Environmental Impacts of the Inflation Reduction Act

Documentation of the USREP-ReEDS Model Analysis

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List of Acronyms

ACA	Affordable Care Act
AEEI	autonomous energy efficiency improvement
AEO	Annual Energy Outlook
ATB	Annual Technology Baseline
BIL	Bipartisan Infrastructure Law
CCS	carbon capture and sequestration
CEB	Climate Economics Branch
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CES	constant elasticity of substitution
CGE	computable general equilibrium
CRS	Congressional Research Service
CSE	cost of saved electricity
CSP	concentrating solar-thermal power
CTL	coal-to-liquids
DAC	direct air capture
DOE	U.S. Department of Energy
EIA	Energy Information Administration
EIS	energy-intensive industry and manufacturing sectors
EO	ethylene oxide
EPA	U.S. Environmental Protection Agency
EPS	Energy Policy Simulator
EQIP	Environmental Quality Incentives Program
GDP	gross domestic product
GSA	General Services Administration
GTL	gas-to-liquids
HDV	heavy-duty vehicles
IRA	Inflation Reduction Act
IRS	Internal Revenue Service
kBtu	thousand British thermal units
kWh	kilowatt-hour
LDV	light-duty vehicles
MIT	Massachusetts Institute of Technology
MSA	metropolitan statistical area
MSRP	manufacturer’s suggested retail price
NETL	National Energy Technology Laboratory
NREL	National Renewable Energy Laboratory
PWA	prevailing wage and apprenticeship
PWBM	Penn Wharton Budget Model
ReEDS	Regional Energy Deployment System
SEDS	State Energy Data System
tWh	terawatt-hour
USREP	U.S. Regional Energy Policy model
USPS	U.S. Postal Service
VMT	vehicle miles traveled
WiNDC	Wisconsin National Data Consortium

1 Introduction

This report documents methods used to analyze the economic and environmental impacts of the Inflation Reduction Act (IRA), enacted in August 2022 by the United States Congress. The analysis relies on the U.S. Regional Energy Policy (USREP) economy-wide model developed by researchers at the Massachusetts Institute of Technology (MIT), linked with the Regional Energy Deployment System (ReEDS) electricity sector model developed by researchers at the National Renewable Energy Laboratory (NREL). The analysis was supported by the U.S. Environmental Protection Agency's (EPA's) Climate Economics Branch (CEB) and conducted through the collaboration of four institutions: EPA, RTI International, MIT, and NREL. To assess the economic and environmental impacts of the IRA, the research team undertook extensive model development and review of the IRA law and existing studies of IRA impacts. The following sections provide a high-level summary of the law, its climate provisions, and select analyses conducted to date. We then document the provisions modeled and approach for doing so using USREP-ReEDS in Section 3.

1.1 Overview of the Law

Public Law 117-369, 136 Stat. 1818—commonly known as the IRA—was advanced as a federal budget reconciliation bill with healthcare, tax, and climate-related provisions. The act was passed by the 117th United States Congress and signed into law by President Biden on August 16, 2022. The bill first passed the Senate on a 51-50 vote, and then the House of Representatives on a 220-207 vote. With a Congressional Budget Office (CBO) estimate of nearly $400 billion invested toward energy security and climate change programs, the law makes the single largest investment in climate and energy in U.S. history (U.S. Department of Energy, 2022a).[1] Early estimates, as discussed in Section 1.3, suggest that the IRA is likely to reduce the federal deficit over the next decade, lower the cost of prescription drugs, and significantly reduce greenhouse gas (GHG) emissions.

The law consists of eight "titles," each identified by the Senate committee responsible for its contents. Under each title, "subtitles" describe the relevant subject matter; some subtitles include "parts." Each part has "sections" with individual provisions—142 in total. The eight titles and committee chairs are:

- Title I: Finance, Chair Sen. Wyden (D-OR)
- Title II: Agriculture, Nutrition, and Forestry, Chair Sen. Stabenow (D-MI)
- Title III: Banking, Housing, and Urban Affairs, Chair Sen. Brown (D-OH)
- Title IV: Commerce, Science, and Transportation, Chair Sen. Cantwell (D-WA)
- Title V: Energy and Natural Resources, Chair Sen. Manchin (D-WV)
- Title VI: Environment and Public Works, Chair Sen. Carper (D-DE)
- Title VII: Homeland Security and Governmental Affairs, Chair Sen. Peters (D-MI)

[1] Climate and energy provisions identified in Congressional Research Service analysis, Leggett and Ramseur (2022).

- Title VIII: Indian Affairs, Chair Sen. Schatz (D-HI).

The law's sections relate to healthcare and deficit reduction, contained primarily in Title I, and climate and energy policy, with provisions distributed among all eight titles. In healthcare, the law extends Affordable Care Act (ACA) subsidies, allows the federal government to negotiate drug prices for Medicare, and caps out-of-pocket prescription drug costs for people on Medicare, among other changes. Additionally, the law authorizes several tax reforms to reduce the deficit, including a 15% corporate minimum tax and increased funding to the Internal Revenue Service (IRS) for tax enforcement.

The climate and energy sections of the IRA—the focus of USREP-ReEDS modeling—aim to mitigate U.S. GHG emissions and promote adaptation and resilience to climate change impacts. These provisions support low- and zero-emission technologies, clean energy infrastructure, and technological research through tax incentives, grants, direct federal expenditures, and loan guarantees. Tax incentives include credits for corporations that produce clean energy technologies and invest in clean energy infrastructure and for consumers who purchase electric vehicles and reduce the emissions intensity of their homes (e.g., through electrification and energy efficiency improvements). Grants and loans include support for conservation efforts and low-emission technology research and development.

The IRA is subject to restrictions on its content because the law was passed as a budget reconciliation procedure. Defined under the Congressional Budget Act of 1974, Senate rules and restrictions, including the Byrd Rule (officially enacted with the Congressional Budget Act of 1990), permit only spending, revenue, and debt limit changes in reconciliation bills, or provisions that have direct fiscal impact (Kogan, 2022).

The total estimated fiscal and environmental impacts of the law's climate provisions vary widely. Official estimates of the fiscal impacts from the CBO suggest that the IRA will reduce the federal deficit by $238 billion (Congressional Budget Office, 2022), but a comparable scoring process does not exist for the environmental impacts of the law; rather, federal agencies are publishing independent analyses subject to interagency review, including the Low Emissions Electricity Program Report issued by EPA that this analysis has supported. Independent estimates of environmental impacts, many of which capture only a portion of the climate provisions, range widely across existing studies (see Section 1.4).

1.2 Qualifications for IRA Provisions

In many IRA provisions, tax incentives include "base" credit values as well as "bonus" values for meeting certain qualifications. Types of bonus qualifications in the IRA include prevailing wages and apprenticeships, domestic content shares, operation in "energy communities," and operation in low-income communities. Table 1 provides a count of provisions with each qualification by sector.

Table 1: Provision Counts by Qualification and Sector

Sector	Prevailing Wage and Apprenticeship	Domestic Content	Energy Communities	Low-Income Communities
Electricity	5	4	4	1
Multi-Sector	2	0	0	0
Transportation	2	0	0	0
Industry	1	0	0	0
Buildings	2	0	0	0
Total	12	4	4	1

Prevailing wage and apprenticeship bonuses are available under Sections 30C, 45, 45L, 45Q, 45U, 45V, 45Y, 45Z, 48, 48C, 48E, and 179D of the Internal Revenue Code. To meet prevailing wage requirements, employers must pay no less than prevailing wages for construction, alteration, or repair of a similar character in their locality. Prevailing wages are determined by the type of construction and geographic location, and they are issued by the U.S. Department of Labor's Wage and Hour Division. To meet apprenticeship requirements, employers must ensure that a certain percentage of total labor hours for the construction of a qualified facility is performed by qualified apprentices. The applicable percentage varies based on the date of construction, and the requirement is subject to applicable apprentice-to-worker ratios. These bonuses provide a total tax incentive of five times the amount of the base credit.[2]

Domestic content bonuses are available under Sections 45, 45Y, 48, and 48E of the Internal Revenue Code. To qualify, projects must meet specific requirements related to the location of origin for certain inputs (e.g., critical materials; iron and steel). These requirements are based on the existing Buy America requirements but have been adapted for the clean energy sector. Retrofitted facilities can also qualify for these credits. Domestic content provisions vary by the incentive and over time, with some increasing in later years of their availability.[3] Generally, qualifying projects can receive up to a 10% increase in credit.

Energy community bonuses are available under Sections 45, 45Y, 48, and 48E of the Internal Revenue Code. These bonuses offer additional benefits to projects, facilities, and technologies situated in energy communities, or those that meet at least one of the following conditions (White House, 2023):

1. A census tract containing coal-fired electric generating units that have retired since December 31, 2009, or coal mines that have closed since December 31, 1999, or census tracts directly adjoining such census tracts

[2] For the latest IRS guidance on prevailing wage and apprenticeship requirements, see https://www.federalregister.gov/documents/2022/11/30/2022-26108/prevailing-wage-and-apprenticeship-initial-guidance-under-section-45b6bii-and-other-substantially, accessed July 17, 2023.
[3] For the latest IRS guidance on domestic content requirements, see https://www.irs.gov/pub/irs-drop/n-23-38.pdf, accessed July 17, 2023.

2. A metropolitan statistical area (MSA) and non-metropolitan statistical area (non-MSA) that meet a certain threshold of employment or tax revenue dependence on fossil fuels, as well as having an unemployment rate higher than the national average
3. A brownfield defined under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

If a taxpayer meets one of these requirements, they are entitled to an additional 10% increase in credit.[4]

The low-income community bonus is established under Section 48(e) of the Internal Revenue Code. Section 48(e) offers an additional investment tax bonus for eligible solar and wind projects located in low-income communities. To qualify for this credit, projects must be situated in a low-income community, on Indian land, or be part of a qualified low-income residential building or economic benefit project, as defined by the latest IRS guidance.[5] The bonus credit program will allocate 1.8 gigawatts (GW) of capacity available in 2023 across four categories for solar and wind projects with maximum output of less than 5 megawatts (MW). The bonus provides up to a 20% credit increase for qualifying wind and solar projects.

1.3 Existing Estimates of Fiscal Impacts

1.3.1 Total Fiscal Impacts of the IRA

The CBO estimates that the IRA will reduce the federal deficit by $238 billion through 2031, with $180 billion in savings expected from increased funding to tax enforcement activities.[6] The remaining $58 billion in expected deficit reductions is the result of $108 billion in net-added tax revenue minus $50 billion in additional spending. These totals do not reflect the estimated total spending or tax revenues from programs specified in the law, because provisions that are expected to increase spending and cut taxes are offset by those that are expected to decrease spending and raise tax revenue. The law includes an estimated $499 billion in spending and tax breaks and $738 billion in offsets (Committee for a Responsible Federal Budget, 2022a). The net increases in revenue are the result of the provisions regarding healthcare, waste emissions charges under the methane emissions reduction program, and greater tax enforcement. The CBO estimated that the energy and climate provisions will cost $391 billion through 2031.[7] The actual direct cost will depend on the extent to which businesses and households claim available tax credits. Table 2 summarizes CBO-estimated deficit impacts by title of the IRA.

