vehicle Credit
- ***Section 13403***, Qualified Commercial Clean Vehicles
- ***Section 13404***, Alternative Fuel Refueling Property Credit
- ***Section 13501***, Extension of the Advanced Energy Project Credit
- ***Section 13502***, Advanced Manufacturing Production Credit
- ***Section 13702***, Clean Electricity Investment Credit

Title II, Agriculture

- ***Section 21001***, Additional Agricultural Conservation Investments
- ***Section 21002***, Conservation Technical Assistance
- ***Section 22001***, Funding for Electric Loans for Renewable Energy
- ***Section 22002***, Rural Energy for America Program
- ***Section 22004***, USDA Assistance for Rural Electric Cooperatives
- ***Section 23002***, Non-Federal Land Forest Restoration and Fuels Reduction Projects and Research
- ***Section 23003***, State and Private Forestry Conservation Programs

Title III, Banking

- ***Section 30002***, Improving Energy Efficiency of Water Efficiency or Climate Resilience of Affordable Housing

Title V, Energy and Natural Resources

- ***Section 50121***, Home Energy Performance-Based, Whole-House Rebates
- ***Section 50122***, High-Efficiency Electric Home Rebate Program
- ***Section 50131***, Assistance for Latest and Zero Building Energy Code Adoption
- ***Section 50144***, Energy Infrastructure Reinvestment Financing
- ***Section 50151***, Transmission Facility Financing
- ***Section 50152***, Grants to Facilitate the Siting of Interstate Electricity Transmission Lines
- ***Section 50161***, Advanced Industrial Facilities Deployment Program
- ***Section 50263***, Royalties on All Extracted Methane
- ***Section 50264***, Lease Sales Under the 2017-2022 Outer Continental Shelf Leasing Program
- ***Section 50265***, Ensuring Energy Security

Title VI, Environment and Public Works

- ***Section 60101***, Clean Heavy-Duty Vehicles
- ***Section 60103***, Greenhouse Gas Reduction Fund
- ***Section 60112***, Environmental Product Declaration Assistance
- ***Section 60113***, Methane Emissions Reduction Program
- ***Section 60116***, Low-Embodied Carbon Labeling for Construction Materials
- ***Section 60502***, Assistance for Federal Buildings
- ***Section 60503***, Use of Low-Carbon Materials
- ***Section 60506***, Low-Carbon Transportation Materials Grants

Title VII, Homeland Security and Government Affairs

- ***Section 70002***, USPS Clean Fleets

Table 8: Provisions Included in Modeling

CONCLUSION

The IRA could reduce emissions an estimated 37 to 43 percent below 2005 levels by 2030. In other words, the IRA could enable the U.S. to close 49 to 71 percent of the emissions gap between BAU and the U.S. NDC in 2030. Realistic executive, state and local actions could lead the U.S. to achieve its 2030 NDC commitment.

The bill's provisions also greatly encourage domestic manufacturing of the clean energy technologies that need to be deployed at a rapid rate across the economy, helping to onshore jobs. Hence, the IRA's climate benefits provide substantial economic and public health co-benefits, generating up to 1.3 million jobs in 2030 and avoiding up to 4,500 deaths in 2030. Avoided deaths and public health benefits disproportionately benefit the low-income communities of color that have borne the brunt of fossil fuel pollution.

In summary, the IRA is the largest and most consequential U.S. climate legislation in history and sets the U.S. up to achieve deep emissions reductions by 2030 and beyond.

