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Leveraging the IRA to Achieve 80x30 in the US Electricity Sector

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Nick Roy is a senior research analyst at RFF, which he joined in June 2020 to work on the Haiku electricity sector simulation model. Using Haiku, Nick has analyzed an array of policies including clean energy tax credits, renewable energy standards, and emissions pricing. In addition to electricity sector modeling, Nick also employs various research methods to analyze freight regulation and electrification in the transportation sector. Prior to joining RFF as a research analyst, Roy was a 2019 summer intern at RFF for Art Fraas investigating energy efficiency device usage among heavy-duty trucks. Between the two positions, he researched port drayage disruptions at the Center for International Trade and Transportation. He graduated from California State University Long Beach with a BA in economics, a BS in applied mathematics, and a minor in philosophy.

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Abstract

The Inflation Reduction Act (IRA) promises to deliver important reductions in CO2 emissions from the electricity sector along with a host of other benefits to citizens and electricity consumers, but it falls short of achieving the 80 percent reduction below 2005 levels by 2030 (80x30) consistent with meeting the nation's Paris goals. This paper examines the consequences of the IRA and of policies designed to hit the Paris targets for generation mix, consumer costs of electricity, the federal budget, air quality, and human health. Our modeling shows that the IRA substantially reduces the allowance price for necessary an emissions cap to meet the 80x30 goal in the power sector and that doing so yields savings to consumers, particularly those with lower incomes, and additional health benefits beyond those promised from the IRA.

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1. Introduction

The 2022 Inflation Reduction Act (IRA) is the most important environmental legislation since the 1970 Clean Air Act and the most important US climate policy. It is a centerpiece of the Biden administration's efforts to deliver on its pledge to the international community to achieve a 50 percent reduction in US greenhouse gas emissions from 2005 levels in 2030. Its greatest impact by 2030 is expected in the electricity sector, where the administration set a goal of 80 percent reduction from 2005 levels by 2030, hence the label "80 by 30" (80x30). Coincidentally, this goal requires roughly 80 percent of electricity generation to come from nonemitting sources, such as renewable energy and nuclear power (DOE 2023). A primary focus is on the electricity sector because major emissions reductions are possible this decade and decarbonization of the sector enables emissions reductions to be achieved, mostly after 2030, in other parts of the economy through electrification of transportation and buildings.

The IRA relies on providing incentives for clean energy development and amplifies the subsidies for investment in clean energy in the Infrastructure Investment and Jobs Act (2021) and billions of dollars to rebuild the US semiconductor industry in the Creating Helpful Incentives to Produce Semiconductors and Science Act (2022). A second federal policy lever involves regulations under the Clean Air Act, including the revised Mercury and Air Toxics Standard, Good Neighbor Rule, and Greenhouse Gas rule, that affect fossil fuel combustion. A third lever and the one most often recommended from an efficiency perspective—a federal price on power sector emissions—is nearly entirely missing in the federal climate policy suite.

This paper examines how far IRA subsidies go toward achieving the nation's 2030 pledge under the Paris Agreement on Climate, the cost, air pollution co-benefits, and distribution of the financial effects across income groups. To evaluate the cost-effectiveness of the subsidy approach, we compare the IRA to the counterfactual alternative of carbon pricing to achieve the same emissions outcome. Looking beyond the IRA, our main interest is to ask how the IRA affects the cost of introducing a binding emissions cap on the power sector to achieve the level of abatement necessary to satisfy the 2030 pledge. To address these questions, we use a national electricity sector model to examine investments and system operation and then map results to a model of the financial incidence for households and one of the health impacts from air pollution.

A voluminous literature explains why subsidies and regulatory approaches embodied generally in current US climate policy are expected to be less effective and efficient in achieving a specified emissions outcome than carbon pricing. For example, subsidies and regulatory approaches can lead to various adverse selection and moral hazard problems (Goulder and Parry 2008). Given the inability of the regulator to acquire or act on private information about the costs of reducing emissions, it is challenging for them to structure subsidies in a way that does not reward firms for investments or changes in operations that would have happened even without the subsidy (Löfgren et al. 2002). Similarly, regulations are frequently differentiated based on the vintage of physical capital (Stavins 2006). Regulating new emissions sources more stringently creates a bias against investment that might have occurred in the absence of regulation and may delay eliminating emissions from more polluting existing sources (Coysh et al. 2020). In contrast, emissions pricing provides direct incentives for a firm to act on its private information about emissions reduction opportunities and an implicit incentive through changes in relative fuel prices to invest in and operate lower-emitting facilities (Baumol and Oates 1988). Last, subsidies suppress the change in the final product price and the behavioral response by consumers and downstream users of the product (Goulder et al. 1999), whereas a carbon price would incentivize reduced consumption.

The IRA can be expected to be less efficient than a carbon pricing approach by most of the measures described in the literature. One reason is that it provides a one-size-fits-all subsidy to each of the various types of clean energy it supports without distinguishing the incremental new investments ("additional investments") from those that would have occurred without the policy ("anyway investments"). In addition, these subsidies create an incentive for clean energy but do not differentiate the implicit disadvantage provided to coal and gas despite coal having an emissions rate that is twice as large. And, by lowering the price of electricity, the IRA does not incentivize reduction in overall demand by end users, although this last effect is likely a benefit if the United States is pursuing a strategy of electrification. The subsidy approach in the IRA coupled with regulations in the electricity sector also do not offer confidence of achieving a specific emissions outcome, as would an emissions cap.

We find that the IRA has higher resource (capital, fuel, and labor) costs than would have been realized under a carbon pricing approach that achieved the same emissions reductions. Nonetheless, despite employing a less efficient policy, the IRA yields benefits, including climate change mitigation and improvement in air quality, that are much larger than its costs. Its emissions reductions are coupled with a more progressive distributional outcome than is likely under carbon pricing, due to a cost shift from electricity ratepayers to taxpayers.[1]

Although a substantial gap remains to achieve the necessary emissions reductions in the electricity sector required to meet the US pledge, the IRA reduces by more than half the carbon price necessary to close the gap. Some of the policy's apparent inefficiencies may improve the ability of the electricity sector to contribute to the decarbonization of buildings and transportation in the next decade. The reduced electricity prices will make electrification more financially attractive to households and businesses. And, compared to efficient short-term emissions reductions (from coal-to-gas switching and demand reduction) that would have been prominent under carbon pricing, the short-term "overbuild" of renewable energy resources resulting from subsidies helps prepare the sector for expected long-term increases in electricity demand.

1 The impact on households under carbon pricing depends primarily on the use of revenues collected, and that decision is more important than the magnitude of the carbon price (Williams et al. 2015). We assume that carbon pricing revenues are returned to households according to their share of capital income, the mirror of how the IRA is funded. A mildly more progressive approach would be to return revenues based on total income, which would be similar to adding to general revenues.

The IRA appears potent overall, taking the country over halfway to achieving the Biden administration's carbon goal for the electricity sector by 2030; however, the outcome is uncertain. The results that we and others (that we review) describe are projections under economic conditions where actors seek to minimize costs in a competitive environment. The IRA does not mandate these emissions reductions. Its effectiveness hinges on the ability of private sector investments in nonemitting electricity generation to overcome barriers that we model only implicitly and do not explore directly, including siting delays for new generation facilities and transmission infrastructure, delays in the interconnection of renewable generation resources to the electricity grid, evolving market rules to support resource adequacy, and consumer embrace of electrification of transportation and buildings. Hence, an important frame for this paper, in addition to the remaining opportunity for economically efficient abatement under the IRA, is the opportunity to reduce uncertainty about the emissions outcome in the power sector.

Although the Biden administration's climate pledge is based on a portfolio of subsidies and regulations, the US pledge to reduce emissions 17 percent below 2005 levels by 2020 delivered to the international community at the 2009 Copenhagen climate conference was based largely on economywide carbon pricing in the proposed Waxman-Markey climate legislation (HR 2454). It would have implemented economywide cap and trade covering 84.5 percent of US emissions, yielding a specific emissions outcome. Although it passed the House of Representatives, it was not enacted. In the absence of carbon pricing, several analysts predicted the US pledge would nonetheless be achieved through regulations under the Clean Air Act directed at power plants and natural gas systems, state and federal policies providing incentives for clean energy, vehicle efficiency standards, and reductions in hydrofluorocarbons (Burtraw and Woerman 2012; Bianco et al. 2013). Anticipated reductions in the electricity sector were achieved; however, economywide emissions ticked up in 2018 and, notwithstanding the COVID-19-related decline in 2020, the United States failed to achieve its Copenhagen pledge (Larsen et al. 2020).

Since the Kyoto climate agreement in 1996, which identified international emissions trading as a global policy framework for industrialized and transitional economies listed in Annex I of the Protocol, most of these countries and the rest of the world have been slow to implement nation-level emissions trading or any other approach to carbon pricing. More recently, some progress toward carbon pricing is embodied in Article 6 of the Paris Agreement and the Carbon Offsetting and Reduction Scheme for International Aviation. One explanation from the policy sequencing literature for the slow embrace of carbon pricing argues that barriers to it must be directly addressed or remedied before it can take hold and that, where it has done so, it has been preceded by subsidies and regulatory policies that lessened these barriers and created constituencies with economic interests in clean energy (Meckling et al. 2015, 2017; Pahle et al. 2018; Linsenmeier et al. 2022). Some barriers include distributional impacts, technology limitations, entrenched political interests, and missing institutions. The prospect of economic competition from jurisdictions with less stringent emissions reduction policy or regulatory approaches is amplified under carbon pricing because of the pass-through of external costs in product pricing, posing an important obstacle. Consequently, most reductions in greenhouse gas emissions have been achieved from subsidies and regulation rather than emissions pricing (Burtraw and Woerman 2013; Cullenward and Victor 2020). Achieving the substantial reductions that are necessary to meet international climate goals will incur increasing costs and require private investments that are many times greater than what can feasibly be supported by public subsidies.

