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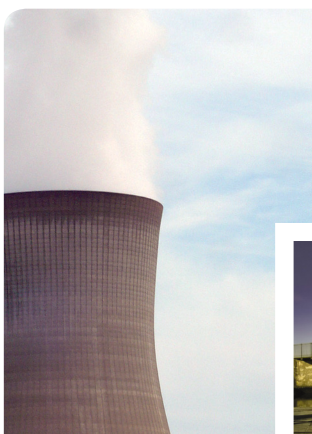
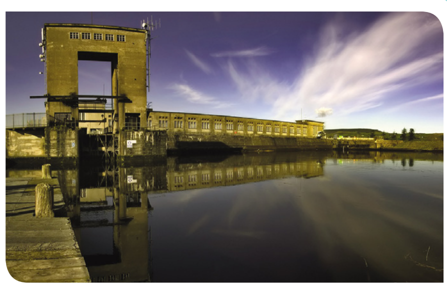
The Full Cost of Electricity (FCe-)

Federal Financial Support for Electricity Generation Technologies

PART OF A SERIES OF WHITE PAPERS





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THE FULL COST OF ELECTRICITY is an interdisciplinary initiative of the Energy Institute of the University of Texas to identify and quantify the full-system cost of electric power generation and delivery – from the power plant to the wall socket. The purpose is to inform public policy discourse with comprehensive, rigorous and impartial analysis.

The generation of electric power and the infrastructure that delivers it is in the midst of dramatic and rapid change. Since 2000, declining renewable energy costs, stringent emissions standards, low-priced natural gas (post-2008), competitive electricity markets, and a host of technological innovations promise to forever change the landscape of an industry that has remained static for decades. Heightened awareness of newfound options available to consumers has injected yet another element to the policy debate surrounding these transformative changes, moving it beyond utility boardrooms and legislative hearing rooms to everyday living rooms.

The Full Cost of Electricity (FCe-) study employs a holistic approach to thoroughly examine the key factors affecting the *total direct and indirect costs* of generating and delivering electricity. As an interdisciplinary project, the FCe- synthesizes the expert analysis and different perspectives of faculty across the UT Austin campus, from engineering, economics, law, and policy. In addition to producing authoritative white papers that provide comprehensive assessment and analysis of various electric power system options, the study team developed online calculators that allow policymakers and other stakeholders, including the public, to estimate the cost implications of potential policy actions. A framework of the research initiative, and a list of research participants and project sponsors are also available on the Energy Institute website: energy.utexas.edu

All authors abide by the disclosure policies of the University of Texas at Austin. The University of Texas at Austin is committed to transparency and disclosure of all potential confli ts of interest. All UT investigators involved with this research have filed their required fi ancial disclosure forms with the university. Th ough this process the university has determined that there are neither confli ts of interest nor the appearance of such confli ts.

This paper is one in a series of Full Cost of Electricity white papers that examine particular aspects of the electricity system.

Other white papers produced through the study can be accessed at the University of Texas Energy Institute website:

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Federal Financial Support for Electricity Generation Technologies

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ABSTRACT

In this report, we compile data from government and other sources on fi ancial support offered to electricity generating technologies by the federal government for the years 2010 and 2013, as well as forecast spending for 2016 and 2019 to refl ct the impact of the programs expected to continue in the near future. We evaluate data across the reports for consistency and relevance to our goal of calculating a dollar-per-megawatt-hour ($/MWh) value. We focus on federal fi ancial support programs with the explicit intent to provide fi ancial uplift o specific eneration technologies or fuels extensively used in power generation. Th s report does not discuss the motivations for these fi ancial support policies or their effectiveness.

We assessed 116 federal programs that provide support to the energy sector with a total value of approximately $60 billion per year. Of these, we believe 76 programs totaling $17.9 billion offered fi ancial support to electricity generation in 2013—the highest level of support in our study period due to American Recovery and Reinvestment Act (ARRA) funding. We estimate that these same programs will provide lower levels of fi ancial support in the future: approximately $11.5 billion in 2016 and $14.2 billion in 2019. Key takeaways include:

- The total value of fi ancial support to the electricity sector from the federal programs we identifi d represented about 0.1% of U.S. GDP in 2013. Without the ARRA funding, the future support will account for a smaller share of the GDP.

- The total value of federal fi ancial support for the fossil fuel industry is comparable to that for the renewables industry. When considering only the portion of fossil fuel support that relates to electric power, however, renewables receive larger support.

- Renewables receive signifiantly more support than conventional technologies on the basis of annual support relative to annual generation from all existing generation assets ($/yr / MWh/yr = $/MWh). Depending on the year, coal receives $0.5-$1/MWh, hydrocarbons $1/MWh, and nuclear $1-2/MWh. Support to wind falls from $57/MWh to $15/MWh over our study period, and support to solar declines from $260/MWh to $43/MWh.

- On a $/MWh basis, renewables support is declining rapidly because our calculation method is based on country-wide annual $ and MWh values, *per technology*, rather than on an *individual project and its lifetime generation*. Spending on coal, hydrocarbons, and nuclear is stable. As generation from renewables grows, the $/MWh differential between renewable and conventional technologies is forecast to decline.

- On a portfolio wide basis, electricity technologies recieve finanical support worth $3-5/MWh.

- Renewable generation is supported by direct subsidies while generation from fossil fuels is supported via indirect subsidies. That is, the government encourages the production of fossil fuels generally, but not their burning for electric power specifi ally.

- There are no subsidies that directly encourage the burning of hydrocarbons for electricity production. Coal subsidies primarily target externalities, but coal also receives approximately 3% of its support through production tax credits.

- Nuclear subsidies are aimed at plant costs (decommissioning, insurance).

This report DOES	This report DOES NOT
Consider federal financial support	Consider state or local support
Focus on generation technologies and fuels used extensively	Assess historical cumulative support
Look forward in terms of financial support mechanisms expected to continue in the near future	Consider support programs that target consumers or non-electricity energy
	Include externalities (environmental or otherwise)
	Include the national security expenses

1 | INTRODUCTION

The purpose of this report is to estimate a per-unit quantity, $/MWh, of different federal fi ancial support mechanisms for the production of electric power from different technologies. There are many fi ancial support mechanisms at federal, state, and local levels that differ in terms of their intent, directness, longevity, and relevance for power generation. We focus primarily on the 2010s, identify programs that are most relevant to power generation, and quantify the magnitude of federal support primarily based on government data. State and local subsidies will be addressed in future studies. First, however, it is useful to understand the broader context for this analysis.

A reliable and affordable supply of energy is crucial for the health of an economy. Energy has been a driver of growth for 200 years and studies have found a strong, positive relationship between energy consumption and gross domestic product. It is unsurprising, therefore, that energy sources, fuels, and generation technologies have received assistance in a multitude of forms since the founding of the U.S., including direct funding, tax preferences, and other forms of support. Some support programs have facilitated access to federal lands, developed common infrastructure, or improved the commercial viability of energy projects. For example, in the ninetieth century, the U.S. government leased great timber stands and coal seams on advantageous terms (e.g., low royalty rates). In the twentieth century, some tax policies aimed at increasing domestic oil and gas production. Eisenhower's Atoms for Peace program funneled billions of dollars into nuclear power research and development (R&D) in the 1950s (Pfund & Healy 2011, 9-12). More recently, renewable energy has benefited from cash grants, direct spending on R&D, and tax preferences.

As the goals of federal energy policy shifted over time, so too did the support offered by the government to different products and technologies. While proportional value associated with some programs has changed, programs are rarely eliminated and the total value in real terms has increased. For example, the Congressional Budget Offi , CBO, (2015) provides a summary of the costs of energy-related federal tax preferences[1] by fuel or technology between 1985 and 2015 (CBO 2015, 4). Where once the government targeted energy production generally, it has shifted its spending focus towards cleaner, lower-carbon sources. Before 2005, the fossil fuel industries (primarily oil and natural gas but also some coal producers) accounted for 60-70% of the total cost of energy tax preferences. Since 2009, the share of fossil fuels fell to about 20%, with tax preferences to renewables and to energy effici cy accounting for 70-80% of the total cost of these preferences (Figure 1).

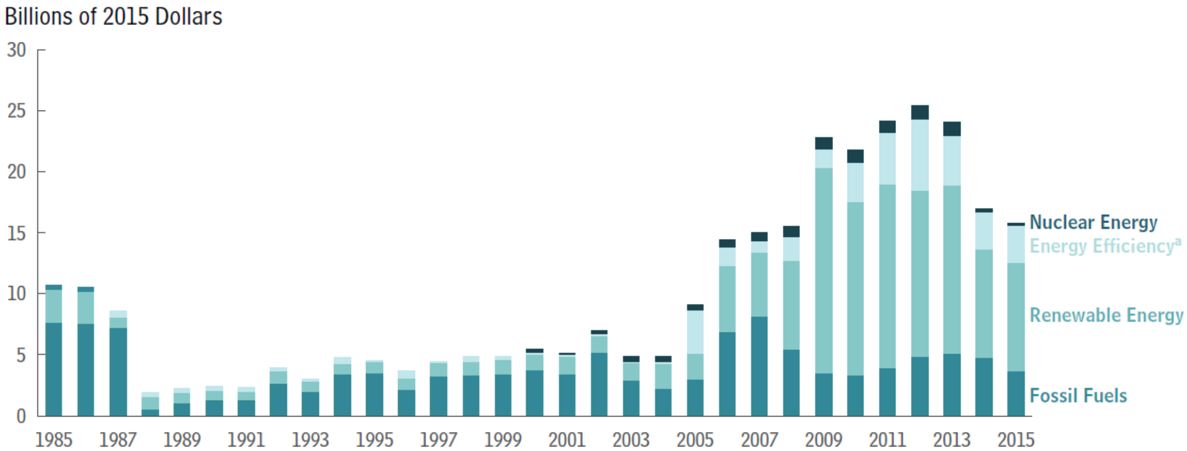
Total spending on fi ancial support has also varied over time but has been trending upward since the mid-2000s. The CBO calculates that total cost of tax preferences, which was almost always below $5 billion in real terms, started to increase in 2005 and peaked at more than $25 billion in 2012.[2] Th tax preferences tabulated by the CBO represent a subset of fi ancial support mechanisms, albeit the largest category for electricity generation considered in this report. It is also relatively easy to identify the intent of the public policy with tax preferences. The CBO analysis is not a perfect match to our analysis in this report. It includes spending on all energy-related programs not just electricity and does not differentiate between one-off rograms and long-term trends.

1 Although called "preferences" in this CBO report, these are mostly the same programs considered under "tax expenditures" in JCT (2015). CBO has traditionally relied on the Joint Committee staff for the production of its annual tax expenditure publications. We use the two terms interchangeably. Other terms commonly used to describe these programs include tax incentives and tax breaks. We will use "spending", following the common practice, to include these tax provisions although government does not "spend" money unlike the direct expenditure programs.

2 In addition, there is Department of Energy (DOE) support for basic R&D, which has averaged $7.6 billion (in $2015) per year in the early 1990s, about $4 billion between 1998 and 2008, and $4.7 billion a year since 2010. With more than $31 billion funding from the American Recovery and Reinvestment Act of 2009 (ARRA), DOE's financial support budget surpassed $46 billion in 2009 (but ARRA funds were spent over time not all in 2009).

FIGURE 1

Costs of Tax Preferences (Expenditures) reproduced from CBO (2015)



Source: Congressional Budget Office based on data from Molly F. Sherlock, *Energy Tax Policy: Historical Perspectives on and Current Status of Energy Tax Expenditures*, Report for Congress R41227 (Congressional Research Service, May 2, 2011), p. 26, and updated data from the Congressional Research Service; Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2014–2018*, JCX-97-14 (August 5, 2014), pp. 23–25, http://go.usa.gov/3zHY5; staff of the Joint Committee on Taxation, "Estimated Revenue Effects of H.R. 5771, The 'Tax Increase Prevention Act of 2014,' Scheduled for Consideration by the House of Representatives on December 3, 2014," JCX-107-14R (December 3, 2014), http://go.usa.gov/3zHDF; and Office of Management and Budget, *Budget of the U.S. Government, Fiscal Year 2016: Appendix* (February 2015), p. 1010, www.whitehouse.gov/omb/budget/Appendix.

Notes: The estimates of the costs of individual tax preferences do not account for any potential interactions between preferences or include the costs of those tax provisions estimated to result in less than $50 million in forgone revenues. Nor do they reflect the amount of revenues that would be raised if those preferences were eliminated and taxpayers adjusted their activities in response to those changes.

a. Includes the costs of tax preferences related to the transmission of electricity, which are typically small.

The federal fi ancial support to the energy sector is minute when put into its larger macroeconomic context. The gross domestic product (GDP) of the U.S. in 2015 was roughly $18 trillion. According to the Joint Committee on Taxation, total federal tax expenditures between fiscal years 2015 and 2019 are estimated at about $7.2 trillion, or about $1.4 trillion per year (JCT 2015, Table 1). Only about $1 trillion out of $7.2 trillion is directed to corporations with the rest going to individuals (for assistance with housing, health, income and other social services). Tax expenditures to the energy sector amount to only about $71 billion, or less than 1% of the total tax expenditures and less than 0.1% of the five-year GDP (assuming a GDP growth rate of 2% per year between 2015 and 2019).[3] Energy companies are allocated about $52 billion (~$32 billion to renewables) and individuals receive over $18 billion of these tax expenditures.

3 Total federal financial support to the energy sector is larger; but, tax expenditures account for the largest portion of targeted support (52% to 89% in the years we analyzed).

2 | WHAT IS A SUBSIDY AND WHAT DO WE INCLUDE IN OUR ANALYSIS?