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[4] For the latest IRS guidance on energy community requirements, see https://www.irs.gov/pub/irs-drop/n-23-29.pdf, accessed July 17, 2023.
[5] For the latest IRS guidance on low-income community requirements, see https://www.irs.gov/pub/irs-drop/n-23-17.pdf, accessed July 17, 2023.
[6] Under federal guidelines, this expected revenue change is not directly included in the provision-by-provision cost estimates (https://www.cbo.gov/publication/56507). See also https://www.cbo.gov/system/files/2022-09/PL117-169_9-7-22.pdf, accessed March 8, 2023.
[7] The exact climate investment figure may differ slightly depending on the classification of the bill's provisions.

Table 2: CBO Spending and Revenue Estimates by IRA Title

Title	Estimated Outlay	Estimated Revenue	Effect on Deficit[8]
Title I. Committee on Finance	-$71 billion	$102 billion	-$173 billion
Title II. Committee on Agriculture, Nutrition, and Forestry	$35 billion	-	$35 billion
Title III. Committee on Banking, Housing, and Urban Affairs	$2 billion	-	$2 billion
Title IV. Committee on Commerce, Science, and Transportation	$4 billion	-	$4 billion
Title V. Committee on Energy and Natural Resources	$35 billion	-	$35 billion
Title VI. Committee on Environment and Public Works	$42 billion	$6 billion	$36 billion
Title VII. Committee on Homeland Security and Governmental Affairs	$4 billion	-	$4 billion
Title VIII. Committee on Indian Affairs	$423 million	-	$423 million
Nonscorable Components (tax enforcement funding)	-	$180 billion	-$180 billion
Total[9]	$51 billion	$289 billion	-$238 billion

Several unofficial estimates of the fiscal impacts of the IRA have also been made. Bistline et al. (2023) predicted that government expenditures from the IRA will range from $900 billion to $1.20 trillion through 2031, with the cost of tax credits alone around $780 billion to $1.07 trillion—both significantly higher than CBO estimates. This estimate reflects a widespread uptake of tax credits, which the group suggests will spur clean energy production and electric vehicle and energy-saving home improvement purchases, and will in turn lower the cost of electricity. Bistline et al. (2023) also indicate the law could modestly raise interest rates and reduce inflation.

Other early estimates support the deficit-reducing potential of the IRA, with the Committee for a Responsible Federal Budget suggesting that the law could reduce deficits by roughly $1 trillion through 2042 (Committee for a Responsible Federal Budget, 2022b). The Penn Wharton Budget Model (PWBM) predicted a more moderate deficit reduction of $248 billion over the budget window, although little to no impact on inflation was predicted by 2031 (Huntley & Ricco, 2022). By contrast, a panel at the United States Association for Energy Economics/International Association for Energy Economics Conference in October 2022 concluded the IRA could increase the gross domestic product (GDP) by $250 billion by 2030 and could create up to 1.5 million jobs (Brooks, 2022). The panel also found that the IRA could prevent up to 4,500 premature deaths from air pollution by 2030.

[8] The effect on the deficit equals outlays minus revenues.
[9] Components may not sum to totals due to rounding.

1.3.2 Climate-Related Fiscal Impacts of the IRA

The climate and energy provisions of the IRA—the focus of the USREP-ReEDS modeling effort—contain grants, federal loan guarantees, and tax incentive credits for consumers and corporations. Tax credits provided per unit of relevant production are production tax credits (PTCs), and those by percent of relevant investments are investment tax credits (ITCs). Table 3 summarizes the expected budget impacts of the climate- and non-climate-related provisions of the IRA. Climate-related provisions in each sector include:

- **Electricity:** The IRA extends and modifies existing tax credits (Sections 13101 and 13102) through 2024 for renewable energy investment and production. The law also extends credits for power sector carbon capture technologies (Section 13104) and creates new tax credits for the construction of new clean energy facilities and production of renewable energy (Sections 13105, 13701, and 13702). The IRA also establishes funding for the U.S. Department of Agriculture (USDA), U.S. Department of Energy (DOE), EPA, and other federal agencies to offer loans for agricultural, tribal, and rural electrification programs (e.g., Sections 22002, 22004, 22005, and 80003).
- **Transportation:** The IRA extends existing tax credits for alternative and renewable fuels (Sections 13201–13203),[10] establishes new tax credits for sustainable fuel production (Section 13704), and offers modified and new tax credits for commercial and consumer purchases of electric vehicles and chargers (Sections 13401–13403). The law also supports grants to support investment in advanced biofuels (e.g., Sections 40007 and 60506), electric heavy-duty vehicles (HDVs) (Section 60101), and funding for the U.S. Postal Service (USPS) to purchase a fleet of electric vehicles (Section 70002).
- **Industry:** The IRA extends and modifies tax credits for carbon capture use and sequestration facilities and direct air capture facilities (Section 13104). The law also provides grants and an ITC for industrial clean energy and efficiency advances (Sections 13501 and 50161) and a PTC for clean energy components (Section 13502).
- **Buildings:** The IRA extends existing ITCs (Sections 13301–13304) for qualified energy efficiency improvements to residential and commercial buildings, and it provides federal funding to support loans, grants, and rebates for efficiency improvements by homeowners and project developers (e.g., Sections 30002, 50121, and 50122). Several provisions (Sections 60502–60504) also provide the General Services Administration (GSA) with funding to improve the energy efficiency of federal buildings.
- **Agriculture and Forestry:** The IRA provides funding for conservation investments through the National Park Service, USDA, Bureau of Land Management, and U.S. Fish and Wildlife Service. The law also supports funding to monitor fossil fuel emissions and authority for EPA to levy a fee on methane emissions.

[10] Eligible fuels include biodiesel, second-generation biofuels, and sustainable aviation fuels.

Table 3: CBO Spending and Revenue Estimates by Climate and Non-Climate Components

Climate	
Total Climate Outlays[11]	$391 billion
Total Climate Revenue (methane [CH_4] fee)	-$7 billion
Climate Provisions: Net Effect on Deficit	**$384 billion**
Non-Climate	
Health Savings	-$281 billion
Tax Savings	-$450 billion
Healthcare Outlays	$108 billion
Non-Climate Provisions: Net Effect on Deficit	**-$623 billion**
All Provisions: Total Effect on Deficit[12]	**-$238 billion**

1.4 Existing Estimates of Environmental Impacts

Several recent reports have estimated the GHG emissions impacts of the IRA. Compared to projections under baseline conditions (policies in place before the IRA), current analyses show that the IRA will reduce GHG emissions by 32–43% relative to 2005 levels by 2030, in comparison to the baseline reductions of 24–35% (see Table 4). The studies vary in the provisions they include, their modeling tools, and their assumptions for representing IRA provisions, which limits their comparability and contributes to a wider range of estimates. More IRA impact studies are underway from modeling teams at DOE, EPA, Pacific Northwest National Laboratory, and others.

The Zero Lab at Princeton University estimated that the IRA would cut annual carbon dioxide- (CO_2-) equivalent emissions in 2030, projected by the Energy Information Administration (EIA) to be 4.2 billion (Annual Energy Outlook [AEO]),[13] by 0.5 to 0.8 billion metric tons (Mt) (Jenkins et al., 2023). That amount is 37–41% below 2005 levels and 10–16% below the AEO's 2030 reference projections. If these estimates are accurate, the IRA would close about two-thirds of the remaining emissions gap between current policy and 2030 climate targets (50% below 2005 levels). The researchers also estimated that by effectively lowering the cost of clean energy technology, such as electric vehicles, through tax credits and federal investments, the law will lower annual U.S. energy expenditures by at least 4% in 2030, equating to nearly $50 billion per year in savings for households, businesses, and industry (Jenkins et al., 2022). The Zero Lab estimates that carbon capture provisions could support 200 million Mt of CO_2 abatement per year.

A report by Rhodium Group (Rhodium) likewise expects significant emissions declines from the IRA—an additional 439–660 Mt of carbon dioxide beyond baseline projections, or net GHG

[11] The exact climate investment figure may differ slightly depending on the classification of the bill's provisions. This classification is based on an analysis by the Committee for a Responsible Federal Budget (2022a).
[12] Components may not sum to totals due to rounding.
[13] https://www.eia.gov/outlooks/aeo/, accessed May 29, 2023.

emissions declines of between 32% and 42% below 2005 levels (Larsen et al., 2022). The Rhodium report also estimates emissions decline by sector, with electric power supporting the largest share of emissions decline. With respect to carbon management technologies, Rhodium reports significant emissions decline because of carbon dioxide capture and sequestration (CCS) and direct air capture (DAC) tax credits. They project an 83–84 Mt increase in carbon abatement because of the IRA, bringing total CCS capacity to about 254 Mt and DAC capacity to about 40 Mt by 2035 in their central scenario. Electric vehicles as a share of light-duty vehicles (LDVs) are also projected to increase and drive transportation emissions down. The analysis in the report also estimates changes in household energy costs, domestic energy production, and fuel prices.

Energy Innovation Policy and Technology LLC used its U.S. Energy Policy Simulator (EPS) to model the effects of the IRA on emissions, job creation, and public health (Mahajan et al., 2022). The finding was that IRA provisions could cut GHG emissions to 37–43% below 2005 levels, compared to 25% reductions under business-as-usual scenarios.

In addition to their fiscal impact analysis, Bistline et al. (2023) reported significant environmental impacts from the IRA. Their assessment suggests that the IRA could lead to a reduction of GHG emissions by 32–42% below 2005 levels by 2030, or 6–11 percentage points lower compared to without the IRA. They also expect the IRA to reduce costs associated with adopting clean technologies and expedite the implementation of clean electricity generation, electric vehicles, and various emerging technologies such as carbon capture and hydrogen.

NREL's recent analysis uses ReEDs to model the impact of power sector provisions in the IRA and the Bipartisan Infrastructure Law (BIL) (Steinberg et al., 2023). They found that power sector CO_2 emissions could decline 72–91% below 2005 levels, which equates to 600 Mt of avoided emissions relative to the baseline case. The report also finds that new policy will lead to rapid deployment of solar and wind technologies, which could drive clean electricity shares up from 41% in 2022 to 71–90% of total power generation by 2030, and a decrease in total power system costs of $8 billion to $25 billion annually by 2030.