Mobilizing private investments requires credible government climate pledges (Nemet et al. 2017). Although carbon pricing is likely to be more efficient, it may be viewed as less sustainable than investments in infrastructure and technology because of potential for policy reversals. Once infrastructure investments are in place, they tend to endure; hence, they may have an especially strong influence on expectations about the durability of climate pledges, which are essential to driving private investment (Campiglio et al. 2023). In other words, to mobilize private capital, getting the prices right may be less of a priority than getting expectations right (Dolphin et al. 2023). Nonetheless, as emissions reductions become increasingly expensive, efficient policy design becomes more important to policy success. From this perspective, policies such as subsidies embodied in the IRA and regulations under the Clean Air Act may establish the preconditions for pricing, but carbon pricing may be necessary to realize climate goals and be the culmination of policy development rather than where it begins, as has often been described. We are motivated to investigate the potential role for carbon pricing given the subsidies and regulations that have been put in place.

The next section of this paper reviews recent modeling and related literature about the IRA and characterizes its provisions for clean energy subsidies. We then describe the models used for this analysis and our policy scenarios. We evaluate the scenarios according to their estimated resource costs, electricity price effects, fiscal costs, and distribution of net household financial costs across income groups. We also look at coincident changes in air pollution and premature mortality from fine particulate matter ($PM_{2.5}$) stemming from changes in emissions of sulfur dioxide (SO_2) and nitrogen oxides (NO_X) from power plants. We present a sensitivity analysis and then conclude.

2. Policy Summary

The IRA provides incentives across several sectors, including tax credits for the purchase of electric light and heavy-duty vehicles, clean fuels, hydrogen production, energy efficiency for nonbusiness buildings, and an advanced manufacturing tax credit. It also provides for substantial investments at the state and local levels to address environmental justice concerns. It initiated permitting reform for new energy infrastructure and implemented a fee on methane emissions that exceed industry-set targets across oil and gas facilities—the one modest example of a federal price on greenhouse gas emissions.

We model three additional provisions that are the most important in determining emissions outcomes in the coming decade. The first is providing clean energy production and investment tax credits—facilities can choose which credit to exercise. Both tax credits are technology neutral, available for projects initiated by 2032, and will remain available for new projects until electricity sector emissions fall below 25 percent of 2022 levels.[2] In our model and most of those reviewed by Bistline et al., (2023b) levels below this target are not achieved until late in the next decade, if ever. Given the IRA companion incentives for electrification of transportation and buildings, growth in electricity demand could delay the achievement of the 25 percent threshold, making the credit available throughout most of the following decade. The second provision we model is Section 45Q, the $85 per ton tax credit for carbon capture of at least 75 percent of emissions from electricity-generating units (a value of about $85/MWh for coal units and $40/MWh for gas units). The third provision is the production tax credit of up to $15/MWh for existing nuclear power plants, which complements the Civil Nuclear Credit production tax credit under the Infrastructure Investment and Jobs Act for plants operating in competitive markets and projected to close for economic reasons.

Bistline et al. (2023b) compare nine independent models to estimate the expected IRA emissions and energy impacts, including earlier analysis (Roy et al. 2022) with the Haiku model, the same model that we use for this paper. The nine models incorporate a range of IRA provisions and input assumptions and model structures. The comparison finds economywide emissions reductions under the IRA are 33–40 percent below 2005 levels in 2030, with 37 percent as an average, growing to 43–48 percent by 2035. This is a reduction from modeled reference case emissions of 25–31 percent below 2005 in 2030 in the absence of the IRA (28 percent average). Hence, the models find generally that the IRA reduces the economywide implementation gap to achieve the US climate pledge for 2030 by about 50 percent. The wide range of outcomes in the models illustrates the uncertainty implicit in using production incentives for clean energy regarding the ultimate emissions reductions that are achieved and helps motivate our interest in the opportunity for carbon pricing, and an emissions cap in particular, to close the gap relative to the 2030 goal.

The electricity sector plays the most prominent role in the modeling reviewed by Bistline et al. (2023b), achieving 38–80 percent of the economywide emissions reductions from the reference case in 2030 (64 percent average) across the set of models. The projected electricity sector emissions in 2030 are 47–83 percent below 2005 levels (68 percent average), compared to 41–60 percent in the reference case (51 percent average). Our results are close to these averages, with our central case IRA representation achieving 63 percent reductions below 2005 levels, compared to a reference case of 56 percent.

2 Electricity sector emissions were 1,539 million metric tons of carbon dioxide (CO_2) in 2022. The production tax credits for renewable energy will not phase out until emissions fall to 25 percent of this level, or 385 million metric tons. For context, emissions were 2,280 million metric tons in 2005.

3. Methods

We use a series of simulation models to analyze the various impacts of the IRA and additional policies on the electricity sector, including effects on emissions of carbon dioxide (CO_2), SO_2 and NO_X, resource costs in the sector, and electricity prices. The financial outputs from the electricity sector modeling are imported into RFF's microsimulation incidence model to estimate the change in household expenditures and revenues resulting from changes in electricity prices and tax burdens. Emissions changes are mapped to a reduced complexity atmospheric transport and health effects model to estimate changes in premature mortality from changes in air pollution.

3.1. The Model Framework

The Haiku electricity market model solves for additions to electricity-generating capacity and future system operations at the state level with the goal of minimizing system cost to meet projected demand with a capacity reserve margin. The model reflects demand and supply within the 48 contiguous states and DC. It includes interstate transmission capabilities, a 25-year horizon, and planned capacity costs and performance characteristics of existing capacity from the S&P Global database. Cost and performance characteristics for new renewable technologies and carbon capture and storage are from the 2022 National Renewable Energy Laboratory's Annual Technologies Baseline "Reference" Scenario, and other technologies are from the *Annual Energy Outlook 2021* (EIA 2021). Fuel costs and electricity demand are also from the *Annual Energy Outlook 2021*, with natural gas prices adjusted, as described later. Assumptions about high electricity demand are based on the National Renewable Energy Laboratory's *Electrification Futures Study* (NREL 2018) and explored in a sensitivity analysis. Electricity demand is categorized into 24 distinct time blocks for each year (three seasons, with four load levels for two times of day: daytime and nighttime). Each state is characterized as participating either in an organized wholesale market or being subject to cost-of-service regulation.

Our modeling of IRA policies in the electricity sector could be characterized as an optimistic implementation because investments are driven by economic factors assuming only modest siting constraints on new facilities and a phase-in of substantial use of the bonus credits. On the other hand, we do not model transmission expansion and grid modernization, which are elements of a clean energy transformation in the electricity sector.

We updated the fuel forecasts to account for recent major changes in natural gas markets. We look to the natural gas futures market to observe that, after the recent spike in fuel prices (approximately 2 times the forecast price), prices from Henry Hub Natural Gas Futures Quotes—CME Group settle approximately 25 percent higher than the *Annual Energy Outlook 2021* reference case in the long term. To adjust our natural gas prices, we set the price in 2022 to twice the level of reference case (for all cases), then have it decline linearly to adjusted long-term projections by 2026. Our new long-term reference case is the average of the *Annual Energy Outlook 2021* reference and low-supply scenarios. In a sensitivity analysis, we explore alternative gas prices.

We use RFF's Social Welfare Incidence Model to estimate the financial impacts of changes in expenditures and taxes for households distinguished by household specific expenditure patterns and levels and sources of income. The model combines information from the Consumer Expenditure Survey, American Communities Survey, Congressional Budget Office, National Income and Products Account, and State Energy Demand System. Changes in residential electricity expenditures resulting from the policy are distributed to households proportional to their share of electricity expenditure. Changes in nonresidential electricity expenditures are distributed to households proportional to their share of spending on other goods and services. The model assumes a balanced budget constraint for government, meaning that any change in government spending requires a corresponding change in revenue. To pay for the clean energy tax subsidies, the IRA includes enhanced enforcement of corporate tax payments; following assumptions of the Joint Committee on Taxation (2013), we assume 25 percent of these increases fall on labor income and 75 percent on owners of capital, which are disproportionately higher-income households. We assume roughly 11 percent of US equity is foreign owned and excluded from the incidence calculations (Department of the Treasury, Federal Reserve Bank of New York, and the Board of Governors of the Federal Reserve System 2021, p. 105).[3] For the carbon price revenue, the same balanced budget constraint is assumed, so revenues are distributed proportional to capital taxes. Impacts on the profits of electricity producers (mostly negative due to lower prices and higher resource costs) are distributed proportionally to capital income.

Greenhouse gas changes in the electricity sector are associated with changes in SO_2 and NO_X, which we estimate at the state level in the Haiku model. Emissions changes were aggregated to the census division level then downscaled to the county level using the National Emissions Inventory. Changes in concentrations of $PM_{2.5}$ and associated health outcomes are estimated at the county level using the Estimating Air Pollution Social Impact Using Regression (EASIUR) atmospheric transport model—a reduced complexity model of air quality changes and premature mortality built by Heo and colleagues (2016, 2017). $PM_{2.5}$ is the primary atmospheric pollutant affecting premature mortality, which is the main health outcome of consequence. Estimates of the changes in health outcomes are based on changes in premature mortality using Krewski et al. (2009) and valued at $17 million per premature death in 2030.[4, 5]

3 The foreign-owned share of equity in US companies has nearly doubled since 2006. We use 10.8 percent, which corresponds to 2010. In 2021, it increased to 15.1 percent.