Financial support is commonly called subsidy. While we will use subsidy as a short-hand for fi ancial support throughout this report, specific programs have different intents and methods, which influences their economic impact on energy projects and costs as well as government cash fl w (e.g., forsaken revenues versus direct expenditures). Over the years, numerous entities, including various government agencies and civil society organizations, have produced reports to document federal fi ancial support mechanisms and their contributions to different energy sectors, fuels and technologies. These analyses employ different defin tions of subsidy and scopes of analysis yielding results that differed by more than an order of magnitude.

For example, a study of fossil fuel production subsidies commissioned by the U.S. Treasury identifi d eleven provisions worth $4.7 billion per year (UST 2014). By contrast, a study, sponsored by the Organization for Economic Cooperation and Development (OECD) of energy subsidies in the U.S. identifi d $74 billion in spending each year (Koplow, 2007, 95). UST (2014) only includes provisions targeting energy production while Koplow (2007) includes a host of spending related to defense, foreign aff irs, and transportation infrastructure. The intent of government support included in UST (2014) is clear and it is relatively straightforward to estimate the magnitude of this support. On the other hand, government intent and costs are less easy to confi m for categories included in Koplow (2007) as some of them such as global spending on defense, military construction, and foreign operations and export fi ancing are not directed to any particular industry **to build generation in the U.S.** although they may have benefited the energy industry **globally** along with other infrastructure industries indirectly. Th s comparison illustrates the disagreement regarding not only the categories to include as a subsidy but also on the set of assumptions needed to estimate the magnitude of each category.

Dictionary defin tions of subsidy focus on direct money fl ws but the Latin root of the word subsidy suggests other forms of support.[4] Th Global Subsidies Initiative (GSI) offers a broader defin tion: "A subsidy is a fi ancial contribution by a government, or agent of a government, that confers a benefit on its recipients" (Steenblik 2007, 8). Th s defin tion, albeit somewhat vague, widens the scope in at least two ways: fi st, a "benefit" can be extended beyond a direct payment, and, second, recipients can include consumers and public entities not just businesses. The GSI then suggests nine categories of subsidy.[5] **Given the scope of our report, we remain closer to the dictionary definition and use the term "subsidy" in the rest of the report as a short-hand for federal programs with the explicit intent to provide financial support to electricity generation or fuels used extensively in power generation.** Next, we provide detailed rationale for inclusion and exclusion of specific ategories in this analysis.

4 The Oxford English Dictionary defines a subsidy as "A sum of money granted by the government or a public body to assist an industry or business so that the price of a commodity or service may remain low or competitive." The Merriam-Webster definition of subsidy is almost identical: "money that is paid usually by a government to keep the price of a product or service low or to help a business or organization to continue to function." The Latin root of the word subsidy, **subsidium**, means "support, assistance, aid, help, protection" and suggests broader possibilities that could include forms of assistance other than direct payments.

5 Cash grants and other direct payments (e.g., biofuel producers in the U.S., agricultural subsidies), tax concessions (e.g., tax preferences such as exemptions, credits, and deferrals discussed earlier), in-kind subsidies (e.g., low-rent housing, bridge to serve a community or an industrial facility, access to public lands for free or at a below-market price), cross subsidy (e.g., electricity prices to residential, commercial and industrial users, fuel subsidies—low-priced diesel, high-priced gasoline), credit subsidies and government guarantees (e.g., low-interest loans, loan guarantees), hybrid subsidies (tax engineering such as tax increment financing), derivative subsidies (a catch-all term to capture downstream and upstream impacts of a subsidized project such as aluminum smelters associated with large hydroelectric dams), government procurement (e.g., requirements to buy domestic), and market price support (e.g., agricultural commodity prices set by governments, import tariffs—e.g., on ethanol in the U.S.) (Steenblick 2007)

Included Types of Financial Support

We identifi d three categories, each with their own sub-groups with sizeable impact on electricity generation: direct expenditures, tax expenditures (also known as “tax preferences”), and government guarantees. There is data reported by government agencies on these categories. We provide detailed description of several high-value programs in Box 1.

- **Direct expenditures** are a cash transfer from the government to industry, academia, or individuals. They can take many forms including cash grants for applied research and development, pilot projects, and jobs programs.
- **Tax expenditures** reduce government tax revenues by granting special exemptions to baseline tax rules.[6] Tax expenditures are typically the largest component of fi ancial support. These can take the form of tax credits, tax deductions (allowance to deduct certain expenditures from taxable income), preferential tax rates (e.g., items being categorized as capital gains instead of ordinary income), or accelerated depreciation.
- **Government guarantees** shift financial risks from private entities to the public sector. Our analysis includes one program, the Price-Anderson Nuclear Industries Indemnity Act, which provides nuclear power plants no-fault, no-cost liability insurance for claims in excess of $12.6 billion. The Act does not ameliorate the risk of nuclear accidents, only who is liable in the event of a catastrophe. Although insurance subsidies differ from tax expenditures, for practical reasons we incorporate Price-Anderson in the tax expenditure section of this report.

6 Tax expenditures are defined under the Congressional Budget and Impoundment Control Act of 1974 (the “Budget Act”) as “revenue losses attributable to provisions of the Federal tax laws which allow a special exclusion, exemption, or deduction from gross income or which provide a special credit, a preferential rate of tax, or a deferral of tax liability.”

Excluded Types of Financial Support

Our analysis excludes a number of subsidy categories for several reasons: they are not relevant for electricity generation, they are technology-neutral, and/or there is no government data. These include:

- **Technology-neutral financial support** such as tax expenditures targeting the electricity sector generally and consumer-directed support mechanisms that help with energy bills, induce energy effici cy, and similar technology-neutral purposes. Transmission assets, for example, are offered accelerated deprecation; but, this infrastructure, in general, benefits all types of electricity generation. In some cases, states have supported the construction of transmission lines that are intended to provide access to renewable power generation facilities, but these state programs are not included in our analysis of federal programs. Similarly, Low Income Home Energy Assistance Program (LIHEAP) funds are spent on electricity, natural gas, and fuel oil used to heat homes. LIHEAP spending is driven by the goal of providing relief to low-income consumers.
- **In-kind subsidies** can include a wide range of programs, many of which focus on consumers and non-energy sectors. For our purposes, the most commonly referenced energy sector item relates to leasing of federal lands or off hore for natural resource exploration and extraction activities such as logging, mining and drilling. If the government receives less than the “fair” market value of the land, then it has foregone potential revenue that should have been collected, assuming that the resource would have been developed without the terms offered by the government. Lease terms for a given parcel are established in advance and exist in perpetuity so foregone revenues may accumulate for decades, depending on prices of resources produced. In-kind subsidies

are excluded from our accounting because there is no government data and there is no consensus over the magnitude of foregone revenue by the independent studies surveyed for this report. Perhaps, more importantly, there is no evidence that the government intended to offer submarket leases. In Appendix 1, we provide a detailed discussion of this category and our reasoning for exclusion.

- **Credit subsidies** such as loan guarantees can be important for some technologies (new nuclear plants, and fi st-of-its-kind technologies such as integrated gasifi ation combined cycle with carbon capture and sequestration); but we exclude them in this analysis because such projects are infrequent, present value calculations associated with new loan guarantees are highly uncertain, and they are designed as revenue neutral.

- In the U.S., there is no direct **market price support** for electricity at the federal level. There is support through low-income pricing in some states. **Cross-subsidies** may arise during the electricity ratemaking process by state regulators to favor one class of customers at the expense of another. Such support is technology-neutral from the perspective of power generation.

- **Legislative or executive action** can offer a kind of cross-subsidy. Laws and executive orders can mandate, or restrict, the use of certain fuels for generation, or promote certain technologies. For example, the Powerplant and Industrial Fuel Use Act of 1978 (PIFUA) banned the use of natural gas in electricity generation by utilities for a decade—the gas was deemed too valuable to burn for power generation. But, combined with the Public Utility Regulatory Policies Act of 1978 (PURPA), natural gas became the fuel of choice for non-utility generators. The Clean Air Act's requirements on power plant emissions is technology neutral although fossil fuel plants (especially coal-fi ed units) were impacted more given their higher emissions. Whether targeting a specific uel in the case of PIFUA or criteria pollutants like the CAA, these policies, often interacting with other federal or local laws and policies, may induce markets to value certain technologies more but do not provide direct subsidies or tax incentives to any technology.

- **Unpriced negative externalities** are conceptually distinct from subsidies. The cost of negative externalities in the energy sector (such as damages from emissions—SO_2, NOx, CO_2, Hg, bird kills by wind turbines, ecosystem impacts from acid rain or coal mine drainage or mining for minerals used in PV and battery manufacturing, and so forth) can be internalized through regulatory mechanisms such as Pigouvian taxes, cap-and-trade systems, or mandates once there is political consensus on the cost of the externality. Many programs have been put in place in the U.S. nationwide or regionally (e.g., SO_2 cap-and-trade) to internalize cost of agreed-upon externalities. Certain externalities such as coal mine remediation or treatment for black lung disease are supported via industry supported trust-funds and are currently costless to the federal government – this could change in future years if coal companies become insolvent. The magnitude and impact of some environmental externalities are explicitly discussed in two other FCe- whitepapers: *EPA's Valuation of Environmental Externalities from Electricity Production* (Wu et al, 2016) and *New U.S. Power Costs: by County, with Environmental Externalities* (Rhodes et al, 2016).

- **Indirect or very-long-term R&D funding.** Th Department of Energy funds applied research as well as basic science – we include the former but not the latter. Energy R&D is often intended to help a particular technology, but only sometimes actually does, or does so only after a long lag. For example, nuclear energy today benefits from the US Navy's Nuclear Propulsion programs of the 1940s and 1950s. In future decades, the electric power sector may benefit from today's fusion research – but it is difficult to establish cost causation. Our use of applied science aligns with the interpretation favored by the Energy Information Agency. The basic research we exclude is worth more than $10 billion annually (AAAS 2016)

Select High-Value Financial Supports Included in the Study:

PRODUCTION TAX CREDIT

The renewable electricity production tax credit is a per-unit-of-generation ($/MWh) tax credit for electricity generated by qualifying resources. A resource is eligible to collect the PTC for a duration of 10 years after the facility is placed into service. Wind farms are the primary beneficiary of the PTC although eight other technologies are eligible. The credit was introduced in the Energy Policy Act of 1992 and has been extended several times since then, albeit with years of no credit in-between. The Consolidated Appropriations Act of 2016 set the PTC's value at $23/MWh for facilities commencing construction in 2016, after which date, technologies other than wind will no longer receive the PTC. New wind power projects will continue to receive PTC as long as they are in the books through 2020, albeit at declining amounts. Presently, wind farms built after 2020 are ineligible for the PTC. Although some resources are eligible for both the PTC and the Investment Tax Credit (ITC), a given project may only receive credits from one of the programs.

The PTC is a "non-refundable" credit, meaning that the PTC can only drive a generator's tax burden to zero and cannot create a negative tax obligation where the government pays the generator. It is possible for a company to not generate enough profits in a year to take advantage of the full amount of the PTC accumulated on the basis of eligible energy generation. Tax equity investors play an important role in helping wind developers capture more of the PTC's value by matching high tax liability companies with low tax burden generators (the two parties sharing the incremental value). These credits are sometimes referred to as "Section 45" credits because they fall under that section of the U.S. Tax Code.

INVESTMENT TAX CREDIT

The investment tax credit (ITC) offers a non-refundable, one-time tax credit to those who have installed qualified electricity resources. The ITC primarily benefits the solar industry although wind, geothermal, and several other resource types are eligible. The ITC targets generation capacity (MW) rather than generation (MWh). Initially introduced in 2008, it was most recently updated in the Consolidated Appropriations Act of 2016. For solar systems built before 2020, the ITC offers a 30% tax credit for residential and commercial properties (Sections 25D and 48, respectively). The credit steps down to 10% between 2020 and 2022 and remains at that level thereafter. Other resources (including wind, geothermal, micro turbines, and combined heat and power) receive credits of 10% to 30% depending on year and technology.

SECTION 1603 CASH GRANTS

The American Recovery and Reinvestment Act of 2009 (ARRA), commonly referred to as "the Stimulus," included a program offering payments for certain energy projects in lieu of tax credits. The Section 1603 grant program, now expired, offered a credit that could be selected in place of PTC or ITC. Unlike the PTC and ITC, Section 1603 Grants were refundable. Developers could submit a receipt to the U.S. Treasury for a project's capital costs and the federal government would write a check for 30% of that cost, irrespective of their tax liability. This allowed firms with modest tax burdens to receive a full 30% credit without relying on tax equity markets or other complex financial transactions.

EXPENSING OF INTANGIBLE DRILLING COSTS

Intangible drilling costs (IDCs) are the costs necessary for drilling and preparing wells for oil and gas. These costs have no salvage value and could include transport of a drilling rig, drilling muds and water, road building, and wages. Instead of deducing IDCs over the lifespan of the well, most companies can deduct 100% of these costs in the year incurred. Large companies may deduct 70% in the first year and the rest is depreciated over the next five years. IDC expensing has existed in the Internal Revenue Code since the Revenue Act of 1913. The American Petroleum Institute argues that IDC expensing is analogous to tax provisions for advertising and pharmaceutical R&D (API 2016). JCT (2015) reports just over $5.5 billion in tax expenditures for the expensing of R&D by all qualifying industries.