Table 4: Summary of Environmental Impact Estimates of IRA Climate Provisions

Modeling Team	GHG Reductions from 2005 by 2030 (%)	
	With the IRA	*Without the IRA*
Princeton REPEAT (Jenkins et al., 2023)[14]	37%–41%	28%
Rhodium (Larsen et al., 2022)[15]	32%–42%	24%–35%
Energy Innovation (Mahajan et al., 2022)	37%–43%	25%
Bistline et al. (2023)	32%–42%	26%–31%
Electricity Sector Only Modeling		

[14] Princeton REPEAT's analysis also included select provisions from the BIL.
[15] The report was released on August 10, 2022, which preceded the passage of the IRA.

Modeling Team	GHG Reductions from 2005 by 2030 (%)	
	With the IRA	*Without the IRA*
Resources for the Future (Rennert et al., 2022)[16]	70%–75%	48%
NREL (Steinberg et al., 2023)[17]	72%–91%	600 additional Mt

2 Modeling Approach

2.1 IRA Provisions

The USREP-ReEDS analysis of the IRA focused on "modellable" climate-related provisions covering $261.5 of the $391.0 billion CBO-estimated climate-related budget outlays. The modeled provisions include ITCs and PTCs, grant funding, and direct spending. For tax credits, we directly adjust tax rates and allow USREP-ReEDS (see Section 2.2 for model overview) to endogenously determine the associated quantities of production or investment based on market conditions. USREP-ReEDS economic and environmental outcomes therefore differ from CBO and other model estimates, even where identical tax rates are used. In the case of grant funding and direct government spending, we convert the value of budget authority into changes in the calibrated value of private energy consumption and capital expenditures in addition to government budget outlays (detailed below). Although we recalibrate the functional forms to match the values of energy, capital, and public expenditures implied by the funding levels, endogenous responses in activity levels and substitution behavior lead to differences in the modeled value and emissions implications of these provisions. Because eligibility for grant, rebate, and certain loan programs is contingent on private expenditures, we must assume private-to-public spending ratios that have yet to be determined. The Greenhouse Gas Reduction Fund, for example, will be implemented by states that design programs to incentivize, among other things, energy efficiency improvements. States will decide how much incentive they will provide recipients, and the fraction of the average energy efficiency improvement they cover will partly determine the program's leverage and uptake.

The Congressional Research Service (CRS) identified 89 provisions in the IRA that are directly or indirectly related to climate change (Huntley & Ricco, 2022). Table 20 in Appendix A lists the provisions identified by CRS but not included in our analysis. Certain of the excluded provisions were targeted broadly for programs that would support improved air quality, conservation, natural resource stewardship, water quality, and resilience, and provide technical assistance. The Environmental Quality Incentives Program (EQIP, IRA Section 21001 with $8.45 billion in funding) is one of the larger such programs intended to benefit the environment but was not well enough targeted to GHG abatement for USREP-ReEDS modeling. We also elected to exclude provisions related to hydrogen and biofuels. While many of these provisions were modellable, we weighed the costs of developing model capacity to accommodate them against their likely

[16] Resources for the Future's analysis covered power-sector provisions only.
[17] ReEDS is a power-sector only model. NREL's analysis also included select provisions from the BIL.

economic and environmental impacts under the IRA alone and elected not to undertake them. With more stringent climate policy, however, these provisions could become quite relevant.

The IRA provisions included in our analysis are summarized by sector in Table 5. The USREP-ReEDS modeling includes 25 provisions covering the electricity, transportation, industry, and buildings sectors in addition to cross-cutting technologies such as DAC. Table 5 presents the IRA section and relevant section of the tax code, where applicable; the mechanism used; and the CBO-estimated outlays. By the CBO-estimated outlays, the USREP-ReEDS analysis includes 67% of the IRA's climate-related spending.

Table 5: List of Provisions Included in the USREP-ReEDS IRA Analysis

Modeled Sector	IRA Section	Description	Tax Code	Mechanism	CBO Est. ($bn)
Electricity	13101	Production Tax Credit for Electricity from Renewables	45	PTC	$51.1
	13102	Investment Tax Credit for Energy Property	48	ITC	$14.0
	13103	Increase in Energy Credit for Solar and Wind Facilities Placed in Service in Connection with Low-Income Communities	45(e), 45E(h)	ITC	$0.0
	13105	Zero-Emission Nuclear Power Production Credit	45U	PTC	$30.0
	13701	Clean Electricity Production Tax Credit	45Y	PTC	$11.2
	13702	Clean Electricity Investment Tax Credit	48E	ITC	$50.9
	13703	Cost Recovery for Qualified Facilities, Qualified Property, and Energy Storage Technology	168(e)(3)(B)	Deduction	$0.6
		Total			**$157.7**
Multiple Sector	13104	Credit for Carbon Oxide Sequestration	45Q	PTC	$3.2
		Total			**$3.2**
Transportation	13401	Clean Vehicle Credit	30D	ITC	$7.5
	13403	Credit for Qualified Commercial Clean Vehicles	45W	ITC	$3.6
	60101	Clean Heavy-Duty Vehicles	N/A	Grants	$1.0
	70002	U.S. Postal Service Clean Fleets	N/A	Dir. Spend	$3.0
		Total			**$15.1**
Industry	13501	Advanced Energy Project Credit	48C	ITC	$6.3
	50161	Advanced Industrial Facilities Deployment Program	N/A	Grants	$5.3
		Total			**$11.5**
Buildings	13301	Energy Efficient Home Improvement Credit	25C	ITC	$12.5
	13302	Residential Clean Energy Credit	25D	ITC	$22.0
	13303	Energy Efficient Commercial Buildings Deduction	179D	ITC	$0.4
	13304	New Energy Efficient Homes Credit	45L	ITC	$2.0
	30002	Green and Resilient Retrofit Program	N/A	Grants, Loans	$1.0

Modeled Sector	IRA Section	Description	Tax Code	Mechanism	CBO Est. ($bn)
	50121	Home Energy Performance-Based, Whole-House Rebates	N/A	Grants	$4.3
	50122	High-Efficiency Electric Home Rebate Program	N/A	Grants	$4.5
	60103	Greenhouse Gas Reduction Fund	N/A	Grants	$20.0
	60114	Climate Pollution Reduction Grants	N/A	Grants	$4.1
	60201	Environmental and Climate Justice Block Grants	N/A	Grants	$3.0
	60502	Assistance for Federal Buildings	N/A	Dir. Spend	$0.3
		Total			**$73.9**
TOTAL: Covered Provisions					**$261.5**
TOTAL: Climate Provisions					**$391.0**

Many of the provisions have a range of possible values (e.g., base tax credit values versus those meeting prevailing wage and apprenticeship [PWA] requirements, grant funding leverage). These ranges require assumptions on the proportion of program recipients that will receive each level of credit, which is not knowable *ex ante*. As a result of this uncertainty in IRA implementation, we developed three scenarios to evaluate a pessimistic-moderate-optimistic range of IRA implementation. In the following subsections, we describe the provision implementation by sector and identify the assumptions taken for each IRA scenario. For side analyses, these core IRA scenarios can be interacted with different sets of assumptions on technological progress, natural resource prices, or additional policy (e.g., extending IRA tax credits, GHG regulations in electricity or other sectors).

2.2 USREP-ReEDS Model Overview

The USREP model is a 12-region, 14-sector computable general equilibrium (CGE) model of the U.S. economy developed at the MIT Joint Program on the Science and Policy of Global Change (Yuan et al., 2019). The model solves in 5-year time steps from 2020 through 2050 in a recursive-dynamic fashion, meaning investment decisions are based on current and past information and future economic shocks are not anticipated. USREP has five representative households per region defined by income (per the household representation based on the Current Population Survey in the model's underlying Wisconsin National Data Consortium [WiNDC] dataset) and one government entity that raises revenue, makes public expenditures, and facilitates transfer payments. Households consume goods and services, as well as leisure, and invest savings for future periods. The government agent is endowed with a fixed reference budget deficit and the agent's welfare is impacted by marginal deficits from counterfactual scenarios.

Representative firms for each of the 15 sectors optimize their production activities subject to prevailing prices and available technologies. Capital stocks are vintaged by sector with no substitution possibilities after the year in which they are placed into service. Firms earn zero economic profit in their activities, meaning the revenues they earn are fully allocated to intermediate purchases, taxes, labor, and capital expenses. Prices are determined by the model to ensure that sectoral production meets intermediate and final demands (i.e., market clearance).

To represent heterogeneity in trade, a so-called “Armington aggregation” combines sectoral output from other U.S. regions and abroad into a single composite good for consumption within each model region. All agents are subject to an income balance requirement in addition to zero profit and market clearance conditions. The USREP model documentation provides mathematical expressions for the behavior of firms, trade, households, government, and market clearance (Yuan et al., 2019).

USREP sectors represent transportation, fossil fuels, services and other commercial, agriculture, and electricity sectors. Multiple technologies exist that can produce sectoral output for transportation, energy-intensive, and electricity sectors. Households also have multiple transportation technologies available to supply personal transportation services (i.e., they can purchase internal combustion, plug-in hybrid, or fully electric vehicles). New transportation is subject to updated fuel economy standards that force capital-fuel substitution for new internal combustion vehicles and/or the adoption of hybrid and fully electric alternatives.

In the linked USREP-ReEDS model used for this study, electricity output prices and input quantities are determined by the ReEDS electricity model and imposed on the USREP model. Conversely, USREP determines the quantity of electricity output demanded and the price of electricity sector inputs that are imposed on the ReEDS model. The models then iterate to agreement on prices and quantities (Yuan et al., 2022).

National accounts data for USREP now come from WiNDC version 3.1 for the base year 2017.[18] USREP solves this benchmark year, then moves to the next period (2020) and continues solving in 5-year steps thereafter to 2050. Table 6 summarizes the total output by sector for the 2017 benchmark year in billions of dollars. Services and other sectors are by far the largest by output, with the remaining sectors smaller by an order of magnitude or more by output but with a significant impact on GHG emissions.

GHG emissions are accounted by calibrating fuel-specific combustion coefficients to observed emissions totals. As fuel consumption changes, so do emissions by these fixed coefficients. Physical quantities of energy are provided by the WiNDC dataset’s “Bluenote” routine that integrates information from the EIA State Energy Data System (SEDS).[19]

[18] https://windc.wisc.edu, accessed May 29, 2023.
[19] https://www.eia.gov/state/seds, accessed May 29, 2023.