4 EASIUR's default value of statistical life is $8.6 million in 2010$. EPA's *Guidelines for Preparing Economic Analysis* recommends that it grow with income, using an income elasticity of 0.4, 0.8, or 1. We choose an elasticity of 1 to adjust the value for 2030. Per capita income growth in 2030 comes from CBO's *2022 Long-Term Budget Outlook*, which projects a 1.5 percent annual GDP per capita growth rate between 2022 and 2030.

5 EASIUR follows most of the epidemiology literature by applying a uniform exposure-response coefficient across the population. Spiller et al. (2021) demonstrate meaningful differences in health outcomes across racial and ethnic groups.

3.2. Scenarios

We consider several policy scenarios, each of which is described next. All of these scenarios are compared to a **Baseline** scenario that reflects projections of electricity supply in the absence of the IRA. All scenarios, including the baseline, incorporate regional representations of state level Renewable Portfolio Standards and state and regional cap-and-trade policies facing electricity generators, including those in California and the Regional Greenhouse Gas Initiative regions.

3.2.1. IRA

The representation of the **IRA** scenario in our modeling focuses on the tax credit provisions that seek to promote renewable and other carbon-free (or very-low-carbon) sources of electricity production. Chief among these is the long-term extension and reformulation of the production tax credit (PTC) and investment tax credit (ITC) to apply to solar and wind but also extend to energy storage and a potentially broader range of new nonemitting generators beginning in 2025. Both the ITC and PTC have base credit levels with additional bonuses that apply for projects that meet specific labor standards, are built in areas defined as "energy communities," and use domestic content. Taken together, these bonus provisions will increase the 30 percent ITC up to 50 percent and the $25/MWh PTC up to $30/MWh. We draw from Raimi and Pesek (2022) to locate energy communities in each state and apply a partial credit based on the percentage of land in each state in that category to adjust the PTC and ITC rates in each state.[6] For the domestic content bonus, we assume that 20 percent of it applies in 2026 and that the effect on crediting rates increases linearly to the full amount by 2030.

Among technologies eligible for tax credits, we represent endogenous economic investments in offshore and onshore wind, solar, and battery storage. Our modeling reflects the provisions of the IRA and Infrastructure Investment and Jobs Act that support nuclear generators by assuming the subsidies successfully maintain the level of nuclear generation achieved in the baseline throughout the projection horizon. PTC for existing nuclear in the proposed legislation is not represented explicitly, and we do not represent associated government expenditures. Consequently, no direct wholesale price benefits from nuclear PTC are accounted for here. We also incorporate the (Section 45Q) tax credit of $85 per ton for new fossil generators that capture at least 75 percent of the carbon emissions from the facility. This credit translates to an $85/MWh tax credit for coal-fired generators equipped with carbon capture and storage and a $40/MWh credit for gas-fired generators. We do not incorporate the option for carbon capture and storage (CCS) retrofits of existing plants, which could lead to an underestimate of the amount of CCS that is built.

6 In April 2023, the Department of Treasury and Internal Revenue Service finalized guidance about how clean energy projects located in energy communities can claim bonus credits, which would lead to a somewhat different geographic distribution of renewables than we obtain in this analysis.

For comparison purposes, we also develop an emissions cap scenario labeled **Cap mimic IRA** that yields the same electricity sector CO_2 emissions outcomes in each year as the IRA but uses carbon pricing in the electricity sector, which the model implements as a cap-and-trade approach.[7] In this and all other cap-and-trade scenarios, we assume that the program includes a revenue-raising auction and emissions allowances are not bankable, making it analytically equivalent to a carbon tax.[8]

3.2.2. 80x30 Scenarios

We consider two pathways for achieving 80 percent emissions reductions by 2030 in the electricity sector (80x30). The **IRA+80x30 Cap** scenario includes the IRA and adds an emissions cap with a straight-line trajectory that brings the sector to the 80 percent below 2005 emissions target of 484 million tons by 2030. In addition, we consider an **80x30 Cap** scenario that imposes a cap-and-trade approach in the absence of the IRA tax incentives, which enables us to compare the contribution of the IRA to achieving the 80x30 goal to the outcome if we were to do so with carbon pricing only.

3.3. Sensitivities

The impacts of the IRA on emissions and on the costs of achieving the 80x30 emissions target depend importantly on underlying factors affecting the electricity sector, including the future price trajectory for natural gas and the impact of other policies. For natural gas, in our central cases, we use reference case fuel prices from the AEO 2021, with adjustments to represent the 2022 spike in gas prices and prices falling back to expected long-term levels by 2026. In sensitivity analysis, we use gas prices from the AEO's low and high oil and gas supply scenarios, increased by the same amount as our reference case to match near-term projections.[9]

The emissions impact of the IRA also depends on other policies that may shape the electricity sector. Electrification policies, including financial support for electric vehicles and residential building electrification, could substantially raise the level of demand. We design a high-demand sensitivity to address this possibility that takes the difference in demand between the high-electrification scenario and the reference scenario from NREL's Electrification Futures Study (NREL 2018) and applies it to the Annual Energy Outlook 2021 reference case demand projections, which are used in our central case assumptions. We assume seasonal time profiles of demand remain the same. Environmental regulations can also impact the electricity sector. We

7 We maintain the parametric representation of electricity demand taken from *Annual Energy Outlook 2021* and vary that in sensitivity analysis.

8 Emissions trading would typically permit banking allowances, which would lower cumulative compliance costs compared to a tax but leave the outcome in 2030 uncertain.

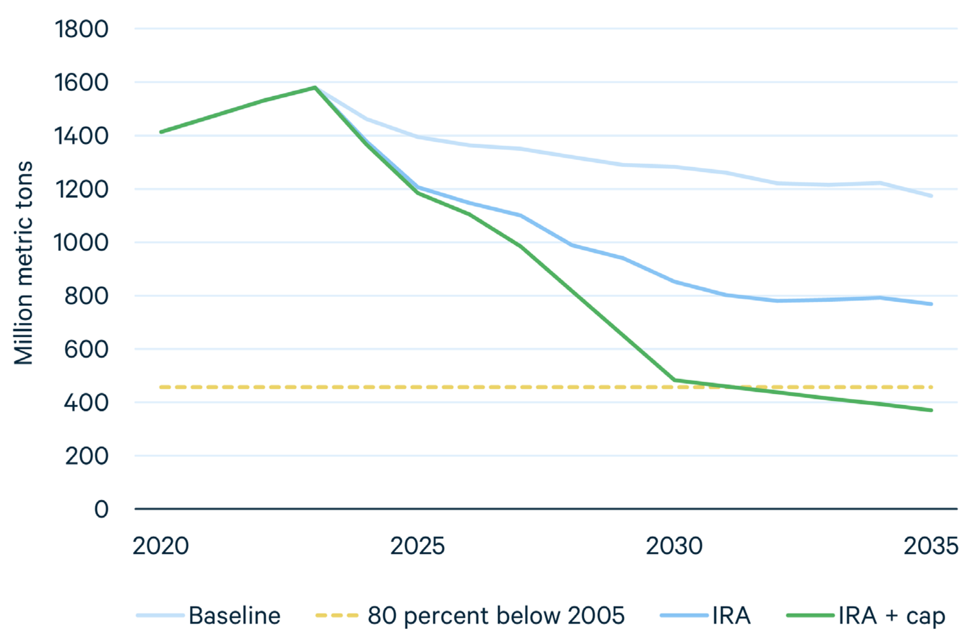
9 For more information on the methodology for projecting natural gas prices, see the appendix in Roy et al. (2022).

designed a sensitivity around EPA's proposed greenhouse gas standards (EPA 2023a) by modeling a natural gas cofiring requirement for existing coal-fired generators (Domeshek and Burtraw 2021), which is one of the technology options included in EPA's draft regulations.[10]

4. Results

Our modeling results indicate that the IRA supports a substantial reduction in carbon emissions from the electricity sector, from 1,283 to 852 million tons in 2030, but falls shy of the 484 million tons that represents 80 percent reductions from 2005 emissions, which, for the electricity sector in the contiguous United States, was about 2,280 million metric tons. Imposing a cap to bring the sector to the 80x30 goal achieves 368 million metric tons additional reductions in 2030. Figure 1 shows that emissions would be expected to fall even in the absence of the IRA and the acceleration of these emission reductions achieved by the IRA. Cumulative reductions between 2020 and 2030 are 1,847 million tons below baseline. Coupling the IRA with an 80x30 cap yields cumulative reductions of 2,872 below the baseline, or 1,025 million tons greater compared to the IRA alone.

Figure 1. Electricity Sector Carbon Emissions



10 Our modeling treatment of a cofiring standard assumes that implementation begins right away (in 2024), whereas EPA's proposal assumes that it takes effect in 2030.

4.1. Generation and Capacity

Getting to the 2030 emissions outcomes associated with these scenarios requires substantial changes in capacity and generation mixes beyond the changes anticipated in the baseline. Table 1 reports capacity changes between 2020 and 2030 under each policy scenario. The IRA leads to more renewable capacity and less coal and gas capacity, with no new natural gas capacity built beyond the already planned additions described in the S&P Global database. The IRA is expected to spark 178 GW of additional new solar capacity and 104 GW of additional new onshore and offshore wind by 2030 relative to baseline. Although 48 percent of the incremental renewable capacity built between 2023 and 2030 in the IRA scenario is also built in the baseline, the IRA pulls forward in time those capacity additions, contributing to greater cumulative emissions reductions. Gas generating capacity falls by 21 GW relative to 2020 levels and 30 GW relative to baseline; coal capacity falls by 67 GW relative to 2020 levels and by 25 GW relative to baseline under the IRA.

