LIFE:POWERED

THE SIREN SONG THAT NEVER ENDS: FEDERAL ENERGY SUBSIDIES AND SUPPORT FROM 2010 TO 2023

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KEY POINTS

- **Over the past 14 years**, wind, solar, nuclear, and fossil fuels have all received substantial federal subsidies—between $20 and $80 billion.
- **While wind and solar** have each received more than twice as much as oil and gas, the more important point is that they depend on federal subsidies for a far greater portion of their revenue.
- **Wind has received** 48 times and solar 168 times more subsidies per unit of electricity generated than oil and gas.
- **The Inflation Reduction Act** of 2022 will push federal energy subsidies to hundreds of billions annually, hampering the ability of energy markets to provide Americans with affordable, reliable energy.
- **Studies that show** certain resources receiving far more subsidies than others, especially studies that report hundreds of billions of dollars in U.S. energy subsidies, are relying on cherry-picked data or inflated definitions of subsidies.

EXECUTIVE SUMMARY

For decades, the federal government has attempted to use energy subsidies—primarily tax breaks, direct spending, and research funding—to stimulate energy production and the development of new energy technologies. The idea that the government can create new jobs and guide the growth of industries is a siren song that has entranced politicians of all political stripes and led to subsidies across a wide range of industries, particularly in the energy sector. However, one challenge in the debate about energy subsidies is cataloging what subsidies exist and how large they are. The Energy Information Administration (EIA) has tabulated federal energy subsidies every three years from 2007 to 2016 and annually since 2016 (EIA, 2023), but no analysis to date has produced a comprehensive annual review when complete data is available, as well as a forecast of future subsidy commitments. This paper undertakes this full review i to improve the quality of the national conversation about this important topic.

Applying the EIA's methodology with a few modifications, this analysis finds that cumulative energy subsidies from 2010 to 2023 for solar, wind, oil and gas, and coal were $76 billion, $65 billion, $33 billion, and $20 billion, respectively. Nuclear received about $26 billion, and hydropower and geothermal each received just over $2 billion. While wind and solar have each received more than twice as much as oil and gas, the more important point is how much they depend on federal subsidies for their profitability. Wind has received 48 times more subsidies per unit of electricity generated than oil and gas and solar 168 times more. Compared to coal, wind has received 20 times more subsidies per unit of electricity generated and solar 71 times more.

It is also important to look beyond the dollar values and consider the nature of different energy subsidies and their effects on energy markets. Wind and solar subsidies are primarily focused on the

installation of generation assets using current technologies rather than on new technology development. Conversely, most energy subsidies for nuclear and fossil fuels are focused on research and specific aspects of exploration and development. Wind and solar subsidies—along with a new production tax credit for existing nuclear power plants—have a strong distorting effect on U.S. electricity markets, especially in Texas (McConnell, 2018; Michaels, 2019). Beyond their direct costs, subsidies are causing artificially low or negative wholesale prices, scarcity prices during periods of high demand and low wind and solar generation, inefficient use of existing assets, and increased transmission costs.

Wind and solar are still a small part of the overall energy industry—with wind comprising 3.5% and solar comprising 2% of total U.S. energy production in 2023 (EIA, 2024a, p. 257)—and therefore depend on subsidies far more than other forms of energy production. With the passage of the of the Inflation Reduction Act (H.R. 5376, 2022), wind and solar subsidies are set to substantially increase, along with new subsidies for energy storage, nuclear, and hydrogen production. These subsidies must be rolled back if the U.S. is to keep electricity affordable and reliable and to maintain its dominance across global energy markets.

INTRODUCTION

Like the infamous "Song That Never Ends," energy subsidies rarely go away once they are introduced. The fundamental philosophy behind energy subsidies is that energy markets are somehow biased toward certain resources, too slow to develop new technologies, and unable to account for environmental externalities. Therefore, governments must step in to assist new technologies and direct energy development toward energy resources that are purported to be cleaner and more sustainable than what energy markets are currently providing. As the new businesses or industries become economically viable or the environmental goals of the energy subsidies are achieved, the government support can be removed.

However, experience has shown that this rarely happens. Subsidies create a group of businesses that depend on government support to remain profitable, and new entrants to the industry, even if their cost base is lower than existing businesses, must also be subsidized to compete with the subsidized businesses. Thus, businesses in a subsidized industry become very effective at lobbying politicians to maintain that support. Just as the end to the "Song That Never Ends" leads back to its beginning, the main effect of energy subsidies is to create demand for more subsidies in a self-perpetuating process that has wasted taxpayer money and distorted energy markets for decades.

One challenge in discussing the subject of energy subsidies is defining what is and is not a subsidy. This paper largely follows the conventions of the Energy Information Administration (EIA) and groups energy subsidies into three categories: tax expenditures, direct expenditures, and research and development (R&D) expenditures (EIA, 2023). Loan guarantees are discussed in this report but are not considered in the final subsidy tallies because their total fiscal impact is difficult to quantify, depending on which loans are repaid and to what extent (DOE, n.d.-a).

Tax expenditures are special provisions in the federal tax code to incentivize certain activities. The government calls them expenditures, but they actually represent lost revenue relative to what would be generated if the provisions did not exist. The Office of Management and Budget (OMB) defines and calculates over 170 of them, including 30 for energy production (OMB, 2024a, pp. 219-239). This paper follows the OMB definitions, with a few exceptions, but there are ongoing debates about these definitions, including how to define the "baseline" tax code, about whether certain tax expenditures are in fact subsidies, and about how to calculate them (Zycher, 2017).

While tax expenditures have existed since the federal income tax was established in 1913 (Library of Congress, n.d.), the modern system of energy subsidies began with the price control-induced oil crises of the 1970s and the creation of the Department of Energy in 1977 (DOE, n.d.-b). This period saw the rise of direct federal spending on energy projects, particularly for energy efficiency and renewable energy, and the rapid expansion of federal energy research beyond nuclear energy. The most notable developments came after President Carter signed the Energy Security Act into law in 1980 (DOE, n.d.-b), which included the Solar Energy and Energy Conservation Act, Renewable Energy Resources Act, and the U.S. Synthetic Fuels Corporation Act.

The purported goal of most energy subsidies since the 1970s has been to reduce our use of fossil fuel resources, especially oil and gas, by promoting alternative energy technologies. Prior to the last 20 years, the fear was that we did not have enough oil and gas resources to meet our future needs, the so-called "peak oil" theory, and that we needed new technologies to reduce our reliance on imports. As the shale revolution turned the U.S. from a net importer to a net exporter of fossil fuels over the past two decades, peak oil fear has been supplanted the fear of catastrophic climate change. This shift in sentiment is reflected in the Inflation Reduction Act (H.R. 5376, 2022), in which the energy provisions are entirely geared toward reducing greenhouse gas emissions.

However, energy subsidies have failed to develop viable alternative energy sources that could achieve this goal of redirecting our energy markets away from fossil fuels. In 1980, 89% of the total energy consumed by the U.S. came from fossil fuels, and in 2023, 78% came from fossil fuels (EIA, 2024a, p. 257). Roughly equal shares of that reduction from 89% to 78% came from increases in the use of nuclear and the combination of wind and solar, with an increase in ethanol consumption providing the remainder. As this paper shows, this small shift toward renewables over the past two decades has come at a great cost to consumers and taxpayers.

Policymakers, energy market participants, and voters must wake up to the fact that the primary results of energy subsidies have been the distortion of energy markets, higher prices for energy consumers, and the incentive to create businesses that would not exist without government support. We should stop repeating the mistakes of the past and eliminate all state and federal energy subsidies so that energy markets can do what they have done well for decades, namely, creating wealth and environmental quality for billions of people around the world.

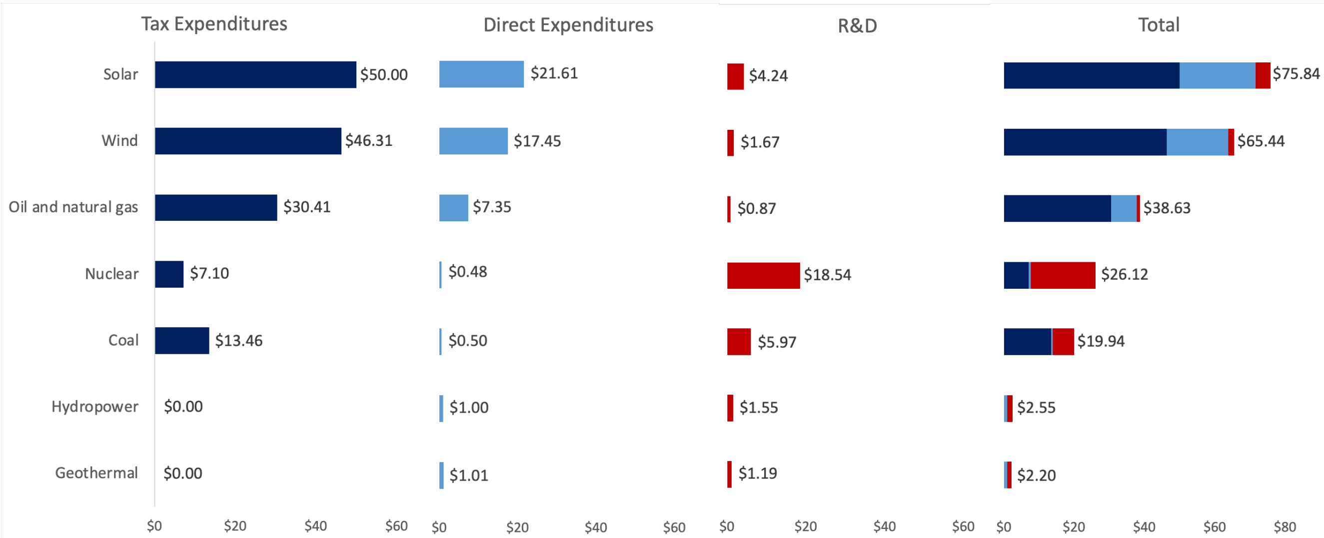
TOTAL FEDERAL ENERGY SUBSIDIES FROM 2010 TO 2023

Regarding the often-debated question about whether wind, solar, or fossil fuels are more heavily subsidized, it should first be noted that every primary energy resource received at least $20 billion in federal subsidies over the past 14 years. From 2010 to 2023, solar and wind received the most federal subsidies, about $76 billion and $65 billion, respectively, while coal received $20 billion and oil and natural gas received $33 billion. Fossil fuels received more federal subsidies than wind and solar prior to 2010, whereas wind and solar have received much more since then and are forecast to receive hundreds of billions more over the next several years with the expansion of subsidies under the Inflation Reduction Act (H.R. 5376, 2022). Furthermore, wind and solar have received much more in subsides per unit of electricity generated than oil and gas: wind 48 times more and solar 168 times more. Wind has also received 20 times more subsidies than coal per unit of electricity generated and solar 71 times more.

Another important facet of this study are the sources of federal financial support, which vary significantly across resources. As shown in **Figure 1**, oil and natural gas received most of their subsidies from tax expenditures, whereas wind and solar received nearly half of their subsidies from direct expenditures in the prior decade but are receiving much more from tax expenditures in recent years. Coal and especially nuclear received a larger proportion of their subsidies from DOE R&D funding than the other resources do. Digging a bit deeper into the nature of the different subsidy programs reveals more about how they affect the production of each resource and how they affect energy markets overall. Appendix C

Figure 1

Total federal energy subsidies from 2010 to 2023 (billions of 2023 USD)



Note: A complete list of data sources is provided in **Appendix C**, and the data was compiled using the methodology described in **Appendix B**.

has a detailed list of the programs included in this analysis. Here, we will explain some of the larger subsidy programs and discuss their market impacts.