Table 6: USREP Sectoral Output by Region

Sector	NEAST	SEAST	CA	TX	NY	NCENT	MOUNT	NENGL	FL	PACIF	SCENT	AK	USA
Services	$5,571	$3,543	$3,457	$1,809	$2,235	$1,385	$1,628	$1,445	$1,366	$1,095	$581	$71	$24,187
Other	1,305	853	465	368	132	354	193	178	103	186	122	6	4,264
Energy Intensive	776	440	341	313	144	167	169	122	126	91	112	6	2,804
Other Transportation	364	212	167	148	87	168	130	47	88	67	74	17	1,569
Agriculture	74	54	95	25	8	95	34	6	16	29	19	1	456
Petroleum Products	82	23	46	127		21	19			17	82	3	420
Trucking	84	35	27	18	10	45	18	11	13	8	15	1	285
Air Transport	52	42	35	36	18	9	27	6	16	16	6	4	266
Electricity	70	45	18	28	13	22	21	9	18	10	13	1	266
Rail Transport	29	19	5	15	2	27	17	2	2	4	9		131
Crude Oil	2	1	7	57	0	17	17		0		10	7	117
Natural Gas	33	1	1	35	0	3	18		0	0	22	2	115
Water Transport	9	9	8	6	4	2	0	3	12	5	8	3	69
Ground Transport	15	6	10	3	11	3	5	4	2	2	1	0	62
Coal	9	3		1		1	10				0	0	24
TOTAL	**$8,474**	**$5,287**	**$4,683**	**$2,987**	**$2,662**	**$2,318**	**$2,306**	**$1,831**	**$1,761**	**$1,530**	**$1,073**	**$122**	**$35,036**

NEAST = {WI, MI, IL, IN, OH, WV, PA, MD, DE, NJ}, SEAST = {KY, VA, TN, NC, MI, AL, GA, SC}, NCENT = {ND, SD, NE, KS, MO, IA, MN}, MOUNT={NM, AZ, NV, UT, CO, WY, ID, MT}, PACIF = {WA, OR}, SCENT = {OK, AR, LA}.

Note: Values are in $billion 2017.

USREP regions conform with U.S. Census divisions west of the Mississippi River, breaking out California, Texas, and Alaska to be independently modeled. USREP also includes single-state representations for Florida and New York. Regions in the eastern United States differ from census divisions to better account for electricity markets, state-level GHG policy (e.g., the Regional Greenhouse Gas Initiative, renewable portfolio standards), and National Climate Assessment regions.

Capital stocks evolve between periods through the subtraction of depreciation and addition of new investment, where the composition of goods is determined by a nested constant elasticity of substitution (CES) structure and the level of investment is determined by household savings. Production from new capital allows for substitution among inputs in response to prevailing prices. Once installed, these ratios are fixed for future production from this vintage of capital. USREP carries four vintages of capital (in addition to new capital), each with potentially different input ratios based on the prevailing market conditions in the period the capital was installed and the autonomous energy efficiency improvement (AEEI). USREP assumes AEEIs over time that are calibrated to match projections form the EIA AEO in certain sectors. For transportation and energy-intensive sectors (EIS), the AEEI trend is now fixed. Regional labor supply increases, which represent population and productivity growth, are calibrated to match AEO GDP growth projections.

USREP also includes fixed factors of production for natural resource inputs and backstop technologies. These resource endowments restrict the amount of output from the sector in each time period to reflect resource scarcity (e.g., fossil fuels) and/or barriers to technology adoption (e.g., electric vehicles). Elasticities of substitution for fossil fuels are calibrated to imply a supply elasticity consistent with empirically estimated reserve quantities and extraction costs. Fixed factors for backstop technologies are assigned as a fraction of capital requirements and the factor endowments are updated over time in proportion to production activity (Morris et al., 2019). Backstop technologies include “markup” factors that set their unit cost of production initially above that of the conventional alternative, falling over time to be cost competitive.

2.3 USREP-ReEDS Model Development for the IRA Analysis

To adequately assess IRA impacts, the USREP model required significant development relative to its last documented version (Yuan et al., 2019). We also updated the model linkage to include the latest available version of the ReEDS model developed by NREL researchers for their independent analysis of the IRA’s impact on the electricity sector (Steinberg et al., 2023). The following subsections document model enhancements to USREP.

2.3.1 National Accounts Data

The USREP model was migrated to the WiNDC data platform version 3.1 (WiNDC 3.1) for this analysis.[20] The WiNDC dataset is a publicly available set of data programs to process publicly available data on national accounts and energy consumption into an annual, state-level

[20] See https://windc.wisc.edu/ for more information.

representation of the U.S. economy. We made several enhancements to the WiNDC 3.1 build. To improve our representation of transportation, we used the WiNDC routine to disaggregate transportation sectors and updated the allocation of transportation energy consumption across sectors to better reflect the demand for different fuels across transportation modes and residential versus other sources of transportation demand. The WiNDC 3.1 release also reflects prior work by our modeling team to update the sector disaggregation routine and reconcile national accounts and SEDS energy data integration.

2.3.2 Reference Projections

We updated reference GDP and emissions projections to align to the Annual Energy Outlook 2023 (AEO 2023) using the USREP baseline projection methods. These methods include using AEEI parameters to adjust the energy intensity of sectors over time to impact emissions. USREP is calibrated to GDP projections by altering labor productivity over time.

We take two approaches to update transportation demand to align with exogenous AEO emission projections. First, to reflect stable U.S. personal vehicle ownership, we calibrate Stone-Geary preferences for households that calibrate a fixed quantity of subsistence transportation demand with the balance of demand allowed to grow with income. By reducing the amount of transportation demand that grows with income, total transportation demand and emissions grow more slowly. Second, we introduce a production tax on transportation sectors to limit output growth.

2.3.3 Carbon Capture and Sequestration

We calibrate a backstop technology for the energy-intensive industry and manufacturing sectors and the natural gas sector with CCS alternative technology based on bottom-up CCS cost and abatement estimates. Cost estimates for the price of capturing carbon per metric ton vary significantly. Some industrial processes, such as chemical production and gas refining, emit a relatively high-purity stream of CO_2 that is less energy-intensive and costly per ton to capture relative to industries such as iron, steel, and cement production, where CO_2 emissions are more diluted. CCS cost analyses report a wide range of costs (IEA, 2019; Irlam, 2017; Moch et al., 2022; Rubin et al., 2015).

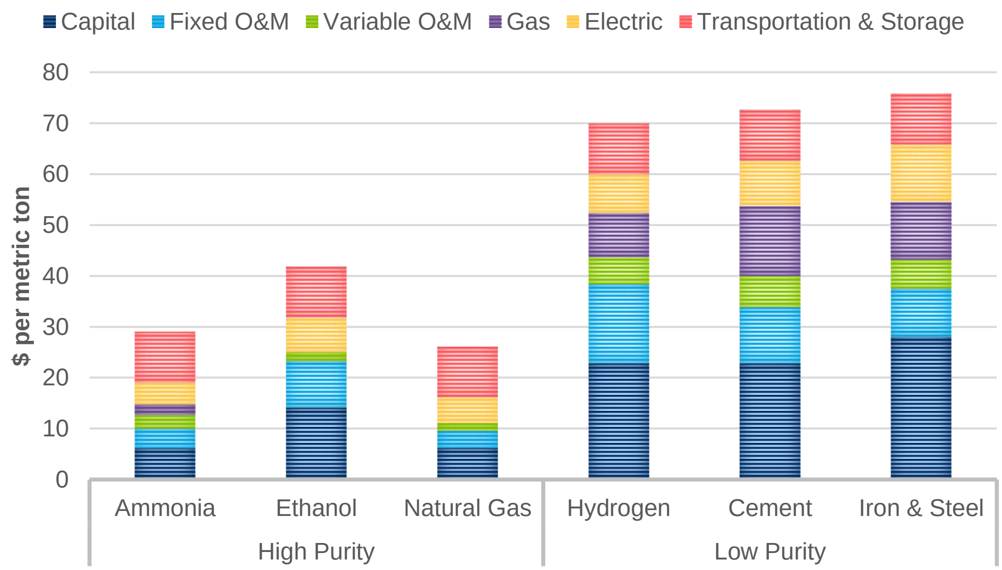
The National Energy Technology Laboratory's (NETL's) Strategic Systems Analysis and Engineering Directorate evaluated the costs of CCS in nine industrial processes; the high-purity sources (greater than 90% CO_2 by volume) include ethanol, ammonia, natural gas processing, ethylene oxide (EO), coal-to-liquids (CTL), and gas-to-liquids (GTL) (Grol, 2022). Low-purity sources (less than 90% CO_2 by volume) include hydrogen (refinery), steel, and cement.

Figure 1 summarizes the NETL CCS cost of capture by sector and cost component for the six industries with >1 Mt CO_2 emissions per year.[21, 22] Costs vary from as low as $16 per Mt in the natural gas processing sector to $66 per Mt for the iron and steel sector. The cost of capture

[21] Grol (2022) reports the total purchased power cost for each industry. The proportions of gas to electric power costs are derived from the NETL report supplement Carbon Capture Retrofit Database Tool (Hughes et al., 2022).
[22] Cost assumptions for low-purity sources are for a 90% capture rate.

does not include the cost of transportation and storage, for which we applied a cost of $10 per Mt (Smith et al., 2021). These costs are all below the credit value of $85 per Mt; however, input prices in USREP may differ from NETL assumptions.

Figure 1: Cost of CCS from Industrial Sources



O&M = operations and maintenance.

We included CCS options for the EIS and natural gas processing in USREP. Components for EIS cost of capture were determined by taking an average of the NETL component costs (in Figure 1) for low-purity industrial sources, weighted by total U.S. emissions in each industry. Components of the cost of carbon capture in the natural gas processing sector were taken directly from NETL. We derived the proportion of fixed O&M costs to taxes and labor from the NETL report supplement Carbon Capture Retrofit Database Tool (Hughes et al., 2022). To allow for CCS retrofits, the CCS technology is allowed to draw on vintaged capital stocks from conventional EIS and natural gas production. Absent a price on GHG emissions, the backstop technology will operate only when the value of the credit exceeds the operating and annualized capital cost of the CCS technology.

Table 7: CCS Model Input Costs

	Natural Gas Processing ($/Mt)	Energy Intensive ($/Mt)
Capital	6.20	24.84
Fixed O&M | Labor	1.69	4.35
Fixed O&M | Taxes	1.71	6.98
Variable O&M	1.50	5.79

Gas	0.00	11.80
Electric	5.00	9.59
Transportation & Storage	10.00	10.00
Total[23]	**26.10**	**73.34**

2.3.4 Direct Air Capture

We developed our DAC assumptions using Fasihi et al. (2019) and modifying to reflect more recent techno-economic research on DAC costs (Herzog, 2022). While costs in Fasihi et al. (2019) start at approximately $250/Mt CO_2 in 2020 and decline to $100/ Mt CO_2 in 2050 with a learning rate of 15% to reach zero emissions worldwide, these costs are low relative to the range in the literature. To align our DAC costs closer to median assumptions, we increased the non-fuel cost to five times of the original value, reduced the learning rate to 3%, and applied USREP's regional energy price to fuel inputs; thus, the DAC starting price ranges from $788/Mt CO_2 in most regions to $1,109/Mt CO_2 in the highest-energy-cost region, Alaska. The future cost of DAC would decline endogenously depending on the production in the previous periods. With these cost assumptions, DAC is not active under the IRA, which offers $185/Mt CO_2 captured, less than the cost to operate DAC.