APPENDIX A: SECTION-BY-SECTION MODELING METHODOLOGY

Section	Name	Methodology
Title I: Committee on Finance		
13101	Extension and Modification of Credit for Electricity Produced from Certain Renewable Resources	First, we calculate the percentage of new plants that will qualify for a) the prevailing wage and apprenticeship requirements and b) the domestic content requirements. For part a, we only calculate the share of plants that would meet the apprenticeship requirement and assume all these plants would also meet the prevailing wage requirement (varying assumptions on the share of qualifying plants across scenarios based on data for the construction industry from American Clean Power's Labor Supply Report[9]). For part b, we calculate the domestic content share for each power plant type. For onshore and offshore wind, we assume 100 percent of plants qualify for the bonus credit, based on an external analysis[10] which lists domestic content shares for various wind components at well over the 55 percent domestic content requirement. For solar, we use the cited domestic content values for cells, modules, and inverters to calculate a weighted domestic content share, given the percentage of solar capital costs by component from the JEDI model.[11] For the Low Scenario, we assume the share of domestic content for solar photovoltaics (PV) remains constant. For the High Scenario, we assume domestic content can gradually increase to meet the 55 percent requirement by 2026. For the Moderate Scenario, we assume an average of the Low and High Scenarios. Next, we add in the energy community bonus, assuming that 25 percent, 50 percent, and 75 percent of capacity additions qualify in our Low, Moderate, and High Scenarios, respectively. We then calculate what the total credit value would be for each technology in each year for both the ITC and the PTC. Here, we assume credits start in 2023 and run at their full value through 2032. For the PTC values, we also adjust the calculated credit by the present value over 10 years divided by the present value over the plant lifetime, because the PTC is only available for the first 10 years of a
13102	Extension and Modification of Energy Credit	

		plant's lifetime. Finally, we apply a transferability multiplier of 10 percent, 7.5 percent, or 5 percent (in the Low, Moderate, and High Scenarios, respectively). This value reduces the credit value available to developers to account for the fact tax credits are transferable. We take the incremental clean electricity share due to tax credits from ReEDS runs that consider a tax credit value of $25.[12] We adjust the incremental share of clean electricity based on our calculated value for tax credits, which incorporates bonus multipliers and a transferability penalty. This is done using a linear scaling factor, which we determined was a reasonable approach based on prior comparison of the Princeton REPEAT model electricity outputs at different tax credit levels. We assume that the reported 2030 values from ReEDS are achieved in 2031, as the ReEDS runs were completed in 2021 before the timeline of the tax credits was shifted forward one year. We limit our analysis to onshore and offshore wind, solar PV, solar thermal, geothermal, municipal solid waste, and battery storage. We do not model credits for qualifying hydro or biogas plants. For solar PV, we calculate a levelized cost of energy for both the ITC and PTC settings to determine whether that resource elects the ITC or the PTC in each year. Because the EPS does not track battery storage as a power plant type, we rely on the external ReEDS runs for the amount of incremental battery storage added to the grid.
13103	Increase in Energy Credit for Solar and Wind Facilities Placed in Service in Connection with Low-Income Communities	We assume an additional 1.8 GW of distributed solar per year as part of qualified low-income residential building projects, which is the annual cap specified in the bill text.
13104	Extension and Modification of Credit for Carbon Oxide Sequestration	We use Rhodium's IRA analysis that evaluated extended 45Q tax credits to model the potential in industry.[13] We do not assume any electricity sector CCS under the 45Q tax credits given how cheap other clean electricity sources will be with the clean electricity tax credits.

		We use the incremental additions in the "High emissions," "Central," and "Low emissions" cases as the inputs for our Low, Moderate, and High Scenarios. We assume credits will run at their full value through 2032. Because our BAU case accounts for currently planned projects through 2027 and new plants will need time for permitting and construction, we assume a 4-year delay before additional CCS capacity begins to come online. Therefore, we phase in Rhodium's projections between 2027 and 2030. Because Rhodium reports capture capacity rather than tons CO_2 captured, we also apply a calculated capacity factor for CCS equipment.
13105	Zero-Emission Nuclear Power Production Credit	The nuclear PTC runs through 2032, and we assume the credits are sufficient to keep all existing nuclear without planned retirement dates online through that time. To determine the weighted average credit value, we ran side cases to determine that between $5.10 to $9.50 per MWh was needed between 2024 and 2032, depending on the scenario.
13204	Clean Hydrogen	We assume varying levels of displacement of gray hydrogen across scenarios with electrolytic hydrogen. In the Low scenario, we assume only offsite produced H2 is replaced, which only affects part of ammonia and part of refineries. In the Moderate Scenario, we assume all non-by product H2 is replaced, covering ammonia and all non-by product refinery demand. In the High Scenario, we assume iron and steel DRI production moves to 30 percent hydrogen feedstock blend. In all cases, the required clean electricity amount is added to the power sector, which builds incremental capacity to meet the new demand for green H2.
13301	Extensions, Increase, and Modifications of Nonbusiness Energy Property Credit (25C)	We reference American Council for an Energy-Efficient Economy (ACEEE) research on the number of heat incremental heat pumps that would be deployed in a scenario with unconstrained rebates for heat pumps.[14] We linearly adjust that value by the ratio of the $2,000 incentive cap for heat pumps in this section to ACEEE's assumed incentive value. We then calculate the average natural gas consumption per unit using data from the EIA's Annual Energy Outlook[15] and apply these savings in the