TAX EXPENDITURES: NOT ALL SUBSIDIES ARE CREATED EQUAL

A key point about tax expenditures is that they vary significantly in their structures and their impacts on energy markets. They are the largest category of energy subsidies, accounting for more than half the total since 2010, and are also subject to the most controversy. However, as mentioned in the introduction, alternative interpretations exist regarding whether certain tax provisions are in fact subsidies and what their market impacts are.

This paper relies on OMB data to quantify tax expenditures and therefore largely follows the OMB's definitions (see **Sidebar**). Some tax expenditures are not fully covered by the OMB, and in those cases, estimates from the Joint Committee on Taxation (JCT) are used. JCT estimates are also used in place of OMB estimates for the cost of the PTC and ITC in 2023 because the current OMB data does not appear to be consistent with prior estimates.

More than 90% of oil and gas subsidies quantified in this paper come from tax expenditures, and 76% comes from three specific tax expenditures: expensing of intangible drilling costs, excess of percentage cost over depletion, and master limited partnerships (MLPs). The classification of each of these tax provisions as subsidies is often challenged, and we count them as subsidies in this analysis for the sake of completeness and consistency with the rest of our work, not to make a definitive claim on their status. It is also important to clarify both how these tax provisions work and the fact that they have very small market impacts relative to tax expenditures for renewable energy resources.

The expensing of most or all intangible drilling costs in the first year is considered a subsidy by the OMB because normal tax treatment would dictate that the costs incurred during the creation of a capital asset, in this case an oil or gas well, would be depreciated over time. Because of the time value of money, expensing those costs in the first year reduces the real tax burden. However, it is often noted that exploration and drilling are more comparable to research and development activities in other industries (Zycher, 2017, p. 4), in the

Definitions of High-Value Tax Expenditures

Production Tax Credit

Also called a "Section 45 credit" in reference to its place in the tax code (26 U.S.C. 45), the PTC provides an inflation-adjusted tax credit to qualifying electricity production from one of nine renewable energy resources. The tax credits are priced per unit of electricity generation ($/MWh) and can be received for 10 years after the facility begins production. The value of the credit has fluctuated over the years, but under the Inflation Reduction Act, the credit is set at $26/MWh for projects that meet prevailing wage and apprenticeship requirements, with other bonuses that could 20% to the credit (DOE, 2023, p. 1). Most of the PTC has been applied to wind, but the recent expansion of the credit could induce more solar to apply for it.

Investment Tax Credit

Also called a "Section 48 credit" (26 U.S.C. 48), this tax credit was created in the 1970s and is provided to offset a portion of the capital costs of commercial solar facilities. Originally set at a value of 10%, it was increased to 30% by the Energy Policy Act of 2005 (H.R. 6, 2005). The 2009 stimulus expanded the ITC to include most renewable energy technologies, but the majority of the credit has gone to solar. It was supposed to phase phased down to 10% by the end of 2022, but the Inflation Reduction Act increased it to 30% for projects that projects that meet prevailing wage and apprenticeship requirements, with other bonuses that could push it to as high as 50% (DOE, 2023, p. 1).

Expensing of Intangible Drilling Costs

This tax provision (26 U.S.C. 263(c)), introduced in the Underwood Tariff Act of 1913 (Library of Congress, n.d.), allows oil and gas companies to deduct drilling preparation and construction costs in the year that they occur instead of deducting them over the lifetime of a well. Non-integrated oil and gas companies (i.e., those that do not have pipeline or refinery operations) can deduct 100% of these costs in the first year, whereas integrated companies must deduct 70% in the first year and depreciate the remainder over the next five years (OMB, 2024a, p. 222).

Excess of Percentage Over Cost Depletion

This provision (26 U.S.C. 611-613A) allows independent oil and gas producers and royalty owners to deduct from their taxes a percentage of their income from an oil and gas well, instead of depreciating the costs of acquiring and developing the well over the lifetime of the well (OMB, 2024a, p. 222). The deduction is 15% of gross income, up to a limit of 100% of net income, which sometimes allows these companies to deduct more than the capital cost of the asset and to do so at a faster rate than through normal cost depletion.

sense that not every acre explored and not every well drilled becomes a capital asset that produces a product, or at least a consistent quantity of product. Therefore, despite the OMB classifying this provision as a tax expenditure, there is debate over whether it constitutes a subsidy.

Excess of percentage cost over depletion also suffers from some ambiguity as to its status. In theory, the baseline tax system would dictate cost depletion, in which the costs of developing and acquiring an asset are capitalized and then gradually reduced over its life (OMB, 2024a, p. 222). Percentage depletion allows for depreciation relative to a producer's income, instead of to the capital cost of the asset. That fact alone does not make this provision a subsidy, as the asset is still depreciated over time. However, percentage depreciation often allows the asset to be depreciated more quickly and allows depreciation beyond the total capital cost. To the extent that it does this, it is often considered a subsidy. But the structure of it and the fact that it is common to all extractive industries means that this classification is still debated.

MLPs utilize an exception in the tax code that allows certain types of companies to be taxed as partnerships instead of corporations while still being publicly traded (EIC, n.d.). There is debate about whether the tax treatment of MLPs qualifies as a subsidy because limited partnerships are a standard business structure for private companies in many industries, and the EIA notably does not include MLPs in their analysis (EIA, 2023). However, we choose to include it here because it is counted as a tax expenditure by the JCT (JCT, n.d.-a, p. 31) and is consistent with our treatment of other tax expenditures. The JCT specifies that its estimate of MLP tax expenditures applies to energy companies, so this analysis takes at face value the JCT's assessment of how much of the total MLP tax breaks relate to energy versus other industries.

The production and investment tax credits (PTC and ITC, respectively), while also classified as tax expenditures, are notably different in structure from these oil and gas tax provisions. They provide tax credits up to a certain amount per unit of electricity produced (PTC) or up to a certain percentage of a project's capital cost (ITC). Because the PTC and ITC cannot reduce a company's tax burden below zero, wind and solar developers will often partner with tax equity investors in order to take full advantage of the credits. The investors pay for a portion of a project's capital costs in return for the project's tax credits. The tax credits and revenues from selling electricity enable the wind or solar project to pay back its steep capital costs and provide a return to its investors.

Therefore, while the PTC and ITC are tax credits relative to the tax equity investors and the government, their effect on wind and solar developers and on electricity markets is more like that of direct expenditures. Because tax equity financing contributes a large portion of initial project capital and the marginal cost of operating is very low, with zero fuel cost, wind and solar generators are often incentivized to build units and produce as much electricity as possible regardless of market conditions. The result is that electricity prices are suppressed when wind and solar generation are high and artificially high when wind and solar resources are low. This is especially true for the PTC, which requires wind generators to produce energy to receive the subsidy, in some cases leading them to sell electricity at negative prices simply to receive the subsidy (McConnell, 2018).

Another key problem with the PTC and ITC is that they do not require wind or solar generators to demonstrate an advancement in technology in order to qualify. Therefore, the tax credits primarily promote the scale-up of older technologies that can be deployed quickly rather than promoting new technologies that might improve the efficiency or reduce the cost and environmental impact of wind and solar. Contrast that with the recent expansion of the tax credit for carbon capture utilization and storage (CCUS), which is supporting a technology that is not yet commercially demonstrated—the capture of carbon dioxide from an anthropogenic source (i.e., a power plant, refinery, or a steel mill) and its permanent sequestration underground. Add in the fact that DOE research funding for wind and solar accounted for only 4% of their total subsidies from 2003 to 2019, and it is evident that most federal subsidies for wind and solar are not well-targeted toward new technology development.

DIRECT EXPENDITURES AND R&D EXPENDITURES

The second category of subsidies is direct expenditures, the largest of which by far is a Section 1603 grant, so named after the provision's location in the American Recovery and Reinvestment Act of 2009 (H.R. 1, 2009, §1603), referred to hereafter as the 2009 stimulus. These grants were cash payments for up to 30 percent of a project's eligible cost that companies could take in lieu of the PTC or ITC, usually if they could not take full advantage of the tax credits. They were enacted as part of the 2009 stimulus and were exclusively available to renewable energy technologies that entered service between 2009 and 2013. According to data from the U.S. Department of the Treasury (U.S. Department of the Treasury, n.d.), a total of $26.2 billion in grants were awarded, including $10.3 billion to solar and $13 billion to wind, and the last grant was awarded in November 2017.

Other direct expenditures include a wide variety of programs from the Department of Agriculture (DOA, 2024), especially the Rural Energy for America program, and from other agencies that are not normally associated with energy. In total, direct expenditures represent only 22% of total subsidies from 2010 to 2023, and Section 1603 grants represent half of all direct expenditures. While direct expenditures will increase soon due to the Inflation Reduction Act, that increase is dwarfed by the projected increase in tax expenditures.

Research and development (R&D) expenditures are the third and smallest category of subsidies, constituting $34 billion since 2010. Coal and nuclear are the largest recipients of R&D expenditures, with $6 billion and $18.5 billion, respectively, since 2010 (see **Figure 1**). More than half of total nuclear subsidies and about a third of coal subsidies come from DOE R&D. While R&D spending might be assisting the growth of those industries through new technology development, it is not significantly affecting the profitability and survival of their core businesses. Therefore, it might be argued that R&D expenditures should not be counted in the same way as direct expenditures and tax expenditures.

Ultimately, the relevance of energy subsidies to the larger debate about energy resources in the U.S. boils down to their impact on energy markets. A common refrain from renewable energy advocates is that other energy sources would be more competitive if subsidies were not inducing more drilling for oil and gas and keeping oil and gas prices artificially low. However, the few billion dollars a year in U.S. subsidies pale in comparison to the multi-trillion-dollar global market for fossil fuels. The Bureau of Economic Analysis estimated that U.S. oil and natural gas extraction alone (not counting transportation, refining, and end uses) generated an average of $190 billion in economic activity annually from 2003 to 2022 (FRED, 2024a), as compared to an annual average of $2.3 billion in federal subsidies for the entire oil and gas industry over that time.

Despite declining prices for building wind and solar power plants, those industries are still far smaller than their fossil fuel competitors and far more dependent on subsidies for their survival. In 2023, wind and solar produced 425 TWh and 238 TWh of electricity (EIA, n.d.-a) and received $4.3 billion and $4.4 billion in federal subsidies, respectively. In other words, they received about $10.20 and $33.72 in federal subsidies per MWh of electricity generated, amounts that are comparable to wholesale electricity prices in many areas of the country. Even as the cost to build wind and solar power plants declines, the electricity they produce becomes less valuable as more generation is built, and they must compete against existing wind and solar generators that receive subsidies. Therefore, as wind and solar generation reach saturation levels in many markets, new builds will likely decline or stop without additional subsidies.

THE IMPACT OF THE 2009 AMERICAN RECOVERY AND REINVESTMENT ACT

The reason this study focuses on the period after 2009 is to capture the full effect of subsidy policies following the 2009 stimulus, most of which held steady throughout the 2010s, while avoiding subsidies that have long expired and are not currently affecting energy markets. However, it is still useful to look further back to 2003, which is the first year with complete data from many of our sources, to understand how the focus of energy policy changed dramatically from the beginning to the end of the 2000s.