2.3.5 Transportation

To improve our representation of transportation, we disaggregated commercial transportation modes to include representation of heavy-duty passenger and freight vehicles and non-road modes including water, rail, and air, as included in the WiNDC 3.1 dataset. We introduced backstop electric vehicle technologies for heavy-duty passenger and freight vehicles to compete with their corresponding conventional technologies. The fuel economy and cost ($/vehicle mile traveled [VMT]) projections for electric vehicle technologies in heavy-duty passenger and freight vehicles, as well as light-duty electric and plug-in electric vehicles, were drawn from forthcoming NREL Annual Technology Baseline (ATB) cost estimates. As with other backstop technologies in USREP, the production of these electric vehicle technologies has a nested CES function with a fixed factor in the top-nest. The penetration of these electric vehicles is endogenously determined in the model, and overall reference transportation demand is aligned with AEO 2023 projections.

3 IRA Implementation

3.1 Electricity

3.1.1 Electricity Generator Production and Investment Tax Credits

The IRA extends and modifies existing ITCs and PTCs for zero-emissions electricity generation, tax deduction rules, and other forms of programmatic and funding support. Existing tax credits

[23] Components may not sum to total due to rounding.

are extended through 2024 then replaced by technology-neutral, emissions-rate-based credits that last through 2034. The electricity sector will also be significantly impacted by incentives for transportation and buildings electrification that will increase load. We model seven provisions directly targeting the electricity sector: Sections 13101, 13105, and 13701 for PTCs; Sections 13102, 13103, and 13105 for ITCs, and Section 13703 for depreciation expense deductions.

The PTCs for renewable generation are reduced from pre-IRA levels for the base credit of $3/megawatt hour (MWh), set equivalent to pre-IRA PTCs when the PWA requirements are met (five times the base credit), and an additional 20% or 10% higher when domestic content and/or energy community provisions are met. The current IRA bonus credit is $27.50/MWh with PWA requirements met and $33/MWh when PWA is met with energy community and domestic content. These credit values are updated from the original text of the law to reflect the latest U.S. Department of the Treasury guidance on inflation adjustments (Internal Revenue Service, 2022). Credits under the PTC extension (IRA Section 13301) are available for solar, onshore wind, geothermal, hydropower, and closed-loop biomass (open-loop biomass receives a lower credit, not modeled) through 2024, and under the new PTC for any technologies with zero or negative GHG emissions rates (potentially including fossil CCS) under Section 13701 for 2025–2034.[24]

ITCs for renewable generation (Sections 13102, 13103, and 13702) were reduced from pre-IRA levels for the base credit of 6%, set equal to pre-IRA levels of 30% when PWA requirements are met, and up to 50% for those satisfying domestic content requirements and located in energy communities. These electricity sector ITCs are available for solar, fuel cells, geothermal, small-capacity wind, energy storage, biogas, microgrid controllers, and combined heat and power properties through 2024, then technology for zero- or negative-emissions technologies through 2034.

Capital owners have a choice in taking either the PTC or ITC, given they have an eligible technology. For example, solar investors have typically taken the ITC and wind and hydro the PTC, largely a function of the facility's expected capital costs and capacity factor. The NREL modeling team have assigned either PTC or ITC to each technology based on their analysis of which provision was likely to be most advantageous. The NREL team assumed that onshore wind, utility-scale photovoltaics (PV), and biopower take the PTC, and offshore wind, concentrating solar-thermal power (CSP), geothermal, hydropower, nuclear, pumped storage, battery storage, and distributed PV take the ITC. Tax credits are also assumed to face a monetization penalty because not all investors will have sufficient tax liability to recoup the tax credit (i.e., costs associated with transacting with tax equity investors) and/or, with transferability provisions under the IRA (Section 13801), may prefer an upfront discounted lump-sum payment to payment over the period of the facility's tax credit eligibility. The IRA also offers direct payment of tax credits to tax-exempt organizations, governments, public and tribal utilities, and

[24] For biomass definitions, see IRS Form 8835 guidance: https://www.irs.gov/pub/irs-pdf/i8835.pdf, accessed May 29, 2023.

co-ops (Section 13801). Tax credits for direct air and carbon capture are eligible for direct pay for a limited, 5-year period for all entities.

The NREL team have assumed that the tax credit bonus rates phase into the target value over the first 5 years of availability as more projects meet the domestic content and energy community provisions. Technologies with CCS earn the $85/Mt of sequestered carbon dioxide under Tax Code 45Q (IRA Section 13104). The NREL team also include a 10% monetization cost on tax credits for renewables and 7.5% for carbon capture technologies.

In addition to the IRA provisions described, NREL's standalone ReEDS model analysis included several provisions from the BIL. Existing nuclear incentives established by the Civil Nuclear Credit Program (BIL Section 40323), distributed PV rollout, and various transmission incentives were modeled directly. Additional BIL electricity provisions were represented in post-processing by adjusting total capacity and generation values.

3.1.2 Scenario Summary

For our IRA cases, we vary the value of zero-emissions sources' PTC and ITCs and monetization costs. For our moderate case, we assume credit rates with PWA and a 10% bonus credit (i.e., 40% ITC and $30.25/MWh PTC) with 10% monetization costs. Our pessimistic (and optimistic) scenarios assume PWA +5% (+15%) and 12.5% (7.5%) monetization costs. Our credits for CCS do not vary across scenarios. The technology-neutral credit does allow the possibility for fossil-CCS facilities to earn both the 45Q and 45Y or 45E credits (IRA "stackability" provision) if they can achieve zero emissions or less, but the NREL team have not included this possibility in their modeling approach. Table 8 summarizes the scenario values for our modeled electricity sector provisions.

Table 8: IRA Sections Modeled for the Electricity Sector[25]

IRA Section	Description	Tax Code	Mechanism	Unit	Pessimistic		Moderate		Optimistic		Expiration
					Credit	Monet.	Credit	Monet.	Credit	Monet.	
13101	Production Tax Credit for Electricity from Renewables	45	PTC	$/MWh	28.88	-3.44	30.25	-2.75	31.63	-2.06	2024
13102	Investment Tax Credit for Energy Property	48	ITC	% cost	35.00	-12.50	40.00	-10.00	45.00	-7.50	2024
13103	Increase in Energy Credit for Solar and Wind Facilities Placed in Service in Connection with Low-Income Communities	45(e), 45E(h)	Bonus		N/A		N/A		N/A		2024
13104	Credit for Carbon Oxide Sequestration (CCS)	45Q	PTC	$/Mt	85.00	-10.63	85.00	-8.50	85.00	-6.38	2032
13105	Zero-Emission Nuclear Power Production Credit	45U*	PTC	$/MWh	27.50		27.50		27.50		2032
13701	Clean Electricity Production Tax Credit	45Y*	PTC	$/MWh	28.88	-3.44	30.25	-2.75	31.63	-2.06	2034
13702	Clean Electricity Investment Tax Credit	48E*	ITC	% cost	35.00	-12.50	40.00	-10.00	45.00	-7.50	2034
13703	Cost Recovery for Qualified Facilities, Qualified Property, and Energy Storage Technology	168(e)(3)(B)	Deduction		N/A		N/A		N/A		2034

[25] The "Monet." column in the table represents deductions on tax credits based on the assumption that monetizing the credits results in some loss of their value.

3.2 Transportation

3.2.1 Tax Credits

The IRA includes several provisions that will support emissions reductions in the transportation sector. The provisions include ITCs for vehicles and infrastructure in addition to PTCs for biofuels and battery production. We apply the clean vehicle credit, IRA Section 13401 (Tax Code Section 30D), to residential LDVs amortized over the modeled useful life of the vehicle (25 years in USREP) at an interest rate of 5%. We then discount the capital cost of light-duty plug-in hybrid and battery electric vehicles by the amortized value of the credit over their useful lives.

IRA Section 13403 (Tax Code Section 45W) provides a tax credit for 30% of the purchase price of qualified commercial clean vehicles up to a value of $40,000.[26] As our average HDV cost, taken from the NREL ATB for vehicles, exceeds $133,333 (i.e., $40,000/30%), we apply a heavy-duty vehicle tax credit of $40,000. The credit is 17% and 26% of the manufacturer's suggested retail price (MSRP) in the 2025 and 2030 model years, respectively. The rise in the credit percentage is the result of declining vehicle cost projections in the NREL ATB data.

3.2.2 Grant Funding

Grants programs established under IRA Sections 60101 and 70002 provide funding to replace heavy-duty (Class 6 and 7) vehicles and U.S. Postal Service (USPS) trucks, respectively, with zero-emission vehicles and charging infrastructure.[27] To represent Section 60101, we first take the total value of grant funding available for vehicle purchases and divide by the NREL ATB's weighted-average MSRP of HDVs to establish the number of HDV purchases the grant funding could support. We apply the VMT per year implied from ATB assumptions and multiply by the corresponding energy efficiency (i.e., energy use per mile traveled) for electric vehicles and internal combustion engine vehicles. We then exogenously increase electricity consumption and decrease oil product consumption in the HDV sector in the 2025 model period only, assuming the grants are fully spent within that period. We follow the same calculations for the purchase of USPS trucks under Section 70002 but using VMT assumptions from USPS.[28]

We aggregate the energy impacts of Section 60101 and 70002 provisions and apply them to new HDV services production in the 2025 model period in USREP. USREP's vintaging structure captures the effect of this electrification and its impact over the sector's assumed useful life for new technologies (≤ 25 years).[29] The cost of the program is assumed to be fully covered by public funds during the 2025 model period. If grant programs were to include private cost shares, the energy and emissions impacts of the provisions would be greater.

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[26] The $40,000 limit applies to vehicles over 14,000 pounds, or vehicles rated Class 4 and above. Section 13403 also provides a credit of up to $7,500 for LDVs, but we assume most LDV purchases are covered under Section 13401.
[27] Section 70002 explicitly proportions funds to vehicle purchasing and supporting charging infrastructure. We assume this proportion is used for Section 60101 funds.
[28] https://about.usps.com/publications/sar2015/sar2015/sar2016_doc_021.htm
[29] The USREP vintaging structure assumes a declining utilization rate for vehicles by age.