		model. Finally, we add the incremental electricity demand (calculated using the average efficiency of heat pumps).
13302	Residential Clean Energy Credit (25D)	We directly implement ACEEE research on expected natural gas and electricity savings from this program.[16] We also assume 1 GW of distributed solar is added per year based on these credits, based on analysis from RMI.[17]
13303	Energy Efficient Commercial Buildings Deduction (179D)	We directly implement ACEEE research on expected natural gas and electricity savings from this program.[18]
13304	Extensions, Increase, and Modifications of New Energy Efficient Home Credit (45L)	We directly implement ACEEE research on expected natural gas and electricity savings from this program.[19]
13401	Clean Vehicle Credit	We calculate a weighted average tax credit in each year based on the fraction of vehicles that may be eligible for the tax credits and the estimated value of the credits for those that do qualify. The new clean vehicle tax credit is bifurcated into a $3,750 credit for US battery manufacturing and a $3,750 credit for meeting certain critical minerals thresholds. Additionally, there is a new adjusted gross income cap of $150,000 individual/$300,000 household, MSRP caps of $55,000 for cars and $80,000 for all other vehicles, and a requirement that final assembly occur in North America. Lastly, there is a provision that disqualifies any vehicle using battery components from entities of concern starting in 2024, or minerals produced or processed by an entity of concern starting in 2025. The credits are not direct pay, but they are transferable, including to the dealer. For the domestic battery component, based on projected North American battery projects, we do not assume U.S. battery manufacturing capacity is a constraint, which makes the full credit available to vehicles that qualify as clean vehicles.[20] For the critical minerals component, we adjust the $3,750 bonus credit based on the share of vehicle sales that could meet the requirements for critical minerals sourced

		domestically or from nations with a free trade agreement. We use data from the U.S. Geological Survey to calculate the share of critical minerals demand that is currently sourced from qualifying nations.[21] In the Low Scenario, we assume this remains constant, whereas the High Scenario assumes the share gradually increases to 80 percent, as is required by the IRA for the full credit, by 2032. The Moderate Scenario takes the average of the Low and High. The two above pieces determine the total credit available for vehicles that qualify for the credits. We then develop a weighted average credit for all EVs by adjusting the average credit amount to exclude the percentage of vehicles that do not satisfy the restrictions around materials from entities of concern. In the Low scenario, we assume no vehicles can meet this requirement, i.e. the effective credit value is $0, whereas in the High scenario we assume the fraction of qualifying vehicles ramps up from 0 percent in 2024 to 100 percent in 2032. The Moderate Scenario takes the average of the Low and High. This set of constraints are the most important determinant of the average incentive available. We also account for the share of electric vehicles with a retail price below the stated MSRP caps (we estimate this at 87 percent of vehicle sales) and for the share of all EV buyers who would be eligible for the tax credit given the income distribution of EV buyers, using publicly available Census data and research from the Fuels Institute.[22]
13403	Qualified Commercial Clean Vehicles	For commercial vehicle credits, we find that the credit caps of $7,500 for vehicles under 14,000 pounds or $40,000 for vehicles over 14,000 pounds apply in all years. We apply the credit to all new sales of commercial trucks, using a weighted average credit value for our freight light-duty vehicle (LDV) category which covers both light- and medium-duty trucks. We also apply the credit to a fraction of buses, excluding buses purchased by the government.
13404	Alternative Fuel Refueling Property Credit	We calculate an incremental number of chargers deployed based on funding and the weighted average charger cost in the EPS. We take estimated funding from the released Joint Committee on Taxation scores[23] and assume 80 percent of