Table 1. Capacity Change 2020–2030

Capacity change 2020–2030 (GW)	Baseline	IRA	Cap mimic IRA	IRA + 80x30	80x30
Solar	198	375	268	452	378
Wind	160	264	228	315	331
Natural gas	8	-21	2	-21	-3
Natural gas (with CCS)	0	0	0	0	0
Coal	-42	-68	-66	-134	-144
Coal (with CCS)	0	0.8	0.0	0.1	0.0
Storage	19	19	19	23	19

Note: Values in the table are rounded, so relative differences may not match the text.

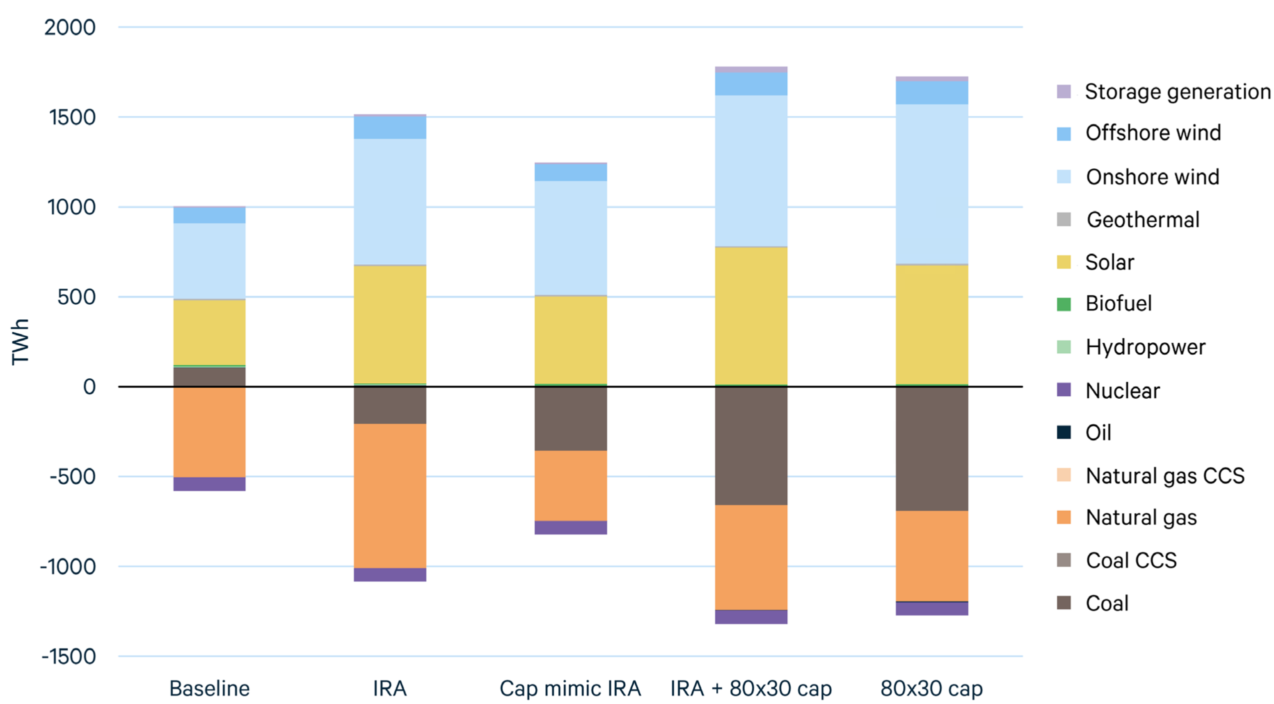
Meeting the 80x30 goal with an emissions cap in addition to the IRA leads to additional investment in wind and solar and a bigger decrease in coal capacity but no further change in natural gas capacity because the carbon price promotes a generation shift from coal to gas.

The policy scenarios that rely exclusively on a carbon price achieve the emissions outcomes with fewer clean energy capacity additions and natural gas retirements than scenarios that include the IRA. In achieving the 80x30 goal, carbon pricing alone leads to the greatest coal retirement and achieves the emissions reductions in 2030 more cost-effectively. Carbon pricing leaves a capacity infrastructure that overall is more heavily fossil fuel based, due to surviving natural gas capacity. In contrast, the greater additional renewables infrastructure built under the IRA may put the United States in a better position to meet longer-term goals.

Figure 2 displays the change in the generation mix in 2030 relative to 2020. The scenarios that include the IRA have more coal generation, yielding fewer air quality benefits than in scenarios that achieve the emissions targets exclusively through cap and trade.

About 868 TWh of growth in renewable generation is expected even in the no-policy baseline compared to 2020. The IRA stimulates 609 TWh of additional renewable generation compared to the baseline in 2030. The generous IRA tax subsidies for new clean generation do not discriminate between new renewables that are incremental to the baseline and those that would have been built anyway (in the baseline) and are therefore likely to yield inframarginal rents that we estimate at about $98 billion in "anyway" subsidies for 2023–2030—although the renewable capacity built under the IRA would likely be of different types in different locations.

Figure 2. Change in the Generation Mix in 2030 Relative to 2020



4.2. Benefits and Costs

We consider several perspectives on the cost and benefits of the policies that we study:

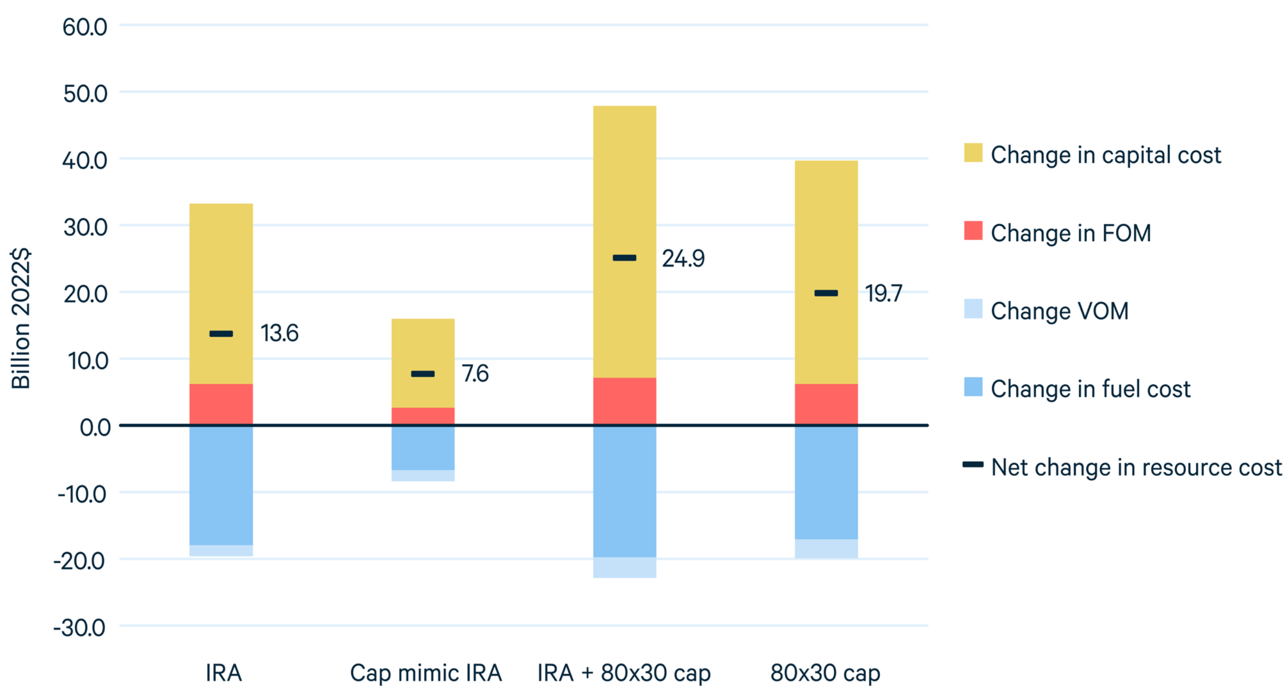
- **Resource costs** include (fuel cost) + (variable operations and maintenance costs) + (fixed operations and maintenance costs) + (annualized capital costs).
- **Cost-effectiveness** is defined as the change in resource costs per ton of emissions reduction.
- **Ratepayer costs** are calculated as the product of the (retail price of electricity) and (electricity consumption).
- **Fiscal costs** describe the net costs to government of the (PTC costs) + (ITC payments) + (the cost of credits for carbon capture) – (revenue from carbon allowance sales in state and regional programs).
- **Social costs (benefits)** include the (change in resource costs) – (health benefits from air quality changes) – (climate benefits). Health and climate benefits are an order of magnitude greater than the change in resource costs.
- **Net household financial impacts** include (direct household ratepayer costs) + (indirect electricity expenditures through the purchase of goods and services) + (generator profits) + (fiscal costs, i.e., net government expenditures). We examine household impacts across income groups.

Each of these measures of costs and benefits is described below. For the total cost measures, we only make comparisons across scenarios that assume the same level of electricity demand.

4.2.1. Resource Costs

The additional annualized resource costs of meeting the 80x30 emissions targets are modest relative to the IRA alone. The primary way we evaluate the cost of the IRA is the change in cumulative resource costs compared to the no-policy baseline.[11] Figure 3 shows the resource cost for each of the policy options segmented by component, driven largely by capital investments associated with renewable electricity generation. Because each scenario induces a shift away from fossil fuels, each conveys fuel costs savings and an associated reduction in variable operation and maintenance cost. Each also includes an increase in fixed operations and maintenance costs associated with greater capital investment. One finding that stands out is that using a carbon price to achieve either the IRA or 80x30 target has a lower resource cost than when the IRA is factored in, which drives additional investments in renewable technologies. Moreover, shifting toward renewables pushes resource costs to be more capital intensive and less fuel intensive. The policies that include the IRA result in higher capital costs and greater avoided fuel costs and greater total resource costs in 2030.

