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The Full Cost of Electricity (FCe-)

State Level Financial Support for Electricity Generation Technologies

AN ANALYSIS OF TEXAS & CALIFORNIA

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

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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: **energy.utexas.edu**

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State Level Financial Support for Electricity Generation Technologies

AN ANALYSIS OF TEXAS & CALIFORNIA

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ABSTRACT:

In this white paper, we compile data from government and other sources on financial support offered to electricity generating technologies by the state governments of Texas and California for the years 2010, 2013, 2016, and (prospectively) 2019. We evaluate data across the sources for consistency and relevance to our goal of calculating a dollar-per-megawatt-hour ($/MWh) value.

We focus on state financial support programs that are associated with specific generation technologies and fuels. Financial support includes direct expenditures, tax expenditures, mandates, and derivatives of these policies. This white paper does not discuss the motivations for these financial support policies or their effectiveness. We exclude some programs that are considered as subsidies in some of the literature because they are technology-neutral and/or they target consumers. Importantly, we do not include unpriced externalities as "financial support" because they are conceptually different. However, we acknowledge that proper public policy assessment needs to include all of these costs, among others, and benefits (including positive externalities). For example, a companion paper of Wu et al. (2016) offers an assessment of how environmental externalities are included into regulation. Another paper (Rhodes et al., 2016) adds air and greenhouse gas emission externality costs to geographically resolved levelized cost calculations. Another paper on dispatch economics (Mann et al., 2017) compares overall electric grid costs and revenues of two scenarios, one with significantly more renewable capacity than the other. We encourage readers to consider this white paper and the one on federal financial support (Griffiths et al., 2017) together with the rest of the Full Cost of Electricity literature to gain a better understanding of the complexity of trade-offs in power systems.

EXECUTIVE SUMMARY

This white paper on state financial support to electric power generation is a complement to the white paper on federal financial support (Griffiths et al., 2017). Both white papers are contributions to the interdisciplinary project, The Full Cost of Electricity (FCe-), managed by the Energy Institute at The University of Texas at Austin. In total there are sixteen white papers covering a wide range of cost factors from several perspectives.

The objective of this white paper is to identify the financial support (subsidies) offered by state governments to different technologies that provide electric power in the states of Texas and California. With that objective, we provide the following points to place this white paper into the larger context of energy and electricity system assessment.

1) This is not a cost-benefit analysis of different generation technologies or of the subsidies that we have identified. We caution readers not to conclude either that technologies receiving large subsidies impose social costs that are larger than their social benefits or vice versa.

2) We focus on financial support (subsidies) to generation technologies or fuels that follow two simple criteria:

    a. Policy/regulatory intent is identifiable

    b. Monetary value is quantifiable

3) We exclude financial support programs that target consumers or that are technology-neutral.

4) We do not treat unpriced externalities (negative or positive) as subsidies because we consider them conceptually different. See Rhodes et al. (2016) for the incorporation of externalities in the cost of electricity.

5) We selected the period (2010-2019) for this study because of its relevance for current policy choices.

6) We investigate only California and Texas for two main reasons.

    a. Practical resource limitations that did not enable in-depth investigation of other states.

    b. California and Texas offer two distinct approaches to energy policy while being the two largest state economies in the United States with large amounts of renewable and conventional energy resources and production.

7) We ignore any financial support in levels lower than the state policy (e.g., city or utility policies or programs). This is a rich area for subsidy research but is outside the scope of this white paper.

Key takeaways from our analysis include:

- Between 2010 and 2019, Texas offers the energy sector financial support worth a total value of approximately \$2–\$3 billion per year. Of this, we estimate that \$0.6 billion in 2010 and \$1.5–\$1.6 billion from 2013-2019 support electricity generation when including the cost of the transmission lines to the Competitive Renewable Energy Zones (CREZ). If not including CREZ transmission, Texas electricity generation support is \$0.5–\$0.6 billion annually. California offers the electricity sector \$2.5-\$7 billion annually in financial support while the state offers no material support to energy outside of the electricity sector. The federal government offers electricity-related support worth \$11-\$18 billion over the same period (Griffiths et al., 2017).

- California offers more support per MWh and per capita than the Federal Government while Texas support is similar, some years offering more, and some years less when including CREZ, but always less when excluding CREZ. The total value of financial support to the electricity sector from the state of Texas in 2016 is valued at \$60/Texan and \$22/

Texan with and without CREZ, respectively. California's support is worth $153/Californian. Federal support is worth approximately $37/ American (Griffiths et al., 2017).

- Renewables receive significantly more support than conventional technologies on a $/ MWh basis. Depending on the year, Texas' conventional generation receives $0-$2/MWh while wind receives $16-$30/MWh (including CREZ) or $2-$3/MWh (excluding CREZ) and solar receives $256-$257/MWh. California renewables receive an average of $56-$102/ MWh while other sources receive negligible support. In California, the support for wind declines from $56/MWh to $40/MWh over the study period, the support for solar drops from $602/MWh to $96/MWh, and other renewables receive constant support at or below $50/MWh.
- Texas generally uses its financial support for economic development while California uses it to meet environmental goals and to drive down the cost of new technologies.
- California directs all of its financial support to a diversified portfolio of renewable electricity technologies while Texas splits its support between hydrocarbon extraction (leading to natural gas-fired electricity) and wind capacity additions.
- Texas offers support using a mixture of direct expenditures, mandates, and tax expenditures. California offers more than 90% of its support through mandates.
- Renewable generation is supported directly while generation from burning fossil fuels is supported indirectly via support to fuel extraction.
- Coal and natural gas power plant facilities receive indirect support that reduces fuel extraction costs but do not receive direct support for electricity sales or capacity additions (e.g., power plant capital projects).
- Nuclear power receives very little support, and that which exists is direct support for research and development and planning. ■

INTRODUCTION

The purpose of this white paper is to estimate a per-unit quantity, $/MWh, of different financial support mechanisms offered by Texas and California for different electricity generation technologies. We focus on Texas, the nation's largest energy producer and home to the largest installed capacity of wind, and California, the country's foremost advocate of renewable electricity technology. We restrict our analysis to the 2010s, identify state financial support programs that are most relevant to power generation, and quantify their magnitude primarily based on government data. We do not consider policies by cities or utilities or other jurisdictions below the state level.

This white paper builds on the framework offered in an earlier Full Cost of Electricity (FCe-) project white paper, *Federal Financial Support for Electricity Generation Technologies* (Griffiths et al., 2017) and provides a complementary analysis. As in that paper, we will use subsidies as a shorthand for financial support programs although readers should be aware that subsidies cover a wider range of policies and programs.

Energy subsidies are often justified as a way to reduce the cost of energy or to remedy negative externalities. Energy has been a driver of economic growth for 200 years and studies have found a strong, positive relationship between energy consumption and gross domestic product (Kalimeris et al, 2013). Subsidies to renewables are sometimes justified by policymakers as compensation for the reduction in negative externalities associated with other sources of energy. Irrespective of the justification, however, governments provide preferences to energy sources, fuels, and generation technologies in a multitude of forms. Griffiths et al. (2017) found that the Federal Government offered electricity-related support valued between $11 and $18 billion in the 2010s translating to an average of 3-5 $/MWh across all electricity supply chains.

States offer both duplicative and complementary support mechanisms to enhance federal efforts on a more local level. The motivations of such programs vary but include job creation, economic development, reducing greenhouse gas emissions, and social welfare. As the goals of state energy policies shifted over time, so too did the support offered by governments 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.

The Database of State Incentives for Renewables & Efficiency (DSIRE), a national database of incentives and policies that support renewables and energy efficiency, identifies 2,683 support programs. These programs are spread across 43 categories ranging from net energy metering, to renewable portfolio standards (RPS), and to property tax incentives. Some of these programs are easily quantifiable while others such as RPS programs require counterfactual estimation of avoided costs. An example is the cost of the generation that might otherwise have occurred had renewables not been mandated by RPS programs.

WHY TEXAS AND CALIFORNIA?

The large number of state-level energy-support mechanisms makes nation-wide assessment a challenging task. Given our resource limitations, we focused on two states. In selecting California and Texas, we sought to highlight extremes in approach, application, and receipt of support. The two states are physically and economically significant, yet their politics and energy policy differ dramatically. Table 1 summarizes some key statistics of these two states.

California and Texas are the two largest states in the country by population and GDP. When combined, they account for nearly 25% of the population, 25% of the energy production and 25% of the energy consumption in the United States. Yet the major energy similarities end there: policy and politics differ significantly. While both states are hydrocarbon producers, Texas produces seven times more energy than California. Texas also has among the highest energy consumption per capita while California has among the lowest. Politically, Texas is Republican-leaning and supportive of markets while California leans Democratic and is more inclined towards market intervention.

TABLE 1:

Comparison of California & Texas

	Quantity		Rank		Source
Statistic	**California**	**Texas**	**California**	**Texas**	
Population (2013, Million)	38.8	27.0	1	2	(a)
State Gross Domestic Product (2013, $ Trillion)	2.2	1.6	1	2	(b)
Share of US Energy Production (2013, %)	2.8	20.2	11	1	(c)
Carbon Emissions (2013, Million Metric Tons)	353.1	641.0	2	1	(d)
Energy Consumption per Capita (MMBtu)	196.0	478.0	6	6	(c)
Carbon Intensity per Capita (2013, Metric Tons/Person)	9.2	24.2	49	15	(d)
% Republican/Lean	32.6	42.9	45	25	(c)
% Democrat/Lean	48.1	37.4	7	38	(c)
Democrat Advantage (Diff. between Dem. & Rep.)	15.5	-5.5	6	32	(c)
Times State Voted for Democrat (D) and Republican (R) Candidate in Past 5 Presidential Elections	5 (D) 0 (R)	0 (D) 5 (R)			

Notes: Source: (a) US Census (2016), (b) Bureau of Economic Analysis (2015), (c) Gallup (2015), (d) EIA (2015)

Texas views its mineral wealth as a core component of its economic success alongside "limited government, pro-growth economic policies and sound financial planning" (Abbott, 2016). It is the leading producer of crude oil, natural gas, and lignite in the United States. It also has the largest installed base of wind turbines, approximately 21 gigawatts (GW) of capacity as of mid-2017 (EIA 2017; AWEA 2017).

California, by contrast, pursues policies that are more progressive. As the wealthiest state in the country, it has taken the lead in clean energy and environmental policies. The California Air Resources Board can single-handedly influence the fuel efficiency standards of automakers and the California Energy Commission has overseen the State's ever-cleaner electricity generation (half of the nation's average carbon intensity). California's Global Warming Solutions Act of 2006 (Assembly Bill 32) requires the state to reduce greenhouse gas (GHG) emissions to 1990 levels by 2020. More recently, the Clean Energy and Pollution Reduction Act of 2015 (Senate Bill 350) strengthened provisions for reducing carbon emissions by increasing renewable electricity procurement to 50 percent by 2030, and doubling energy efficiency savings by 2030 (CEC 2016a). Given its favorable climate and natural resource endowment, many are optimistic that the state will meet these goals. In July 2017, via Assembly Bill 398, California lawmakers voted to extend, through 2030, the state's cap and trade policy that is intended to further reduce greenhouse gas emissions. In 2015, California was the 3rd largest producer of oil in the country and 15th for natural gas. California has no coal production. Nevertheless, the state ranks 49th in the nation for energy consumption per capita due to its moderate climate, a relatively small number of energy- intensive industries, and longstanding energy efficiency efforts.

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

Financial support is commonly called a "subsidy". While we will use subsidy as a shorthand for financial support throughout this white paper, specific programs have different intents and methods, which influence their economic impact on energy projects and costs as well as government cash flow (e.g., forsaken revenues versus direct expenditures).

In this white paper, we rely on the same definition of subsidy and the same general framework that we used in Griffiths et al. (2017) for Federal financial support. In that paper, we focused on the *intent* of

DEFINITIONS OF SUBSIDY

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 is similar. The Latin root of the word, subsidium, means "support, assistance, aid, help, protection" and suggests forms of assistance other than direct payments.

The Global Subsidies Initiative (GSI) offers another definition: "A subsidy is a financial contribution by a government, or agent of a government, that confers a benefit on its recipients" (Steenblik 2007, 8). This definition, albeit somewhat vague, widens the scope in at least two ways: first, a "benefit" can be extended beyond a direct payment, and, second, recipients can include consumers and public entities, and not just businesses. The GSI then suggests nine categories of subsidy. 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.)

the federal government policy to provide financial support to generation technologies or fuels (see box). Thus, a state government must intend to offer a specific benefit to a certain group or technology, as distinct from baseline policy, for us to qualify a program as a subsidy. We do not distinguish among the rationales of such subsidies (e.g., to correct market failures, to reduce the production cost of electricity, to create local jobs, to enhance energy security). If, however, a program applies to all firms in the electric power industry, we would exclude it from our analysis because it does not target particular generation technologies or fuels. With these criteria, research and development (R&D) funding, tax preferences, mandates, and cash grants are all included as forms of financial support for the energy industry.

Included Types of Financial Support

We identified four categories, each with their own sub-groups with sizeable impact on electricity generation: direct expenditures, tax expenditures (also known as "tax preferences"), legislative mandates, and derivative subsidies.

- **Direct expenditures** are cash transfers from the government to industry, academia, or individuals. They can take many forms including cash grants, applied R&D, pilot projects, and jobs programs.
- **Tax expenditures** reduce government tax revenues by granting special exemptions to baseline tax rules.[1] Tax expenditures are typically the largest component of financial support as was the case with federal programs. 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.
- **Legislative mandates** are requirements established by the government requiring other parties to undertake specific action. For example, a Renewable Portfolio Standard (RPS) requires electricity providers to generate or procure a portion of their energy from renewable sources. The costs associated with these procurements are passed on to ratepayers. Mandates and direct expenditures may produce the same end-result but they differ in who pays. Direct expenditures are paid through taxes and show up in a government's budget while a mandate is ultimately paid by customers, usually via their

1 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." Texas' use of the term "exemptions" includes exemptions, exclusions, discounts, deductions, special accounting methods, credits, refunds, and special appraisals.

electric utility bills. Note that in a previous assessment of federal support (Griffiths, et al., 2017) we considered several examples of federal legislation that impacted generation technologies in different ways, sometimes conflicting with each other, but excluded them from our analysis because none of them mandated market shares by a certain date for specific generation technology as the state-level RPS programs do.[2]

- **Derivative subsidies** (also known as indirect subsidies) is a general term to capture upstream and downstream impacts of a direct subsidy. For example, RPS programs may necessitate new transmission infrastructure in excess of what would be required if a planning agency were only concerned about system reliability, in a much faster timeframe. Similarly, federal tax credits can induce much faster development of renewable generation capacity than transmission capacity expansion. While there may be other varieties of derivative subsidies depending on generation portfolios, load profiles, and environmental policies, we only identified policy-driven transmission infrastructure as important in Texas and California.

Our analysis excludes four categories of subsidies for our purposes of estimating a dollar-per-MWh quantity by generation technology in the electricity sector.

- **Cross-subsidies** can occur in different ways. For example, when one group of electric power customers is charged higher prices to offset lower prices for another. In traditional ratemaking, regulators approximate a fair allocation of costs but cross-subsidies are inevitable (e.g., between residential and commercial customers or between apartment dwellers and detached single-family homes). Some states require utilities to provide lower rates for low-income ratepayers. These are technology-neutral for our purposes and hence excluded. In contrast, net energy metering (NEM) creates explicit and intentional cross subsidies using rate design. NEM shifts fixed distribution system costs from customers with rooftop solar to those without. In Texas, there is no state policy mandating NEM. Instead, utilities and other Load Serving Entities pursue it if they so choose. In California, there is a NEM policy for rooftop solar but the owner has the option to utilize this incentive or one via the California Solar Initiative. Which option is chosen is not readily available to researchers, which makes NEM costs difficult to quantify. Hence, we exclude the analysis of both sorts of cross subsidies in our analysis.

- **Price support** for electricity is analogous to administered agricultural commodity prices in many countries. Occasionally, states have established floor or ceiling prices in electricity markets. For example, during the California electricity crisis, the state imposed retail price caps restricting residential exposure to wholesale price volatility. In a similar vein, wholesale markets have administered price caps. In the case of power generation, wholesale and retail price controls are technology-neutral.

- **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 efficiency, and similar generation-technology-neutral purposes. Funding for energy efficiency projects is the largest form of technology-neutral support but other forms exist too. Federal 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. Transmission assets built for reliability reasons, for example, are offered accelerated depreciation; but, this infrastructure, in general, benefits all types of electricity generation. As noted above, we include transmission

2 Examples of federal legislation include the Powerplant and Industrial Fuel Use Act of 1978 (PIFUA) and Public Utility Regulatory Policies Act of 1978 (PURPA).

intended to facilitate a particular project or type of generation technology.

Environmental impacts / externalities associated with power generation may include long-term damages from CO_2 emissions, birds killed by wind turbines, ecosystem impacts from acid rain or coal mine drainage, environmental impacts of fuel/mineral extraction and processing, and so forth. A recent IMF report estimates that the global value of untaxed air pollution and greenhouse gas emissions is approximately $5 trillion per year (IMF, 2015). However, we do not consider the cost of these externalities in this report for two reasons. First, the federal government has internalized the cost of area pollutants such as sulfur dioxide by setting emission standards for them that mitigate these damages. Some states or regions price and/or cap CO_2 emissions, including California, although there is no nationwide carbon price. Second, and more importantly, unpriced externalities are conceptually distinct from subsidies.[3] Following our criteria, there is no governmental intent associated with targeting an individual technology to provide support or benefits. Likewise, we do not include the cost of environmental regulations, but implicitly assume these are intended to balance environmental impacts versus economic efficiency. However, these externalities should be an integral part of overall energy policy assessments. As part of the FCe- project, 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*[4] (Rhodes et al., 2016).

3 Note that the Global Subsidies Initiative does not consider externalities in one of its nine categories of subsidies (see text box above) although the cost of externalities are discussed in many of the studies available at the GSI web site within the context of proper public policy assessment.

4 Rhodes et al. (2016) develop a methodology to calculate the levelized cost of electricity (LCOE) for 12 major power plant types for every county in the continental U.S. The method includes both the cost of adding a marginal amount of local air pollution (by county) from a power plant and the cost of carbon dioxide emissions due to constructing and operating a power plant. An interactive calculator of these calculations is available at: http://calculators.energy.utexas.edu/.

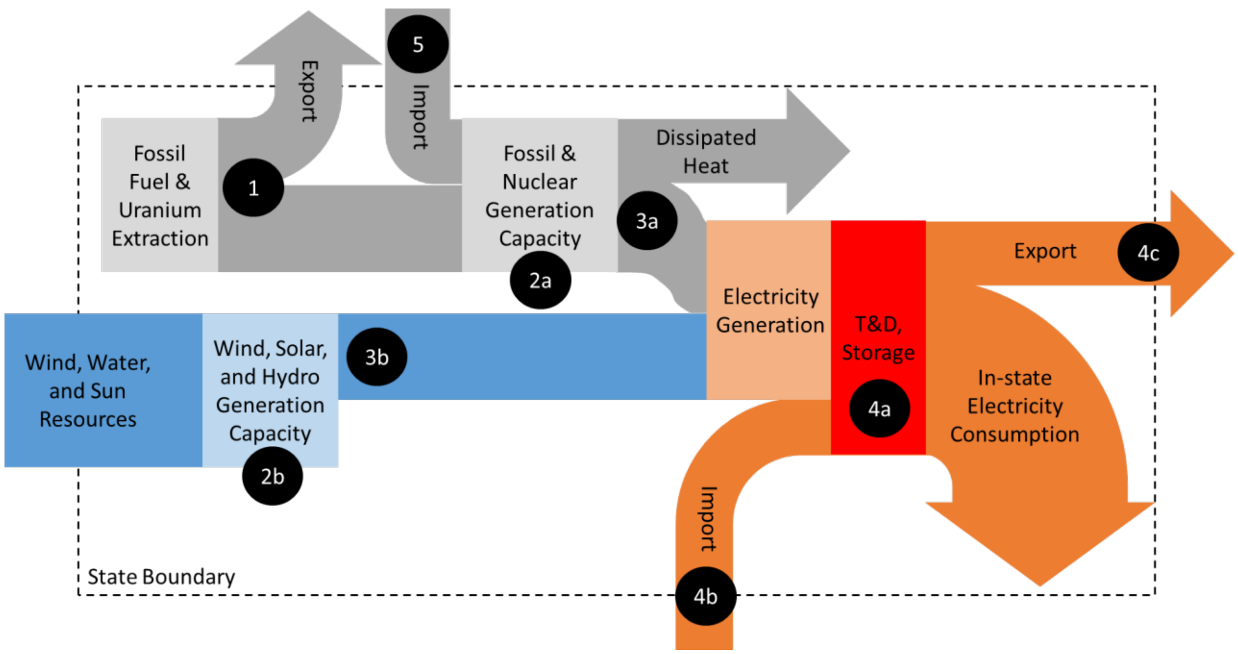
CATEGORIZATION OF FINANCIAL SUPPORT

In Griffiths et al. (2017), we grouped various forms of financial support into four categories that denote their proximity to electric power generation. We take this opportunity to add a few more categories to enhance our discussion of state subsidies. Each category refers to one or more points along the supply chain of providing electricity as shown in Figure 1. Subsidies for fossil versus renewable electricity supply chains interact in different points and subsidy categories.

- **Fuel Sales (1 in Figure 1):** Subsidies in this category include per-barrel or per-mcf tax reductions applied when products are supplied to the market. For example, federal marginal well and enhanced oil recovery credits offered when oil or gas prices fall below certain thresholds (see Griffiths et al, 2017). We consider state severance tax exemptions (e.g., for high-cost drilling in Texas) in this category.
- **Fuel Extraction (and Production) Costs (1 in Figure 1):** Many subsidies are intended to reduce the tax burden of fossil fuel resource development and extraction (upstream) generally but they cannot be attributed to any particular type of fuel. Federal examples include the expensing of intangible drilling costs, excess of cost over depletion, and treatment of geophysical costs (see Griffiths et al, 2017). There are similar exemptions at the state level such as oil well servicing or recycling of hydraulic fracturing water in Texas.
- **Power Plant Capital (2a and 2b in Figure 1):** Some subsidies target costs associated with building, maintaining, and decommissioning power plants. Incentives for building "clean coal" power plants or solar capacity are examples of subsidies for power plant capital expenditures.
- **Electricity Sales (3a and 3b in Figure 1):** This category is the most direct in terms of impact on electricity prices and includes

FIGURE 1:

State government financial support, or subsidies, can interact at one or more points (labeled with numbers) within the supply chain of energy: (1) fuel sales and extraction; (2) power plant capacity (or capital), in MW, for (a) fossil and nuclear power, or (b) renewable power; (3) electricity output in units of energy (MWh) for (a) fossil or nuclear electricity or (b) renewable electricity; (4) transmission, distribution, and storage for (a) in-state generation for in-state load and storage, (b) imports from out-of-state electricity for in-state load, (c) in-state generation for out-of-state load; and (5) fuel imports from other states or countries.



payments for a unit of electricity generated by a specified fuel source. Net energy metering (excluded in our analysis) and renewable energy credits (RECs) associated with RPS programs are both forms of support targeting electricity sales.

- **Transmission, Distribution and Storage (4a, 4b, and 4c in in Figure 1):** Mandates or other monetary or non-monetary incentives to build transmission, distribution, or energy storage infrastructure that is outside of typical mandates under reliability criteria and if this infrastructure is deemed necessary for facilitating electricity generation of any specific type or power plant project.

- **Fuel purchases from out-of-state: (5 in Figure 1):** A state could choose to subsidize purchase of fuels (for electricity generation) from out of the state. We do not consider any subsidies related to fuel imports into a state.

TEXAS

Texas is the leading producer of crude oil, natural gas, and lignite, a form of coal used in electric power plants, in the United States. The State also has the largest installed wind capacity, approximately 21 gigawatts (GW) as of mid-2017 (EIA 2017, AWEA, 2017). Today, Texas exports more than half of the energy it produces to other states and countries. While the energy industry's fraction of state GDP has declined over the past half century, the state still views energy production as core to economic development. To that end, it has developed a range of financial support measures for various energy industries, especially for oil and gas production.

In this section, we report on total cost of subsidies in the four included categories, and classify each in terms of proximity/directness to final MWh generated. Table 2 through Table 5 summarize direct expenditures, tax expenditures, mandate expenditures, and certain local/utility expenditures, respectively.

Our analysis is based on a variety of state reports, especially the Comptroller's 2015 *Tax Exemptions and Tax Incidence* report (Comptroller, 2015). The state does not provide regular estimates of some hydrocarbon subsidies (e.g., severance tax exemptions for low- producing wells during low-price periods) in their biannual reports.[5] Nevertheless, several studies commissioned for the Texas Legislature have provided snapshots of these financial supports. There are also special reports from the Comptroller and the Texas Railroad Commission (RRC). We used open records

5 From what we can tell, the Comptroller does not publish the value of these subsidies because Section 403.014 of the Texas Government Code does not include these tax expenditures within reporting requirements.

TABLE 2:

Texas Direct Expenditures on Energy by Category and Year ($ million, Nominal).

Type	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Included	**184.8**	**184.8**	**71.9**	**297.6**	**48.4**	**271.5**	**46.4**	**39.8**	**43.1**	**43.1**	**43.1**
Coal	3.4	3.4	3.5	3.2	3.3	3.2	3.2	3.2	3.2	3.2	3.2
Hydrocarbons	178	178	65	291	43	267	41	35	38	38	38
Nuclear	1.4	1.4	1.4	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.0
Renewables	1.5	1.5	1.5	1.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Wind	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Solar	-	-	-	-	-	-	-	-	-	-	-
Biopower	1.5	1.5	1.5	1.5	-	-	-	-	-	-	-
Excluded	**339**	**339**	**391**	**287**	**608**	**262**	**484**	**158**	**321**	**321**	**321**
General Electricity	76.1	76.1	65.1	87.1	451.1	105.1	325.5	-	163	163	163
Energy R&D	5.1	5.1	5.1	5.1	5.1	5.1	12.0	12.0	12.0	12.0	12.0
Energy Efficiency	258	258	321	195	152	152	146	146	146	146	146
Total	**524**	**524**	**463**	**585**	**657**	**534**	**530**	**198**	**364**	**364**	**364**

Notes: Subtotals may not add to stated totals due to rounding. Budget Data provided by the Legislative Budget Board for the years 2012-2017 using their "State Budget by Program" web tool (LBB 2016). The LBB's Fiscal Size-up offers budget details in report form (e.g., LBB 2017). Spending in 2010 and 2011 is estimated as the simple average of spending in 2012 and 2013, while 2018-2020 are the simple average of spending in 2016 and 2017. Budget programs identified using keywords oil, gas, coal, mining, energy, electric*, wind, solar, and bio* (" * " represents a wild card). Identified programs are listed in Appendix 1.

requests to supplement the existing reports, and list data in the Appendix Tables A-7 to A-9.