As shown in **Table 1**, fossil fuel and nuclear subsidies were dominant prior to 2010. While the PTC and ITC existed prior to 2010, the wind and solar industries were so small that they did not take in many subsidies. Coal subsidies were elevated by the alternative fuels

Table 1
Total federal energy subsidies by decade from 2003 to 2023 (thousands of 2023 USD) and forecast tax expenditures from 2024-2027

Subsidy Category	2003-2009	2010-2019	2020-2023	2024-2027
Solar	2,270,956	42,606,059	33,235,368	80,300,000
Wind	6,743,785	44,344,080	21,097,375	35,100,000
Hydropower	782,903	1,842,102	703,445	0
Geothermal	300,608	1,721,007	483,923	0
Nuclear	12,077,944	18,612,837	7,505,863	10,100,000
Coal	29,993,714	16,935,506	3,001,260	800,000
Oil and natural gas	23.559,550	27,339,991	11.289,856	9,100,000
Energy efficiency	29,738,265	54,313,151	29,240,854	18,800,000
Bioenergy	35,915,249	63,368,055	24,266,852	N/A
Transmission	10,533,226	3,285,863	1,359,156	8,200,000

Note: Total subsidies from 2003 to 2023 are derived from the data in Appendix C using the methodology described in Appendix B. Forecast tax expenditures for 2024 to 2027 are taken from *Estimates Of Federal Tax Expenditures For Fiscal Years 2023-2027*, Joint Committee on Taxation, n.d., (https://www.jct.gov/publications/?category_name=Tax+Expenditures). The JCT does not forecast bioenergy tax credits.

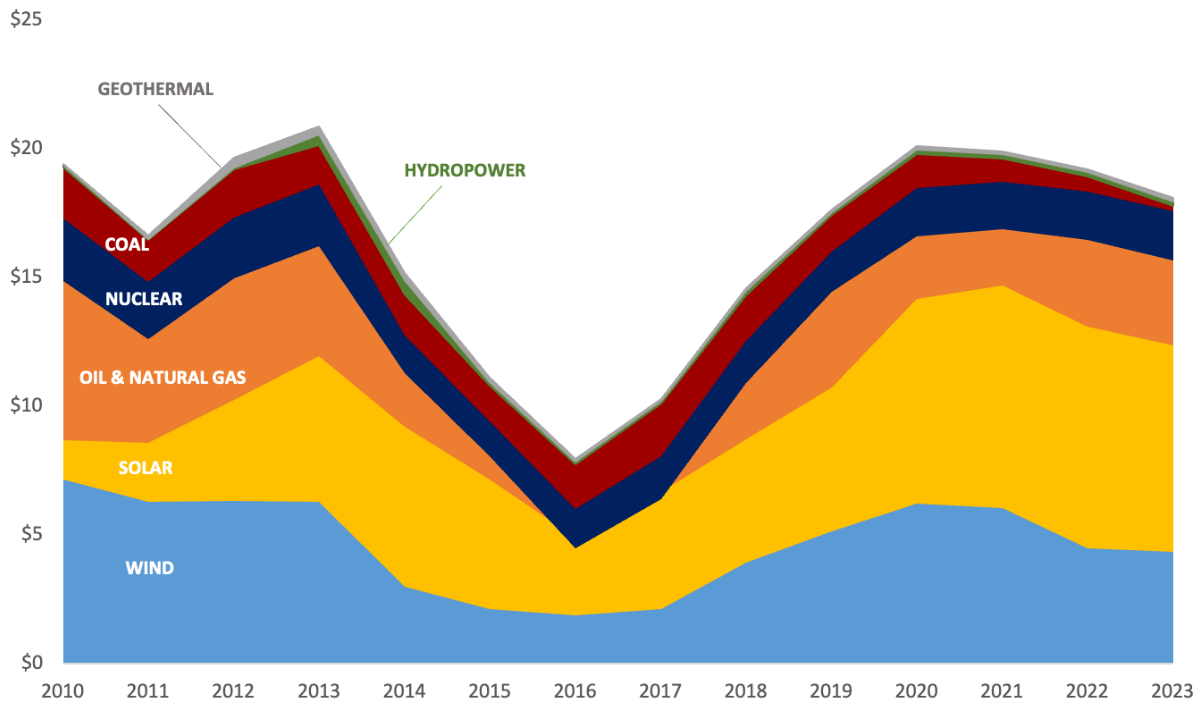
production credit, which, contrary to most subsidies that are constantly renewed or made permanent, largely expired in 2007 and went away entirely in 2013. It is important to note that this subsidy was for making synthetic fuels from coal, not for producing electricity, and therefore, it is not counted in the later parts of this paper that concern only electricity generation.

The 2009 stimulus supercharged wind and solar development via the Section 1603 grants, which, by providing direct cash payments to wind and solar developers, mitigated the need to obtain project financing and tax equity investors for the extremely high capital cost of those projects. The Section 1603 cash infusions propelled development and drove economies of scale and cost declines such that, once the program ended, the PTC and ITC were by themselves sufficient to drive further wind and solar growth. However, as price declines leveled out in recent years (Lazard, 2024, p. 16) and interest rates rose, the wind and solar industries have remained reliant on the PTC and ITC to spur further development.

While this study focuses on technologies used for electricity generation, we also include energy efficiency, bioenergy (primarily biofuels), and transmission in this table for completeness. Bioenergy took in more than 50% more subsidies than either wind or solar from 2003 to 2023, the majority of which came from tax credits for ethanol and biodiesel. That number does not account for the subsidy impacts of the renewable fuel standard, which is significant but is outside the scope of this paper to quantify. Energy efficiency programs remain popular ways to funnel money to favored constituencies, despite research showing that they have low or negative rates of return (Fowlie et al., 2018). Energy efficiency expenditures averaged $5.4 billion a year from 2003 to 2023, more than either wind or solar over that time, primarily due to the Weatherization Assistance Program and tax credits for efficiency upgrades.

Figure 2

Annual federal energy subsidies from 2010 to 2023 (billions of 2023 USD)



Note: A complete list of data sources is provided in **Appendix C**, and the data was compiled using the methodology described in **Appendix B**.

TRENDS IN FEDERAL ENERGY SUBSIDIES FROM 2010 TO 2023

One reason the debate over energy subsidies is often confusing is that most studies look at only a single year or a discontinuous subset of years. As **Figure 2** shows, the subsidies for each resource can vary widely from year to year, which makes it imperative to look at averages over a longer period—such as the 14 years highlighted in this study. Examining the evolution of subsidies over time also provides a more complete picture of the effects of policies being enacted.

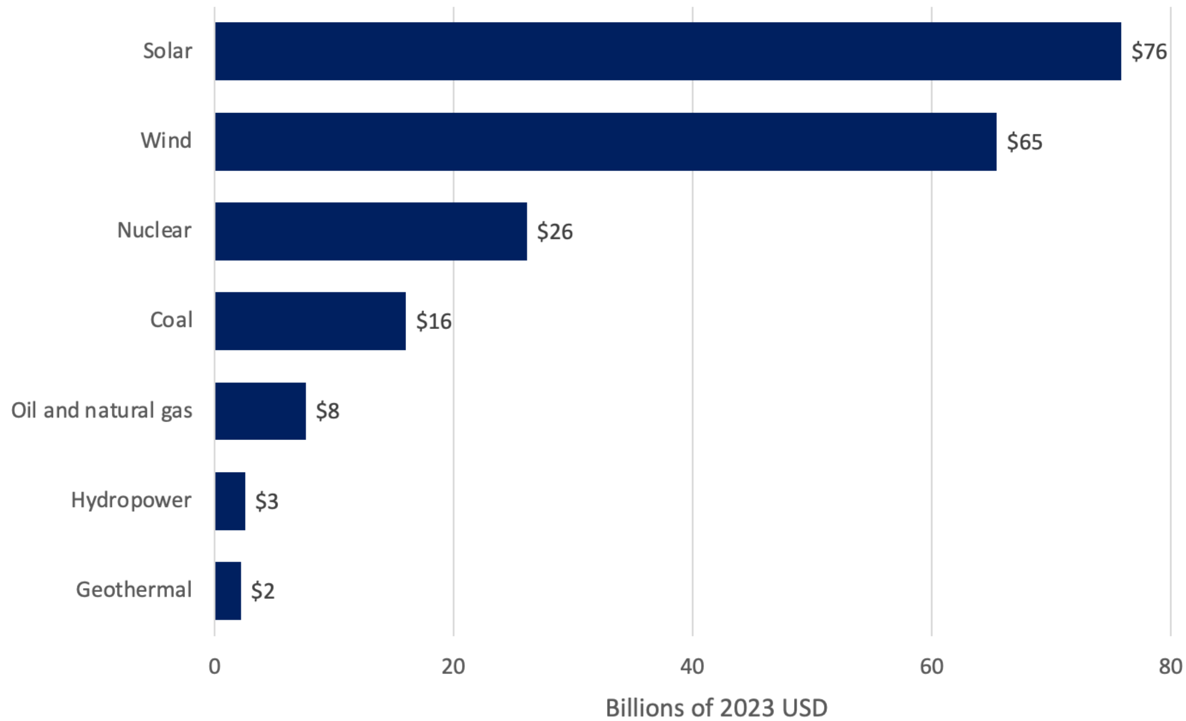
Oil and natural gas subsidies come primarily in the form of tax provisions that are permanent features of the tax code. Those subsidies are largely dependent on the amount of activity and the profitability of oil and gas companies. From 2010 to 2013, oil prices were high, and drilling and exploration boomed. Then from 2014 to 2017, as prices sank and activity dwindled, oil and gas subsidies shrank dramatically. The decline was also driven by the expiration at the end of 2013 of a temporary measure that allowed for special expensing of certain refinery equipment. This tax expenditure is discussed further in **Appendix C**.

Coal has received most of its support since 2010 from tax provisions allowing for the amortization of pollution control equipment and for carbon capture and sequestration research and demonstration programs. Subsidies for nuclear are primarily DOE research funds and have been very consistent from 2010 to 2023. Hydropower and geothermal received some boosts in direct expenditures from programs in the 2009 stimulus, but otherwise, subsidies for those two energy sources have been relatively low.

Section 1603 of the 2009 stimulus provided more than $23 billion directly toward the capital costs of new wind and solar projects from 2009 until the last

Figure 3

Total federal subsidies for electricity generation, 2010 to 2023 (billions of 2023 USD)



Note: Data derived by applying the conversion factors in Appendix E to the data in **Figure 1**.

award in 2018. These funds constituted most of the wind and solar subsidies from 2010 through 2013. Programs through the Department of Agriculture, such as the Rural Energy for America program, have added nearly $8 billion in direct expenditures. In the latter half of the last decade, the PTC and ITC became the primary subsidies for wind and solar, and now those credits make up the vast majority. In 2023, wind and solar received $4.2 billion and $7.2 billion from the PTC and ITC, respectively, making them by far the most subsidized energy resources in the most recent year of available data.