RULES GOVERNING MASTER LIMITED PARTNERSHIPS

MLPs are a unique business structure that is taxed like a partnership but traded like a corporate stock. Unlike other corporate structures (e.g., C corps), MLPs are subject to a single layer of taxation where income flows from the partnership to equity owners who pay taxes on income as individuals. The structure also allows for deferred taxation on distributions to partners and lower tax rates on carried interest by MLP general partners. While MLPs are not only used for energy businesses, most are. Congress established MLPs as a business structure in the 1980s but scaled back their usage in 1987. A narrow exemption allowed for continued use of the structure for MLPs that derived 90% of their income from passive sources or natural resources. In 2016 the MLP Association, an industry trade group, estimated the total market capital of MLPs at $361 billion, more than 89% of which was in the fossil fuel sector (MLP Association 2016, 3-5).

3 TOTAL FEDERAL FINANCIAL SUPPORT FOR ELECTRICITY GENERATION

In this section, we report on total cost of subsidies in the three included categories, and classify each in terms of proximity / directness to fi al MWh generated. Our report is based primarily on data and analyses found in *Direct Federal Financial Interventions and Subsidies in Energy in Fiscal Year 2013* by the Energy Information Administration (EIA 2015). The EIA gathers information on direct expenditures from a variety of government sources but relies on the Joint Committee on Taxation (JCT) and the Office f Management and Budget (OMB) when tabulating tax expenditures. The EIA tabulates most costs for 2010 and 2013 but there are a modest number of programs EIA excludes from its analysis that we believe should be included. For the 2016 and 2019 forecasts, we rely heavily on data from the JCT's *Estimates of Federal Tax Expenditures* published in 2015 (JCT 2015) and the OMB's *Analytical Perspectives: Budget of the U.S., Fiscal Year 2017* (OMB 2015). We also consult the work of other government agencies like the Congressional Budget Office (O), Congressional Research Service (CRS) and Government Accountability Office (O); industry organizations such as the American Petroleum Institute (API); and civic organizations such as the Environmental Law Institute (ELI). These secondary sources often rely on the work of the JCT and OMB in their analysis.

Direct Expenditures

Direct expenditures are cash outlays from the government that pay for specific rograms. For 2013, EIA found 46 different programs,

TABLE 1:

Direct Spending on Section 1603 Grants, R&D, and other Programs in 2010 and 2013 ($ million, nominal).

	Section 1603		R&D		Other		Total	
Fuel Type	**2010**	**2013**	**2010**	**2013**	**2010**	**2013**	**2010**	**2013**
Coal	-	-	307	202	46	74	353	276
HC	-	-	9	34	45	50	54	84
Nuclear	-	-	446	406	46	9	492	415
Renewables	4,481	8,169	1,060	976	26	11	5,567	9,156
Wind	4,002	4,273	58	49	1	1	4,061	4,323
Solar	359	2,941	320	284	22	6	701	3,231
Other-RE	120	955	682	643	3	4	805	1,602
Biomass	112	310	301	251	1	1	414	562
Geothermal	4	310	2	2	1	2	7	314
Hydropower	-	196	11	10	-	1	11	207
Other	4	139	368	380	1	-	373	519
Total	**4,481**	**8,169**	**1,822**	**1,618**	**163**	**144**	**6,466**	**9,931**

Notes: Direct expenditure data is from the EIA (2015); program-by-program descriptions can be found in that document. *Other-RE is the sum of Biomass, Geothermal, Hydropower, and other renewables. R&D from EIA (2015), Table 15. Section 1603 spending from EIA (2015), Table 12. EIA relied on the U.S. Department of Energy, Office of the Chief Financial Officer, Base Financial Data, FY 2010 and FY 2013; Office of Management and Budget, USASpending.gov - Government spending at your fingertips; and Office of Management and Budget and U.S. General Services Administration, 2014 Catalog of Federal Domestic Assistance, (Washington, DC, October 2014).* ***Excluded Programs*** *include all spending on Electricity, Conservation, and End Use. Other programs included in EIA (2015), Table 12 but excluded from our analysis total $692 million in 2010 and $130 million in 2013. The following programs were excluded from our analysis: EPA State Clean Diesel Grant; DOT Clean Fuels; NRC Education Programs; DOE nuclear epidemiology and health studies, State Energy Program, Energy Efficiency and Renewable Energy Information; DOL Green Jobs Innovation Fund Grants; DOA Rural Energy for America, Wood Utilization Assistance, and Regional Biomass Energy Programs.*

worth $9.9 billion, supporting the electric power industry spread across seven different government departments (EIA 2015, Table 12).

Table 1 summarizes the EIA's fi dings.

The ARRA Section 1603 grant program accounts for 82% of 2013 direct spending. R&D taking place at national labs and government sponsored university research programs accounts for 16% of direct expenditures. A little over 1% of direct spending was for other purposes and has not been characterized.

Tax Expenditures

Tax preferences are called tax expenditures by government agencies, and constitute the largest and most complicated type of federal support for electricity. Estimates of costs of this kind of fi ancial support vary across reports and even across federal government agencies. Qualifi ations for some of the stipulated tax benefits are complex and dependent on factors such oil and gas prices, and capital and operating costs that vary over time, space, and company. Because different analysts employ different assumptions, their analyses yield different estimates for the same subsidy. A comprehensive analysis of 21 tax provisions noted that U.S. Treasury and JCT estimates differed by an average of 32% (Koplow 2010, 29). In our analysis of 2016 and 2019 data, we fi d that the upper bound for tax expenditures is 50% higher than the lower bound (see Appendix 2).

We identifi d 29 distinct, preferential tax treatments and have organized them into four categories of decreasing **directness** to electricity generation.

- *Electricity Sales:* Th s category is the most direct in terms of impact on electricity prices and includes payments for a unit of electricity generated by a specifi d fuel source. For example, the PTC offers $23/MWh for 10 years for wind energy and other qualifi d renewables projects if they start construction before 2018, at which date, the PTC decreases to $18.4/MWh (again for 10 years). PTC is further reduced to $13.8 in 2019 and $9.2 in 2020.
- *Power Plants:* Some subsidies target costs associated with building, maintaining, and decommissioning power plants. The ITC provides a 30% refund on the capital investment of solar, wind and other eligible renewable facilities. The ITC refund declines to 10% in 2022. The Credit for Investment in Clean Coal Facilities offers a 20% credit to advanced coal projects using integrated gasifi ation combined-cycle technology. Accelerated depreciation for certain generation types (e.g., 5 years for wind, solar, geothermal and biomass, 15 years for nuclear, 20 years for most other thermal) writes off lant costs faster than other assets, thereby reducing the tax obligation on a generator. Nuclear catastrophe insurance (Price-Anderson Act), while technically an insurance subsidy, is included in this category.
- *Fuel Sales*: There are two tax credits associated with the production of fuels: the marginal well credit and the enhanced oil recovery credit. Since the mid-2000s, these tax credits have been nil because their value is based on the price of oil, which has been high enough. Should the average oil price remains below $46/bbl for the remainder of 2016, however, the credits will have positive value again (IRS 2016). Also, there is a credit offering $20 per metric ton of carbon-dioxide sequestered. While not a direct fuel subsidy, it has the potential to reduce the net fuel cost at a power plant.
- *Fuel Production:* There are many subsidies that aim to reduce the tax burden of fossil fuel producers. These include the expensing of intangible drilling costs (Expensing of Exploration and Development Costs in Table 2), excess of cost over depletion, and treatment of geophysical costs. We have also included the tax preferences offered to Master Limited Partnerships in this category.

Table 2 provides a program-by-program assessment of total cost for the four study years. 2010 and 2013 data is sourced primarily from EIA (2015) and supplemented with other sources. Data for 2016 and 2019 is primarily from JCT (2015). Appendix

TABLE 2:

Total Cost of Tax Expenditures by Type and Year ($ million, nominal)

Subsidy Category	Beneficiary	2010	2013	2016	2019
Electricity Sales		**1,624**	**1,670**	**2,745**	**4,476**
Energy Production Credit		1,624	1,670	3,260	5,151
for Wind	Wind	1,338	1,367	2,700	4,591
for Other Renewables		258	263	520	520
Open-loop biomass	RE	178	182	360	360
Closed-loop biomass	RE	10	10	20	20
Geothermal	RE	10	10	20	20
Qualified Hydropower	RE	10	10	20	20
Small Irrigation Power	RE	10	10	20	20
Municipal Solid Waste	RE	40	40	80	80
for Coal	COAL	28	40	40	40
Production from Nuclear Power Facilities Credit	NUC	-	-	140	340
Power Plants		**2,371**	**5,420**	**4,516**	**4,900**
Energy Investment Credit		137	1,950	1,800	2,553
for Solar	SOLAR	123	1,755	1,620	2,473
for Other Renewables		14	195	180	80
Geothermal	RE	2	33	30	13
Fuel Cell	RE	2	33	30	13
Microturbine	RE	2	33	30	13
Combined Heat & Power	RE	2	33	30	13
Small Wind	RE	2	33	30	13
Geothermal Heat Pumps	RE	2	33	30	13
Credit for Residential Energy Efficient Property	SOLAR	232	960	1,200	872
Amortization of Certain Pollution Control Facilities	COAL	105	400	400	300
5-Year Depreciation for Certain Energy Property	RE	300	300	300	200
Nuclear Liability Insurance (Price-Anderson Act)	NUC	180	180	180	180
Nuclear Decommissioning	NUC	949	1,100	200	300
Credit for Investment in Clean Coal Facilities	COAL	253	180	160	230
Credit for Holding Clean Renewable Energy Bonds	RE	74	70	86	143
Advanced Energy Manufacturing Facility Tax Credit		190	210	280	180
for renewables	RE	132	133	177	114
for nuclear	NUC	8	9	12	8
for coal	COAL	1	1	1	1
for excluded categories		49	67	89	57

Table continued on next page…

TABLE 2 (CONTINUED):

Total Cost of Tax Expenditures by Type and Year ($ million, nominal)

Subsidy Category	Beneficiary	2010	2013	2016	2019
Fuel Sales		**-**	**80**	**110**	**872**
Enhanced Oil Recovery (EOR) Credit	HC	-	-	+	792
Marginal Well Credit	HC	-	-	-	-
Carbon Dioxide (CO2) Sequestration Credit	COAL	-	80	110	80
Fuel Production		**3,326**	**3,610**	**5,897**	**5,998**
Excess of Percentage over Cost Depletion		1,033	530	1,540	1,940
for oil & gas	HC	885	454	1,320	1,620
for hard mineral fossil fuels (e.g. coal)	COAL	148	76	220	320
Expensing of Exploration and Development Costs		422	550	1,620	1,420
for oil & gas	HC	396	516	1,520	1,320
for hard mineral fossil fuels (e.g. coal)	COAL	26	34	100	100
15-Year Depreciation for Natural Gas Distr. Pipelines	HC	127	100	220	120
MLP Tax Preferences	HC	500	1,200	1,200	1,200
Dual Capacity Tax Payer	HC	950	950	950	950
Capital Gains Treatment of Royalties on Coal	COAL	53	90	120	130
Amortize Geological & Geophys. Expend. over 2 Years	HC	158	100	140	140
Exception from Passive Loss Limitation O/G Properties	HC	32	20	40	40
Exclusion of Special Benefits for Disabled Coal Miners	COAL	41	30	30	20
Partial Expensing for Advanced Mine Safety Equipment	COAL	3	27	27	27
Deduction for Tertiary Injectants	HC	5	10	7	8
Mine Rescue Training Credit	COAL	-	1	1	1
Natural Gas Arbitrage Exemption	HC	1	1	1	1
7-Year Depreciation for Natural Gas Gathering Lines	HC	1	1	1	1
Expensing of CapEx to Comply with EPA Sulfur Regs	HC	-	-	-	-
Total		**7,321**	**10,780**	**13,923**	**17,261**

Notes: *For information on specific tax expenditures and their rationale, see Congressional Research Service (2012). Data and sources discussed in Appendix 2, which also includes expenditure estimates from the OMB.*

2 provides data values, sources, and commentary on specific ax expenditures. We rely on the JCT data for two reasons. First, the JCT offers an upper-bound estimate of fi ancial support—a trend that holds across technologies. Second, the JCT is a bi-partisan committee of the U.S. Congress, and considered more impartial. We provide alternative calculations for fi ancial support using OMB's tax expenditure estimates in Appendix 3.

In 2013, energy related tax expenditures totaled $10.8 billion and are forecast to increase to $17.3 billion by 2019 (Table 2). Certain subsidies comingle fuel types or generation technologies making the identifi ation of cost-causation impossible. The two most prominent examples are the use of a single hydrocarbon (HC) category instead of discrete breakdowns by oil and gas, and undifferentiated renewables (RE). Federal subsidies do not make a distinction between costs incurred when looking for oil or natural gas. Often, natural gas production is associated with oil; and well economics is driven by oil (in fact, associated gas can be a burden if there is no infrastructure to handle the gas). As such, it is difficult to allocate a share of the support to natural gas.

We report the aggregate value of non-wind, non-solar renewables because of their small magnitude, lack of annual values, and lack of inclusion in other FCe- studies. For example, JCT (2015) estimates that more than 90% of the ITC's value will go to solar between 2015 and 2019, with geothermal, fuel cells, micro-turbines, combined heat and power, small wind, and geothermal heat pumps making up the rest (JCT 2015, Table 1). Also, certain programs are technology-neutral and report only lump-sum values.

Total Spending on Energy and Electricity

With the value of direct expenditures, and tax expenditures (including select government guarantees) established, we can calculate the total spending on energy (Table 3). Direct expenditures for 2010 and 2013 come directly from Table 1. A comprehensive analysis of direct spending in 2016 and 2019 was not undertaken because detailed budget data (down to the program level) is not yet available. Given the lack of data for these years, we average the non-ARRA direct expenditures for 2010 and 2013 and then inflate the averaged value by 2% per year (approximately equal to the CBO (2016) forecast for inflation and growth in real GDP). There is no ARRA spending in 2016 or 2019.[7] Tax expenditure data comes directly from Table 2.