		the spending is directed toward public chargers. We do not attempt to model the effects of private chargers. The number of additional chargers is then fed into our model's calculations for the shadow price used to represent range/charging anxiety for passenger LDV owners, which is partially determined by the ratio of charging infrastructure to gasoline pumps. This adjustment helps to drop the shadow price in response to additional infrastructure and increase consumer adoption of EVs.
13501	Extension of the Advanced Energy Project Credit	See methodology for Section 13502.
13502	Advanced Manufacturing Production Credit	We use the sector breakdowns from a Data for Progress analysis.[24] We leverage the tax credits into total increased output of industries. Next, we use the model's 'buy in-region' policy to increase outputs of selected industries by the correct totals. We assume the stimulus results in permanent job creation, even after the tax credits expire. We also apply a credit of $35/kWh for battery cells and $10/kWh for assembly for onroad vehicle batteries. We use several external sources to determine the average kWh battery capacity for each vehicle type.[25,26,27,28] We then apply a multiplier ranging from 0 to 25 percent to account for the fact that the credits paid to producers may not be passed on to consumers, or if the pass-through amount would likely be limited, based on conversations with industry experts. We scale these multipliers in so that the maximum value is reached in 2032. Finally, we assume the $3 billion set aside for emissions reductions is used for efficiency. See methodology for Section 50161 for a full description of how we modeled industrial efficiency spending.
13701	Clean Electricity Production Credit	See methodology for Sections 13101-13102.
13702	Clean Electricity Investment Credit	See methodology for Sections 13101-13102.
Title II: Committee on Agriculture, Nutrition, and Forestry		

21001	Additional Agricultural Conservation Investments	The EPS includes marginal abatement cost curves for agricultural practices that specify emissions abatement levels at different cost tiers. To model 21001, we compute the reductions using these curves such that the total spend equals the funding in the IRA. This is done by adjusting the model's "crop and rice measures," "livestock measures," and "improved soil measures" levers so that cumulative spending matches the total funding in this section.
21002	Conservation Technical Assistance	Our approach is to adjust the stringency of the model's "crop and rice measures," "livestock measures," and "improved soil measures" levers so that cumulative spending matches the total funding in this Section. We exclude funding for the emissions quantification program or administrative costs.
22001	Funding for Electric Loans for Renewable Energy (Sec. 317)	We combine Sections 22001 and 22002 (Forgivable loans for Renewable Energy and the Rural Energy for America Program). We take historical energy spend by the Rural Utilities Service and apportion the new funding as in the past.[29] We allocate funding for energy efficiency to buildings, and allocate all the remaining funding for clean electricity sources to increase the share of clean electricity.
22002	Rural Energy for America Program	See methodology for Section 22001.
22004	USDA Assistance for Rural Electric Cooperatives	We assume a $500/kW incentive is enough to retire all majority owned co-op coal plants. We get data on co-op ownership shares from EIA Form 860.[30] We exclude industrial CHP and non-CHP, because those facilities have different economics and offtakers (available on request; file is large). Data on outstanding coal debt is taken from public sources. We then estimate the cost based on the minimum of remaining coal debt or max of the policy setting and the remaining coal MW. For utilities missing data, we use the full debt relief to be conservative. We allocate the reductions between 2023 and 2030. This results in roughly 20 GW of incremental coal retirements.
23001	National Forest System Restoration and Fuels Reduction Projects	We sum forestry funding that aligns with the scope of the EPS land use, land use change, and forestry (LULUCF) sector, then assign it to either the model's "forest management" or "afforestation and reforestation" levers.