The state offers only modest support for electricity, and data on these programs are sourced primarily from utility reporting and from the Public Utility Commission of Texas (PUCT). Direct expenditures values are compiled from the State's published budget.

DIRECT EXPENDITURES

Direct expenditures are cash outlays from the government that pay for specific programs. For the 2016-2017 two-year budget cycle, $730 billion was appropriated for all state activity with just over half of this amount coming from the state's general fund. Energy-related expenditures over this period were approximately $200 to $650 million per year (less than 0.4% of all state spending). Table 2 summarizes our analysis of direct expenditures. Appendix 1 includes a complete list of the 32 programs included in Table 2 and their categorization.

We consider only the "included" subset of the programs listed in Table 2 following our subsidy definition (that is, intent to target a particular generation technology). The cost of these programs ranged from an estimated low of $40 million in 2017 to a high of $300 million in 2013. Of total energy spending in 2016, only $46 million can be attributed to a specific electricity-generation technology. This portion is included in the remainder of this analysis.

Table 2 also includes programs we exclude going forward such as spending on R&D programs, energy efficiency and conservation projects, and managing the externalities associated with energy production (e.g., repairing roads "located in areas of the state affected by increased oil and gas production" or capping abandoned wells). Table 2 does not include general regulation expenditures such as administration of the Railroad Commission or General Land Office (which manages mineral leasing). An additional $12 million in R&D funding to excluded because its end-use is undifferentiated between energy and other spending.

TAX EXPENDITURES

Tax preferences are called tax expenditures by government agencies, and they constitute the largest and most complicated type of government support for electricity. Estimates of costs of this kind of financial support vary across reports and even across government agencies. Qualifications for some of the stipulated tax benefits are complex and dependent on factors such oil and gas prices, or capital and operating costs that vary over time, location, and company.

Energy-related tax expenditures in Texas have been trending upward. In 2016, they totaled approximately $2 billion. They are forecast to increase from $1.5 billion in 2010 to $2.1 billion in 2019 (Table 3). We identified 28 distinct, preferential tax treatments. We have organized them into the six categories defined earlier: fuel sales, fuel extraction, power plants, electricity sales, transmission and distribution (T&D) and storage, and fuel imports. There are no tax expenditures in Texas on T&D, electricity sales, and fuel imports. For most fuel subsidies, Texas distinguishes between those for oil and those for gas. Certain subsidies comingle fuel types or generation technologies making the identification of cost-causation impossible. For generic hydrocarbon subsidies, we currently denote these as such using the "HC" identifier and allocate this to specific fuels in a later section.

TABLE 3:

Texas Total Energy-Related Tax Expenditures ($ million, nominal)

Type	Tax Code Section	Beneficiary	2010	2013	2016	2019
Fuel Sales			**1,182**	**1,235**	**1,459**	**1,396**
Severance tax relief for marginal oil wells[a]	202.057	Oil	0	0	5	0
Enhanced efficiency equipment severance tax credit	202.061	Oil	*	*	*	*
Oil and gas from wells previously inactive	202.056	HC	62	33	32	25
Qualification of oil from new or expanded enhanced Recovery project for special tax rate	202.054	Oil	42	43	42	51
Qualifying low-producing oil leases	202.058	Oil	*	*	*	*
Oil and gas from reactivated orphaned wells	202.06	Oil	*	*	*	*
Oil incidentally produced in association with the production of geothermal energy	202.063	Oil	*	*	*	*
High cost ng tax rate reduction program	201.057	NG	989	810	1,062	1,012
Incentive to market previously flared or vented casinghead gas.	201.058	NG	*	210	210	210
Severance tax relief for marginal gas wells	201.059	NG	12	49	31	31
Lack of severance tax on lignite mining	---	Coal	77	94	77	66
Fuel Extraction			**255**	**317**	**321**	**402**
Incentive for reuse/recycling of hydraulic fracturing water (HB 4)	151.355	HC	6	6	*	*
Enhanced recovery projects using anthropogenic CO_2	202.0545	Oil	#	#	*	*
Sales tax exemption for offshore spill response containment property	151.356	Oil	N/A	N/A	*	*
Offshore drilling equipment not in use	11.271	Oil	cbe	cbe	0	0
Sales tax exemption for oil well servicing items taxed by other law (oil well servicing)	151.308	HC	84	283	161	200
Franchise tax exclusion from revenue of certain payments made by an entity performing landman services	171.1011 (g-11)	HC	N/A	N/A	1	1
Franchise tax exclusion for cost of goods sold subtraction for certain pipeline entities	171.1012 (k-2)	HC	#	#	5	5
Limited sales and use tax exemption – mining[b]	151.317	HC	36	38	39	41
Limited sales and use tax exemption – mining[b]	151.317	Coal	0.4	0.4	0.4	0.4
Texas economic development act – for HC	Ch. 313	HC	40	43	114	153
Enhanced recovery projects using anthropogenic CO_2	202.0545	Oil	#	#	*	*
Sales tax exemption for offshore spill response containment property	151.356	Oil	N/A	N/A	*	*
Offshore drilling equipment not in use	11.271	Oil	cbe	cbe	0	0
Power Plants			**95**	**105**	**203**	**273**
Franchise tax deduction of cost of clean coal project from margin apportioned to this state	171.108	Coal	*	*	*	*
Tax credit for a clean energy project	171.652	RE	NA	N/A	0	cbe
Solar and wind energy devices (property tax exemption)	11.27	RE	3	0	1	2
Franchise tax exempt for corporation with business interest in solar energy devices	171.056	Solar	1	2	2	2
Franchise tax deduction of cost of solar energy device from margin apportioned to this sate	171.107	Solar	*	*	*	*
Texas economic development act – for RE	Ch. 313		46	51	100	135
For wind		Wind	44	49	88	118
For solar		Solar	2	3	13	17
Electricity Sales			**N/A**	**N/A**	**N/A**	**N/A**
T&D and Storage			**N/A**	**N/A**	**cbe**	**cbe**
Energy storage system in non-attainment area	11.315	AES	N/A	N/A	cbe	cbe
Total			**1,443**	**1,711**	**1,984**	**2,071**

Notes: Tax Expenditures marked with an " * " are considered "negligible" by the Comptroller; values marked "cbe" cannot be estimated, according to the same office. Similar to entries marked cbe, the "#" indicates values that we cannot estimate due to a lack of information. "N/A" means the exemption was not applicable for that year. Unless otherwise noted, tax expenditure data for 2016 and 2019 are from Comptroller (2015); 2013 from Comptroller (2013); 2010 from Comptroller (2009). Details of program estimation found in Appendix 1. "AES" stands for "Advanced Energy Storage". a: Severance tax relief for marginal oil wells depends upon low oil prices, and the only qualifying time period from 2005-2016 was February 2016 through June 2016. b: Per correspondence (December 11, 2017) with the State Comptroller of Texas, using quinquennial data from the U.S. Census, they estimate that 98% of this exemption is for oil and gas mining, 1% is for coal mining, and 1% is for other mining. We use these percentages applied to the total expenditures listed by the Comptroller under 151.317.

MANDATES

Texas has two mandates designed to encourage the development of renewable energy, particularly wind, in the state. One is for generation capacity, and the other for additional transmission infrastructure, as listed in Table 4 and summarized in the following subsections.

RPS Program

As part of Texas's electric power sector restructuring efforts (Senate Bill 7, 1999), the legislature created the Renewable Portfolio Standard (RPS) that mandated a quantity of renewable energy capacity in the state. The legislature later increased the mandate to 5,880 MW of total renewable capacity by 2015 and a target of 10,000 MW by 2025 (Senate Bill 20, 2005). Many sources of renewable energy were eligible, and there was an additional non-binding goal that at least 500 MW would come from sources other than wind energy (TX Util. Code. § 2.B.39.904). The 2015 mandate was met by 2008, 7 years ahead of schedule, and the 2025 target was achieved by 2012, 13 years ahead of schedule. The Renewable Energy Certificate (REC) market (1 REC = 1 MWh of renewable electricity) was created to facilitate trading of renewable generation to retail electric providers. Today, RECs are still traded to meet compliance obligations but given the modest demand and over-supply, Texas REC prices have been below 2 $/MWh most of the time since 2010, and averaged approximately 0.30 $/MWh in 2017. Before 2015, our estimate of state support via the RPS is from Lawrence Berkeley National Labs. From 2015 through 2020, our estimated cost of the RECs is 5 million per year, equal to a REC of 0.3 $/MWh multiplied by the generation from 5,880 MW of wind at 33% capacity factor (see Appendix 1).

Transmission Expansion – Competitive Renewable Energy Zones

By the early 2000s, it was becoming clear that developers could potentially build far more wind capacity than the local grid in West Texas, a low-demand region, could handle. In fact, the Electric Reliability Council of Texas (ERCOT), the system operator, started to curtail wind generation due to transmission bottlenecks. Wind developers were not able to make financial commitments that were necessary for PUCT to issue a certificate of convenience and necessity (CCN) for new transmission development. Still various upgrades within the West Texas zone provided partial relief, but it was recognized that curtailments of exports to the rest of ERCOT would become increasingly problematic. Moreover, according to the ERCOT market rules at the time, wind farms were compensated for at least some of the power not generated due to curtailment including the value of lost federal production tax credits and state RECs. As part of the PUCT Project 25819 (Proceedings to Address Transmission Constraints Affecting West Texas Wind Power Generators), the PUCT staff proposed eliminating at least some of these payments and pursuing cost-causation to assign congestion costs.[6]

As part of the PUCT Project 25819, among other ideas, the designation of competitive wind power areas (CWPAs) and changes to the CCN process were discussed.[7] In 2005, these efforts

6 For example, see http://interchange.puc.state.tx.us/WebApp/Interchange/Documents/25819_4_362543.PDF.

7 For example, see http://interchange.puc.state.tx.us/WebApp/Interchange/Documents/25819_25_374356.PDF.

TABLE 4:
Texas Mandate Costs ($ million, Nominal)

Type	Beneficiary	2010	2013	2016	2019
RPS	Wind	22	26	0	0
CREZ Transmission Lines	Wind	101	968	1,045	976
Total		**123**	**993**	**1,045**	**976**

culminated in the passage of Senate Bill 20 (SB 20) by the Texas Legislature, which mandated the construction of transmission to connect wind-rich resource zones in West Texas and the panhandle to load in the eastern portion of the state (79th Texas Leg, 2005).[8] SB 20 mandated that the PUCT facilitate the designation of Competitive Renewable Energy Zones (CREZs). These CREZ regions were located primarily in West Texas where the wind conditions were determined to be most favorable for wind power project development. In particular, SB 20 allowed the PUCT to disregard the adequacy of existing service and the need for additional service, two usual requirements for issuing a CCN from the Public Utility Regulatory Act (PURA), for the CREZ transmission projects.

In response to SB 20, the PUCT chose five of many candidate CREZs in West Texas and the panhandle region for transmission buildout. Among several options studied, "Scenario 2" was selected as the most cost-effective build-out: 2,334 miles of 345-kV and 42 miles of new 138-kV right-of-way to add 11,552 MW of new transmission capacity to connect a total of 18,456 MW of renewable (wind) capacity. The final cost at the end of CREZ transmission construction was $6.9 billion (Andrade and Baldick, 2016), roughly $2 billion more than the original estimate.

Transmission lines in ERCOT are open-access facilities. Any generator can use them subject to the system operator rules. In ERCOT, the costs of building new transmission or upgrading existing transmission are socialized (i.e., paid by all consumers) rather than paid by particular loads or generators that might have initially needed them.[9] Like other grid operators, ERCOT conducts transmission planning based on demand and generation forecasts. The primary goal is to meet reliability standards and to ensure that new demand is satisfied. If a new transmission line is needed then the relevant transmission-owning utility is asked to build it upon approval from the PUCT. ERCOT is required to interconnect new generating assets but it is not required to mandate building of new long-distance transmission lines to make new projects profitable.

New transmission capacity additions of the size and rapid buildout of the CREZ projects are unprecedented in recent history of the restructured ERCOT market (Andrade and Baldick, 2016). The CREZ projects were developed to avoid costs associated with wind curtailment, and to encourage new wind generation, not to provide reliability service. As such, they provided an out-of-market solution to improve the economics of West Texas wind farms and solve the "chicken or the egg" problem where wind development was not proceeding largely because of a lack of transmission One reason is that transmission lines take longer to construct than wind farms. Thus, there was too much risk to start developing a wind farm and then assume that transmission would later be constructed to transmit the wind power. However, it is important to note that most transmission development in ERCOT occurs to address reliable power delivery to load centers, and not due to electric market drivers. Thus, the CREZs are not unique in terms of a non-market basis for transmission.

Note that this white paper does not offer a cost-benefit analysis of a subsidy. Like any other category of subsidy we include in this white paper or the companion paper on federal energy subsidies (Griffiths et al., 2017), CREZ transmission lines and resulting wind capacity buildout may or may

8 "It is the intent of the legislature that by January 1, 2015, an additional 5,000 megawatts of generating capacity from renewable energy technologies will have been installed in this state...The [PUCT], (1) shall designate competitive renewable energy zones throughout this state in areas in which renewable energy resources and suitable land areas are sufficient to develop generating capacity from renewable energy technologies; (2) shall develop a plan to construct transmission capacity necessary to deliver to electric customers, in a manner that is most beneficial and cost-effective to the customers, the electric output from renewable energy technologies in the competitive renewable energy zones" (S.B 20). This intent was made clearer by statements of Senator Fraser, author of SB 20, who "stated that the expectation was to get to a higher number as quickly as reliability issues can be addressed in ERCOT, and mentioned *cost of transmission development as a secondary factor.*" (*italics* added, PUCT Docket No. 33672, Commission Staff's Petition for Designation of Competitive Renewable- Energy Zones).

9 In the early days of electricity sector restructuring, there were discussions regarding the allocation of transmission costs based on cost-causation. Some jurisdictions around the world allocate the cost of some transmission facilities to generators. However, all transmission and distribution costs in ERCOT are allocated to end-use customers, with a partial refund of some of those charges to load-serving entities on the basis of proceeds of congestion revenue right auctions.

not yield net benefits for consumers. We designate CREZ a subsidy whether it would have had a net cost or net benefit relative to any counterfactual investment scenarios. Some analyses performed during the planning stages of the CREZ projects considered the direct costs and benefits (e.g., costs related to investment and operation of the electric power system). For example, a 2006 ERCOT study showed a payback time of 8-10 years (including both capital costs of incremental wind generation and transmission capital costs) due to lower fuel consumption costs (i.e., less coal and natural gas generation) (ERCOT, 2006). For the assumption of attributing 100% of the cost of the CREZ transmission lines to wind power, our cost calculation is as follows (see Appendix 1 for more details). The CREZ lines were built between 2009 and 2014. We allocate the funds following the in-service date of transmission capacity as depicted in Figure 9 of Andrade and Baldick (2016). Although the total capital cost of CREZ lines was $6.9 billion, annual carrying cost varies over the lifetime of a project, starting near 14-16% of total capital cost before declining through the asset life (assumed at 40 years). The annual carrying cost typically covers operating and maintenance expenses, depreciation, upgrades, and a rate of return, which has been near 9% on a weighted average cost of capital (WACC) basis during the 2010s. Table 4 reports those annual allocations. Andrade and Baldick (2016) also report increases in transmission charges from about $25/kW in 2009 to almost $50/kW in 2014 associated with CREZ lines.

The cash flow associated with the repayment of the cost of CREZ lines was forecasted from 2009 to 2054 with five-year construction and 40-year lifetimes. Appendix 1 and Table A-5 describe the cash flow used for the analysis that has a net present value cost of $7,250 million. The CREZ transmission lines enable approximately 1,700 TWh of wind generation over their economic lifespan. Thus, the lifetime CREZ cost is estimated as *4.3 $/MWh*. Assuming a Texas household consumes 1.2 MWh/month (Wible and King 2016), the monthly CREZ cost is 5.1 $/month. This monthly value is near the range of an additional 4-5 $/month on customer electric bills as stated by the Texas Public Utility Commission (Galbraith 2011). The annual revenue requirement for CREZ transmission divided by the annual CREZ wind generation (42.5 TWh/yr after 2017) is 24 $/MWh in 2018 and declines to 4 $/MWh in 2054.

Arguments Against Considering CREZ as Financial Support for Wind

We recognize that there are arguments both for and against attributing the cost of the CREZ transmission lines to wind power generation. Here we discuss the main arguments for not considering CREZ as a subsidy. First, transmission lines are open-access and the costs in ERCOT are always socialized to be paid for by consumers, not generators. Second, CREZ transmission investment cost recovery goes directly to regulated T&D utilities, not to wind farm developers. Third, no market structures or regulations are 100% neutral towards any form of generation. Thus, SB 20 and the CREZ process is no different from the creation of past electricity-related legislation. Fourth, wind farms can be developed faster than transmission lines, and the Texas Legislature recognized the “chicken or the egg” problem with regard to wind farm development. Thus, Senate Bill 20 is simply a continuation of the Texas government’s role in creating rules for the electricity market and regulated T&D utilities. Finally, while SB 20 established the CREZ process, it only mandated 5,880 MW of renewable capacity within the Texas RPS. SB 20 did not specify any upper limit to the size of the CREZs (e.g., the MW of wind power to be served). The chosen target from CREZ for total Texas renewable capacity was over 18,000 MW, indicating a desire to go beyond 5,880 MW (which was already achieved by the time the CREZ plan was approved). In short, demand for wind development was the driver for SB 20 and CREZ, not the other way around.

The CREZ transmission line costs are not trivial. Thus, we present our summary findings for Texas state support both including and excluding the cost of the CREZ transmission (listed in Table 4) in the final sum for all state level support for energy and electricity (Tables 6, 7, and 9). If we had the relevant data, we would consider as a potential subsidy any

TABLE 5:

Texas Sub-State Level Incentives for Generation Technologies ($ million, Nominal) (data in this table not included in total state-level $ or $/MWh estimates)

Type	Beneficiary	2010	2013	2016	2019
Chapter 312 Tax Abatement	Wind	14.2	15.65	28.21	37.97
Solar Incentives		4.3	18.2	16.6	17.5
Munis & Coops	Solar	2.1	9.1	8.3	8.8
T&D Utilities	Solar	0.8	8.3	8.3	8.5
Utilities outside of ERCOT	Solar	1.4	0.7	-	0.2
Solar Leasing	Solar	cbe	cbe	cbe	cbe
Wind Incentives	Wind	cbe	cbe	cbe	cbe
Net Energy Metering	Solar	cbe	cbe	cbe	cbe
Total		**18.5**	**33.8**	**44.9**	**55.5**

Notes: Values marked "cbe" translate to "cannot be estimated" according to the Texas Comptroller.

long-distance, high-voltage transmission line dedicated to a particular generator or a technology with similarly clear legislative intent.

MUNICIPAL, LOCAL, & UTILITY INCENTIVES

Separate from the state level spending described above, certain Texas munis, coops, and communities offer incentives for renewable electricity. These may take the form of cash incentives, preferential rate design like net metering, or certain lease structures. While we exclude these in our final *state-level* analysis because they do not involve funds from the *state government budget*, they are worth noting because they are the primary source of support for solar energy today. Table 5 presents the value of some of these support programs and is not intended to be an exclusive list.

TOTAL ENERGY SUPPORT OFFERED BY THE STATE GOVERNMENT IN TEXAS

Table 6 combines data reported in Table 2 through Table 4 to present the total financial support for the energy industry offered by Texas. Research and development expenditures for renewables and nuclear are allocated to Power Plants while fossil fuel related to R&D is allocated to Fuel Extraction.

The total value of energy-related support rises from $1.8 billion in 2010 to $3.0 billion in 2016. Texas spends 4% or less of total support via direct expenditures while approximately two-thirds comes from tax expenditures.

Tax preferences for energy heavily favor the exploration, production, and sale of fossil fuels. In 2016, more than 80% of tax expenditures were for

TABLE 6:

Value of Texas Energy-Related Financial Support ($ million, Nominal)

Proximity and Fuel	2010	2013	2016	2019
Fuel Sales	**1,182**	**1,235**	**1,459**	**1,396**
Coal	77	90	77	66
Hydrocarbons	1,105	1,145	1,382	1,299
Oil	42	43	47	51
Natural Gas	1,001	1,070	1,303	1,253
Undifferentiated	62	33	32	25
Fuel Extraction	**348**	**665**	**365**	**443**
Coal	4	4	4	4
Hydrocarbons	344	661	361	439
Power Plants	**51**	**55**	**105**	**141**
Nuclear	1	1	2	2
Renewables	49	54	103	139
Wind	44	49	88	118
Solar	2	5	15	19
Other RE	3	0	1	2
Electricity Sales	**22**	**26**	**6**	**5**
Renewables	22	26	6	5
Wind	22	26	6	5
T&D and Storage	**101**	**968**	**1,045**	**976**
Renewables	101	968	1,045	976
Wind	101	968	1,045	976
Total (without CREZ)	**1,603**	**1,982**	**1,935**	**1,984**
Total	**1,704**	**2,949**	**2,980**	**2,961**
Coal	81	94	81	70
Hydrocarbons	1,450	1,807	1,744	1,769
Oil	42	43	47	51
Natural Gas	1,001	1,070	1,303	1,253
Undifferentiated	407	694	393	464
Nuclear	1	1	2	2
Renewables	172	1,047	1,154	1,120
Wind	167	1,042	1,138	1,099
Solar	2	5	15	19
Other RE	3	0	1	2

Notes: "Total (without CREZ)" refers to annual Texas financial support that does not include CREZ costs.

fossil fuels and, of these, the three largest programs target natural gas alone. Oil and gas production account for almost two-thirds of energy subsidies, and about one-third for the CREZ transmission lines. In the 2010s, coal, oil, and nuclear receive less support at 3%, 2%, and < 0.1%, respectively.

Texas has no tax preferences (such as analogs of the federal production tax credit) for the sale of electricity from any type of generator and little for new generating capacity (such as analogs of the federal investment tax credit). Direct support mostly comes from property tax abatements or reduced tax rates offered at the discretion of local taxing authorities. While these do benefit electricity production, the state is not explicitly targeting new capacity, and local support is out of scope for this paper. The CREZ lines, included as a potential support for electricity production have no federal analogue.[10]

TEXAS ELECTRICITY RELATED SPENDING

Only a portion of the total energy-sector support benefits electricity generation. Financial support for fossil fuels is directed at *energy* generally, not *electricity* in particular. Texas' status as a net exporter of fuels adds additional complexity. The state is targeting not only energy production but also general economic activity. Texas has a robust manufacturing sector that also benefits from inexpensive energy and the nation's largest petrochemical sector which benefits from plentiful, inexpensive feedstock. Only 50% of the energy the state produces is used in state. Of that share, less than 30% (10-15% of total production) is used for electricity production.

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 approach assumes that 10-15% of natural gas is electricity related, depending on electricity production and gas extraction. Oil and coal are easier to assess. Texas generates less than 0.3% of its electricity from petroleum even though oil accounts for about $40-$50 million in annual financial support (several hundred million including undifferentiated hydrocarbons). In contrast, 99% of Texas coal is burned for electric power generation (EIA 2016c, Tables 1 and 26). In our analysis, we assume that no oil subsidy relates to electricity while all coal subsidies are electricity-related.

To calculate the portion of energy subsidies that can be assigned to electricity generation, we focus on production, not consumption, figures. Equation 1 converts a given fossil fuel energy subsidy into its equivalent electricity subsidy.

EQUATION 1:

Electricity Subsidy Value

$$Electricity\ Subsidy_{Fuel_X,\,Year_i} =$$

$$Energy\ Subsidy._{Fuel_X,\,Year_i} \times$$

$$\frac{Energy\ for\ \ Electricity_{Fuel_X,\,Year_i}}{Total\ Energy\ Produced\ _{Fuel_X,\,Year_i}}$$

Applying Equation 1 to appropriate cells of Table 6 yields the value of support for electricity generating technologies only (Table 7). This adjustment removes $1.2 – $1.6 billion per year in fossil fuel subsidies from our analysis for the years 2010 – 2019.

Without considering CREZ costs, Texas electricity-related subsidies are approximately $500–$600

10 The federal government has supported transmission buildout in the past through its rural electrification efforts. Further, direct efforts like the Tennessee Valley Authority and Bonneville Power Administration built transmission assets (among other infrastructure). Both are excluded from this paper and the Federal paper because these efforts did not seek to benefit particular technologies.

TABLE 7:

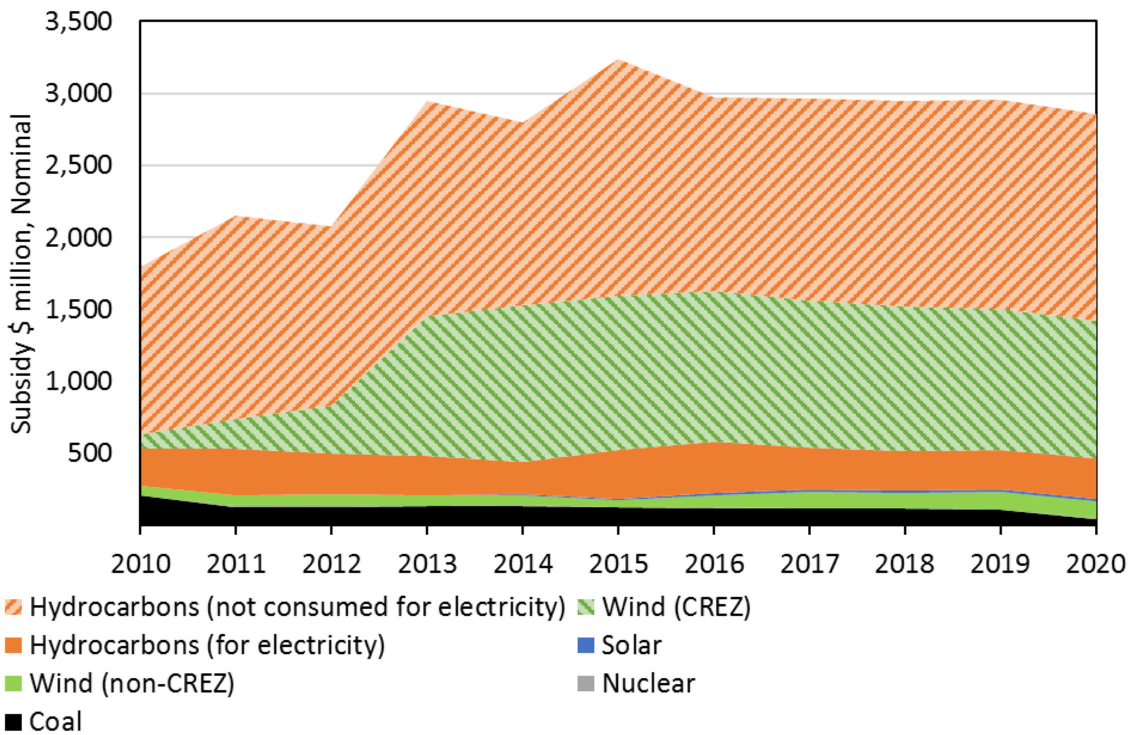
Value of Texas Electricity-Related Financial Support ($ million, nominal)

Proximity and Fuel	2010	2013	2016	2019
Fuel Sales	**287**	**293**	**395**	**299**
Coal	77	90	77	66
Hydrocarbons	210	203	318	233
Oil	< 0.1	<0.1	< 0.1	< 0.1
Natural Gas	201	199	314	230
Undifferentiated	9	4	4	3
Fuel Extraction	**55**	**78**	**52**	**49**
Coal	4	4	4	4
Hydrocarbons	51	74	49	45
Electricity Sales	**22**	**26**	**6**	**5**
Renewables	22	26	6	5
Wind	22	26	6	5
Power Plants	**51**	**55**	**105**	**141**
Nuclear	1	1	2	2
Renewables	49	54	103	139
Wind	44	49	88	118
Solar	2	5	15	19
Other RE	3	0	1	2
T&D and Storage	**101**	**968**	**1,045**	**976**
Renewables	101	968	1,045	976
Wind	101	968	1,045	976
Total (without CREZ)	**415**	**452**	**559**	**493**
Total	**516**	**1,419**	**1,604**	**1,470**
Coal	81	94	81	70
Oil	0	0	0	0
Natural Gas	201	199	314	230
Undifferentiated Hydrocarbons	60	78	53	48
Nuclear	1	1	2	2
Renewables	172	1,047	1,154	1,120
Wind	167	1,042	1,138	1,099
Solar	2	5	15	19
Other RE	3	0	1	2

Notes: "Total (without CREZ)" refers to annual Texas financial support for electricity when subtracting our estimated costs for the CREZ transmission lines.