Between 2010 and 2019, energy spending ranges from $13.8 billion to $20.6 billion, which happens in 2013 because of Section 1603 (ARRA) spending. In each year, renewables account for the largest share of the total: 58%, 69%, 50% and 52% for 2010, 2013, 2016 and 2019, respectively. Fossil fuel subsidies are expected to double between 2010 and 2019 due to increased hydrocarbon production.

Total energy sector support, however, does not directly address support for electricity generation. Financial support for fossil fuels is directed at *energy* generally, not *electricity* in particular. In the U.S., oil is largely used in the transportation sector followed by industrial processes and residential and commercial heating. Less than 1% of electricity is generated from oil. After a period of increasing gas burn for power generation, roughly one-third of natural gas produced in the U.S. is used for power generation in 2016. Still, two-thirds of natural gas is used for industrial purposes (e.g., feedstock for the petrochemicals processes) and heating. Similarly, most coal is used for power generation but some is used for industrial purposes.

In short, when the government supports the fossil fuel sector, it supports a variety of industries and overall economic activity by keeping the cost of energy low. Still, it is reasonable to allocate the cost of fossil fuel subsidies proportionately to electric power generation. Functionally, this means that 98% of hydrocarbon subsidies are discounted while only about one-third of coal subsidies are similarly discounted. For renewables and nuclear, energy spending is equivalent to electricity spending. Spending in other categories, like the tax treatment of pollution controls, is unaffected.

To calculate the portion of energy subsidies that can be assigned to electricity generation, we focus on production, not consumption, figu es. Fossil fuel subsidies are concentrated heavily in the fuel production category, which also includes tax expenditures associated with MLPs in our analysis. Companies can only deduct intangible drilling costs or exploration costs related to production in the U.S. The U.S. consumes foreign oil, coal and, to a lesser extent, natural gas; but also exports some of each. Some U.S. coal plants burn low-sulfur Indonesian coal; some Massachusetts combined-cycle units burn LNG from Trinidad and Tobago but these external fuel sources do not receive any fi ancial support from the federal government. Accordingly, we focus on domestic production of fossil fuels. To convert a given fossil fuel energy subsidy into its equivalent electricity subsidy we use Equation 1.

7 Direct spending (excluding ARRA) is a modest portion of overall financial support for electricity, so our analysis of total federal support will not be materially altered should spending patterns alter. A doubling of direct spending in 2016 would only increase total support by 10% (halving direct spending would decrease it by 6%).

TABLE 3:

Energy Spending by Type & Fuel (2010, 2013, 2016, 2019, $ million, nominal)

Type	Direct Expenditures				Tax Expenditures					Total
	Section 1603	R&D	Other	Subtotal	Elec. Sales	Power Plants	Fuel Sales	Fuel Prod.	Subtotal	
FY2010 Spending Summary by Type & Fuel										
Coal	-	307	46	353	28	359	-	271	658	1,011
HC	-	9	45	54	-	-	-	3,055	3,055	3,109
Nuclear	-	446	46	492	-	1,137	-	-	1,137	1,629
Renewables	4,481	1,060	26	5,567	1,596	875	-	-	2,471	8,038
Wind	4,002	58	1	4,061	1,338	-	-	-	1,338	5,399
Solar	359	320	22	701	-	355	-	-	355	1,056
Other	120	682	3	805	258	520	-	-	777	1,582
Total	**4,481**	**1,822**	**163**	**6,466**	**1,624**	**2,371**	**-**	**3,326**	**7,321**	**13,787**
FY2013 Spending Summary by Type & Fuel										
Coal	-	202	74	276	40	581	80	258	959	1,235
HC	-	34	50	84	-	-	-	3,352	3,352	3,436
Nuclear	-	406	9	415	-	1,289	-	-	1,289	1,704
Renewables	8,169	976	11	9,156	1,630	3,413	-	-	5,043	14,199
Wind	4,273	49	1	4,323	1,367	-	-	-	1,367	5,690
Solar	2,941	284	6	3,231	-	2,715	-	-	2,715	5,946
Other	955	643	4	1,602	263	698	-	-	961	2,563
Total	**8,169**	**1,618**	**144**	**9,931**	**1,670**	**5,283**	**80**	**3,610**	**10,643**	**20,574**
FY2016 Spending Summary by Type & Fuel										
Coal	-	270	64	334	40	561	110	498	1,209	1,543
HC	-	23	50	73	-	-	-	5,399	5,399	5,472
Nuclear	-	452	29	481	140	392	-	-	532	1,013
Renewables	-	1,080	20	1,100	3,220	3,563	-	-	6,783	7,883
Wind	-	57		57	2,700	-	-	-	2,700	2,757
Solar	-	320		320	-	2,820	-	-	2,820	3,140
Other	-	703		703	520	743	-	-	1,263	1,966
Total	**-**	**1,825**	**163**	**1,988**	**3,400**	**4,516**	**110**	**5,897**	**13,923**	**15,911**
FY2019 Spending Summary by Type & Fuel										
Coal	-	287	68	354	40	531	80	598	1,249	1,603
HC	-	24	53	78	-	-	792	5,400	6,192	6,269
Nuclear	-	480	31	511	340	488	-	-	828	1,338
Renewables	-	1,146	21	1,167	5,111	3,882	-	-	8,993	10,160
Wind	-	60		60	4,591	-	-	-	4,591	4,651
Solar	-	340		340	-	3,345	-	-	3,345	3,685
Other	-	746		746	520	537	-	-	1,057	1,803
Total	**-**	**1,937**	**173**	**2,110**	**5,491**	**4,900**	**872**	**5,998**	**17,261**	**19,371**

Note: italicized values are subtotals.

(1)

$$Energy\ Subsidy\ \$_{Fuel_X,\ year_i} \times \frac{Energy\ Used\ in\ Electricity_{Fuel_X,\ year_i}}{Total\ Energy\ Produced_{Fuel_X,\ year_i}} = Electricity\ Subsidy\ \$_{Fuel_X,\ year_i}$$

Table 4 provides the share of energy used in electric power generation. Domestic Energy Production represents the amount of energy produced by fuel type in a given year. Consumption by Generators is the amount of energy consumed for power generation fuel type (e.g., 8.62 quadrillion Btu of hydrocarbons—almost exclusively natural gas—were burned in power plants in 2013). Dividing consumption by production yields the energy use for electric power generation (e.g., 21% percent of hydrocarbons were burned in power plants in 2013). Over this period, the EIA forecasts that the share of coal production used in electric generation will drop from 87% in 2010 to 82% in 2019. For hydrocarbons, the share drops from 24% to 18%.

Applying Equation 1 to appropriate cells of Table 3 yields only the value of support for electricity generating technologies (Table 5). Th s adjustment removes $2.4 billion in fossil fuel subsidies from our analysis for 2010 rising to $5.2 billion in 2019.

Federal financial support for the electricity-generating technologies ranges from $11.5 to $18 billion per year in the 2010s. Support was highest in 2013 due to American Recovery and Reinvestment Act (ARRA) related funding which exceeded $8 billion in 2013. Excluding this temporary source of funding, electricity support totaled approximately $7 billion in 2010 and is expected to rise to $14 billion in 2019. Of the 76 programs identifi d as electricity-related in 2013, 46 were direct expenditures (worth $9.9 billion) and 29 were tax expenditure programs or the Price-Anderson Act ($7.9 billion).

In subsequent years, direct expenditures make up only 15% of support. In general, the government prefers to support energy companies using the tax code rather than direct spending. We conclude that 41 programs, worth more than $33 billion, do not target the electricity sector (excluded programs are discussed in Appendix 1).

TABLE 4:

Share of Fossil Fuels used in Electric Power Generation (%)

Type	2010	2013	2016	2019
Hydrocarbons				
Domestic Energy Production (Quad Btu)	33.41	40.67	46.73	49.60
Consumption by Generators (Quad Btu)	7.94	8.62	9.99	9.16
Energy for Electric Power Generation (%)	24%	21%	21%	18%
Coal				
Domestic Energy Production (Quad Btu)	22.04	19.99	17.03	17.50
Consumption by Generators (Quad Btu)	19.13	16.49	14.12	14.35
Energy for Electric Power Generation (%)	87%	82%	83%	82%

Notes: Historic 2010 data from Annual Energy Outlook 2013 (EIA 2013, Reference Case, Tables 1 & 2). Historic 2013 data from Annual Energy Outlook 2015 (EIA 2015b, Reference Case, Tables 1 & 2). Forecast 2016 and 2019 data from Annual Energy Outlook 2016 (EIA 2016, Reference Case, Tables 1 & 2)

TABLE 5:

Electricity Spending by Type & Fuel (2010, 2013, 2016, 2019, $ million, nominal)

	Direct Expenditures				Tax Expenditures					
Type	**Section 1603**	**R&D**	**Other**	**Subtotal**	**Elec. Sales**	**Power Plants**	**Fuel Sales**	**Fuel Prod.**	**Subtotal**	**Total**
FY2010 Spending Summary by Type & Fuel										
Coal	-	307	46	353	28	359	-	235	622	**975**
HC	-	9	45	54	-	-	-	726	726	**780**
Nuclear	-	446	46	492	-	1,137	-	-	1,137	**1,629**
Renewables	4,481	1,060	26	5,567	1,596	875	-	-	2,471	**8,038**
Wind	4,002	58	1	*4,061*	1,338	-	-	-	*1,338*	**5,399**
Solar	359	320	22	*701*	-	355	-	-	*355*	**1,056**
Other	120	682	3	*805*	258	520	-	-	*777*	**1,582**
Total	**4,481**	**1,822**	**163**	**6,466**	**1,624**	**2,371**	**-**	**961**	**4,956**	**11,422**
FY2013 Spending Summary by Type & Fuel										
Coal	-	202	74	276	40	581	66	213	900	**1,176**
HC	-	34	50	84	-	-	-	711	711	**795**
Nuclear	-	406	9	415	-	1,289	-	-	1,289	**1,704**
Renewables	8,169	976	11	9,156	1,630	3,413	-	-	5,043	**14,199**
Wind	*4,273*	*49*	*1*	*4,323*	*1,367*	-	-	-	*1,367*	***5,690***
Solar	*2,941*	*284*	*6*	*3,231*	-	*2,715*	-	-	*2,715*	***5,946***
Other	*955*	*643*	*4*	*1,602*	*263*	*698*	-	-	*961*	***2,563***
Total	**8,169**	**1,618**	**144**	**9,931**	**1,670**	**5,283**	**66**	**923**	**7,942**	**17,873**
FY2016 Spending Summary by Type & Fuel										
Coal	-	270	64	334	40	561	91	413	1,105	**1,439**
HC	-	23	50	73	-	-	-	1,154	1,154	**1,227**
Nuclear	-	452	29	481	140	392	-	-	532	**1,013**
Renewables	-	1,080	20	1,100	3,220	3,563	-	-	6,783	**7,883**
Wind	-	*57*		*57*	*2,700*	-	-	-	*2,700*	***2,757***
Solar	-	*320*		*320*	-	*2,820*	-	-	*2,820*	***3,140***
Other	-	*703*		*703*	*520*	*743*	-	-	*1,263*	***1,966***
Total	**-**	**1,825**	**163**	**1,988**	**3,400**	**4,516**	**91**	**1,567**	**9,575**	**11,563**
FY2019 Spending Summary by Type & Fuel										
Coal	-	287	68	354	40	531	66	490	1,127	**1,481**
HC	-	24	53	78	-	-	146	997	1,143	**1,221**
Nuclear	-	480	31	511	340	488	-	-	828	**1,338**
Renewables	-	1,146	21	1,167	5,111	3,882	-	-	8,993	**10,160**
Wind	-	*60*		*60*	*4,591*	-	-	-	*4,591*	***4,651***
Solar	-	*340*		*340*	-	*3,345*	-	-	*3,345*	***3,685***
Other	-	*746*		*746*	*520*	*537*	-	-	*1,057*	***1,803***
Total	**-**	**1,937**	**173**	**2,110**	**5,491**	**4,900**	**212**	**1,487**	**12,091**	**14,200**

Notes: ARRA Section 1603 spending is assumed to be zero for 2016 although pending litigation could result in a small, positive value for this year.

Financial support for electricity generation is generally growing, but ARRA spending complicates the picture (Figure 2). ARRA spending accounted for 40% of total expenditures in 2010 and 46% of total in 2013. Spending on perennial expenditures is forecast to nearly double between 2010 and 2019, from $6.9 billion to $14.2 billion. Th s increase is due almost entirely to renewables. In particular, tax expenditures associated with electricity sales (mostly, PTCs) are expected to triple. Renewables spending (excluding ARRA), is two to three times higher than fossil fuel spending attributable to electricity. Including ARRA costs, 2013 spending on renewables peaked at seven times fossil fuel spending attributable to electricity. Including all energy spending, not just electricity related, perennial renewables spending is comparable to fossil fuel spending. Fossil fuels received slightly more support than renewables in 2010; and receive less than renewables in 2013, 2016, and 2019. Perennial renewable fi ancial support is slightly below that for conventional energy (fossil fuels plus nuclear) in three of the four years.

Subsidies included in this analysis support renewables to *generate electricity or install generation capacity* while they support fossil fuels for *energy extraction*. Figure 3 depicts the target of funding by fuel and year (out of 100%). For simplicity, it combines support for fuel sales with support for fuel companies (both relatively small amounts) and it combines R&D spending with other direct spending, which represents a small share of total direct expenditures. All ARRA Section 1603 spending went to building power plants but is broken out from that category to highlight the impact of that program.