FEDERAL SUBSIDIES FOR ELECTRICITY GENERATION

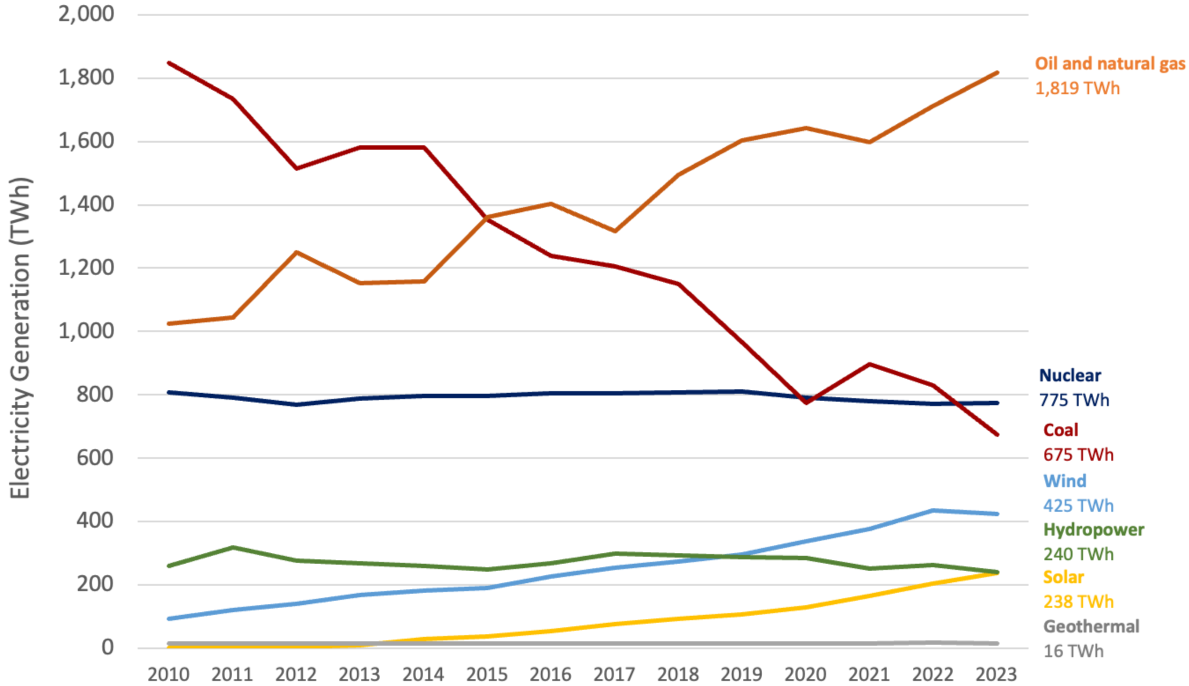
Because wind, solar, hydroelectric, geothermal, and nuclear are only used for electricity generation, whereas fossil fuels are also used for heating, transportation, and other applications, it is important to compare the effects of different subsidies within the context of electricity markets. In order to make this comparison, we adjust the subsidies for natural gas, oil, and coal by the percentage of the total energy from those fuels used for electricity production each year. The adjustment method is described in detail in **Appendix E**, and the adjusted subsidy totals are shown in **Figure 3** above.

When measuring the impact of subsidies, it is important to compare the number of subsidies to the size of the industry, and in electricity, the most common measure of size is net generation (i.e., the amount of electricity that is actually put into the electric grid). **Figure 4** shows the trends in U.S. net generation for each resource from 2010 to 2023.

Until 2015, coal was the largest source of electricity in the U.S., comprising 46% of U.S. net generation as late as 2010. It has since been overtaken by natural gas. Because it is difficult to separate the subsidies for oil

Figure 4

U.S. net electricity generation by source, 2010-2023 (TWh)



Note: Data from *Electricity Data Browser*, "Net generation, United States, all sectors, annual," U.S. Energy Information Administration, n.d., (https://www.eia.gov/electricity/data/browser/).

and natural gas, we continue to keep them grouped together. While some petroleum coke and liquids are still used for electricity generation, oil's contribution to U.S. net generation has declined from about 3.1% in 2003 to 0.4% in 2024 (EIA, n.d.-a).

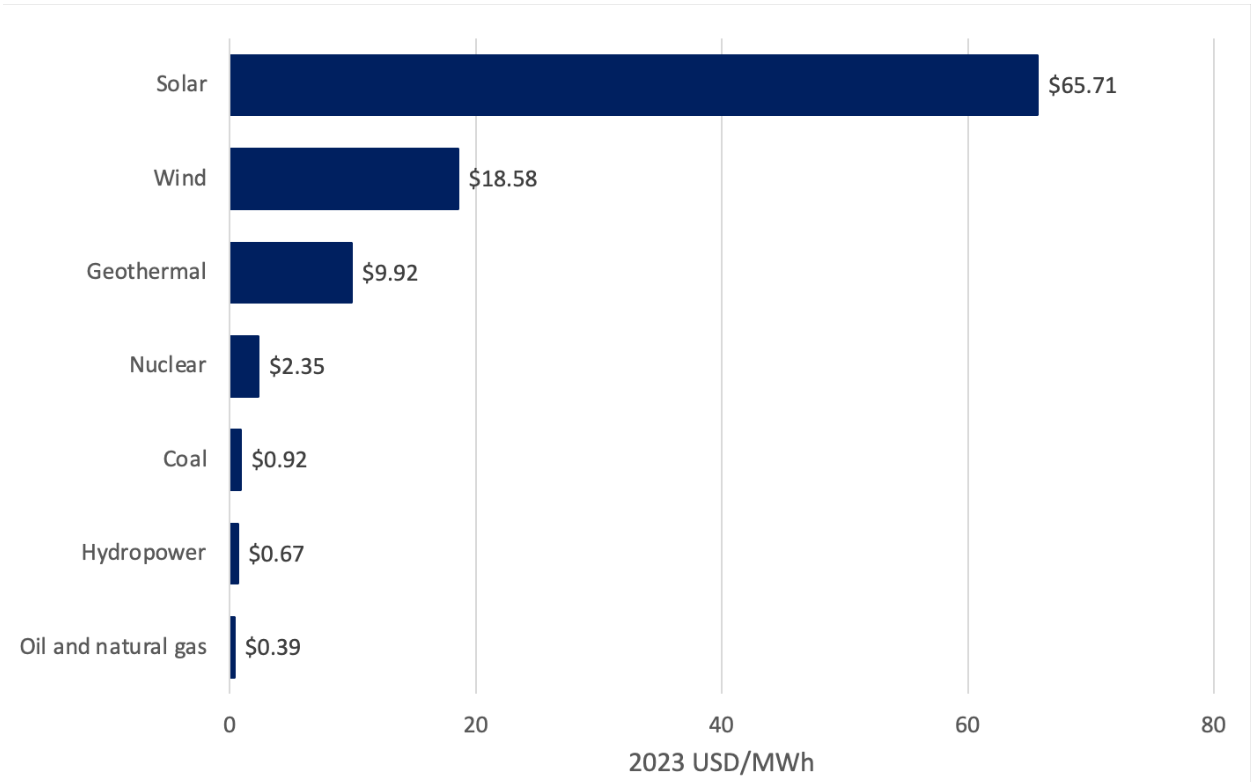
Nuclear and hydroelectric generation remained steady as very few expansions or closures occurred during this period. Wind and solar have risen steadily but still only comprised 10.2% and 3.9%, respectively, of U.S. net generation in 2023 (EIA, n.d.-a). Only in 2019 did wind overtake hydroelectric as the largest source of renewable electricity in the U.S.

Scientific Units for Measuring Electricity Consumption

The fundamental unit for power, or how much energy is consumed over a given time, is a watt (W). The power rating of most home appliances is given in W. For example, a typical home refrigerator uses about 300 W when it is running. A kilowatt (kW) is 1000 watts and is close to the average power usage of an American home. Therefore, residential electricity consumption is typically measured in kilowatt-hours (kWh), which is a unit of energy equal to 1 kW times 1 hour. A home that utilizes 1 kW of power for 24 hours consumes 24 kWh of energy. Retail electricity prices are given in $/kWh, with the U.S. residential average being $0.1598/kWh in 2023 (EIA, n.d.-b). The other units used when discussing the much larger output of power plants and the electric grid use the typical convention of Greek prefixes: 1,000 kW = 1 megawatt (MW), 1,000 MW = 1 gigawatt (GW), and 1,000 GW = 1 terawatt (TW).

Figure 5

Federal subsidies per unit of electricity generated, 2010 to 2023 (2023 USD/MWh)



Note: Data derived by dividing the subsidy values in **Figure 3** by the total electricity generation for each resource from 2010 to 2023 (see **Figure 4**).

Dividing total federal subsidies from 2010 to 2023 (**Figure 3**) by total electricity generated (**Figure 4**) provides a common metric for the subsidies received relative to the size of the industry, which is shown in **Figure 5**. Solar has by far received the most subsidies per unit of electricity because it is one of the largest recipients of subsidies while producing the second least amount of electricity since 2010. Wind is second on this list because, while it produced more electricity than solar, it is still a small part of the U.S. electricity mix. Nuclear and fossil fuels generate much more electricity relative to the subsidies they received, which indicates they are less dependent on subsidies for their revenue and profitability than wind and solar.

Another way to view this data is to compare the number of subsidies to the value of electricity from these energy sources. A report from Lawrence Berkeley National Laboratory estimates the average wholesale value of electricity from wind in 2023 was between $13/MWh and $60/MWh, depending on the regional market (LBNL, 2024, p. 58). The largest wind markets (ERCOT, SPP, and MISO) were all at or below $23/MWh. Therefore, we estimate that wind generators on average have received nearly as much money from subsidies as they have from selling electricity in these markets. Similar DOE estimates for the wholesale value of solar electricity are not available, but given that the average wholesale price of electricity in the U.S. in 2023 was about $64/MWh (EIA, 2024b), it is likely that the subsidy/revenue ratio for solar is greater than 1:1.

A major problem for wind and solar is that, absent the ability to store their electricity and dispatch it during periods of high demand and high prices, they will depress prices during the times when they

Treatments of Externalities and Indirect Subsidies in Other Studies

A significant problem in the literature on energy subsidies is that many studies expand the definition of a subsidy to give the impression that developed nations still subsidize fossil fuels and nuclear far more than renewable energy sources. The fact that governmental bodies such as the International Monetary Fund (IMF) and World Bank propagate many of these flawed subsidy definitions makes the problem even worse (Coady et al., 2019; Flochel & Gooptu, 2018).

One of the most common mischaracterizations of subsidies is classifying energy-related poverty assistance programs as subsidies for fossil fuels. For example, the Low-Income Home Energy Assistance Program (LIHEAP) pays out several billion dollars annually to assist low-income households with heating and electricity bills, far more than any single subsidy for energy production. Some studies call "end-use" programs like this one a fossil fuel subsidy (Worrall et al., 2018, p. 6), when the goal of the subsidy has nothing to do with supporting fossil fuel production. The same error is often made when classifying tax breaks that are not directed at energy industries but that benefit certain energy companies. While these programs are market-distorting and, for the most part, ineffective policies, we do not classify them as energy subsidies.

Some studies go even further by trying to quantify environmental and societal costs related to our use of fossil fuels, such as air pollution, global warming, and car accidents. Not only is it an egregious overstatement to classify these assumed costs as subsidies, but there are also numerous scientific flaws in how these supposed costs are calculated.