FIGURE 2:

Texas Financial Support for Energy & Electricity by Fuel and Year ($ million, nominal)



Notes: "Non-CREZ" costs for wind are those related to subsidies that are not the CREZ transmission lines.

million per year (see Figure 2). Including CREZ during our time span of analysis adds approximately $1 billion per year. Because a small share of Texas hydrocarbon production ends up as fuel for electricity generation, $1.2 to $1.5 billion per year in hydrocarbon subsidies relate to fossil fuels consumed for non-electricity services.

PER-MWH FINANCIAL SUPPORT FOR ELECTRICITY GENERATION

The comparison of total Texas financial support to different generation technologies is informative but does not tell the whole story. Technologies have different capital costs and operational characteristics. 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 average cost per-MWh value. Converting total dollars to dollars-per-MWh illustrates how far each subsidy dollar goes in terms of electricity generation.

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 the same year. In Equation 1, we established the value of electricity related subsidies. Dividing that amount by the same-year electricity generation provides a $/MWh estimate (see Equation 2).

EQUATION 2:

Electricity Subsidy Value

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

TABLE 8:

Texas Electricity Production by Technology and Year (TWh)

	Historic						Forecast				
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Coal	150	158	138	149	148	122	69	111	124	135	141
Hydrocarbons	191	205	218	207	207	243	287	234	224	222	228
Oil	1	1	1	1	0	0	-	-	-	-	-
Gas	190	204	217	206	207	243	287	234	224	222	228
Nuclear	41	40	38	38	39	39	38	38	38	38	38
Renewables	28	32	34	38	42	47	59	69	71	71	72
Wind (non-CREZ)	26	31	28	31	28	21	20	22	22	22	22
Wind (CREZ)	0	0	5	5	12	24	33	40	43	43	43
Solar	0.0	0.0	0.1	0.2	0.3	0.4	1.7	1.8	1.8	1.8	1.8
Other RE	3	2	2	2	2	2	5	5	5	5	5
TOTAL	**410**	**435**	**429**	**433**	**437**	**451**	**454**	**452**	**458**	**466**	**478**

Notes: Forecast details can be found in Appendix 1. 2010-2015 data from EIA AEO (Actuals); 2016-2020 is estimated in two parts. First, we rely on the base case of the ERCOT specific forecast derived for the FCe- study (Mann et al, 2017). Second, we scale the annual energy values by the ratio of Texas-to-ERCOT generation by fuel type found in the EIA Form 923 (2015). Third, for generation outside of ERCOT we assume all electricity generated in Texas is consumed in Texas.

We obtain per-MWh subsidy estimates (Table 9) by dividing the annual dollar spending in Table 7 by the annual electricity production figures found in Table 8. While fossil fuels receive significant subsidies, their per-MWh cost is quite modest due to the very large installed base and the high quantity of generation. Renewables, by contrast, have higher per-MWh costs due to a similar dollar value of subsidies but a lower quantity of generation. This is partially an artifact of basing our calculations on annual financial support divided by annual electricity generation as opposed to the annualized lifetime financial support divided by lifetime electricity generation. All technologies do not receive the same amount of subsidy every year. If they did, the comparison would remain the same. Since subsidies such as CREZ are not continuous, per-MWh calculations based on annualized lifetime support and generation would yield smaller gaps across technologies.

Wind subsidies peak near $30/MWh of wind generation if including CREZ costs, but stay below $3/MWh if not including CREZ costs. One reason the per-MWh cost of CREZ lines is relatively high is the relatively low capacity factor of wind generation: lines cannot be used fully at all times because of intermittency of wind. As such, it would be beneficial for other generators to use the lines to reduce the per-unit cost of transmission for everyone. Regardless of how much power flows through the transmission lines, the cost of the transmission to consumers is the same. Initial estimates of annual production cost savings from CREZ were $1,677 million per year due to reductions in fuel purchases for electric generators.[11] Because natural gas prices dropped significantly after the initial CREZ cost-benefit analyses, the cost savings is likely lower than anticipated in 2008. However, the fuel cost savings are in the same range as the annual cost of CREZ in Table 4.[12]

11 Cost savings of $1,677 million is the average of fuel cost savings of 38 $/MWh (assuming natural gas at 7 $/MMBtu), multiplied by assumed 64,031 GWh/yr of wind generation ($2.4 billion) minus the modeled low and high collection costs, $580 million and $820 million, respectively. Numbers are from PUCT Docket. No 33672, May 15, 2008, available September 11, 2017 at: http://interchange.puc.state.tx.us/WebApp/Interchange/Documents/33672_1114_584050.PDF: For Scenario 2"The average system fuel-cost savings for each megawatt-hour of wind in this scenario was $38/MWh. … The estimated collection costs for this plan range from $580 million to $820 million."

12 An average natural gas price of 5 $/MMBtu lowers the system fuel cost savings from 38 to 18 $/MWh (assuming 1 $/MMBtu translates to 10 $/MWh). We model wind generation from CREZ at 42,500 GWh/yr (11,550 MW at 42% capacity factor), lower than in pre-CREZ cost-benefit analysis. Thus, annual fuel cost savings are = (18 $/MWh)(42,500,000 MWh/yr) = 765 $million/yr. The annual cost of CREZ in our cash flow is $1,100 million in 2014 declining to $670 million after 20 years and $270 million after 40 years.

TABLE 9:

Texas $/MWh Financial Support by Type & Fuel (2010, 2013, 2016, 2019, annual $ nominal divided by annual generation per fuel)

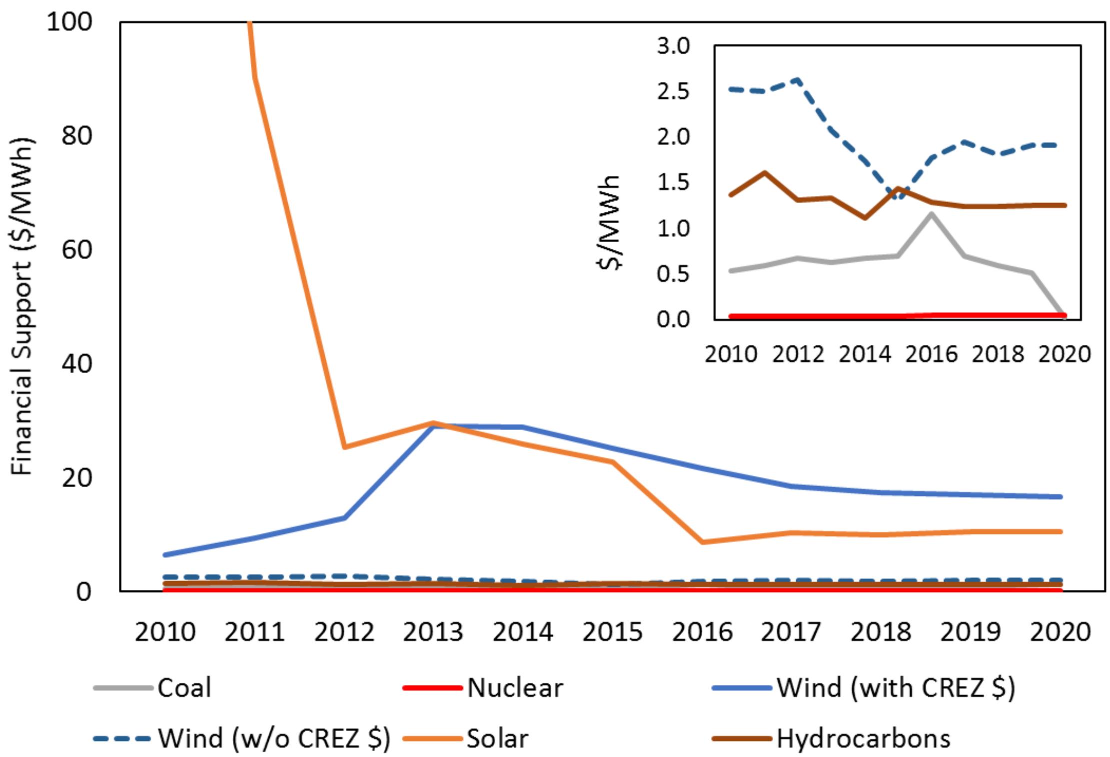
Proximity and Fuel	2010	2013	2016	2019
Fuel Sales	0.70	0.68	0.87	0.64
Coal	0.51	0.60	1.11	0.49
Hydrocarbons	1.10	0.98	1.11	1.05
Fuel Extraction	0.13	0.18	0.12	0.10
Coal	0.02	0.02	0.05	0.03
Hydrocarbons	0.27	0.36	0.17	0.20
Power Plants	0.12	0.13	0.23	0.30
Nuclear	0.03	0.04	0.05	0.05
Renewables	1.78	1.42	1.74	1.95
Wind	1.68	1.36	1.66	1.83
Solar	256	29.6	8.72	10.6
Other RE	1.07	0.14	-	-
Electricity Sales	0.05	0.06	0.01	0.01
Wind	0.84	0.72	0.11	0.08
T&D and Storage	3.86	27.0	19.8	15.2
Renewables	3.86	27.0	19.8	15.2
Wind	3.86	27.0	19.8	15.2
Portfolio Total (wtd. avg., without CREZ)	1.01	1.04	1.23	1.06
Portfolio Total (wtd. avg., with CREZ)	1.26	3.28	3.54	3.15
Coal	0.54	0.63	1.16	0.52
Hydrocarbons	1.37	1.34	1.28	1.25
Nuclear	0.03	0.04	0.05	0.05
Renewables (with CREZ $)	6.22	27.7	19.4	15.7
Renewables (without CREZ $)	2.57	2.11	1.84	2.02
Wind (with CREZ $)	6.38	29.1	21.6	17.1
Wind (without CREZ $)	2.52	2.07	1.77	1.91
Solar	256	29.6	8.72	10.6
Other RE	1.07	0.14	0	0

Notes: Total and subtotal values are category subsidy subtotal divided by total Texas electricity generation from all generator types. (with CREZ $): refers to total annual wind subsidies, including CREZ costs, divided by annual electricity generation from all wind farms. (without CREZ $): refers to total annual wind subsidies, not including CREZ costs, divided by annual electricity generation from all wind farms.

On a portfolio wide basis, financial support for electricity generating technologies is worth 2-4 $/MWh over the study period (Table 9). If one neglected CREZ costs, the value is about 1 $/MWh. The overall 2-4 $/MWh calculation is slightly below the range we estimated for federal support at 3-5 $/MWh for electricity generation (Griffiths, et al., 2017). These Texas benefits differ dramatically by year and technology. Conventional fuels like coal and natural gas receive 1-2 $/MWh. Wind receives up to 30 $/MWh (at peak) if including CREZ costs, but receives approximately 2 $/MWh when not including CREZ costs. These results hold despite our estimate that fossil fuels receive

FIGURE 3:

Texas $/MWh Financial Support by Type & Fuel (annual $ nominal divided by annual generation per fuel)



Note: that per-MWh costs of Solar and Wind (with CREZ $) are much higher than the vertical scale of the inset graphic.

approximately twice as much annual support as renewable energy overall (Figure 2 and Table 6).

Solar spending falls dramatically from 256 $/MWh to 10 $/MWh in the 2010s even as total solar support rises from $2 million to $19 million over the same period because solar generation was negligible in 2010. Note, however, that we do not have reliable data on distributed solar generation before 2016. As such, per-MWh values might be somewhat inflated, especially for 2010. The growth of solar generation in Texas is driven predominately by federal subsidies like the Investment Tax Credit rather than these modest state initiatives. The notable peak in wind spending in 2013 is a result of how we distribute costs for CREZ over 40 years. As the CREZ transmission lines are paid off over time, the annual subsidy we estimate drops continuously through 2054 due to the cash flow assessment (see Table A-5 in Appendix 1).

TEXAS CONCLUSIONS

At the state government level, Texas offers energy subsidies worth nearly $3 billion per year. On the one hand, this number represents less than 0.02% of the Texas GDP. On the other hand, it is between 13% and 19% of the value of all federal support for the energy industry in 2013 and 2016 (Griffiths et al., 2017). Texas energy consumption and production account for about 14% and 21% of the total for the U.S., respectively. Interestingly, Texas energy subsidies and energy production are both about 10%–20% of the respective quantities for the U.S. overall.

Electricity related spending is expected to grow from $600 million/year in 2010 to $1.6 billion in 2016 (or remain near $600 million if excluding the CREZ lines). Natural gas and wind, together, account for approximately 80% of spending on energy over the study period, and absolute spending for natural gas and wind is approximately equal. If excluding CREZ costs, natural gas spending alone accounts for 64% of the total, and is over ten times higher than for wind.

On an electricity basis (excluding support for fuels not used for electricity) from 2010-2019, wind receives 70% (with CREZ) or 15%-20% (without CREZ) of Texas subsidy expenditures, but support via CREZ will drop to zero in the 2050s as debt is repaid.

On a $/MWh basis, wind receives $30/MWh in 2013 dropping to 17 $/MWh by 2019 (and to zero in the 2050s) while coal and natural gas financial support accounts for less than 2 $/MWh, but on an ongoing basis. Excluding CREZ costs, wind receives 1-3 $/MWh. Solar, a newcomer to Texas, receives modest state support in total dollars; but, on per-MWh basis the support is greater than 20 $/MWh before 2015, and then $10/MWh after 2015.

The direct support that Texas offers fossil fuels is for energy generally, not electricity in particular. Texas offers relatively few high value subsidies for electricity. In particular, Texas offers no benefits for the sale of electric power. It offers a number of programs to reduce the cost of power plants, infrastructure, and other capital-intensive projects. Chapters 312 and 313 of the Texas Tax Code extend specific benefits to power plants but these benefits are also offered to other capital-intensive projects like refineries and petrochemical production.

The CREZ transmission lines offer a unique case. Although they are open-access facilities, the regulatory and legislative intent was clear in facilitating as much wind as reliably possible with secondary consideration of costs for transmission (per comment of Texas State Senator Fraser quoted in footnote 9). Wind generation developers did not receive direct funding but could not have developed their facilities and dispatched their generation without these lines. When the state and federal support programs are examined together, the value of financial support for Texas renewable electricity is significant assuming the implicit subsidy of the CREZ lines. Paired with the Federal Production Tax Credit (PTC) offer, CREZ-installed wind farms benefit about $43/MWh for the first ten years with approximately $20/MWh in 2016 from CREZ (see Table 9) and $23/MWh from the federal Production Tax Credit (PTC) applicable to the first 10 years of renewable power generation. Both CREZ (increasing wind generation) and PTC (by statute) benefits decline after 2017. For a CREZ wind project constructed in 2018, the CREZ + PTC benefit would decline to near $10/MWh from 2017 through 2027. Nonetheless, the value of CREZ plus the PTC was higher than the average clearing price of the ERCOT market in 2015 and 2016. Though more modest, state and federal support for natural gas reaches almost $3/MWh. This subsidy is worth 7% to 15% of ERCOT's clearing price since 2010. Considering CREZ costs and natural gas support, Texas state support effectively doubles the federal offering. ■

CALIFORNIA

California has, by many accounts, the most aggressive and interventionist energy policy in the country. California's Global Warming Solutions Act of 2006 (Assembly Bill 32) requires the state to reduce GHG emissions to 1990 levels by 2020. More recently, the Clean Energy and Pollution Reduction Act of 2015 (Senate Bill 350) strengthened provisions for reducing carbon emissions: increasing renewable electricity procurement to 50 percent by 2030, and doubling energy efficiency savings by 2030 (CEC 2016a). The state has a favorable climate and an endowment of natural resources that allows it to meet these goals, together with transmission capacity that allows imports of electricity from other regions. In 2017, Assembly Bill 398 extended the state's cap and trade policy through 2030 to maintain progress on carbon reduction goals.

In 2015, California was the 3rd largest producer of oil in the country and 15th for natural gas (EIA 2016b). California has no coal production (EIA 2016c, Table 1). Nevertheless, the state ranks 48th in the nation for energy consumption per capita. In his 2015 inaugural address, Governor Brown proclaimed, "Taking significant amounts of carbon out of our economy without harming its vibrancy is exactly the sort of challenge at which California excels" (Brown, 2015). It may not harm the economy but it is, nevertheless, expensive.

In this section, we report on total magnitude of subsidies offered by California jurisdictions in terms of proximity / directness to final MWh generated. This section parallels the analysis offered of Texas by first tabulating programs by category and then calculating total support for energy, for electricity, and per-MWh. Unlike Texas where the value of support for a majority of programs can be derived directly from government reports, California has elected to conduct much of its policy through mandates. This makes cost estimation much more difficult given the dispersion of data sources. Direct Expenditure and Tax Expenditure data are from the California Department of Finance. Mandate data are sourced from a variety of locations including utility compliance filings, the California Public Utility Commission (CPUC), and the California Energy Commission (CEC).

California offers a range of cross subsidies and credit subsidies that fall outside of the scope of this white paper but are worth mentioning. We omit credit subsidies offered by the California Infrastructure and Economic Development Bank Fund and the California Alternative Energy and Advanced Transportation Financing Authority. Both groups offer financing for various clean energy and manufacturing projects – neither targets electricity in particular. Proceeds from the state's CO2 Cap-and-Trade program, worth $1.1 billion in 2016, fund a range of energy related programs with particular focus on supporting transportation and low-income communities. The program was extended in 2017 with proceeds directed towards such projects as California's high-speed rail project and tax credits for electric vehicles. Cap-and-Trade funding comes from emitters including power generators, so this program can be considered a cross subsidy, albeit one that is not direct. Some power generators subsidize environmental programs but only a small portion is electric-electric cross-subsidy. Conversely, the Low Carbon Fuel Standards administered by the California Air Resources Board (CARB) offer transportation-to-electricity cross subsidies to encourage electrification of transportation (because the California electric power fuel mix is less carbon intensive than gasoline or diesel fuels). Also excluded from this white paper is funding for energy efficiency. This technology-neutral spending is worth approximately $1 billion per year.

CALIFORNIA DIRECT EXPENDITURES

Direct expenditures are cash outlays from the government that pay for specific programs. This section only includes spending that is in the state budget and not cash expenditures made through mandate programs. For the 2016-2017 budget cycle, $171 billion was appropriated for all state activity with just over half of this coming from the state's general fund (DOF 2016). The magnitude

TABLE 10:

California Direct Spending on Energy by Category and Year ($ million, Nominal)

Category	Beneficiary	2010	2013	2016	2019
CEC (Select Programs)	RE	166	67	139	116
Cap & Trade Funding	RE	6.17	6.17	53.67	32.56
Dairy digester research and development program	Bio	2.5	2.5	50.0	28.9
Single-family solar photovoltaics (Low Income)	Solar	3.7	3.7	3.7	3.7
Nuclear Planning Assessment	Nuclear	4.3	4.5	3.1	2.9
Total		**177**	**78**	**195**	**152**

of California's energy-and electricity-related direct expenditures is difficult to calculate due to the lack of detail provided and the state's general preference to target climate change holistically.

More problematic for estimation, the distinction between direct expenditures and other state-sanctioned aid is complicated due to California's reliance on various trust funds and non-tax revenue.[13] For example, certain programs collect funds from ratepayers through surcharges that benefit the California Energy Commission, which, in turn, distributes funds back to utilities for various incentives. In one court case, Southern California Edison questioned whether the Electric Program Investment Charge was a mandate or a tax. Though the courts sided with the CPUC, the case highlights the ambiguity embedded in the state's funding framework (SCE v. CPUC (2014) Cal.App.2/3d B246782). The Electric Program Investment Charge (EPIC) program is included in the mandate portion of this white paper. EPIC is a large-IOU ratepayer funded program that conducts applied R&D, technology demonstration, and market facilitation (see Appendix Table A-23).

The total value of possible energy and environmental expenditures is approximately $1 billion per year – if we include all spending by the CEC, CPUC, and CARB.[14] Of this, we estimate that electricity-related direct expenditures total $100-200 million. This is approximately 0.01% of all state spending and about 10% of the state's energy related spending. This subset comprises a majority of the California Energy Commission's development program, Cap-and-Trade funds used for energy projects, and several other special purpose accounts. This subset excludes regulatory and administrative spending, transportation focused expenditures, and energy efficiency/ conservation.

Excluded from direct expenditures are various emissions programs by the Air Resources board and energy efficiency projects by the CEC and CPUC. Given California's efforts to reduce the carbon intensity of transportation and industry, our exclusions likely result in a modest amount of undercounting.

13 For example, a 2012 study from the LAO found $1.6 billion in spending for that year; $1 billion of which was for energy efficiency and $617 million for other energy programs. This list includes programs we consider to be mandates like California Solar Initiative and the Self Generation Incentive Program. These programs are included in the LAO analysis because money flows from utilities to state coffers and back out to project administrators.

14 2016/17 Budget; Topline numbers

TABLE 11:

California Total Energy-Related Tax Expenditures ($ million, Nominal)

Category	Beneficiary	2010	2013	2016	2019
Power Plants		**170.5**	**293.7**	**377.5**	**379.2**
Sales and Use Tax Exclusion for Advanced Transportation and Alternative Energy Manufacturing Program	Solar	8.5	6.5	10.0	10.0
Partial Sales and Use Tax Exemption for Agricultural Solar Power Facilities (California)	Solar	-	23.5	59.5	78.9
Property Tax Exclusion for Solar Energy Systems	Solar	162.0	263.7	308.0	290.4
Fuel Extraction		**23.5**	**23.5**	**33.0**	**35.0**
Percentage depletion of mineral and other natural resources	HC	23.5	23.5	33.0	35.0
Total		**194.0**	**317.2**	**410.5**	**414.2**

Notes: See Appendix 2 for data sources and calculation methodology

While these exclusions sound substantial, they are modest in comparison to California's tax expenditures and mandate expenditures. These latter categories of support total approximately $5 to $6 billion between 2014 and 2016 (see Figure 4). Doubling (or halving) our estimates of direct expenditures would have no meaningful impact on our overall subsidy estimates.

CALIFORNIA TAX EXPENDITURES

Tax preferences are called tax expenditures by government agencies, and these preferences constitute the most complicated type of state support for electricity. Qualifications for some of the stipulated tax benefits are complex and dependent on factors such oil and gas prices, or capital and operating costs that vary over time, location, and company. California, unlike Texas or the Federal Government, offers only a modest amount of support via the tax code.

California only offers four tax breaks for energy – three for solar and one for hydrocarbons. Combined these subsidies range from $200 million to $400 million annually. The largest exemption is the property tax exclusion for solar systems. This exemption comprises 70% to 84% of all energy-related tax expenditures.

CALIFORNIA LEGISLATIVE MANDATES

While California offers some support via direct expenditures and tax expenditures, it primarily influences energy policy through legislative mandates. California uses mandates to subsidize both electricity sales and power plant capacity (especially for solar and storage). This is in line with the state's explicit goal to reduce emissions and to encourage renewables. In total, the state is forecast to spend $2.4 billion to $6.6 billion annually between 2010 and 2019 through mandates (see Table 12).

A majority of spending is attributable to the Renewable Portfolio Standard (RPS) – the state's largest energy program. After accounting for avoided costs, the RPS has a direct cost of $1.9 billion to $4.6 billion over the study period. Additionally, an estimated $1.3 billion in transmission upgrades are required to meet the RPS. The RPS and its associated transmission development constitute approximately 90% of all mandate spending.

California also requires utilities to spend money on things that would be identified traditionally as direct expenditures like applied research and development, or incentive programs for novel

TABLE 12:

California Total Energy-Related Legislative Mandates ($ million, Nominal)

Category	Beneficiary	2010	2013	2016	2019
Electricity Sales		**1,934**	**2,623**	**4,021**	**4,621**
Renewable Portfolio Standard (Net Cost)		1,934	2,623	4,021	4,621
For Wind	Wind	760	1,201	1,044	1,093
For Solar	Solar	105	565	2,264	2,908
For Geothermal	Geo	482	364	347	304
For Biopower	Bio	404	399	267	218
For Small Hydro	Hydro	183	93	99	98
Power Plants and Capital		**514**	**993**	**1,246**	**1,837**
California Solar Initiative (IOUs)	Solar	225	325	33	1
POU Compliance with SB1	Solar	62	97	70	1
SGIP (for fuel cells, storage, small RE)		210	48	64	146
For Storage	AES	1	8	27	106
For RE	RE	12	2	1	14
For Conventionals	NG	-	5	2	1
For Fuel Cells	FC	197	33	35	26
For Solar	Solar	-	-	-	-
Emerging Renewables Program		2	-	-	-
For Wind	Wind	2	-	-	-
For Fuel Cells	FC	-	-	-	-
Transmission	RE	-	470	770	1,312
For Wind					
For Solar					
For other renewables					
New solar Homes Partnership (NSHP)	Solar	15	29	86	-
Battery Mandate	AES	-	-	223	377
Solar Incentive Administration (via EPIC)	Solar	-	25	-	-
Fuel Sales (Volumetric)					
None					
Fuel Extraction					
None					
R&D		**-**	**128**	**130**	**130**
EPIC			128	130	130
Elec	Elec		24	24	24
EE/DR	Elec		39	40	40
RE	RE		57	58	58
Conventional	NG		6	6	6
Storage	AES		2	2	2
Total		**2,448**	**3,744**	**5,397**	**6,587**

Note: Data sources and calculation methodology found in Appendix 2. "Conventionals" are traditional fossil fuel power plants; "AES" is advanced energy storage technologies. For example, the Self-Generation Incentive Program provides a funding mechanism for fuel cells and energy storage, while the EPIC program funds various R&D efforts. From a societal standpoint, the mandates serve the same function as direct spending but achieves this goal using a different funding mechanism. With direct expenditures, residents pay taxes. With mandates, they pay a "public goods charge" to their utility. In both cases, the legislature generally determines how the funds will be spent. For legislators, mandates have the advantage that costs do not appear in the state budget.