Wind energy uniquely benefits from tax credits on electricity sales. For 2016 and 2019, more than 95% of all federal support for wind comes through the PTC (worth $2.7 billion and $4.5 billion respectively). The lack of R&D spending on wind indicates that it is a mature technology. Solar receives most of its support through ITC for adding new generation capacity. There are no subsidies that directly encourage the burning of hydrocarbons for electricity production. Coal and nuclear have the most diversifi d set of subsidies. Nuclear benefits from R&D spending, tax credits on electricity sales, and programs aimed at plant costs (decommissioning, insurance). Coal receives 3% of its total support ($40 million a year) in production tax credits, but a majority of its support targets emissions. There are tax preferences for coal that reduce the cost of adding pollution controls to power plants as well as R&D spending on clean coal and carbon sequestration.

FIGURE 2:

Spending on Electricity by Fuel and Year ($ million, nominal)

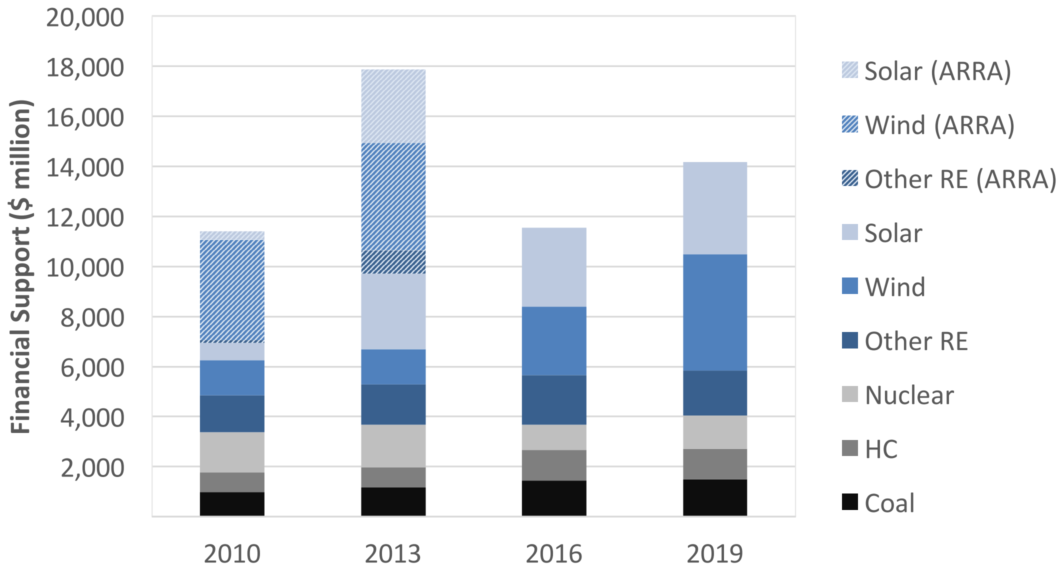
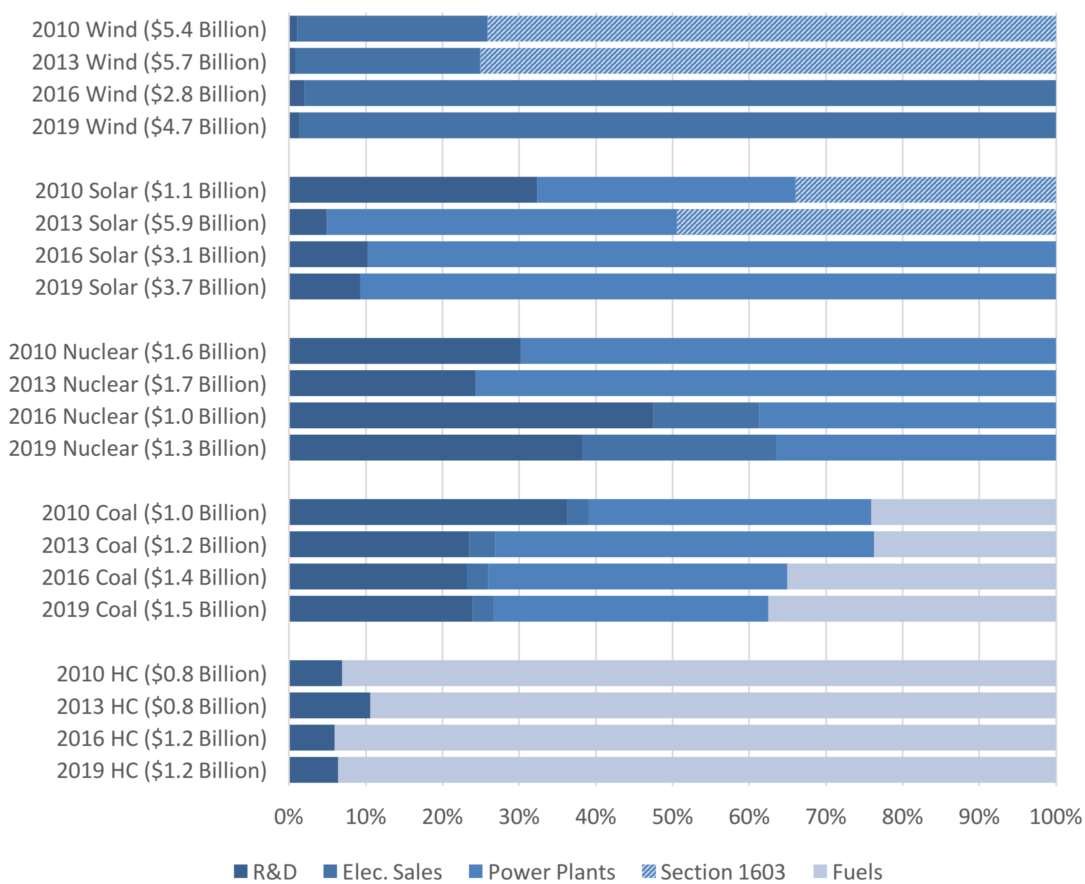


FIGURE 3:

Composition of Support by Fuel and Year



4 PER-MWH FINANCIAL SUPPORT FOR ELECTRICITY GENERATION

The comparison of total federal fi ancial support to different generation technologies is informative but does not tell the whole story. Technologies have different capital costs and operational characteristics; one MW of capacity is not the same for all technologies. As such, it is essential to investigate the generation by each technology that might be associated with these subsidies. In this section we convert the total spending previously established to an equivalent per-MWh value.

Our conversion approach requires parsing out the portion of the subsidy that relates to electricity generation in a given year and then spreading those dollars over the amount of electricity generated by that fuel. In Equation 1, we established the value of electricity related subsidy. Dividing that amount by the same-year electricity generation provides us with a $/MWh estimate:

(2)

$$Electricity\ Subsidy\ \$_{Fuel_X,\ year_i} \times \frac{1}{Total\ MWh_{Fuel_X,\ year_i}} = \frac{\$}{MWh}$$

Combining Equation 1 and Equation 2 we get the complete formula (3) for converting a fossil fuel subsidy into a per-unit-of-generation electricity subsidy.

All renewables and nuclear subsidies target electricity generation. Hence, the second term of Equation 3 can be excluded. We rely on data from the Energy Information Administration's Annual Energy Outlook releases for our generation figu es (Table 6).

(3)

$$Energy\ Subsidy\ \$_{Fuel_X,\ year_i} \times \frac{Energy\ Used\ in\ Electricity_{Fuel_X,\ year_i}}{Total\ Energy\ Produced_{Fuel_X,\ year_i}} \times \frac{1}{Total\ MWh_{Fuel_X,\ year_i}} = \frac{\$}{MWh}$$

TABLE 6:

Electricity Generation by Fuel and Year (million MWh)

	Million MWh				Percent of Total Generation			
Type	**2010**	**2013**	**2016**	**2019**	**2010**	**2013**	**2016**	**2019**
Hydrocarbons	1,007	1,145	1,355	1,281	24.5%	28.1%	33.0%	30.3%
Oil	37	27	24	15	0.9%	0.7%	0.6%	0.4%
NG	970	1,118	1,330	1,266	23.6%	27.5%	32.4%	29.9%
Coal	1,847	1,586	1,357	1,387	44.9%	39.0%	33.0%	32.8%
Nuclear	807	789	781	770	19.6%	19.4%	19.0%	18.2%
All RE (excl. Conventional Hydro)	169	262	341	473	4.1%	6.4%	8.3%	11.2%
Solar	4	19	51	87	0.1%	0.5%	1.2%	2.0%
Wind	95	168	216	307	2.3%	4.1%	5.3%	7.3%
Other RE	70	76	74	79	1.7%	1.9%	1.8%	1.9%
Large Hydro	260	267	256	294	6.3%	6.6%	6.2%	7.0%
Other Generation	19	20	17	27	0.5%	0.5%	0.4%	0.6%
Total	**4,110**	**4,070**	**4,108**	**4,232**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Notes: Historic 2010 data from Annual Energy Outlook 2013 (EIA 2013, Reference Case, Tables 11 &16). Historic 2013 data from Annual Energy Outlook 2015 (EIA 2015b, Reference Case, Tables 11 &16) Forecast 2016 and 2019 data from Annual Energy Outlook 2016 (EIA 2016, Reference Case, Tables 11 &16).

Over this period, the EIA forecasts that natural gas fi ed generation will increase by 30%. Coal generation is projected to decrease by 25% over the same period. Renewables, by contrast, are forecasted to increase their production dramatically from 2010 to 2019. EIA assumes a three-fold increase in wind generation and a 21-fold increase in solar generation. In 2019, wind is forecast to generate about 7% of the nation's electricity and solar is forecast to generate about 2%.

We obtain per-MWh subsidy estimates (Table 7) by dividing the absolute dollar spending in Table 5 by the annual energy production figu es found in Table 6. While fossil fuels receive large total subsidies, their per-MWh cost is quite modest due to the very large installed base and the high quantity of generation. Renewables, by contrast, receive somewhat more money but generate signifi antly less electricity. Converting total dollars to dollars-per-MWh illustrates how far each subsidy dollar goes in terms of electricity generation.

It can be argued that the estimates reported in Table 7 inflate the per-unit cost of subsidies because they correlate one year's subsidy to that year's generation levels. Th s concern does not apply to subsidies such as PTC, which is realized based on generation; but subsidies such as ITC that induces new plant investment needs further consideration. Since a power plant will operate for 20 years or more, subsidy value could be calculated for the plant's lifetime generation. However, there are several countervailing arguments. First, subsidy is fully realized in the year of its installation; future generation would need some kind of discounting to refl ct its impact in present value terms. Second, not all of the 2013 generation included in the denominator of Equation 2 is from the plant that received the ITC that year. In a sense, this larger denominator provides some of the discounting. Finally, all technologies are treated the same way, which renders our estimates comparable.

Almost all of the support to fossil fuels is indirect from the perspective of electric power generation whereas support to renewables is directly impacting generation costs either via construction or sales credits. Figure 4 represent the per-MWh subsidy impact by type and fuel.

FIGURE 4:

Per-MWh Subsidy by Type & Fuel

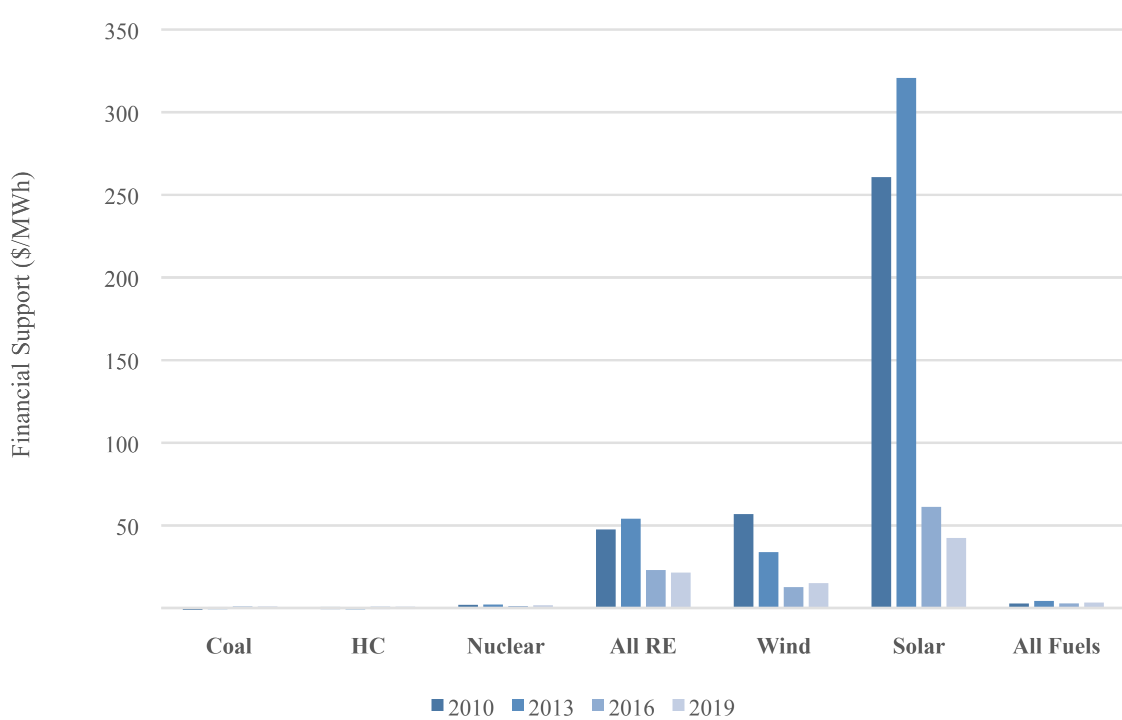


TABLE 7:

Per-MWh Subsidy by Type & Fuel (2010, 2013, 2016, 2019, $ nominal)