These studies often attribute hundreds of billions of dollars in costs to air pollution from fossil fuels (Coady et al., 2019, p. 13; Flochel & Gooptu, 2018, p. 16), even though the vast majority of the United States is "in attainment" with national air quality standards (EPA, n.d.). The idea that current levels of air pollution in the U.S. are causing measurable public health consequences is a subject of heated debate both inside and outside the EPA (Cox et al., 2019; White & Bennett, 2019), yet these studies claim there is a quantifiable public health cost to fossil fuel emissions in the U.S. and that this externality constitutes a subsidy for fossil fuels.

The most recent IMF study goes even further and classifies the future costs of global warming as a fossil fuel subsidy. The study uses a price of $40 per ton of CO_2 emissions (Coady et al., 2019, p. 9), which includes forecasted damages more than a century into the future, to claim that the U.S. subsidizes fossil fuel CO_2 emissions to the tune of more $200 billion annually (Coady et al., 2019). Even if the U.S. eliminates all fossil fuel CO_2 emissions by 2050, the rise in global temperatures by 2100 would likely only be reduced by 0.08 degrees Celsius (Bennett, 2023), hardly enough to mitigate $200 billion in annual damages.

The IMF study also quantifies increased costs related to traffic congestion and car accidents as a fossil fuel subsidy (Coady et al., 2019, p. 13), even though increasing the use of hybrid and electric vehicles will not reduce accidents and congestion. Such costs are more logically tied to the design of our cities and transportation systems than to a government-induced advantage for fossil energy. Expanding public transportation or forcing people to use it may reduce congestion and accidents but will increase taxes and other societal costs.

While these studies inflate the societal costs of fossil fuels, they also ignore: 1) the enormous societal benefits of using domestic, affordable, and energy-dense fuels, and 2) the costs, both societal and environmental, of alternative energy sources.

Inflating the definition of a subsidy and trying to classify certain externalities as subsidies only serve to confuse the public and policymakers and increase support for more government intervention in energy markets. Using the standard definition of a subsidy as a government payment or tax break to support a certain type of energy production leads to the conclusion that fossil fuels and nuclear do not receive more federal subsidies than wind or solar.

are producing electricity and increase prices when they are not producing. These market distortions are becoming more evident in regions with high wind and solar penetration, especially in Texas (McConnell 2018; Michaels, 2019). Despite increasing wind and solar generation capacity in ERCOT, has seen increased scarcity pricing (Potomac Economics, 2024, pp. 19-21) and a need for more fossil fuel generation capacity to meet demand growth (p. 32). This is one reason average wholesale market prices in 2023 were more than double their level in 2015-2018, despite historically low natural gas prices (p. 15).

As more wind and solar are added to the grid without storage, the value of the electricity they provide, and their revenue per unit of electricity sold ($/MWh) will decline. It is likely that wind and solar companies will continue to advocate for extensions of the PTC and ITC—despite the falling costs of building wind turbines and solar panels—because new generators will need more subsidies to make up for future declines in unit revenue and to compete against existing wind and solar generators that have already received subsidies.

IMPACTS OF THE INFLATION REDUCTION ACT AND THE INFRASTRUCTURE INVESTMENT AND JOBS ACT

Summary of the Total Impact

The Inflation Reduction Act (IRA) (H.R. 5376, 2022) is the most consequential change in U.S. energy policy since at least the 2009 stimulus. Because most of its provisions did not take effect until 2023, it does not have a significant impact on the data presented in this paper. However, the changes imposed by the law demand further discussion due to the significant impacts on the federal energy subsidy regime over the next few years. Because this paper is focused on the historical and current costs of federal energy subsidies, we will only offer near-term cost forecasts to avoid too much speculation on the future effects of this legislation[1].

Projections for the total cost of the energy and environment provisions of the IRA vary widely, but every current estimate far exceeds the original budget score (and widely cited value) of $391 billion from the Congressional Budget Office (CBO, 2022)[2], which only forecasted outlays from 2022 to 2031. Many of the tax credits do not have cost caps or firm expiration dates, including the new clean electricity tax credits, which is uncapped and will only expire when annual greenhouse gas emissions from electricity production in the U.S. decline by more than 75% relative to 2022. In fact, the CBO in February 2024 increased its cost estimate for the IRA over the 2024-2033 budget window by $428 billion from its 2023 estimate (CBO, 2024, pp. 86-87). The main reasons given are the EPA's new emissions standards, which are projected to increase clean vehicle tax credits and reduce gas tax receipts by a combined $224 billion, and greater investment in batteries, wind, and solar than originally projected.

While these cost estimates depend heavily on the pace of infrastructure buildout, and whether the Biden Administration's regulations remain in effect over the entire forecasted horizon, there is little doubt that unless the subsidies are repealed, they will cost much more than the CBO's 2022 estimate of $391 billion. Academic and private sector estimates of the cost of the IRA run even higher. The Penn-Wharton Budget Model estimates the total cost of the IRA through 2031 will be $1.045 trillion, with $263 billion for wind, solar, and energy storage (Penn Wharton University of Pennsylvania, 2023). Goldman Sachs produced a similar estimate of $1.2 trillion in total cost through 2031, which includes $274 billion for wind, solar, and energy storage (Vigna et al., 2023). If these estimates pan out, then the annual subsidies for electricity production and adjacent technologies

1 For more information regarding the future costs of the IRA, please refer to the work of Travis Fisher and Joshua Loucks at the Cato Institute (2024).

2 The CBO does not actually publish this number in their report. The author calculated it by adding up the direct spending and revenue reduction from the energy and environment programs listed in the report.

will be roughly triple what they were from 2010 to 2022, with a large piece of the increase going toward energy storage.

The Infrastructure Investment and Jobs Act (H.R. 3684, 2021) was a $1.2 trillion bill that extended and expanded many existing infrastructure programs while also adding $550 billion in new programs, particularly in the areas of energy and electric vehicles (Akin Gump, 2021, p. 2). In total, the bill allocates $37.8 billion toward energy infrastructure and $14.3 billion toward low- or zero-emission vehicles and charging infrastructure. Many of these expenditures are difficult to attribute to individual energy resources because they are primary directed at grid infrastructure and energy supply chains, but to the extent that they can be attributed, this study will count them as direct expenditures or R&D expenditures.

Tax Credit Programs in the IRA

A significant part of the IRA is related to aspects of the energy system that are not covered in this paper. For example, the single largest subset of subsidies in the bill relate to battery production for electric vehicles. Hydrogen production and energy storage are also significant elements of the bill, as are provisions to subsidize emissions reduction, like carbon capture. It is not appropriate to compare these subsidies to subsidies that are aimed solely at increasing electricity generation, which is the focus of this paper. However, to provide the reader with some perspective on how large and impactful the entire IRA is, below is a breakdown of the key tax provisions related to electricity generation, transmission, and storage in the IRA. The tax expenditures in the bill will likely comprise more than 90% of the total cost, so these provisions are of the utmost importance.

Clean electricity investment credit (Internal Revenue Code Sec. 48E): The ITC was phased down from 30% of the total investment for projects that began construction in 2019 to 26% for 2020, to 2022 projects to 22% for 2023 projects, and finally settling at a 10% of total investment for projects in 2024 and beyond (CRS, 2021, p. 3). The IRA raised the ITC back to 30% for projects that began construction in 2022 or later that meet prevailing wage and apprenticeship requirements (Prevailing Wage and Apprenticeship Initial Guidance, 2022). It also includes extra 10% bonuses for meeting domestic content requirements and for locating in disadvantaged communities (IRS, n.d.). Beginning in 2025, the ITC will switch from being specific to solar, small wind, geothermal, and a few other technologies to being a technology-neutral clean energy investment tax credit (26 U.S.C. 48E). The JCT estimates the ITC cost $7.2 billion in 2023, ballooning to an annual average of $20 billion from 2024 to 2027 (JCT, n.d.-a), a significant increase from the average annual cost of $3.6 billion during the 2010-2023 period covered by this study.

Clean electricity production credit (IRC 45Y): The PTC was set to be eliminated for projects that began construction after December 31, 2021, but the IRA reinstated a credit of 2.6 cents/kWh (indexed to inflation) for projects that began construction in 2022, 2023, or 2024 (DOE, 2023, p. 2), provided they meet prevailing wage and apprenticeship requirements. The credit applies for the first 10 years of electricity generation. Like the ITC, developers get 10% bonuses for meeting domestic content requirements and locating in disadvantaged communities. Beginning in 2025, the PTC will switch from being specific to wind, geothermal, biomass, and a few other technologies to being a technology-neutral clean energy production tax credit (26 U.S.C. 45Y). The JCT estimates the PTC cost $4.2 billion in 2023 and will average $8.8 billion annually from 2024 to 2027 (JCT, n.d.-a), a significant increase from the average annual cost of $3.3 billion during the 2010-2023 period covered by this study.

Advanced energy property credit (IRC 48C): The base credit rate is 6%, but the credit increases to 30% for projects that meet prevailing wage and registered apprenticeship requirements. It applies to a vast range of energy projects, from wind and solar manufacturing facilities to electric and hybrid vehicles to carbon capture. This is one of the few capped provisions within the IRA, as the statute only allocates $10.0 billion for the credit, $4.0 billion of which must be deployed in energy communities or communities that have not previously received tax credits under this section (26 U.S.C. 48C).

Advanced manufacturing production credit (IRC 45X): This production tax credit applies to the manufacture of components for solar modules, wind turbines, inverters, and batteries, which are given a credit per unit produced, as well as to the production of 50 critical minerals, which is granted a credit equal to 10% of the total cost of production. The full list of components covered by the credit, as well as the amount of credit per component, can be found in the relevant section of the United States Code (26 U.S.C. 45X). However, of note are the credits for battery cells, which is $35/kWh, and battery modules, which is $10/kWh. With $45/kWh of tax credits per battery system, a battery manufacturing facility that produces 100 GWh of batteries annually—which is Tesla's goal for its expanded Gigafactory in Nevada (Tesla, 2023)—will bring in *$4.5 billion every year* from this credit if its entire production capacity is eligible. The credit is currently set to phase down beginning in 2030 and ending after 2032. The JCT estimates this credit cost $5.5 billion in 2023 and will average $16.8 billion annually from 2024 to 2027 (JCT, n.d.-a). The JCT's report does not provide a breakdown of the amount of the credit by technology type, but batteries will likely take up the lion's share of it.

Credit for carbon oxide sequestration (IRC 45Q): For carbon capture equipment placed in service after February 8, 2018, and before January 1, 2023, the credit is (in 2023 dollars) $40.89 per metric ton of CO_2 captured that is placed in secure geological storage without being used for other purposes or $27.61/ton if the CO_2 is used for enhanced oil recovery or for other qualified uses. For facilities placed in service on or after January 1, 2023, that meet prevailing wage and apprenticeship requirements, the credit for storage is $85/ton ($180/ton for direct air capture) and $60/ton ($130/ton for direct air capture) if the CO_2 is used for enhanced oil recovery or for other qualified uses (CRS, 2023, p. 2). The credit is indexed to inflation beginning in 2026. Construction on the facility must begin by the end of 2032, and the credit extends for 12 years beyond the date the facility is placed in service (26 U.S.C. 45Q). The JCT estimates the credit will cost $4.8 billion from 2024 to 2027 (JCT, n.d.-a).