Figure 3. Resource Costs in 2030



11 We do not add an estimate of the government cost of funds to resource cost estimate. The excess burden associated with the corporate income tax is among the greatest of any tax (Hafstead and Goulder 2017). However, Auerbach and Hines (2002) point out that if the product price exceeds its marginal cost, "there is deadweight loss in the absence of taxation," so in a simple partial-equilibrium setting, "tax policies that stimulate additional output reduce deadweight loss" (p. 1392). As we note, the price of electricity exceeds its marginal social cost in many parts of the country, especially where generation is relatively low emitting, and investments under the IRA reduce prices, helping to reduce deadweight loss in the sector.

4.2.2. Cost-Effectiveness

Carbon pricing (emissions cap and trade) achieves emissions reductions more cost-effectively than the IRA. We evaluate cost-effectiveness as the change in resource costs per ton of emissions reduction. The IRA achieves reductions at an average cost of $32 per ton, in contrast to carbon pricing, which achieves the same level at an average cost of $18 per ton (Appendix Table 1).

The average cost of achieving the 80x30 emissions outcome is $31/ton under the IRA combined with carbon pricing. One reason the average resource cost is lower for this higher level of reductions is that the carbon price contribution to achieving incremental reductions brings down the average cost. Second, IRA payments to renewable generators that do not drive emissions reductions at the margin are captured under the IRA scenario already. The average cost of the carbon price without the IRA increases with the stringency of the emissions target, rising from $18 in the cap mimic IRA scenario to $25/ton in the 80x30 carbon pricing scenario (Appendix Table 1).

Carbon pricing is expected to achieve emissions reductions at less cost than the IRA. We estimate a $12 per ton (marginal) carbon price would be necessary to achieve the IRA level for the electricity sector if the IRA were not in place; Bistline et al. (2023a) also find that a $12 per ton carbon price in 2030 yields IRA emissions levels in the electricity sector.[12]

Although the IRA appears costly relative to carbon pricing, it has an important legacy effect in lowering the incremental cost of achieving additional emissions reductions. To observe this, we exercise the model to estimate the emissions price that would be necessary to achieve the 80x30 goal for the electricity sector. We compare two policy formulations: a cap combined with the IRA and a cap by itself. The necessary carbon price with the IRA would be about $28 per ton, which is a 58 percent reduction from the $67 per ton estimate of the necessary carbon price without it. The incremental annual resource cost in 2030 of achieving 80x30 with the IRA is $11.3 billion, compared to $19.7 billion without it. Although the resource mix that results at the IRA level of emissions varied considerably under the IRA versus the carbon price in achieving the 80x30 emissions target, we observe a proximate alignment of generation resources between the two relevant scenarios, including a substantial and comparable reduction in coal generation (Figure 2). The IRA+80x30 Cap scenario has a modestly greater level of renewable generation than carbon pricing without the IRA, due to the subsidies for clean electricity, and it has less gas, with slightly more coal generation.

12 For both the Cap mimic IRA scenario and the IRA + 80x30 Cap scenario, the marginal price of emissions reductions (allowance price) is lower than the average cost in 2030, which is contrary to expectations of what will occur in a system with increasing marginal costs. In the IRA + 80x30 scenario, this is not surprising, given that the IRA leads to up-front investments that lower long-term costs. The Cap mimic IRA case might seem surprising because a simple cap might be expected to have increasing marginal costs. However, the cap in that scenario is designed to mimic the IRA emissions pathway, so it is imposed annually (rather than with banking, which would require intertemporal consistency), meaning no guarantee that the investment choices made in early years will yield a lower average cost than the marginal cost of reductions in later years.

4.2.3. Retail Electricity Price

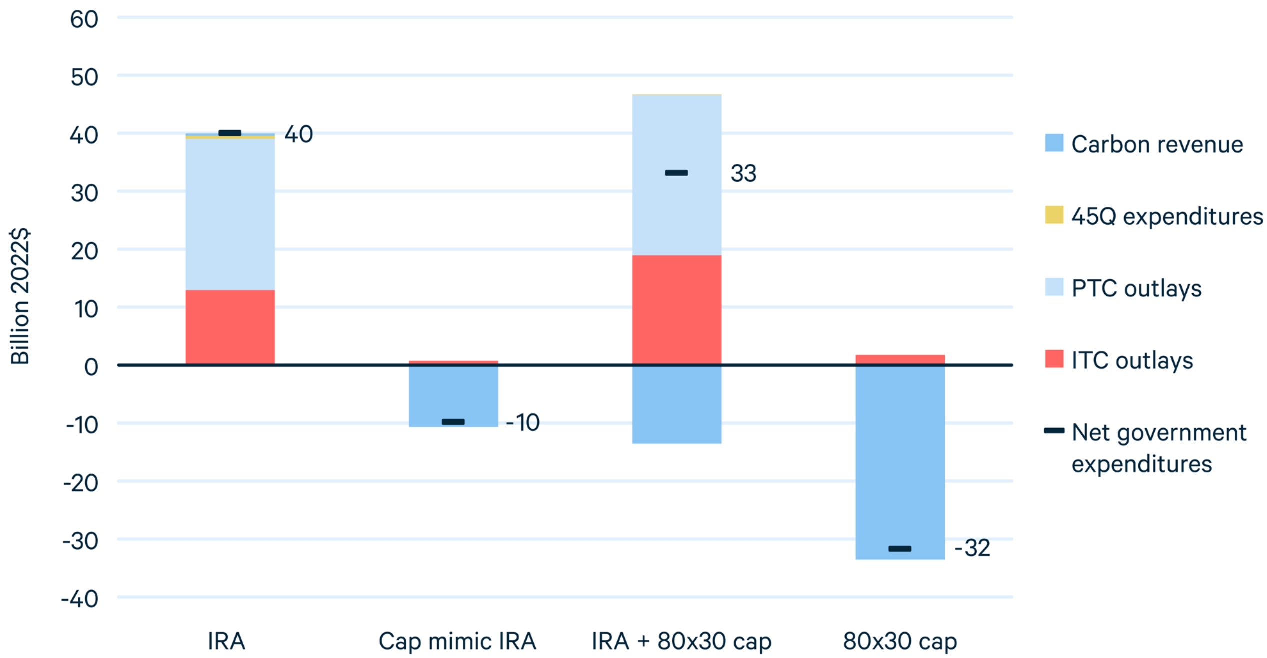
Policies that rely exclusively on a cap-and-trade approach result in higher prices to consumers than those that include the IRA. The retail electricity price remains 3.4 percent below baseline levels when the IRA is coupled with carbon pricing to achieve 80x30 goals. Policy scenarios that include the IRA tend to lower retail prices; scenarios that use only carbon pricing tend to raise them. In the absence of policy, the average retail price in 2030 is $117/MWh (2022$), about equal to the 2020 price level of $118. Including the IRA introduces an important downward shift in retail prices as the resource costs of clean generation that would have been born by electricity ratepayers under the baseline scenario are shifted to taxpayers. The IRA leads to an 8.5 percent decline in the retail price from 2020 prices. Achieving the 80x30 target without the IRA results in an 11 percent increase in the electricity price relative to 2020 levels.[13] However, as noted, when the IRA is coupled with carbon pricing, electricity prices remain below baseline levels.

4.2.4. Fiscal Costs

The fiscal costs for government are not the same thing as resource costs, with the difference constituting essentially transfers within the economy. Nonetheless, fiscal constraints affect government's ability to enact policy. In 2030, the IRA has $50 billion in greater fiscal costs than would a carbon price calibrated to the same emissions outcome. Using carbon pricing to achieve additional reductions would reduce fiscal costs. The different policy approaches have very different fiscal impacts. We estimate that the government incurs $40 billion in fiscal costs in 2030 due to the IRA. For scenarios with carbon pricing, we assume that the allowances created by the program under the emissions cap are auctioned by the government, yielding revenues. Under the carbon pricing only scenarios, there is a slight change in outlays for tax credits due to the scheduled phase-out of the prior ITC policy (pre-IRA) and a slight change in revenues from state and regional carbon pricing (not shown). The carbon price (cap) that mimics IRA emissions outcomes raises $10.7 billion in revenues for the federal government in 2030, resulting in a net fiscal benefit (negative cost) of $10 billion. The incremental fiscal costs of moving from the IRA alone to the IRA plus a cap-and-trade policy to achieve the 80x30 targets raises federal revenues in 2030 of 13.6 billion and drives additional uptake of the renewable energy tax credits, resulting in net federal fiscal costs of $33 billion. A cap to achieve 80x30 emissions targets without the IRA raises $33.6 billion in federal revenues and $32 billion in net revenues (Figure 4).

13 Changes in retail price reflect only changes in generation costs—other cost changes related to transmission and distribution upgrades for electrification are not included.