CALIFORNIA EXCLUDED LOCAL/ UTILITY PROGRAMS

California regularly directs municipalities and utilities to create incentive programs. We do not tabulate excluded local/utility programs for California, because relatively little electricity spending is not included in the preceding categories. Solar subsidies are illustrative of this behavior. For Texas we considered including, but ultimately excluded, solar incentives paid by local utilities because they are not mandated by the state. By contrast, California's utilities are required to participate in the RPS. For example, when California passed Senate Bill 1 (SB1) in 2006 to further encourage solar adoption, it created requirements for both large IOUs and publicly owned utilities (POUs). The IOUs created the California Solar Initiative under the purview of the CPUC while POUs created their own programs. Public utilities created 47 different solar incentive programs, with annual funding as high as $120 million annually (see Table 12).

CALIFORNIA TOTAL ENERGY AND ELECTRICITY RELATED SPENDING

Across all support catagories, California is forecast to spend $2.5 billion to $7 billion annually between 2010 and 2020 on energy subsidies (see Figure 4). In early years, this is comparable to spending in Texas but grows to be nearly three times larger by 2020.

Unlike the support offered by Texas and the Federal government, the vast majority of support

FIGURE 4:

California Energy-Related Financial Support by Fuel and Technology ($ million, Nominal)

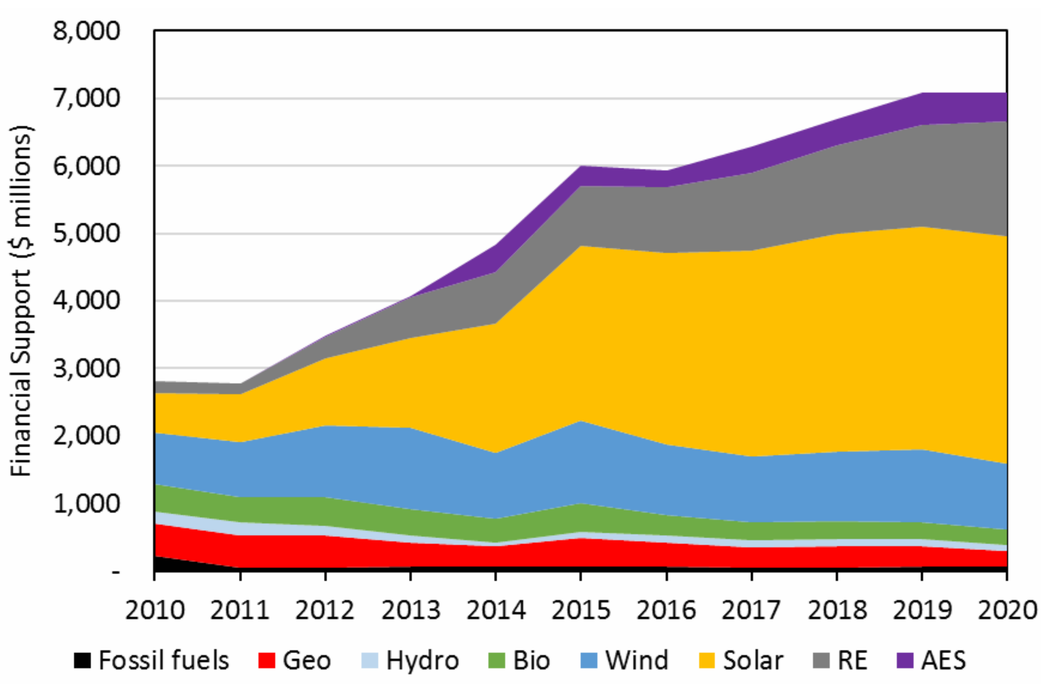


TABLE 13:

California Energy-related Financial Support by Type & Fuel (2010, 2013, 2016, 2019, $ million, nominal)

Category	2010	2013	2016	2019
Electricity Sales	**1,934**	**2,623**	**4,021**	**4,621**
Renewables	1,934	2,623	4,021	4,621
Wind	760	1,201	1,044	1,093
Solar	105	565	2,264	2,908
Geothermal	482	364	347	304
Biopower	404	399	267	218
Hydro	183	93	99	98
Power Plants and Capital	**854**	**1,353**	**1,765**	**2,335**
Renewables	652	1,308	1,476	1,823
Wind	2	-	-	-
Solar	476	772	570	385
Geothermal	-	-	-	-
Biopower	-	-	-	-
Hydro	-	-	-	-
RE (Undifferentiated)	178	540	910	1,442
Nuclear	4	4	3	3
Fuel Cells	197	33	35	26
Energy Storage	1	8	250	483
Fuel Sales & Extraction	**24**	**24**	**33**	**35**
Hydrocarbons	24	24	33	35
R&D	**3**	**130**	**180**	**158**
Electricity	-	63	64	64
Biopower	3	3	50	29
Other Renewables	-	57	58	58
Hydrocarbons	-	6	6	6
Energy Storage	-	2	2	2
Total	**2,819**	**4,071**	**5,937**	**7,088**
Renewables	2,587	3,931	5,497	6,444
Wind	762	1,201	1,044	1,093
Solar	581	1,337	2,834	3,293
Geothermal	482	364	347	304
Biopower	407	401	317	247
Hydro	183	93	99	98
RE (Undifferentiated)	178	596	967	1,500
Hydrocarbons	24	29	39	41
Nuclear	4	4	3	3
Fuel Cells	197	33	35	26
Energy Storage	1	10	252	485

in California is electricity related. We list only one state program, percentage depletion of mineral and other natural resources, that benefits energy production but not electricity production. We attribute this small program entirely to oil and gas (California mines no coal), but it is possible other extractive industries also benefit from this provision.[15] The difference between total California energy-related and electricity-related total expenditures is less than 0.01%, and thus we do not separately list a California total electricity (only) table of financial support.

California's financial support for electricity generating technologies ranges between $2.5 and $7 billion in the 2010s (and Figure 4). Over the study period, California directs 90% or more of its energy subsidy to renewables. In the early 2010s, the ratio of spending is relatively even between wind, solar, biofuels and geothermal. By 2016, the share attributable to solar is expected to grow to 50% of all support; in this same period, other technologies receive constant or declining support. Nascent technologies like fuel cells and advanced energy storage (AES) receive as much as $500 million per year, but this remains modest compared to total spending.

15 We do not list this number separately in this report, but we estimate it as follows. In 2016, 19% of the oil and gas energy produced in California was from NG (81% from petroleum). About 33% of NG consumed in CA is used for electricity. Thus, 19% multiplied by 33% comes to approximately 6%. This means that about 6% of percentage depletion relates to electricity, and this electricity-related quantity totals 1.5 $M to 2 $M per year.

PER-MWH FINANCIAL SUPPORT FOR ELECTRICITY GENERATION

As in the analysis for Texas, the comparison of total financial support to different generation technologies is informative but incomplete. In this section we convert California's total spending to an equivalent per-MWh value. Again, we rely on Equation 2 to convert between total dollars and the per-MWh value. This equation divides total support for a specific technology in a given year by the quantity of electricity production in that year by that same technology. Table 14 tabulates the historic generation for 2010 through 2015 and forecasts generation for 2016 through 2019.

We obtain per-MWh subsidy estimates (Table 15) by dividing the absolute dollar spending in Table 13 by the annual energy production figures found in Table 14. Converting total dollars to dollars-per-MWh illustrates how far each subsidy dollar goes in terms of electricity generation of that year.

TABLE 14:

California Electricity Production by Technology and Year (TWh)

	Historic						Forecast				
Technology	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Coal	22	24	23	23	19	18	15	15	13	12	12
Large Hydro	31	38	25	23	16	16	18	18	18	18	18
Natural Gas	122	104	131	131	132	130	168	165	163	162	156
Nuclear	40	45	27	26	25	27	21	21	22	20	22
Renewables	40	41	47	56	60	65	64	70	75	81	87
Biomass	7	6	7	8	8	8	5	5	5	4	4
Geothermal	13	13	13	13	13	13	12	10	11	11	11
Small Hydro	6	6	4	4	3	3	12	4	4	4	4
Solar	1	1	3	5	13	18	21	28	31	34	41
Wind	14	15	19	25	24	24	22	23	25	27	28
Oil	0	0	0	0	0	0	-	-	-	-	-
Other	-	0	0	0	0	0	-	-	-	-	-
Unspecified Sources	35	42	50	37	44	40	-	-	-	-	-
Total	**291**	**294**	**302**	**297**	**297**	**295**	**286**	**288**	**291**	**293**	**296**

Note: Forecast methodology described in Appendix 2.

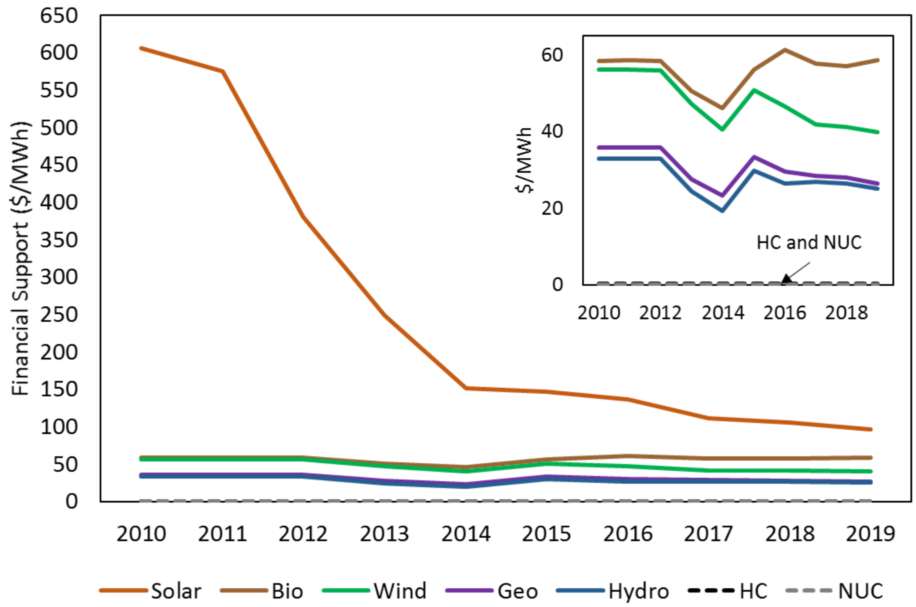
TABLE 15:
California Volumetric Electricity-Related Financial Support ($/MWh)

Category	2010	2013	2016	2019
Electricity Sales	**6.66**	**8.84**	**15.2**	**17.0**
Renewables	47.9	47.1	79.0	72.4
Wind	56.1	47.4	46.6	39.9
Solar	110	105	109	85.0
Geothermal	36.0	27.6	29.7	26.6
Biopower	58.2	50.3	51.7	51.9
Hydro	32.9	24.5	26.5	25.0
Power Plants and Capital	**2.94**	**4.56**	**6.65**	**8.59**
Renewables	16.2	23.6	29.1	28.6
Wind	0.14	-	-	-
Solar	496	143	27.4	11.2
Nuclear	0.11	0.17	0.15	0.15
Fuel Sales & Production	**0.01**	**0.00**	**0.01**	**0.01**
Hydrocarbons	0.01	0.01	0.01	0.02
R&D	**0.01**	**0.44**	**0.68**	**0.58**
Biopower	0.36	0.32	9.7	6.9
Renewables	-	1.02	1.13	0.90
Hydrocarbons	-	0.04	0.04	0.04
Total	**9.70**	**13.7**	**22.4**	**26.1**
Renewables	64.1	70.7	108	101
Wind	56.3	47.4	46.6	39.9
Solar	606	248	136	96.2
Geothermal	36.0	27.6	29.7	26.6
Biopower	58.6	50.3	61.4	58.7
Hydro	32.9	24.5	26.5	25.0
Hydrocarbons	0.19	0.22	0.26	0.29
Nuclear	0.11	0.17	0.15	0.15

Note: Bolded values are the subcategory of financial support dollars divided by total California electricity generation.

FIGURE 5:

California Volumetric Financial Support for Electricity ($/MWh)



This method both over and under estimates the $/MWh. The under-estimating effect is caused by including the MWh from all previously installed generation technologies, thus having a relatively larger denominator. The over-estimating effect is caused by attributing the annual spending to MWh generated only in the current year, whereas in capital spending in any given year enables generation for years to decades later.

We make some assumptions about fuel use when calculating MWh totals in Table 14. The EIA's Annual Energy Outlook does not estimate the quantity of oil and "other" generation for 2016 and 2019, so we assume no generation from these sources. Further, we do not include estimates per-MWh for fuel cells or energy storage. For fuel cells, there are no reliable estimates of generation and for storage, energy *generation* is not an appropriate measure of usage because during a round trip of charge and discharge, energy is dissipated. For example, electricity storage is used for a variety of applications in California but most commonly for "demand charge management"—reducing peak (instantaneous) demand. Energy arbitrage, frequency regulation, and demand side management (DSM) are other cited applications.

On a portfolio wide basis, California is offering electricity generating technologies $10- 26/MWh over the study period (See Figure 5). On the system basis, support is rising on a per-MWh basis because a growing percentage of load is being served by solar (the most heavily subsidized technology). Support benefits nevertheless differ dramatically by year and technology. While conventional fuels like natural gas receive a few cents per-MWh, renewables receive 300x more support on an energy-weighted basis.

Over the study period, solar support drops from $600/MWh to $96/MWh. Renewable technologies like geothermal, biomass, and hydro receive an approximately constant amount of support over the study period. This is unsurprising because these technologies only benefit from the RPS and the RPS has certain carve-outs for these technologies. Wind, a relatively more mature technology, sees modest per-MWh declines over the 2010s.

CALIFORNIA CONCLUSIONS

California offers a robust range of financial support mechanisms for renewables and functionally none for other technologies. Both

TABLE 16:

Financial Support per-MWh and per-Capita by State and Year

Year	United States	Texas (with CREZ)	Texas (without CREZ)	California
Electricity Spending Per MWh ($/MWh)				
Year	**United States**	**Texas (with CREZ)**	**Texas (without CREZ)**	**California**
2010	3.0	1.3	1.0	8.4
2013	4.8	3.3	1.0	12.6
2016	3.1	3.5	1.2	17.5
2019	3.7	3.2	1.1	19.8
Electricity Spending per Capita ($/person)				
Year	**United States**	**Texas (with CREZ)**	**Texas (without CREZ)**	**California**
2010	36	19	15	73
2013	56	53	17	105
2016	37	59	21	153
2019	45	54	18	183
Electricity as Percentage of Energy Spending				
Year	**United States**	**Texas (with CREZ)**	**Texas (without CREZ)**	**California**
2010	83%	30%	26%	99%
2013	87%	48%	23%	99%
2016	73%	54%	29%	99%
2019	73%	50%	25%	99%

the magnitude of support and its diversity is substantial. In magnitude, the $3-7 billion spent annually is roughly 30% of the size of Federal support while the state consumes less than 25% of the total energy in the nation. On a per capita basis, California subsidies total $184 per person in 2019 (see Table 16) – three times higher than per-capita federal support.

California heavily targets renewables with more than 90% of funding directed to low/no carbon sources. Yet within renewables, the state has taken an "all-of-the-above" approach. Where some states only offer support to a single technology, California traditionally spread its funding around. In future years, support for solar grows disproportionately higher compared to other renewables like geothermal, hydro, and wind.

The RPS accounts for two-thirds to three-fourths of all spending and many renewable technologies only receive support through that program.

California also offers a range of support for novel technologies that are in the R&D or early deployment stages. Unlike the pure R&D that the federal government often supports, California has demonstrated a general tendency to offer support to new technologies by rationalizing this will "buy down" their cost – that is, using incentives to reduce unit costs by increasing demand for products that in turn increases production volume. In the mid-2000s, California sought to reduce the costs of solar through its Emerging Renewables Program and later through the California Solar Initiative. In the early 2010s, it sought to reduce the cost of fuel cells. Today, it seeks to drive down the costs of energy storage using the Self- Generated Incentive Program (SGIP) and the storage mandate. Over the study period, the state offers more than $3 billion in financial support for fuel cells and energy storage (approximately $285 million per year). California, unlike the federal government or Texas, offers support to technologies that burn natural gas and petroleum through their fuel-cell programs and the SGIP program. While R&D funding for hydrocarbons is modest ($6 million annually starting in 2013 via EPIC), it is nevertheless unique over our surveyed jurisdictions (CPUC 2016b). ■

COMPARISON OF TEXAS, CALIFORNIA, AND FEDERAL SUPPORT

In offering financial support for energy and electricity technologies, the federal government, Texas, and California take radically different approaches. The intent of offering aid, the recipients of largess, and the sources of funding differ by jurisdiction.

Over the study period from 2010 to 2020, Texas offers financial support to the energy sector worth approximately $1–$2 billion per year with an additional $1 billion per year if including CREZ costs. Of the $2 billion per year, we believe that $1.6 billion supports electricity generation. California offers electricity $2.5-$7 billion of state-level support annually over the study period. It offers no material support to energy outside of the electricity sector.

California offers more support per-MWh and per-capita than both Texas and the Federal government. Texas per-MWh and per-capita support is approximately the same (including CREZ) or less (excluding CREZ) than the federal government. The impact on electricity rates and per-capita costs differ by jurisdiction. When spread across all fuels, electricity support at a federal and Texas-state level equates to less than $5/MWh throughout the 2010s. In California, by contrast, rates of support have grown from $9/MWh to nearly $25/MWh. Per Capita, the story is similar but to a lesser extent. Californians pay more for the supports offered by the state, but this is offset, somewhat, by lower rates of electricity consumption in the state – **while electricity is more expensive per unit in California, fewer units are consumed in total.**

The beneficiaries of financial support differ by jurisdiction. While the federal government broadly diversifies its support across the energy sector, Texas and California both take more targeted approaches (See Figure 6). California directed all of its financial support to a diversified portfolio of renewable electricity technologies while Texas split its support between hydrocarbon extraction and wind capacity additions.

The different beneficiaries highlight a critical difference in subsidy intent. *Texas generally uses its financial support for economic development while California uses it to meet environmental goals and drive down the cost of new technologies.* These spending patterns are apparent in the magnitude of support by technology. California

FIGURE 6:

Financial Support for Energy by Fuel Type in 2016 by (a) percentage of total spending and (b) total annual spending

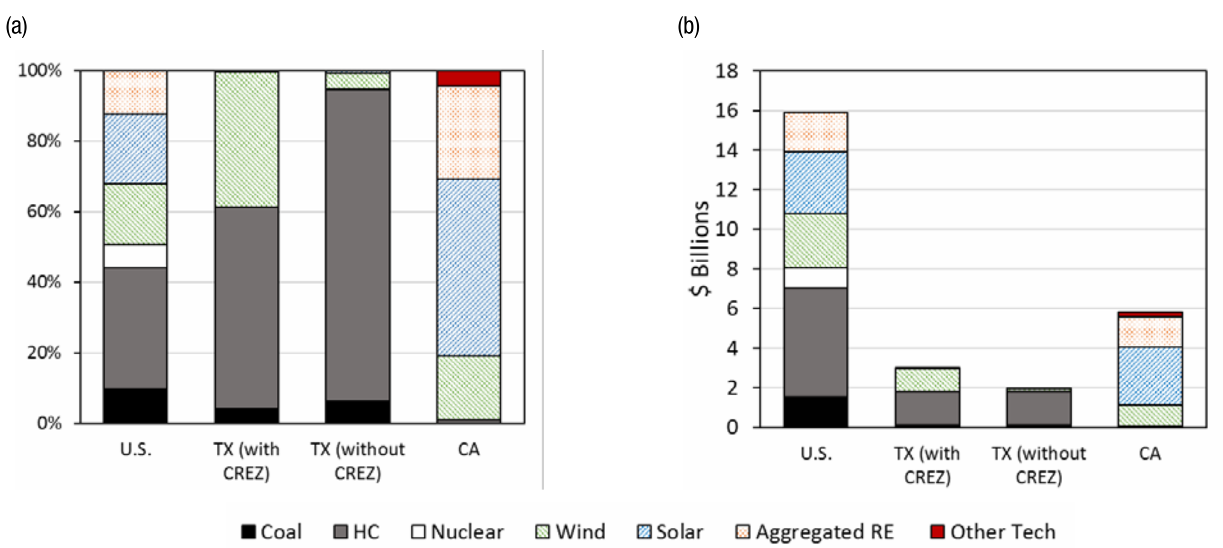
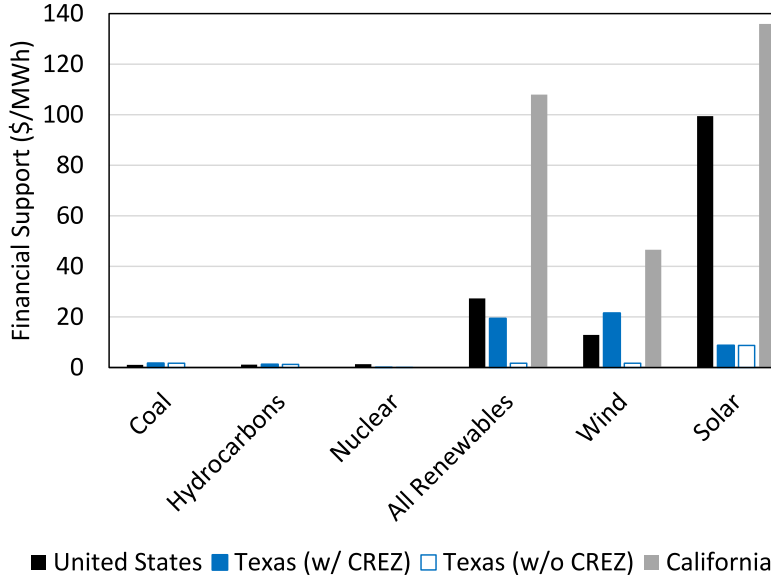


FIGURE 7:

Support by Technology, 2016, ($/MWh)



NOTE: A levelized cost of CREZ transmission lines relative to CREZ electricity generation is approximately 4 $/MWh.

spends significantly more money on renewables generally than either Texas or the Federal government (Figure 7), a trend that holds irrespective of the renewable technology.

Different intents are also reflected in the proximity of support to electricity production (Figure 8). The federal government offers significant funding to fuel production, electricity production, and electricity sales; Texas offers support for fuel sales and electricity production; and California offers support for electricity only with a strong bias towards electricity sales.

Finally, the sources of financial support differ across jurisdictions. The U.S. and Texas both have a preference for tax expenditures while California has a strong preference for mandates (Figure 9).

FIGURE 8:

Proximity of Support to Electricity, 2016 Energy-Related Spending by (a) percentage of total spending and (b) total annual spending

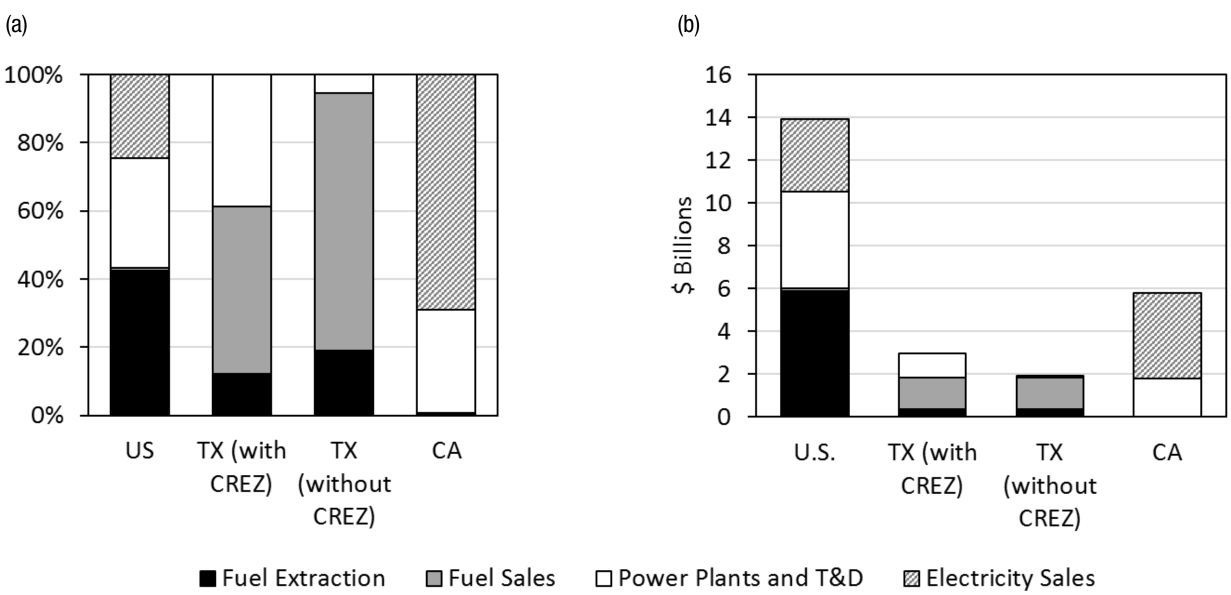
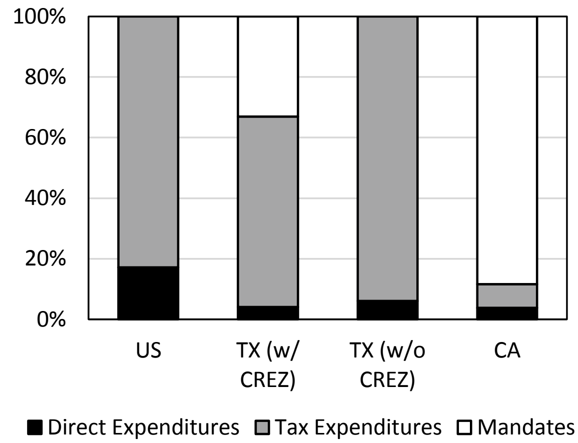


FIGURE 9:

Method of Financial Support (2016 Funding for all Energy)



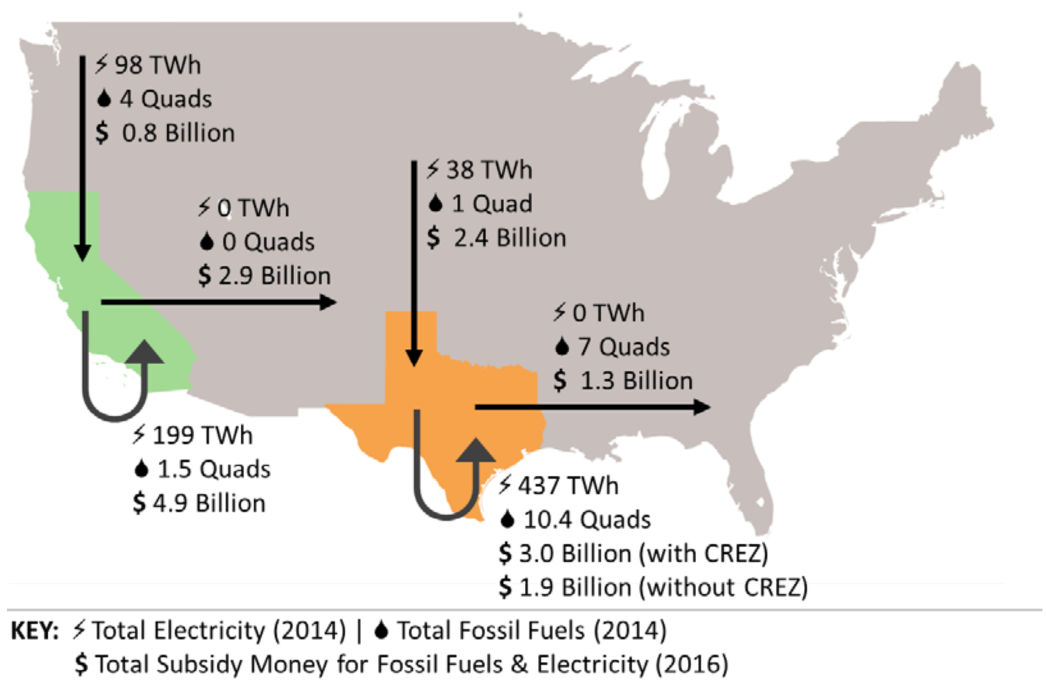
Mandates are not used to offer support to particular technologies by the federal government but are liberally used by both states. Renewable Portfolio Standards exist in many states, including Texas and California, but not at the federal level. A majority of mandates have the effect of direct expenditures – the state compels utilities to spend ratepayer (electricity consumer) funds on specific goods like renewable electricity or new transmission lines. Mandates have the political advantage of not appearing on state budgets.