3.2.3 Scenario Summary

We vary the clean vehicle tax credit across IRA scenarios. For the pessimistic case, we apply a $3,750 credit, equal to the value of the credit for vehicles that meet one, but not both, of the critical mineral and battery component requirements for domestic production. For the optimistic case, we assume vehicles meet both qualifications and apply the full $7,500 credit. We apply the average of these two values for the moderate case. We do not vary the other transportation provisions across IRA scenarios; however, the implied credit rates and number of vehicle purchases vary with technology cost assumptions in the Technology Scenarios (Section 3.4).

Table 9: IRA Sections Modeled for the Transportation Sector

IRA Section	Description	Tax Code	Mechanism	Unit	Pessimistic	Moderate	Optimistic	Expiration
13401	Clean Vehicle Credit	30D	ITC	$	3,750	5,625	7,500	2032
13403	Credit for Qualified Commercial Clean Vehicles	45W	ITC	$	40,000	40,000	40,000	2034
60101	Clean Heavy-Duty Vehicles	N/A	Grants	$mm	1,000	1,000	1,000	2031
70002	U.S. Postal Service Clean Fleets	N/A	Dir. Spend	$mm	3,000	3,000	3,000	2031

mm = million.

3.3 Buildings

IRA provisions in the buildings sector include tax credits for residential and commercial energy efficiency improvements, new energy efficient clean buildings credits, grants to improve home-energy performance, and assistance for federal buildings. We consider three possible activities these provisions could support that would impact building energy use: energy efficiency improvements, electrification via HVAC and hot water heat pump purchases, and weatherization through building shell improvements. To model these provisions, we allocate funding to the three activities using the following four assumptions:

1. Applicability: Amount of funding that will be directed to one of the three building energy activities; energy efficiency, electrification, and weatherization based on the provision text.[30]

[30] Eligible uses of spending vary significantly by provision, and in many cases are not applicable to spending on buildings. The Environmental and Climate Justice Block Grant Provision (Section 60201), for example, allocates money broadly toward reducing air pollution, monitoring for pollution, and improving community resilience. We apply lower applicability shares to these provisions. Government spending allocated for each provision is listed in Table 19.

2. Leverage: Amount of private spending per dollar of public spending. For tax credits and provisions with cost share requirements, these amounts are explicit. For other provisions (e.g., grants), leverage will be determined at implementation.
3. Allocation: Fraction of applicable funds that will be spent on efficiency, electrification, and weatherization. We assume even allocation to the three categories unless the text of the provision indicates otherwise.
4. Low-Income: Amount of total spending that will be targeted toward low-income households. Some provisions, like the Greenhouse Gas Reduction Fund (Section 60103), give explicit guidance on the proportion of funds dedicated to energy justice communities. For those that do not, we assume 40% of funds go to low-income households consistent with the Justice40 initiative.

Expenditure on each activity for all modeled buildings provisions is equal to funding authorization times applicability and leverage, then multiplied by the allocation share for each activity type. For provisions without an explicit funding authorization (e.g., ITCs), we use the CBO outlay estimate.

For residential provisions, we allocate the low-income share of these totals to USREP's first two household quintiles and distribute the balance of project impacts among all other quintiles according to their energy expenditures. Public expenditures occur lump-sum in the 2025 model period. Household expenditures are amortized over 10 years to alter residential consumption expenditures for the 2025 and 2030 periods. As household expenditures are not subject to capital vintaging as in sectoral production, we apply the energy impacts of the three activities consistent with their useful lives: 11 years for energy efficiency, 15 years for heat pumps, and 20 years for weatherization. Commercial expenditures are amortized and energy impacts last over the 25-year useful life of the capital vintage.

3.3.1 Residential Energy Efficiency

The model structure in residential buildings allows us to specify annual energy and capital inputs every 5 years. The following sections represent the methods used to calculate impacts for these years in energy efficiency, electrification, and weatherization. We aggregate these changes for each income group and apply these shocks to the model. We also calculate average private spending for each period year, assuming capital expenditures are amortized over 10 years from when the expenditure was applied toward each stream.

For dollars allocated toward energy efficiency, we rely on a Lawrence Berkeley National Laboratory (LBNL) report on the cost of saving electricity to determine the electricity savings from spending (Goldman et al., 2020). The cost of saved electricity (CSE) is an indicator of the cost performance of electricity-saving activities, with savings levelized over the economic lifetime of the installed measures. The report finds the program administrator (PA) CSE in various sectors, which we assume represents the effectiveness of government spending on efficiency measures, and the total CSE, which we assume represents the effectiveness of government and leveraged private spending. Table 10 displays these costs for residential and low-income end-users.

Table 10: Energy Efficiency Data Inputs

	PA Cost	Total Cost	Source
Residential	$0.022/kWh	$0.039/kWh	Goldman et al. (2020)
Low-Income	$0.132/kWh	$0.145/kWh	Goldman et al. (2020)

We calculate the total energy saved by efficiency spending over a program lifetime by multiplying the money spent on efficiency in each income group by the corresponding total CSE value. We then divide by the weighted-average program lifetime of 11.25 years.[31] Annual energy changes are calculated using one year of spending, which we assume last for 11.25 years. We aggregate these changes over the period from 2023–2043 with additional spending and corresponding energy shocks turning on each year through 2032, and we input the 5-year annual averages for each period. Table 11Table 11 summarizes the electricity impacts of modeled energy efficiency programs.

Table 11: Annual Energy Changes from Residential Energy Efficiency Spending (terawatt-hour [tWh]), IRA Moderate Case

	2025	2030	2035	2040	2045	2050
Electricity (low income)	-6.71	-17.91	-18.35	-7.27	-0.11	0.00
Electricity (other)	-27.12	-72.33	-74.14	-29.38	-0.45	0.00

3.3.2 Residential Electrification

We assume money spent on electrification is allocated toward installing air-source heat pumps and heat pump water heaters. We use ENERGY STAR V. 6.1 standards to determine the reference case for cooling and heating efficiency for air-source heat pumps,[32] and ENERGY STAR V. 4.0 standards for heat pump water heaters. EIA reports that the total cost of installation for a new 36 thousand British thermal units (kBtu)/hour air-source heat pump with these efficiency standards is $6,940, while the reference heat pump water heater (36-gallon capacity) costs $2,230 (U.S. Energy Information Administration, 2023). The Federal Energy Management Program (FEMP), a DOE program that provides acquisition guidance for residential air-source heat pumps, reports that the average annual energy use for a 36 kBtu/hour heat pump with these efficiency standards, operated with 1,400 cooling mode hours and 1,400 heating mode hours per year, is 9,777 kilowatt-hours (kWh), while the

[31] Average program lifetime for utility programs reported in Cohn (2021).
[32] We therefore assume SEER2 is 15.2, and HSPF2 is 7.8.

reference heat pump water heater uses 1,476 kWh per year (U.S. Department of Energy, 2022b, 2023). Table 12 summarizes the data inputs for residential electrification activities.

Table 12: Electrification Data Inputs

	Air-Source	Water Heater	Source
Annual Energy Use (kWh)	9,777	1,476	U.S. Department of Energy (2022b, 2023)
Total Installation Cost	$6,940	$2,230	U.S. Energy Information Administration (2023)
Natural Gas Efficiency Factor	3.2	3.5	McKenna (2020), EPA
% of spending	76%	34%	Assumption based on prices

We calculate the additional annual electricity from heat pump purchases by multiplying the dollars allocated to electrification in each income group times the ratio of annual energy use to installation costs. We then calculate the reduced natural gas volume by multiplying by an efficiency factor ratio between a reference heat pump and an ENERGY STAR gas furnace or gas-powered water heater. These annual energy changes are calculated using one year of spending and last for an average of 15.2 years.[33] We aggregate these changes over the period from 2023–2050, reporting the 5-year annual averages for each period. Table 13 summarizes the increased electricity and reduced natural gas demand from residential electrification over time.

Table 13: Annual Energy Changes from Residential Electrification (tWh), IRA Moderate Case

	2025	2030	2035	2040	2045	2050
Electricity (low income)	9.60	25.59	31.99	23.03	7.04	0.00
Electricity (other)	11.16	29.75	37.19	26.77	8.18	0.00
Natural Gas (low income)	-0.12	-0.32	-0.39	-0.28	-0.09	0.00
Natural Gas (other)	-0.02	-0.04	-0.05	-0.04	-0.01	0.00

3.3.3 Residential Weatherization

We rely on a DOE Office of Energy Efficiency and Renewable Energy report on the Weatherization Assistance Program (U.S. Department of Energy, 2022c) to determine the energy impact of spending on weatherization. DOE reports that for $4,695, a home saves an average of 18% annually in heating consumption and 7% annually in electricity consumption.

[33] This value is based on the average lifetime of heat pumps in reported in EIA (2023).

We divide weatherization spending by this amount to determine the number of homes to apply these savings.

EIA (2021) reports the average home uses 77 million British thermal units (MMBtu) of energy per year, and that 43% of energy is used for heating. We apply 18% heating savings to average heating energy consumption and 7% electricity savings to average electricity consumption to calculate decreases in energy consumption from weatherization spending. Table 14 summarizes the weatherization assumptions.

Table 14: Weatherization Data Inputs

Cost or Energy Variable	Value	Source
Average Cost of Weatherization	$4,695	U.S. Department of Energy (2022c)
Annual Heating Consumption Savings	18%	U.S. Department of Energy (2022c)
Annual Electric Consumption Savings	7%	U.S. Department of Energy (2022c)
Heating Energy Consumption per Household (MMBtu)	33	U.S. Energy Information Administration (2021)
Electric Energy Consumption per Household (MMBtu)	44	U.S. Energy Information Administration (2021)
% Electric Heating	36%	U.S. Energy Information Administration (2021)

Annual energy changes are calculated using one year of spending and last for an average of 20 years (Hogan, 2015). We aggregate these changes over the period from 2023–2050, reporting the 5-year annual averages for each period. Table 15 summarizes the modeled changes in residential energy use from weatherization programs.

Table 15: Annual Energy Changes from Residential Weatherization (tWh), IRA Moderate Case

	2025	2030	2035	2040	2045	2050
Electricity (low income)	-2.12	-5.66	-7.07	-7.07	-4.95	-2.83
Electricity (other)	-2.32	-6.20	-7.75	-7.75	-5.42	-3.10
Natural Gas (low income)	-0.03	-0.08	-0.10	-0.10	-0.07	-0.04
Natural Gas (other)	0.00	-0.01	-0.01	-0.01	-0.01	-0.01

3.3.4 Commercial and Government Buildings

IRA Section 13303 (Tax Code Section 179D) provides a tax credit for commercial building improvements that reduce GHG emissions. Section 60502 provides direct spending for federal building improvements. We assume this money is spent on energy efficiency and calculate annual energy savings based on the total CSE value reported in Goldman et al. (2020) of $0.055 per kWh saved.