Figure 4. Fiscal Costs by Category



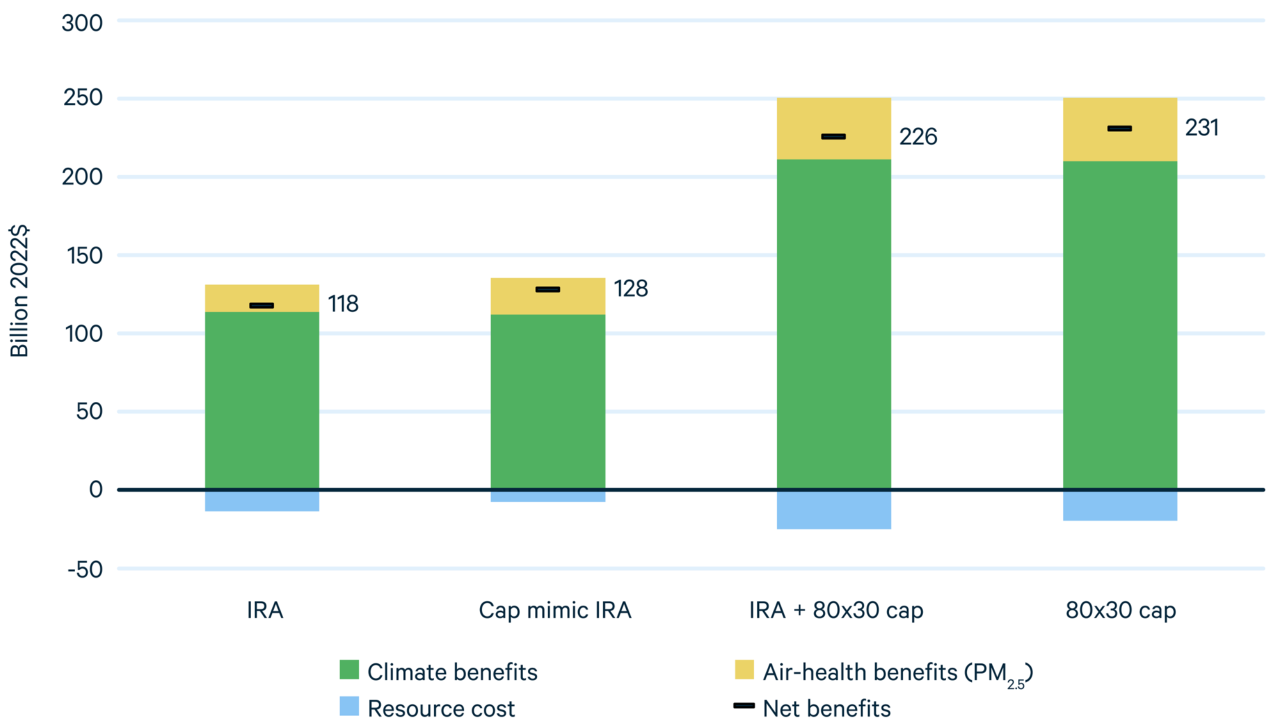
Estimated cumulative fiscal costs reported in several studies since the passage of the IRA vary widely. The initial scoring of the bill from the Congressional Budget Office (CBO 2022) in September 2022 estimated the cumulative costs of power sector provisions to be $142 billion by 2030. In April 2023, CBO (2023) released an updated scoring for the savings of repealing the IRA clean energy tax credits under the Limit, Save, Grow Act at $414 billion by 2030, more than doubling its original estimate. Bistline et al. (2023a) estimated the fiscal impact of power provisions to be $321 billion by 2031 using the US-REGEN model. Bistline et al. (2023b) reviewed eight models (including US-REGEN and the model used in this paper) and reported estimates of fiscal costs of $80–407 billion by 2030.

Considering fiscal impacts after 2030 leads to an even broader range of estimates across studies. CBO's April 2023 estimate ends at $570 billion by 2033. The lowest estimate in Bistline et al. (2023b) projects $235 billion by 2035, with the highest estimate reaching nearly a trillion dollars in power sector provision spending by 2035. Bistline et al. (2023a) estimate that $780 billion will be spent by 2040. These differences can be largely attributed to different CCS technology availability, long-term electricity demand impacts of the IRA, and other assumptions in models that determine the usage of the tax credits. Our estimates of the cumulative IRA electricity sector subsidies are $199 and $386 billion through 2030 and 2035, respectively. Adding an emissions trading program to the US climate policy suite would raise revenue that could cover part of these fiscal costs but also lead to greater uptake of IRA tax credits, eroding some of that revenue. The investments from the IRA are far greater than the revenue raised by the emissions trading we represent.

4.2.5. Social Costs (Benefits)

Each policy yields climate- and air-related health benefits that substantially outweigh its resource costs. Like Denholm et al. (2022) we find that the health benefits alone across all the scenarios greatly exceed the resource costs (Figure 5). For a given level of carbon emissions, net social benefits are slightly higher for carbon pricing than IRA scenarios due to slightly lower resource costs and greater reductions in emissions of SO_2 and NO_x from greater reductions in coal generation. However, this difference is small compared to the total climate and health benefits at a given level of emissions reductions. And, as we move from IRA-level emissions to the 80x30 target, changes in resource costs are far smaller than the additional climate and health benefits.

Figure 5. Net Social Costs and Benefits



4.2.6. Net Household Financial Impacts

The IRA's progressivity is preserved when it is coupled with carbon pricing to achieve the 80x30 emissions cap. The financial effects on households involve changes in expenditures on electricity and goods and services to which electricity is an input, the effects on generator profits, and the changes in tax burdens. Reduced electricity prices are particularly beneficial to low-income households because electricity requires a larger percentage of their income, and other financial effects (mostly negative) impact them less.

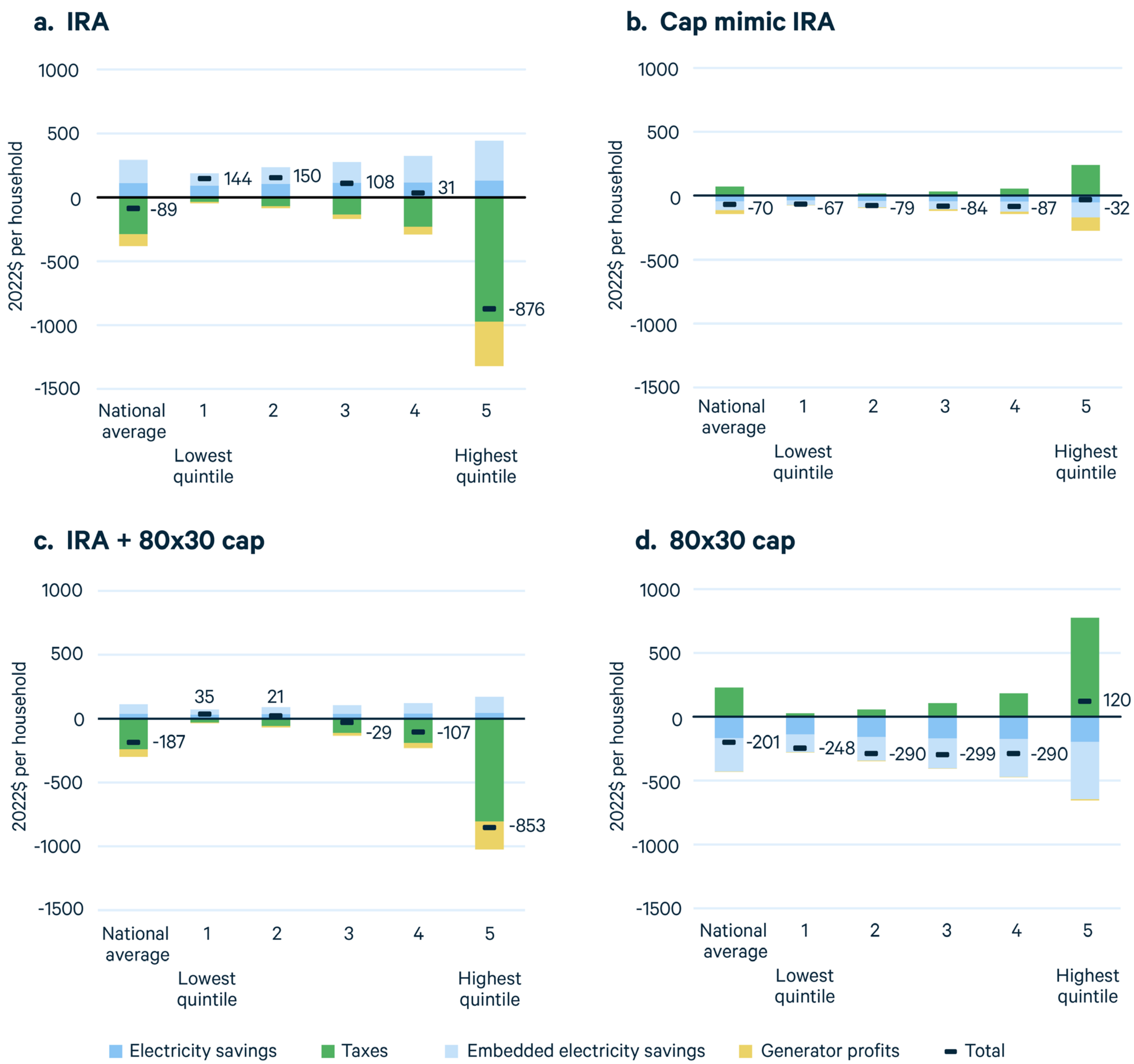
The Social Welfare Incidence Model distributes changes in expenditures on residential electricity consumption proportional to current household electricity expenditures. Because this consumption constitutes roughly 38–40 percent of the national total, we assume that changes in electricity expenditures elsewhere in the economy flow through to households as changes in the price of goods and services and accrue in proportion to all other household expenditures. Electricity consumption and expenditure grows with income, so the higher a household's income, the more it spends on electricity. As a share of household income, however, the pattern is reversed: the lowest-income households spend the greatest share on electricity. Consequently, the effect of shifting a portion of the cost of new sources of clean energy from ratepayers to taxpayers varies substantially across the distribution of household income.