Financial support can also be thought of as flows of money for flows of energy. These flows exist both within the state and between the states and the country as a whole. Using the subsidy values calculated in this paper and its Federal companion paper (Griffiths et al., 2017), we calculate the monetary subsidy flows from and into Texas and California and show them in Figure 10.[16] Money out of Texas and California is each state's contribution to total federal energy subsidies, and for California, it includes money paid for out-of-state electricity to meet the California RPS. Money into each state is the amount of federal energy subsidies received by each state. The lightning bolt represents electricity only, the liquid drop represents all energy that is not in the form of electricity (measured in quadrillion

16 Energy Data from EIA 2016a and EIA 2016b. Data includes all energy production; net flow is production less consumption. The energy value includes all energy – not just energy consumed in the form of electricity.

FIGURE 10:

Flows of energy (quads) & federal and state financial support ($) for energy between California, Texas, and the US overall.



Notes: Money out of Texas and California is each state's contribution to total federal energy subsidies, and for California it includes money paid for out-of-state electricity to meet the California RPS. Money into each state is the amount of federal energy subsidies received by each state.

TABLE 17:

Flow of Energy, Electricity, and Money

Flow Type	TX	CA
Inflows		
Electricity (TWh)	38	99
Subsidized Electricity	0	17
Unsubsidized Electricity	38	82
Fossil Fuels (Quads)	1	4
Subsidized Energy	0	0
Market Energy	1	4
Money ($ billion)	2.4	0.8
Money (Fed Subsidies into State)	2.4	0.8
Market Money	NQ	NQ
Outflows		
Electricity (TWh)	0	0
Subsidized Electricity	0	0
Unsubsidized Electricity	0	0
Fossil Fuels (Quads)	7	0
Money ($ billion)	1.3	2.9
Money to Feds for Subsidies	1.3	1.9
State Subsidy Money to out-of-state Energy & Elec	0	1.0
State Money for unsubsidized Energy & Elec.	NQ	NQ
Intra-State		
Electricity, Total (TWh)	438	199
Fossil Fuels, Total (Quads)	10	2
Money ($ billion) [including CREZ; excluding CREZ]	3.0; 1.9	4.9
State Money for in-state subsidies	3.0; 1.9	4.9
State money for in-state mkt purchases	NQ	NQ

Notes: "NQ" means Not Quantified. Subsidy money for 2016; energy data for 2014. Total Energy and Electricity Production & Consumption from EIA 2016a and EIA2016b. CA Electricity data from CEC2016b. Subsidy values from this white paper and Griffiths et al., (2017).

British Thermal Units, known as a "quad"), and the dollar sign represents money flows specifically related to financial support for electricity.

The states may provide money to other portions of the nation in two ways: first, they may provide tax receipts to the federal government; second, they may procure resources (California, for example, procures 25% of its RPS from other western states). States also receive financial support from the federal government – in direct expenditures, tax preferences, and R&D spending. These countervailing flows are netted against one another. Similarly, states may use financial support to export or import energy. Within this framework, the distinction between California and Texas is obvious. California provides money for energy resources imports while Texas provides money for energy resources exports. Texas exports more than one-third of its total energy production whereas California imports nearly twice as much as it self-supplies. Texas is also a net recipient of federal-financial support for energy – because of its substantial hydrocarbon resources and wind farms — while California is a net donor. California gives more federal tax allocable to energy than it receives back; and it gives money to other states in return for renewable energy. On a net money basis, nearly 70% of California's financial support money stays within the state.

CONCLUSION

This paper used data from various state and federal agencies to determine both the total and per-MWh values of federal financial support attributable to electricity generation in Texas and California. A comprehensive assessment of direct and indirect subsidies was undertaken.

We find that there are major differences between these states in the magnitude of support, technologies supported, and sources of funding. Texas offers the energy sector support worth approximately \$2-\$3 billion per year (or \$1.6–\$2.2 billion per year excluding costs for Competitive Renewable Energy Zone transmission lines). Of this, we believe that the support offered to electricity generation is \$0.6–\$1.6 or \$0.5–\$0.6 billion per year if including or excluding CREZ costs, respectively. California offers electricity \$2.5-\$7 billion annually over the study period. It offers no material support to energy outside of the electricity sector. The total value of financial support to the electricity sector from the state of Texas in 2016 is valued at \$60/person and \$22/person including and excluding CREZ costs, respectively. California's support is worth \$153/person. Federal support is worth approximately \$37/person. ■

APPENDIX 1: TEXAS SUPPLY FORECAST & INCENTIVE ESTIMATION

SUPPLY FORECAST

The Texas electricity supply forecast is compiled from two sources: The Energy Information Agency (EIA) and other FCe- white papers. For the historic period 2010-2015, we rely on data in EIA's Annual Energy Outlook, which includes generation data for the entire state by fuel type and year. For 2016 through 2020, we rely on data from the Full Cost of Electricity study by Mann et al (2017) on the ERCOT generation mix and assume the generation mix of Texas overall will be that of ERCOT. ERCOT only represents approximately 80% of the state's entire load. After 2015, we scale up the ERCOT generation to Texas generation by multiplying by the "TX/ERCOT Ratio" of Texas generation to ERCOT generation by fuel type in 2015 from EIA Form 923, as indicated in Table A-1.

TABLE A-1:

ERCOT to Texas Scaling Factors from EIA Form 923 (2015)

Fuel Type	Texas TWh	ERCOT TWh	non-ERCOT TWh	TX/ERCOT Ratio
Hydrocarbons	243.32	195.44	47.88	1.24
Natural Gas	243.21	195.36	47.85	1.24
Oil	0.11	0.08	0.03	1.31
Coal	121.69	97.76	23.93	1.24
Nuclear	39.35	39.35	-	1.00
Renewables	47.63	41.91	5.72	1.14
Wind	44.83	39.70	5.14	1.13
Biopower	1.44	1.13	0.31	1.28
Hydro	0.96	0.71	0.25	1.35
Solar	0.40	0.37	0.03	1.07
Other	0.73	0.74	(0.00)	1.00
Total	**452.73**	**375.20**	**77.53**	**1.21**

Source: 2015 EIA Form-923.

TABLE A-2:

Texas Supply Forecast by Fuel Type, 2010-2020 (TWh)

	Historic						Forecast				
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Coal	150	158	138	149	148	122	106	61	97	108	118
Hydrocarbons	191	205	218	207	207	243	210	254	207	199	196
Oil	1	1	1	1	0	0	-	-	-	-	-
Gas	190	204	217	206	207	243	210	254	207	199	196
Nuclear	41	40	38	38	39	39	38	38	38	38	38
Renewables	28	32	34	38	42	47	60	73	85	89	89
Wind	26	31	32	36	40	45	60	71	83	86	86
Solar	0.0	0.0	0.1	0.2	0.3	0.4	0.4	2.7	2.7	2.7	2.7
Other RE	3	2	2	2	2	2	-	-	-	-	-
Total	**410**	**435**	**429**	**433**	**437**	**451**	**423**	**432**	**435**	**442**	**449**

Notes: Details for forecast are found in Appendix 1. 2010-2015 data from EIA form 923; 2016-2020 is estimated in two parts. First, we rely on the base case of the ERCOT specific forecast derived for the FCe- study using AURORAxmp (Mann et al, 2017). Second, we scale the annual energy values by the ratio of Texas-to-ERCOT generation by fuel type found in the EIA form 923 (2015).

INCENTIVE ESTIMATION

Texas primarily uses its tax code to offer financial support to the energy sector. For most programs, we use the State Comptroller's official estimates of tax expenditures as published in their *Tax Exemptions & Tax Incidence* White paper (Comptroller 2015). Certain high value tax breaks related to the oil industry are excluded from these white papers and require estimation.

DIRECT EXPENDITURES

Direct expenditures are tabulated using budget data from the Texas Legislative Budget Board. The LBB provides program level information for the budgets created by the 83rd and 84th legislative sessions (2013 and 2015). These documents provide data on expenditures, budgets, and appropriations for the period 2012 through 2017. Energy related programs are characterized as related to (1) energy efficiency

TABLE A-3:

Texas Direct Expenditures by Program, 2012-2017 ($ million)

Program	Beneficiary	2012	2013	2014	2015	2016	2017	Type
Low-Income Electric Discount Program	ELEC	65	87	450	104	326	-	EE/C
Nuclear Power Institute	NUC	1	1	2	2	2	2	R&D
Offshore Technology Research Center	HC	1	1	0	0	0	0	R&D
Prevention of Wildfire Caused by Power Lines	ELEC	-	-	2	2	-	-	R&D
Bureau of Economic Geology	HC	1	1	2	6	2	2	R&D
Bureau of Economic Geology - Project STARR	HC	5	5	5	5	5	5	R&D
Killgore Research Center	EXCL	0	0	0	0	0	0	R&D
Low Income Energy Assistance Program	EE/C	126	130	-	-	-	-	LIHEAP
Weatherization Assistance Program	EE/C	9	5	133	133	133	133	EE/C
Bioenergy Research	BIO	1	1	-	-	-	-	R&D
Energy Resources Program	EXCL	1	1	1	1	0	0	R&D
Energy Research	EXCL	1	1	1	1	1	1	R&D
Environmental Resource Management	EXCL	0	0	0	0	0	0	R&D
Energy Research Cluster	EXCL	4	4	4	4	4	4	R&D
Center for Energy	HC	0	0	0	0	0	0	R&D
Wind Energy Research	WIND	0	0	0	0	0	0	R&D
Distribution of Oil Overcharge Settlement Funds	EE/C	34	49	17	17	11	11	EE/C
Distribution of Other State Energy Program (SEP) Funds	EE/C	149	9	-	-	-	-	EE/C
State Energy Conservation Office (SECO) Administration	EE/C	3	3	2	2	2	2	EE/C
Coastal Impact Assistance Program	HC	14	30	3	7	7	0	Energy
Oil Spill Research & Development	HC	1	1	1	1	1	1	R&D
AFRED Marketing and Public Education	HC	12	2	1	1	0	0	Energy
AFRED Rebates	HC	0	0	-	-	-	-	Energy
AFRED Training	HC	1	1	1	1	1	1	Energy
Oil and Gas Well Plugging	HC	22	20	19	19	19	19	Energy
Operator Cleanup Assistance	HC	4	4	4	4	4	4	Energy
State-Managed Cleanup (Site Remediation)	HC	3	1	1	1	1	1	Energy
Surface Mining Reclamation	COAL	4	3	3	3	3	3	Energy
Voluntary Cleanup Program (VCP) / Brownfields Response Program (BRP)	HC	0	0	0	0	0	0	Energy
County Transportation Infrastructure	HC	-	225	5	220	-	-	Energy
Center for Advances in Water and Air Quality	HC	-	-	-	-	1	1	Energy
Comprehensive Research Fund	EXCL	-	-	-	-	7	7	R&D
Total		**463**	**585**	**657**	**534**	**530**	**198**	

TABLE A-4:

RPS Cost in Texas

Value	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Cost ($ million)	22.01	22.03	30.13	25.72	15.44	9.4	5.8	5.1	5.1	5.1	5.1
TX (TWh)	9.05	9.06	12.39	12.62	15.00	17[a]	17[a]	17[a]	17[a]	17[a]	17[a]
Per-MWh Cost	2.43	2.43	2.43	2.04	1.03	--	--	--	--	--	--
REC price ($/MWh)	--	--	--	--	--	0.55	0.34	0.30	0.30[b]	0.30[b]	0.30[b]

a: Applicable wind generation after 2015 is assumed to be the quantity of wind generated by the RPS requirement of 5,880 MW of capacity assumed operating at 33% capacity factor, equal to 17 TWh/yr.

b: TX REC prices averaged approximately 0.55, 0.34, and 0.30 $/MWh in 2015, 2016, and 2017, respectively. For 2017 through 2020, we assume they remain at 0.30 $/MWh for compliance costs.

or conservation; (2) Research & Development; (3) Low Income Home Heating Assistance; and (4) Energy. Those in Energy are subcategorized by fuel type. Table A-3 provides a summary of included programs. Details on these programs can be found on the LBB website (LBB 2016).

RENEWABLE PORTFOLIO STANDARD (RPS)

As part of Texas's electric sector restructuring efforts (Senate Bill 7, 1999), the legislature created a goal for renewable energy in the state to add 2,000 MW of capacity in addition to an existing 880 MW. With SB 20 in 2005, the legislature raised the RPS to a target of 5,000 MW of` additional capacity (5,880 MW total) by the beginning of 2015 and set a non-RPS goal of 10,000 MW by the beginning of 2025. Many sources of renewables were eligible and a non-binding "goal" was set for 500 MW to come from sources other than wind energy (TX Util. Code. § 2.B.39.904). By the end of 2009 over 10,00 MW of renewable capacity was installed in Texas, 15 years ahead of schedule (ERCOT 2013).

According to LBNL, RPS compliance costs fell from $30 million in 2012 to $15 million in 2014 (or, $2-3/MWh-RE). Today, RECs are still traded to meet compliance obligations but given the modest demand and over-supply, their value is close to nil (Barbose 2016, 28).

Unlike some states where REC prices can get as high as $60/MWh, Texas's RECs reliably trade for $0.30-$1/MWh, making the RPS a trivial driver of value for new projects. Further, the already low values likely overstate the actual value of the state subsidy because as much as 60% of the demand for RECs comes from voluntary buyers rather than compliance obligation (Luhavalja 2015).

For 2012 through 2014 we rely on LBNL RPS cost and compliance data. For 2010 and 2011, we rely on LBNL's compliance data for the quantity of RPS energy and their 2012 estimate of cost ($2.43/MWh-RE). TX REC prices averaged approximately 0.55, 0.34, and 1.30 $/MWh in 2015, 2016, and 2017, respectively, and we multiply these price by the generation from the RPS 5,880 MW of wind at 33% capacity factor. From 2017 through 2020, our estimated cost of the RECs is 5.1 million per year, equal to a REC of 0.3 $/MWh multiplied by the generation from 5,880 MW of wind at 33% capacity factor. Table A-4 summarizes the results from our RPS analysis.

COMPETITIVE RENEWABLE ENERGY ZONES (CREZ) TRANSMISSION

In 2005, the Texas Legislature passed Senate Bill 20 (SB20), which sought to increase the amount of wind generation in the state by building transmission to resource rich regions. In all, 2,334 miles of 345kW transmission lines were approved to enable enough transmission for a total renewable power capacity of 18,552 MW. The total cost was approximately $6.9 billion (Andrade and Baldick 2016). The approved lines were built between 2009 and 2014. We attribute the entire cost of the CREZ projects to wind energy. While transmission offers many benefits including reliability and improved price formation, the Texas Legislature makes clear that the intent was to encourage the development of renewables in West Texas and the Panhandle.

We estimate the annual cost of CREZ as follows. First, we assume capital expenditures were distributed according to the timeline indicated in Andrade and Baldick (2016) from (RS&H, 2013). We assume a 9% regulated rate of return on the net rate base, which is equal to the portion of capital expenditures that has not yet depreciated. We assume straight-line depreciation over 40 years, thus 2.5% of total capital cost each year. Operation and Maintenance (O&M) cost is assumed at 2.1% of the total capital cost spent to date (e.g., 6,900 million × 2.1%/yr = 145 million/yr). We assume the entity building the CREZ transmission lines pays federal income tax (FIT) at 35% and that this tax is incorporated into the transmission utility's revenue charge (FIT = (revenue return on rate base – interest + FIT)(0.35)/(1-0.35)). The annual interest charge to the utility assumes that 60% of the total capital cost is financed via debt and 40% via equity. Thus, interest is paid on only 60% of capital spending.

Our estimated subsidy value for CREZ transmission is the net present value (discounted at 9%/yr, the assumed rate of return on capital) of the Total Revenue Requirement (TRR), equal to $7,250 million, divided by the total electricity generation of the additional 11,552 MW of wind capacity operating with an assumed 42% capacity factor, equal to approximately 1.7 TWh from 2009 to 2054 (2054 is the 40th year of the last installed CREZ transmission lines). Our final CREZ subsidy value is 4.3 $/MWh of wind electricity, and near the range of 4-5 $/month on customer electric bills as stated by the Texas Public Utility Commission (Galbraith 2011) (assuming 1.2 MWh/month (Wible and King 2016), the monthly CREZ cost is 5.1 $/month).

TABLE A-5:

Annual CREZ Transmission Spending and assumed MW installed and TWh for wind farms in CREZs (units are $millions, nominal, unless otherwise indicated)

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Incremental Spending	200	500	700	800	4500	200	0	0	0	0	0
Total Capital Spending	200	700	1400	2200	6700	6900	6900	6900	6900	6900	6900
Net Rate Base (Cumulative Undepreciated capital)	200	695	1378	2143	6588	6620	6448	6275	6103	5930	5758
Return on rate base	18	63	124	193	593	596	580	565	549	534	518
Depreciation	0	5	18	35	55	168	173	173	173	173	173
O&M	4	15	29	46	141	145	145	145	145	145	145
Federal Income Tax	5	19	37	58	179	177	170	162	155	148	141
Interest on debt	8	27	54	85	260	266	265	263	261	259	257
Total Revenue Requirement (TRR)	28	101	208	332	968	1086	1068	1045	1022	999	976
TRR / Total Capiwtal Spending (%)	13.8%	14.5%	14.9%	15.1%	14.4%	15.7%	15.5%	15.1%	14.8%	14.5%	14.1%
Assumed cumulative MW of wind	-	-	-	1,271	1,421	3,148	6,542	8,859	10,859	11,552	11,552
Assumed Capacity Factor of wind (%)				42%	42%	42%	42%	42%	42%	42%	42%
Incremental wind generation (TWh)	-	-	-	4.7	5.2	11.6	24.1	32.6	40.0	42.5	42.5

SEVERANCE TAX RELIEF OF MARGINAL WELLS

Tax relief for marginal wells was originally adopted by the legislature in 2009 (HB 2161) and made permanent two years later (HB2982). A marginal oil well means is a well that produces 10 barrels of oil or less per day on average during a month. A marginal gas well is a well whose production during a three-month period is no more than 90 mcf per day, excluding flared gas. This legislation provides severance tax relief for the producers of marginal oil or gas wells when market prices fall below certain, pre-determined, levels (RRC 2017). The bills provide three levels of reduction, ranging from 25% to 100%, for any given month depending on the average taxable price of the commodity. We estimate the value of the rate relief for oil and gas separately.

TAX EXEMPTION FOR QUALIFYING LOW-PRODUCING OIL LEASES

The current thresholds for tax relief for oil are as follows:

- a 25% tax credit if the average taxable oil price were above $25 per barrel but not more than $30 (adjusted to 2005 dollars);
- a 50% tax credit if the price were above $22 per barrel but not more than $25; and
- a 100% tax credit if the price were $22 or less.

Between January 2005 and September 2016, there have only been five months that qualified for some level of tax relief according to the comptroller's estimates (February through June 2016). The

TABLE A-6:

Monthly Value of Severance Tax Relief for Low Producing Oil Leases

Filing Year	Filing Month	Net Value of Oil Sold ($)	2005 Trigger Oil Price ($/BBL)	Discount	Effective Rate	Tax Relief ($)
2015	08	-	42.56	0%	4.6%	-
2015	09	-	38.95	0%	4.6%	-
2015	10	-	35.63	0%	4.6%	-
2015	11	-	34.62	0%	4.6%	-
2015	12	-	34.67	0%	4.6%	-
2016	01	-	32.53	0%	4.6%	-
2016	02	44,202,090	28.48	25%	3.5%	508,324
2016	03	57,995,884	24.76	50%	2.3%	1,333,905
2016	04	61,191,192	24.13	50%	2.3%	1,407,397
2016	05	70,713,436	25.90	25%	3.5%	813,205
2016	06	73,368,238	29.52	25%	3.5%	843,735
2016	07	-	32.24	0%	4.6%	-
2016	08	-	33.39	0%	4.6%	-
2016	09	-	33.68	0%	4.6%	-
Total		**307,470,839**				**4,906,566**

value of the exemption comes from the Texas Comptroller's Office via our open records request (#12933380409), and we provide the results below.

TAX EXEMPTION FOR QUALIFYING LOW-PRODUCING GAS WELLS

Low producing gas wells are defined as those that average, over a three-month period, 90 mcf per day or less. The legislature used the same approach for gas as it did for oil, but set the threshold prices much higher. The current thresholds for tax relief for gas are as follows:

- a 25% tax credit if the average taxable gas price were more than \$3.00 per mcf but not more than \$3.50 (adjusted to 2005 dollars)
- a 50% tax credit if the price were more than \$2.50 per mcf but not more than \$3.00;
- a 100% tax credit if the price were \$2.50 or less.

Unlike oil wells, which rarely qualify for rate relief, gas wells usually do. Between January 2010 and September 2016, a period of 81 months, only five months in 2014 and seven months in 2010 did not qualify for some level of relief. Relief averaged 52% over the study period. Table A-7, below, quantifies the value of the tax relief for historic years. As with the low producing oil subsidy above, data are provided by the Texas Comptroller's Office via our open records request (#12933380409). Table A-7 calculates the monthly value of the subsidy while Table A-8

TABLE A-7:

Monthly Value of Tax exemption for qualifying low-producing gas wells

Filing Year	Filing Month	Net Value of Natural Gas Sold ($)	2005 Trigger Gas Price	Discount	Effective Tax Rate	Tax Relief ($)
2010	01	0	3.90	0%	7.5%	-
2010	02	0	4.12	0%	7.5%	-
2010	03	0	4.27	0%	7.5%	-
2010	04	0	3.99	0%	7.5%	-
2010	05	0	3.58	0%	7.5%	-
2010	06	115,557,474	3.29	25%	5.6%	2,166,703
2010	07	125,614,135	3.42	25%	5.6%	2,355,265
2010	08	0	3.55	0%	7.5%	-
2010	09	0	3.57	0%	7.5%	-
2010	10	122,460,912	3.34	25%	5.6%	2,296,142
2010	11	111,217,372	3.07	25%	5.6%	2,085,326
2010	12	139,539,499	3.02	25%	5.6%	2,616,366
2011	01	134,647,306	3.12	25%	5.6%	2,524,637
2011	02	120,459,011	3.35	25%	5.6%	2,258,606
2011	03	143,308,358	3.34	25%	5.6%	2,687,032
2011	04	146,258,447	3.26	25%	5.6%	2,742,346
2011	05	160,387,245	3.18	25%	5.6%	3,007,261
2011	06	148,884,809	3.23	25%	5.6%	2,791,590
2011	07	160,336,949	3.34	25%	5.6%	3,006,318
2011	08	154,254,956	3.35	25%	5.6%	2,892,280
2011	09	139,659,018	3.26	25%	5.6%	2,618,607
2011	10	143,922,227	3.08	25%	5.6%	2,698,542
2011	11	153,956,525	2.97	50%	3.8%	5,773,370
2011	12	151,438,790	2.94	50%	3.8%	5,678,955
2012	01	138,395,324	2.85	50%	3.8%	5,189,825
2012	02	112,497,383	2.60	50%	3.8%	4,218,652
2012	03	134,180,081	2.32	100%	0.0%	10,063,506
2012	04	121,958,290	2.05	100%	0.0%	9,146,872
2012	05	111,756,222	1.86	100%	0.0%	8,381,717

2012	06	110,343,592	1.84	100%	0.0%	8,275,769
2012	07	132,203,352	1.89	100%	0.0%	9,915,251
2012	08	142,620,256	2.14	100%	0.0%	10,696,519
2012	09	125,568,633	2.23	100%	0.0%	9,417,647
2012	10	143,803,461	2.33	100%	0.0%	10,785,260
2012	11	153,697,029	2.47	100%	0.0%	11,527,277
2012	12	131,120,055	2.71	50%	3.8%	4,917,002
2013	01	124,598,890	2.85	50%	3.8%	4,672,458
2013	02	110,991,367	2.82	50%	3.8%	4,162,176
2013	03	121,490,651	2.71	50%	3.8%	4,555,899
2013	04	132,002,088	2.78	50%	3.8%	4,950,078
2013	05	136,903,594	2.99	50%	3.8%	5,133,885
2013	06	115,404,650	3.19	25%	5.6%	2,158,067
2013	07	113,545,807	3.20	25%	5.6%	2,123,307
2013	08	114,220,399	3.05	25%	5.6%	2,135,921
2013	09	122,080,173	2.87	50%	3.8%	4,578,006
2013	10	126,360,240	2.82	50%	3.8%	4,738,509
2013	11	122,374,797	2.82	50%	3.8%	4,589,055
2013	12	134,226,139	2.89	50%	3.8%	5,033,480
2014	01	138,282,910	3.07	25%	5.6%	2,585,890
2014	02	146,592,733	3.30	25%	5.6%	2,741,284
2014	03	0	3.70	0%	7.5%	-
2014	04	0	3.74	0%	7.5%	-
2014	05	0	3.74	0%	7.5%	-
2014	06	0	3.56	0%	7.5%	-
2014	07	0	3.57	0%	7.5%	-
2014	08	110,001,916	3.41	25%	5.6%	2,057,036
2014	09	113,177,875	3.25	25%	5.6%	2,116,426
2014	10	107,086,526	3.08	25%	5.6%	2,002,518
2014	11	97,488,042	3.02	25%	5.6%	1,823,026
2014	12	92,468,317	3.12	25%	5.6%	1,729,158
2015	01	62,827,642	3.02	25%	5.6%	1,174,877
2015	02	60,482,680	2.77	50%	3.8%	2,268,101
2015	03	72,216,050	2.32	100%	0.0%	5,416,204
2015	04	66,382,013	2.05	100%	0.0%	4,978,651
2015	05	65,700,275	1.91	100%	0.0%	4,927,521
2015	06	64,017,977	1.89	100%	0.0%	4,801,348
2015	07	70,155,000	1.82	100%	0.0%	5,261,625
2015	08	68,699,301	1.81	100%	0.0%	5,152,448
2015	09	63,053,349	1.71	100%	0.0%	4,729,001
2015	10	58,458,781	1.64	100%	0.0%	4,384,409
2015	11	45,704,694	1.55	100%	0.0%	3,427,852
2015	12	41,771,818	1.48	100%	0.0%	3,132,886
2016	01	39,456,169	1.37	100%	0.0%	2,959,213
2016	02	32,925,514	1.34	100%	0.0%	2,469,414
2016	03	29,292,449	1.22	100%	0.0%	2,196,934
2016	04	30,828,082	1.14	100%	0.0%	2,312,106
2016	05	33,184,217	1.06	100%	0.0%	2,488,816
2016	06	34,943,945	1.10	100%	0.0%	2,620,796
2016	07	38,885,573	1.29	100%	0.0%	2,916,418
2016	08	35,231,653	1.46	100%	0.0%	2,642,374
2016	09	33,125,793	1.56	100%	0.0%	2,484,434

TABLE A-8:

Annual Summary of Tax exemption for qualifying low-producing gas wells

Year	Net Value of Natural Gas Sold ($)	Tax Relief ($)
2010	614,389,392	11,519,801
2011	1,757,513,640	38,679,543
2012	1,558,143,676	102,535,297
2013	1,474,198,794	48,830,843
2014	805,098,319	15,055,339
2015	739,469,580	49,654,922
2016	307,873,396	23,090,505

presents the annual value. Both are published here because they were previously undisclosed.