Zero-emission nuclear power production credit (IRC 45U): Qualified nuclear power facilities are taxpayer-owned facilities that use nuclear power to generate electricity, do not receive an advanced nuclear production tax credit allocation under Section 45J, and were placed in service before August 16, 2022. The base tax credit is 0.3 cents per kWh (adjusted for inflation), but projects that meet prevailing wage requirements are eligible for a tax credit of five times the base amount (1.5 cents per kWh). Credits are reduced by 16% of the excess of gross receipts from electricity produced by the facility and sold over the product of 2.5 cents times the amount of electricity sold during the taxable year. Thus, the credit would phase down as annual average prices exceed 2.5 cents per kWh. The credit went into effect on January 1, 2024, and expires at the end of 2032 (26 U.S.C. 45U). The JCT estimates the credit will cost $10.1 billion from 2024 to 2027, or an average or $2.5 billion annually (JCT, n.d.-a).

Credit for production of clean hydrogen (IRC 45V): The baseline credit is $0.60 per kilogram of qualified clean hydrogen (QCH), adjusted annually for inflation. Taxpayers producing

Subsidies for Nuclear on the Rise

The proposals to reopen the Palisades nuclear plant in Michigan and the recently retired Unit 1 at Three Mile Island in Pennsylvania (Halper, 2024) highlight how the IRA has supercharged incentives for nuclear power. Crushing regulations from the Nuclear Regulatory Agency and subsidies for wind and solar have made it uneconomic to build new nuclear power plants and even to continue operating some existing nuclear plants. But as usual, the government solution to a government-created problem is not to fix the problem but to pretend to fix it by throwing taxpayer money at it.

The first tranche of money are the loan guarantees and grants in the IRA and the Jobs Act. The Palisades restart is set to receive a $1.52 billion loan (The White House, 2024), part of a total of $250 billion in loan guarantees available through 2026 via the Energy Infrastructure Reinvestment Financing program (DOE, n.d.-c). The Jobs Act also directs $6 billion toward a new credit program for nuclear reactors that are at risk of retiring due to economic factors (Akin Gump, 2021, p. 14). Nearly $1 billion has already been appropriated toward small modular reactor demonstration projects, and the DOE is standing up an Advanced Reactor Demonstration Program to assist nuclear companies with technology development (The White House, 2024).

Then there is the zero-emission nuclear power production credit, which will be by far the largest source of support for nuclear over the next decade and will further entrench the role of the federal government in that industry. The Palisades and Three Mile Island projects, if successful, will be the first-ever decommissioned U.S. nuclear facilities to be restarted and will each receive more than $100 million annually from the credit if they qualify for the full $15/MWh. This generous credit prompted Microsoft—no doubt under the direction of billionaire co-founder and prolific energy investor Bill Gates—to buy the entire output of the Three Mile Island unit (Halper, 2024). The subsidized electricity will be earmarked to feed what is expected to be a voracious appetite for electricity from Microsoft's AI operations.

The JCT estimates the credit will cost $10.1 billion from 2024 to 2027, or an average or $2.5 billion annually (JCT, n.d.-a), but that estimate could be very conservative. Nuclear generated 775 million MWh of power in 2023 (EIA, n.d.-a), so if every nuclear power plant took advantage of the full $15/MWh credit, the total annual cost would be $11.6 billion a year. The true cost is likely to fall somewhere between these two numbers, and nuclear might become the second most subsidized source of electricity behind solar for the next decade.

Given the steep cost of restarting existing power plants, scaling up new nuclear technologies will likely be an even greater challenge. Restarting a 835 MW unit for $1.6 billion seems like a bargain compared to the $35 billion spent on the two new units Plant Vogtle in Georgia (Amy, 2024), but taxpayers are on the hook to offset some of the costs of new reactors thanks to the new PTC and ITC, which are technology neutral and will be available to any new nuclear projects, allowing them to opt for either a $26/MWh credit or a 30% credit on their capital costs. Furthermore, while the caps on liability for nuclear accidents, first established by the Price-Anderson Act in 1957, are set to expire at the end of 2025, this provision has been extended four times in the past and will likely be extended again next year (CRS, 2024).

A proper energy policy would remove the barriers to building new nuclear plants, as well as the subsidies and market distortions for unreliable power that make the reliable power from nuclear uncompetitive. Instead, the federal government is avoiding fixing these problems and is shifting the cost burden from utilities to taxpayers.

QCH with lifecycle GHG emissions below 0.45 kilograms of CO2e per kilogram of H_2 through the point of production are eligible for the full baseline credit. Taxpayers are eligible for 33.4% of the baseline credit if the CO2e emissions rate is between 0.45 and 1.5 kilograms; 25% of the baseline credit if the rate is between 1.5 and 2.5 kilograms; and 20% of the baseline credit if the rate is between 2.5 and 4.0 kilograms. These credit amounts are multiplied by 5 for producers meeting prevailing wage and qualified apprenticeship requirements. Credits are only available during the first 10 years after the facility is placed in service, and construction must begin by the end of 2032 (26 U.S.C. 45V).

Direct Subsidies and Loan Programs in the IRA and in the Jobs Act

In addition to the hundreds of billions in tax expenditures that are likely to result from the IRA, totaling the various energy and emissions-related appropriations in the IRA and in the Jobs Act yields an additional $204 billion in subsidies, $120 billion in the IRA (Akin Gump, 2022) and $84 billion in the Jobs Act (Akin Gump, 2021). This spending blowout is primarily directed at the EPA, the DOE, and the USDA, which and is more than double the combined 2025 budget requests for those agencies (OMB, 2024b, pp. 55, 73, 123). As with much of the pandemic era spending programs, pushing out so much money in a short amount of time will no doubt result in plenty of benefits for favored political constituencies and relatively few benefits for the American taxpayers who are providing the funds.

The IRA doles out $41.5 billion through the EPA, of which $27 billion is earmarked for the Greenhouse Gas Reduction Fund—a historic appropriation for an agency with an operating budget of about $10 billion (OMB, 2024b, p. 123). The appropriation is further broken down into $7 billion for a grant and loan program to support the deployment and use of zero emission technologies, $12 billion for competitive grants to support GHG reductions, and $8 billion for direct and indirect investments in low income and disadvantaged communities. The DOE received $28.15 billion in direct appropriations, and the U.S. Department of Agriculture got $36.35 billion, with $20 billion of that designated to a program designed to sequester GHGs in soil. The IRA also appropriates $2 billion to provide loans for the construction or modification of electric transmission facilities, which will primarily serve as a support for wind and solar installations located far from the urban areas that consume the electricity they generate.

For its part, the Jobs Act appropriated $50.8 billion to the DOE, of which $10 billion was for grid resiliency, $19 billion to the Department of the Interior, and $14.3 billion to the Department of Transportation. One of the largest programs is $5 billion—$1 billion each year from 2022 to 2026—for the National Electric Vehicle Infrastructure Formula Program to deploy electric vehicle charging infrastructure (FHWA, 2022). Another $2.5 billion was allocated for EV chargers and for hydrogen, propane and natural gas fueling infrastructure along designated "alternative fuel corridors" (Akin Gump, 2021), but as of May 2024, *Autoweek* reported that the total output of this investment was eight charging stations (Motavalli, 2024). Unfortunately, such outcomes are par for the course when federal agencies are tasked with spending vast sums of other people's money, while their ability to do so effectively far exceeds their management capabilities.

CONCLUSION

Unfortunately for U.S. taxpayers and advocates for limiting government intervention in energy markets, energy subsidies have become a permanent feature of the U.S. energy landscape. Without political pressure from taxpayers and energy consumers, the prospect of reducing energy subsidies and preventing the creation of new subsidies is dim. The growing size and lobbying power of the wind and solar industries, along with the consistent drumbeat from the environmental lobby to reduce carbon dioxide emissions by building more wind and solar, is a powerful force against any attempts to eliminate subsidies. Plans for hastening an "energy transition" to renewable energy, exemplified by the Inflation Reduction Act, will only increase the problems and costs of government intervention exponentially.

Meanwhile, many of the tax breaks for oil and gas production are permanent features of the tax code with no set expiration dates, and new programs for carbon capture and other technologies will expand the scope of fossil fuel subsidies into the foreseeable future. As explained above, most of these subsidies have fewer market-distorting effects than wind and solar subsidies, particularly on electricity markets. However, their existence perpetuates the idea that all energy production is subsidized, which justifies more government interventions in the U.S. energy economy. And new subsidies for carbon capture, hydrogen production, and advanced nuclear will create more businesses that depend on taxpayer support and will lobby for more subsidies to survive.

Another problem that confuses the policy landscape is the multitude of studies that are designed and written to give the impression that fossil fuels and nuclear energy receive far more subsidies than renewable energy sources. The fact that many of these flawed studies come from governmental bodies like the IMF, written by taxpayer-funded bureaucrats, makes the problem even worse. Attempts to classify inflated externalities as subsidies and failures to document the effects of subsidies on energy markets, especially electricity markets, do not advance the goal of eliminating energy subsidies and improving energy markets.

Instead of correcting supposed flaws in energy markets, energy subsidies exacerbate and enable the creation of more flaws by fostering industries and subindustries that depend on government support for their existence and profitability. As with all forms of cronyism, energy subsidies benefit politically connected businesses at the expense of taxpayers who do not notice the effects enough to demand changes. To effect that change, voters and businesses that pay for the subsidies must pressure lawmakers to eliminate these damaging policies. ■

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APPENDIX A: PREVIOUS REVIEWS OF FEDERAL ENERGY SUBSIDIES

This paper is far from the first to catalog and comment on federal energy subsidies. Several government reports along with numerous academic research papers and studies from nonprofit organizations have sought to define what energy subsidies exist and how much they cost. However, most of these studies look only at subsidies in the year or two prior to their publishing date or consider only certain types of energy subsidies, rather than compiling a complete set of data over multiple years. This practice leads to confusion because energy subsidies can vary dramatically from year to year depending on policies and market conditions. All energy subsidies are also not created equal. Subsidies for different energy sources tend to come through different avenues and have very different effects on energy markets.

The Energy Information Administration publishes a report roughly every three years titled "Direct Federal Financial Interventions and Subsidies in Energy" (EIA, 2023). The upside to this report is that it covers all types of energy production and uses all available government data. Most of the methodology detailed in the next section follows the EIA's methodology. This report's downside is that, until the 2023 report that covered all years from 2016 to 2022, it only analyzed data from one year instead of looking at all the data over the three years since the prior report.

Many studies rely on EIA data or follow their methodology, including this study. Previous work from our group has taken this approach, with a particular focus on wind subsidies (Erickson, 2018). The University of Texas at Austin's Energy Institute released a study in 2017 (Griffiths et al., 2017) that largely follows the EIA's methodology but explores in greater detail the different types of financial assistance and the practical effects of those subsidies on energy markets.

The Institute for Energy Research, a non-profit research institute focused on energy policy, has released a brief report following each of the last three EIA reports (IER, 2011; IER, 2015; IER, 2018; IER, 2023) detailing how wind and solar received more subsidies than fossil fuels in recent years, especially relative to the size of the respective industries. To perform this comparison, they divide the total subsidies for each resource by the amount of electricity generated by that resource to get the subsidy amount per megawatt-hour (MWh). We perform a similar comparison in this report.

The Government Accountability Office has released several reports over the past decade and a half. A 2014 report (GAO, 2014) commissioned by Senator Lisa Murkowski offered the most comprehensive review of energy subsidies performed up until that time, covering all subsidies granted from 2000 to 2013. Other GAO studies include reviews of oil and gas royalty payments on federal lands in 2007 (GAO, 2007), 2008 (GAO, 2008), and 2013 (GAO, 2013), in particular the effects of the Outer Continental Shelf Deep Water Royalty Relief Act of 1995. Outside of the obvious subsidies granted in that bill, it is not well-determined whether the royalty rates on most federal lands are below market rates and constitute a subsidy. This topic will be discussed further in **Appendix D**, where we outline different forms of possible financial support that we did not include in this paper.