		We then find the policy setting that matches total government spend over the period of 2023-2031. For Section 23001, we only include the protection of old-growth forests funding and exclude hazardous fuels reduction and vegetation management, which are outside the scope of the model.
23002	Non-Federal Land Forest Restoration and Fuels Reduction Projects and Research	We sum forestry funding that aligns with the scope of the EPS LULUCF sector, then assign it to either the model's "forest management" or "afforestation and reforestation" levers. We then find the policy setting that matches total government spend over the period between 2023 and 2031. For Sections 23002 and 23003, we include all funding.
23003	State and Private Forestry Conservation Programs	
Title III: Committee on Banking, Housing, and Urban Affairs		
30002	Improving Energy Efficiency or Water Efficiency or Climate Resilience of Affordable Housing	We directly implement ACEEE research on expected natural gas and electricity savings from this program, scaling by the ratio of actual funding to ACEEE's funding assumptions and adjusting so that total spend occurs across 2023-2031.[31]
Title V: Committee on Energy and Natural Resources		
50121	Home Energy Performance-Based, Whole-House Rebates	We directly implement ACEEE research on expected natural gas and electricity savings from this program, scaling by the ratio of actual funding to ACEEE's funding assumptions and adjusting so that total spend occurs across 2023-2031.[32]
50122	High-Efficiency Electric Home Rebate Program	We directly implement ACEEE research on expected natural gas and electricity savings from this program, scaling by the ratio of actual funding to ACEEE's funding assumptions and adjusting so that total spend occurs across the period between 2023 and 2031.[33]
50131	Assistance for Latest and Zero Building Energy Code Adoption	We use a Pacific Northwest National Laboratory (PNNL) report that evaluates the prospective impacts of national model building energy codes from 2010 through 2040.[34] The report identifies annual emissions reductions, electricity, gas, and fuel oil savings possible by 2030. We assume funding can enable 25 percent, 50 percent, or 75 percent of these savings in commercial and residential buildings in our Low, Moderate, and High Scenarios, respectively. The PNNL report uses 2010 as a baseline. We assume reported savings grow linearly between 2010 and

		2030, meaning that at year 12, 60 percent of the savings have already been realized. Therefore, adjust total savings to only account for 2023 to 2030.
50144	Energy Infrastructure Reinvestment Financing	The 1706 program provides allocates $5 billion to DOE for up to $250 billion in guaranteed loans for reinvestment in communities with retiring energy infrastructure, including refinancing. Historically, the DOE's Loan Program Office has raised $20 billion in private capital for every $30 billion in public loans.[35] The potential investment is then about $417 billion. We assume this funding is used to replace retiring fossil fuel assets with clean electricity and calculate the incremental clean share that would result from replacing retiring fossil assets with clean electricity. We assume 25 percent, 50 percent, and 75 percent coverage in each of our scenarios, to reflect varying ranges of market coverage, friction in the system, and overlap with other tax incentives. Though the program says loans must be made by 2026, we assume the build out of the clean electricity continues through 2032, i.e. loans are made well in advance of construction.
50151	Transmission Facility Financing	We use a report by Americans for a Clean Energy Grid and Grid Strategies LLC that reports the estimated impact and costs of building 22 shovel ready transmission projects to find an average cost per MW-mile.[36] We then calculate additional transmission based on funding levels and a leverage ratio of 2.
50152	Grants to Facilitate the Siting of Interstate Electricity Transmission Lines	
50161	Advanced Industrial Facilities Deployment Program	This program has a maximum government spend of 50 percent of total project costs and $6 billion in funding. In the Low scenario, we assume 50 percent private/public. In the Moderate we assume 40 percent public/60 percent private. In the High scenario, we assume 30 percent public, 70 percent private. We also add in $3 billion from the 48C program for industry using the same leverage ratios. We then use the EPS to identify the incremental investment in energy efficiency that these fundings levels correspond to.
50263	Royalties on All Extracted Methane	The methane royalty rate for production of natural gas is extended to apply to all produced gas, including gas consumed onsite or vented, flared, or leaked. We apply this in the model as an additional fuel tax on leaked methane.

50264	Lease Sales Under The 2017-2022 Outer Continental Shelf Leasing Program	Please see Appendix B for a full description of our methodology.
50265	Ensuring Energy Security	
Title VI: Committee on Environment and Public Works		
60101	Clean Heavy-Duty Vehicles	We take total funding for Clean Heavy-Duty Vehicles and assign it to buses, using the model's EV subsidy lever to find the incremental incentive needed to match total government spend.
60103	Greenhouse Gas Reduction Fund (Technology Accelerator)	This section includes $27 billion in passthrough to the EPA for non-profit institutions to assist in financing clean energy. $7 billion of this is carved out for zero-emission technologies in low-income and disadvantaged communities, which we apply to distributed solar. The language targets funding at projects that have limited financing options. Historically, investments by green banks (e.g. NY and CT) vary by project type, but are mostly allocated to building efficiency/retrofits and rooftop/community solar. Given the many other incentives and programs in the IRA, we assume that the remaining $20 billion in this program would be directed primarily to buildings, where funding is more limited. This most closely follows the model of the CT Green Bank, which has a heavy emphasis on C-PACE and multifamily. We use the Coalition for Green Capital's (CGC) estimate of leverage to estimate the net impact of an initial capitalization at $20 billion.[37] CGC estimates that 3.4 dollars of investment per one dollar of capitalization is possible, with revenue recycling every seven or so years. We therefore assume a leverage ratio of 3.4 meaning $20 billion in initial capitalization could yield $68 billion in total capital investment by 2031. Because there is separate carve out for grants for distributed solar within the fund, we don't consider those projects here. We assign 100 percent of the green bank investment to commercial building retrofits, in line with previous experience and missing areas of funding under the IRA. For our scenarios, we use the guidance on the outlays