The 2016 EIA AEO forecasts that natural gas and oil prices will be higher than the incentive ceiling price in future years so the value of these subsidies is assumed zero after 2016.

HIGH COST NATURAL GAS TAX RATE RELIEF

Introduced by the 71st legislature in 1989, the High Cost gas incentive was created to encourage the development of less profitable gas plays by reducing the severance tax on certain high cost wells. More specifically, Section 201.057 of the Texas Tax Code codifies the requirements and quantifies the value of the incentive as follows:

> High-cost gas … is entitled to a reduction of the tax imposed by this chapter for the first 120 consecutive calendar months beginning on the first day of production, or until the cumulative value of the tax reduction equals 50 percent of the drilling and completion costs incurred for the well, whichever occurs first. (TX Tax Code §201).

The incentive originally applied to 3% of gas produced in 1997 but now applies to more than half (Comptroller 2014, 8). The rise in "high cost" gas is primarily due to hydraulic fracturing which has more expensive drilling and completion costs than traditional wells.

While the value of the high cost gas incentive is not included in the biannual *Tax Exemptions & Tax Incidence* White paper, the Comptroller issued a study on its costs and benefits in 2014. The *High-Cost Natural Gas Tax Rate Incentive Study* estimated that the program had a value to drillers of $12.7 billion between 1997 and 2014 (Comptroller 2014, 3). The average annual value between 2005 and 2014 was just over $1 billion. See Table A- 9, below.

The value of the incentive has increased in recent years because of the reclassification of some wells from oil to gas. The Comptroller's 2015 Certification of Revenue Estimate noted the following: "In addition, the Texas Railroad Commission has reclassified some oil wells as natural gas wells, making them potentially eligible for the high-cost natural gas tax rate reduction. If such reclassifications were expanded, it could adversely affect revenues as a result of refunds and reduced natural gas tax collections" (Comptroller 2015b, cover letter). The Comptroller also noted that eligible reclassifications in the Eagle Ford Shale could cost "up to $250 million during the 2016-2017 budget cycle and more than $200 million over the following two years" (Malewitz 2015).

We calculate the cost of the incentive as follows. For the period 2010 through 2014, we rely on estimates from the Comptroller's study. For 2015 through 2020 we use the average value of the program between 2005 and 2014. Onto this, we add $250 million for 2016 and 2017 and $200 million for 2018 and 2019, per the comptroller estimates. This may understate the true cost of the program if drilling continues to expand in the state.

TABLE A-9:

Value of High-Cost (H-C) Natural Gas Tax Rate Reduction Program by Year

Fiscal Year	H-C Wells Submitted to Comptroller	H-C Average Tax Rate*	H-C Taxable Production (Mcf)	H-C Share of Total Taxable Production	Cost of H-C Rate Reduction
1997	599	1.45%	168,889,339	3%	$22,833,506
1998	1,714	1.16%	678,138,262	13%	$95,191,380
1999	1,413	1.06%	1,019,239,081	21%	$120,481,661
2000	1,150	1.31%	1,253,491,342	25%	$210,540,431
2001	1,888	1.45%	1,512,895,659	29%	$470,126,351
2002	2,943	1.36%	1,850,608,829	36%	$283,167,835
2003	2,966	1.64%	1,974,548,381	38%	$505,039,972
2004	3,467	1.90%	2,188,664,203	41%	$596,071,963
2005	4,297	1.79%	2,402,241,501	44%	$808,802,827
2006	4,392	1.42%	2,743,103,257	47%	$1,300,354,421
2007	7,406	1.18%	3,231,149,020	51%	$1,293,536,442
2008	6,253	1.32%	4,146,520,207	56%	$1,974,204,232
2009	9,774	1.48%	4,748,150,593	61%	$1,481,625,687
2010	6,111	1.65%	4,453,472,268	61%	$989,419,185
2011	3,350	1.63%	4,704,948,871	62%	$1,079,717,312
2012	3,516	1.44%	4,755,614,578	62%	$906,806,900
2013	3,092	1.32%	4,323,609,415	56%	$810,493,709
2014	2,670	1.44%	3,516,210,409	46%	$812,295,780

Reproduced from Comptroller (2014), 3. H-C Average Tax rate reflect, for each year, the average reduced tax rate associated with all high-cost wells and the aggregate value of production from those wells

TEXAS' LACK OF SEVERANCE TAX FOR COAL MINING

Six of the top ten coal producing states include some sort of severance tax (either ad valorem or a flat rate per ton). Texas – along with Illinois, Indiana, and Pennsylvania – has no such provision on the books (See Table A-10). Texas does have severance tax provisions for oil (4.6%) and for natural gas (7.5%), so the lack of a severance tax on coal constitutes a subsidy for lignite production, given the definition of subsidy as preferential treatment. During proposed severance tax reform in 2001, the Texas House of Representatives noted the preferentiality of lignite compared to oil and gas as one reason for reform (HRO 2001, 9).

We recognize that there is no one correct choice for taxing each type of fossil fuel extraction. This is a policy decision based on many factors including the entire suite of taxes and other sources of revenues that constitute total state revenues. However, to compare with non-zero coal severance taxes in other states, including those that mine lignite, we decided it was most pertinent to consider Texas' lack of a severance tax on coal as a tax expenditure due to loss of some potential revenue that is theoretically replaced with other taxes.

TABLE A-10:

Coal production and Severance Tax Rates for 10 Largest Coal Producing States

State	Production in 2015 (Thousand Short Tons)	Severance Tax Surface Coal
Wyoming	375,773	7% or a maximum of $0.6/ton
West Virginia	95,633	1-5% depending on Type
Kentucky	61,425	4.5%; minimum of $0.5/ton
Illinois	56,101	NONE
Pennsylvania	50,031	NONE
Montana	41,864	10-15%; 10% on lignite
Texas	35,918	NONE
Indiana	34,295	NONE
North Dakota	28,802	$0.395/ton
New Mexico	19,679	$1.85/ton

Texas receives less tax revenue than it otherwise could because of the lack of a severance tax on coal and lignite. The exact magnitude is hard to discern because of both a wide range of possible tax regimes and possible price/substitution effects associated with adding a tax. Table A-11 depicts Texas revenues from a coal severance tax for 2015 assuming the severance tax rates used in other top coal-producing states. Assuming no price or quantity changes, a severance tax would have generated $14 million to $80 million in additional state revenue depending on tax rate. Using a simple average of seven other state rates, Texas could generate an additional $43 million annually through a severance tax on coal. We repeat the calculation of Table A-11 for our four benchmark years in Table A-12.

TABLE A-11:

Foregone revenue in Texas for 2015 assuming the Coal Tax Regime of other coal mining States

State	Regime	$Million
Wyoming	7% or a maximum of $0.6/ton	21.6
West Virginia Total	1-5% depending on Type (5% assumed)	40.2
Kentucky Total	4.5%; minimum of $0.5/ton	36.1
Montana	10-15%; 10% on lignite	80.3
North Dakota	$0.395/ton	14.2
New Mexico	$1.85/ton	66.4
Min		**14.2**
Simple Average		**43.1**
Max		**80.3**

Notes: Texas produced 35,918 thousand tons of lignite in 2015, and we assume the U.S. reported lignite price of $22.36/ton (EIA 2016c).

TABLE A-12:

Estimated foregone revenue in Texas for 2009, 2013, 2016, and 2019 assuming the Coal Tax Regime of other coal mining States as in Table A-11.

Year	TX coal production (1000 short tons)	US lignite price ($/ton)	Min Tax ($Million)	Max Tax ($Million)	Simple Average Tax ($Million)
2009	35093	17.26	13.9	64.9	36.3
2013	42851	22	16.9	94.3	51.0
2016	35000	22	13.8	77.0	41.6
2019	30000	22	11.9	66.0	35.7

Notes: Prices for 2013, 2016, and 2019 are assumed as similar to 2015 price. Production for 2016 and 2019 is assumed to drop slightly from 2015 levels.

TEXAS TAX ABATEMENTS FOR ENERGY PROPERTY

The State of Texas offers two kinds of property tax subsidies for certain capital-intensive projects. Advanced coal power plants, nuclear generators, and wind farms explicitly qualify for these abatements but so do a variety of other manufacturing and industrial facilities. Wind farms and, more recently, solar plants frequently solicit these tax authorities to offer these abatements in return citing projects in specific communities. The preamble to Chapter 313 of the Texas Tax Code stresses that its goal is to encourage economic development generally, and of capital-intensive businesses in particular. It reads:

(1) many states have enacted aggressive economic development laws designed to attract large employers, create jobs, and strengthen their economies;

(2) the State of Texas has slipped in its national ranking each year between 1993 and 2000 in terms of attracting major new manufacturing facilities to this state;

(3) a significant portion of the Texas economy continues to be based in the manufacturing industry, and the continued growth and overall health of the manufacturing sector serves the Texas economy well;

(4) without a vibrant, strong manufacturing sector, other sectors of the economy, especially the state's service sector, will also suffer adverse consequences; and

(5) the current property tax system of this state does not favor capital-intensive businesses such as manufacturers.

Chapter 312 of the Texas Tax Code allows sub-state taxing authorities to tax a property on only a portion of its total value while Chapter 313 lessens the *ad valorem* tax rate on a piece of property. Chapter 313 is available to school districts while 312 is available for all other taxing authorities like counties, libraries or community colleges. While these taxing decisions are made on a sub-state level, the state makes up the revenues forgone when a school district offers an abatement under Chapter 313 (the state does not offer similar reimbursement for agreements made under Chapter 312).

CHAPTER 313: TEXAS ECONOMIC DEVELOPMENT ACT

Chapter 313 of the Texas Tax Code allows school districts to temporarily reduce *ad valorem* tax rates on certain capital-intensive property. Because these agreements interact with the State's complex school funding mechanisms, the Texas state budget treats Chapter 313 as a tax expenditure. The Comptroller's *Tax Exemptions and Tax Incidence* white paper estimates the total value of Chapter 313 but it does not break out value by sector. The Comptroller also

TABLE A-13:

Chapter 313 Project Counts & Amount of Lifetime Tax Benefit by Technology

Study Year	2009	2011	2013	2015
# Wind Projects	63	76	127	144
$ Wind Gross Tax Benefits ($mm)	712	840	1375	1564
# Solar Projects	1	2	9	22
$ Solar Gross Tax Benefits ($mm)	21	32	77	223
# Total Projects	98	128	259	311
$ Total Gross Tax Benefits ($mm)	1910	2388	5540	7119
Wind Projects as % of Total Projects	64%	59%	49%	46%
Wind Projects as % of Total Tax Benefits	37%	35%	25%	22%
Solar Projects as % of Total Projects	1%	2%	3%	7%
Solar Projects as % of Total Tax Benefits	1%	1%	1%	3%

Sources. All Data from Table 1 of multiple Comptroller's White paper of the Texas Economic Development Act. 2009 Data from 2011 White paper; 2011 Data from 2013 White paper; 2013 Data from 2015 White paper; 2015 Data from 2017 White paper.

compiles a biennial white paper on the Texas Economic Development Act offering detail on a per abatement basis. Using the 2012, 2014, and 2016 white papers, we calculate the number of projects, percentage of total investment, and the gross value of the tax benefit by sector. In 2015, renewable energy projects accounted for 53% of all tax abatements but only 25% of total investment.

Nine out of 10 dollars spent on renewables via Chapter 313 in 2015 were for wind farms. In our study period renewable resources are the only electricity generating faculties that benefit from Chapter 313 even though advanced coal and nuclear power plants are also eligible. Electricity-related R&D may be included elsewhere in Chapter 313 but is neither broken out nor included in our analysis.

We apply the percentage of lifetime gross tax benefits attributable to wind farms and solar projects to total estimated gross tax benefits across years. Table A-14 calculates the value of Chapter 313 for wind farms and solar plants for each year. We assume that the annual tax abatements in Table

TABLE A-14:

Annual Value of Chapter 313 Tax Abatements for Wind and Solar ($ million)

Year	Gross Benefits (TX Comptroller)	% Wind	% Solar	Wind Value ($mm)	Solar Value ($mm)
2009	75	37%	1%	27.8	0.8
2010	122	36%	1%	44.1	1.5
2011	154	35%	1%	54.2	2.1
2012	182	30%	1%	54.5	2.5
2013	196	25%	1%	48.6	2.7
2014	230.5	23%	2%	53.9	5.2
2015	221.5	22%	3%	48.7	6.9
2016	398.7	22%	3%	87.6	12.5
2017	525.1	22%	3%	115.4	16.5
2018	505.1	22%	3%	111.0	15.8
2019	536.6	22%	3%	117.9	16.8
2020	538.0	22%	3%	118.2	16.9
Total				**854.0**	**99.5**

Note: 2009-2013 Gross Benefits from annual white papers; 2014-2020 from Comptroller's Tax Expenditure White paper

A-14 are attributed to wind and solar at the same proportion as the lifetime benefits listed in Table A-13. Between 2010 and 2020, we estimate wind farms are to receive more than $850mm in Chapter 313 tax abatements while solar plants are estimated to receive about $100mm.

CHAPTER 312: PROPERTY REDEVELOPMENT AND TAX ABATEMENT ACT

Chapter 312 offers local taxing authorities the ability to offer property tax abatements by temporarily reducing the taxable value of real property. Unlike Chapter 313 agreements (see below), those under Chapter 312 are exclusively between a property developer and a local taxing authority. While the state has enabled local jurisdictions to offer these deals, they are costless from the state perspective. For this reason, we exclude them from our final analysis of state subsidies. They are discussed here because of its similarity to the included Chapter 313 abatements and because it has provided material support to wind developers.

In 2015, 11 energy projects were included in the 156 known abatements; the dollar value of these agreements is unknown (Comptroller 2016b, 7). Over the period 2010-2019, wind farms are the only known recipient from the electricity sector. HB 2994 (2007) offers a special carve out for new nuclear and IGCC projects.

The Texas Clean Energy Project, an integrated gasification combined cycle plus carbon capture and sequestration plant, that has been in various development stages over the past several years, would be eligible for this abatement in future years.

Comprehensive analysis is hampered by a lack of data availability: the Texas Comptroller does not have complete records on the size of the abatement, the duration, or the beneficiary. Anecdotal investigation indicates that Chapter 312 tax abatements vary widely in value. Table A-15 calculates the value of eight tax abatement agreements that are worth between $0.25 and $3/MWh. The range in abatement value depends on local tax rates, abatement schedules, payments in lieu of taxes, and whether a development has signed multiple 312 agreements with different taxing authorities. The analyzed agreements are heterogeneous: while all are 10 years in duration, the abatement value ranges from 40% to 100% and payments in lieu of taxes range from nil to $2000/MW/year.

We calculate the overall Chapter 312 incentive value as a percentage of the Chapter 313 estimates found

TABLE A-15:

Select Chapter 312 Agreements

	Taxing Authority		Project Description		10 Year Total of Tax Abatement			
Developer	Local Agent	Nom. Tax Rate (%)	Size (MW)	Value ($mm)	Gross Value ($mm)	PILOT ($mm)	Net Value ($mm)	Net Value ($/MWh)
Scandia Wind Southwest	Parmer Co.	0.57%	600	750	36.61	9.00	27.61	1.69
Hildago	Hidalgo Co	0.59%	100	70	2.89	-	2.89	1.06
Duke Wind	South Texas College	0.18%	203	462	7.07	0.65	6.42	1.16
Langford Wind	Tom Green Co.	0.51%	150	120	1.81	-	1.81	0.45
Santa Rita Wind Farm	Reagan Co.	0.33%	300	200	6.61	4.50	2.11	0.26
Red Raider Wind Farm	Hockney Co.	0.46%	70	105.4	4.82	1.05	3.77	1.98
Mariah del Norte	Parmer Co.	0.57%	232	348	16.99	3.48	13.51	2.14
Mariah del Norte	Parmer Hospital Dist.	0.25%	232	348	7.35	2.90	4.45	0.71

in Table A-13. Assuming that windfarms receive both Chapter 312 and Chapter 313 abatements, we calculate the value of Chapter 312:

$$Chap.\,312 = Chap.\,313 \times \frac{Mean\ County\ Tax\ Rate}{Mean\ ISD\ Tax\ Rate} \times \frac{Net\ Value\ of\ 312\ Agreement}{Gross\ Value\ of\ 312\ Agreement}$$

In Texas, the mean Independent School District (ISD) tax rate is 1.3% while the mean county tax rate is 0.55%. The ratio of county to ISD tax rate is 43%. From Table A-15, we calculate the net to gross ratio of Chapter 312 agreements at 75%. Put together, this suggests that Chapter 312 agreements are worth approximately 1/3 as much as the Chapter 313 agreements. Table A-16 calculates the scaled value of Chapter 312 agreements. This table does not calculate the value of Chapter 312 agreements with entities other than counties and, therefore, understates the true value by an unknown amount.

TABLE A-16:

Value of Chapter 312 Tax Abatements

Year	Chapter 313 Wind Value ($mm)	Scaled Chapter 312 Value ($mm)
2009	27.80	8.95
2010	44.10	14.20
2011	54.20	17.46
2012	54.50	17.55
2013	48.60	15.65
2014	53.90	17.36
2015	48.70	15.69
2016	87.60	28.21
2017	115.40	37.17
2018	111.00	35.75
2019	117.90	37.97
2020	118.20	38.07
Total	**881.9**	**275.05**

SOLAR INCENTIVES

All solar incentives offered by utilities within the state of Texas fall outside of the scope of this white paper but are briefly discussed here. Between 2011 and 2015 various utilities offered more than $100 million in total solar incentives (see Table A-17).

TABLE A-17:

Solar Incentives by Utility and Year (values in $ millions)

Utility Type	2011	2012	2013	2014	2015	2016	Total
Investor Owned	**2.21**	**1.96**	**9.08**	**15.12**	**9.21**	**8.32**	**37.58**
Oncor	-	-	7.84	14.06	8.23	7.80	30.13
AEP - TCC	0.59	0.36	0.36	0.36	0.36	0.36	2.03
AEP - TNC	0.18	0.16	0.13	0.16	0.16	0.16	0.80
AEP - SWEPCO	0.09	0.29	0.32	0.12	0.24	-	1.07
El Paso	1.35	1.15	0.43	0.42	0.21	-	3.55
Muni & Coop	**11.83**	**14.48**	**14.94**	**17.62**	**18.21**	**10.20**	**77.08**
CPS	6.67	6.67	6.67	10.00	10.00	10.00	40.00
AE	4.96	7.61	8.07	7.42	8.01	N/A	36.08
Denton	0.20	0.20	0.20	0.20	0.20	0.20	1.00
Total	**14.04**	**16.44**	**24.02**	**32.73**	**27.42**	**18.52**	**114.65**

Sources: AEP 2017; El Paso 2017; Oncor 2017, 7; Saporito 2015; Austin Energy 2017, Table 37.

Transmission and Distribution utilities are allowed to include rooftop solar as part of their energy efficiency / peak demand reduction plans. Oncor and, to a lesser extent, AEP both offer solar incentives under this guise. Oncor provided $37 million in solar incentives between 2011 and 2016. AEP's T&D utilities, by contrast, has offered about $3.3 million over the same timeframe. Other T&D utilities have elected to meet their efficiency targets without solar incentives.

Two IOU utilities, El Paso Electric and SWEPCo, offer solar incentives to their customers. These two utilities are geographically within Texas but outside of ERCOT and the competitive market and are covered by traditional utility regulation. El Paso has offered $3.5 million in subsidies between 2011 and 2015 but these rates have declined in recent years. SWEPCo, another AEP company, offered solar incentives between 2011 and 2013 worth approximately $700,000. Since 2014, SWEPCo has not offered solar incentives.

Municipal ("munis") and cooperative ("co-ops") utilities may also offer incentives as approved by their constituents. Twelve munis and co-ops offer solar incentives in one form or another. CPS and Austin Energy, the munis of San Antonio and Austin respectively, offer the lion's share of solar incentives. CPS has offered $90 million in solar incentives since 2008 through several different programs. Austin Energy offered $36 million between 2011 and 2015. Informal data requests from the other 10 munis on budget size for solar incentives yielded only one response. The City of Denton has a budget of $200,000 per year for solar incentives. The unresponsive munis likely have budgets more in line with Denton than with CPS of San Antonio and Austin Energy given their modest number of customers.

POSSIBLE SEVERANCE TAX LOSSES DUE TO FLARING OF NATURAL GAS

Texas regulators have sometimes permitted the flaring of natural gas associated with oil production either for economic reasons or for periods that exceed regulatory maximums. When this happens one might view that permission as a subsidy because there is state revenue that might be uncollected (via the severance tax on natural gas production) from resources that were extracted but not sold in the market.

Anti-flaring rules are designed to prohibit physical waste of hydrocarbons, yet Texas permits flaring for economic reasons. Section 201.053 of the Texas Tax Code outlines a severance tax exemption for "lawfully vented or flared" natural gas from oil wells[17]. Texas rules impose time limits on flaring, yet regulators sometimes grant waivers of those limits. When this happens, operators save the costs they would otherwise incur building gathering lines, or the costs of reinjecting the gas into the underground formation. Calculating the value of this subsidy is extremely difficult, because we cannot know what producers would do absent these permissions: e.g., how much they would contribute to the construction of gathering lines, whether they would instead reinject the gas, or not drill the well in the first place.

Thus, this report does not attempt to estimate any state support related to the venting or flaring of natural gas from oil or natural gas wells. ■

17 Texas Tax Code - TAX § 201.053. Gas Not Taxed "The tax imposed by this chapter does not apply to gas:
(1) injected into the earth in this state, unless sold for that purpose;
(2) produced from oil wells with oil and lawfully vented or flared;
(3) used for lifting oil, unless sold for that purpose; or
(4) produced in this state from a well that qualifies under Section 202.056 or 202.060."

Appendix 2: California Supply Forecast & Incentive Estimation

Most of California's support for electricity measures are offered through mandates or aggregated tax expenditures. This requires us to estimate various programs directly, rather than relying on a government estimate. In this section we describe our calculation methodologies for subsidies that are not directly computed by a third party.

ENERGY SUPPLY FORECAST

Forecasts of supply and demand are offered across a number of different state documents, each subject to distinct confidentiality requirements. For the period 2010-2015, we rely on data compiled by the California Energy Commission in their annual "Total System Power" White paper (CEC 2016b). To calculate the prospective energy by technology and year, however, substantial estimation is required. Our analysis of supply starts with the CEC's 2015 assessment Net Energy for Load by Agency and Balancing Authority using a baseline forecast ("Energy Demand Forecast, 2016 - 2026, Preliminary Mid Demand Baseline Case, No AAEE Savings" (CEC 2015)). From this forecast, we subtract known supply from large-scale hydro, nuclear, and coal generators that utilities provided as part of their 2015 Electricity Resource Plans (CEC 2015b). Unfortunately, utilities provided many of the 2015- 2017 data under confidentiality orders but later years are provided in the public versions. For large hydro and nuclear power, we assume that the 2016-2017 data are the simple average of the 2018-2020 period data. We include all listed coal generation in our analysis as it closely matches the CEC's 2015 resource assessment found in "Actual and Expected Energy From Coal for California" (CEC 2016c).