The Congressional Budget Office has produced a series of reports and congressional testimony over the past decade under the title "Federal Support for the Development, Production, and Use of Fuels and Energy Technologies" (CBO, 2012; CBO, 2015; Dinan, 2017). These reports cover the longest time series, at least 30 years, but they only offer a detailed breakdown of the data for the most recent year.

By compiling annual data back to 2003, with a particular focus on the past decade, we can look at average subsidies over a long period and see the trends in different subsidies over time. Much of the discussion about energy subsidies has been confused by misunderstandings about what qualifies as a subsidy, the disparate impacts of different types of subsidies, and the large year-to-year variations in subsidy amounts. We hope this paper can help clarify that discussion and serve as a valuable reference for policymakers and energy policy observers.

APPENDIX B: METHODOLOGY

In general, this paper follows the methodology used by the EIA in their latest report (EIA, 2023) but compiles data every year instead of in three-year increments. The three primary forms of financial support covered in that report are tax expenditures, direct expenditures, and research and development spending. We chose not to include loan guarantees because the value of those subsidies is difficult to quantify and because they are infrequently used outside of some one-time programs from the 2009 stimulus. In total, we estimate that this report covers over 90% of federal subsidies directed toward energy-producing industries, excluding biofuels and end-use subsidies. A complete list of the federal programs covered in this report is provided in **Appendix C**.

This report emphasizes the energy industries that have some role in electricity production—coal, natural gas, petroleum, wind, solar, hydroelectric, geothermal, and nuclear. The purpose of this restriction is to enable a more even comparison between renewable resources that only produce electricity and fossil fuels that have a variety of other end uses. This distinction helps eliminate the complexities of including subsidies for transportation fuels, heating fuels, electric vehicles, and other products. Some data on those subsidies are mentioned briefly here but are not within the scope of this study.

An important comparison is the subsidies per unit of electricity produced from each energy resource. Because natural gas, petroleum, and coal have other end uses aside from producing electricity, we apply a conversion factor when making this comparison that reduces the subsidies for those fuels by the percentage used for electricity production. While we report the total amount of subsidies throughout the paper, in the section on subsidies for electricity, we only consider these adjusted amounts. This adjustment is described in greater detail in **Appendix E**.

As noted in the introduction, tax expenditures are the oldest and most common form of energy subsidy. Tax expenditures primarily take the form of reduced taxes or accelerated depreciation for certain activities and materials and tax credits that can be sold and traded to finance certain types of energy projects. While the former directly reduce the tax bill of the energy producer, the later reduce the tax bill for a financing company while providing extra capital or revenue for the energy producer.

Our primary source of tax expenditure data is the Office of Management and Budget's *Analytical Perspectives* reports on the federal budget (OMB, 2024a). In a couple of cases where OMB data was missing, noted in **Appendix C**, we use data from the Joint Committee on Taxation's annual Estimates of Federal Tax Expenditures (JCT, n.d.-b).

Direct expenditures are, as the name suggests, direct financial support for commercial projects. These types of programs were not common until the late 1970s but have become more prevalent in the past decade. Over the period from 2003 to 2019, Section 1603 grants (U.S. Department of the Treasury, n.d.) for renewable energy from the 2009 stimulus and rural energy programs within the Department of Agriculture (DOA, 2024) account for a large portion of direct expenditures.

Following the EIA's methodology (EIA, 2023), we also include a wide variety of programs supporting oil and gas, coal, and nuclear energy, most of which can be found by searching the Catalog of Federal Direct Assistance (CFDA) on the USASpending.gov website (USASpending.gov, n.d.). Direct expenditures to support energy consumption are not counted in this study. Some of these expenditures (i.e., the Low-Income Heating Assistance Program) are very large, costing billions of dollars over the past 15 years. However, this study considers only subsidies that directly support energy production, not end-use subsidies that support certain energy resources as a side effect. A full list of federal programs that are excluded from this study is provided in **Appendix D**.

Research and development grants are awarded to governmental institutions, academia, and private businesses in order to achieve goals such as national defense, public health, or, in this case, energy technologies that are more affordable and less harmful to the environment. The main premise of federal R&D spending is that private markets tend to underinvest in high-risk research or basic research without a near-term commercial purpose. Therefore, it is in the national interest for the federal government to invest in these types of projects.

This paper only covers R&D spending under the DOE, using the data from the agency's annual budgets (DOE, n.d.-d). The Statistical Tables by Appropriation section breaks down the R&D expenditures by each energy technology. Department of Defense energy R&D spending is not included because those projects are usually developed to support specific military applications and not to develop energy technologies for public use, although sometimes certain technologies do make their way into the public domain.

Finally, all dollar values are reported in constant 2019 dollars, adjusted for inflation using the consumer price index, excluding food and energy, from the St. Louis Federal Reserve Bank (FRED, 2024b).

APPENDIX C: FINANCIAL SUPPORT INCLUDED IN THIS ANALYSIS

Tables A1 to **A7** provide a detailed list of the programs included in this analysis and their total value from 2003 to 2023. For all tables in **Appendices C** and **D**, all amounts are in thousands of constant 2023 dollars. The references under the "Source" column are all provided in the "Methodology" section of the paper.

A couple of key assumptions for solar and wind subsidies are that the ITC is used entirely for solar and the PTC entirely for wind. The ITC can be applied to many different types of energy projects, but the EIA found that solar accounts for almost all of the credit, with the residual being negligible (EIA, 2023, p. 27). A separate ITC for homeowners, also called the "Credit for Residential Energy Efficient Property" (26 U.S.C. 25D), applies to several kinds of home energy generation technologies. While it is likely that the vast majority has been used for solar PV installations, we follow the EIA and count it as an end-use subsidy (EIA, 2018, p. 26).

Table A1. Financial support for solar

Program	Total Assistance	Source
Energy investment credit (ITC, assumed to be all solar)	50,451,730	OMB/JCT
Credit for residential purchases and installations of solar and fuel cells (assumed to be all solar)	214,333	OMB
Section 1603	13,344,017	Treasury
Department of Agriculture	8,466,736	DOA
Solar energy R&D	5,635,566	DOE
Total Solar	**78,112,383**	

Wind became eligible for either the ITC or PTC following the 2009 stimulus, but it is not possible to determine in any given year how many projects took one credit or the other. Following the EIA's methodology (EIA, 2023, p. 28), we assume that wind projects are choosing the PTC. The JCT only counts wind as receiving PTCs, with other energy resources assumed to be negligible (JCT, n.d.-a, p. 30), so we choose to apply the PTC entirely wind in this analysis.

Table A2. Financial support for wind

Program	Total Assistance	Source
Energy production credit (PTC)	46,312,447	OMB/JCT
New technology credit (PTC)	4,656,880	OMB
Section 1603	17,546,644	Treasury
Department of Agriculture	1,370,089	DOA
Wind energy R&D	2,299,181	DOE
Total Wind	**72,185,240**	

Hydroelectric and geothermal electricity production received no tax credits from 2003 to 2019 but did receive support from Section 1603 grants, the DOA, and consistent R&D spending.

Table A3. Financial support for hydroelectric

Program	Total Assistance	Source
Section 1603	700,281	Treasury
Department of Agriculture	424,127	DOA
Hydroelectric R&D	2,204,042	DOE
Total Hydropower	**3,328,449**	

Table A4. Financial support for geothermal

Program	Total Assistance	Source
Section 1603	998,868	Treasury
Department of Agriculture	20,559	DOA
Geothermal R&D	1,486,111	DOE
Total Geothermal	**2,505,538**	

A large subsidy for nuclear comes in the form of a reduced tax rate for decommissioning, which was created by the Energy Policy Act of 2005 (H.R. 6, 2005) to facilitate the retirement of aging nuclear plants. Befitting the origins of the DOE as the Atomic Energy Commission, nuclear continues to receive more R&D than any other energy generation technology.

Table A5. Financial support for nuclear

Program	Total Assistance	Source
Reduced tax rate for nuclear decommissioning funds	12,469,967	OMB
Advanced nuclear power production credit	30,000	OMB
Nuclear waste disposal siting	289,127	OMB
Transport of transuranic waste	425,210	CFDA
Nuclear education grant program	34,754	CFDA
Minority serving institutions program	17,364	CFDA
Scholarship and fellowship program	228,417	CFDA
Nuclear R&D	24,731,804	DOE
Total Nuclear	**38,226,644**	

In the 2000s, the largest subsidy for coal production was the alternative fuel production credit, which provided a tax credit for plants producing synthetic fuel from coal and biomass. This credit expired after 2007, although a portion of the credit for coke and coke gas applied to plants that were placed into service before 2010. Coal has received relatively few direct expenditures but did receive more than $3 billion in R&D funding from the 2009 stimulus, primarily for carbon capture research.

Table A6. Financial support for coal

Program	Total Assistance	Source
Amortization of certain pollution control facilities	6,948,656	JCT
Credit for investment in clean coal facilities	2,806,626	OMB
Capital gains treatment of royalties on coal	2,874,792	OMB
Exclusion of special benefits for disabled coal miners	960,731	OMB
Alternative fuel production credit	17,424,409	OMB
Expensing of exploration and development costs, coal	887,251	OMB
Excess of percentage over cost depletion, coal	2,208,128	OMB
Clean coal power initiative	444,291	CFDA
Carbon capture and storage - Future Gen	18,780	CFDA
University coal research	71,810	CFDA
Coal R&D	15,285,005	DOE
Total Coal	**49,930,479**	

One program for oil and natural gas that bears some further explanation is the temporary 50 percent expensing for the equipment used in the refining of liquid fuels (26 U.S.C 179C). This tax provision was enacted in the 2005 Energy Policy Act (H.R. 6, 2005) and allowed for accelerated cost recovery for refinery investments up to the end of 2013. It also applied to biomass refining (26 U.S.C. 45K), but since it is unclear how much applied to different types of refineries, we follow the EIA (EIA, 2018, p. 25) by applying the entire provision to oil and gas.

This tax expenditure is unique in that it was negative over the life of the program. A negative tax expenditure occurs when a provision provides a less favorable treatment than normal income tax law (JCT, n.d.-a, p. 3) (i.e., the opposite of a subsidy). Sometimes, this situation can occur temporarily when a tax break causes tax payments to be shifted over time, which is the case here. However, both OMB and JCT data show that there was more negative expenditure after the provision's expiration in 2013 than there was positive expenditure before it. None of the reports explain why this is the case, but for the sake of consistency, we choose to follow their accounting and simply note the discrepancy.

Another important set of subsidies in this category are the subsidies for fuel reserves, the most famous of which is the Strategic Petroleum Reserve. All three of these programs are designed to store crude oil or petroleum products and provide a buffer for consumers or the military during times of crisis, so they are better considered consumption subsides rather than production subsidies. However, since they provide price support by holding resources out of the market, they create an indirect subsidy for oil producers. Therefore, we choose to count them in this study.