	Direct Expenditures				Tax Expenditures					
Type	Section 1603	R&D	Other	Subtotal	Elec. Sales	Power Plants	Fuel Sales	Fuel Comp.	Subtotal	Total
FY2010 Spending Summary by Type & Fuel										
Coal	-	0.17	0.02	0.19	0.02	0.19	-	0.13	0.34	0.53
HC	-	0.01	0.04	0.05	-	-	-	0.72	0.72	0.77
Nuclear	-	0.55	0.06	0.61	-	1.41	-	-	1.41	2.02
Renewables	26.51	6.27	0.15	32.94	9.44	5.18	-	-	14.62	47.56
Wind	42.19	0.61	0.01	42.82	14.11	-	-	-	14.11	56.93
Solar	88.60	78.98	5.43	173.01	-	87.69	-	-	87.69	260.69
Other	1.71	9.73	0.04	11.48	3.68	7.41	-	-	11.09	22.57
Avg. All Fuel	**1.09**	**0.44**	**0.04**	**1.57**	**0.40**	**0.58**	**-**	**0.23**	**1.21**	**2.78**
FY2013 Spending Summary by Type & Fuel										
Coal	-	0.13	0.05	0.17	0.03	0.37	0.04	0.13	0.57	0.74
HC	-	0.03	0.04	0.07	-	-	-	0.62	0.62	0.69
Nuclear	-	0.51	0.01	0.53	-	1.63	-	-	1.63	2.16
Renewables	31.13	3.72	0.04	34.90	6.21	13.01	-	-	19.22	54.12
Wind	25.46	0.29	0.01	25.76	8.14	-	-	-	8.14	33.90
Solar	158.63	15.32	0.32	174.27	-	146.44	-	-	146.44	320.71
Other	12.56	8.46	0.05	21.08	3.46	9.18	-	-	12.65	33.72
Avg. All Fuel	**2.01**	**0.40**	**0.04**	**2.44**	**0.41**	**1.30**	**0.02**	**0.23**	**1.95**	**4.39**
FY2016 Spending Summary by Type & Fuel										
Coal	-	0.20	0.05	0.25	0.03	0.41	0.07	0.30	0.81	1.06
HC	-	0.02	0.04	0.05	-	-	-	0.85	0.85	0.91
Nuclear	-	0.58	0.04	0.62	0.18	0.50	-	-	0.68	1.30
Renewables	-	3.17	0.06	3.22	9.43	10.44	-	-	19.87	23.10
Wind	-	0.26	-	0.26	12.48	-	-	-	12.48	12.74
Solar	-	6.26	-	6.26	-	55.05	-	-	55.05	61.31
Other	-	9.54	-	9.54	7.06	10.08	-	-	17.14	26.68
Avg. All Fuel	**-**	**0.44**	**0.04**	**0.48**	**0.83**	**1.10**	**0.02**	**0.38**	**2.33**	**2.81**
FY2019 Spending Summary by Type & Fuel										
Coal	-	0.21	0.05	0.26	0.03	0.38	0.05	0.35	0.81	1.07
HC	-	0.02	0.04	0.06	-	-	0.11	0.78	0.89	0.95
Nuclear	-	0.62	0.04	0.66	0.44	0.63	-	-	1.07	1.74
Renewables	-	2.43	0.04	2.47	10.81	8.21	-	-	19.03	21.50
Wind	-	0.20	-	0.20	14.95	-	-	-	14.95	15.15
Solar	-	3.92	-	3.92	-	38.59	-	-	38.59	42.51
Other	-	9.46	-	9.46	6.59	6.80	-	-	13.40	22.85
Avg. All Fuel	**-**	**0.46**	**0.04**	**0.50**	**1.30**	**1.16**	**0.05**	**0.35**	**2.86**	**3.36**

On a $/MWh basis, renewables receive significantly more support than fossil fuels, and this is particularly true for solar power. Subsidies for fossil fuels are relatively stable (and slightly increasing) across the years whereas subsidies to renewables decline dramatically. Coal receives $0.53-$1.07/MWh, hydrocarbons $0.69-0.95/MWh, and nuclear $1.30-2.16/MWh. By contrast, wind received $57/MWh in 2010, $34 in 2013, and is expected to receive about $13 in 2016 and about $15 in 2019. The higher level of subsidy in 2010 and 2013 is explained by the ARRA funding. The contrast is even more striking with solar: $261/MWh in 2010 and $321/MWh in 2013 versus $61/MWh and $43/MWh in 2016 and 2019, respectively.[8] The ARRA funding created a signifi ant distortion in terms of both the short-term competitiveness of these technologies in electricity markets and the longer-term uncertainty created by their elimination.

The high level of per-unit subsidies realized by renewables is partially a statistical artifact related to relative size of installed capacity. For coal and natural gas (hydrocarbons), the federal support is spread over a large installed base so the per-unit cost is small. By contrast, the installed capacity of renewables is much smaller and younger.

8 The values for conventional fuels differ only modestly when using OMB's estimates of tax expenditures for 2016 and 2019. For wind and solar, however, the difference is substantial: using OMB's estimates would lessen the magnitude of financial support for renewables by $23-33/MWh for solar and $5-6/MWh for wind (see Appendix 3).

So, a larger proportion of renewable capacity is eligible for tax credits. However, there are two other important reasons. First, overnight capital cost of wind and solar are more expensive than gas-fi ed generation. Second, capacity factors (average ratio of generation to installed capacity) are much higher for thermal generators that burn coal or natural gas than wind or solar generators, which are dependent on availability of resources.[9] As such, even if they receive exactly the same total subsidy, more gas than renewables capacity could be built; and, the gas plants would be able to generate more electricity than renewables for the same installed capacity over a year. As a result, per-MWh subsidy will be higher for the renewables.

However, the installed capacity of renewables has been growing quickly. Overnight capital costs have been coming down. There could be further technology improvements to enhance capacity factors.[10] Most signifi ant subsidies (PTC and ITC) are expected to gradually phase out by the early 2020s. Accordingly, per-MWh cost of these subsidies will decrease.

9 Coal and gas plants can be run at capacity factors as high as 80% or more depending on system needs and fuel prices. Nuclear plants in the U.S. have been averaging about 90% in recent years. In best resource areas, wind farms can average as high as 40%, and solar facilities as high as 25% over a year.

10 However, as best wind and solar locations are developed, new projects may have to be cited in locations with lower resource quality and decreasing marginal productivity. Any technology improvement would have to be large enough to compensate for this decline to sustain or improve capacity factors.

5 | CONCLUSION

Th s paper used data from the Energy Information Agency, the Joint Committee on Taxation, and other government sources to determine both the total and per-MWh values of federal fi ancial support attributable to electricity generation. A comprehensive assessment of direct and indirect subsidies was undertaken. We fi d that renewables spending is modestly higher in absolute terms but several orders of magnitude higher on a per-MWh basis. Between 2010 and 2019, the federal financial support to electric power generation is estimated between roughly $11.5 billion to $18 billion per year, depending on the year and the programs in place. The highest estimate refers to 2013 when ARRA funding was significant. On a portfolio wide basis, Americans pay $3-$5/MWh for the measures that support electricity generating technologies.

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APPENDIX 1: EXCLUDED FORMS OF FEDERAL FINANCIAL SUPPORT

Most studies calculating the value of subsidies focus on *energy* and not *electricity.* Hence, a large number of items that focus on energy do not pertain to electricity. In total, we excluded 41 catagories of direct spending, tax expenditures, and research and development funding, worth $33.8 billion from the subsidy list (Table A1). Table A1 does not include speculative costs associated with energy security or externalties. Separately, we excluded in-kind subsidies to extractive industries worth between zero and $2 billion per year depending on rationale and assumptions (see detailed discussion below). The program costs listed in Table A1 are from different years because once we identifi d a budget item to exclude, we did not track the specific co t for our study years. Costs for these programs in the past could have been different, and they may change in the future owing to changing funding priorities of the federal government.

Excluded items relate to fossil fuels and non-generation electricity. There are no exclusions related to renewable electricity or nuclear. Biofuels are a substantial recipient of fi ancial support but this aid targets transportation not electricity. No appreciable amount of biofuels are used in electricity production. Transportation is the single largest category excluded, accounting for a substantial amount of funding for alternative fuels such as ethanol and biodiesel. Also substantial is spending that may induce demand for energy consumption like the Highway Trust Fund or federal petroleum reserves. Government spending of this sort may induce more demand for energy but there is only a tenuous link between that spending and increased demand for a specific lectricity technology.

OCI (2014) and ELI (2007) include tax exemption of environmental remediation costs while government and industry reports do not. We exclude this spending because this exemption is not unique to energy companies; all industries benefit from it. Also, companies are taxed on profits, not revenue, and remediation costs reduce profit. As a practical matter, the value varies widely depending on the occurrence and severity of environmental damage, which is unevenly and randomly distributed over the years. It is not possible to forecast future costs. Similarly, we exclude other programs that are not unique to energy companies but considered by OCI (2014) and ELI (2009): foreign tax credits, domestic manufacturing, and overseas project development assistance. Overseas projects are developed for a number of non-energy reasons like increasing commerce or improving foreign relations. Assuming the study period's average generation by fuel type (Table 6) and electricity-to-energy ratio (Table 4), including these programs in our analysis would add a few cents to our coal figu e and about $3/MWh for hydrocarbons. These values are indicative only; the mixed year data and estimation ambiguity makes percise comments difficult.

In-kind Subsidies

Unlike the direct expenditures and tax expenditures that can be relatively easily (albeit imperfectly) estimated and that are reported in studies by various government agencies, estimates of in-kind subsidies are largely subjective and not calculated regularly by government agencies or published in peer-reviewed studies.

A prime example is the foregone revenues by the federal government from leasing federal lands and, especially federal off hore, to extractive industries below "market value." There is dispute over whether this category of subsidy exists in the U.S. and, if it does, what it is worth. Th s calculation is difficult because the market value of natural resources (e.g., minerals, land) is not a known quantity but rather dependent on future market conditions and production profile. For example, the price of oil is determined in a global market and has been highly volatile. The resource quality and future production profile also carry

TABLE A1:

Summary of Excluded Programs

Exclusion Category	Value ($ mm)	Source Year	Source
Transportation	***12,524***		
Alcohol Fuel Exemption	5,989	2013	EIA (2013)
Ethanol Excise Tax Incentives	3,500	2013	CRS (2015)
Fuel tax exemption for farmers	1,000	2011	OCI (2014)
Temporary 50% Expensing for Equipment used in Refining of Liquid Fuels	801	2013	EIA (2013)
Biodiesel Producer Tax Credit	517	2013	EIA (2013)
Credit and Deduction for Clean-Burning Vehicles	264	2013	EIA (2013)
Alternative Fuel and Fuel Mixture Credit	179	2013	EIA (2013)
Alternative Fuel Production Credit	179	2013	EIA (2013)
Alcohol Fuel Credits	74	2013	EIA (2013)
Biodiesel and Small Agri-Biodiesel Producer Tax Credits	21	2013	EIA (2013)
Subsidies not energy specific (estimates are for the fossil fuel portion only)	***7,536***		
Financing Projects Overseas via US EXIM Bank, OPIC, and other	4,100	2013	OCI (2014)
Foreign Tax Credit	2,186	2009	ELI (2009)
Domestic manufacturing deduction	1,250	2015	UST (2014)
Subsidies Tangentially related to Energy	***6,117***		
Highway Trust Fund	6,000	2013	OCI (2014)
Water Infrastructure	117	2009*	ELI (2009)
Mass Transit Account	N/A	2009*	ELI (2009)
Commuter Benefits Exclusion from Income	N/A	2009*	ELI (2009)
LNG Terminals	N/A	2009*	ELI (2009)
Home Heating	***3,979***		
Direct Expenditures (Including LIHEAP)	3,513	2013	EIA (2013)
R&D	466	2013	EIA (2013)
Conservation & Energy Efficiency	***1,849***		
Direct Expenditures	833	2013	EIA (2013)
R&D	501	2013	EIA (2013)
Credit for Energy Efficiency Improvements to Existing Homes	232	2013	EIA (2013)
Advanced Energy Manufacturing Facility Investment Tax Credit (for EE)	158	2013	EIA (2013)
Credit for Construction of New Energy Efficient Homes	63	2013	EIA (2013)
Credit for Energy Efficient Appliances	41	2013	EIA (2013)
Allowance for Deduction of Energy Efficient Commercial Building Property	21	2013	EIA (2013)
Qualified Energy Conservation Bonds	0	2013	EIA (2013)
Exclude Income of Conservation Subsidies Provided by Public Utilities Tax	N/A	2013	EIA (2013)

Table continued on next page

TABLE A1 (CONTINUED):

Summary of Excluded Programs

Exclusion Category	Value ($ mm)	Source Year	Source
Petroleum Reserves	***894***		
Strategic Petroleum Reserve	883	2009	ELI (2009)
Northeast Home Heating Oil Reserve	7	2009	ELI (2009)
Naval Petroleum and Oil Shale Reserves	4	2009	ELI (2009)
Environmental Remediation	***786***		
Deduction for oil spill remediation costs	679	2013	OCI (2014)
Tar sands exemption from payments into the Oil Spill Liability Trust Fund	44	2013	OCI (2014)
Tax deduction for costs from clean-up, closure of coal mining & waste sites	40	2013	OCI (2014)
Special Rules for Mining Reclamation Reserves	23	2009	ELI (2009)
Electricity Generally	***213***		
Transmission Property Treated as Fifteen-Year Property	105	2013	EIA (2013)
10-Year Depreciation for Smart Electric Distribution Property	100	2013	CRS (2015)
Advanced Energy Manufacturing Facility Tax Credit (Transmission)	8	2013	EIA (2013)
5-Year Net Operating Loss Carryover for Electric Transmission Equipment	0	2013	EIA (2013)
Deferral of Gain from Disposition of Transmission Property to Implement FERC Restructuring Policy	0	2013	EIA (2013)
Total of all Exclusions	**33,898**		

signifi ant uncertainty. The implicit assumption for considering foregone revenues as a subsidy is that the federal government knew the market value, having resolved all uncertainties regarding future prices and production, and offered terms that were benefic al to the bidders intentionally. Th s is hard to demonstrate. Still, it is important to understand the debate surrounding foregone federal revenues.