To estimate a generation supply quantity for California, we use the following approach. We assume conventional power plants (natural gas, nuclear, and coal) supply generation equal to gross electricity demand minus renewable generation from the RPS and minus generation from "behind the meter" generation such as rooftop solar photovoltaics. Note that this assumption means

TABLE A-18:

Energy Supply by Technology and Year (2010-2020) in TWh

	Historic						Forecast				
Technology	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Coal	22	24	23	23	19	18	15	15	13	12	12
Large Hydro	31	38	25	23	16	16	18	18	18	18	18
Natural Gas	122	104	131	131	132	130	168	165	163	162	156
Nuclear	40	45	27	26	25	27	21	21	22	20	22
Renewables	40	41	47	56	60	65	64	70	75	81	87
Biomass	7	6	7	8	8	8	5	5	5	4	4
Geothermal	13	13	13	13	13	13	12	10	11	11	11
Small Hydro	6	6	4	4	3	3	12	4	4	4	4
Solar	1	1	3	5	13	18	21	28	31	34	41
Wind	14	15	19	25	24	24	22	23	25	27	28
Oil	0	0	0	0	0	0	-	-	-	-	-
Other	-	0	0	0	0	0	-	-	-	-	-
Unspecified Sources	35	42	50	37	44	40	-	-	-	-	-
Total	**291**	**294**	**302**	**297**	**297**	**295**	**286**	**288**	**291**	**293**	**296**

rooftop solar is demand-modifying and not relevant for contributing to the RPS (see "Renewable Portfolio Standard" section). We assume there is no generation from oil and "other" fuels, because between 2010 and 2015, these fuel sources accounted for 0.02% of all energy used in the state. All unsourced energy is assumed to be fired using natural gas. Between the last historic year and the first forecast year, total load drops by about 3% (9 TWh) – a difference we leave unreconciled.

RENEWABLE PORTFOLIO STANDARD

California has one of the most aggressive renewable portfolio standards in the nation: 33% of 2020 and 50% by 2030. Under SB350, Rooftop solar qualifies for either net-energy-metering (NEM) or the RPS, but not both. We assume rooftop solar does not count for meeting the California RPS because NEM is usually more lucrative for the rooftop PV owner, and thus most rooftop PV owners choose to use NEM. Senate Bill X1-2 in 2011 requires both investor- and publically-owned utilities to comply with the RPS.

We compute the value of the RPS in two ways. First, we estimate the gross cost of the RPS by calculating the cost of all contracts required to meet the requirement of the mandate. Second, we estimate the net cost of the RPS by subtracting out the avoided cost of generation, which we estimate at the cost of building a new natural gas fired power plant – the same approach used in the California RPS calculator. Because the IOUs provide the available RPS data, we must scale data known about the IOU RPS portfolios to make comments about the system as a whole. Equation A-1 calculates the net cost of the RPS.

EQUATION A-1:

Net cost of RPS

$$Net\ RPS\ Cost = \left(\sum_{Technology\ t}^{T} Cost_t \times Generation_t \right) - Cost_{NGCC} \left(\sum_{Technology\ t}^{T} Generation_t \right)$$

The first term represents the gross cost of generating energy from each qualifying technology type. The second term represents the cost of generating that same quantity of electricity from a natural gas combined cycle (NGCC) power plant.

Technology cost data for the period 2012-2020 is sourced from E3's RPS Calculator v6.3 using the base settings (E3, 2016). We assume that generation costs in 2010-2012 remain at the 2012 levels. For generation, we rely on actual data for the period 2010-2014 and forecast data for 2015-2020. The historic data comes from the CPUC's 2016 biennial RPS white paper and the forecast data is an output from the RPS calculator (CPUC 2016a).

To calculate the gross cost, we scale up the IOU compliance costs to reflect the costs for compliance across California. IOUs, community-choice aggregators (CCA), small or multi- jurisdictional utility (SMJU), and electric service provides are all required to comply with the RPS. The big IOUs reflect approximately 70% of RPS eligible load so we scale those numbers by the ratio of total load to IOU load. This scaling assumes that the California renewable portfolio, as a whole, mimics the technology distribution found in the IOU portfolios. This scaling increases the total cost of the RPS but makes no change to the $/MWh impact.

TABLE A-19:

California RPS Cost, 2013-2020

Estimated Electricity Generation Required to Satisfy RPS (GWh), Large IOUs Only

Technology	2013	2014	2015	2016	2017	2018	2019	2020
Biogas	713	767	906	906	545	533	533	513
Biomass	3,254	3,354	3,669	3,081	3,053	2,823	2,304	2,202
Geothermal	10,732	10,887	9,354	9,044	8,136	8,124	7,719	7,023
Hydro	2,672	2,956	2,972	2,894	2,824	2,651	2,647	2,601
Solar PV	646	4,314	9,933	13,375	18,742	19,304	20,360	23,603
Solar Thermal	638	638	2,736	2,729	2,729	2,676	2,745	2,720
Wind	14,980	16,461	17,086	17,314	18,195	18,010	18,491	17,881
Biopower (combined)	3,967	4,122	4,576	3,988	3,598	3,356	2,837	2,716
Solar (combined)	1,284	4,952	12,668	16,104	21,471	21,980	23,105	26,323
Subtotal	**33,634**	**39,377**	**46,656**	**49,343**	**54,225**	**54,121**	**54,799**	**56,543**

Estimated Electricity Generation Required to Satisfy RPS (GWh), CA Total

Technology	2013	2014	2015	2016	2017	2018	2019	2020
Biogas	1,078	1,069	1,158	1,172	699	742	790	792
Biomass	4,925	4,674	4,686	3,984	3,914	3,932	3,413	3,400
Geothermal	16,242	15,171	11,946	11,693	10,428	11,313	11,436	10,842
Hydro	4,043	4,119	3,795	3,742	3,620	3,691	3,922	4,016
Solar PV	977	6,011	12,685	17,293	24,023	26,881	30,164	36,439
Solar Thermal	966	890	3,494	3,528	3,498	3,727	4,066	4,199
Wind	22,672	22,938	21,821	22,386	23,322	25,080	27,394	27,606
Biopower (combined)	6,004	5,744	5,844	5,156	4,612	4,674	4,203	4,192
Solar (combined)	1,943	6,901	16,179	20,821	27,521	30,608	34,230	40,638
Subtotal	**50,904**	**54,873**	**59,584**	**63,799**	**69,503**	**75,366**	**81,185**	**87,294**

Gross Energy Costs by Technology Type and Year ($/MWh)

Technology	2013	2014	2015	2016	2017	2018	2019	2020
Natural Gas Comb. Cycle	$33.06	$33.06	$33.06	$41.39	$45.70	$35.25	$38.95	$40.21
Biogas	$69.09	$69.49	$68.23	$68.23	$75.69	$76.52	$76.20	$76.04
Biomass	$96.65	$96.67	$96.72	$97.27	$97.27	$97.27	$98.23	$99.91
Geothermal	$69.02	$69.06	$68.59	$68.62	$68.74	$68.74	$68.80	$68.93
Hydro	$65.91	$65.10	$65.14	$65.40	$67.07	$67.29	$67.29	$68.03
Solar PV	$157.56	$134.62	$144.13	$149.35	$130.44	$128.35	$125.53	$118.21
Solar Thermal	$134.84	$134.84	$139.64	$139.65	$139.65	$139.74	$139.62	$139.83
Wind	$88.75	$86.32	$86.03	$85.56	$82.02	$81.91	$82.15	$82.08
Biopower (combined)	$91.70	$91.61	$91.08	$90.67	$94.00	$93.97	$94.09	$95.40
Solar (combined)	$146.26	$134.65	$143.16	$147.71	$131.61	$129.74	$127.20	$120.44
Subtotal	**$83.18**	**$86.58**	**$97.21**	**$101.97**	**$99.68**	**$99.39**	**$99.17**	**$98.30**

Net Energy Costs by Technology Type and Year ($/MWh)

Technology	2013	2014	2015	2016	2017	2018	2019	2020
Natural Gas Comb. Cycle	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Biogas	$36.03	$36.43	$35.17	$26.84	$29.99	$41.27	$37.25	$35.83
Biomass	$63.59	$63.61	$63.66	$55.88	$51.57	$62.02	$59.28	$59.70
Geothermal	$35.96	$36.00	$35.53	$27.23	$23.04	$33.49	$29.85	$28.72
Hydro	$32.85	$32.04	$32.08	$24.01	$21.37	$32.04	$28.34	$27.82
Solar PV	$124.50	$101.56	$111.07	$107.96	$84.74	$93.10	$86.58	$78.00
Solar Thermal	$101.78	$101.78	$106.58	$98.26	$93.95	$104.49	$100.67	$99.62
Wind	$55.69	$53.26	$52.97	$44.17	$36.32	$46.66	$43.20	$41.87
Biopower (combined)	$58.64	$58.55	$58.02	$49.28	$48.30	$58.72	$55.14	$55.19
Solar (combined)	$113.20	$101.59	$110.10	$106.32	$85.91	$94.49	$88.25	$80.23
Subtotal	**$50.12**	**$53.52**	**$64.15**	**$60.58**	**$53.98**	**$64.14**	**$60.22**	**$58.09**

Net RPS Cost by Type and Year ($ million)

Technology	2013	2014	2015	2016	2017	2018	2019	2020
Natural Gas Comb. Cycle	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Biogas	$36.03	$36.43	$35.17	$26.84	$29.99	$41.27	$37.25	$35.83
Biomass	$63.59	$63.61	$63.66	$55.88	$51.57	$62.02	$59.28	$59.70
Geothermal	$35.96	$36.00	$35.53	$27.23	$23.04	$33.49	$29.85	$28.72
Hydro	$32.85	$32.04	$32.08	$24.01	$21.37	$32.04	$28.34	$27.82
Solar PV	$124.50	$101.56	$111.07	$107.96	$84.74	$93.10	$86.58	$78.00
Solar Thermal	$101.78	$101.78	$106.58	$98.26	$93.95	$104.49	$100.67	$99.62
Wind	$55.69	$53.26	$52.97	$44.17	$36.32	$46.66	$43.20	$41.87
Biopower (combined)	$58.64	$58.55	$58.02	$49.28	$48.30	$58.72	$55.14	$55.19
Solar (combined)	$113.20	$101.59	$110.10	$106.32	$85.91	$94.49	$88.25	$80.23
Subtotal	**$50.12**	**$53.52**	**$64.15**	**$60.58**	**$53.98**	**$64.14**	**$60.22**	**$58.09**

Net System Cost of RPS by Type & Year ($ million)

Technology	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Net cost of RPS	1,934	1,996	2,395	2,623	2,806	4,055	4,021	4,133	4,418	4,621	4,494
For Wind	*760*	*818*	*1,074*	*1,201*	*974*	*1,224*	*1,044*	*975*	*1,032*	*1,093*	*974*
For Solar	*105*	*136*	*287*	*565*	*1,120*	*1,902*	*2,264*	*2,515*	*2,723*	*2,908*	*2,992*
For Geothermal	*482*	*477*	*476*	*364*	*304*	*429*	*347*	*298*	*316*	*304*	*240*
For Biopower	*404*	*362*	*412*	*399*	*347*	*421*	*267*	*248*	*249*	*218*	*204*
For Small Hydro	*183*	*203*	*147*	*93*	*60*	*78*	*99*	*97*	*98*	*98*	*85*

TRANSMISSION RELATED TO THE RENEWABLE PORTFOLIO STANDARD

The California Energy Commission believes that certain transmission upgrades will be required between 2011 and 2020 to meet the State's 33% RPS. In 2011, the California ISO estimated RPS-related transmission could cost $7.2 billion. The Large IOUs have estimated the cost of RPS-related transmission somewhat higher: $9.2 billion to $10.4 billion before 2020 (see CPUC 2016a; CPUC 2014). Transmission cost causation is difficult to establish because of the benefits it will add to reliability. The CEC notes:

> Over the next decade a number of new transmission projects will be brought online that will support the state's 33 percent RPS program. In addition to facilitating the delivery of renewable resources, these projects will also increase reliability and provide transmission access for conventional resources. Given the multiple benefits associated with these transmission projects, it is not yet clear how the costs of these transmission lines should be allocated between renewable resources and other conventional resources (CPUC 2016a, 9).

In this white paper we allocate transmission based on the forecast of new capacity added in support of the RPS. For the purposes of our calculations, we assume that new transmission allows for the interconnection of *new* projects only and that transmission lines have a maximum capacity that can flow down them (even if they have a utilization factor of 1). Functionally, this means that biopower, geothermal, and small hydro incur no transmission related costs because of their constant or declining generation over the study period (see Table A-18).

TABLE A-20:

Incremental Transmission for Meeting RPS

Year	Total Spend ($mm)	Source
CAISO Forecast	7,200	CPUC 2016a, 9
2013 White paper	9,200	CPUC 2013, 7
2014 White paper	10,400	CPUC 2014, 12
2016 White paper	9,900	CPUC 2016a, 9
Average by Forecast		
CAISO	*7,200*	
Avg. IOU Forecasts	*9,833*	
Avg. All Forecasts	*9,175*	

We take the simple average of the 4 known cost estimates offered by CAISO and the Large IOUs (Table A-20) as the total spending on transmission required between 2012 and 2016.

Next, we allocate this total spending of $9.2 billion by the amount of new RPS compliant capacity added in a given year. Finally, we divide total annual spending by the incremental capacity by generation type. This provides the annual transmission spending attributable to a given technology in a given year.

Although infrastructure is completed in a given year, those capital costs are recovered over several decades. The CEC notes "As a very general rule of thumb, the amount collected in rates each year is roughly equivalent to 15 percent to 18 percent of the total capital expenditures" (CPUC 2016a, 9). Hence, we estimate that 16.5% of the transmission costs incurred in a given year are collected in all subsequent years. This provides a rough estimate of the costs incurred to interconnect different technologies. The annual cost of this RPS- driven transmission is provided in Table A-21.

TABLE A-21:

($ million)

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Incremental Transmission Buildout for RPS	918	918	918	918	918	918	918	918	918	918
Cumulative Transmission Buildout for RPS	918	1,835	2,753	3,670	4,588	5,505	6,423	7,340	8,258	9,175
RPS-related Transmission Cost @ 16.5% of capital	151	303	454	606	757	908	1,060	1,211	1,362	1,514

CALIFORNIA SOLAR INITIATIVE

California's Senate Bill 1 (2006) initiated the California Solar Initiative (CSI) and the "million solar roof initiative". CSI authorized spending $2.167 billion dollars between 2007 and 2016 on solar incentives. The CSI applied only to the large IOUs although all utilities were required to comply with SB1, including municipal and cooperative utilities (see next subsection).

We compile costs using a variety of sources. For the period 2007-2014 we rely on audits conducted in 2014 and 2016.[18] For 2015 and 2016 we rely on data in the CSI "Working Dataset" (CEC 2016c). This workbook provides information on projects completed by year and the total value of the incentives those projects received. It also provides data on projects receiving performance based incentives (PBI) including the start date of PBI benefits. We first calculate the sum of projects completed in 2015 and 2016. Next, we calculate the PBI paid out in 2015 and later years. PBI was offered in a number of ways, but for simplicity, we assume that all PBI projects had their incentives paid uniformly over five years. Thus, projects completed as early as 2011 still received PBI payments in 2015.

Combining these two sources of data, our calculation yields a total program cost of $2.110 billion – 99% of the nominal $2.167 billion budget. To reconcile our calculation's $26 million shortfall, we distribute this value proportionally to spending in the years 2015-2020.

POU COMPLIANCE WITH SB1

While the CSI was narrowly focused on the large-IOUs, publically owned utilities (POUs) were also subject to SB1's solar initiatives. As part of SB1 compliance, 47 POUs write white papers to summarize their own solar incentives by year. Using the annual white papers filed with the CEC, we calculate the spending by year for the period 2008 to 2015 (CEC 2016d). We have no data on expected spending patterns for 2016 and following years, so we scale the funds remaining at the end of 2015 proportional to the CSI spending for the period 2016- 2020.

One methodological addendum: the Los Angeles Department of Water and Power (LADWP) presents a spurious value for "total incentive paid" for 2014 – five times higher than any other year. It appears that they calculated their total, cumulative spending rather than their incremental spending for this year. LADWP's 2015 Briefing Book calculates cumulative SB1 solar spending at $200 million, suggesting 2014 incremental spending was approximately $16 million (LADWP 2015, 9). We use this $16 million figure for LADWP when calculating annual POU spending.

NEW SOLAR HOMES PARTNERSHIP

The New Solar Homes Partnership (NSHP) is related to but is separate from the CSI. This program provides financial incentives and support for new homes incorporating solar panels. For 2007 to 2015 program costs, we rely on CEC data provided in "Supporting Information For Energy Commission Request For Continuation Of New Solar Homes Partnership Program And Designation As Program Administrator" (CPUC 2016c). This document notes the NSHP program has an authorized lifetime budget of $400 million. It had spent $136 million by the end of 3Q2015 and had another $149 million encumbered (funds for reserved projects that had not yet been paid). Decision 16-06-006, published in June 2016, authorized sufficient funding to ensure the lifetime budget would be met (CPUC 2016c, 36).

To calculate the cost of the NSHP, we use actual spending by year through 2014. For 2015, we annualize the 10-month spending presented. We further assume that the NSHP will exhaust its budget by the end of 2018 (when the program statutorily concludes) and that spending between 2016 and 2018 is uniform.

18 California Public Utilities Commission; California Solar Initiative External Audit; Program Years 2010 & 2011. Published May 28, 2013

STORAGE MANDATE

California's three large IOUs have a mandate to procure 1.3 GW of energy storage by 2020. Assembly Bill 2514 (2013) called for a mandate to enable market transformation of these new technologies and, in 2013, CPUC developed the specific rules as part of its quasi- legislative rulemaking R.10-12-007. The mandate is paid for through ratepayer funds.

Estimating the cost of the storage mandate is difficult because all cost data to date is confidential. The CPUC and others have, however, estimated the cost of energy storage. GTM Research indicates that installed energy storage costs were $1950/kW in 2015 and are expected to fall to $1372/kW by 2021 (GTM 2016, pg. 15-16).

TABLE A-22:

Market Size and Installed Storage Capacity for Select Years

Year	2015	2016	2021
Mkt Size (million)	441	474	2,908
Size (MW)	226	287	2,118
$Million/MW	1.951	1.651	1.372
$/kW	1951	1651	1,372

Source: GTM Research 2016, 15-16.

These numbers are approximately consistent with inputs for the RPS calculator (v6.2) which suggest costs will be $1733/kW in 2017 falling to $1563/kW in 2020. The GTM estimates bookend those from E3 (the consulting company and creator of the RPS calculator).

Quantity is easier to determine. The CPUC offered biannual procurement targets for 2014 through 2020. We assume that resources are procured evenly over each procurement window, yielding a step function.

The annual cost is estimated by multiplying the annual procurement goal by the annual cost of storage technology ($/MW). Finally, we subtract out the Self-Generation Incentive Program funding for energy storage to avoid double counting the storage funded through that program. The remaining storage is assumed to be paid for through some utility program or another but the actual funding mechanism is unknown (and, perhaps, not yet developed). Although incentives for a unit meeting each procurement may be offered over a number of years, we realize them in the first year only.

PROPERTY TAX EXCLUSION FOR SOLAR ENERGY SYSTEMS

In 1980, voters approved a ballot initiative that excludes solar systems from property taxes (CA-BOE 2008, 1-2). More specifically, it allowed for the promulgation of legislation that would allow for such an exclusion. Since then, the legislature has enacted and extended such a bill many times, most recently in 2014 as SB-871. Solar systems incorporated into new construction and the addition of a system to existing housing both qualify for the exemption.

The value of this exemption is equal to the magnitude of foregone local revenues. In 2014, the budget office estimated that the bill would result in an annual reduction of $5 million/year

TABLE A-23:

E3 Estimates of Storage Cost and Installed Capacity

			2017	2018	2019	2020
Storage Characteristics	Installed Capacity	MW	165	330	495	660
	Charging Capacity	MWh	575	1,150	1,724	2,299
	NQC Capacity	MW	103	206	309	413
Cost	Unit Cost	$/MWh	$173,329	$169,077	$162,696	$156,316
	Total Cost	$Million	$100	$195	$285	$369

Source: E3 2016, Inputs.

TABLE A-24:

CPUC Energy Storage Targets, 2014-2020 (MW)

Storage Grid Domain Points of Interconnection	2014	2016	2018	2020	Total
Southern California Edison					
Transmission	50	65	85	110	310
Distribution	30	40	50	65	185
Customer	10	15	25	35	85
Subtotal SCE	90	120	160	210	580
Pacific Gas & Electric					
Transmission	50	65	85	110	310
Distribution	30	40	50	65	185
Customer	10	15	25	35	85
Subtotal PG&E	90	120	160	210	580
San Diego Gas & Electric					
Transmission	10	15	22	33	80
Distribution	7	10	15	23	55
Customer	3	5	8	14	30
Subtotal SDG&E	20	30	45	70	165
Total — All 3 utilities	**200**	**270**	**365**	**490**	**1325**

Reproduced from CPUC 2013, Table 2

in *ad valorem* revenues (Meindl 2014, 1). It further estimated that if all new homes included solar systems (170,000/year), then the value of the exemption would rise to $128 million.

We use several sources of data to calculate the value of this exemption. To calculate the value of solar systems between 2010 and 2014, we use incremental capacity and $/watt estimates from the California Soar Initiative. For the period 2015-2020 we use GTM Research forecasts on solar costs and incremental distribution-level capacity data from E3's RPS calculator (Munsell 2016). We use the State's assumed property tax rate of 2.5% (see SB-871 analysis).

To calculate the value of the property tax exclusion, we must know both the value of solar installed each year as well as the depreciated value of solar installed in prior years. Table A-25 calculates this value for solar panels installed from 2007 through 2020. The first value of each row is the installed value of solar installed in that year (capacity times average cost). This value is reduced in columns to the right using a 20-year straight-line schedule. Summing across each row in a given column represents the total value of the subsidy for that year. We find that the value of this program ranges from $32 million to $307 million depending on the year.

PARTIAL SALES AND USE TAX EXEMPTION FOR AGRICULTURAL SOLAR POWER FACILITIES

In November 2012, The California Board of Equalization (BOE) announced that solar power facilities might qualify as farm equipment and therefore qualify for partial sales and use tax exemption (CA-BOE 2012, 1). The annual tax expenditure white papers produced by the California Department of Finance (DOF) estimate the total cost of the farm equipment exemption but do not break out the portion related to solar assets.

California's annual tax expenditure white papers provide a 5-year forecast of annual cost (two historic years, three future years). Given the BOE ruled in November 2012, the earliest the DOF would have modified their calculations is FY2013/14 or, more likely, FY2014/15. Plotting the tax expenditures by white paper, the DOF increased estimated costs by nearly $50mm per year between the 2014/15 annual and the 2015/16 white paper.

TABLE A-25:

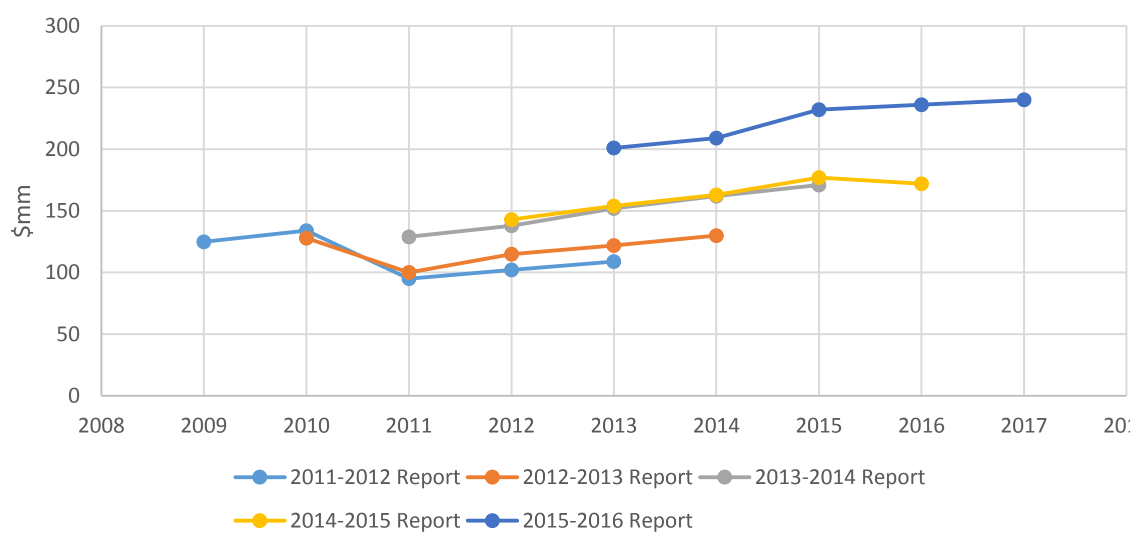
Property Tax Exclusion for Solar Energy Systems by Year

Year	Cap (MW)	Avg. Cost ($/Watt)	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
2007	135	$9.66	1299	1234	1169	1104	1039	974	909	844	779	714	649	585	520	455
2008	108	$9.65		1045	993	941	889	836	784	732	679	627	575	523	470	418
2009	163	$9.15			1488	1414	1339	1265	1191	1116	1042	967	893	819	744	670
2010	368	$8.22				3021	2870	2719	2568	2417	2266	2115	1964	1813	1661	1510
2011	234	$7.67					1793	1703	1613	1524	1434	1344	1255	1165	1076	986
2012	305	$6.25						1906	1810	1715	1620	1525	1429	1334	1239	1143
2013	299	$5.60							1673	1590	1506	1422	1339	1255	1171	1088
2014	246	$5.08								1252	1189	1127	1064	1001	939	876
2015	324	$4.77									1547	1469	1392	1315	1237	1160
2016	299	$3.38										1011	960	910	859	809
2017	253	$2.97											751	713	676	638
2018	192	$2.79												536	509	482
2019	198	$2.59													513	487
2020	195	$2.48														482
Value Installed Solar ($M)			1299	2279	3650	6480	7930	9403	10549	11189	12062	12322	12271	11968	11615	11205
Foregone Taxes ($M)			32	57	91	162	198	235	264	280	302	308	307	299	290	280

Over the same period, farm income is white papered as relatively flat (CDFA 2015, 9). Either the increase in spending is attributable to the inclusion of solar assets within the farm equipment exemption or, alternatively, there was a significant build-up in non-solar capital assets that have not increased farm income – such as water systems used to maintain productivity during a draught. We assume that the increase is attributable to solar alone. For years after the DOF forecast, we assume a growth rate of 8%, which is the average year- over-year rate found in the DOF white papers between 2013/14 to 2016/7.

FIGURE A-1:

Exemption for Farm Equipment & Machinery by Tax Incidence White paper



Sources: CA-DOF 2015; CA-DOF 2014; CA-DOF 2013; CA-DOF 2012; CA-DOF 2011.