The impacts of the four policies analyzed are presented in the four panels of Figure 6, which display net household financial impacts by income quintiles compared to the no-policy baseline in 2030. In each scenario with a cap-and-trade policy, we assume that the revenues from the auction of CO_2 emissions allowances offsets potential subsidy costs, and positive net revenue under the carbon price scenario is returned proportionately to owners of capital according to the average tax rate in each quintile.

The IRA's progressivity is illustrated in the top left panel. That progressivity is preserved when it is coupled with the 80x30 emissions cap (bottom left panel). In contrast, when considered independent of the IRA, our representation of the carbon price is regressive, as illustrated in the two right panels.

The cost shift from ratepayers to taxpayers is not only progressive but also likely to be efficient. Borenstein and Bushnell (2022) illustrate that all energy sources are mispriced from an efficiency perspective due to the unpriced pollution they emit. Despite that failure to price pollution, the incorporation of other types of program costs into electricity rates means that residential consumers face prices that are above social marginal costs in many areas of the country, which is greater the greater the value of the social cost of carbon. For example, in California, households pay retail prices that are 2–3 times the incremental social cost of generation, making electrification less attractive to consumers and implementing a regressive recovery of electricity system costs (Borenstein et al. 2022). Price reduction may improve efficiency and will accelerate the electrification of other parts of the economy, with associated climate benefits, while improving distributional outcomes.

Figure 6. Distribution of Financial Impacts Across Households by Income Group

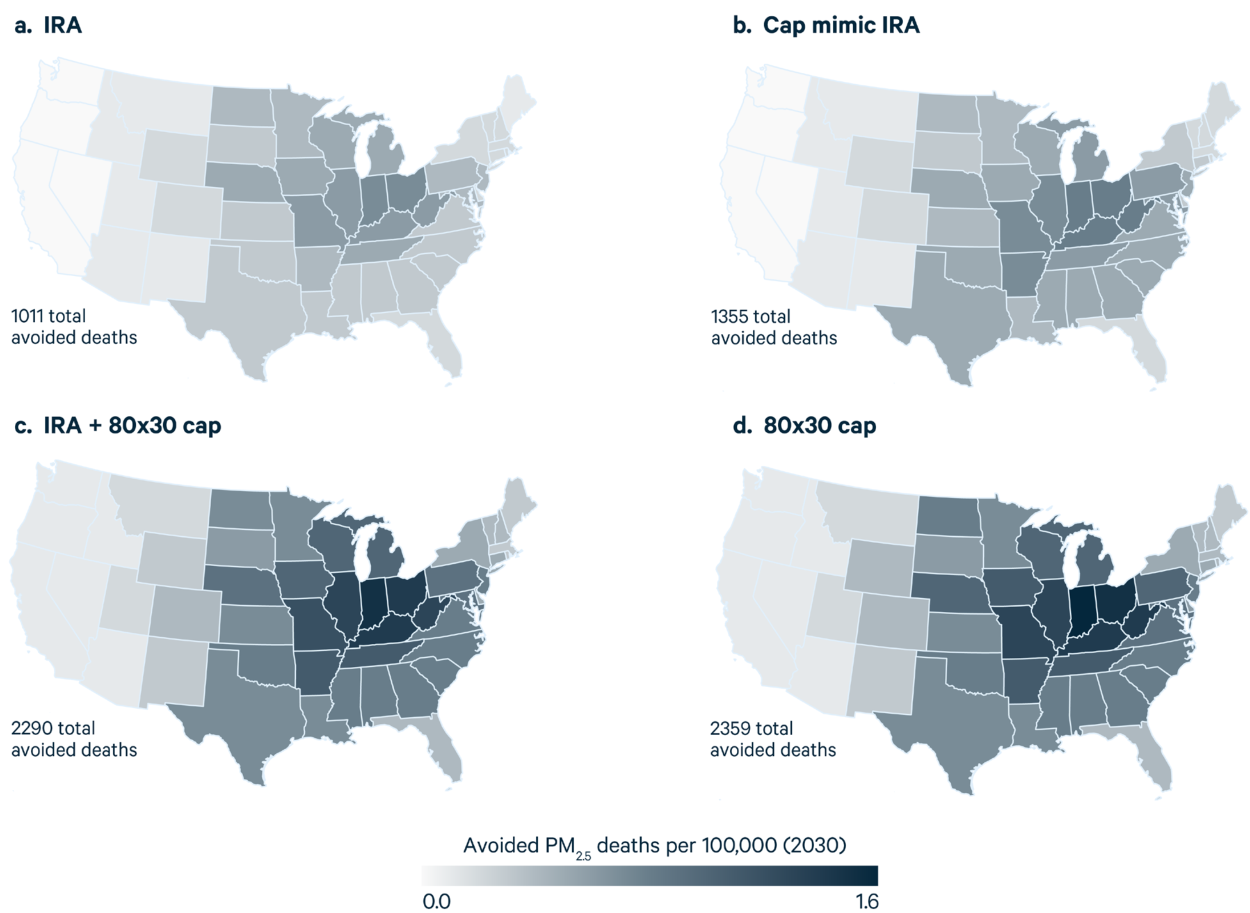


4.3. Air Quality

Greenhouse gas changes in the electricity sector are associated with changes in SO_2 and NO_X, which are evaluated for their effect on concentrations of $PM_{2.5}$, the primary atmospheric pollutant affecting human health. The distribution of air quality impacts of the different policies across the states depends on where existing fossil generators are located and which generators scale back the most. The four panels of Figure 7 show avoided premature deaths in 2030 compared to the no-policy baseline by state and nationally.

The greatest air-quality-related health benefits accrue in the Midwest under each of the policy scenarios. Adding the 80x30 emissions cap to the policy mix significantly increases the public health benefits beyond those achieved under the IRA targets, with greater reductions in greenhouse gases mapping into greater reductions in SO_2 and NO_x emissions and greater improvements in human health. Although more renewable generation occurs under the IRA scenarios, more coal also survives, which lowers the health benefits relative to using carbon pricing to achieve the same carbon emissions target. However, the distinction in air quality with and without IRA is negligible at the 80x30 emissions outcome, as most coal generation is removed from the system.

Figure 7. Mortality Benefits by Location



4.4. Sensitivity Analysis

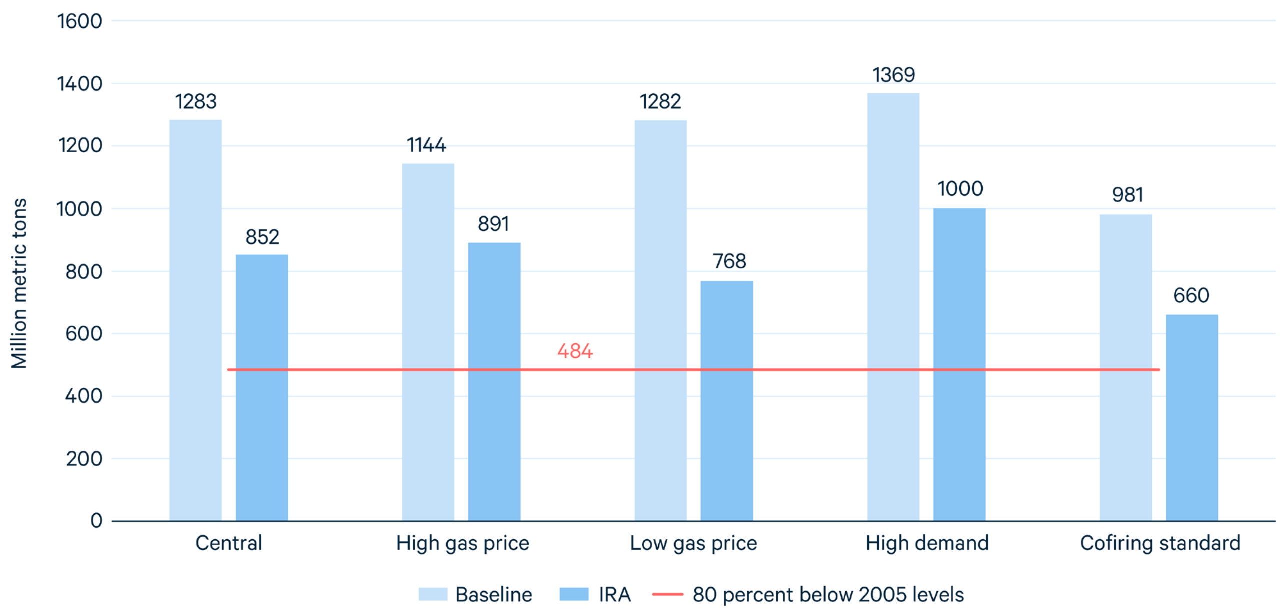
The emissions outcomes under the IRA vary across the different sensitivities that we analyze and thus so does the marginal cost of bringing emissions in line with the 80x30 goal. Figure 8 shows the CO_2 emissions in 2030 for a baseline scenario and the IRA scenario under a set of alternative baseline assumptions. The emissions outcomes vary considerably, but under all these scenarios, the IRA falls short of achieving the target. Both low gas prices and CO_2 emissions regulation with a cofiring standard exhibit lower gaps between IRA emissions and the 484 million metric ton 2030 target. With high gas prices or high demand levels, the gap is bigger, suggesting that more effort will be required under those assumptions to hit the target for the sector.