The vintaging structure in USREP will maintain energy shocks in the commercial sector for a given capital stock's useful life of 25 years, so we divide total energy savings and amortize private costs over that time frame at a 5% discount rate. Public spending occurs lump-sum in the 2025 model period. We assume all projects occur within the 2025 model year. Independent estimates suggest the actual useful lives of energy efficiency projects may be significantly shorter, meaning our modeled energy savings and capital expenditures are lower in the near term and higher in the long term (Cohn, 2021).

3.3.5 Scenario Summary

We vary assumed federal spending, applicability of spending to building energy shocks, and private leverage assumptions across scenarios. Table 16 displays the applicable public expenditures we assume for each provision in each IRA scenario. For a more detailed description of our assumptions, see Table 19 in Appendix A.

Table 16: IRA Provisions Modeled for the Buildlings Sector

IRA Section	Description	Tax Code	Mechanism	Unit	Pessimistic	Moderate	Optimistic	Expiration
13301	Energy Efficient Home Improvement Credit	25C	ITC	$mm	26,562	33,203	39,843	2032
13302	Residential Clean Energy Credit	25D	ITC	$mm	46,980	58,725	70,470	2034
13303	Energy Efficient Commercial Buildings Deduction	179D	ITC	$mm	965	965	965	N/A
13304	New Energy Efficient Homes Credit	45L	ITC	$mm	13,208	1,634	1,961	2032
30002	Green and Resilient Retrofit Program	N/A	Grants, Loans	$mm	1,200	2,000	2,800	2029
50121	Home Energy Performance-Based, Whole-House Rebates	N/A	Grants	$mm	4,439	5,548	6,658	2031
50122	High-Efficiency Electric Home Rebate Program	N/A	Grants	$mm	4,114	5,143	6,171	2031
60103	Greenhouse Gas Reduction Fund	N/A	Grants	$mm	38,880	64,800	97,200	2024

IRA Section	Description	Tax Code	Mechanism	Unit	Pessimistic	Moderate	Optimistic	Expiration
60114	Climate Pollution Reduction Grants	N/A	Grants	$mm	3,200	4,000	4,800	2031
60201	Environmental and Climate Justice Block Grants	N/A	Grants	$mm	1,440	3,000	5,040	2026
60502	Assistance for Federal Buildings	N/A	Dir. Spend	$mm	75	125	175	2031

3.4 Industry

3.4.1 Energy Efficiency Improvements

IRA Section 13501 provides $10 billion in funding for 30% ITCs (Tax Code Section 48C; base credit of 6% if PWA is not met) for upgraded or new facilities that recycle or produce clean energy equipment, vehicles, or critical minerals. Section 50161 provides $5.81 billion in grants and rebates to support the purchase and installation of technologies that reduce GHG emissions in industrial facilities. Funding for these provisions will cover 30% of project costs for the Section 13501 tax credit and up to 50% for Section 50161, or leverage ratios of 3.33 and 2, respectively. As the provisions could be applied to a broader set of projects than those that would impact industrial energy, we discount authorized funding for each provision for applicability. In our moderate scenario, we assume 25% of the funding for Section 13501 and 50% of the funding for Section 50161 will directly fund energy efficiency improvements with the leverage indicated above.[34]

We rely on an LBNL report on the cost of saving electricity (Goldman et al., 2020) to estimate the energy savings associated with a given level of efficiency project spending. The CSE is an indicator of the average cost performance of electricity-saving programs administered by electric utilities nationwide, with savings levelized over the economic lifetime of the installed measures. We calculate the total energy saved by efficiency spending over a program lifetime by dividing the total (public and private) applicable spending (i.e., program funding times leverage times one minus the discount) supported by Section 13501 and 50161 programs by the corresponding CSE value to arrive at total energy savings, which we value at USREP electricity prices.

Industrial production within USREP is highly aggregated into one EIS, so we calculate the impact of the efficiency spending of these programs as a single-sector exogenous shift in electricity demands. The vintaging structure in USREP will maintain energy shocks for a given

[34] 25% is the average of the applicability discount used by Princeton REPEAT and Energy Innovation's IRA modeling for Section 13501. While these modeling teams assume 100% applicability for Section 50161, we took a more conservative approach in our moderate case of 50%.

capital stock's useful life of 25 years, so we divide total energy savings and amortize private costs over that time frame at a 5% discount rate. We assume all projects and public spending occur within the 2025 model period. Independent estimates suggest the actual useful lives of energy efficiency projects may be significantly shorter than the 25-year useful life for USREP capital, meaning our modeled energy savings and capital expenditures are lower in the near term and higher in the long term (Cohn, 2021).

3.4.2 Carbon Management

IRA Section 13104 (Tax Code Section 45Q) provides an $85/Mt production tax credit for CCS technologies (carbon capture and utilization receives a lower credit value) and $180/Mt for DAC technologies.[35] These credits are sector-neutral, and the same CCS credit is applied for the electricity sector. To represent CCS for industrial sources in USREP, we calibrate a backstop EIS with CCS alternative technology based on bottom-up CCS cost and abatement estimates. The EIS-CCS backstop technology has the same input requirements as the EIS, less the emissions permit requirements for abated emissions (which have zero cost without a carbon policy), less the value of 45Q credit payments, and plus additional capital, labor, and energy inputs to operate the CCS technology. To allow for CCS retrofits, the EIS-CCS technology is allowed to draw on vintaged capital stocks from conventional EIS production. Absent a price on GHG emissions, the backstop technology will operate only when the value of the credit exceeds the operating cost of the CCS technology. Similarly, we calibrate a backstop DAC technology that is only active when the value of the 45Q credit exceeds the DAC operating costs less the market value of abatement (i.e., carbon price times abatement quantity), which it does not given our technology cost assumptions.

3.4.3 Scenario Summary

Table 17 summarizes the IRA sections we modeled for industrial sectors and their scenario values. We do not vary the CCS or DAC credit values. We vary the level of applicability (i.e., the amount of total funding allocated to industrial energy efficiency projects) for the Section 13501 (10%, 25%, 40%) and Section 50161 (25%, 50%, 75%) provisions for each of the IRA scenarios (pessimistic, moderate, optimistic).

Table 17: IRA Provisions Modeled for Industrial Sectors

IRA Section	Description	Tax Code	Mechanism	Unit	Pessimistic	Moderate	Optimistic	Expiration
13104	Credit for Carbon Oxide Sequestration - *CCS*	45Q	PTC	$/Mt	85.00	85.00	85.00	2032

[35] The tax credit is $17/Mt of CCS abatement (lower for carbon capture and utilization) and $36/Mt of DAC abatement when PWA requirements are not met.

IRA Section	Description	Tax Code	Mechanism	Unit	Pessimistic	Moderate	Optimistic	Expiration
	Credit for Carbon Oxide Sequestration - *DAC*	45Q	PTC	$/Mt	180.00	180.00	180.00	2032
13501	Advanced Energy Project Credit	48C	ITC	$mm	1,000	2,500	4,000	2032
50161	Advanced Industrial Facilities Deployment Program	N/A	Grants	$mm	1,453	2,906	4,359	2026

3.5 Technology Scenarios

We ran technology sensitivity scenarios with the USREP-ReEDS model interacted with the IRA scenarios. For these scenarios, we vary technology costs based on NREL's ATB scenarios, where applicable, or by a notional +/-20% where only one reference technology cost is available. For the electricity sector, the model inputs cost assumptions from the ATB advanced scenario for clean energy technologies: PV, wind, battery, nuclear, geothermal, and CSP (Steinberg et al., 2023). For the transportation sector, the purchasing costs of LDVs and HDVs are reduced by 10% in 2025 and by 20% from 2030–2050 relative to the base case. In the industrial sector, the capital costs of gas CCS and industrial CCS are reduced by 20% in every year relative to the base case. Table 18 summarizes the conservative and advanced technology scenario assumptions relative to base case technology assumptions.

Table 18: Advanced Technology Scenario Design by Sector

Sector	Conservative	Advanced
Electricity	NREL Constrained	NREL AdvAllClean
Transportation	NREL ATB Conservative	NREL Aggressive -10% (2025), -20% (2030)
Industry	Energy Efficiency $0.07/kwh CCS Capital Costs +20%	Energy Efficiency $0.04/kwh CCS Capital Costs -20%
Buildings	Capital and EE Costs +20%	Capital and EE Costs -20%

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Appendix A

Table 19: Description of Provisions Included in the IRA Analysis

Section	Description	Tax Code	Incentive	Model Assumptions	Scenario Variation
Electricity					
13101	Production Tax Credit for Electricity from Renewables	45	PTC	Assume PWA requirements are met. Apply $27.5/MWh to onshore wind, utility-scale PV, and biopower.	{-12.5, -10.0, -7.5} % for monetization {5, 10, 15} % for bonus credits
13102	Investment Tax Credit for Energy Property	48	ITC	Assume PWA requirements are met. Apply 30% credit to offshore wind, CSP, geothermal, hydropower, nuclear, pumped storage, battery storage, and distributed PV.	{-12.5, -10.0, -7.5} % for monetization {5, 10, 15} % for bonus credits
13103	Increase in Energy Credit for Solar and Wind Facilities Placed in Service in Connection with Low-Income Communities	45(e), 45E(h)	ITC	0.9 GW per year (50% of the maximum total annual capacity allowed to receive the low-income community bonus) of distributed PV added to the Distributed Generation Market Demand (dGen) model projections through 2032.	N/A
13105	Zero-Emission Nuclear Power Production Credit	45U*	PTC	Assume PWA requirements are met. Apply $27.5/MWh to nuclear power production.	Not varied
13701	Clean Electricity Production Tax Credit	45Y*	PTC	Same as 13101.	{-12.5, -10.0, -7.5} % for monetization {5, 10, 15} % for bonus credits
13702	Clean Electricity Investment Tax Credit	48E*	ITC	Same as 13102.	{-12.5, -10.0, -7.5} % for monetization {5, 10, 15} % for bonus credits
13703	Cost Recovery for Qualified Facilities, Qualified Property, and Energy Storage Technology	168(e)(3)(B)	Deduction	Captured in ReEDS within the financing calculations according to Ho et al. (2021).	N/A