At various points over the past half-century, the federal government has questioned whether it is receiving its fair share of revenues from extractive industries. In the 1970s and early-1980s, the Department of Interior faced criticism from the Government Accountability Office (O), Offic of Inspector General, and Congress about its management of its natural resources. These efforts culminated in the 1981 Linowes Commission which stated "management of royalties for the nation's energy resources has been a failure for more than 20 years. Because the federal government has not adequately managed this multibillion dollar enterprise, the oil and gas industry is not paying all the royalties it rightly owes" (GAO 2013,2; Commission on Fiscal Accountability of the Nation's Energy Resources 1982, xv). Coal fared little better: a GAO analysis of the 1982 Powder River Basin lease sale found "that the lease value estimates undervalued the tracts by $95 million" (GAO 1983, 1). Similar concerns resurfaced in the mid-2000s when the GAO issued several reports pointing out the need for re-assessment of federal fiscal terms by the Department of the Interior. The GAO placed the management of oil and gas resources in its "high-risk" list in 2011 owing to continued worry that the government was not receiving a "fair return" on its oil and gas resources because of a lack of suffici t and trained personnel and inappropriate organizational structure (GAO 2011, 13).

GAO (2007), focusing on the Gulf of Mexico and surveying numerous studies by private companies, consultants and government agencies, reported that "the U.S. federal government receives one of the lowest government takes in the world" (GAO 2007, 2).[11] These conclusions refl cted the possibility that the U.S. was not getting the best possible deal when leasing federal lands. However, the report

11 The GAO defines "government take" as the share of revenue the government receives from the total market value of the natural resources extracted flowing from royalties, taxes, and other fiscal terms offered by the government.

also acknowledged that "In deciding where and when to invest oil and gas development dollars, companies consider the government take as well as other factors, including the size and availability of the oil and gas resources in the ground; the costs of fi ding and developing these resources, including labor costs and the costs of compliance with environmental regulations; and the stability of the fiscal system and the country in general."

GAO (2008) pointed out that royalty relief provided to the industry during the low oil price period of the late 1990s could have led to potential unrealized revenues of $21 to $53 billion during the high-price period of mid-2000s unless updated as pursued by the Department of the Interior at the time of the GAO report (GAO 2008, 16). However, the report also pointed out that increasing the royalty rate without evaluating the rest of the fiscal system could not strike the right balance between investment and government take. In fact, GAO's main recommendation has been a comprehensive assessment of fiscal terms periodically so that the investment can continue and the federal government can receive a fair take.[12]

GAO (2014) reports similar concerns regarding coal leasing (GAO 2014, 15-19). More specifi ally, the GAO found that the vast majority of coal leases received a single bid (about 90 percent). The vast majority of these bids were accepted by the DOI. The GAO found that 83 percent of federal coal tracts were leased the fi st time they were offered for sale. The GAO found that for the 18 coal tracts where the initial coal company bid was rejected, companies always bid again and submitted higher bids. These observations suggested the possibility that the DOI has been undervaluing federal coal resources or accepting bids that did not refl ct robust price formation.

Estimates of foregone revenue range from $0 to more than $1 billion per year for both hydrocarbons and coal. EIA (2008) excludes foregone revenues from its analysis of subsidies entirely, noting: "to the extent that the federal government is forgoing revenues by not "optimizing" royalty payments, the federal government may be providing a subsidy similar to a tax expenditure…[but], the existence of 'favorable' royalty payments —again, in theory— should be off et by higher bids for leases" (EIA 2007, 13). The Mineral Management Service, which managed off hore leasing before it was dissolved in 2011, conducted a study on increasing royalties in the Gulf of Mexico from 12.5% to 16.67%. Their analysis concluded that the higher royalty rates would increase net revenues to the government by $3.6 billion over 20 years, or $184 million per year on a simple average basis (GAO 2007, 3). On the high end, ELI (2008) estimated annualized foregone revenues of $1 billion for off hore oil and gas owing to below market lease rates, considering the period from 2002 to 2008, a period of relatively high to historically high prices, which collapsed at the second half of 2008 (ELI 2009, 12-13). On the coal side, Sanzillo (2012) estimated that the "U.S. Treasury has lost approximately $28.9 billion in revenue throughout the past 30 years," which translates into just less than $1 billion per year (Sanzillo 2012, 3). Assuming the study period's average generation by fuel type (Table 6) and electricity-to-energy ratio (Table 4), including in-kind subsides would increase the value of fi ancial support to coal generation by approximately $0.55/MWh and add $0.22/MWh for hydrocarbon fueled plants. Importantly, it is not clear that the U.S. government ever intended to offer "below-market" fiscal terms. Ultimately, this lack of demonstrated intent led us to exclude this category, for which we had no consistent estimate, especially for future values.

Finally, it is worth noting that the government has taken steps to ensure more effici   t lease sales. GAO (2015) reported that management of oil and gas resources met or partially met GAO's five criteria to be removed from the high-risk list (GAO 2015, 94). The off hore leasing regime has updated both royalty rates and auction mechanisms to better ensure the government receives a fair take. These improvements suggest that foregone revenues, whatever their magnitude, may decrease in future years.

12 Interestingly, the oil price collapses in late 2008 and 2009; and since late 2014, would have necessitated another "royalty relief" if one wanted to sustain GOM investment. These cyclicality problems are not unique to the U.S. Some fiscal regimes tie their terms (e.g., royalty rates, tax rates, cost recovery rates, and others) to the price of oil to "fix" the rate-of-return of companies. This kind of "automated" systems can eliminate the need for continuous assessments although their sustainability is still questionable since the global upstream investment is very competitive and governments can change terms if they desire to attract more investment.

APPENDIX 2: CALCULATION OF TAX EXPENDITURES

Two groups in the federal government make assessments of tax expenditures: the Joint Committee on Taxation (JCT) is a non-partisan committee of the Congress and the Office f Management and Budget (OMB) is part of the White House. Both offer annual assessments which are widely cited but their assessments can differ by more than $1 billion for some categories. In the main body of the report, we reported and used the data provided by the JCT because it provides an upper bound to the value of tax expenditures and because it is bi-partisan. Nevertheless, JCT only reports data on subsidies worth more than $50 million and only presents data in $100 million increments. For lower value subsidies, the OMB reports data. For very low value subsidies (less than $1 million), we rely on third parties because neither the JCT nor the OMB provide estimates.

Table 2 of the report is primarily sourced from EIA (2015) for the years 2010 and 2013 and from JCT (2015) for 2016 and 2019. The EIA relied, in turn, on JCT and OMB reports when conducting their analysis of energy tax expenditures. We supplement the EIA and JCT estimates with other data due to the limitations described above. The values used in Table 2 are shaded grey in the table below. In addition to default "JCT+" case we also calculate the value of tax expenditures primarily relying on the OMB and supplementing as necessary. Table A2, below, presents these values by program, case, and year. The JCT is consistently higher than the OMB and offers an upper bound estimate of the programs we consider fi ancial supports. The maximum case is about 1% higher than the "JCT" case. The value tax expenditures, total energy spending, total electricity spending, and $/MWh subsidy value for each case is computed in Appendix 3.

TABLE A2:

Tabulation of 2010 and 2013 Tax Expenditures & Calculation of 2016 and 2019 Tax Expenditures ($ nominal)

	Cui Bono	2010	2013	2016		2019		Note
Subsidy Category		**EIA**	**EIA**	**JCT +**	**OMB+**	**JCT +**	**OMB+**	**[1]**
Electricity Sales		**1,624**	**1,670**	**3,400**	**2,090**	**5,491**	**3,461**	
Energy Production Credit		1,624	1,670	3,260	1,950	5,151	3,121	**[2]**
for Wind	Wind	*1,338*	*1,367*	2,700	1,615	4,591	2,782	**[3]**
for Other Renewables		*258*	*263*	520	311	520	315	
Open-loop biomass	RE	*178*	*182*	360	215	360	218	
Closed-loop biomass	RE	*10*	*10*	20	12	20	12	
Geothermal	RE	*10*	*10*	20	12	20	12	
Qualified Hydropower	RE	*10*	*10*	20	12	20	12	
Small Irrigation Power	RE	*10*	*10*	20	12	20	12	
Municipal Solid Waste	RE	*40*	*40*	80	48	80	48	
for Coal	Coal	*28*	*40*	40	24	40	24	**[4]**
Production from Nuclear Power Facilities Credit	NUC	-	-	140	140	340	340	**[5]**

Table continued on next page…

TABLE A2 (CONTINUED):

Tabulation of 2010 and 2013 Tax Expenditures & Calculation of 2016 and 2019 Tax Expenditures ($ nominal)

	Cui Bono	2010	2013	2016		2019		Note
Subsidy Category		EIA	EIA	JCT +	OMB+	JCT +	OMB+	[1]
Power Plants		**2,371**	**5,283**	**4,516**	**3,527**	**4,900**	**2,905**	**[6]**
Energy Investment Credit		137	1,950	1,800	1,470	2,553	793	**[7]**
for Solar	Solar	*123*	*1,755*	1,620	1,323	2,473	768	**[8]**
for Other Renewables		*14*	*195*	180	147	80	25	
Geothermal	RE	*2*	*33*	30	25	13	4	
Fuel Cell	RE	*2*	*33*	30	25	13	4	
Microturbine	RE	*2*	*33*	30	25	13	4	
Combined Heat & Power	RE	*2*	*33*	30	25	13	4	
Small Wind	RE	*2*	*33*	30	25	13	4	
Geothermal Heat Pumps	RE	*2*	*33*	30	25	13	4	
Credit for Residential Energy Efficient Property	Solar	232	960	1,200	770	872	912	**[9]**
Amortization of Certain Pollution Control Facilities	Coal	105	400	400	400	300	300	**[10]**
5-Year Depreciation for Certain Energy Property	RE	300	300	300	300	200	200	**[11]**
Nuclear Liability Insurance (Price-Anderson Act)	NUC	**180**	**180**	180	180	180	180	**[12]**
Nuclear Decommissioning	NUC	949	1,100	200	170	300	240	**[13]**
Credit for Investment in Clean Coal Facilities	Coal	253	180	160	160	230	230	**[14]**
Credit for Holding Clean Renewable Energy Bonds	RE	74	70	86	70	143	70	**[15]**
Advanced Energy Manufacturing Facility Tax Credit		190	210	280	10	180	(30)	**[16]**
for RE	RE	132	133	177	6	114	(19)	**[17]**
for NUC	NUC	8	9	12	0	8	(1)	**[18]**
for coal	Coal	1	1	1	0	1	(0)	**[19]**
for excluded categories		49	67	89	3	57	(10)	
Fuel Sales		**-**	**80**	**110**	**110**	**872**	**872**	
Enhanced Oil Recovery (EOR) Credit	HC	-	-	+	+	792	792	**[20]**
Marginal Well Credit	HC	-	-	-	-	-	-	**[21]**
Carbon Dioxide (CO2) Sequestration Credit	Coal	-	**80**	110	110	80	80	**[22]**
Fuel Production		**3,326**	**3,610**	**5,897**	**3,817**	**5,998**	**4,348**	
Excess of Percentage over Cost Depletion		1,033	530	1,540	710	1,940	1,150	**[24]**
for oil & gas	HC	*885*	*454*	1,320	609	1,620	960	
for hard mineral fossil fuels (e.g. coal)	Coal	*148*	*76*	220	101	320	190	
Expensing of Exploration and Development Costs		422	550	1,620	470	1,420	560	**[23]**
for oil & gas	HC	*396*	*516*	1,520	441	1,320	521	
for hard mineral fossil fuels (e.g. coal)	Coal	*26*	*34*	100	29	100	39	
15-Year Depreciation for Natural Gas Distr. Pipelines	HC	127	100	220	160	120	170	**[25]**
MLP Tax Preferences	HC	**500**	**1,200**	1,200	1,200	1,200	1,200	**[26]**
Dual Capacity Tax Payer	HC	**950**	**950**	950	950	950	950	**[27]**
Capital Gains Treatment of Royalties on Coal	Coal	53	90	120	120	130	130	
Amortize Geological & Geophys Expend. over 2 Years	HC	158	100	140	100	140	90	**[28]**
Exception from Passive Loss Limitation O/G Properties	HC	32	20	40	40	40	40	**[29]**
Exclusion of Special Benefits for Disabled Coal Miners	Coal	41	30	30	30	20	20	**[30]**
Partial Expensing for Advanced Mine Safety Equipment	Coal	3	27	27	27	27	27	
Deduction for Tertiary Injectants	HC	**5**	**10**	7	7	8	8	**[31]**
Mine Rescue Training Credit	Coal	-	1	1	1	1	1	**[32]**
Natural Gas Arbitrage Exemption	HC	**1**	**1**	1	1	1	1	**[33]**
7-Year Depreciation for Natural Gas Gathering Lines	HC	**1**	**1**	1	1	1	1	**[34]**
Expensing of CapEx to Comply with EPA Sulfur Regs	HC	-	-	-	-	-	-	
Total		**7,321**	**10,643**	**13,923**	**9,544**	**17,261**	**11,585**	