Under no-policy baseline assumptions, high gas prices lead to less gas generation and greater investment and generation from renewables, yielding a decrease in emissions. However, with the IRA, which substantially expands investment in renewables across all scenarios, the reduction in gas generation due to high gas prices leads to more generation from coal, with some increase in renewables and a net increase in emissions compared to central case gas prices. In the low-gas-price sensitivity, baseline emissions are virtually unchanged from the central case. Under the IRA, the low gas price draws generation away from coal, leading to a decrease in emissions compared to the central case.

The findings of our high-demand scenario suggest that high demand incentivized by the IRA (such as from more EVs on the road) may lead to higher emissions and a bigger gap to the 80x30 target. However, coupling the IRA with a cofiring standard that proxies for greenhouse gas regulations under the Clean Air Act closes the emissions gap between the IRA and the 80 by 30 target by more than half. Note that with the IRA in place, emissions from the cofiring standard that we model fall by about 200 million metric tons in 2030, which is substantially larger than the decline in emissions from electricity-generating units anticipated under EPA's Regulatory Impact Analysis of the emissions standards for existing coal units, which are 83–107 tons in 2030.[14] Other factors could also impact the rate of investment in renewables. For example, Bistline et al. (2023a) point out that continued high interest rates could slow investment in renewables.

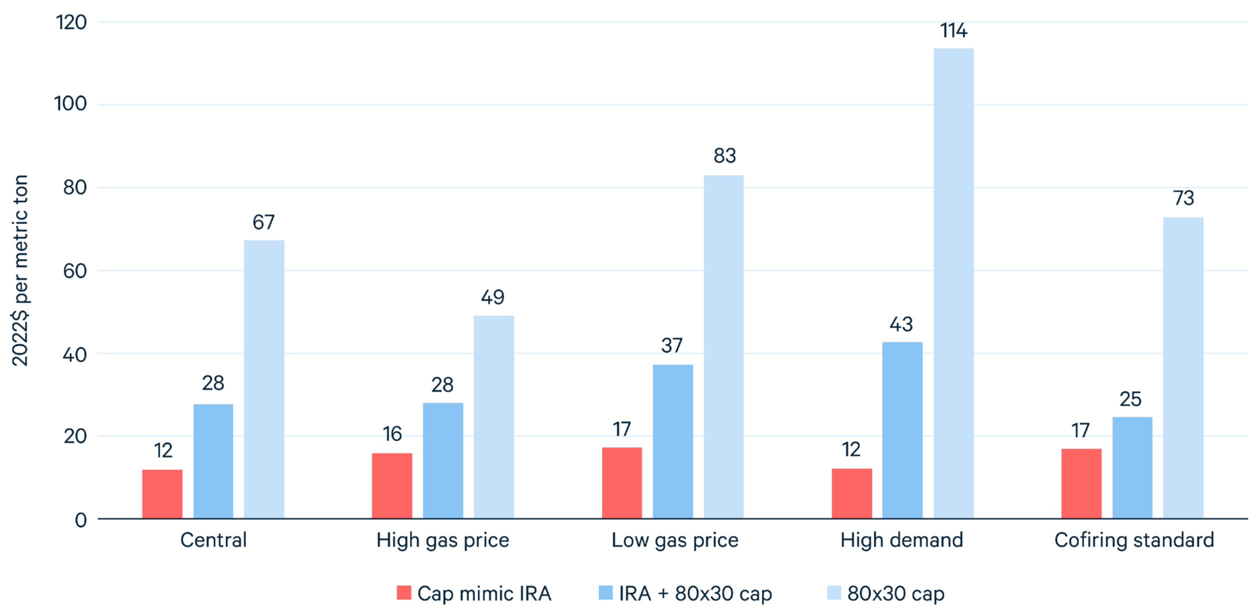
14 EPA (2023, Table ES-1). Our cofiring scenario assumed that to remain online, all coal plants had to cofire with natural gas for 20 percent of heat input by 2024, which is similar to the scenarios analyzed in Domeshek and Burtraw (2021), where such regulations went into effect in 2022. Under EPA's proposal, the cofiring requirement imposes a higher standard (40 percent of heat input) but only applies to generators that plan to retire by 2035 and operate at higher than 20 percent capacity factors. Plants that opt to retire by 2032 face no emissions control requirements, and generators that plan to stay online after 2040 are required to retrofit with carbon capture and storage.

Figure 8. 2030 CO_2 Emissions with and Without the IRA Across Sensitivities



The range of assumptions in sensitivity analysis also leads to a range of allowance prices in the carbon pricing scenarios. Figure 9 shows that including the IRA substantially reduces the allowance price required to hit the 80x30 target under all scenarios, especially in the high-demand case. We include the allowance prices from the higher emissions cap that requires emissions reductions equivalent to the IRA.

Figure 9. Sensitivity of Allowance Prices



In addition to the explicit sensitivities considered, other factors will affect the pace of the transformation of the electricity sector and associated emission reductions. Realizing the rapid increase in renewable generation enabled by the IRA requires large amounts of new generation to be sited, permitted, and built with valid grid interconnection rights, and all of these steps may cause the speed with which new generators are added to deviate from the predicted by the model. Additional policies to enable transmission upgrades or ease interconnection may be needed to unlock the promise of the IRA and reach the 80x30 goal. Actual implementation may vary from what is represented in the model, either because bonus credits are more difficult to access than we assume or state and local laws preclude rapid growth in renewables on the grid, or, conversely, state and governments engage in a race to site facilities to capture the financial value of federal tax credits. Carbon pricing through emissions cap and trade provides certainty over the emissions outcome across sensitivities.

5. Conclusion

Although the IRA promises to bring substantial and meaningful changes to how the US produces electricity in the next decade and beyond, it does not bring the electricity sector to where it needs to be to achieve the 80x30 emissions targets necessary to meet international commitments to fight climate change. Nonetheless, the IRA makes it much easier for the US to reach its nationally determined contribution.

As a policy based solely on generic incentives for clean energy generation without distinguishing its marginal contribution in achieving emissions reductions, the IRA is likely to result in higher economic and fiscal costs relative to carbon pricing that penalizes emissions directly. However, it insulates electricity consumers from increases in retail prices that could accompany carbon pricing or price fluctuations that could result from volatile fossil fuel markets. Furthermore, the tax subsidies in the IRA are funded by increases in taxes on capital income, which tends to make it more progressive than other policy types.

The air quality benefits of the IRA are substantial, but they would be higher under a cap-and-trade approach due to its greater ability to target coal-fired generation than happens with the IRA, which does not distinguish among emitting generators. Combining the IRA with a cap to achieve the 80x30 target would result in roughly 70 percent additional air quality benefits.

One of the main virtues of using a cap-and-trade approach to close the gap between IRA emissions reductions and the target is to provide certainty over emissions outcomes. A cap applied in addition would lock in the projections for reductions under the IRA, providing a signal to the markets and to private investors that the United States is committed to meeting this goal, as it would be formally tied to a specific policy. By lowering the marginal costs of making that commitment, the IRA makes the 80x30 policy a lighter lift for policy makers and firms and others affected by it.

Appendix

Table A1. Overall Inputs

	Baseline	Baseline	IRA	Cap mimic IRA	IRA + 80x30	80x30
	2020			2030		
CO_2 emissions **Change relative to baseline (mmtons)**		-	-430	-424	-799	-794
Cumulative emissions **Change relative to baseline 2020–2030**		-	-1847	-1830	-2872	-2596
			Capacity (GW)			
Total	1147	1480	1703	1588	1767	1715
Wind	125	285	389	353	440	456
Solar	49	247	425	318	501	427
Other nonemitting (nuclear, hydropower, geothermal)	184	174	174	174	174	174
Gas	519	527	498	521	499	516
Coal	200	159	133	135	67	56
Coal with CCS	0.00	0.00	0.78	0.00	0.05	0.00
Other emitting (oil, biofuel, other)	41	40	37	40	35	38
Storage	29	47	47	47	52	48

	Baseline	Baseline	IRA	Cap mimic IRA	IRA + 80x30	80x30
			Generation (TWh)			
Total	3834	4245	4248	4245	4257	4253
Wind	330	838	1154	1059	1296	1344
Solar	90	449	742	575	850	750
Other nonemitting (nuclear, hydropower, geothermal)	1084	1023	1023	1023	1023	1023
Gas	1515	1010	713	1124	932	1011
Coal	770	873	562	414	110	78
Coal with CCS	0	0	5	0	0	0
Other emitting (oil, biofuel, other)	46	53	49	49	49	49
			Emissions (percent of 2005)			
CO_2 (2,282 mmt in 2005)	1414 (62%)	1283 (56%)	852 (37%)	858 (38%)	484 (21%)	488 (21%)
SO_2 (10,063 kmt in 2005)	735 (7%)	889 (9%)	587 (6%)	456 (5%)	155 (2%)	120 (1%)
NO_x (3,694 kmt in 2005)	788 (21%)	793 (21%)	558 (15%)	501 (14%)	313 (8%)	347 (9%)

	Baseline	Baseline	IRA	Cap mimic IRA	IRA + 80x30	80x30
Retail price 2030 [$/MWh]	118	117	108	121	114	131
Retail prices (consumption weighted average 2023–2032) [$/MWh]	-	117	110	120	112	123
Resource costs [billion $]	-	-	13.6	7.6	24.9	19.7
Average resource cost [$/ton]	-	-	32	18	31	25
Marginal cost (allowance price) [$/ton]	-	-	-	12	28	67
Net fiscal cost [billion $]	-	-	40	-10	33	-32
Net social benefits [billion $]			118	128	226	231
Average financial cost per household [$/household]			89	70	187	201
Distributional effect			Progressive	Regressive	Progressive	Regressive

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