		estimated by the Congressional Budget Office (CBO).[38] The Low scenario discounts the spending by the ratio CBO estimates, the Moderate Scenario splits that and the total funding available, and the High Scenario takes the full amount on the table. Using the CBO score as guidance, we assume the program takes five years to scale up. The distributed solar calculations use the same approach of adjusting by CBO estimates and a 3.4 leverage ratio above, then deploy distributed solar based on the total funding available and the average cost per watt.
60112	Environmental Product Declaration Assistance	We rely on research from BlueGreen Alliance reporting a range of emissions outcomes and incremental costs for cement and iron and steel as a result of these initiatives, scaling the impacts by total funding available and market coverage. For example, roughly 50 percent of concrete consumption in the U.S. is for federal projects, but only 5 percent of iron and steel consumption is for federal projects.[39,40] Our estimates include ranges for the combined impact from both procurement pilots and environmental product declaration (EPD) programs. We do not include spillover effects. For concrete, it is assumed that the primary way of lower emissions is through different mixing ratios. For example, existing EPDs suggest significant reductions are possible through using less cement in ready-mixed concrete. Because the concrete and cement sectors are the same in the EPS, this is approximated as a reduction in energy consumption and process emissions rather than a reduction in product demand. Some additional reductions are achieved through fuel switching (coal to gas) and cement clinker substitution in the cement sector. For iron and steel, the primary pathway for compliance is through procurement of clean energy to supply electric arc furnace – direct reduced iron (EAF-DRI) facilities. Beyond that, there could be a switch from blast furnace—basic oxygen furnace (BF-BOF) to EAF-DRI technology, but without additional funding mechanisms, that is less likely.

		In the Low and Moderate Scenarios, we assume reductions are met with procurement of clean energy and in High we add in technology shifting
60113(a) & (b)	Methane Emissions Reduction Program (Spending)	Only facilities that report via EPA's Greenhouse Gas Reporting Program are subject to the methane fee. We use EPA's FLIGHT tool to find these covered emissions,[41] then use external analysis[42] to develop an estimate of the percentage of covered emissions that fall below this section's leakage thresholds (we find 78 percent of covered emissions are subject to the fee). This results in a total of 55 MMT methane emissions covered by the program. We then use EPA's Non-CO_2 Greenhouse Gas Emission Projections & Mitigation report data[43] (scaled to align with the EPA's latest Greenhouse Gas Inventory)[44] to apply all abatement potential at or below the fee amount of $60/ton to the covered emissions, i.e. only a fraction of the 55 MMT of covered emissions are reduced.
60113(e)	Methane Emissions Reduction Program (Revenue)	
60116	Low-Embodied Carbon Labeling for Construction Materials	See methodology for Section 60112.
60502	Assistance for Federal Buildings	We take a PNNL study on efficiency potential in federal buildings, which gives the average cost per square foot and kBTU per square foot for efficiency measures.[45] This allows us to determine the BTU savings from federal buildings investments.
60503	Use of Low-Carbon Materials	See methodology for Section 60112.
60506	Low-Carbon Transportation Materials Grants	See methodology for Section 60112.
Title VII: Committee on Homeland Security and Governmental Affairs		
70002	USPS Clean Fleets	We take total funding for USPS Clean Fleets and assign it to freight LDVs, using the model's EV subsidy lever to find the incremental incentive needed to match total government spend.