Table A7. Financial support for oil and natural gas

Program	Total Assistance	Source
Expensing of exploration and development costs, fuels	13,178,465	OMB
Excess of percentage over cost depletion, fuels	18,817,012	OMB
Natural gas distribution pipelines treated as 15-year property	2,163,512	OMB
Amortize all geological and geophysical expenditures over 2 years	2,123,929	OMB
Exception from passive loss limitation for working interests in oil and gas properties	650,484	OMB
Temporary 50 percent expensing for equipment used in the refining of liquid fuels	-3,665,420	OMB
Marginal wells credit	921,230	OMB
Enhanced oil recovery credit	4,612,378	OMB
Pass through low sulfur diesel expensing to cooperative owners	62,417	OMB
Expensing of capital costs with respect to complying with EPA sulfur regulations	102,084	OMB
Exception for publicly traded partnership with qualified income derived from certain energy-related activities	11,715,634	JCT
Industrial CCS application	5,408,113	CFDA
Strategic Petroleum Reserve	469,628	DOE
Naval Petroleum & Oil Shale Reserve	200,135	DOE
Northeast Home Heating Oil Reserve	1,604,314	DOE
State heating oil and propane program	3,187	CFDA
Clean diesel emissions reduction	922,601	CFDA
State clean diesel grant program	184,987	CFDA
Pipeline safety program base grant	799,746	CFDA
Pipeline safety program one call grant	16,508	CFDA
Air emissions and energy initiative	10,086	CFDA
Clean fuels	300,806	CFDA
State and tribal coordination		CFDA
Oil and natural gas R&D	1,440,785	DOE
Total Oil and Natural Gas	**62,042,622**	

APPENDIX D: FINANCIAL SUPPORT NOT INCLUDED IN THIS ANALYSIS

As mentioned briefly in the methodology, this analysis only covers subsidies for energy resources used in electricity generation. By design, it does not cover subsidies for alternative transportation fuels, electric vehicles, and energy consumption or end-use subsidies. This appendix will explain a few of the important subsidies in these categories and show how large some of them are, often larger than the subsidies for electricity generating technologies that receive far more attention. These subsidies will be the focus of future studies.

Biofuels take in far more subsidies than any other energy resource—more than $120 billion from 2003 to 2023—and receive many other forms of support through mandates like the Renewable Fuels Standard. Because biofuels are not used for electricity generation, and their markets are largely separate from the fuels used for electricity, we do not include them in this study.

Table A8. Financial support for biofuels

Program	Total Assistance	Source
Alcohol fuel credits	1,556,559	OMB
Biodiesel and small agri-biodiesel producer tax credits	1,077,663	OMB
Alcohol fuel exemption	50,315,278	OMB
Biodiesel producer tax credit	42,780,493	OMB
Alternative fuel mixture credit	8,028,031	OMB
Section 1603	1,792,683	CFDA
Department of Agriculture	10,717,847	CFDA
Biofuel infrastructure partnership	71,374	CFDA
Bioenergy program for advanced biofuels	354,575	CFDA
Biomass crop assistance program	87,998	CFDA
Wood utilization program	200,949	CFDA
Sun grant program	34,477	CFDA
State bulk fuel revolving fund grants	15,855	CFDA
Forest biomass for energy	0	CFDA
Repowering assistance	14,016	CFDA
Community wood energy program	35	CFDA
Regional biomass energy programs	69,206	CFDA
Bioenergy R&D	6,433,117	DOE
Total Biofuels	**123,550,155**	

Subsidies for energy efficiency programs topped $110 billion over the 2003 to 2023 period. The EIA includes these subsidies in their reports, but we do not include them because they are consumer programs that only affect electricity demand and do not apply to any specific electricity production technologies.

Table A9. Financial support for energy efficiency programs

Program	Total Assistance	Source
Credit for residential energy efficient property	30,002,987	OMB
Credit for energy efficiency improvements to existing homes	19,427,442	OMB
Exclusion of utility conservation subsidies	6,047,418	OMB
Credit for construction of new energy-efficient homes	2,146,712	OMB
Allowance of deduction for certain energy-efficient commercial building property	2,346,764	OMB
Qualified energy conservation bonds	1,029,510	OMB
Credit for energy-efficient appliances	1,910,330	OMB
Weatherization assistance program	25,663,577	CFDA
Department of Agriculture	3,779,333	CFDA
Energy efficiency and conversation block grant program	6,926,704	CFDA
Energy efficiency appliance rebate program	457,294	CFDA
Green retrofit investments program	232,345	CFDA
Energy efficiency R&D	13,321,853	DOE
Total Energy Efficiency	**113,292,270**	

Electric vehicles and alternative fuel vehicles also receive significant tax credits and R&D support, over $17 billion since 2003. The tax credits for clean fuel-burning vehicles and refueling property apply to plug-in electric vehicles, alternative fuel vehicle refueling property, two-wheeled electric vehicles, and fuel cell vehicles. The IRA split this credit into two credits, one for vehicles and one for refueling, and significantly expanded the scope of the vehicle credit. The estimated cost of the vehicle credit in 2023 alone was more than $10 billion.

Table A10. Financial support for vehicle technologies

Program	Total Assistance	Source
Tax credits for clean fuel-burning vehicles and refueling property	19,911,303	OMB
Vehicle technology R&D	7,967,684	DOE
Total Vehicles	**27,878,987**	

Certain transmission and utility assets receive favorable depreciation and expensing in the tax code, with additional credits added by the IRA. Also, the DOE has spent several billion dollars on electricity delivery R&D, with more than $4 billion from the 2009 stimulus. Although a large portion of new transmission over the past 15 years has been built to support wind and solar development, particularly in Texas, these subsidies are not directed toward any specific generation technology and therefore cannot be categorized by energy resource.

Table A11. Financial support for electricity delivery and reliability

Program	Total Assistance	Source
15-year MACRS for certain electric transmission property	1,585,761	JCT
Deferral of gain from dispositions of transmission property to implement FERC restructuring policy	2,039,967	OMB
5-year carryback period for certain net operating expenses of electric utility companies	151,172	JCT
10-year MACRS for smart electric distribution property (from JCT)	100,000	JCT

5-year MACRS for certain energy property (from JCT)	100,000	JCT
Energy credit for qualified interconnection property (from JCT)	700,000	JCT
Electricity delivery and energy reliability R&D	11,401,344	DOE
Total Electricity Delivery and Reliability	**16,078,244**	

It is also important to note a significant subsidy for energy consumption, the Low-Income Home Energy Assistance Program (LIHEAP, n.d.). This program spent nearly $74 billion on heating and cooling assistance during the past 16 years, plus about $10 billion on weatherization, which we count as an energy efficiency expenditure. Energy consumption subsidies are by far the largest and most common form of energy subsidies globally, particularly subsidies for gasoline and home heating. The LIHEAP program alone has been larger than the total subsidies for any single energy resource except biofuels. However, because it is difficult to attribute the effect of LIHEAP to any single energy resource and because its impact on energy production is hard to discern, it is not possible to include this subsidy in this analysis.

Table A12. Financial support for energy consumption

Program	Total Assistance	Source
Low-Income Home Energy Assistance Program (end use)	73,847,883	LIHEAP
Total End-Use	**73,847,883**	

Programs to provide royalty relief to oil and gas companies drilling on federal land may be considered an in-kind subsidy if royalties are not being paid at market rates. According to a 2008 GAO study, royalty relief offered to oil companies in the 1990s when oil prices were low may have led to $21 billion to $53 billion in unrealized revenue during the 2000s when oil prices were high (GAO, 2008, p. 6). However, both the GAO and EIA (EIA, 2008, p. 13) note that optimizing royalty rates is difficult in light of future price uncertainty and the balance of lower royalties vs. higher revenues from leasing. While the GAO places a large value on the royalty relief programs, that value is, in fact, very difficult to quantify. Following the EIA methodology, we do not count royalty relief programs as a subsidy in this analysis.

There are also many subsidy programs that apply to multiple energy technologies and therefore cannot be used for comparative purposes. Most of these programs apply to renewable energy technologies and cannot be broken out by individual technologies. An example is the Industrial CO2 Capture and Sequestration tax credit, which incentivizes power plants to install carbon capture technologies to reduce CO2 emissions. Because this tax credit can be used by coal or natural gas power plants, it is difficult to calculate how much of an impact this tax expenditure has on each type of technology.

Table A13. Unclassified forms of financial support

Program	Total Assistance	Source
Partial expensing for advanced mine safety equipment	43,006	JCT
Credit for business installation of qualified fuel cells and stationary microturbine power plants	238,501	OMB
Advanced energy manufacturing facility investment tax credit	2,464,513	OMB
Industrial CO_2 capture and sequestration tax credit	2,439,892	OMB
Exclusion of interest on energy facility bonds	798,116	OMB
Credit for holding clean renewable energy bonds	2,002,655	OMB

Advanced manufacturing investment credit	0	OMB
Advanced manufacturing production credit	430,000	OMB
Clean fuel production credit	0	OMB
Clean hydrogen production credit	340,000	OMB
Energy credit for energy storage	100,000	JCT
State energy program	5,737,668	CFDA
State energy program special projects	275,768	CFDA
Renewable energy outreach	1,029,003	CFDA
Green jobs innovation fund grants	1,107,254	CFDA
Capital assistance program	440,849	CFDA
Denali Commission program	1,181,396	CFDA
Rural Energy for America program	1,056,387	CFDA
Assistance to high energy cost rural communities	143,885	CFDA
Minerals and mining on Indian lands	51,060	CFDA
Advanced Research Projects Agency - Energy	5,762,908	DOE
Hydrogen and fuel cell technologies R&D	1,849,541	DOE
Total Unclassified	**27,492,404**	

APPENDIX E: NATURAL GAS, PETROLEUM, AND COAL SUBSIDIES FOR ELECTRICITY

When comparing the total subsidies for electricity generation, it is important to note that natural gas, petroleum, and coal have a wide variety of uses outside of electricity, whereas wind, solar, hydroelectric, geothermal, and nuclear are used solely for electricity. About 20% of the total energy the U.S. produces from natural gas and petroleum is used for electricity, with the rest going to transportation, heating, exports, and other uses (EIA, n.d.-c; EIA, n.d.-d). Sixty-two percent of U.S. coal production in 2023 was used for electricity production, with the rest being exported or used for steel or combined heat and power production.

When comparing subsidies for electricity production, we account for these alternative uses of coal, natural gas, and oil by multiplying the total subsidy by the percentage of energy production that is used for electricity.

$$Energy\ Subsidy\ \$_{\text{Fuel X, Year i}} \text{ X } \frac{Energy\ Used\ in\ Electricity_{\text{ Fuel X, Year i}}}{Total\ Energy\ Produced_{\text{Fuel X, Year i}}} = Electricity\ Subsidy\ \$_{\ Fuel\ X,\ Year\ i}$$

Using the formula above, we calculated an adjustment factor for coal, natural gas, and oil each year from 2003-2023 and used the adjusted numbers (as noted in the paper) to compare subsidies for electricity generation. The energy used for electricity generation (EIA, n.d.-c) and the total energy produced (EIA, n.d.-d) from each fuel source comes from the EIA.

ABOUT THE AUTHOR

Brent Bennett, Ph.D., is the policy director for Life:Powered, an initiative of the Texas Public Policy Foundation to raise America's energy IQ.

As part of the Life:Powered team, Dr. Bennett regularly speaks with policymakers, energy experts, and industry associations across the country. He is responsible for researching, fact-checking, and spearheading many of the team's policy and regulatory initiatives. He has written extensively on how America has improved its environment while growing its energy use and on future energy technologies.

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