Section	Description	Tax Code	Incentive	Model Assumptions	Scenario Variation
Multiple Sector					
13104	Credit for Carbon Oxide Sequestration (CCS)	45Q	PTC	Assume PWA requirements are met. Apply $85/Mt credit to industrial and power applications. Assume -7.5% credit for cost of monetization in the power sector. Industrial CCS cost assumptions based on NETL's report on the cost of CCS by industry. Apply $180/Mt credit for DAC.	{-11.25, -7.5, -3.75} % for monetization in electricity sector
Transportation					
13401	Clean Vehicle Credit	30D*	ITC	Assume $5,625 to reflect moderate assumption on vehicles meeting critical battery and mineral component requirements.	{$3,750, $5,625, $7,500}
13403	Credit for Qualified Commercial Clean Vehicles	45W*	ITC	Apply $40,000 as a reduction in costs for all heavy-duty electric vehicles.	Not varied
60101	Clean Heavy-Duty Vehicles	N/A	Grants	$1 billion grant over 10 years (2022–2031) assigned to the purchase of new zero-emission buses. Apportioned spending and infrastructure costs based on proportion used to support USPS fleet (Section 70002), so $433 million for vehicle purchases and $567 million for charging infrastructure. Used weighted-average ATB vehicle costs for Class 6 and Class 8 Box battery electric vehicles and U.S. Department of Transportation reported VMT data to determine number of vehicles purchased and gas saved through replacement with EVs.	Not varied
70002	U.S. Postal Service Clean Fleets	N/A	Dir. Spend	$1.3 billion grant allocated for the purchase of new zero-emission USPS vehicles and $1.7 billion for fleet infrastructure and charging. Used ATB vehicle costs for Class 4 Box vehicles and USPS VMT data to determine number of vehicles purchased and gas saved	Not varied

Section	Description	Tax Code	Incentive	Model Assumptions	Scenario Variation
				through replacement with EVs.	
Industry					
13501	Advanced Energy Project Credit	48C	ITC	We vary federal spending based on applicability assumptions across scenarios. We assume 30% tax credit results in 3.33 leverage of private funds. We use data from LBNL to determine the CSE from spending in industrial sectors and apply an exogenous shift in electricity demand to the model.	{10, 25, 40} % federal spending
50161	Advanced Industrial Facilities Deployment Program	N/A	Grants	We vary federal spending based on applicability assumptions across scenarios. We assume 2.0 private leverage based on maximum of 50% cost share stated in the provision. We use data from LBNL to determine the CSE in industrial sectors and apply an exogenous shift in electricity demand to the model.	{25, 50, 75} % federal spending
Buildings					
13301	Energy Efficient Home Improvement Credit	25C	ITC	Apportion CBO-estimated outlays for this program ($12.5 billion) to residential electrification, weatherization, and energy efficiency programs (with applicability and leverage assumptions) and apply exogenous shift in energy demand to the model. Assume 80% applicability, 3.3 private: public leverage.	{-20, 0, 20} % federal spending
13302	Residential Clean Energy Credit	25D	ITC	Apportion CBO-estimated outlays for this program ($22.0 billion) to residential electrification, weatherization, and energy efficiency programs (with applicability and leverage assumptions) and apply exogenous shift in energy demand to the model. Assume 80% applicability, 3.3 private: public leverage.	{-20, 0, 20} % federal spending

Section	Description	Tax Code	Incentive	Model Assumptions	Scenario Variation
13303	Energy Efficient Commercial Buildings Deduction	179D	ITC	Apportion CBO-estimated outlays for this program ($362 million) to commercial energy efficiency programs (with applicability and leverage assumptions) and apply exogenous shift in energy demand to the model. Assume 80% applicability, 3.3 private: public leverage.	{-20, 0, 20} % federal spending
13304	New Energy Efficient Homes Credit	45L	ITC	Apportion CBO-estimated outlays for this program ($2 billion) to residential electrification, weatherization, and energy efficiency programs (with applicability and leverage assumptions) and apply exogenous shift in energy demand to the model. Assume 80% applicability, 1.0 private: public leverage.	{-20, 0, 20} % federal spending
30002	Green and Resilient Retrofit Program	N/A	Grants, Loans	We apportion CBO Budget Authority for this program ($990 million) to residential electrification, weatherization, and energy efficiency programs (with applicability and leverage assumptions) and apply exogenous shift in energy demand to the model. Assume 50% applicability, 4.0 private: public leverage. Full description of buildings methodology can be found in Section 3.3.	{-20, 0, 20} % applicability
50121	Home Energy Performance-Based, Whole-House Rebates	N/A	Grants	We apportion CBO Budget Authority for this program ($4.3 billion) to residential electrification, weatherization, and energy efficiency programs (with applicability and leverage assumptions) and apply exogenous shift in energy demand to the model. Assume 80% applicability, 1.6 private: public leverage. Full description of buildings methodology can be found in Section 3.3.	{-20, 0, 20} % leverage
50122	High-Efficiency Electric Home Rebate Program	N/A	Grants	Apportion CBO Budget Authority for this program ($4.3 billion) to residential electrification, weatherization, and energy efficiency programs (with applicability	{-20, 0, 20} % leverage

Section	Description	Tax Code	Incentive	Model Assumptions	Scenario Variation
				and leverage assumptions) and apply exogenous shift in energy demand to the model. Assume 80% applicability, 1.6 private: public leverage.	
60103	Greenhouse Gas Reduction Fund	N/A	Grants	Apportion CBO Budget Authority for this program ($4.5 billion) to residential electrification, weatherization, and energy efficiency programs (with applicability and leverage assumptions) and apply exogenous shift in energy demand to the model. Assume 80% applicability, 1.4 private: public leverage.	{-20, 0, 20} % leverage {-20, 0, 20} % applicability
60114	Climate Pollution Reduction Grants	N/A	Grants	Apportion CBO Budget Authority for this program ($5 billion) to residential electrification, weatherization, and energy efficiency programs (with applicability and leverage assumptions) and apply exogenous shift in energy demand to the model. Assume 80% applicability, 1.0 private: public leverage.	{-20, 0, 20} % leverage
60201	Environmental and Climate Justice Block Grants	N/A	Grants	Apportion CBO Budget Authority for this program ($3,250 million) to government electrification, weatherization, and energy efficiency programs (with applicability and leverage assumptions) and apply exogenous shift in energy demand to the model. Assume 50% applicability, 2.0 private: public leverage.	{-20, 0, 20} % leverage {-20, 0, 20} % applicability
60502	Assistance for Federal Buildings	N/A	Direct Spending	Apportion CBO Budget Authority for this program ($3 billion) to energy efficiency programs (with applicability and leverage assumptions) and apply exogenous shift in energy demand to the model. Assume 50% applicability, 1.0 private: public leverage.	{-20, 0, 20} % applicability

Table 20: Climate-Related Provisions not Included in USREP-ReEDS Analysis

IRA Section	Sector	Description	CBO Outlays ($ billion)
13201	Transportation	Extension of Incentives for Biodiesel, Renewable Diesel, and Alternative Fuels	5.57
13202	Transportation	Extension of Second-Generation Biofuel Incentives	0.05
13203	Transportation	Sustainable Aviation Fuel Credit	0.05
13204	Transportation	Production of Clean hydrogen	13.17
13402	Transportation	Used-EV Purchase	1.35
13404	Transportation	Investment in Depreciable Alternative Fueling and EV Recharging Property	1.74
13502	Industry	Advanced Manufacturing Production Credit	30.63
13704	Transportation	Clean Fuel Production Credit	2.95
21001	Forestry & Ag	For Environmental Quality Incentives Program (EQIP)	15.31
21002	Forestry & Ag	Quantification of Carbon Sequestration and GHG Emissions in Agricultural Lands	1.40
22001	Electricity	Additional Funding for Electric Loans for Renewable Energy	1.00
22002	Forestry & Ag	Promoting Energy Efficiency and Renewable Energy Development for Agriculture	1.98
22003	Forestry & Ag	Biofuel Infrastructure and Agriculture Product Market Expansion	0.50
22004	Electricity	Assistance for Rural Electric Co-Ops	9.60
22005	Electricity	Additional USDA Rural Development Administrative Funds	0.10
23001	Other	National Forest System Restoration and Fuels Reduction Projects	2.15
23002	Other	Competitive Grants for Non-Federal Forest Landowners	0.55
23003	Other	State and Private Forestry Conservation Programs	2.00
40001	Other	Investing in Coastal Communities and Climate Resilience	2.60
40004	Other	Oceanic and Atmospheric Research and Forecasting for Weather and Climate	0.20
40005	Other	Computing Capacity and Research for Weather, Oceans, and Climate	0.19
40007	Transportation	Alternative Fuel and Low Emission Aviation Technology Program	0.29
50123	Buildings	State-Based Home Energy Efficiency Contractor Training Grants	0.20
50131	Buildings	Assistance for Latest and Zero Building Energy Code Adoption	0.90
50141	Electricity	Funding for Department of Energy Loan Programs Office	3.34
50142	Industry	Advanced Technology Vehicle Manufacturing	0.92

IRA Section	Sector	Description	CBO Outlays ($ billion)
50144	Electricity	Energy Infrastructure Reinvestment Financing	3.50
50145	Electricity	Tribal Energy Loan Guarantee Program	0.08
50151	Electricity	Construction/Modification of Electric Transmission Facilities	1.46
50152	Electricity	Grants to Facilitate the Siting of Interstate Electricity Transmission Lines	0.73
50153	Electricity	Interregional and Offshore Wind Electricity Transmission Planning, Modeling, and Analysis	0.10
50172	Other	National Laboratory Infrastructure	2.00
50221	Other	National Parks and Public Lands Conservation and Resilience	0.25
50222	Other	For NPS Hiring	0.25
50232	Other	Canal Improvement Projects	0.03
50233	Other	Drought Mitigation in the Reclamation States	3.60
50251	Electricity	Leasing on the Outer Continental Shelf	-0.16
50261–50265	Other	Fossil Fuel Resources	-0.48
60102	Transportation	Grants to Reduce Air Pollution at Ports	3.00
60104	Transportation	Diesel Emissions Reductions	0.06
60105	Transportation	Funding to Address Air Pollution	0.24
60107	Electricity	Low Emissions Electricity Program	0.09
60108	Transportation	Funding for Section 211(O) of the Clean Air Act	0.02
60111	Other	Greenhouse Gas Corporate Reporting	0.01
60113[36]	Other	Incentivizing Methane Mitigation and Monitoring	-4.80
60302	Other	Funding for the United States Fish and Wildlife Service to Address Weather Events	0.13
60501	Transportation	Neighborhood Access and Equity Grants Program	2.90
60503	Buildings	Use of Low-Carbon Materials	2.15
60504	Buildings	General Services Administration Emerging Technologies	0.98
60506	Transportation	Low-Carbon Transportation Materials Grants	1.70
70006	Buildings	FEMA Building Materials Program	0.06
80003	Electricity	Provision of Electricity to Unelectrified Tribal Homes	0.15

[36] CBO estimate includes $6.35 billion expected revenue increases and $1.55 estimated outlays.