APPENDIX B: DETAILED OIL AND GAS LEASE PROVISION METHODOLOGY

To estimate the change in economy-wide GHG emissions from increased oil and gas lease auctions, we estimated the difference in oil and gas production from these provisions. We then fed these production changes into the EPS to forecast associated changes in emissions from extraction, processing, transmission, and distribution. These changes include increased, incremental energy use in the oil and gas sector and process emissions from the oil and gas sector. We developed price elasticities from the EIA to estimate changes in fuel prices and to estimate change in energy demand and emissions. Finally, we estimated international emissions changes using data from a paper by Brian Prest at Resources the Future.[46] A detailed description of our approach is included in this Appendix.

Reinstated and New Oil and Gas Lease Auction Provisions in the IRA

The IRA requires annual oil and gas lease auctions on federal land as a requirement for federal land leases for renewable energy. The IRA includes the following requirements:

- Reinstatement of the following lease auctions that were cancelled/expired: 257, 258, 259, 261
- Offshore and onshore renewable leasing tied to oil and gas lease auctions:
    - A new offshore wind lease cannot be issued unless, in the prior year, the government held an offshore lease auction (called a "lease sale" in the IRA) for oil and gas of at least 60 million acres
    - A new onshore lease for renewables cannot be issued unless, in the prior year the government held an onshore lease auction for oil and gas for at least 2 million acres or 50 percent of the acreage with expressed interest
    - For both onshore and offshore lease auctions, the auctions must result in at least one lease issuance if there are any "acceptable bids"

Functionally, these provisions mean that in order to lease public land or waters for renewables development, government must complete lease auctions of at least 60 million acres per year for offshore and 2 million acres per year for onshore which result in the issuance of leases if there are any acceptable bids.

Scenarios

We developed three scenarios to determine the incremental impact of expanded oil and gas drilling under the proposed IRA above business-as-usual. These are coupled with two variations on assumed international leakage.

- Scenario 1: BAU Low Oil and Gas Development: Assumes in the BAU Scenario, 2022 rate of oil and gas leasing under the Biden administration continues through 2050. Assume no impact on federal leasing for renewable energy production.

- Scenario 2: BAU No Oil and Gas Development: Assumes there is no new federal leasing of onshore and offshore land for oil and gas development.
- Scenario 3: IRA Oil and Gas Auctions: Assumes four cancelled 2022 offshore lease auctions are reinstated in 2022, BOEM's 5-year plan is implemented through 2028, incremental additional offshore acreage is offered to meet 60-million-acre program goal between 2023 and 2050. Assume 2 million acres are offered for lease annually for onshore oil and gas development in 2022 through 2050.
- International leakage: Uses upper and lower bound estimates of rest-of-world incremental supply and consumption based on data from Brian Prest's research at RFF.[47]

Methodology

Our methodology starts with the acres offered at auction from our scenarios. Then we convert these to estimated lease sales. To determine how much land is leased at auction, we used historical data covering multiple administrations. Notably, the share of land that is leased at auction for offshore auctions is very low, around two percent. For onshore auctions, approximately 30 percent of acreage offered is leased.

After determining the amount of land that is leased at auction, we produce drilling profiles per unit land area. For offshore, we used BOEM data on the timeline of well completions for a given area of development. Generally speaking, new drilled wells are spread out over about 30 years, peaking about halfway through and following a fairly linear trajectory up to and after peaking. We take the average of the Low and High Production Scenarios from the figure below. This results in a production profile of about 50 years.[48]

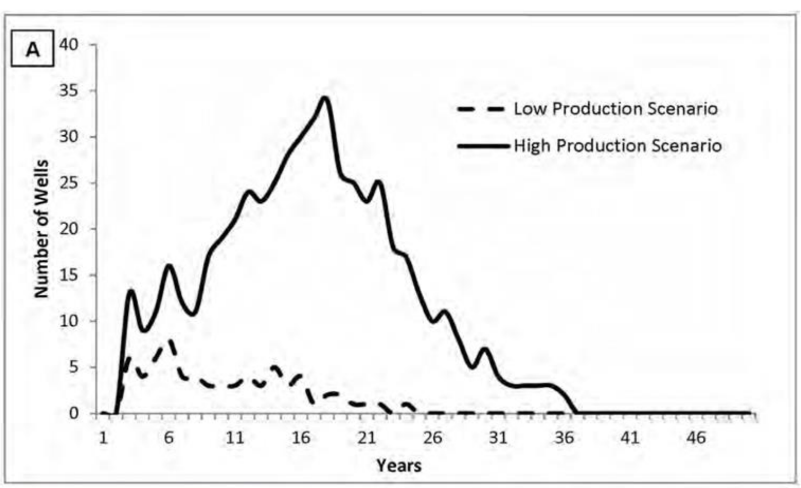


Figure 11: BOEM Well Drilling Profile for Offshore Leases.