Notes on next page

Note	Comment
[1]	Numbers in italics are scaled subtotals. Numbers in Bold are from other sources (see notes for details). Unless otherwise noted, data for 2010 and 2013 from EIA (2015) Table 1; 2016 and 2019 data from JCT (2015), Table 1 and OMB (2015), Table 14-1. EIA (2015) relies on JCT and OMB data for tax expenditures. Certain tax expenditures are not estimated by one or more of these sources. In these rare instances, we note our source in the notes.
[2]	OMB and JCT estimated Tax Expenditures before Congress passed the Consolidated Appropriations Act, 2016 which included extensions to a number of renewable energy tax credits. JCT estimated $4260 million and OMB estimated $2230 million for 2019. CBO (2015b) estimates an additional $891 million in spending for 2019. We add the CBO's assessment of incremental value to the estimates provided by the JCT and OMB. For certain data, JCT's single year estimates do not add up to their estimate of 2015-2019 spending; in these cases we distribute the difference across all years.
[3]	JCT does not provide annual estimates of expenditures less than $50 million, so for the "other renewables," we annualize JCT's five-year total estimate. For 2016 and 2019, we estimate technology subtotals for OMB using JCT proportions because OMB does not provide technology-specific reakdowns. Similarly, EIA provides total values for 2010 and 2013 but not technology-specific e timates. For conformity, we scale technology-specific v lues for renewables in these years proportional to their share in JCT for 2016.
[4]	A carve-out to the production tax credit affords tax credits for refi ed coal or coal produced on Indian reservations. *See* U.S. Code §45(c)(7) and USC §45(c)(9). Th s may be considered a subsidy for Indian tribes more than coal *per se*.
[5]	JCT does not report this value; data in JCT columns from OMB (2015). Four new units under construction at Vogtle and V.C. Summer will qualify for this 8-year $18/MWh credit. Each unit will receive credits worth $162 million annually (assuming 1,117 MW capacity, and the nuclear fl et's 92% capacity factor). Two of these units are expected to be operational in 2019.
[6]	Total does not include the excluded categories associated with the Advanced Energy Manufacturing Facility Tax Credit
[7]	OMB and JCT estimated Tax Expenditures before Congress passed the Consolidated Appropriations Act, 2016 which included extensions to a number of renewable energy tax credits. JCT estimated $1800 million and OMB estimated $40 million for 2019. The OMB estimate looks suspect but is nevertheless included. CBO (2015b) estimates an additional $753 million in spending for solar for 2019. We add the CBO's assessment of incremental value to the estimates provided by the JCT and OMB. For certain data, JCT's single year estimates do not add up to their estimate of 2015-2019 spending; in these cases we distribute the difference across all years.
[8]	Renewable technology estimates using the same methodology as described in Note [3]
[9]	EPAct2005 Section 1335 offers a 30% personal credit (up to $2,000) for solar PV, heat pumps, fuel cells, and small wind. EIA categorizes this as energy effici cy / conservation but growth it claims is coming from Solar PV mostly. Allocated to solar but an unknown portion goes to heat pumps, fuel cells, and small wind. OMB and JCT estimated Tax Expenditures before Congress passed the Consolidated Appropriations Act, 2016 which included extensions to a number of renewable energy tax credits. JCT estimated $0 million and OMB estimated $40 million for 2019. CBO (2015b) estimates an additional $872 million in spending for solar for 2019. We add CBO's assessment of incremental value to the estimates provided by the JCT and OMB.
[10]	OMB does not report this value; data in OMB columns from JCT (2015).
[11]	Data for 2010 and 2013 from CRS (2015), Table 2. OMB does not report this value; data in OMB columns from JCT (2015).
[12]	As noted in the report, Price-Anderson Act is not a tax expenditure but is included in this table for convenience. The Price-Anderson Act, which provides nuclear power plants no-fault no-cost liability insurance for claims in excess of $12.6 billion, is a form of government guarantee. While this catastrophe insurance is a clear subsidy to the nuclear industry, it has never been invoked. In past years Price-Anderson has been costless, but it exposes the federal government to potential future costs. An MIT study estimated expected fair value of this subsidy would be no higher than about $3 million/year/plant (Deutch et al, 2003); CBO estimated the subsidy at $600k/year/plant (CBO 2008). We take the simple average of these two studies and assume that there are 100 units in operation.
[13]	Drop in spending from change in calculation method.
[14]	JCT does not report this value; data in JCT columns from OMB (2015).
[15]	JCT's single year estimates do not add up to their estimate of 2015-2019 spending; in these cases we distribute the difference across all years.
[16]	Total includes funding for projects not attributable to electricity generation. JCT and OMB data for subcategories proportional to EIA 2013 data.

Note	Comment
[17]	EIA (2015), Table 3.
[18]	EIA (2015), Table 7.
[19]	EIA (2015), Table 2.
[20]	JCT does not report this value; data in JCT columns from OMB (2015). OMB (2015), Table 12-2. The EOR credit offers a tax credit equal to 15% of EOR costs when prices fall below a certain threshold (in 2015, $45.49 per barrel). The threshold is designed to mimic the cost of recovery using low-cost EOR techniques and the whole credit is tied to barrels lifted. In 2016, some level of EOR credit is expected as the oil price is likely to average below $45/bbl.
[21]	JCT does not report this value; data in JCT columns from OMB (2015). Currently worth nothing due to low oil prices and expected to remain this way through 2026.
[22]	JCT does not report this value; data in JCT columns from OMB (2015). Credit offers $20/tonne if CO2 is sequestered; $10/tonne if used in EOR. Credit does not specify source but currently CO2 sequestration credit is only offered to coal units. 2013 data from OMB (2013), Table 14-1.
[23]	Commonly known as expensing of "intangible drilling costs." Neither EIA (2015) nor CBO (2015) provide a breakdown for coal and HC. We estimate the 2010 and 2013 subtotal values by JCT's ratio in 2016. We similarly estimate OMB data using the same-year JCT ratio. For certain data, JCT's single year estimates do not add up to their estimate of 2015-2019 spending; in these cases we distribute the difference across all years.
[24]	EIA (2015) allocates all of this category to HC but it is split between coal and HC. Neither EIA (2015) nor CBO (2015) provide a breakdown for coal and HC. We estimate the 2010 and 2013 subtotal values by JCT's ratio in 2016. We similarly estimate OMB data using the same-year JCT ratio. JCT's single year estimates do not always add up to their estimate of 2015-2019 spending; in these cases we distribute the difference across all years.
[25]	JCT's single year estimates do not add up to their estimate of 2015-2019 spending, so we distribute the difference across all years.
[26]	OMB does not report this value; data in OMB columns from JCT (2015). EIA (2015) excludes MLP's from their analysis. For 2010 and 2013, we rely on data from CRS (2015), Table 2. Listed in JCT (2015) and OMB (2015) as "Exceptions for publicly traded partnerships with qualifying income derived from certain energy-related activities." OMB (2015) Table 12-2 estimates the value of taxing PTP's as C-Corporations, but only provides that assessment for 2022 and following. In those years, they estimate PTPs are worth $201million to $323 million. Koplow (2013) estimates MLP preferences are worth $3.9 billion/yr. While not the only benefic ary, midstream and downstream oil and gas companies receive most of the benefit.
[27]	JCT does not report this value; data in JCT columns from OMB (2015). Values presented are the OMB's estimates of the revenue increase that would occur from stricter application of dual capacity rules. OMB (2015) assumes that a phase-in would after the current fiscal year so it does not present a same-year estimate of value. OMB historic estimates vary year-to-year but are roughly $950 million. OMB (2015), Table 12-2 estimates the 2018-2022 value at $4584 million ($916 million/year). OMB (2012), Table 12-2 estimates the 2014-2018 value at $5146 million ($1029 million/year). Proposed changes are discussed at length by the JCT (JCT 2012, 403-410).
[28]	JCT's single year estimates do not add up to their estimate of 2015-2019 spending, so we distribute the difference across all years.
[29]	JCT does not report this value; data in JCT columns from OMB (2015). Listed as "Exception from Passive Loss Limitation for Working Interests in Oil and Gas Properties"
[30]	JCT does not report this value; data in JCT columns from OMB (2015).
[31]	JCT does not report this value; data in JCT columns from OMB (2015). EIA (2015) does not include this deduction in its analysis. OMB never estimated its value in 2010 so we present the 2011 value found in OMB (2012), Table 12-2. Data for 2013 is from OMB (2012), Table 12-2; 2016 is from OMB (2014), Table 12-2; and 2019 is from OMB (2015), Table 12-2.
[32]	EIA (2015) data assumed constant for 2016 and 2019.
[33]	Estimated in ELI (2009), data assumed constant for all years.
[34]	EIA (2015) data assumed constant for 2016 and 2019.

APPENDIX 3: CALCULATION OF SUBSIDY VALUE IN 2016 AND 2019 FOR JCT & OMB ESTIMATES

In this section, we calculate the value of fi ancial supports based on alternative assessments of tax expenditure developed in Appendix 2. The following tables are analogous to Tables 2, 3, 5, and 7 of the primary report. We do not conduct the same analysis for 2010 and 2013. Tax expenditure estimates for 2016 range from $9.5 billion to $13.9 billion (Table A3a). For 2019, values range from $11.5 billion to $17.3 billion. Th s translates into total support for electric generating technologies ranging from $8.7 billion to $11.5 billion for 2016 and $9.7 billion to $14.3 billion for 2019 (Table A3c). On a portfolio basis, this spending is equivalent to $2.31-3.07/MWh in 2016 and $2.52-3.70/MWh in 2019 (Table A3d). For conventional fuels the difference is modest across cases but for wind and solar the maximum case is 30% to 88% larger than the minimum case. Using the minimum figu es instead of the JCT figu es would lessen the magnitude of fi ancial support for renewables by $23-33/MWh for solar and $5-6/MWh for wind.

TABLE A3:

Total Energy, Electricity, and $/MWh Spending using OMB figures

TABLE A3A: Total Energy Tax Expenditures by Type & Fuel (2016, 2019, $ nominal)

	2016			2019		
Type	**JCT**	**OMB**	**OMB - JCT**	**JCT**	**OMB**	**OMB - JCT**
Coal	1,209	1,002	(207)	1,249	1,041	(208)
HC	5,399	3,508	(1,890)	6,192	4,733	(1,459)
Nuclear	532	490	(42)	828	759	(69)
Renewables	6,783	4,542	(2,241)	8,993	5,053	(3,940)
Wind	*2,700*	*1,615*	(1,085)	*4,591*	*2,782*	(1,809)
Solar	*2,820*	*2,093*	(727)	*3,345*	*1,680*	(1,665)
Other	*1,263*	*834*	(429)	*1,057*	*591*	(466)
Total	**13,923**	**9,544**	**(4,380)**	**17,261**	**11,585**	**(5,676)**

Source: Table A2

TABLE A3B: Total Energy Spending by Type & Fuel (2016, 2019, $ nominal)

	2016			2019		
Type	**JCT**	**OMB**	**OMB - JCT**	**JCT**	**OMB**	**OMB - JCT**
Coal	1,543	1,336	(207)	1,249	1,041	(208)
HC	5,472	3,581	(1,890)	6,192	4,733	(1,459)
Nuclear	1,013	972	(42)	828	759	(69)
Renewables	7,883	5,642	(2,241)	8,993	5,053	(3,940)
Wind	*2,757*	*1,672*	(1,085)	*4,591*	*2,782*	(1,809)
Solar	*3,140*	*2,413*	(727)	*3,345*	*1,680*	(1,665)
Other	*1,966*	*1,537*	(429)	*1,057*	*591*	(466)
Total	**15,911**	**11,532**	**(4,380)**	**17,261**	**11,585**	**(5,676)**

Sources: Table 1 and Table A2

TABLE A3C: Total Electricity Spending by Type & Fuel (2016, 2019, $ nominal)

	2016			2019		
Type	**JCT**	**OMB**	**OMB - JCT**	**JCT**	**OMB**	**OMB - JCT**
Coal	1,439	1,265	(175)	1,481	1,308	(173)
HC	1,227	823	(404)	1,221	951	(269)
Nuclear	1,013	972	(42)	1,338	1,269	(69)
Renewables	7,883	5,642	(2,241)	10,160	6,220	(3,940)
Wind	*2,757*	*1,672*	(1,085)	*4,651*	*2,842*	(1,809)
Solar	*3,140*	*2,413*	(727)	*3,685*	*2,020*	(1,665)
Other	*1,966*	*1,537*	(429)	*1,803*	*1,337*	(466)
Total	**11,563**	**8,702**	**(2,861)**	**14,200**	**9,749**	**(4,452)**

Sources: Table 5 and Table A2

TABLE A3D: Per-MWh Subsidy by Type & Fuel (2016, 2019, $ nominal)

	2016			2019		
Type	**JCT**	**OMB**	**OMB - JCT**	**JCT**	**OMB**	**OMB - JCT**
Coal	1.09	0.96	(0.13)	1.09	0.97	(0.13)
HC	1.10	0.74	(0.36)	1.19	0.93	(0.26)
Nuclear	1.30	1.24	(0.05)	1.74	1.65	(0.09)
Renewables	27.33	19.56	(7.77)	25.08	15.35	(9.72)
Wind	*12.92*	*7.84*	(5.09)	*15.30*	*9.35*	(5.95)
Solar	*99.48*	*76.45*	(23.03)	*70.53*	*38.67*	(31.86)
Other	*45.12*	*35.28*	(9.84)	*36.87*	*27.34*	(9.53)
Total	**3.07**	**2.31**	**(0.76)**	**3.69**	**2.53**	**(1.16)**

Sources: Table 7 and Table A2

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