TABLE A-26:

EPIC Funding Categories and Spending Levels

Proposed Funding Allocation for the Applied Research and Development Program Area	3 Year Spend	Allocation
EPIC Total	**158.7**	
Energy Efficiency and Demand Response $64.7	**64.7**	
S1 Strategic Objective: Develop Next-Generation End-Use Efficiency Technologies and Strategies for the Building Sector	43.3	EE/DR
S2 Strategic Objective: Develop New Technologies and Applications That Enable Cost-Beneficial Customer-Side-of-the-Meter Energy Choices	21.4	EE/DR
Clean Generation $44.0	**44**	
S3 Strategic Objective: Develop Innovative Technologies, Tools, and Strategies to Improve the Affordability of Distributed Generation	19.5	RE
S4 Strategic Objective: Develop Emerging Utility-Scale Renewable Generation Technologies and Strategies to Increase Power Plant Performance, Reduce Costs, and Expand the Resource Base	9.5	RE
S5 Strategic Objective: Reduce the Environmental and Public Health Impacts of Electricity Generation and Make the Electricity System Less Vulnerable to Climate Impacts	15	Conventional
Smart Grid Enabling Clean Energy $23.0	**23**	
S6 Strategic Objective: Develop Technologies, Tools, and Strategies to Enable the Smart Grid of 2020	8	Elec
S7 Strategic Objective: Develop Operational Tools, Models, and Simulations for Improved Planning of Grid Resources	5	Elec
S8 Strategic Objective: Integrate Grid-Level Energy Storage Technologies and Determine Best Use Applications to Provide Locational Benefits	6	Storage
S9 Strategic Objective: Advance Technologies and Strategies That Optimize the Benefits of Plug-in Electric Vehicles to the Electricity System.	4	Elec
Cross-Cutting $27.0	***27***	
S10 Strategic Objective: Leverage California's Regional Innovation Clusters to Accelerate the Deployment of Early-Stage Technologies and Companies $27.0	27	RE
Table 20: Proposed Funding Allocation for the Technology Demonstration and Deployment Program Area by Strategic Objective	**129.7**	
S12 Strategic Objective: Demonstrate and Evaluate the Technical and Economic Performance of Emerging Efficiency and Demand-Side Management Technologies and Strategies in Major End-Use Sectors	37.3	EE/DR
S13 Strategic Objective: Demonstrate and Evaluate Clean Energy Generation Technologies and Deployment Strategies	48	RE
S14 Strategic Objective: Demonstrate the Reliable Integration of Energy Efficient Demand-side Resources, Distributed Clean Energy Generation, and Smart Grid Components to Enable Energy-Smart Community Development	44.4	Elec
Table 25: Proposed Funding Allocation for the Market Facilitation Program Area by Strategic Objective	**43.3**	
S16 Strategic Objective: Collaborate with local jurisdictions and stakeholder groups in IOU territories to establish strategies for enhancing current regulatory assistance and permit streamlining efforts that facilitate coordinated investments and widespread deployment of clean energy infrastructure	23.3	RE
S17 Strategic Objective: Strengthen the clean energy workforce by creating tools and resources that connect the clean energy industry to the labor market	4.5	RE
S18 Strategic Objective: Guide EPIC investments through effective market assessment, program evaluation, and stakeholder outreach.	15.5	RE

Source: CEC 2012, Table 8.

ELECTRIC PROGRAM INVESTMENT CHARGE (EPIC)

The Electric Program Investment Charge (EPIC) is a large-IOU ratepayer funded program that conducts applied R&D, technology demonstration, and market facilitation. It was established in Decision 12-05-037 for Rulemaking 11-10-003 on May 24, 2012. Each funding allocation is for a 3-year period. Using the First Triennial (2012-2014) as our starting point, we identified the 3-year spend by use and then allocated it proportional to the annual budget. Table A-26 depicts the objectives, proposed budget, and allocation by technology type.

For the Second Triennial (2015-2017), the Energy Commission included total costs by year but not program specific costs (CEC 2014, Table 3). We assume that spending by category (and technology type) is proportional to the first Triennial as the goals of the two plans match closely. The third Triennial (2018-2020) has been announced but no scoping documents have been created. We assume that the third triennial is identical to the second. Spending by year is depicted in Table A-27.

SELF-GENERATION INCENTIVE PROGRAM (SGIP)

The Self Generation Incentive Program is a direct expenditure program mandated by the state and funded by the IOUs using ratepayer funds. It provides cash incentives for specific types of technology with a focus on energy storage, fuel cells, and solar (in early years). For very small projects, the incentives were offered in a lump sum but for larger projects, a 5- year PBI was used. In 2016, the legislature increased the program funding level from $83mm to $166mm and directed more funding to energy storage.

For the period 2010-2014, we allocated the SGIP funds using historic data on incentives and project types from the "SGIP Weekly Statewide White paper" dated 10/17/2016 (Center for Sustainable Energy, 2016). The weekly white paper provided PBI and completed spending on an individual project basis. For completed projects, we attributed all incentives to the program year. For projects currently receiving PBI, we allocated those funds using the program rules that allot 50% upfront and 10% per year for 5 years based on baseline performance and technology capacity factor. Here, again, we

TABLE A-27:

EPIC spending by Year

	First Triennial			Second Triennial			Third Triennial		
Year	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Total Spend	113.1	127.8	127.8	129.6	129.6	129.6	129.6	129.6	129.6
EE/DR	34.8	39.3	39.3	39.8	39.8	39.8	39.8	39.8	39.8
RE	50.2	56.7	56.7	57.5	57.5	57.5	57.5	57.5	57.5
Conventional	5.1	5.8	5.8	5.9	5.9	5.9	5.9	5.9	5.9
Storage	2.0	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Elec	20.9	23.7	23.7	24.0	24.0	24.0	24.0	24.0	24.0
Solar Admin	25.0	25.0	25.0						

TABLE A-28:

SGIP Incentives by Technology Type and Percentage Funding, 2013, 2014

Payment Completed + Total PBI	2013	2014	Average 2013 & 2014	Scaled 2015
Fuel Cell CHP	3,858,000	2,198,000	0.05	3,736,162.09
Internal Combustion	206,400	1,189,203	0.01	860,997.32
Photovoltaic	-	-	-	-
Microturbine	2,476,800	-	0.02	1,528,026.13
Gas Turbine	-	-	-	-
Wind Turbine	1,438,686	-	0.01	887,576.76
Fuel Cell Electric	45,498,345	29,805,510	0.56	46,457,630.20
Advanced Energy Storage (AES)	12,005,933	35,538,121	0.35	29,331,620.52
Pressure Reduction Turbine	-	320,920	0.00	197,986.98
Waste Heat to Power	-	-	-	-
Total	**65,484,164**	**69,051,755**	**1.00**	**83,000,000**

Source: Center for Sustainable Energy, 2016, "SGIP Weekly Statewide White paper" dated 10/17/2016.

assigned the first year of incentive spending to the program year in which the incentive was offered.

For the periods 2015 and 2016, most projects that have reserved funding have not yet completed their projects so the same methodology cannot be used. For these years, we allocate the average proportion of spending a given technology received in 2013 and 2014**.** This approach assumes that the total incentive to each technology will be in proportion to the prior levels.

For 2016-2019, the program structure was radically altered and more funding was allocated to energy storage. Under the new rules, 75% of total funding is reserved for energy storage and 25% for generation (CPUC 2016b). Of that 25%, 40% is reserved for renewable projects and 60% for conventional projects. Fuel Cells that are not powered by biogas are considered conventional. We assume that the money reserved for conventional will be proportional to the 2013-2014 split between fuel cells and other traditional technologies like gas turbines. Functionally this means that 95% of the conventional category will be fuel cells, and 5% will be internal combustion generators or gas turbines.

The discussion above allocates the proportion of total spending to a given technology but does not assign the year in which it will occur. We note that 60% of reserved spending in 2012-2014 went to PBI projects and assume the same proportion will occur in future years. Thus we allocate 70% of spending to year 0 (40% + 50% of 60%) with the remaining 30% of funding evenly distributed over the next five years. Finally, to calculate the results found in Table 12, we sum up the completed spend and the PBI spend by technology and year. ■

REFERENCES

79th Texas Legislature, 2005. *AN ACT relating to this state's goal for renewable energy*, S.B. 20. Available at: http://www.capitol.state.tx.us/BillLookup/Text.aspx?LegSess=791&Bill=SB20

Abbott, G, Patrick, D, and Straus, J, 2016. *2016 Budget Letter*. Available at: http://gov.texas.gov/files/press- office/BudgetLetter_06302016.pdf

AEP, 2017. *Texas Incentives, Program Status Page*. Accessed 1-23-2017. Available at: http://www.txreincentives.com/apv/status.php

Andrade, Juan, Baldick, Ross, "Estimation of Transmission Costs for New Generation," White Paper UTEI/2016-09-2, 2017, available at http://energy.utexas.edu/the-full- cost-of-electricity-fce/.

Austin Energy, 2015. *Austin Energy Annual Performance White paper:* Year Ended September 2015. Available at: http://austinenergy.com/wps/wcm/connect/6157fa61-3612-4443-8985- 34f1d98b9eb3/2015AnnualPerformance White paper.pdf?MOD=AJPERES

AWEA, 2017. Texas Wind Energy Fact Sheet, available September 16, 2017 at: http://awea.files.cms- plus.com/FileDownloads/pdfs/Texas.pdf.

Barbose, G., 2016. U.S. *Renewables Portfolio Standards: 2016 Annual Status White paper.* Lawrence Berkeley National Laboratory. Available at: https://emp.lbl.gov/sites/all/files/lbnl-1005057.pdf

Barbose, Galen, 2016. Private RPS correspondence

Brown, E, 2015. *Inaugural Address of Edmund G. Brown, Jr.* Available at: https://www.gov.ca.gov/news.php?id=18828

Bureau of Economic Analysis (2015). *Gross Domestic Product by State: Advance Statistics for 2014 and Revised Statistics for 1997–2013.* Available at: https://bea.gov/scb/pdf/2015/07%20July/0715_gross_domestic_product_by_state.pdf

California Department of Finance (CA-DOF), 2011. *Tax Expenditure White paper: 2011-12*. Available at: http://www.dof.ca.gov/Forecasting/Economics/Tax_Expenditure_White papers

California Department of Finance (CA-DOF), 2012. *Tax Expenditure White paper: 2012-13*. Available at: http://www.dof.ca.gov/Forecasting/Economics/Tax_Expenditure_White papers

California Department of Finance (CA-DOF), 2013. *Tax Expenditure White paper: 2013-14*. Available at: http://www.dof.ca.gov/Forecasting/Economics/Tax_Expenditure_White papers

California Department of Finance (CA-DOF), 2014. *Tax Expenditure White paper: 2014-15*. Available at: http://www.dof.ca.gov/Forecasting/Economics/Tax_Expenditure_White papers

California Department of Finance (CA-DOF), 2015. *Tax Expenditure White paper: 2015-16*. Available at: http://www.dof.ca.gov/Forecasting/Economics/Tax_Expenditure_White papers

California Department of Finance (CA-DOF), 2016. *Tax Expenditure White paper: 2016-17*. Available at: http://www.dof.ca.gov/Forecasting/Economics/Tax_Expenditure_White papers

California Department of Finance (DOF), 2016. *California State Budget, 2016-17.* Available at: http://www.ebudget.ca.gov/2016-17/Enacted/agencies.html

California Department of Food and Agriculture (CDFA), 2015. *California Agricultural Statistics Review, 2014- 2015.* Available at: https://www.cdfa.ca.gov/ statistics/PDFs/2015White paper.pdf

California Energy Commission (CEC), 2012. *The Electric Program Investment Charge: Proposed 2012-14 Triennial Investment Plan.* Document # CEC-500-2012-082-SF. Available at: http://www.energy.ca.gov/2012publications/CEC-500-2012-082/CEC-500-2012-082-SF.pdf

California Energy Commission (CEC), 2014. *The Electric Program Investment Charge: Proposed 2015-17 Triennial Investment Plan.* Document # CEC-500-2014-038-CMF. Available at: http://www.energy.ca.gov/2014publications/CEC-500-2014-038/CEC-500-2014-038-CMF.pdf

California Energy Commission (CEC), 2015. *Preliminary Demand Forecast Forms; "Energy Demand Forecast, 2016 - 2026, Preliminary Mid Demand Baseline Case, No AAEE Savings".* Retrieved from: http://www.energy.ca.gov/2015_energypolicy/documents/2015-07- 07_preliminary_forecast_forms.html

California Energy Commission (CEC), 2015. *Supporting Information for Energy Commission Request for Continuation of New Solar Homes Partnership Program and Designation As Program Administrator.* Available at: http://www.gosolarcalifornia.ca.gov/about/documents/2015-12- 04_Support_Material_for_CPUC_on_NSHP.pdf

California Energy Commission (CEC), 2015b. *Utility Capacity Supply Plans from 2015.* Retrieved from: http://www.energy.ca.gov/almanac/electricity_data/s-1_supply_forms_2015/

California Energy Commission (CEC), 2016a. *2015 Integrated Energy Policy White paper*. Available at: http://docketpublic.energy.ca.gov/PublicDocuments/15-IEPR- 01/TN212017_20160629T154354_2015_Integrated_Energy_Policy_White paper_Small_File_Size.pdf

California Energy Commission (CEC), 2016b. *Total Electricity System Power.* Available at: http://www.energy.ca.gov/almanac/electricity_data/total_system_power.html

California Energy Commission (CEC), 2016c. *CSI Working Data Set.* Current as of Jan. 11, 2017. Retrieved from: https://www.californiasolarstatistics.ca.gov/data_downloads/.

California Energy Commission (CEC), 2016c. *Actual and Expected Energy from Coal for California.* Available at: http://www.energy.ca.gov/renewables/tracking_progress/documents/current_expected_energy_fro m_coal.pdf

California Energy Commission (CEC), 2016d. *Publicly Owned Utilities White paper Summary, January 1, 2015 to December 31, 2015.* Retrieved from: http://www.energy.ca.gov/sb1/pou_white papers/

California Public Utilities Commission (CPUC), 2012. *White paper to the Legislature in Compliance with Public Utilities Code Section 910.*

California Public Utilities Commission (CPUC), 2014. *White paper to the Legislature in Compliance with Public Utilities Code Section 910.*

California Public Utilities Commission (CPUC), 2016a. *White paper to the Legislature in Compliance with Public Utilities Code Section 913.3.* Available at: http://www.cpuc.ca.gov/uploadedFiles/CPUC_Website/Content/Utilities_and_Industries/Energy/W hite papers_and_White_Papers/Pub%20Util%20913.3%20White paper%20-%20Final%20-%20Print%20-%20Revised.pdf

California Public Utilities Commission (CPUC), 2016c. *Biennial RPS Program Update In Compliance with Public Utilities Code Section 913.6.* Available at: http://www.cpuc.ca.gov/RPS_White papers_Docs/

California Public Utilities Commission (CPUC), June 23, 2016b. *Decision 16-06-055: Decision Revising the Self- Generation Incentive Program Pursuant to Senate Bill 861, Assembly Bill 1478, and Implementing Other Changes.* Available at: http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M163/K928/163928075.PDF

California Public Utilities Commission (CPUC), June 9, 2016c. *Decision 16-06-006: Decision Funding Authorizations and Related Measures for Continuation of the New Solar Homes Partnership Program.* Availableat: http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M163/K266/163266780.PDF

California Public Utilities Commission (CPUC), October 17, 2013. *Rulemaking 10-12-007: Decision Adopting Energy Storage Procurement Framework and Design Program*. Available at: http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M078/K912/78912194.PDF

California State Board of Equalization (CA-BOE), May 21, 2008. *Solar Energy Property Tax Incentive*. Available at: https://www.boe.ca.gov/proptaxes/pdf/lta08037.pdf

California State Board of Equalization (CA-BOE), November 2012. *Special Note Solar Power Facilities May Qualify as Farm Equipment.* Available at: https://www.boe.ca.gov/news/pdf/l330.pdf .

Center for Sustainable Energy, 2016, *Self Generation Incentive Program Weekly Statewide White paper.* White paper dated 10/17/2016. Available at: https://www.selfgenca.com/home/resources/

El Paso, 2017. Texas Incentives, Program Status Page. Accessed 1-23-2017. Available at: http://www.txreincentives.com/elpasopv/status.php

Electric Reliability Council of Texas (ERCOT), Analysis of Transmission Alternatives for Competitive Renewable Energy Zones in Texas, December 2006.

Electric Reliability Council of Texas (ERCOT), 2013. *Renewable energy generation in Texas continues to grow, up 7 percent from 2011.* Available at: http://www.ercot.com/news/releases/show/26445

Energy + Environmental Economics, 2016. *RPS Calculator*. Created for the California Public Utilities Commission. Available at: http://www.cpuc.ca.gov/RPS_Calculator/

Energy Information Administration (EIA), 2015. *Energy-Related Carbon Dioxide Emissions at the State Level, 2000-2013.* Available at: http://www.eia.gov/environment/emissions/state/analysis/pdf/stateanalysis.pdf

Energy Information Administration (EIA), 2016c. *Annual Coal White paper 2015*. Available at: http://www.eia.gov/coal/annual/pdf/acr.pdf

Energy Information Administration (EIA), 2016a, *State Profile and Energy Estimates: Texas*. Available at: http://www.eia.gov/state/?sid=TX

Energy Information Administration (EIA), 2016b, *State Profile and Energy Estimates: California*. Available at: http://www.eia.gov/state/?sid=CA

Energy Information Administration (EIA), 2017, June 2017 Preliminary Monthly Electric Generator Inventory (based on Form EIA-860M as a supplement to Form EIA-860). Available September 18, 2017 at: https://www.eia.gov/electricity/data/eia860m/.http://www.eia.gov/state/?sid=CA

Galbraith, K., 2011. Cost of Wind Power Transmission Lines Rises Sharply to $6.79 Billion, *Texas Tribune*, August 24, 2011, available July 10, 2017 at: https://www.texastribune.org/2011/08/24/cost-texas-wind-transmission-lines-nears-7-billion/.

Gallup (2015). State of the States. Available at: http://www.gallup.com/poll/125066/state-states.aspx . Griffiths, Benjamin W., Gülen, Gürcan, Dyer, James S., Spence, David, and King, Carey W.. "Federal Financial

Support for Electricity Generation Technologies" White Paper UTEI/2016- 11-2, 2017, available at: http://energy.utexas.edu/the-full-cost-of-electricity-fce/.

GTM Research, 2016. *U.S. Energy Storage Monitor: Q3 2016 Executive Summary*. Available at: https://www.greentechmedia.com/research/subscription/u.s.-energy-storage-monitor

HRO 2001. Relief from Severance Taxes: Incentive or Windfall? Focus Report Number 77-5 of the House Research Organization of the Texas House of Representatives. Available September 1, 2017 at http://www.hro.house.state.tx.us/focus/sever.pdf.

Kalimeris, P., Richardson, C., & Bithas K, 2013. *A meta-analysis investigation of the direction of the energy-GDP causal relationship: implications for the growth-degrowth dialogue.* Journal of Cleaner Production. Vol 67, 1-13. DOI: 10.1016/j.jclepro.2013.12.040. Available at: http://csis.msu.edu/research/publications/meta-analysis-investigation-direction-energy-gdp- causal-relationship-implicati

Legislative Budget Board of Texas (LBB), 2016. *State Budget by Program: 84th Regular Session (2016-17).* Retrieved from: http://sbp.lbb.state.tx.us/

Legislative Budget Board of Texas (LBB), 2017. Fiscal Size-up: 2016-17 Biennium, available September 18, 2017 at: http://www.lbb.state.tx.us/Documents/Publications/Fiscal_SizeUp/Fiscal_SizeUp.pdf.

Los Angeles Department of Water & Power (LADWP), 2015. *2015 Briefing Book*. Available at: http://www.ladwpnews.com/external/content/document/1475/2606574/1/2015%20Briefing%2 0Book%2002-26-2015LR.pdf

Luhavalja, A., 2015. *Texas REC prices stall beneath $1/MWh amid bearish supply, demand factor.* SNL Energy. Available at: http://www.clearenergybrokerage.com/texas-rec-prices-stall-beneath-1mwh-amid- bearish-supply-demand-factors/

Malewitz, J., 14-Oct-2013. *$7 Billion Wind Power Project Nears Finish*. The Texas Tribune. Available at: https://www.texastribune.org/2013/10/14/7-billion-crez-project-nears-finish-aiding-wind-po/

Malewitz, J., 20-Oct-2014. *First Wind, Now Gas: Tax Breaks Face Scrutiny*. The Texas Tribune. Available at: https://www.texastribune.org/2014/10/20/big-tax-break-natural-gas-get-scrutiny/

Malewitz, J., 29-Oct-2015. *When Oil Wells Become Gas Wells, the State Loses.* The Texas Tribune. Available at: https://www.texastribune.org/2015/10/29/reclassified-wells-might-mean-less-texas-revenue/

Mann, N., Tsai, Chen-Hao, Gülen, Gürcan, Schneider, Erich, Cuevas, Pedro, Dyer, James S., Butler, John C., Baldick, Ross, Deetjen, Thomas, and Morneau, Rachel. 2017. "Capacity Expansion and Dispatch Modeling: Model Documentation and Results for ERCOT Scenarios" White Paper UTEI/2017-4-14, available at: http://energy.utexas.edu/policy/fce.

Meindl, G, June 15, 2014. *Assembly Floor Analysis of SB-871*. California Budget Office. Available at: http://leginfo.legislature.ca.gov/faces/billAnalysisClient.xhtml?bill_id=201320140SB871#

Munsell, M. 1-June-2016. "Solar PV Prices Will Fall Below $1.00 per Watt by 2020" in Greentechmedia. Available at: https://www.greentechmedia.com/articles/read/solar-pv-prices-to-fall-below-1.00- per-watt-by-2020

National Academies of Sciences, Engineering, and Medicine, 2017, Valuing climate damages: Updating estimation of the social cost of carbon dioxide. Washington, DC: The National Academies Press, 280 p., doi: https://doi.org/10.17226/24651.

Oil Change International (OCI), 2014 "*Cashing in on All of the Above: U.S. Fossil Fuel Production Subsidies under Obama*" Available at http://priceofoil.org/content/uploads/2014/07/OCI_US_FF_Subsidies_Final_Screen.pdf

Oncor, 2017. *Solar Photovoltaic Standard Offer Program: 2017 Program Manual.* Available at: https://www.oncoreepm.com/Documents/Solar%20Photovoltaic%20Program%20Manual.pdf

Railroad Commission of Texas (RRC), 2017. Present Texas Severance Tax Incentives. Visited 1-27-2017. Available at: http://www.rrc.state.tx.us/oil-gas/publications-and-notices/texas-severance-tax- incentives-past-and-present/presenttax/

Rhodes, Joshua D., King, Carey W. Gülen, Gürcan, Olmstead, Sheila M., Dyer, James S., Hebner, Robert E., Beach, Fred C., Edgar, Thomas F., and Webber, Michael E., 2016. "A Geographically Resolved Method to Estimate Levelized Power Plant Costs with Environmental Externalities", White Paper UTEI/2016- 04-1, 2016, available at http://energy.utexas.edu/the-full-cost-of-electricity-fce/

RS&H, 2013. Competitive Renewable Energy Zone Program Oversight: CREZ Progress Report No. 12 (July Update), prepared for Public Utility Commission of Texas.

Saporito, S., 2015. *CPS puts millions into new solar rebate program* in San Antonio Business Journal. Available at: http://www.bizjournals.com/sanantonio/news/2015/12/15/cps-puts-millions-into-new-solar- rebate-program.html

Texas Comptroller of Public Accounts (Comptroller), 2015, *Tax Exemptions & Tax Incidence: A White paper to the Governor and the 84th Texas Legislature.* Available at: https://www.comptroller.texas.gov/transparency/white papers/tax-exemptions-and-incidence/

Texas Comptroller of Public Accounts, 2009, *Tax Exemptions & Tax Incidence: A White paper to the Governor and the 81nd Texas Legislature.*

Texas Comptroller of Public Accounts, 2011, *Tax Exemptions & Tax Incidence: A White paper to the Governor and the 82nd Texas Legislature.* Available at: https://www.comptroller.texas.gov/transparency/white papers/tax-exemptions-and-incidence/

Texas Comptroller of Public Accounts, 2011b. *White paper of the Texas Economic Development Act 2011*. Available at: http://www.comptroller.texas.gov/economy/local/ch313/biennial-white papers.php Texas Comptroller of Public Accounts, 2013*, Tax Exemptions & Tax Incidence: A White paper to the Governor and the 83rd Texas Legislature.* Available at: https://www.comptroller.texas.gov/transparency/white papers/tax-exemptions-and-incidence/

Texas Comptroller of Public Accounts, 2013b. *White paper of the Texas Economic Development Act 2013*. Available at: http://www.comptroller.texas.gov/economy/local/ch313/biennial-white papers.php Texas Comptroller of Public Accounts, 2014. *High-Cost Natural Gas Tax Rate Incentive Study.* Available at: https://www.comptroller.texas.gov/transparency/white papers/high-cost-natural-gas/high-cost- natural-gas.pdf

Texas Comptroller of Public Accounts, 2015b. *White paper of the Texas Economic Development Act 2015*. Available at: http://www.comptroller.texas.gov/economy/local/ch313/biennial-white papers.php Texas Comptroller of Public Accounts, 2015b. *The 2016-17 Certification Revenue Estimate*. Available at: https://www.comptroller.texas.gov/transparency/white papers/certification-revenue- estimate/2016-17/cre.pdf .

Texas Comptroller of Public Accounts, 2016b. *Biennial Registries of Reinvestment Zones for Tax Abatements and Tax Increment Financing 2016*. Available at: https://www.comptroller.texas.gov/economy/docs/96-1726-tif-abate-2016-reg.pdf

Texas Comptroller of Public Accounts, 2017. *White paper of the Texas Economic Development Act 2017.* Available at: http://www.comptroller.texas.gov/economy/local/ch313/biennial-white papers.php TX Util. Code. § 2.B.39.904 "GOAL FOR RENEWABLE ENERGY." Available at: http://www.statutes.legis.state.tx.us/docs/ut/htm/ut.39.htm#39.904

U.S. Department of Energy, 2016. *Renewable Energy Certificate Retail Products: REC Prices.* Available at: http://apps3.eere.energy.gov/greenpower/resources/tables/certificates.shtml?page=5

United States Census Bureau (2016*). Annual Estimates of the Resident Population for the United States, Regions, States, and Puerto Rico: April 1, 2010 to July 1, 2016* (NST-EST2016-01). Retrieved from: http://www.census.gov/data/tables/2016/demo/popest/nation-total.html

Wible, Jason A., King, Carey W., 2016. "Household Energy Costs for Texans" White Paper UTEI/2016-03-1, 2016, available at http://energy.utexas.edu/the-full-cost-of-electricity-fce/.

Wu, Tiffany, Olmstead, Sheila, Spence, David B., "EPA's Valuation of Environmental Externalities from Electricity Production," White Paper UTEI/2016-09-1, 2016, available at http://energy.utexas.edu/the-full-cost-of-electricity-fce/.