For onshore production we could not find data on drilling and production profiles, and we assume land goes into production at average production to area values once the land is leased at auction. Onshore production tends to be much smaller than offshore production.

We build on the drilling profiles for offshore land by then applying production profiles to the wells that reflect the varying amount of product produced over the lifetime of the well. For example, around 50 percent of a well's total product is produced in the first year after it is drilled, with diminishing output after as shown in Figure 12.

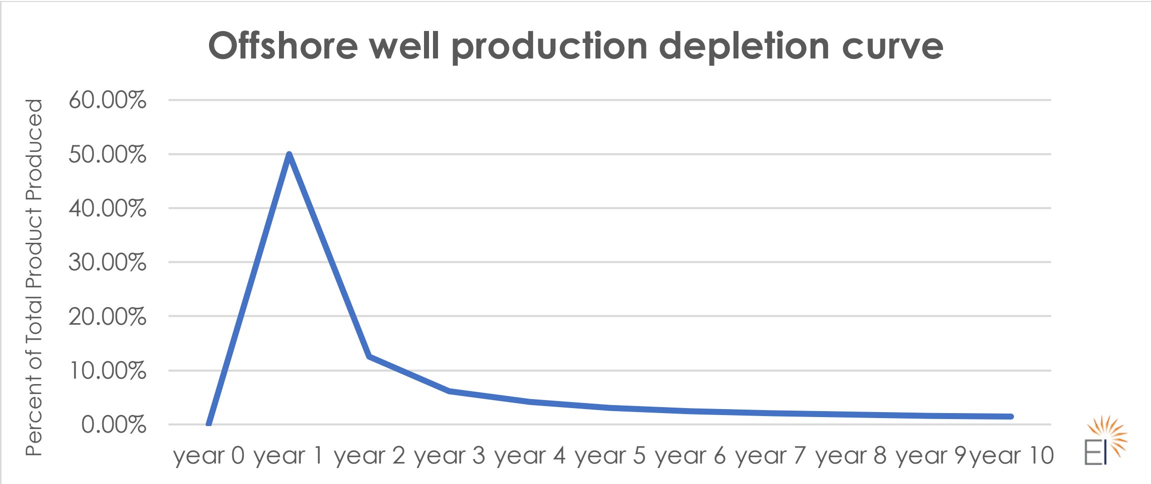


Figure 12: Offshore Well Production Profile

Data from the Prest paper concludes that about 30 percent of increased production on public lands is offset by decreases on private land, so we reduce our estimated production values by 30 percent.

With production increases estimated, we then calculate the change in U.S. fuel prices that result from the incremental production. To do this, we developed price elasticities of supply using data from the U.S. EIA's Annual Energy Outlook 2022.

We input the increased production values and the estimated annual price changes into the EPS to simulate changes in production, processing, transmission, and distribution emissions as well as changes in consumption that result from lower prices. The resulting changes in emissions reflect the total change in domestic emissions from increased oil and gas production and changes to consumption from the incremental production.

Finally, we estimate rest-of-world emissions from the incremental supply using data from the Prest paper. We assume production by permit using the 2017-2022 and 2023-2028 BOEM reports.[49] For future wells where production values are unknown, we use an average production value per permit from the 2023-2028 report.[50]

Findings

Based on the methodology above, we find U.S. production changes of 1.4 to 2.4 percent for crude oil and 0.5 to 0.6 percent for natural gas in 2030.

These production changes result in price decreases of 1.02 to 1.72 percent for crude oil and petroleum products and 1.72 to 2.41 percent for natural gas in 2030.

Rest-of-world emissions range from 14 to 36 MMT CO_2e in 2030

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